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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 16-2

“Landmine Detection”
(«Обнаружение мин»)

Публикации в трудах конференций

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"Sliding Mode Control Using Fast Output Sampling for a Mine Sweeping Plough"

For the severe nonlinearity and time-varied problems of controlled object existed in mine sweeping plough electro-hydraulic servo system of a weapon, this paper presents a discrete-time sliding mode control technique using fast output sampling. Fast output sampling enables arbitrary sliding mode design and an equivalent fast output feedback control. In practice the system states needed in the sliding mode method are sometimes difficult to obtain. FOS method, which makes use of only the output samples, is combined with sliding mode method to accommodate the incomplete system state information. Thus, the control approach is more practical and easy to implement. The method and its stabilization are examined under numerical simulations and the results show that the proposed method produces excellent results and multimodel robust stabilization is achieved. [C1]

"Management information system for provincial mineral resources based on ArcGIS"

Methodology and key technology of provincial information system of mine resources planning and management based on ArcGIS were discussed. Geographic Information System (GIS) is a comprehensive information technology capable to store, manage, analyze and display spatial data, and its powerful spatial query and spatial analysis function have been widely used in management of land resources. The regional GIS for mineral resources management has a 3-layered architecture, which are provincial, municipal, and county lever respectively. The informationization method of the mineral resources management was studied theoretically and practically. Spatial databases combined with graphic databases and attribute databases were established with ArcSDE, which is a database engine developed by the Environmental Systems Research Institute (ESRI). The interior table of the graphic database and the outside table of the attribute database are linked by the key fields. The graphic data together with the attribute data, can be stored, processed and analyzed in accordance. ArcGIS developed by ESRI was chosen as GIS development platform,and Oracle was chosen as database platform. The developing languages were Microsoft Visual Basic, VB.NET and Javascript. The developed system can support the functions of mineral resources management, data maintenance, data update, data share and data publishing. The development of the above mentioned system provided a successful scheme for the management of regional mine resources. [C2]

"A noise robust variant of context extraction for local fusion"

Context extraction for local fusion (CELF) is a local approach that combines multiple classifier outputs with the help of feature space information. CELF is based on an objective function that integrates context extraction and decision fusion. Context extraction divides the feature space into homogeneous regions; decision fusion combines multiple classifier outputs in each region or context. Although CELF is a generalization of previous fusion methods, it has some problems and noise sensitivity is one of them. The noise sensitivity problem comes from the fact that there are large number of parameters that should be optimized. Some variants of CELF were propose to mitigate the noise sensitivity problem and they showed better results than CELF. However, they also have their own shortcomings. In this paper, we proposed another variant of CELF to reduce the noise sensitivity and to overcome the shortcomings in the variants of CELF. The proposed method, CELF with regularization (CELF-R), uses regularization, which is a well-known method to reduce noise sensitivity by smoothing solution space. The noise robustness in CELF-R helps it to achieve better results than CELF and its variants. Experiments using landmine data sets also support this. [C3]

"A segmentation-based CFAR algorithm for subsurface targets detection in FLGPSAR"

Forward-Looking Ground Penetrating Synthetic Aperture Radar (FLGPSAR) has the capability of forming two-dimensional high-resolution images of subsurface objects from a standoff distance. This paper addresses the detection of subsurface targets, i.e. landmines, in FLGPSAR images. The conventional Constant False-Alarm Rate (CFAR) algorithm has been widely used in SAR image target detection, but its performance will degrade in subsurface targets detection because of the presence of interfering targets and clutter power transition. In this

paper, a segmentation-based CFAR (S-CFAR) algorithm is proposed. The S-CFAR algorithm can remove the interfering targets or clutter power transition before estimating the parameters of the clutter background to achieve a better performance than the conventional CFAR algorithm. The real data processing results are given to validate the efficiency of the proposed method. [C4]

"ALIS: GPR for humanitarian demining and its evaluation in Cambodia"

The authors developed dual sensor ALIS, which is equipped with GPR and metal detector. The image reconstruction algorithm is useful for clutter reduction and buried landmine image can be obtained. The system has been evaluated by test in minefields in Cambodia and could detect more than 30 mines. We are planning to continue this evaluation tests, and plan real deployments. [C5]

"Feature extraction and selection for landmine detection using textures of Time-Frequency Representation"

Ground Penetrating Radar (GPR) is widely used in the probe of subsurface targets, in which the Time-Frequency Representation (TFR) approaches have been proved effective for GPR signatures. Since we can treat TFR results as 2-D images, texture analysis is an applicable way for image discrimination. In this study, we propose a target detection method based on TFR textures of GPR A-scans and then select 20 descriptors to interpret TFR image into texture features for decision. The mutual correlation and discrimination ability of the descriptors are studied based on the comparative experiment. According to the results, it is clear that the twenty descriptors are redundant and can be grouped into three weak-correlated classes: 11 descriptors of the first class and 2 of the second one are helpful and recommended to use in texture discrimination while the rest can be discarded. [C6]

"Spatial multiple instance learning for hyperspectral image analysis"

Standard multiple instance learning (MIL) techniques are capable of learning when there is a lack of target information (including size, shape, and even location); however, this is attained at the cost of the utility of spatial information. This is unfortunate because in many image analysis applications, there is a substantial amount of observable spatial information. The research presented in the following investigates appropriate methods to incorporate spatial information into the MIL framework while maintaining the benefits of the MIL paradigm. The proposed Spatial Multiple Instance Learning (S-MIL) method is applied to a hyperspectral data set for the purposes of landmine detection. [C7]

"SIMO-based approach for subsurface sensing"

In this paper, application of near-field digital beamforming for shallow subsurface imaging is described. The main novelty of the approach is SIMO topology of the sensing (single transmit-multiple receive antennas). Dedicated antenna systems and imaging algorithms have been developed in order to take maximal advantages from the SIMO data acquisition. Verification of the approach has been done by development of a radar system for landmine detection. Field tests have demonstrated reliable detection of antipersonnel mines by scanning velocity of 10m/s. [C8]

"GPR modeling for landmine detection"

Ground penetrating radar (GPR), which can detect shallow buried low dielectric contrast objects in a variety of soils by non-invasive subsurface sensing, is a promising technology for imaging low-metal or non-metallic landmines. In this paper we present a complete model of a complex GPR scenario which is solved via finite element method, and includes the actual impulse GPR system, interface, soil and targets. We obtain time domain signatures for different testmines and small objects under different soil conditions which are satisfactorily correlated with measurements. The simulated responses give us a broad understanding about the factors which control the electromagnetic scattering by small objects and are used to interpret the characteristics of the signatures according to the target and background parameters. These obtained waveforms may be applied to reduce the false alarm. [C9]

"CCD camera and IGPS tracking of geophysical sensors for visualization of buried explosive devices"

High-resolution Ground Penetrating Radar (GPR) images of the ground surface and shallow subsurface are needed in order to detect and identify small buried explosive materials such as Anti-Personnel (AP) landmines. A key requirement to produce sharp visualizations is centimetre-precise sensor positioning with real-time imaging results. We are pursuing two complementary approaches to accomplish this task: 1) Sensor tracking with a CCD

camera, 2) and large work volume Indoor GPS. In outdoor field tests both methods have successfully imaged small landmine targets, which has a plastic body of less than 10cm diameter. [C10]

"Dirichlet process based context learning for mine detection in hyperspectral imagery"

Hyperspectral imagery (HSI) has been shown to be a powerful remote sensing phenomenology that is appropriate for a variety of classification and detection tasks. Standard detection and classification algorithms applied to hyperspectral data are hindered by environmental factors that alter the statistics of the data such as sun intensity, atmospheric conditions or soil properties. Detection and classification algorithms operating on HSI must account for the changing context underlying each observation for robust performance. This work focuses on algorithms that incorporate knowledge of underlying context for the discrimination of landmine responses from other surface or sub-surface anomalies using airborne HSI. This work compares both generative context models, that model context at a given location using features of the surrounding data, and discriminative context models that determine the context at a given location to maximize performance. Both approaches utilize a Dirichlet process prior to infer the number of contexts within the data without the need to explicitly label the context of each image or location within the image. Results indicate that Dirichlet process based generative context clustering determines contexts that are congruent with physical characteristics such as time of day, but does not necessarily lead to performance improvements. Dirichlet process based discriminative clustering, however, yields performance greater than a labeled generative approach. [C11]

"Variational Mixture of Experts for Classification with Applications to Landmine Detection"

In this paper, we (1) provide a complete framework for classification using Variational Mixture of Experts (VME); (2) derive the variational lower bound; and (3) apply the method to landmine, or simply mine, detection and compare the results to the Mixtures of Experts trained with Expectation Maximization (EMME). VME has previously been used for regression and Waterhouse explained how to apply VME to classification (which we will call as VMEC). However, the steps to train the model were not made clear since the equations were applicable to vector valued parameters as opposed to matrices for each expert. Also, a variational lower bound was not provided. The variational lower bound provides an excellent stopping criterion that resists over-training. We demonstrate the efficacy of the method on real-world mine classification; in which, training robust mine classification algorithms is difficult because of the small number of samples per class. In our experiments VMEC consistently improved performance over EMME. [C12]

"Cross Entropy Optimization of the Random Set Framework for Multiple Instance Learning"

Multiple instance learning (MIL) is a recently researched technique used for learning a target concept in the presence of noise. Previously, a random set framework for multiple instance learning (RSF-MIL) was proposed; however, the proposed optimization strategy did not permit the harmonious optimization of model parameters. A cross entropy, based optimization strategy is proposed. Experimental results on synthetic examples, benchmark and landmine data sets illustrate the benefits of the proposed optimization strategy. [C13]

"Performance evaluation of a GPR system for mine detection using a 3D-SAR algorithm"

Within the "International Test & Evaluation Program" (ITEP) a measurement campaign (ITEP project 2.4.2.13) was held in Oberjettenberg, Germany, to evaluate novel evaluation procedures for the test and evaluation of dual sensor (DS) mine detection devices (metal detector MD and ground penetrating radar GPR). FHR contributed with a UWB GPR sensor and a novel radar data processing algorithm. The improvement of the application of a near field 3D-SAR algorithm compared to standard GPR data processing is shown in terms of the receiver operating characteristics (ROC) curve. [C14]

"A robust CMOS Receiver front-end for Nuclear Quadrupole Resonance based explosives detection"

Hidden bombs and abandoned military landmines buried in the afterwar field has become a severe threat to the society. A stand-off, high sensitive and portable explosive detection system is required to help this situation. Nuclear Quadrupole Resonance (NQR) detection technology has proven to be a highly effective solution for unambiguously detecting explosives, since NQR is an inherent characteristic of explosive substances. However, the current NQR based explosive detectors for field application have bulky size, and are vulnerable to the noise and Radio Frequency Interference (RFI). To address this problem, a robust CMOS Receiver front-end for NQR signal detection is proposed in this work. A Continuous Time Least Mean Square (CTLMS) adaptive filter is employed to mitigate RFI in the analog domain before the data quantization and further processing. With the proposed receiver circuit, the requirement of high precision data acquisition and complex detection algorithms downstream with high computation cost can be effectively relaxed. The proposed circuit system is implemented

with 0.18 μm RF CMOS process. [C15]

"Adaptive linear prediction based buried object detection with varying detector height"

In the GPR underground inspection problem, received GPR signal is notably dependent on the height of the detector head. A great deal of the former research in this area assumes constant detector height, as absence of this constancy will result in undesired change in the returning signal, which will reduce the success of the detection and identification stages. In this study, we propose a buried object detection method which removes the deforming effect of the variable sensor height. In our approach, adaptive one-sided linear prediction is utilized in a specific manner. The proposed algorithm is causal, which makes it convenient for real time buried object detection applications. [C16]

"SAR and Stolt Migration processing for plastic landmine detection"

The paper describes the plastic mine detection by Ground Penetrating Radar. The received data evaluation and imaging are based on two- and three-dimensional Synthetic Aperture Radar (SAR) and Stolt Migration methods. The results of the processing that are subject to discussion were presented using the examples of measurement of antitank mine situated on the sand surface and anti-personal mine located both on and under the sand surface. [C17]

"Planar landmark detection using a specific arrangement of LIDAR scanners"

All terrestrial applications which depend on a GPS receiver for a precise position fix suffer in the urban environments. A Terrestrial Mobile Mapping System is one such application. We have been working on a Terrestrial LIDAR (Light Detection and Ranging)scanner (or Laser scanner) based Mobile Mapping System (MMS) in our laboratory. To aid the localization of our moving mapping platform (a land vehicle), we opted to use the technology similar to SLAM (Simultaneous Localization and Mapping). Our primary focus is on the urban canyons where the GPS signal perturbations are highly likely to occur. The main characteristic of an urban canyon is the planar sections of the man made buildings. In this paper, we present a specific arrangement of the LIDAR scanners tailored to extract the planar landmarks. This is the first important step in improving the localization functionality. Here we discuss about our new LIDAR system configuration and the design justifications along with the obtained results of planar landmark extraction. [C18]

"Motion compensation for landmine detecting vehicle-borne SAR"

In this paper we consider motion compensation of vehicle-borne SAR for landmine detecting, where the motion error is one of the major challenges. Motion compensations algorithms in both azimuth and range direction are discussed. Aiming at vehicle-borne SAR, the motion compensation in range direction utilizes only one 1-axis MEMS accelerometer instead of a 6 Degrees of Freedom inertial sensor, and the motion compensation in azimuth direction can be done only by the knowledge of the vehicle's velocity. The experiment results demonstrate that the motion compensation algorithm together with a standard low-cost accelerometer can yield very useful images for vehicle-borne SAR for landmine detection. [C19]

"Taper-walled linearly tapered slot antenna: A low direct-coupling antenna for subsurface imaging"

Ground penetrating radars attract attention of many researchers as a new technique to visualize antipersonnel plastic landmines. Previously we proposed a high-density and wideband array that realizes high-resolution and quick imaging. However, the high-density array sometimes suffers from direct coupling among antenna elements, which decreases the performance of the landmine detection. In this paper, we propose a new antenna element employing open slits and tapered aperture to decrease the direct coupling. [C20]

"GPR measurements and FDTD simulations for landmine detection"

Among the technologies used to improve landmine detection, Ground Penetrating Radar (GPR) techniques are being developed and tested jointly by "Sapienza" and "Roma Tre" Universities. Using three-dimensional Finite Difference Time Domain (FDTD) simulations, the electromagnetic field scattered by five different buried objects has been calculated and the solutions have been compared to the measurements obtained by a GPR system on a (1.3 Ч 3.5 Ч 0.5) m3sandbox, located in the Humanitarian Demining Laboratory at Cisterna di Latina, to assess the reliability of the simulations. A combination of pre-calculated FDTD solutions and GPR scans, may make the detection process more accurate. [C21]

"Landmines detection using finite-difference time-domain and artificial neural networks"

In this paper, the performances of the neural-network approach for discrimination of the landmine depth from the ground surface and the landmine radius are carried out. A sensor for landmines detection consists of two microstrip antennas is used. One of the antennas is used as transmitting antenna and the second is considered as receiving antenna. Circular cylindrical shape metallic landmine is used. The neural-network process data are obtained from the FDTD formulation of the electromagnetic scattering. The inputs in the input layer of the neural network are the magnitude of the mutual coupling between the microstrip antennas, |S21| while the outputs are landmine depth from the ground surface and landmine radius. Good agreement with exact profile has been observed. The computation time and computer memory of the inverse problem are considerably reduced. [C22]

"Deployment of GPR system ALIS for humanitarian demining in Cambodia"

ALIS is a hand-held dual sensor developed by Tohoku University, Japan since 2002. Dual sensor is a general name of sensor for humanitarian demining, which are equipped with metal detector and GPR. ALIS is only one hand-held dual sensor, which can record the sensor position with sensor signals. Therefore, the data can be processed after data acquisition, and can increase the imaging capability. ALIS has been tested in some mine affected courtiers including Afghanistan (2004), Egypt(2005), Croatia(2006-) and Cambodia(2007-). Mine fields at each country has different conditions and soil types. Therefore testes at the real mine fields are very important. ALIS has detected more than 30 AP-Mines in evaluation test in Cambodia held in 2009. [C23]

"Detection and classification of landmines using AR modeling of GPR data"

In this paper we present some results on detection and classification of low metal content anti personnel (AP) landmines using a modified version of the Auto Regressive (AR) modeling algorithm presented in. A statistical distance is computed between the AR coefficients of the measured GPR time signal and the AR coefficients of a reference database (containing the AR models of the mines of interest) and a detection is declared if this distance is below a given threshold. [C24]

"Influence of soil inhomogeneity on GPR for landmine detection"

Landmine detection by ground-penetrating radar (GPR) becomes challenging when soil is inhomogeneous. Soil inhomogeneity causes unwanted reflections (clutter) which disturb reflections from landmines. Thorough investigations on the influence of soil inhomogeneity and clutter on GPR are important for the use in demining to assess the performance and ensure the safety of the operation. In order to observe the influence of soil inhomogeneity an irrigation test was carried out and GPR data were collected after the irrigation while soil water content distribution was changing. Correlation length and variability of soil electric properties are determined by geostatistical analysis from GPR data. The theoretical calculation of Mie scattering using the determined parameters is in good agreement with power of clutter extracted from GPR data. Therefore it is demonstrated that scattering by soil inhomogeneity is governed by Mie scattering. [C25]

"Humanitarian demining robot Gryphon: New vision techniques and optimization methods"

Landmines continue killing and injuring people even many years after the end of conflicts. Mechanical systems and robots have been used for assisting in landmines location and improving the quality of humanitarian demining tasks. These new systems are expected to enhance safety, efficiency, time duration, etc, but many improvements are still needed in order to realize a practical system. In this paper, new vision techniques for improving the effectiveness of terrain mapping using stereo vision camera under high-contrast light conditions, i.e., mixed direct sunlight and shadowed areas, are introduced. Furthermore, trajectory optimization taking in account the obtained terrain map is also analyzed, which greatly reduces time consumption for landmine location marking tasks. These newly introduced methods greatly contribute to overall increase in reliability and efficiency of humanitarian demining tasks. [C26]

"Design of mine detection robot for Korean mine field"

This paper presents the critical design constraints of mine detection robots for Korean minefield. As a part of a demining robot development project, the environment of Korean minefield was investigated, and the requirements for suitable robot design were determined. Most of landmines in Korean minefield were buried close to the demilitarized zone (DMZ) more than half of a century ago. The areas have not been urbanized at all since the Korea War, and the potential locations of the explosives by military tactics have been covered by vegetation. Therefore, at the initial stage of the demining robot system development, the target areas were investigated and the suitable design for Korean minefield terrain was determined. The design includes a track type main platform with a simple moving arm and a mine detection sensor (consists of a metal detector and a GPR at this stage). In addition, in order to maintain the effective distance between the landmine sensors and ground surface, a distance sensing technique for terrain adaptability was developed and briefly introduced in this paper. The overall

design of this robot was determined by considering the speed of the whole mine detection process and a point of economic view to replace human in minefield. Thus, the detail of the conceptual design and the mine detection scenario is presented in this paper. [C27]

"Design and implementation of multi-sensor based autonomous minesweeping robot"

The scope of this paper is to introduce the architecture of a minesweeping robot which is designed and implemented as a research project. Reduction of the human activities in dangerous environment is the first objective of employing the autonomous mobile robots in many applications. Mine detection is a risky action that can be done by either human or robot. Aria Robot is an autonomous four wheels robot that is designed to search through an arbitrary minefield for detecting landmines. Wireless connection is established between the local controller on the robot and general controller that is installed at the outside of the minefield to handle the whole navigation procedure. A personal computer (PC) acts as the general controller which is responsible for mapping the landmines and determining some general settings for local controller. The local controller navigates the robot based on the feedbacks from several sensors to detect the barriers and landmines such as digital compass, optical shaft encoder, current sensor, ultrasonic range finder sensors, infrared (IR) sensor and mine detector sensor. [C28]

"Remote mine sensing technology using a mobile wheeled robot RAT-1"

To conduct mine detection experiments using an octal wheeled prototype robot RAT-1, we developed end effectors to be attached to the driving wheels of the robot. This enables the robot to step safely and stably without hitting hidden mines. We created a simulation model for this study to test the movement of a robot having metal sensors attached to the front of its wheels and a driving algorithm with effect control based on IR cameras. We verified the efficiency of the system in actual walking experiments. We also studied remote sensing technology uses for IR cameras combined with other metal sensors. Tests with trial mines were used to study the detection characteristics of IR cameras and various technologies for collecting and processing image data in real time for optimum mine detection. [C29]

"Nanostructured surface enhanced Raman scattering substrates for explosives detection"

Here we present a method for trace detection of explosives in the gas phase using novel surface enhanced Raman scattering (SERS) spectroscopy substrates. Novel substrates that produce an exceptionally large enhancement of the Raman effect were used to amplify the Raman signal of explosives molecules adsorbed onto the substrate. The substrates were fabricated in a cleanroom process which only requires two steps to produce well controlled nano-sized high aspect ratio metal pillars. These substrates had superior chemical sensing performance in addition to a more cost effective fabrication process compared to existing commercial substrates. Therefore it is believed that these novel substrates will be able to make SERS more applicable in mobile explosives detection systems to be deployed in for example landmine clearance actions. [C30]

"Cepstral detection of buried landmines from acoustic images with a spiral scan"

This paper introduces a cepstral approach for the detection of landmines from acoustic images. This approach is based on transforming the 2D landmine images to 1D signals using a spiral scan to make object pixels as close as possible to each other after the scan. The Mel-frequency cepstral coefficients (MFCCs) and polynomial shape coefficients are extracted from these 1D signals to form a database of features, which can be used to train a neural network. The discrete cosine transform (DCT) and the discrete wavelet transform (DWT) are also investigated in this paper for the possible extraction of features from these transforms of the original images and/or the original images themselves. The detection of landmines can be performed by extracting features from any new image with the same method used in the training phase. These features are tested with the neural network to decide whether a landmine exists or not. Experimental results show that, the proposed cepstral approach with features extracted from the 2D DCT are the most robust and reliable features in the detection process because of its strong energy compaction property. [C31]

"Land Mine Detecting Robot Capable of Path Planning"

The Landmine detecting robots are designed to cover maximum possible area of landmine field for detection of landmines. The detected landmines along with scanned and leftover area are represented on a visual map with accuracy in millimeters. This paper presents a prototype model of land mine detecting robot that is powerful yet low cost and easily controllable. A graphical user interface is developed for plotting the landmines, scanned & leftover area presentation, PID tuning and camera alignment. Emphasis is placed on the control of the differential drive robot in auto mode, semi-auto mode and the manual mode. Image processing technique is employed to find the accurate position of robot which provides the live reckoning feedback to the dead reckoning

servo control of the robot. Metal detector is the sensor used to detect landmines. The graphical user interface for the remote terminal computer provides the effective control for the robot. The system is simple but powerful and intelligible to achieve the required results. [C32]

"A development project of autonomous marine surface vehicles for sea demining"

A sea demining system using autonomous marine surface vehicles (AMSV) is introduced. The research involves the development of exemplars of these vehicles, and the procedures for area scanning and coverage. The demining is made by field influence, towing a submerged "fish". This study is made both with simulations and with scale experiments. [C33]

"Investigation on improved target detection capabilities using multi-channel, multiple receive coil metal detector data"

Metal detectors are widely used in landmine detection and other military applications. Knowledge of the depth, size and orientation of buried targets could contribute significantly to a reduction in the false alarm rate and improved efficiency in route clearance and other field applications. This paper explores a possible approach that could be used to determine target depth and target types using a metal detector with multiple receive coils of different configurations. The proposed approach has been practically implemented in an advanced dual receive coil metal detector array data set. Burial depths have been estimated for a range of targets buried from flush to 24 inches. This approach is shown to be robust to changes in target orientation and background soil conditions. This paper then explores a method which can be used to estimate depths without prior knowledge of the target type. [C34]

"Ground penetrating radar measurements: Applications to synthetic data generation and target characterization"

Ground penetrating radar (GPR) is widely studied for detection of landmines and mine-like targets; GPR is particularly useful for detecting minimum metal mines which are harder to detect using traditional metal detection devices alone. In order to expand the phenomenology for GPR, careful measurements of homogeneous and heterogeneous soils with and without targets (landmine simulants and metal objects) are performed in a controlled environment. These measurements will aid in the development of models for soil response beyond the initial air-ground interface. Such explicit models for soil will increase the effectiveness of algorithms designed to discriminate between returns from targets and from naturally occurring geologic materials and interfaces. Furthermore, careful measurement of soil characteristics will enable comparison and refinement of models of soil with embedded targets developed in electromagnetic simulations (using finite-difference time-domain codes (FDTD), e.g.). [C35]

"Spatial latency reduction in GPR processing using stochastic sampling"

Ground penetrating radar (GPR) is a promising technique for buried threat detection which provides a complimentary phenomenology to electro-magnetic induction (EMI) based sensing. However, many successful GPR-based buried threat detection algorithms require data collected both before and after an object of interest is encountered to make a declaration (typically this data is used to perform background normalization, or to adequately characterize the object's shape). Samples taken past an object of interest, but before a decision is made, constitute an algorithm's "spatial latency". For vehicular mounted antennae arrays, where vehicle stopping distance is a function of vehicle dynamics, driver responsiveness, and algorithmic spatial latency, reducing an algorithm's spatial latency can increase overall system safety and help keep operators out of harm's way. In this work we propose a stochastic sampling algorithm that can help reduce spatial latency for a wide range of GPR-based buried threat detection algorithms. [C36]

"Model level fusion of edge histogram descriptors and gabor wavelets for landmine detection with ground penetrating radar"

We propose a discriminative method for combining heterogeneous sets of features for the continuous hidden Markov model classifier. We use a model level fusion approach and apply it to the problem of landmine detection using ground penetrating radar (GPR). We hypothesize that each signature (mine or non-mine) can be characterized better by multiple synchronous sequences that can capture different and complementary features. Our work is motivated by the fact that mines and clutter objects can have different characteristics depending on the mine type, soil and weather conditions, and burial depth. Thus, different sets of specialized feature extraction mechanisms, may be needed to achieve high detection and low false alarm rates. In order to fuse the different modalities, a multi-stream continuous HMM that includes a stream relevance weighting component is developed.

In particular, we modify the probability density function that characterizes the standard continuous HMM to include state and component dependent stream relevance weights. We generalize the Minimum Classification Error (MCE) objective function to include stream relevance weights and derive the necessary conditions to update all model parameters simultaneously. Results on a large collection of GPR alarms show that the proposed model level fusion outperforms the baseline HMM when each feature is used independently and when both features are combined with equal weights. [C37]

"A multimodal Matching Pursuits Dissimilarity Measure applied to landmine/clutter discrimination"

The Matching Pursuits Dissimilarity Measure (MPDM) is an effective way to to compare signals that are sparsely approximated using a Matching Pursuits method. The CAMP algorithm uses an MPDM distance measure in Competitive Agglomeration clustering to model and classify signals. The MPDM approach can only compare signals originating from a single source. Many landmine detection systems use multiple sensors to make simultaneous measurements of the same region of interest. In this paper we propose a Multimodal MPDM that can be used with CAMP to fuse signals from multiple sensors. We demonstrate the effectiveness of the Multimodal MPDM over the single sensor MPDM in improving discrimination of landmines from clutter objects. [C38]

"Modeling the measured em induction response of targets as a sum of dipole terms each with a discrete relaxation frequency"

Broadband electromagnetic induction (EMI) sensors have been shown to be able to reduce false alarm rates and increase the probability of detecting landmines. To aid in the development of these sensors and associated detection algorithms, a testing facility and inversion technique have been developed to characterize the response of typical targets and clutter objects as a function of orientation and frequency. [C39]

"Context-dependent landmine detection with ground-penetrating radar using a Hidden Markov Context Model"

Context-dependent approaches to landmine detection have been developed in recent years to exploit the sensitivity of ground-penetrating radar (GPR) to changes in environmental conditions. Previous approaches to context-dependent fusion have only considered the special case of statistically independent observations. This work proposes the use of Hidden Markov Models, trained on the GPR background, for modeling the context of observation sequences. The performances of context-dependent fusion using two statistical context models were compared in an experiment with field data. One approach utilized a Hidden Markov Context Model (HMCM), and the other utilized a Gaussian mixture. Experimental results illustrated that the HMCM improved performance of context-dependent fusion. These results suggest that spatial dependencies are an important source of contextual information for landmine detection that warrants further investigation. [C40]

"AN SVM classifier with HMM-based kernel for landmine detection using ground penetrating radar"

We propose a landmine detection algorithm using ground penetrating radar data that is based on an SVM classifier. The kernel function for the SVM is constructed using discrete hidden Markov modeling (HMM). Typically, the kernel matrix could be obtained by defining an adequate similarity measure in the feature space. However, this approach is inappropriate as it is not trivial to define a meaningful distance metric for sequence comparison. Our proposed approach is based on HMM modeling and has two main steps. First, one HMM is fit to each of the N individual sequences. For each fitted model, we evaluate the log-likelihood of each sequence. This will result in an N Ч N log-likelihood similarity matrix that will be adapted to serve as the kernel of the SVM classifier. In the second step, we train an SVM classifier to learn a decision boundary between the positive and negative samples. [C41]

"NQR-based explosives detection-an overview"

Nuclear quadrupole resonance (NQR) is a radio frequency spectroscopic technique that can be used to detect solid-state compounds containing quadrupolar nuclei, a requirement fulfilled by most high explosives (and narcotics). In this paper, we present an overview of recent research in the detection of explosives using this technique. We also present mathematical models for the data for different acquisition techniques and discuss different state of the art detection algorithms. Finally, we evaluate various algorithms on measured and simulated NQR data. [C42]

"Landmines discrimination using scattering parameters and an artificial neural network"

In this paper, the performances of the neural-network approach for discrimination of the landmine depth from the

ground surface and the landmine radius are carried out. A sensor for landmines detection consists of two microstrip antennas is used. One of the antennas is used as transmitting antenna and the second is considered as receiving antenna. Circular cylindrical shape metallic landmine is used. The neural-network process data are obtained from the FDTD formulation of the electromagnetic scattering. The inputs in the input layer of the neural network are the magnitude of the mutual coupling between the microstrip antennas, |..S21| while the outputs are landmine depth from the ground surface and landmine radius. Good agreement with exact profile has been observed. The computation time and computer memory of the inverse problem are considerably reduced. [C43]

"Optimizing automatic object detection from images in Laser Doppler Vibrometer based Acoustic to Seismic landmine detection system"

The Laser Doppler Vibrometer (LDV) based Acoustic to Seismic (A/S) landmine detection system is one of the reliable and powerful landmine detection systems. The interpretation of the LDV based A/S data is performed off-line, manually, depending heavily on the skills, experience, alertness and consistency of a trained operator. This takes a long time. The manually obtained results suffer from errors, particularly when dealing with large volumes of data. This paper proposes some techniques for the automatic detection of objects from the acoustic images which are obtained from the LDV-based A/S landmine detection system. These techniques are based on color image transformations, morphological image processing and the wavelet transform. The proposed techniques are compared considering the probability of detection, the false alarm rate, the accuracy and the processing speed. [C44]

"Lean robotics for humanitarian mine sweeping"

The robot mine clearing, based on cheap farming equipment, aims at transforming the terrorist anti-personnel mine into useless practice, after that the land reclamation is readily fulfilled by standard means. The paper addresses the following lines: ldr to conceive and implement low-cost robotic equipment, assuring effective, safe and reliable demining; ldr to allow simple equipment integration, with resort to low-cost and widely available agricultural fixtures; ldr to provide the basis for on-duty assessment and training assistance by alarm (warning, emergency) effective management; ldr to make easier the operators groundwork, involved in self-learning and up-grading duties. The mixed-mode automation, through remote-steered robotic effectors, grants balanced resources use on the strategic, tactical and execution horizons. [C45]

"Self Actor-Actor Connectivity Restoration in Wireless Sensor and Actor Networks"

Wireless sensor and actor networks (WSANs) are a set of coexistence sensors and actors connected wirelessly to perform cooperatively sensing and interaction to physical environment. Nowadays, WSANs are used in many important application areas. Main concern in all networks is connectivity of the network nodes, in WSANs because of majority of their applications, connectivity issue is even more vital. As WSANs deployment environment is not deterministic and mostly harsh, failure and partitioning of network upon actorpsilas failure is more probable. In this paper we put forward a distributed, proactive algorithm to restore actor-actor connectivity of WSANs that minimizes time of reconnecting the network and also total required movements of actors. We identify critical actor nodes and when a critical actor fails, we try to reconnect the network by relocating other actors. We validate our superiority through simulative experiments. Our approach serves significant decrease in total number of communicated messages through decision making for restoration planning and consequently decreases in network reconnection time compared to optimal cascading and other works. It also minimizes total movement of actors compared to other works. [C46]

"LIDAR techniques for studying insect migration and distributions"

LIDAR techniques have been extensively used for studies of aerosol particles. Fluorescence LIDAR was employed for studying natural bio aerosols, such as pollen, but also possible warfare agents. Insects, being "large aerosol" particles clearly give rise to LIDAR returns. Recently, honey bees were studied by polarization reflectance LIDAR and their superior olfactory abilities were used in attempts to detect landmines. Together with coworkers at the section for Animal Ecology, Lund University, we have initiated a project for using LIDAR, and in particular its fluorescence variety, to study the migration and distribution of two species of damselflies of special interest (Caloptoryx virgo and C. splendens). LIDAR techniques may be an interesting possibility to study the behavior and migration of insects, of relevance to ecology, agriculture and evolution. [C47]

"Effects of soil physical properties on landmines detection using microstrip antenna as a sensor"

The effect of soil properties on landmines detection using microstrip antenna with corrugated ground between the two microstrip elements as a sensor has been investigated. The effect of the electrical properties of the soil as well as the shape of the soil surface on the detection capability of the sensor is studied. The finite-difference

time-domain (FDTD) has been used to simulate the sensor for landmines detection. [C48]

"Feature Extraction and Recognition of Landmine"

As a new detecting landmine method, Ground Penetrating Radar (GPR) is introduced into the field of detecting buried landmine. In order to improve the detection accuracy, A approach based on the Support Vector Machine (SVMs) is presented in the paper. The Support Vector Machines (SVMs) has solved the inevitable partial minimum problem and overcome the disadvantage which the traditional neural network cannot avoid, especially, it is suitable for the high dimension data space and sample less situations, it is used to extract feature vector and recognize landmine. In order to improve the accuracy of detection landmine, WP (wave packet)-based preprocessing algorithm is used to clutter reducing and the genetic algorithms (Gas) is used in the feature selection. The experiment result shows the feasibility and advantage of the presented algorithm. [C49]

"Sub-Array Processing for parameters estimate of embedded conducting cylinders"

A hybrid electromagnetic-statistic approach for the detection and localization of buried perfectly-conducting circular cylinders is presented. The data used for simulating the scenario are produced by using the cylindrical wave approach (CWA) method. The inverse scattering problem is treated by means of a statistical detection technique. In particular, by the use of a SAP (sub-array processing) structure, it is possible to apply several algorithms of direction of arrival (DOA) estimation. By triangulating the DOAs, a set of crossings, condensed around the expected object locations, is obtained. To process the crossing pattern, we develop a statistical model for the crossings distribution, and employ hypothesis testing procedures to identify a collection of small windows containing targets. By defining a suitable threshold from a desired false alarm rate, and dividing the region in small windows it is possible to ascribe each window to the ground or to an object. [C50]

"Multi-channel landmine detection radar signal processing using blind deconvolution"

Landmine detection using multichannel radar poses many signal processing challenges, but the main issue lies with the variability of the propagation characteristics of the soil. These affect the spatial signature of the mine and require adaptive signal processing algorithms to optimise the performance. Investigation of various spatial deconvolution techniques has shown that blind deconvolution offers best image reconstruction compared with Wiener, Lucy and regular deconvolution. This paper describes the application of these processing techniques to multi-channel radar data. [C51]

"Adaptive model-based mine detection/localization using noisy Laser Doppler vibration measurements"

The acoustic detection of buried mines is hampered by the fact that at the frequencies required for obtaining useful penetration, the energy is quickly absorbed by the ground. A recent approach which avoids this problem, is to excite the ground with a high-level low frequency sound, which excites low frequency resonances in the mine. These resonances cause a low-level vibration on the surface which can be detected by a Laser Doppler Vibrometer. This paper presents a method of quickly and efficiently detecting these vibrations by sensing a change in the statistics of the signal when the mine is present. Results based on real data are shown. [C52]

"Context-Dependent Fusion for mine detection using Airborne Hyperspectral Imagery"

We present a method for fusing the decisions of multiple algorithms that use different hyperspectral imagery (HI) classification methods and apply it to mine detection. The proposed fusion method, called Cumulative Separation-Based (CSB) method, is embedded into our Context-Dependent Fusion for Multiple Algorithms(CDF-MA) framework. The CDF-MA is motivated by the fact that the relative performance of different algorithms can vary significantly depending on the type of the different targets and other environmental conditions. Results on real world HI data show that the proposed method can identify meaningful and coherent clusters and that different expert algorithms can be identified for the different contexts. Our initial experiments have also indicated that the proposed method outperforms all individual algorithms and the global weighted average fusion method. [C53]

"Multiple instance and context dependent learning in hyperspectral data"

Hyperspectral imaging (HSI) is a powerful tool for various remote sensing tasks including agricultural modeling and landmine/ unexploded ordnance clearance. Although the application of standard supervised learning techniques to HSI data has previously been explored, several aspects of hyperspectral data collection and ground truth labeling make some of the assumptions underlying standard machine learning techniques invalid. For example, HSI is highly dependent upon local environmental conditions, and pixel-by-pixel labels for HSI data

are often not available. As a result, data from hyperspectral sensing under various scenarios is not typically i.i.d., and correct data labels must be inferred from training data while learning decision boundaries. In this work we explore two possible solutions to these problems: context-dependent learning for overcoming variations between collections, and multiple instance learning for simultaneously inferring local target labels and global target decision boundaries. Results are compared to standard logistic discriminant classification approaches. [C54]

"2D imaging of shallow buried objects based on frequency domain data"

A new buried object detection algorithm using ground penetrating radar system based on the UWB frequency domain measurements is proposed. With the implementation of C-scan data acquisition and wide angle reflection and refraction schemes, the 2D imaging of metallic and plastic mine-like targets buried in dry soil is demonstrated. [C55]

"Design of tapered-slot antenna arrays for landmine detection"

Two compact ultra-wideband antenna arrays built of tapered-slot antennas and intended for landmine surveys are described. In one array, the antennas are arranged in two parallel lines differing by the antenna polarizations. Polarimetric data collected by the array are important for the detection of lengthy objects buried in the ground. The antennas in the second array form a zigzag line with reduced spacing between adjacent transmitting/receiving antenna pairs. Such a dense array is useful to detect small buried targets like landmines. Some experimental examples for the both arrays are presented. [C56]

"Minimizing the Cost of Mine Selection Via Sensor Networks"

In this paper, we study sensor enabled landmine networks by formulating a minimum-cost mine selection problem. The problem arises in a target defence scenario, where the objective is to destroy the intruding targets using the minimum-cost pre-deployed mines. Due to the problem complexity, we first transform it using a novel bucket-tub model, and then propose several approximation algorithms. Among them, it is shown that the layering algorithm can achieve an approximation ratio of alpha ldr f, where alpha ges 1 is the tunable relaxation factor and f is the maximum number of mines that a target is associated with, and that the greedy algorithm has an approximation ratio of SigmajRj, where Rjis the coefficient in the related integer program. We also present a localized greedy algorithm which is shown to produce the same solution set as the global greedy algorithm. Theoretical analysis and extensive simulations demonstrate the effectiveness of the proposed algorithms. [C57]

"A Combined Classifier to Detect Landmines Using Rough Set Theory and Hebb Net Learning & Fuzzy Filter as Neural Networks"

Landmines are significant barrier to financial, economic & social development in various parts of the world. The demand of dependable, trustworthy, intelligent diagnostic systems in the field of landmines detection has been increasing rapidly. Metal detectors used in mine decontamination, cannot differentiate a mine from metallic debris where the soil contains large quantities of metal scrap & cartridge cases, so a device is required that will reliably confirm that the ground being tested does not contain an explosive device, with almost perfect reliability. Human experts are unable to give belief & plausibility to the rules devised from the huge databases. In this paper two combined classifiers have been discussed. In the first classifier Hebb Net learning is used with rough set theory and in the second one Fuzzy filter neural network is used with the rough set theory. Rough sets have been applied to classify the landmine data because in this theory no prior knowledge of rules are needed, these rules are automatically discovered from the database. The rough logic classifier uses lower & upper approximations for determining the class of the objects. The neural network is for training the data, and has been used especially to avoid the boundary rules given by the rough sets that do not classify the data with cent percentage probability. [C58]

"Mine detecting GPS-based unmanned ground vehicle"

Mines which are located on the ground have been threating not only military forces but also civilians. These threating mines are classified as wooden, plastic and metal types. In this study a detector, which is able to detect all the mines placed on the ground, has been developed. Detecting and destroying the mines on a suspicious area without personel have been possible with remote control devices. In our work we aimed to produce a GPS-based mobile prototype vehicle carrying a system which can jam electromagnetic waves to blow up the mines with a remote control. This vehicle runs on solar energy and it can be steered by simulation glasses. [C59]

"Modeling of the backscatter behavior of typical antipersonnel landmines by computer simulations"

This work will focus on modeling of different types of antipersonnel land mines (APL's) without environment (i.e.,

in free space). The received backscattered electric fields as a function of the frequency (called fingerprints) are computed at different distances above the mines computed by using different excitations, i.e., dipole, point source, and homogenous plane wave. The work is devoted to study the Ground Penetrating Radar (GPR) sensor as a promising tool for humanitarian demining. For a reliable detection of antipersonnel land mines it is necessary to calculate the electromagnetic backscattering characteristics in order to make an accurate modeling of the material properties which are important to identify modern plastic antipersonnel land mines in a realistic environment. These interactions can play the role in making false alarms when they are embedded in a realistic environment. To increase the spatial resolution of the operating radar, the simulations have been done in the frequency range 200-8000 MHz. To model these APL mines, the Integral Equation Method-Method of Moments (MoM) and the Finite difference in Time Domain (FDTD) have been used. [C60]

"Metal Equivalent Measurement Based on Low-Frequency Electromagnetic Induction Method"

In order to evaluate the detectability of landmine, a new method based on results of metal equivalent measurement is developed. A series of studies are carried out to evaluate the detectability of landmine academically and experimentally, from the aspect of the relation between detection method and induced signal, the impact of metal mass to induced signal, and landmine metal mass equivalent detection method. In addition, by analyzing the relationship between second field signal and metal mass using the principle of low-frequency electromagnetics, it is verified that in the same detection height and the same medium, mine detector's answer output is directly proportional to the quality of metal. Thus a fitting formula of induction signal and detection height, metal mass is concluded. Experimental results prove that using the method of metal equivalent measurement to evaluate detectability of landmine is effective. [C61]

"Optimization of a resistively-loaded horn for mine detection"

Five basic versions of an U.S. Army Research Laboratory (ARL) built Synchronous Impulse Reconstruction (SIRE) radar antenna were modeled using the method of moments (MOM) algorithm in FEKO computational electromagnetics software with the goal of improving the antenna performance. The antennas consist of two-sided, open horns where horizontal, resistively loaded parallel plates were attached at the radiating end of the horn. Three of the models featured cylindrical flares attached to the end of the parallel plates. Each of the five versions was optimized over a small range of geometry and resistance parameters. The computations predicted that the design using resistive sheets in the parallel line structure with no flare had the best performance because of its combination of favorably low S11 parameters and forward-directed vertical electric far field. [C62]

"Evaluation of microwave sensors for landmine detection"

Landmines and improvised explosive devices (IED) continue to be a leading cause of death and injury to civilians and military personnel abroad. The detection and removal of these devices before detonation is necessary to improve safety. This work proposes the use of microwave radiometry for long-range monitoring and microwave coplanar sensors for short-range monitoring. The sharp contrast between the thermal and electrical properties of IEDs and the surrounding medium (soil and air) can be utilized to detect their presence. The feasibility of using planar transmission lines as landmine and IED detectors is explored. This will create a safe environment for the indigenous population and security personnel overseas. [C63]

"Improvised explosive device (IED) counter-measures in Iraq"

Summary form only given: Land mines have been used in warfare since the 13l century. Their greatest weakness has always been to coordinate the timing of the explosion with an enemy's movement. improvised explosive devices (IED's) are mines that are constructed in the field using available munitions. In the 16thcentury these were detonated using a clock-timer or concealed trip-wire. Remote RF-controlled IED's were first used in 1984, using a model airplane controller. The modern car fob, which allows remote opening of car doors, was invented in 1996, and rapidly became ubiquitous. However, it was unanticipated that it would rapidly become the heart of a major weapons system, commonly called a RF-IED. IED's currently cause more than 70% of the U.S. casualties in Iraq. The use of RF-IED's allows the IED to be controlled up to several miles away (using a cell phone) and allows accurate timing of the detonation. New research is beginning to point to ways to deactivate the IED RF electronic controls without detonation of the explosives, using particle radiation (soft fails). Experiments with many types of radiation have shown remarkable effects, which are not well understood. [C64]

"Active learning for semi-supervised multi-task learning"

We present an algorithm for active learning (adaptive selection of training data) within the context of semi-supervised multi-task classifier design. The semi-supervised multi-task classifier exploits manifold information provided by the unlabeled data, while also leveraging relevant information across multiple data sets. The active-

learning component defines which data would be most informative to classifier design if the associated labels are acquired. The framework is demonstrated through application to a real landmine detection problem. [C65]

"Development of big danger disposal manipulator-Proposal and mechatronic system design -"

This paper describes the basic proposal and mechatronic system design of a novel developed big danger disposal manipulator, named as ldquoBIG HANDrdquo in the later chapters. It is developed mainly for rescue and public security purpose, and is supposed to have real application in public sites such as airports, stations, and so on, while being carried by some powerful mobile equipment. Among dozens of similar purpose manipulators having been developed, the one published here has following characteristics in mechatronic system, which seldom has been implemented integratedly before: redundant in DOF (degree of freedom)-7 including 1 in gripper; big in size-with maximum 4.4 m in length; big in payload ability-32 kg in its horizontal full extension posture; multi-sensor integrated system. We discuss the necessity of building such a ldquoBIGrdquo and redundant manipulator; analyze its design difficulty and realization in mechanism, also report the basic experiments in this paper. [C66]

"Real Time Defense Communicator Using Video Processing, Bluetooth and GPS"

The main idea of this work is to detect, place and explode mines and target killing of objects using real time video processing at country's border. For this purpose a Robo Car is designed. The theme is implemented for the armed forces to make them more equipped and advanced. The heart of the system is a PIC micro-controller (PIC16F877). It controls the whole system and sends data to the Personal Computer (PC). The wireless video camera is also connected with the PC for real time video processing. The PC also controls the placement, detection and explosion of the mines through stepper and DC motors connected with the Robo Car. The Global Positioning System (GPS) is also used to find the exact location of the car. [C67]

"Investigation of EMI response for magnetically susceptible and conductive rough surfaces"

Electromagnetic induction (EMI) sensing has been identified as most promising technology for the detection and discrimination of subsurface metallic objects, particularly unexploded ordnances (UXO). In EMI, the sensors are detecting signals that are produced by induced and permanent magnetic polarizations. Soils, which contain small magnetic particles, called magnetically susceptible soils, can produce EMI responses and, therefore, mask or modify the object's EMI response. These soils are a major source of false positives when searching for UXO using magnetic or EMI sensors. Studies show that in adverse areas up to 30% of identified electromagnetic (EM) anomalies are attributed to geology. Therefore, to enhance UXO detection as well as discrimination in geological environments, the effects of the magnetic soils on the magnetic and EMI signal need to be studied in details. In this paper, the method of auxiliary sources (MAS) is applied to investigate the EMI response from magnetically susceptible rough surfaces. [C68]

"Wiener prediction-based change detection for locating mines in multilook SAR imagery"

In this paper, we present a Wiener-based change detection method and compare its performance with several other methods for a pair of multi-look synthetic aperture radar (SAR) images of the same scene. We implement and compare several techniques which vary in complexity. Among the simple methods that are implemented are differencing, Euclidean distance, and image ratioing. These methods require minimal processing time, with little computational complexity, and incorporate no statistical information. We also implemented methods which incorporate second order statistic calculations in making a change decision in efforts to mitigate false alarms arising from the speckle noise, misregistration errors, and nonlinear variations in SAR images. These methods include a Wiener prediction-based method, Mahalanobis distance measure and subspace projection method. We compare the performance of these methods using multi-look SAR images containing several targets (mines). We present results in the form of receiver operating characteristics (ROC) curves. [C69]

"A study of acoustic methods for compliant landmines detection by using the surface acceleration parameter"

This paper presents the experimental results for an acousto-seismic buried landmine detection method. The excitation source used was a woofer loudspeaker and lightweight silicon MEMS accelerometers were adopted to measure the ground surface acceleration. The experiments were performed in an outdoor unconsohdated sand test-bed with several kinds of compliant and rigid test-objects, all buried at depth of 4cm and placed at distances ranging from 10cm to 50cm. The different responses of the compliant and rigid objects was processed in both time and frequency domains. A novel audio representation of the acquired signals was developed for exploiting the human-hearing capabilities for the identification of buried objects. [C70]

"Combined metal detector and ground-penetrating radar sensor experiments in a variety of soil conditions"

Landmine detection is a hazardous operation. To reduce the human casualties during landmine detection, unmanned ground vehicles (UGV) can be used. There are many landmine detection modalities that can be used with a UGV. However, the ground-penetrating radar (GPR) and the metal detector (MD; electromagnetic induction sensor) are fast and may be the most reliable means of landmine detection. In addition, GPR and MD sensors can easily be packaged in one sensor head. It is also easy to configure the sensor heads in an array. To combine GPR and MD sensor data, a series of experiments has been performed. The GPR and MD combined sensor is scanned over a 2 m ГґВ— 2 m ГґВ— 1 m soil box at a constant height. The soil box contains stony sand and a landmine, which is buried at 200 mm depth when measured from the surface of the ground to the top of the landmine. The control parameters for the experiments are sensor height and soil moisture. The sensor height is varied from 40 mm to 100 mm with 20 mm increment from the soil. The soil moisture conditions considered in the experiments are dry and wet. The stony sand used in the experiments contains rocks with approximately 100 mm diameter scattered in a random manner and a brick placed 200 mm apart horizontally from the landmine. The GPR and MD responses are recorded for all control parameter combinations and later analyzed. The GPR images are generated using time-domain back projection (TDBP) algorithm. The GPR images and MD responses are compared for the soil conditions and sensor heights. A combination algorithm, which enhances GPR images using MD responses, is also presented. [C71]

"Use of neural networks and SAR interferometry for the automatic retrieval of tectonic parameters"

The basic idea of this paper relies on the concurrent exploitation of the capabilities of neural networks and SAR interferometry for the characterization of a seismic source and the estimation of its geometric parameters. When a moderate-to-strong earthquake occurs we can apply SAR Interferometry (InSAR) technique to compute a differential interferogram. The earthquake has been generated by an active, seismogenic, fault having its own specific geometry. Therefore each differential interferogram contains in principle information concerning the geometry of the seismic source the earthquake comes from. To perform the inversion operation an approach based on neural networks can be considered. The paper illustrates such a methodology and its assessment on experimental data. [C72]

"New fuzzy-based anti-swing controller for helicopter slung-load system near hover"

In this paper, a new fuzzy based anti-swing controller for helicopter slung load system near hover flight is proposed. The output from this controller is additional displacements that are added to the helicopter trajectory in the longitudinal and lateral directions. Hence, its implementation is simple and it just needs small modification to the software of helicopter position controller. The rules of the anti-swing controller are derived based on the time-delayed feedback of the load swing angles. The simulation results show the effectiveness of the proposed controller in suppressing the swing of the suspended load and stabilizing the system. [C73]

"Fragment size detection within homogeneous material using Ground Penetrating Radar"

Ground Penetrating Radar (GPR) offers the ability to observe the internal structure of a pile of rocks. Large fragments within the pile may not be visible on the surface. Determining these large fragment sizes before collection can improve mine productivity. This research has examined the potential to identify objects where the background media and the object exhibit the same dielectric properties. Preliminary results are presented which show identification is possible using standard GPR equipment. [C74]

"Three-dimensional real-time localization of subsurface objects-From theory to experimental validation"

The detection of buried landmines or unexploded ordnances is a problem of great interest in both civilian and military applications. In such a framework, this paper presents an approach for real-time localization of unknown subsurface objects. Such a technique is aimed at defining high resolution risk maps by means of a classification strategy based on a support vector machine and a multi-resolution approach. In order to assess its effectiveness, a selected set of numerical results regarding multiple target scenarios are presented. [C75]

"Nonparametric spatial analysis for mine line detection"

The development of tools for automated analysis of data collected for mine countermeasures (MCM) search, classify and map (SCM) has predominantly focused on automated target recognition for individual mines. As MCM target detection becomes more automated, detecting spatial patterns in the positioning of mines should

follow. Natural restrictions on mine deployment such as depth and bottom contour as well as mine deployment methodology and protocol effectively create mine line patterns that are typical to coastal areas. We have developed a mine line detection algorithm that uses nonparametric spatial analysis to identify mine-like contacts (MLCs) that fit into mine line patterns dictated by standard mine laying protocol in coastal regions. In general, a set of MLCs reported from a mine detection sensor will consist of both actual mines and false alarms; the algorithm classifies every MLC in this set into one of three classes: fixed-the MLC?fits into a mine line pattern with fixed mine spacing; random -the MLC?fits into a mine line pattern with random mine spacing; or false alarm-?-the MLC?does not fit into a mine line pattern and is subsequently not considered a mine. The latest version of the algorithm utilizes nonparametric techniques and requires no knowledge of either the detection sensor's probability of detection (Pd) or probability of false alarm (Pfa). A nonparametric anomaly detector first identifies regions with unusually high MLC density for more detailed analysis. Suspected regions are subsequently analyzed for unusually regular patterns of MLCs. The probabilities that the observed target densities and target patterns could occur simply by chance are estimated by comparison with results from nearby areas using basic information about mine deployment. To ensure that a mine line's full extent is captured, the algorithm attempts to grow a line after it is detected. And a more detailed probability analysis distinguishes random mine li- nes from fixed-spaced mine lines. Extensive Matlab simulations characterize the algorithm's performance across a wide range of operating environments and simulated minefield configurations. In total, ten replications each of 1,367 different configurations have been evaluated. These configurations include three different water depths (10 ft., 6 ft. and 200 ft.), six false notional alarm rates (1, 2,5,10,15 and 20 false alarms per sq. NM), three false alarm distributions (uniform, sloped, and striped), three sensor probabilities of detections (0.4, 0.6 and 0.9), three target confidence scores (0.6,0.8 and 1.0) and four false alarm confidence scores (0.5, 0.6, 0.8 and 1.0). The range of simulation parameters was selected in part as an attempt to push the algorithm past its acceptable performance limits. However, the algorithm performed remarkably well even under the worst conditions. For MLC sets with false alarm rates as high as 20 per square nautical mile, the algorithm correctly classifies over 98% of the MLCs as mines and detects 97% of the mine lines. Furthermore, it reduces the false alarm rate from 20 to 0.2 per square nautical mile with a false mine line rate of 0.14 false lines per square nautical mile. The algorithm achieves even lower false alarm rates when the initial false alarm rate is less than 20. The automated mine line detection discovers many obscure lines that are virtually undetectable to the naked eye. [C76]

"A qualitative two-step inversion approach for the reconstruction of subsurface defects"

In this work, the problem of the localization and shaping of buried objects or voids is addressed considering an innovative two steps strategy in order to enhance the reconstruction accuracy. In particular, at the first step the approach is aimed at firstly estimating the region-of-interest where the defect is supposed to be located. Then at the second step, the qualitative imaging of the object is improved through a level-set based shaping procedure. In order to assess the effectiveness of the proposed approach, selected numerical results concerned with different scenarios and noisy data are presented and discussed. [C77]

"Combating Man-Made Disaster Using Remote Sensing"

Today man-made disasters caused by terrorism is the most serious problem in the Chhattisgarh region of India. Activities include landmine blasts, railway track damage, and the destruction of power supply units. Effective response to natural and human-induced disasters requires rapid analysis of imagery and other sensor data acquired both before and after the event. Such information will enable emergency response services to clear blocked transportation routes rapidly and to reroute traffic efficiently. Likewise, recovery efforts depend on the acquisition and analysis of timely imagery and other remotely sense data that might indicate the presence of arms, explosives and ammunitions. Compatible, interoperable geospatial databases containing base information that can be rapidly updated will assist in saving lives and reducing costs. [C78]

"New approach of signal processing for classification problems using a-priori information"

Metal detectors based on the eddy current principle are widely used in humanitarian demining, but their main disadvantage is the high false alarm rate caused by harmless clutter objects or Г‚ВїuncooperativeГ‚Вї soils. In most cases, the types of mines in the field are known a-priori. So their influence on the metal detector can be measured and stored in a database. In this paper a new method is described that uses this information to adapt the soil compensation and the signal classification to achieve a significant reduction of false alarms. Therefore a fuzzy classifier is used that adapt to the signal quality and feature variance of the known objects. The ability to lower the false alarm rate was verified by trials on the test lane for mine detection provided by the Joint Research Center in Ispra (Italy). [C79]

"Inversion of soil's and immersed objects's electromagnetic parameters symultaneously"

This paper presents results of numerical simulation and algorithm of simultaneous inversion of soil's and immersed object's electromagnetic parameters. Inversion is performed from data of electromagnetic induction (EMI) sensing, when all other geometric parameters of the problem are known. Discrimination procedure of subsurface objects such as landmines and unexploded ordnances (UXO) accomplishes higher accuracy when mentioned parameters are determined a priori. A specially, when interaction effects between object its surrounding media is significant and there is no exact information about materials of UXO produced in different time. Combining Method of Auxiliary Sources (MAS) with Gauss-Newton minimization algorithm, we developed optimization methodology that simultaneously inverts for the EM parameters of both the object and the surrounding medium. [C80]

"Context-Dependent Fusion of Multiple Algorithms with Minimum Classification Error Learning"

We present a novel method for fusing the decisions of multiple classification algorithms which use different features, classification methods, and data sources. The proposed method, called context dependent fusion of multiple algorithms (CDF-MA) is motivated by the fact that the relative performance of different algorithms can vary significantly as the characteristics of the input data vary. The training part of CDF-MA has two main components: context extraction and algorithm fusion. In context extraction, the features used by the distinct algorithms are combined and clustered into groups of similar contexts. The algorithm fusion component embeds a variation of the MCE/GPD method to assigns an aggregation weight to each algorithm based on its loss function within each context. Results on real world data show that the proposed method can identify meaningful and coherent clusters, and outperform all individual classifiers and the global weighted average fusion method. [C81]

"Detection of land cover changes in El Rawashda Forest, Sudan: A systematic comparison"

This study compares six change detection techniques to study land cover change associated with tropical forest (El Rawashda forest reserve, Gedaref State, Sudan). For this site, Landsat 7 Enhanced Thematic Mapper (ETM+) data acquired on March 22, 2003 and Aster data acquired on February 26, 2006 were used. The change detection techniques employed in this study were Post-Classification Comparison (PCC), image differencing of different vegetation indices (Normalized Difference Vegetation Index (NDVI), Soil-Adjusted Vegetation Index (SAVI) and Transformed Difference Vegetation Index (TDVI)), Principal Component Analysis (PCA), Multivariate Alteration Detection (MAD), Change Vector Analysis (CVA) and Tasseled Cap Analysis (TCA). As field validation data did not exist for 2003, a manual classification was performed, then a change map was conducted to locate and identify change in vegetation. This change map was used as a reference to quantitatively assess the accuracy of each change-detection techniques. Based on accuracy assessment, the most successful technique was the PCC technique with an accuracy of 94%. This was followed by the MAD technique with an accuracy 88.8%. However, among vegetation indices techniques, TDVI stood out as better than NDVI and SAVI in its ability to accurately identify vegetation change. [C82]

"3D SAR focusing for subsurface point targets"

In this work we develop a methodology for imaging subsurface point targets using a single-pass strip-map synthetic aperture radar (SAR). The point targets are embedded in an arbitrary homogeneous half space, and are located at arbitrary depths. It is assumed that the radar frequency is low enough and system sensitivity high enough to allow the required two-way penetration depth to target. The succession of steps required to form the image of the subsurface point targets are described, including the estimation of the subsurface wave velocity, estimation of the depth of the point target, and the modified range and azimuth filters to achieve optimum resolution. The theoretical approach is described and results are presented for a range of point target depths, subsurface velocities, and radar system parameters. It is found that with the assumptions made it is possible to image the point targets in 3D with good range, azimuth, and depth accuracy. [C83]

"Estimating gas-source location in outdoor environment using mobile robot equipped with gas sensors and anemometer"

This paper investigates the applicability of a gas-source localization method in outdoor environment. In the proposed method, a mobile robot is used to scan the area under consideration and to collect data on gas concentration and airflow velocity at various locations. The location of the gas source is estimated by applying a turbulent diffusion model of a gas plume to the data obtained by partial observation of the gas distribution in the given area. Discussion is made on the adjustment of the turbulent diffusion coefficient in the plume model to achieve successful estimation under various airflow conditions. [C84]

"Landmines recognition system using thermovision techniques"

Sub-surface and buried landmines, with the surrounding environment constitute a complex system with variable characteristics. Infrared thermography techniques are attractive candidates for this kind of applications. They can be used from a considerable standoff distance to provide information on several mine properties, and they can also rapidly survey large areas. This paper presents a robust method for landmine detection and recognition. It uses the mean-shift algorithm to segment the acquired infrared image. The segmented image retains pixels associated with mines together with background clutters. To determine which pixels represent the mines, a second phase of segmentation is applied to the output of the mean-shift algorithm by using a self-organizing maps (SOM) algorithm. Depending on the resulted cluster intensity variations, the chips extracted from the segmented image are processed to extract mine signatures. After that, the extracted signatures are scanned horizontally, vertically, and diagonally to build a cluster intensity variation profile. This profile is statistically compared with the known mine signature profiles v. The proposed system is applied on series of time variant mid-wave infrared images (MWIR), and the test result show that the system can effectively recognize the mines with low false alarm rate. [C85]

"Time Frequency Representations for Classification of Landmine Using UWB Impulse GPR"

In this paper, Time Frequency Representations (TFRs) for classification of landmine using Ultra Wideband (UWB) impulse Ground Penetrating Radar (GPR) is presented. GPR signal is composed of three parts: ground bounce, clutter and target echo signal, the target signal is seriously deteriorated by ground bounce and clutter. To extract intricate structures of target signal, wavelet packet transforms (WPT)-based algorithm is used to ground bounce removal and clutter reduction. Then the Fisher Dsicriminant Ratio (FDR) for feature subset selection method is used to select the suboptimal feature subset of target signal, thereby a Learning Vector Quantization (LVQ) classifier is designed. Experimental results based on GPR measured data are presented, showing that the feasibility and advantage of the presented algorithm. [C86]

"Procedures to improve the performances of a Sfcw radar used for landmine detection"

In the last decades a lot of research has been done to develop different types of ground penetrating radars to be used for antipersonnel landmine detection, archaeological investigations, search for underground pipes etc. They have to provide a resolution comparable with the dimension of the smallest landmine and the needed penetration for each application. To comply with high resolution requirement a ultra wide band system is required and it can be manufactured to work either in time domain or in frequency domain. In this paper two procedures to improve downrange and cross range resolution of stepped frequency continuous wave (SFCW) radar are described. The two procedures are applied to experimental data collected with SFCW radar and the improvements in the radar performances are described in the paper. [C87]

"Development of mine detection system for mobile robot system"

This paper introduces a development process of a manipulator that is installed to a mobile robot system and used to detect explosive ordnance and dispose it. Based on system requirements, its boundary conditions are analyzed and the minimum driving ranges and RPMs of each joint are calculated. To choose the optimum actuators including reduction ratiopsilas of the gearbox, the advanced Straete et al.psilas normalization method is used after conducting dynamic analysis. Two kinds of dynamic analyses are executed to confirm the result, one is MATLABpsilas SimMechanics and the other one is PRO-Engineerpsilas Mechanism. Finally, structural analysis is conducted to verify the robustness of the designed system. [C88]

"Feature Extraction and Recognition Based on SVM"

As a mature detection technique, ground penetrating radar (GPR) is applied into many fields. The GPR signal explanation and recognition is so important that it affects the result reliability and accuracy of the detection. The support vector machines can obtain the overall optimal solution in sample less situations. It has solved the inevitable partial minimum problem and overcome the disadvantage, which the traditional neural network cannot avoid. In this paper the GPR signal explanation model is established based on the support vector machine and the dyadic wavelet transform (DyWT) theory. It is applied in the counterfort of railway disease detection. The experiment result proved the method is valid, and it can enhance GPR explanation precision and efficiency. The recognition ratio can reach 91.2%. [C89]

"Imaging of buried antipersonnel landmines by direction-sensitive scintillation detectors for neutron activated prompt gamma-rays"

This work aims at investigating the improvement of performances that can be obtained by using a transportable large-area landmine-imaging device. It is made of modular detecting systems, which operation is based on

radioisotopic neutron source(s), appropriate moderating and shielding structure(s) and a set of collimator-less direction sensitive scintillation detectors. These localize the prevailing directions of the prompt gammas that have energy values falling within selected windows. The key element of such a device is the ability to produce an image of the examined field of view in which the areas, respect to the surrounding soil, that produce energy patterns compatible with the components of the explosive substance are highlighted. Starting from the experience made with a small-scale 3D detector an extensive modeling activity has been started for designing a real-scale prototype module to be submitted to field tests. [C90]

"UWB array-based radar imaging using modified Kirchhoff migration"

This paper presents a new modification of Kirchhoff migration algorithm for ultra-wideband (UWB) array-based radar imaging. The developed algorithm is evolved from traditional Kirchhoff migration which is based on the classical integral theorem of Helmholtz and Kirchhoff. The new algorithm is designed for array-based radar imaging with arbitrary multiple input multiple output (MIMO) configuration. The developed algorithm is compared with conventional diffraction stack migration using both synthetic data from numerical simulation and measurement data from landmine detection. The results have shown promising improvements in the aspects of beamwidth, side-lobe rejection ratio and the ability to reconstruct shapes of distributed targets. [C91]

"A hand-held dual-sensor system using impulse GPR for demining"

A hand-held dual-sensor system for demining has been developed. The system integrates ground-penetrating radar (GPR) and a metal detector. One of the features of the system is imaging capability. The system achieves the position information by tracking the sensor head. Thus synthetic aperture radar (SAR) processing can be applied and the performance can be significantly improved. The system was tested by real deminers in Croatia 2007. The trial results confirmed that false alarms (alarms from other than landmines) were significantly reduced by using GPR, meaning total demining operation can be accelerated. Them we started a half-year evaluation test of the system in quality-control (QC) test in Croatia in December 2007. This test will be conducted in various soil environmental conditions in Croatia. [C92]

"X-ray imaging for homeland security"

Since 9/11 there has been a growing interest to improve the security both of air travel and of cargo shipping. Visual inspection is the simplest tool and is very efficient, when single objects of small size are to be checked. The complexity of inspection increases as we have large "boxes" and when several objects are packed into a closed space, such as in a luggage or even in larger volumes like shipping containers or trucks. An obvious method to check these objects is using X-rays, which can penetrate through the shipping "boxes" and let us see what is inside. It is well known that the X-ray absorption of an object depends on the absorption coefficient and the thickness of a given material. So X-ray is an excellent tool to check luggage without opening and manually checking each of them. This paper gives an overview of different x-ray luggage inspection techniques from simple transmission imaging to multi-energy and 3D X-ray computer tomography (CT). However, none of the X-ray imaging methods give a full differentiation between a plastic explosive and a bag of flour of the same shape. X-ray diffraction is a more sophisticated method to differentiate materials with and without crystalline structure and among materials of different crystalline structures. There is also a real danger that not only traditional explosives but nuclear materials can be smuggled into the US in cargo containers and trucks. Not only the explosion of a nuclear bomb but also a so called "dirty bomb" could cause death and panic in large cities. So to check the containers before they enter the country, for explosives and especially for nuclear materials is a primary goal. As it was mentioned earlier the X-ray absorption of the materials depends on the X-ray energy. Higher energy mega-electronvolt X-rays can penetrate through thick steels and other highly absorbent materials. This makes it possible to check the content of shipping containers or trucks with steel walls in the loading area. The the--ory and limits of high energy X-ray imaging, dual energy X-ray imaging, and high energy CT are also demonstrated. A further application using X-rays is back scatter imaging. This technique is especially useful for detection of landmines and IEDs (Improvised Explosive Devices) as it will be shown below. Finally, the use of neutron detection for identifying nuclear materials will be mentioned. Neutron detection is a viable alternative to X-ray imaging for finding nuclear materials. [C93]

"Performance improvement plastic landmine visualization system by employing local correlation method"

We have been studying ground-penetrating radars to visualize antipersonnel plastic landmines by treating amplitude and phase data of electromagnetic reflection and scattering by using a complex self-organizing map (CSOM). In this paper, we propose a new method, namely local correlation method, to extract feature quantity for higher performance. [C94]

"Model Based Unsupervised Learning Guided by Abundant Background Samples"

Many data sets contain an abundance of background data or samples belonging to classes not currently under consideration. We present a new unsupervised learning method based on fuzzy c-means to learn sub models of a class using background samples to guide cluster split and merge operations. The proposed method demonstrates how background samples can be used to guide and improve the clustering process. The proposed method results in more accurate clusters and helps to escape locally minimum solutions. In addition, the number of clusters is determined for the class under consideration. The method demonstrates remarkable performance on both synthetic 2D and real world data from the MNIST dataset of hand written digits. [C95]

"Classification of landmines using GPR"

This paper describes a study carried out into the discrimination and classification of anti-personnel landmines using the MINEHOUND GPR. Other techniques, well reported in the literature, are not considered in this study. The techniques investigated enabled the classification of landmines to be achieved on a restricted set of targets. The approach proposes a method whereby a library of radar signatures of landmines is acquired under controlled conditions and then used to classify unknown signatures. Initial results show that this method enables clutter targets to be well separated from landmine targets, with the exception of air voids, such as pipes. The technique offers the potential of a reduction in false alarm rate to 10% of the current performance. [C96]

"Modeling of Mine Countermeasure Dart Dispense"

Mine countermeasure systems are currently under development to defeat beach and surf zone mines by dispensing small darts from a larger primary projectile body (Hydra-7, MODS, and CMCO). These programs currently lack modeling and simulation techniques that incorporate all of the complexities of the aerodynamics of the dart dispense. OVERFLOW software will be used to perform computational fluid dynamics (CFD) simulations, using overset structured grids (created with OVERGRID), of representative delivery vehicles dispensing numerous (up to 381) mine countermeasure darts. These darts, approximately 5 to 6 inches in length, are designed to disable mines in the beach and surf zones after being dispensed in a uniform pattern over a given area. OVERFLOW will solve the equations of motion for each moving dart body and thus provide a time-accurate prediction of the dispense event. The results of 8 OVERFLOW dart dispense simulations of Venom Penetrator darts, each with a different Mach number, spin rate, and number of darts, will be presented and discussed. [C97]

"A method for subsurface metallic landmine identification in GPSAR"

A method for subsurface metallic landmine identification in air- or vehicle-borne ground penetrating synthetic aperture radar (GPSAR) using finite difference time domain (FDTD) method combined with genetic algorithm is proposed. To identify the real object, the framework information on landmine is obtained according to the matching algorithm based on number and relative location of one dimensional scattering center. By identifying two kinds of metallic landmines buried beneath a Gaussian rough interface, the effectiveness of the proposed method is testified. [C98]

"Silicon micromachined accelerometers for the detection of compliant anti-personnel landmines"

Acoustic methods have been recently investigated for the detection of shallow landmines. Some plastic landmines have a compliant case which can made to vibrate by an airborne excitation like a loudspeaker. Our study is based on the possibility to detect landmines by contact or non-contact sensors like accelerometers or phonometers. Phonometers can provide sufficient seismic sensitivity but their response is influenced by direct acoustic wave coupling from the driving source. On the contrary accelerometers are much less influenced by the direct acoustic wave coupling and they have high sensitivity to acquire soil surface vibrations. In our experiments we can measure typical accelerations in order of 2 m/s2with sensitivity of 800 mV/g. The acceleration signal elaboration and visualization developed in this work demonstrates the suitability of these sensors for acoustic landmine detection study and allows a fast analysis to evaluate the presence of a buried landmine. [C99]

"Study on the Ultra-Wide Band High Power Microwave coupling effect on electronic fuze system"

The experimental method and results of ultra-wide band (UWB) high power microwave (HPM) radiation on the land minespsila fuzes are introduced, and the mechanism of the HPM coupling effects on electronic fuze systems is analyzed also. The coupling electric field of HPM radiation on the object was numerically simulated using the finite-difference time-domain (FD-TD) method. The coupling action principle of HPM on fuze systems is studied, and the sensitive points of fuzes have been discussed and discovered. These are very important for the studies on the HPM weapons and the HPM effects on other electronic systems, and the techniques of HPM

reinforcement also. [C100]

"Applicability analysis of CFAR algorithm for landmines detection applied to vehicle-mounted forward-looking SAR"

For the vehicle-mounted forward-looking synthetic aperture radar (SAR), detecting algorithms should be effective, robust and real-time. This paper proposed a fast statistic detecting algorithm based on circulatory iteration. We also presented feasible methods to select the optimal parameters of constant false alarm rate (CFAR) detector. Experiment results showed that our algorithm had high detecting rate, low false alarm rate, good adaptability and much less computation load. [C101]

"Handheld metal detector with online visualisation and classification for the humanitarian mine clearance"

Today for clearing areas from landmines, beside dogs and searching needles, almost only metal detectors are used. Metal detectors for mine clearance are high sensitive inductive sensors which react also on small metal parts. Nevertheless, they give no further information about the buried object (depth, size, shape, material). Besides, the high false alarm rate (up to 1000 per mine) makes the mine clearance a protracted and cost-intensive process. Reasons for the false alarms are "uncooperative" soils, harmless metallic objects and the low metal content in newer anti-personnel mines. In this paper a method is described which provides more information about the buried object by using image processing and signature classification, which works also in the presence of "uncooperative" soil. Based on an algorithm for soil compensation and object classification, this paper describes a handheld system with online visualization and classification. Therefore a commercial metal detector was enhanced with additional signal processing and an ultrasonic position reference system. [C102]

"Shape normalized subspace analysis for underwater mine detection"

We present a method for classification and localization of sea mines in 2D side-scan sonar imagery. The approach parallels closely Turk and Pentland's method of eigenfaces and treats mine detection as a two dimensional object recognition and localization problem acknowledging the fact that mine patches are endowed with a measure of regularity in geometry and appearance. We, therefore, set out with the hypothesis that mine patches can be described fairly accurately using low complexity parametric models. We outline a method for constructing a low dimensional non-linear shape plus appearance decomposition model from 2D sonar imaging data. We then characterize the parameter space and formulate a distance metric in this space. The distance metric is used as a mine similarity measure, and thus forms the basis of our mine detector. We show results demonstrating the discriminative power of the mine detector on a benchmarking data created from the mine dataset used in. [C103]

"A fundamental study of bistatic UWB radar for detection of buried objects"

We have developed a bistatic radar system for detection of buried objects. The targets include buried land mines, and explosive material in a wall. The system is composed of a fixed transmitting antenna and a small receiving antenna. The receiving antenna uses a passive optical electric field sensor. Due to its small size of the receiving sensor, the operation of the system is easy in various conditions. Then we propose an effective signal processing by F-K filtering. By suppressing the strong transmitting signal, we could obtain clear images of the buried objects. We think this radar system is useful in various security issues. [C104]

"Microstrip antenna with corrugated ground plane surface as a sensor for landmines detection"

A proposed sensor for landmines detection consists of two parallel microstrip antennas placed on the same ground plane and with corrugated ground surface between the arrays has been investigated. The microstrip patch array with corrugated ground surface has the advantage of a low mutual coupling compared with the classic arrays. The finite-difference time-domain (FDTD) is used to simulate the sensor for landmines detection. [C105]

"Landmine detection utilizing an unmanned aerial vehicle"

Landmines pose a great danger to people in many areas. It is imperative to correctly identify the location of landmines for proper removal. Hence, there is a need to efficiently and accurately identify locations of landmines. The objective of this project is to conduct preliminary system analysis of three unmanned aerial vehicles (UAVs) utilizing ground penetrating synthetic aperture radar (GPSAR) aiding in the detection of landmines. Moreover, the effort will aid in assessing the overall effectiveness of landmine detection utilizing a UAV. Three design alternatives are modeled and tested. The first design alternative is a MQ-1 Predator; a long-endurance UAV

primarily used for reconnaissance and surveillance missions. The second alternative is a Shadow 600. The Shadow 600 is capable of carrying various payloads. The third design alternative is the Shadow 200 which can be launched from the ground using a catapult. Each design alternative carries an unfocused GPSAR utilizing the length of the fuselage to increase aperture efficiency. Using satellite tool kit (STK) analysis software, design alternatives are assessed by their performance in scanning a one square kilometer area of interest (AOI). Critical figures of merit used to elicit system effectiveness include time on target (time that the radar pulses the landmine), area overlap percentage, area coverage, coverage speed, and energy consumption. Acquisition cost, operational cost, and maintenance cost of each design alternative are plotted against system effectiveness to identify the best alternative. [C106]

"Clutter reduction and detection of landmine objects in ground penetrating radar data using likelihood method"

In this paper, an algorithm is proposed to reduce clutter signal due to the reflection from the ground surface in ground penetrating radar (GPR) measurements. The proposed technique has been applied to a GPR, which has been used to detect subsurface anti-personnel (AP) landmines. A very simple model is used to model the GPR clutter and the target signal. This model has been used to derive a detector based on a likelihood ratio test using some estimated parameters. A new threshold formula has been derived and has been applied to the data. The data sources include 1 GHz pulse GPR data and 1 GHz to 4 GHz stepped- frequency GPR data, from laboratory measurements. In all measurements, the reflections from the surface have been removed or at least reduced in great quantities. [C107]

"Modeling of metallic landmine electromagnetic characteristic in GPSAR"

Air- or vehicle-borne ground penetrating synthetic aperture radar (GPSAR) has the capability to detect subsurface objects over large area from a standoff distance quickly. In order to reduce the false alarms in object detection, it is needed the design efficient detector on the electromagnetic characteristics between mines and clutter. A method on analyzing electromagnetic characteristic on subsurface objects using FDTD method combined with Fourier transform is proposed. We model the time-domain scattered field of metallic landmine buried in soil. Numerical results fit the data computed by moment method. Finally, we model the M6A1 metallic landmine buried in soil. Numerical results fit real data based on actual measurement. Electromagnetic modeling result will improve the landmine detection performance greatly. [C108]

"Image formation techniques for Vehicle-Mounted Forward-Looking Ground Penetrating SAR"

A vehicle-mounted forward-looking ground penetrate synthetic aperture radar (VMFL-GPSAR) is newly developed in China for real-time mine detection. The VMFL-GPSAR is an impulse radar system. With a 6 meter long antenna array, the radar can output 0.15 m by 0.15 m real-time images at a velocity of 15 Km/h. This paper presents some key techniques in developing the system, including antenna dispersion compensation, channel equalization, RFI suppression, fast backprojection image formation algorithm and along range multi-look image enhance algorithm. Tests conducted in Changsha last year indicate that the system can detect both metallic and plastic landmines. [C109]

"A High Performance Time Domain UWB Radar Design"

A single board ultra-wideband (UWB) radar has been developed to provide a compact, rugged, high performance capability for hand held applications such as anti-personnel landmine detection. This paper discusses the radar system developed by ERA Technology, which provides the radar functionality of the MINEHOUND dual sensor detector. [C110]

"On particle filters for landmine detection using impulse ground penetrating radar"

In this paper, we present an online stochastic approach for landmine detection based on ground penetrating radar (GPR) signals using sequential Monte Carlo (SMC) methods. Since the existence of true landmines is unknown and random, we propose to use the reversible jump Markov chain Monte Carlo (RJMCMC) in association with the SMC methods to jointly detect and localize landmines in the light of observations. Computer simulations on real GPR measurements demonstrate the robust and consistent performance of the proposed method. [C111]

"Polarization filtering enhancement of buried landmine"

Here the optimum polarization of antenna for buried landmines detection in soil surface clutter is investigated theoretically to enhance radar target back scattered power. An expression of the Mueller matrix from this fractal

surface is obtained. The optimum polarization to reduce clutter is given. Then, the variations are found of power density of buried landmines with polarization state, and the optimum polarization is given to increase power density. In the end, the paper researches the polarization filtering enhancement of buried landmines in soil surface clutter. [C112]

"A novel preprocessing method for vehicular-mounted forward-looking UWB SAR system"

The forward-looking ground penetrating radar (FLGPR) has been widely considered as an applicable landmines detection technology, but the self-signature and the strong ground clutter will severely degrade the SAR image. We present a novel method for interference and ground clutter suppression in the image domain based on the distance-band partition and iterative operation techniques, which can realize the parallel processing and adaptive update of the parameters on line. By using the property of FLGPR systems that the same spatial region is observed several times at different standoff distances, we exploit a range multi-look processing based on the iterative technique to obtain the high quality image. The proposed method in this paper is adaptive and efficient enough to work in a real-time operational scenario, so it can effectively meet the needs of the preprocessing in the vehicular-mounted forward-looking (VMFL) detection system. The effectiveness of our approaches is demonstrated with an experimental data set. [C113]

"On the use of aggregation operator for humanitarian demining using hand-held GPR"

This paper applies the OWA aggregation operator to hand-held GPR data to improve the detection of landmines. Data from a number of sweeps are collected when the hand-held detector is operating in discrimination mode. The energy density spectra of the GPR signal return from individual sweeps are estimated and two OWA aggregation operations are performed to select the good quality sweeps that will be used for landmine detection. Experimental results using the real data collected from two different test sites show that the OWA operations provide significant performance improvement for landmine detection at high probability of detection. [C114]

"Maximum A Posteriori EM MCE Logistic LASSO for learning fuzzy measures"

A novel algorithm is introduced for learning fuzzy measures for Choquet integral-based information fusion. The new algorithm goes beyond previously published MCE-based approaches. It has the advantage that it is applicable to general measures, as opposed to only the Sugeno class of measures. In addition, the monotonicity constraints are handled easily with minimal time or storage requirements. Learning the fuzzy measure is framed as a maximum a posteriori (MAP) parameter learning problem. In order to maintain the constraints, this MAP problem is solved with a Gibbs sampler using an expectation maximization (EM) framework. For these reasons, the new algorithm is referred to as the MAP-EM MCE logistic LASSO algorithm. Results are given on synthetic and real data sets, the latter obtained from a landmine detection problem. Average reductions in false alarms of about 25% are achieved on the landmine detection problem and probabilities of detection in the interesting and meaningful range of 85%-95%. [C115]

"An adaptive ground penetrating radar imaging system based on complex-valued self-organizing map-recent progress and experiments in Cambodia -"

This paper reports recent progress in an adaptive ground penetrating radar imaging system based on a complex-valued neural network (CVNN), i.e., a complex-valued self-organizing map (CSOM). In the CSOM processing, we deal with feature vectors that represent complex-amplitude texture in space and frequency domains. We developed a switched walled linearly tapered slot antenna (walled-LTSA) array for the front-end. A higher resolution results in a better classification quality. To realize a high resolution in range and azimuth directions, we utilize a wide frequency bandwidth in frequency stepping operation, and a special switching scheme for the walled LTSA. We conducted experiments in Cambodia. In this paper, we report successful plastic landmine visualization, not only for targets buried in normal sand but also for those in wet laterite soil at the Siem Reap test site. Adaptive coherent radar imaging is one of the most potential application fields of the CVNNs. [C116]

"Landmind detection with IR sensors using Karhunen Loeve transformation and watershed segmentation"

In this paper, we present our idea of using the Karhunen Loeve transformation (KLT) and watershed segmentation to detect landmine objects from infrared images. On doing this, we proposed a simplified process for reducing the computation in the Karhunen Loeve transformation using a smaller number of images than traditional methods do. We effectively used the marker based watershed segmentation to detect the mines with high performance detection rate. We tested our proposed method on three different mine fields with two different

soil types. Our proposed method consists of four stages: feature extraction, enhancement, object segmentation, and object recognition. The results are promising. [C117]

"Distributed Recovery of Actor Failures in Wireless Sensor and Actor Networks"

Wireless sensor and actor networks (WSANs) additionally employ actor nodes within the wireless sensor network (WSN) which can process the sensed data and perform certain actions based on this collected data. In most applications, inter-actor coordination is required to provide the best response. This suggests that the employed actors should form and maintain a connected inter-actor network at all times. However, WSANs often operate unattended in harsh environments where actors can easily fail or get damaged. Such failures can partition the inter-actor network and thus eventually make the network useless. In order to handle such failures, we present a connected dominating set (CDS) based partition detection and recovery algorithm. The idea is to identify whether the failure of a node causes partitioning or not in advance. If a partitioning is to occur, the algorithm designates one of the neighboring nodes to initiate the connectivity restoration process. This process involves repositioning of a set of actors in order to restore the connectivity. The overall goal in this restoration process is to localize the scope of the recovery and minimize the movement overhead imposed on the involved actors. The effectiveness of the approach is validated through simulation experiments. [C118]

"Extending the RX anomaly detection algorithm to continuous spectral and spatial domains"

The RX anomaly detection algorithm is a statistical method for detecting pixels in hyperspectral imagery that are significantly different from the other pixels in their locale. The RX algorithm is based upon the assumption of an existing uniform discrete sampling in both space and spectrum. In this report, we give consideration to extending the RX algorithm to continuous spatial and spectral domains so that future optical devices may be optimally constructed for anomaly detection. This report gives a heuristic outline for the extension of the RX algorithm to continuous spatial and spectral domains, explores new concepts in functional statistics necessary to make the algorithm rigorous, and suggests directions for the continuation of this research in the future. [C119]

"Learning fuzzy measure parameters by logistic LASSO"

In this paper, a novel Bayesian hierarchical method is defined by the use of logistic distribution and a Laplacian prior to learn the parameters on fuzzy measures. The new algorithm goes beyond previously published MCE based approaches. It has the advantage that it is applicable to general measures, as opposed to only the Sugeno class of measures. In addition, the monotonicity constraints are handled easily with minimal time or storage requirements. This is made by the use of an alternated sampling to avoid favoring maxlike operators or min-like operators. The use of the logistic distribution eliminates the necessity of using desired outputs, and the Laplacian prior regularize the parameters in the fuzzy measures. Results are given on synthetic and real data sets, the latter obtained from a landmine detection problem. [C120]

"Authentication Mechanisms for Mobile Ad-Hoc Networks and Resistance to Sybil Attack"

In Sybil attack, an attacker acquires multiple identities and uses them simultaneously or one by one to attack various operation of the network. Such attacks pose a serious threat to the security of self-organized networks like mobile ad-hoc networks (MANETs) that require unique and unchangeable identity per node for detecting routing misbehavior and reliable computation of node's reputation. The purpose of this paper is to analyze the effectiveness of current authentication mechanism for MANETs in coping with the Sybil attack, the infrastructure requirement posed by these mechanisms and applicability of these mechanisms to different kinds of ad hoc networks. We identify open research issues that need to be addressed by the next generation of authentication mechanisms for MANETs. [C121]

"Constructive neural network for landmine classification using ultra wideband GPR"

In this paper, constructive neural network for landmine classification using ultra wideband (UWB) ground penetrating radar (GPR) is presented. GPR echo signal is composed of three parts: ground bounce, clutter and target echo signal, the target echo signal is deteriorated by the clutter. Firstly WP-based preprocessing algorithm is used to ground bounce removal and clutter reduction and feature extraction of GPR echo signal. Then wrapper based approach is adopted to feature subset selection of GPR echo signal using genetic algorithm(GA) in conjunction with constructive neural network learning algorithm, and at the meanwhile, the result of classification of landmine is obtained. Experiment result based on GPR measured data shows that the feasibility and advantage of the presented algorithm. [C122]

"Signature Evaluation for Thermal Infrared Countermine and IED Detection Systems"

The countermine computational testbed is a coupled system of parallelized computer codes and associated software tools that can simulate images from remote sensors operating in the visible and infrared portions of the electromagnetic spectrum. The testbed is used to explore thermal and hydrologic process interaction at a fine scale to understand the contrast between target and background. The testbed provides an opportunity to exploit knowledge of the ground state (soil moisture, soil, or vegetation temperature) and material properties (hydraulic and thermal), to optimize sensor selection and time of flight, and to improve automated target recognition algorithms (ATRs) by limiting false alarms. For example, the testbed provided simulated data to provide field guidance on sensor performance taking into account weather events. The use of simulated data to improve ATR performance is described in detail. [C123]

"Study of Emission from Finite-Size Objects using FDTD"

A 3D-FDTD algorithm is developed and used to compute the emissivity of finite-size and arbitrary-shape objects. Under thermal equilibrium, the emissivity of an object is the same as its absorptivity. The absorptivity is a function of both the scattering cross section and the absorption cross section of the object; in this study, these cross sections were computed using the FDTD approach. Emissivity values for spherical, cylindrical and landmine-like objects as function of observation angle, polarization and permittivity are generated and presented in this paper. [C124]

"Applications for remote laser vibration sensing"

Laser vibrometry based on coherent detection techniques allows to measure vibration characteristics of objects due to the high Doppler resolution. Examples for applications in the field of defense and security such as target classification and identification including camouflaged or partly concealed targets as well as the detection of buried land mines are presented. [C125]

"A distributed algorithm for restoring actor-actor connectivity in wireless sensor and actor networks"

Wireless sensor and actor networks (WSANs) consist of powerful actors and resource constraint sensors which are linked together by wireless networks. In some applications, actors must communicate with each other to take appropriate decisions and make coordinated actions. Actor-actor network connectivity is vital to networks in such applications. Since WSAN applications are mostly deployed in harsh environments, actor nodes may fail and partition their network. This paper proposes a distributed algorithm to restore actor-actor connectivity upon the failure of any actors by identifying critical actors and use of sensor channel. The proposed algorithm minimizes the movements of each actor on one hand and total actors' movements on the other hand. If the failed actor is a critical node, its neighborhood actors would be relocated in a coordinated way to reconnect the actor network. The effectiveness of the proposed approach has been validated through simulation experiments and the results show nearly 33% improvement in total movement of actors compared to related works. [C126]

"Polarimetric Characterization of Magnetic Flat Dipole Embedded in Multilayer Structures"

The scattering properties of an embedded planar magnetic dipole are addressed in this paper. In order to obtain the scattered fields the method of moments in spectral domain is applied. The dipole scattering is characterized by the radar cross section (RCS), the polarimetric response and the alpha-angle from Cloude-Pottier's target decomposition theorem. The results point out that alpha-angle is the most sensible parameter to variations on incident angles. The RCS is influenced by the incident angles and by the geometrical dipole area. The incident angles have also influence over polarimetric response, showing its use and interpretation must be done with extremely care. [C127]

"Broadband Array of Electromagnetic Induction Sensors for Detecting Buried Landmines"

A broadband electromagnetic induction (EMI) sensor is developed to help discriminate between buried landmines and metal clutter. The detector uses a single dipole transmit coil and an array of three quadrapole receive coils. The sensor operates in the frequency domain and collects data at 21 logarithmically spaced frequencies from 300 Hz to 90 kHz. Experimental results are presented for several targets. [C128]

"Modeling Highly Permeable and Conductive Ellipsoidal Clutter for the Detection of UXO in the Electromagnetic Induction Regime"

The modeling of unexploded ordnances in the electromagnetic induction regime (from tens of hertz to a few kilohertz) is carried out in the ellipsoidal coordinate system, thus presenting an important generalization of the existing dipole model or spheroidal approach. Ellipsoidal geometries are of interest because of their ability to more accurately model real 3D objects while retaining the appeal of an analytical solution. Computation speed is

minimized here by assuming objects of high permeability and conductivity, allowing for the use of the small penetration approximation, and avoiding the necessity of solving the wave equation using ellipsoidal wave functions inside the object. Simulations are compared with both existing numerical solutions and with measured data on fabricated ellipsoids, and prove the validity of our model. [C129]

"Analysis of an Information-Based Sensor Manager Applicable to Landmine Detection"

Previously, a framework for sensor management has been developed for the detection of static targets such as landmines. The sensor manager functions by tasking the available sensors to greedily maximize the expected information gain obtained with each new sensor observation. This paper examines several of the key assumptions and decisions that were made in the formulation of this sensor manager to assess both the validity and the performance effects of these decisions. Specifically, this paper examines which unmanaged sensing technique is best used to make performance comparisons with the sensor manager, whether multiple sensors should be optimized independently or jointly, and finally whether the Kullback-Leibler divergence or Renyi divergence is the best choice of information measure to use. This paper demonstrates that in all three cases, the choices made in the original formulation of the sensor manager are the most effective and appropriate. [C130]

"Time-constrained optimization of multi-AUV cooperative mine detection"

An increasingly important tool of mine counter-measures (MCM) is a team of autonomous unmanned vehicles (AUV) working in cooperation to provide effective mine detection. This approach reduces the total time required to create a map of mines in an underwater field while minimizing physical risk to humans. The challenge for the designers is to most effectively use the resources of the AUV team to obtain the most accurate possible map of the mines in the shortest possible time period. This paper presents several contributions toward solving this problem. First, a background demonstrates the relevant considerations of the cooperative AUV mission along with the shortcomings of previous research. A strategy is then presented that seeks to optimize the accuracy of a map of mines in an underwater field provided by the AUV team under an unknown time constraint. The strategy is encapsulated into an algorithm that optimizes the total assignments of search targets to all individual AUVs. Finally, results are shown from a simulation implementing the algorithm. [C131]

"Applications of AUVs with SAS"

Autonomous underwater vehicles with high-resolution synthetic aperture sonar (SAS) are now becoming available as products. The main benefit of such a system is very high and range-independent resolution (typically 2-5 cm both along- and across-track) across a very wide swath (typically 100-200 m). High-end SAS systems can also deliver additional products such as high resolution bathymetry. The technology was originally developed for naval mine countermeasures due to its requirements for very high resolution imaging and high area coverage rates. However, SAS clearly also has other uses. This article discusses and illustrates some of the potential applications for this technology, in particular in the civilian sector. [C132]

"Improved magnetic STAR methods for real-time, point-by-point localization of unexploded ordnance and buried mines"

There is a pressing need for a practical and effective magnetic sensing technology that can be deployed onboard highly maneuverable sensing platforms and used for real-time, point-by-point detection, localization and classification (DLC) of magnetic targets such as ferrous unexploded ordnance (UXO) e.g., bombs, buried mines and artillery shells. Therefore the Strategic Environmental Research and Development Program (SERDP) has supported research and development, by Naval Surface Warfare Center Panama City Division (NSWC PCD), of a novel man-portable Magnetic Scalar Triangulation and Ranging (i.e., "STAR" and/or "MagSTAR") technology for DLC of UXO. The STAR concept uses scalar magnitudes of magnetic gradient tensors to triangulate the locations of magnetic targets. The magnitudes are analogous to central potential-type functions and they can provide true point-by-point DLC capabilities for sensing platforms in general, unconstrained motion. A prototype man-portable STAR Gradiometer was designed and constructed at NSWC PCD to provide a completely portable and user-friendly technology for real-time DLC of magnetic UXO. The prototype STAR Sensor comprises: a) A cubic array of eight fluxgate magnetometers, b) A 24-channel data acquisition/signal processing system. In field tests the man-portable sensor has demonstrated very robust, motion-noise-resistant DLC performance against isolated dipole type targets . This paper describes work that is ongoing to enhance the performance of the MagSTAR Technology. In particular, two improved algorithms for solving the "STAR Equations" are described: 1) A directional derivative (DD) method based on the fact that the gradient of a central potential field is a vector that points toward the target/source of the locally strongest gradient. 2) A least-squares-fit (LSF) method that iteratively calculates a magnetic target's location and magnetic signature. The DD method is being developed for better discrimination between multiple target- s but for isolated targets it is more susceptible to sensor noise

than the LSF method. The initial LSF method applies primarily to DLC of isolated dipole targets. Thus, the methods preferably should be used concurrently as complementary DLC modalities in environments that may be magnetically complex. These improved methods should help facilitate the transition of the STAR Technology from man-portable applications to applications using highly maneuverable autonomous sensing platforms for real-time "on the fly" DLC of magnetic targets such as UXO and buried mines. [C133]

"Novel algorithm for real time imaging of objects in a half-space with unknown characteristics"

In this paper a novel auto-focusing approach has been proposed to the reconstruction of dielectric objects in a lossy earth with unknown characteristics. The fast Fourier transform has been used to cut down the computing time. An exponential refocusing time factor has been introduced. The rule to choose the optimal focusing time is determined by the minimum entropy criterion. Numerical results have shown that the proposed algorithm can provide a good location of the embedded objects in a short computing time despite the inaccurate estimation of earth electrical parameters. [C134]

"Modeling of coupling of loudspeakers for ANC system in a confined space"

In this paper the problem of coupling of acoustic sources in a confined space in treated. By considering the coupling of sources in a rectangular enclosure the set of coupled equations governing the acoustical behavior of enclosure are solved. The resulted model can be used to analyze the behavior of a multi-input multi-output (MIMO) active noise control (ANC) system in real application where coupling of sources can not be neglected. The developed model is an improved description of the acoustic environment inside the rectangular enclosure, especially in an ANC system when interaction among sources will change the radiation impedance of other sources. [C135]

"Humanitarian demining: Difficulties, needs and the prospect of technology"

Humanitarian demining is a critical first step for reconstruction of post-conflict countries and it requires that the entire land area to be free of mines and hence it is necessary to locates and removes reliably and safely every single mine, and UXO from targeted ground. The problem associated with humanitarian demining is characterized by an enormous variability in the nature of explosive ordnance to be removed, climate diversity, and in the type of terrain and vegetation. Current demining is a dangerous, time consuming, and costly process. To increase mine clearance daily performance by improving productivity and accuracy, and to increase safety of demining operations and personnel, there is a need for an efficient, reliable and cost effective humanitarian mine action equipment with flexible and modular mechanisms with adaptable mobility and equipped with some level of decision making capabilities. Technologies to be developed should take into account the facts that many of the demining operators will have had minimal formal education and that the countries where the equipment is to be used have poor technological infrastructure for equipment maintenance, operation, and deployment. In addition, it is necessary to overcome the constrain on the resources by developing innovative, cost effective and practical technology inspired by locality and real minefield needs to help in speeding up the demining process and enhance accuracy, productivity, operation and personnel safety, achieve a higher quality of the service, and contribute to local economy. [C136]

"A method for subsurface metallic landmine identification in GPSAR"

A method for subsurface metallic landmine identification in Air- or vehicle- borne ground penetrating synthetic aperture radar (GPSAR) using finite difference time domain method combined with genetic algorithm is proposed. To identify the real object, the framework information on landmine is obtained according to the matching algorithm based on number and relative location of one dimensional scattering center. By identifying two kinds of metallic landmines buried beneath a Gaussian rough interface, the effectiveness of the proposed method is testified. Electromagnetic modeling result will improve the landmine detection performance greatly. [C137]

"Simulation of GPR returns from finite-length dielectric cylinders"

An approximate analytical solution for time-domain impulse response of low-contrast dielectric targets is derived. The Born approximation is used to calculate the scattered field. The detailed analysis is performed for a finite-length circular cylinder. The way of application of the obtained results to buried dielectric targets is proposed. [C138]

"Automatic object detection from acoustic to Seismic landmine images"

This paper presents two innovative techniques developed and implemented for the automation of the landmine

detection in a data scanned by the laser Doppler vibrometer (LDV) based acoustic to seismic (A/S) landmine detection system. These techniques are based on the intensity component of the color landmine images or on grayscale versions of these images. The obtained results are promising in terms of accuracy, consistency, reliability and processing time. [C139]

"Lanthanum halides improve thermal neutron activation landmine detection-a comparison of fast inorganic scintillators"

The Improved Landmine Detector System is a vehicle-mounted multi-sensor landmine detector, conceived and developed by Defence R&D Canada (DRDC). Suspicious targets are identified by fusing data from scanning sensors. A Thermal Neutron Activation (TNA) detector, developed by DRDC and Bubble Technology Industries (BTI), then confirms the presence of a mine by detecting the bulk nitrogen in its explosives. While the first generation TNA detector has been fielded by the Canadian Forces, DRDC and BTI have continued development and optimization of a second generation TNA sensor based around an electronic neutron generator source. By implementing faster detectors, faster electronics and more intense neutron sources, it is possible that this system could achieve 10 to 15 times higher rates, allowing correspondingly higher sensitivity or shorter detection times for landmines. The chief bottleneck to achieving the maximum possible performance from the present TNA or a future system is the relatively slow fluorescent decay time of the NaI(Tl) scintillators which are currently used. An experimental investigation was undertaken to compare a number of modern, fast inorganic scintillators to NaI(Tl) with respect to parameters relevant to TNA, including efficiency, energy resolution, linearity, available size and cost. This paper presents results in the context of the high-rate, high-gamma-energy environments expected in a TNA application. Large (7.62 cm Ч 7.62 cm) LaBr3:Ce scintillators, and to a lesser degree LaCl3:Ce, were found to stand-out as as the principal candidates for the detector upgrade to the TNA confirmation system. Their properties also make them ideal candidates for fast neutron activation and associated particle imaging bulk explosives detectors. [C140]

"Performance of UWB array-based radar sensor in a multi-sensor vehicle-based suit for landmine detection"

In this paper, integration of an UWB array-based time-domain radar sensor in a vehicle-mounted multi-sensor system for landmine detection is described. Dedicated real-time signal processing algorithms are developed to compute the radar sensor confidence map which is used for sensor fusion. Performance of developed algorithms for stand-alone GPR sensor and multi-sensor suit is verified experimentally. [C141]

"Optimal background subtraction in GPR for humanitarian demining"

Comparative study of different background subtraction methods has been performed. A criterion for quantitative comparison of different algorithms has been introduced. Based on this criterion, performance of different algorithms has been tested for scenarios with relatively smooth ground surface and very rough one. Optimal algorithms for each type of surfaces have been determined. Different ground bounce removal techniques influence GPR imaging. This dependency has been evaluated, after focusing, by means of the ratio between signal energy and remaining clutter. A very exigent scenario has served to this end. [C142]

"A review of landmine detection using GPR"

This paper reviews the current situation of landmine detection and classification using GPR techniques. [C143]

"ALIS development for humanitarian demining and its evaluation tests"

ALIS is a hand-held dual-sensor developed for humanitarian demining. The dual-sensor ALIS is equipped with a metal detector and a GPR (ground penetrating radar). An unique and novel sensor tracking system, which can record the GPR and metal detector signal with its location is equipped in ALIS. Due to its sensor location information, we can reconstruct buried land mine images after data acquisition. The image reconstruction, or migration processing drastically increases the quality of the image of the buried objects. ALIS evaluation test was conducted in Croatia in October 2007. Then after, we stared a half-year evaluation test of ALIS in QC test in Croatia in December 2007. This test will be conducted in various soil and environmental conditions in Croatia. [C144]

"Subsurface Sensing of Near Surface Object Using Cavity Backed Slot (CBS) Antenna"

This paper presents a novel cavity backed slot (CBS) antenna for subsurface sensing applications. The CBS antenna is designed to be "matched" in the two-half-space configuration (one half space air; and the other ground) over a relatively wide frequency band. As a result, when attached onto ground surface, it is able to

efficiently couple microwave power into and out of the ground. In this study, CBS antennas with operating frequency range [8.5 GHz, 13.6 GHz] are designed to detect objects buried in sand. Data acquisition is carried out using a sandpit with size (125 cm times 100 cm times 80 cm) as the test bed. One transmitting CBS antenna is fixed at the center of the sandpit and one receiving antenna is physically moved along a rectangular grid (i.e., multi-static measurement). An inverse synthetic aperture radar (ISAR) algorithm is adopted for inverse processing. A 4-inch-diameter metallic sphere is used as calibration target; and three targets are tested, including a 3-inch-diameter metallic sphere, a T-shaped copper target, and a landmine simulant. Imaging results are presented and compared with those obtained using horn antennas (which are not "matched" to the air-ground interface). Better signal-to-clutter ratios are demonstrated by the proposed CBS antennas. [C145]

"Dual Sensor ALIS for Humanitarian Demining and its Evaluation Test in Mine Fields in Croatia"

More than 60 courtiers are still suffered from land mines. ALIS is a hand-held dual-sensor developed for humanitarian demining, which has been developed at Tohoku University, Japan since 2002. The dual-sensor ALIS is equipped with a metal detector and a GPR (Ground Penetrating Radar). A unique and novel sensor tracking system, which can record the GPR and Metal detector signal with their acquired locations, is equipped in ALIS. Due to its sensor location information, we can reconstruct buried land mine images in 3D space after data acquisition. IN addition, we found that the image reconstruction or migration processing drastically increases the quality of the image of the buried objects. ALIS evaluation test was conducted in Croatia in October 2007. Then a half-year evaluation test of ALIS in QC test in Croatia was held during December 2007 and April 2008. In this test, we could obtain fruitful experience in various soil and environmental conditions in Croatia. [C146]

"Context-Dependent Multi-Sensor Fusion for Landmine Detection"

We present a novel method for fusing the results of multiple landmine detection algorithms that use different types of features, different classification methods, and different sensors. The proposed fusion method, called context-dependent multi-sensor fusion (CDMSF) is motivated by the fact that the relative performance of different detectors can vary significantly depending on the sensor, mine type, geographical site, soil and weather conditions, and burial depth. The training part of CDMSF has two components: context extraction and algorithm fusion. In context extraction, the features used by the different algorithms are combined and used to partition the feature space into groups of similar signatures, or contexts. The algorithm fusion component assigns an aggregation weight to each detector in each context based on its relative performance within the context. Results on ground penetrating radar (GPR) and wideband electromagnetic induction (WEMI) data collections show that the proposed method can identify meaningful and coherent clusters and that different expert algorithms can be identified for the different contexts. Our initial experiments have also indicated that the context-dependent fusion outperforms all individual detectors. [C147]

"Statistical Models for Landmine Detection in Ground Penetrating Radar: Applications to Synthetic Data Generation and Pre-Screening"

As ground penetrating radar phenomenology continues to improve, more advanced statistical signal processing approaches become applicable to subsurface inference in GPR data. Despite the wide body of literature exploring the applications of various approaches to processing GPR data, statistical modeling of realistic soil responses is a difficult task, and the algorithms developed for real-time fielded GPR processing are rarely directly motivated by statistical models of GPR data. In this work, we present a tractable spatial statistical model for volumetric GPR data which can be used to motivate the application of various signal processing approaches to solving problems of interest in GPR data like pre-screening, feature extraction, and air/ground response tracking. [C148]

"Texture Feature Selection for Buried Mine Detection in Airborne Multispectral Imagery"

In this paper, a methodology for the detection of buried mines in airborne multispectral imagery is explored. The approach is based on utilizing the color texture information in the buried mine signatures, which is extracted using the cross-co-occurrence texture features. A systematic two-stage approach, using Bhattacharya coefficient-based analysis and principal feature analysis, is developed for the selection of a small subset of discriminatory features. Detection results from actual airborne data from two different sites are presented. The performances are compiled for four different feature-based detectors, and are compared with the conventional multiband RX anomaly detector, to validate the feature selection approach and demonstrate buried mine detection performance based on texture features. [C149]

"Hierarchical Methods for Landmine Detection with Wideband Electro-Magnetic Induction and Ground Penetrating Radar Multi-Sensor Systems"

A variety of algorithms are presented and employed in a hierarchical fashion to discriminate both anti-tank (AT) and anti-personnel (AP) landmines using data collected from wideband electromagnetic induction (WEMI) and ground penetrating radar (GPR) sensors mounted on a robotic platform. The two new algorithms for WEMI are based on the In-phase vs. Quadrature plot (the Argand diagram) of the complex measurement obtained at a single spatial location. The angle prototype match method uses the sequence of angles as a feature vector. Prototypes are constructed from these feature vectors and used to assign mine confidence to a test sample. The angle model based KNN method uses a two parameter model; where the parameters are fit to the In-phase and Quadrature data. For the GPR data, the Linear Prediction Processing and Spectral Features are calculated. All four features from WEMI and GPR are used in a Hierarchical Mixture of Experts model to increase the landmine detection rate. The EM algorithm is used to estimate the parameters of the hierarchical mixture. Instead of a two way mine/non-mine decision, the HME structure is trained to make a five way decision which aids in the detection of the low metal anti personnel mines. [C150]

"Fast Hyperspectral Anomaly Detection via SVDD"

We present a method for fast anomaly detection in hyperspectral imagery (HSI) based on the support vector data description (SVDD) algorithm. The SVDD is a single class, non-parametric approach for modeling the support of a distribution. A global SVDD anomaly detector is developed that utilizes the SVDD to model the distribution of the spectra of pixels randomly selected from the entire image. Experiments on wide area airborne mine detection (WAAMD) hyperspectral data show improved receiver operating characteristic (ROC) detection performance when compared to the local SVDD detector and other standard anomaly detectors (including RX and GMRF). Furthermore, one-second processing time using desktop computers on several 256 times 256 times 145 datacubes is achieved. [C151]

"Bistatic UWB Radar System"

A new GPR system using an optical electric field sensor was proposed. The system has a bistatic radar configuration, which is consisted from a TEM horn antenna as a transmitter and an optical electric field sensor as a receiver. The new system employs a time-domain data acquisition, and it made the data acquisition very fast. Laboratory measurements showed that a metallic sphere can be detected by the new system. Applications of this system will include landmine detection and through wall imaging. [C152]

"UWB measurement, complex-amplitude texture, and Walled-LTSA array in plastic landmine visualization"

We describe the importance of ultra wideband (UWB) reflection measurement in the adaptive target visualization. We use a complex-valued self-organizing map (CSOM) to deal with complex-amplitude texture obtained by stepped-frequency UWB reflection measurement. We distinguish targets from clutter by paying attention to the difference in texture in space and frequency domains. In the technique, a wideband measurement is desirable to obtain precise texture. We employ a newly developed antenna, walled LTSA, with which we can construct a wideband, dense array for high-resolution imaging. [C153]

"UWB-GPR Data Processing for Identification of Anti-personnel Landmines under Rough Ground Surface"

A process for finding buried landmines by using GPRs is divided into two stages, detection and identification. In the detection stage, all buried objects including the desired landmines together with other clutter objects are detected. In the identification stage, the detected objects are classified and the landmines are differentiated from the other objects. In this research, we focus on the identification stage and propose a GPR data processing for identification of shallow!) buried antipersonnel landmines. After suppressing the ground surface reflection, we extract features related to waveform correlation from the GPR data. As an identification algorithm, an approach based on a matched filter is employed. In order to check the identification performance, Monte Carlo simulations are carried out using dataset generated by a 2D-FDTD method. Results are shown in the form of ROC curves and AUC values, and effects of soil condition (i.e. ground surface roughness, inhomogeneity, and moisture in soil) on identification performance are assessed. [C154]

"Low Pressure Operation of Radially Convergent Beam Fusion Using Differentially-Pumped Ion Sources"

Radially convergent beam fusion (RCBF) has been studied for practical use as a portable neutron/proton source for various applications such as landmine detection and positron emission tomography. In a conventional RCBF device using a glow discharge, the neutron/proton production rate is proportional to the cathode current because

beam-background reactions are dominant in contrast with the original RCBF concept. However, since the neutron/proton production rate of beam-beam reactions is proportional to the cathode current squared, beam-beam reactions have a potential to increase the neutron/proton production rate in a high cathode current region. In this study, a new RCBF system using differentially-pumped ion sources was designed for the low pressure operation without the glow discharge. In the RCBF chamber, a cylindrical grid cathode is concentrically placed on the axis of a cylindrical mesh anode, and two ion sources are oppositely mounted around the mesh anode. The ion sources allow the RCBF device to be operated at a pressure of 10-4Torr in the RCBF chamber, which is much lower than that of 10-1Torr in the ion sources. Generated ions in the ion sources are extracted through each orifice by the pressure gradient and the extraction electric field, and then accelerated to the RCBF cathode. At first, a performance as differential pumping system and discharge characteristics of ion sources were investigated. Then, the neutron production rate at a lower pressure compared with that of a conventional RCBF device was measured. Neutron production rate at a pressure of 0.30 mTorr was proportional to the ion current to the power of 1.19-1.23. This implies that the fraction of beam-beam reactions was increased by the reduction of background pressure in the RCBF chamber. [C155]

"Generalization Error Analysis for FDR Controlled Classification"

The false discovery rate (FDR) and false nondiscovery rate (FNDR) have received considerable attention in the literature on multiple testing. These performance measures are also appropriate for classification, and in this work we develop generalization error bounds for FDR and FNDR from the perspective of statistical learning theory. Unlike more conventional classification performance measures, the empirical FDR and FNDR are not binomial random variables but rather a ratio of binomials, which introduces several challenges not addressed in conventional analyses. We develop distribution-free uniform deviation bounds and apply these, in conjunction with the Borel-Cantelli lemma, to obtain a strongly consistent learning rule. [C156]

"An Analytical Expression for Estimating a Buried Object's Location, Orientation and Magnetic Polarization to Support UXO Discrimination"

A new physics based expression is presented for determining a buried object's location, orientation and magnetic polarizability. The approach assumes the target exhibits a dipolar response and uses only three global values: (1) a H magnetic field vector, (2) a vector potential A and (3) a scalar magnetic potential psi all at a single location in space. To illustrate the accuracy of the proposed algorithm, several numerical results are demonstrated using synthetic data for one and three dipoles. [C157]

"Double Negative Metamaterials for Subsurface Detection"

The realization of double negative (DNG) meta-materials and the evanescent field amplification feature of these materials engendered new approaches to subwavelength imaging. In this paper, we study the possibility of subsurface detection using evanescent fields in the presence of a DNG lens. Evanescent fields at lower frequencies can have better penetration characteristics compared to the propagating fields at higher frequencies. Using DNG materials, subwavelength images of targets buried in a homogeneous lossy medium are presented. [C158]

"Experimental evaluation of an array GPR for landmine detection"

This paper presents an experimental evaluation procedure for a landmine detection GPR with a single transmit antenna and a receive antenna array. The procedure includes calibration of the ultra-wideband array, estimation of its footprint and cross-range resolution for different size of the aperture, checking the capability to image landmines buried within the array aperture. For the evaluation, the authors developed an imaging algorithm combining a synthetic aperture focusing in the mechanical scan direction with a focusing of the array in the cross-scan direction. [C159]

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"Optimal area covering using genetic algorithms"

Path planning problems involve computing or finding a collision free path between two positions. A special kind of path planning is complete coverage path planning, where a robot sweeps all area of free space in an environment. There are different methods to cover the complete area; however, they are not designed to optimize the process. This paper proposes a novel method of complete coverage path planning based on genetic algorithms. In order to check the viability of this approach the optimal path is tested in a virtual environment. The simulation results confirm the feasibility of this method. [C161]

"Millimetre wave radar visualisation in mines"

This paper describes the development of millimetre- wave frequency modulated continuous wave radar visualization systems for mining applications. The implementations and performance verifications of the radar sensor for range and 3D profiling in underground and surface mines are presented in applications ranging from cavity, stope fill and ore-pass monitoring to dragline and rope shovel environmental mapping. [C162]

"A Geometrical Feature Based Sensor Fusion Model of GPR and IR for the Detection and Classification of Anti-Personnel Mines"

The Ground penetrating radar (GPR) and Infrared (IR) imaging have become two established sensors for detecting buried anti-personnel mines (APM) which contain no or a little metal. The paper introduces the GPR and IR techniques briefly and compares the two sensors with respect to their strengths and weaknesses for target detection and emphasizes the necessity of fusion to harness the advantages of each of the methods. We propose a geometrical feature based sensor fusion framework, combining GPR and IR, as an effective technique for detection and classification of APM, which will reduce the false alarm rate significantly. We consider the basic geometrical shape descriptor features of an object and construct a feature vector for each of the objects. These feature vectors are used to train a Probabilistic Neural Network (PNN) for the classification of APMs. The method gives almost perfect detection accuracy. [C163]

"Identification of Hidden Mines"

This paper reviews the state of knowledge concerning the identification of buried mines and unexploded ordnance using techniques based on the singularity expansion method, supplemented by symmetry. It includes a list of important references which, in turn, give a very large list of references. This is supplemented by some more recent specific references. [C164]

"Characterization of terrain background in LWIR hyperspectral data to aid landmine detection"

Spectral target recognition algorithms function by distinguishing specified target spectra from those of the environment in which they are embedded. Typically this discrimination is done by comparing a pixel's spectral signature to those in a known library or by looking for spectral outliers within a single image. A high probability of detection results when the target and background signature distributions are well known and significantly separated. While much work has gone into defining target signature distributions, significantly less effort has gone into defining background distributions, hi fact, improvements in background definition results in lower false alarm rates and higher probability of detection. [C165]

"Application of a dielectric lens for focusing of a GPR"

It will be investigated whether the resolution of ground penetrating radar (GPR) can be improved using a dielectric lens for focusing the transmitted waves. For the design of the entire GPR system a 3D field simulation will be used. The theoretical results will be compared with measurement results of a real GPR system which has been set up according to the design considerations which are presented in this contribution. [C166]

"Microstrip Antenna with Shorting Pins As A sensor for Landmines Detection"

A proposed sensor for landmines detection consists of two parallel microstrip antennas placed on same ground plane with shorting pins between the patch and the ground plane has been investigated. The microstrip patch array with shorting pins has the advantage of a low coupling and size reduction compared with classic arrays. The finite-difference time-domain (FDTD) is used to simulate the senor for landmines detection. [C167]

"Performance Evaluation of Separated Aperture Sensor GPR System for Land Mine Detection"

In this paper, the performance of the separated-aperture sensor working as ground- penetrating radar (GPR) is assessed over the operating frequency band. The capability of the separated-aperture sensor to detect buried targets is examined by evaluating and comparing the electromagnetic coupling between the transmitting and

receiving antennas in two cases: (i) when the system is placed over an empty ground and (ii) when it is placed over a ground inside which a practical target is buried at the proper depth. The finite-difference time-domain (FDTD) method is used for electromagnetic simulation and the results concerning the coupling between the transmitting and receiving antennas are presented considering various practical parameters such as the operating frequency, the electric properties of the ground soil and the buried target, and the depth at which the target is buried under the ground surface, it is shown that target detectability using the separated-aperture sensor is strongly dependent on all of the above parameters. [C168]

"Training Method for Ground Bounce Removal with Ground Penetrating Radar"

Downward looking ground penetrating radar (GPR) has been considered a viable technology for landmine detection. For such a GPR with the antennas positioned very close to the ground surface, the reflections from the ground surface, i.e., the ground bounce, are very strong and can completely dominate the weak returns from shallowly buried non-metallic mines. Hence, one of the key challenges of using GPRs for landmine detection is to remove the ground bounce as completely as possible without altering the landmine return. The ground bounce varies with surface roughness and soil conditions and leads to performance degradation for many ground bounce removal algorithms without reference data selection. In this paper we introduce NHD-based reference data selection methods for ground bounce removal. Experimental results are provided to illustrate the performance of the proposed method. [C169]

"Algorithm Overview Based On Image Processing with Electromagnetic (EM) Techniques in X Band and GA Approach for Depth Estimation of Shallow Burried Dummy Mines"

Detection of buried landmines and estimation of depth by modeling layered media is a complex and computationally intensive task. Microwave remote sensing with the capability to penetrate subsurface and its ability to resolve landmines as well as non-lethal targets can therefore be used for subsurface landmine detection. A model based on electromagnetic scattering and image analysis techniques at X-band frequency for sub-surface detection of dummy landmines buried under a sand layer and estimation of its depth has been proposed in this paper. An extensive set of lab experiments have been carried out using dummy landmines (without explosives) and backscatter observed at different depths. The raw data is processed through a series of image processing steps, the detection is carried out using Otsu's thresholding and the depth estimated by optimizing through a GA (genetic algorithm) based electromagnetic model developed. The method does not have any requirement of separate training and test data set to train the optimizer and validate the results. The results under laboratory conditions indicate that detection of dummy landmines is possible using thresholding techniques with data generated in X band and the proposed model is capable of estimating depth of the buried landmine to a significant accuracy. [C170]

"Method for Designating the Wind Condition in MDP-based Motion Planning of Under-actuated Blimp type UAV"

Blimp-type unmanned aerial vehicles (BUAVs) does not consume any energy in keeping their longitudinal position in the air, so their use as a platform for mine searching missions is anticipated. For mine searching missions, a BUAV must fly near the ground. Because there is severe limitation on the weight of equipment, such as sensors and actuators, most BUAVs are so-called under-actuated robots. For a BUAV to fly near the ground safely, a sophisticated obstacle avoidance algorithm that considers the kinematical constraints of under-actuated BUAV is needed. In developing the obstacle avoidance algorithm for under actuated robot, establishing a motion planning method is essential. To carry out applicable motion planning calculation for a BUAV, detail information about the wind velocity condition and geometry of obstacles in the mission environment is needed; however, it is very difficult to accurately estimate wind velocity distribution that is disturbed by the obstacles. In this paper, a method for estimating a rough wind condition near the ground considering the geometrical property of obstacles is proposed. The estimated rough wind condition is applied to the stochastic motion planning calculation based on dynamic programming (DP) in Markov decision process (MDP). The performance of the method is examined by computational fluid dynamical (CFD) simulation. [C171]

"Locating a Circular Biochemical Source: Modeling and Control"

This paper applies the modified Fisher information matrix (FIM) motion algorithm previously proposed by the authors to the task of locating a circular biochemical source. We develop the diffusion model for a circular source and perform control theoretic analysis of the resulting FIM motion algorithm. While in our previous work we established that the source location is an equilibrium point of the system, in the present paper we show that due to the consistency of the maximum likelihood (ML) estimator, the equilibrium point is unique. Simulations are presented that compare our motion algorithm to conventional concentration gradient motion algorithms. The

simulations confirm that by using our motion algorithm, the circular biochemical source is located with a high degree of accuracy. [C172]

"Gaussian Process Classification using Image Deformation"

An image deformation algorithm is integrated with a Gaussian process classifier for application to remote-sensing tasks in which data is in the form of imagery. To combine these disparate techniques, we introduce a novel kernel covariance function for the Gaussian process that allows us to incorporate the result of the image deformation algorithm into a rigorous Bayesian classification framework. The resulting classifier is completely non-parametric in the sense that no parameters or hyperparameters must be learned. The promise of the proposed algorithm is demonstrated on a data set of real, measured land mine data [C173]

"Web Services-Based Architecture for the Interactions between End-User Applications and Sink-Less Wireless Sensor Networks"

First Page of the Article [C174]

"Comparison of Information-Theoretic Objective Functions for Decision Support in Sensor Systems"

Information-driven sensor management aims at making optimal decisions regarding the sensor type, mode and configuration in view of the sensing objectives. In this paper, an approach is developed for computing two information-theoretic functions, expected discrimination gain and expected entropy reduction, to optimize target classification accuracy based on multiple and heterogeneous sensors fusion. The measurement process is modeled by means of Bayesian networks (BNs). The two objective functions utilize the BN models to represent the expected effectiveness of the sensors search sequence. New theoretic solutions are presented and implemented for computing the objective functions efficiently, based on the BN factorization of the underlying joint probability distributions. Dempster-Shafer fusion rule is embedded in the computations in order to account for the complementarity of multiple, heterogeneous sensor measurements. The efficiency of the two objective functions is demonstrated and compared using a landmine detection and classification application. [C175]

"Collective Plume Tracing: A Minimal Information Approach to Collective Control"

A team of simple robots are used to trace a chemical plume to its source in order to find buried landmines. The goal of this paper is to analyze and design "emergent" behaviors to enable the team of simple robots to perform plume tracing with the assistance of information theory. The first step in the design process is to define a fundamental tradeoff for collective systems between processing, memory, and communications for each robot in order to execute the desired collective behaviors. The baseline problem is to determine the minimum values for processing, memory, and communications simultaneously. This will enable the designer to determine the required information flow and how effectively the information resources are being utilized in collective systems. The solution to this baseline problem is an 8-bit processor, no memory, and three words to communicate. The details of this solution are described in this paper. The second step is to extend the previous kinematic solution to a more general Hamiltonian based solution to develop a Fisher information equivalency. The Fisher information equivalency leads directly to necessary and sufficient conditions for stability and control of nonlinear collective systems via physical and information exergy flows. In particular, the creation of a "virtual/information potential" by the team of robots via the decentralized distributed networked sensors produces a direct relationship between proportional feedback control, stored exergy in the system, and Fisher Information. This nonlinear stability formulation through Fisher Information directly provides an optimization problem to "tune" the performance of the team of robots as a function of required information resources. [C176]

"An Empirical Analysis of Ad hoc Routing Protocols for Hybrid Wireless Sensor Networks"

This paper investigates and evaluates the possible use of existing ad hoc routing protocols for hybrid wireless sensor networks. The key idea is to adopt the routing protocols designed for Mobile Ad hoc Networks (MANETs) in a hybrid sensor network that consist of resource enriched nodes (which may be mobile or static) and resource constrained nodes (static). The role of resource constrained sensor nodes is to deliver the sensed data to a nearest resource enriched node that can either store/process the data or transmit it to a central base station using high power transmission. By virtue of this, we might be able to save time and effort involved in the design of a completely new routing protocol from scratch for such a hybrid and more practical scenario. Our study is inspired by the similarities found in both MANETs and wireless sensor networks e.g. ad hoc arrangement of nodes, energy constrained devices, wireless communications etc Based on the similarities of the two networks, we formulated a set of design principles on the basis of which a protocol designed for ad-hoc networks may be

declared feasible for a hybrids sensor network. Our work is supported by an experimental analysis in which an example protocol primarily designed for MANETs has been shown to perform efficiently in a resource constrained sensor network. [C177]

"Endpoint Vibration Control of a Mobile Mine-Detecting Robotic Manipulator"

The procedure for humanitarian land mine removal varies greatly. However, one central element is detecting and marking suspected mine locations using sensors such as trained dogs and metal detectors. This step is expensive, tedious, and dangerous. In order to improve the land mine detection process, a reliable, low-cost robotic manipulation system has been constructed. The system consists of long-reach manipulator mounted on a commercially available All-Terrain Vehicle. The system is capable of autonomously scanning for mines with different types of sensors. An electromagnetic induction metal detector is used in conjunction with ground-penetrating radar to detect metal and larger heterogeneities in the ground, i.e. mine detonators and mine casings, respectively. This sensor combination greatly reduces the number of false alarms over the traditional single-sensor approach. Given the long reach of the arm, the endpoint is susceptible to unwanted oscillations that corrupt the scanning information. This paper describes a control system that utilizes input shaping to improve endpoint tracking. The result is a system that generates high-quality sensor information for precise mine identification. [C178]

"Development of the Hand held dual sensor ALIS and its evaluation"

GPR has been thought a useful sensor for detection of buried land mines, but no GPR has been practically deployed in humanitarian demining. Since 2002, we have developed a new hand-held land mine detection dual-sensor ALIS. ALIS is equipped with a metal detector and a GPR, and it has a sensor tracking system, which can record the GPR and Metal detector signal with its location. It makes possible to process the data afterwards, including migration. The migration processing drastically increases the quality of the image of the buried objects. ALIS uses two different GPR systems, namely VNA (Vector Network Analyzer) based GPR and an Impulse GPR. VNA based GPR can provide better quality GPR images, although the impulse GPR is faster and light weight. ALIS evaluation tests have been held in mine affected courtiers including Afghanistan, Croatia, Egypt and Cambodia. In the two-month evaluation test in Cambodia, ALIS worked without any problem. After some demonstrations and evaluation, we got many useful suggestions. Using these advises, we have modified the ALIS and it is now more easy to use. ALIS will be commercialized in 2007. [C179]

"Fast Extraction of Hyperbolic Signatures in GPR"

The hyperbola exhibited from the local target in B-scan of GPR can contribute to estimate the propagation velocity and locate target. In this paper, a new method of fast extracting hyperbolas and apex is presented. The method is based on peak tracing and the symmetry of hyperbolas. The method was tested on experiments, and the results indicate that it can be achieved in near real-time. [C180]

"Time-frequency domain signature analysis of GPR data for landmine identification"

In this paper, the problem of detecting buried antipersonnel (AP) landmines is tackled in the broader context of target identification: determining relevant features, extracted from impulse ground-penetrating radar (GPR) signals, which can be used to classify landmines. These features are extracted in the time-frequency domain using the Wigner-Ville distribution (WVD) and the wavelet transform (WT). Radar data are collected using the MINEHOUNDTM hand-held dual-sensor system over two types of soil and for different landmines and objects. The Wilk's lambda value is used as a criterion for optimal discrimination. Results show that time-frequency signatures from WVD contain more valuable information than the features extracted using WT. Therefore, they could improve landmine and false alarm classification and help to differentiate between two different landmines. [C181]

"Array-Based GPR for Shallow Subsurface Imaging"

Recently we have reported development of an UWB array-based time-domain Ground Penetrating Radar for landmine detection. The radar is designed to be used within a vehicle-mounted multi-sensor system for humanitarian demining and produces 3D images of subsurface by ID mechanical scanning. In this paper, we demonstrate imaging capabilities of the developed system. The imaging capability of the radar is realized via electronic steering of the receive antenna footprint in cross-scan direction and synthetic aperture processing in along-scan direction. Imaging via footprint steering allows for drastic increase of the scanning speed. [C182]

"Control strategy for a snake-like robot based on constraint force and its validation"

This paper is concerned with a method for the locomotion of a snake-like robot, and proposes a control strategy based on the friction force between its body and the ground for the robot. It is said that the locomotion of a snake utilizes the friction force between the body and the ground. Our concept of a control system design is that a control law should be based on the friction force as a real snake is. A three- link serial robot is considered as an experimental system, and its mathematical models, both the equation of motion of the robot and the friction, are derived by the projection method proposed by W. Blajer. A snake-like robot has holonomic and nonholonomic constraints. The advantage of the projection method is that it can deal with these different types of constraint simultaneously in the modeling process. The friction model is evaluated by the cost function of the control system design based on state dependent Riccati equations. As a result a derived control law takes the friction effect into account. The effectiveness of the proposed method is verified and evaluated through some numerical simulations. [C183]

"Signature Evaluation for Thermal Infrared Countermine and IED Detection Systems"

A high-resolution, computational suite has been constructed to produce synthetic thermal imagery of vegetated soil surfaces with landmines or other targets. The imagery is created by coupling models for the ground, vegetation, ray casting, and sensor characteristics to produce realistic thermal infrared simulated imagery. These simulations provide information ranging from simple temperature contrasts to high-resolution images comparable to actual sensor images that can be used to evaluate or train automatic target recognition (ATR) systems. Analyses of the ATR results allow development of recommendations for optimal sensing strategies and additional training to improve ATR performance. The modeling and characterization occurs at the centimeter scale, which requires massively parallel computational resources to meet the demands of the simulation. The models run simultaneously on a single, parallel, or serial computer and communicate using sockets or files. The soil model is a three-dimensional, spatially adaptive, continuous Galerkin, finite element model that simulates partially-saturated flow and heat transport, coupled to two-dimensional surface water flow. The vegetation model simulates infrared absorption, reflection, and transmission by discretized plant leaves and stems. Ray casting provides boundary conditions for the soil and vegetation thermal models, and produces multi-spectral images of energy reflected and emitted from the synthetic scene. Subsurface phase change, distributed root zone moisture uptake and transpiration, and flow through macro pores and cracks are processes under construction. The parallelization of the individual testbed components is relatively straight-forward. The central difficulty in achieving acceptable performance for the computational testbed in a parallel computing environment is the sequencing of data transfers between components. Example calculations to be presented include a multi-million element simulation for an arid test s- ite that is only a few meters in its longest dimension. The models are driven with meteorological data and are built using material property data collected at the field site. Synthetic images produced are compared against those from thermal cameras. A long-term goal of this work is to help build parameter estimation software to infer ground state information (soil moisture and physical property distributions) from airborne imagery. [C184]

"Wrapper approach for feature subset selection using GA"

In this paper, wrapper based approach is presented to feature subset selection of ground penetrating radar (GPR) echo signal using genetic algorithm in conjunction with constructive learning algorithm. GPR echo signal inherently has the non- stationary characteristic and the target echo signal is deteriorated by the clutter. Firstly, WP-based preprocessing algorithm is used to clutter reduction and feature extraction. Then wrapper based approach is adopted to find optimal feature subset, and at meanwhile obtain the result of classification. Experiment result based on GPR landmine data shows the feasibility and advantage of the presented algorithm. [C185]

"Research and development of the humanitarian landmine detection system by a compact fusion neutron source"

Results of 5 years task are described on the research and development of the advanced humanitarian landmine detection system by using a compact discharge-type fusion neutron source called IECF(inertial-electrostatic confinement fusion) device and dual sensors made of BGO and NaI. With 107neutrons/s stably produced in CW mode, 10.8 MeV, gamma rays from (n, gamma) reaction with nitrogen atoms in the explosives (explosive simulant in our study) are measured for two kinds of explosives(TNT, RDX), under the conditions of three different buried depths, and soil moistures. Tentative detection probability for arid soil is found to be in excess of 80%. [C186]

"An efficient electromagnetic approach to train the SVM for depth estimation of shallow buried obi ects with microwave remote sensing data"

Present paper deals the fusion of image analysis with electromagnetic and support vector machine (SVM) optimization approach to estimate the depth of shallow buried metallic and dummy mine (i.e., without explosive) objects with microwave remote sensing data at X-band (i.e., 10 GHz). The objects were buried under dry and smooth sand. For this purpose, a monostatic scatterometer at X-band has been indigenously developed, which consists a transmitter and receiver mounted on the stand of the sand pit and when operated it moves over it in X- and Y- axis. An algorithm has been proposed for identification of suspected region first i.e., region of interest (ROI) that contains buried objects in the image by proposing a quantity "detection figure" (D), which further proceed for depth estimation of buried objects. Algorithm includes image processing, electromagnetic multi layer interaction and SVM approach. The convolution-using image processing techniques has been applied to avoid the overlapping of the return signal. The support vector machine (SVM) approach has been analyzed for estimation of depth and an efficient method based on electromagnetic multiplayer interaction concept has been proposed to train the SVM. The depth estimated for Al sheet gives better result than dummy landmine, but the estimated depths results for both objects are in good agreement with actual depths. The present approach may be quite helpful to develop an automatic satellite data based information systems to estimate the depth of various shallow buried objects with satellite or air-borne radar data. [C187]

"Transient spherical wave front steadying in the near zone of an antenna"

Some concepts of transformation of a transient wave front in the near zone of an antenna into a spherical one in the far zone are considered. The characteristics of an antenna relevant to the wave front like amplitude decay centre, time delay centre and prompt impedance that can be useful in modeling short range radar are discussed. [C188]

"Controlling a robot arm using exoskeleton for land-mines disposal"

Robotics, Virtual Reality, Exoskeleton and Human Machine Interface are fields of growing interest and applications every day. Robotic systems have enormous potential to reduce human exposure to dangerous situations and/or increase human presence in remote locations. Most of industrial robots are usually controlled by a computer or micro controllers to perform systematic sequence of actions stored in its memory. Navigation of autonomous robots involves following trajectories generated by automatic motion planners. For non-autonomous systems, the robot's trajectories are provided by the operator, either trajectories that are pre-set or fed in an on-line fashion, such as teleoperation. Teleoperation is widely used for the direct control of non-autonomous robots from a remote location. The objective of this paper is to facilitate the controlling process by using human-machine interface techniques instead of predefined limited actions in its memory; this is done in order to be able to control the robot arm remotely to discover the World Wide II mines that are still in the western desert of Egypt. [C189]

"An unsupervised multi-feature framework for landmine detection"

A multi-feature framework for the detection of antipersonnel landmines with Ground Penetrating Radar (GPR) is suggested. The features result from independently acquired and processed GPR measurements. The initial detection in the confidence maps is made independently after which these detection coordinates are co-located. The marginal feature distributions are normalized via Johnson;s transform prior to the process of their fusion. A Maximum Likelihood based classifier is used as a fusion operator. The operator takes a quadratic form due to the enforced normality of the feature distributions. The framework trains the classifier using secondary data acquired at an open site. The framework;s performance is illustrated using the data acquired over a specifically designed test-site. [C190]

"Wireless Controlled Laser Tracking Based Hovering Mine Detector"

The main methods used for demining on land are manual detection using metal detectors and prodders, detection by specially trained dogs and mechanical clearance using armored vehicles fitted with frails, tillers or similar devices, however in all the methods the position of mine prior to detection is unknown. A lot of causalities occur during demining operation. Existing mechanical systems are expensive and very difficult to deploy specially in those areas where it is not possible to take heavy machinery. Due to the advancement in tracking systems, an integrated system employing latest tracking techniques using laser range finder as tracker can be used to detect the exact location of mine in the minefield. Radio frequency transmitter controls the aerospace vehicle. This new idea of detecting mines by integrating the above-mentioned technologies is implemented on a home made hovercraft using laser range finder system as a tracking tool thus providing a fixed reference point. [C191]

"Design and Implementation of a Low Cost VLF Metal Detector with Metal-Type Discrimination Capabilities"

Land mine detectors, security metal doors that we all go through in buildings and airports, as well as metal mining detectors are just examples of metal detector use in our daily lives. In this paper we present a cost efficient, low complexity very low frequency (VLF) handheld reconfigurable metal detector (MD) design and implementation that has the capability of discriminating between various metal types. A concentric coil consisting of an outer transmitter coil, an inner receiver coil and a feedback coil. The coils operate in the 5.5 KHz frequency range. An amplitude and phase detection circuits were designed to detect and distinguish between metal types. The detection algorithm was implemented using a PIC microcontroller. The results from the actual implemented metal detector are shown and discussed for 3 types of metals: Iron, Copper, and Aluminum at various distances. The MD can detect metals about 16 cm below its coils. [C192]

"Sensor coverage with a multi-robot system"

The present paper develops a novel strategy for the exploration of an unknown environment with a multi-robot system. It is required that the entire free space is covered by the sensors of the robots, with a certainty of 100%. Communication between the robots is restricted to line-of-sight and to a maximum interdistance between robots. Contrary to most exploration problems, the topographical properties of the space need not be mapped. An algorithm is presented that guides a group of N robots, scanning the free space for target objects. The group splits to pass obstacles of unknown size and shape. The decision of splitting the group takes a trade-off between group coherence and speed of advancing into account. A direct application of the algorithm is mine held clearance. [C193]

"Acoustic interrogation of soil and possible remote detection of shallow buried inclusions"

Here we address the problem of remotely interrogating the shallow subsurface of soil using low power mechanical energy transmission and sensing the subsequent backscattering from the soil bed to find small buried objects at very shallow depths (~ 15 cm or less). The effort is geared towards the development of better technologies for the remote detection and imaging of buried land mines, improvised explosive devices (IEDs) and other undesirable objects. We present our studies against the backdrop of what is known in this field today. Our ongoing work is briefly summarized with an outline of the underlying physics of acoustic backscattering from shallow buried objects and of how such backscattering can be inexpensively and remotely detected and interpreted for possible use in automated mine clearance operations. [C194]

"Hand held dual sensor ALIS and its evaluation test in Cambodia"

Since 2002, we have developed a new hand-held land mine detection dual-sensor ALIS. ALIS is equipped with a metal detector and a GPR, and it has a sensor tracking system, which can record the GPR and Metal detector signal with its location. It makes possible to process the data afterwards, including migration. The migration processing drastically increases the quality of the image of the buried objects. ALIS uses two different GPR systems, namely VNA (Vector Network Analyzer) based GPR and an Impulse GPR VNA based GPR can provide better quality GPR images, although the impulse GPR is faster and light weight. ALIS evaluation tests were held in mine affected courtiers including Afghanistan, Croatia, Egypt and Cambodia. In the two-month evaluation test in Cambodia, ALIS worked without any problem. After some demonstrations and evaluation, we got many useful suggestions. Using these advises, we have modified the ALIS and it is now more easy to use. ALIS will be commercialized in 2007. [C195]

"Broadband electromagnetic induction sensor for detecting buried landmines"

A broadband electromagnetic induction (EMI) sensor is developed to help discriminate between buried land mines and metal clutter. The detector uses simple dipole transmit and receive coils along with a secondary bucking transformer to mostly cancel the coupling between the coils. The technique allows the cancellation that can be obtained using a quadrupole receive coil while maintaining the depth sensitivity and simple detection zone of a dipole coil. Experimental results are presented for several targets. [C196]

"Use of an application-specific dictionary for matching pursuits discrimination of landmines and clutter"

The HSTAMIDS handheld landmine detection system has been used in a number of humanitarian demining activities. Existing algorithms used with this system to assist human in discrimination process do a better job than the operator alone. However, they are unable to model mine and clutter signatures completely, leading to inaccurate mine confidence assignment. This paper presents a matching pursuits (MP) based landmine detection system using an application-specific dictionary. Prototypes for mine and clutter classes are built using MP decomposition of class members. A fuzzy K-nearest neighbor rule is used to assign confidence values for mine

and clutter discrimination. The proposed algorithm is demonstrated on data acquired from three different landmines test sites. [C197]

"Possibilistic multi-sensor fusion for humanitarian demining"

We propose a method for combining humanitarian mine detection sensors based on possibility theory. Firstly, different features are extracted from the sensor data. Possibility distributions are then derived from the features based on prior information. After that, the combination of possibility degrees is performed in two steps, on separate sensor level and between the sensors. Combination operators are chosen to account for the different characteristics of the sensors. The final decision is obtained by thresholding the fusion result. Promising results have been obtained on a set of real mines and non-dangerous objects. In particular a 100% mine recognition rate was achieved, with a limited number of false alarms. [C198]

"3D template based automatic landmine detection from GPR data"

In this paper, we present a 3D template based landmine automatic detection from GPR data. A 3D template is chosen and a 3D fuzzy template is designed. The choice of the 3D template is decided based on smooth changing position of the maximum amplitude at every C-scan as well as the threshold of its background average intensity. The 3D fuzzy template is extracted from 3D template crisp data. GPR similarity for both the 3D template as well as its fuzzy template is examined by crisp similarity measure and fuzzy similarity measure respectively. The cross correlation is applied as a similarity measure in crisp case while a fuzzy similarity measure, based on similarity of a measured data to a fuzzy rule, is applied in the fuzzy template case. Results of similarity applying both methods for automatic landmine detection are presented. The results show the promise of 3D fuzzy template and the fuzzy similarity measure in differentiating a landmine from other objects. [C199]

"Do olfactory receptors respond to explosives?"

Olfactory receptors (ORs) comprise a large gene family (-1200 proteins encoded by OR genes) and thus are excellent candidates for the fabrication of sensitive biosensors for explosives and other chemicals of interest. Our research project aims to address these two fundamental questions: Which are the volatile components of landmines recognized specifically by animals? How do olfactory neurons located in their nasal cavity respond to the "perfume" of mines? As regards the first question, six different plastic components of six different kinds of landmines have been analyzed. To address the second question, the response of olfactory neurons to these volatile organic compounds present in the vapors of mines, as well as to TNT and RDX, has been studied both in the pig and in the rat. Studies on rat olfactory mucosa have been carried out with electro-olfactogram (EOG) and calcium imaging techniques, while changes in the cAMP levels following exposure to odorants and explosives were used as criterion to evaluate the interaction of TNT and RDX with olfactory receptors in a preparation of isolated pig olfactory cilia. Our studies demonstrate, for the first time, that mammalian olfactory receptors can be activated by explosives and chemical given off from explosive devices and represent a deeper understanding of the molecular mechanisms by which landmine volatiles interact with sensory olfactory neurons and their receptors, necessary for the preparation of a successful biosensor. [C200]

"Application of random set-based clustering to landmine detection with hyperspectral imagery"

We apply a population-based classifier to Long Wave HyperSpectral Imagery (LWHSI) for the purposes of landmine detection. In LWHSI, there are many environmental factors that are correlated with groups of samples (pixels in an image) in sample populations (individual images). These factors greatly affect samples' values making it difficult for standard classification models to perform well on a consistent basis. Population-based classifiers capture information correlated with sample populations. We perform classification experiments over a range of LWHSI imagery and compare results between the population-based classifier and standard kNN. After analysis, we show that the use of population-correlated information in LWHSI greatly improves classification results and consistency. [C201]

"Automatic landslide detection from remote sensing images using supervised classification methods"

The creation of a landslide inventory map by manual interpretation of remote sensing images is very time-consuming. This study aims at developing an automated procedure for the detection of landslides from multi-spectral remote sensing images. According to the type of landslide, the parameters for detecting the slope instabilities will differ. In a first step, predefined input parameters derived from the images are incorporated in a supervised pixel classification algorithm. In this study, we use a maximum likelihood classification method, which shows positive preliminary results. In order to evaluate the accuracy and applicability of the method, the results

are compared with ANN classification. Segmentation of the output image (containing likelihood values to be a landslide) into landslide and non-landslide areas is conducted by using the double threshold technique in combination with a histogram-based thresholding. Additional filtering of the detected blobs based on shape and geomorphologic properties allows to eliminate spurious areas. Validation of the results is done by comparison with manually defined landslides. [C202]

"Numerical simulation of electromagnetic-wave propagation for land mine detection using GPR"

The ground penetrating radar (GPR) has demonstrated good potential for the remote imaging of surface-laid or shallow-buried landmine-like objects (typically ~ 5-30 cm) and its use is currently receiving much attention. It has turned out to be a promising alternative technology for low dielectric contrast objects, a difficult detection situation that is often encountered in practise (e.g. detection of plastic mines in dry or sandy soils environment). This paper examines numerically the imaging of buried objects using ultrawide-band (UWB) time domain radar. We develop a simplified model to characterize the system, air-ground-buried targets-antennas and simulate the electromagnetic wave propagation and scattering at a bandwidth of 0.5-2.5 Ghz. All the elements need to be modelled simultaneously in order to obtain an accurate estimation of our radar performance and surface response to the incoming radar pulses. The final goal is to improve the detection rate of plastic antipersonnel mines, reducing the false alarm level. We show some simulated results in 2D and 3D assuming plane waves and afterwards we introduce a model for our GPR antennas to characterize the real source. [C203]

"Application of 3D-SAR nearfield imaging algorithms to GPR data"

This contribution addresses the utilization of near field 3D-SAR imaging algorithms applied to radar data from an ultra wideband (UWB) ground penetrating radar (GPR) system. The measured data were collected at the test field of the multi sensor mine signature (MsMs) group at the European Joint Research Centre (JRC) in Ispra/IT. The layout of this test field was designed for the more difficult problem of detecting targets representing anti-personnel mines. The 3D-SAR imaging algorithms can be implemented in time-domain or frequency domain. This contribution focuses on the time-domain implementation. The influence of the quality of the 3D-SAR imaging algorithm on the performance of an automated detection process is evaluated. [C204]

"Polarimetric feature fusion in GPR for landmine detection"

A polarimetric multi-feature framework for the detection of antipersonnel landmines with ground penetrating radar (GPR) is suggested. The features result from independently acquired and processed GPR measurements in co- and cross-polar configurations. The initial detection in the confidence maps is made independently after which the coordinates of the detected targets are co-located. The marginal feature distributions are normalized via Johnson's transform prior to the fusion process and a Maximum Likelihood based linear-quadratic classifier is used as a fusion rule. The framework makes use of secondary data acquired from an open test site to train the classifier. The framework performance is illustrated on the data acquired over a specifically designed test- site. [C205]

"FPGA Implementation of 3-D Thermal Model Simulator"

Infrared thermography is a technique for the detection of plastic mines. Its application requires the solution of the equations that govern the heat transfer processes. We present an FPGA projection of a system that solves these equations [C206]

"Coupling Effects in Resistive UWB Antenna Arrays"

The self- and mutual impedances of elements in the dissipative antenna array are known to involve radiative resistances and loss resistances. This paper is dedicated to analyzing the structure of the mutual impedance between resistive load elements and its effect on the radiation efficiency of the array [C207]

"Portable Magnetic Gradiometer for Real-Time Localization and Classification of Unexploded Ordnance"

We report progress toward achievement of a new magnetic tensor gradiometer technology that is being developed with support from the Strategic Environmental Research and Development Program (SERDP). The objective of this R & D effort is to provide a man-portable magnetic tensor gradiometer for real-time, point-by-point detection, localization and classification (DLC) of unexploded ordnance (UXO). The portable gradiometer processes data from triaxial fluxgate magnetometers to develop sets of rotationally invariant, "gradient-contraction-type" scalar parameters. The scalar parameters provide the basis for a unique Scalar Triangulation and Ranging (STAR) method that determines the UXO's position and magnetic signature. In particular, our paper

presents: (a) A review of the magnetic STAR concept, (b) Details of construction and operation of the portable STAR-type gradiometer, (c) Results of computer simulations of the effects of fluxgate noise on the gradiometer's target-tracking performance and (d) Results of experimental measurements of uncorrelated fluxgate noise and correlated gradient channel imbalance errors, (e) Preliminary results from a gradient imbalance noise compensation algorithm. The R & D results indicate that the magnetic STAR concept potentially will provide an exceptionally valuable, motion-noise-resistant magnetic sensing technology for real-time, DLC of UXO, and buried mines [C208]

"Detection of Natural Landmarks for Mapping by a Demining Robot"

To enable automated landmine detection a number of practical problems must be overcome. One of them is the mapping of data from landmine detection sensors using a mobile demining robot in an unstructured outdoor environment. The odometry of the robot used for mapping can be improved by using an additional vision system. It is proposed in this paper to utilize natural landmarks which can be found on the ground for this purpose. New simple algorithms for detection and association of natural landmarks are developed and described. Finally, the experimental results of applying these algorithms on a set of images obtained from a camera mounted on the robot are presented. The results show their robustness for different environmental conditions and robot motions [C209]

"UWB Radars for Chalenging Applications"

A number of challenging radar applications (such as antipersonnel mine detection and human being detection) has been discussed. In these applications UWB technology has a number of advantages of over the traditional narrow-band approach, in particular very high positioning accuracy, rigidity to multi-path propagation and target classification abilities. On a number of examples recent advances of UWB technology in radar have been demonstrated and remaining challenges have been discussed [C210]

"A Novel Method of Landmines Detection Based on Improved SVM"

To detect landmines in real SAR images, detection process based on PCA and SVM techniques is proposed in this paper. Firstly, a referential deflection-optimal linear-quadratic(DOLQ) detector is presented. Then, the proposed centering PCA+SVM method is developed and compared with the above benchmark. A morphological processing procedure is used to remove the isolated spurious pixels and to form landmine objects in the binary images. Finally, the experimental results show that the novel method can constantly outperform the DOLQ detector in terms of POD(probility of detection) and the SVM method in terms of training and classification times in landmine detection. [C211]

"Ultra-wide band SAR subsurface metallic landmine images: simulation and measurement"

Air- or vehicle-borne ultra-wide band synthetic aperture radar (UWB SAR) has the capability to detect landmines over large area from a standoff distance quickly, which is the trend of landmine detection. The study of electromagnetic characteristic of landmine is eagerly required to improve the landmine detection performance. In this paper, simulation and measurement of UWB SAR subsurface metallic landmine images are compared. Simulation and measurement results both show that metallic landmines have double-peak characteristic, which is valuable for landmine detection [C212]

"Aspect-invariant feature extraction and associated landmine detector in UWB SAR"

Vehicle- or air-borne ultra-wide band synthetic aperture radar (UWB SAR) can perform landmine detection over large areas, where too many false alarms is the major problem for UWB SAR application in practice. In this paper, landmine aspect-invariant feature extraction using the space-wavenumber distribution (SWD) and its associated support vector machine (SVM) with a hypersphere classification boundary are proposed in landmine detection procedure. The proposed methods have been tested by the real data collected with the rail-GPSAR system [C213]

"The evidence framework applied to fuzzy hypersphere SVM for UWB SAR landmine detection"

The fuzzy hypersphere support vector machine (FHS-SVM) has stronger generalization capability than the hyperplane SVM (HP-SVM) in UWB SAR landmine detection. In this paper, the evidence framework is applied to optimize the hyperparameters of FHS-SVM. Firstly, the equivalence between FHS-SVM training and the level 1 Bayesian inference of the evidence framework is proved. Next, the FHS-SVM hyperparameter optimization iterative method is proposed based on the evidence framework. The proposed method has been validated with the ultra-wide band synthetic aperture radar (UWB SAR) landmine detection data [C214]

"Sensor Fusion Based Fuzzy Rules Learning for Humanitarian Mine Detection"

In this paper, a sensor fusion based fuzzy rules for humanitarian demining are presented. A fuzzy learning algorithm for extracting fuzzy fusion rules from experimental data of robot-manipulated ground penetrating radar (GPR) and metal detector (MD) is presented. The inputs to the fuzzy learning algorithm are features extracted from both a GPR and an MD while its output is a set of fuzzy rules. Applying the learnt fuzzy fusion rules and knowing GPR and the MD features of a given scan, it is possible to decide if there is a land mine and its approximate depth underground. The features chosen for this fusion algorithm are the peak amplitude of a processed GPR output signal and the peak value of the cumulative sum of amplitudes of MD output signal for the same scanned area. Experimental test results are presented for verifying the validity of the proposed learnt fuzzy fusion rule base [C215]

"Motion Control of Landmine Detection Vehicle Equipped with Low-Ground-Pressure Tires"

Most of landmine detection robots proposed before have been strongly restricted to locomote because they have not been able to enter the minefield. So we have proposed a mine detection vehicle which can enter minefield with low-ground-pressure tires and scan landmines directly using GPR. Low-ground-pressure tire decrease ground contact pressure. And we are intended to make accurate map that point out the position where landmines are buried. The position of the vehicle is able to be observed with internal sensors (for the posture measurement) and external sensors (for the position measurement). However, when controlling the vehicle, the sampling time of external sensors and communication time from external sensors to the vehicle cannot be disregarded. Exact position of the vehicle must be predicted with dynamical model of the vehicle. We therefore propose dynamical model of the vehicle for low-ground-pressure vehicle. Based on experimental results, the dynamical model for low-ground-pressure vehicle is in consistency with actual behavior of it [C216]

"Advanced Signal Processing for Reduction of False Alarm Rate of Metal Detectors for Humanitarian Mine Clearance"

Today for clearing areas from landmines, beside dogs and searching needles, almost excluding metal detectors are used. Available metal detectors, specialised for mine clearance, are highly sensitive also on small metal parts. Nevertheless, they give no further information about the buried object (depth, size, shape, material). Besides, the high false alarm rate of the hand-held detectors makes the mine clearance a protracted and cost-intensive process. Reasons for the high false alarm rate (up to 1000 false alarms per mine) are "uncooperative" soils, harmless metallic objects like shell splinters, but also the low metal content in newer anti-personnel mines. In this paper a method is described which provides more information about the buried object by using image processing and signature classification, which works also in the presence of "uncooperative" soil. In many cases, there are only one or two different mines in a minefield. So it is possible to use a database with mine signatures for an automatic object classification in order to decrease the false alarm rate [C217]

"Soil Moisture and Surface Roughness Effects in Ground Penetrating Radar Detection of Land Mines"

Nonmetallic mine detection with GPR is challenging because of poor target/soil contrast and clutter from the random rough ground surface. Greater soil moisture implies higher dielectric constant, which in turn increases contrast and scattering of radar waves, but also increases the contrast between the air and the soil, increasing clutter. The finite difference time domain method for modeling impulse radar is use to quantify the effects of clutter on the target signal for both ideal smooth ground surfaces and rough surfaces for uniformly dry, wet, and a profiled moisture distribution characteristic of short-time watering. Results indicate that each uniform moisture case offers detection features that allow for the distinct temporal and spatial separation of target and clutter signals, but that non-uniform soil moisture makes nonmetallic mine detection problematic [C218]

"A Novel Method of P2P Hosts Detection Based on Flexible Neural Tree"

It is estimated that 70 percent or more of broadband bandwidth is consumed by transporting music, games, video, and other content through P2P clients. In order to identify, and manage of P2P traffic, some port, payload and connection features based methods were proposed. But most of them focus on identifying P2P traffic based on rules and most of them can't identify P2P traffic with new features. None of the proposed methods can effectively help controlling and managing the P2P hosts. In this paper, we created a new P2P feature set, which include most of the proposed and new P2P features proposed by us. And a new anormaly detection method based on the feature set and flexible neural tree (FNT) is applied to detect P2P hosts. This approach is the first intelligent P2P hosts detection method. Experimental results show that the new method proposed by this paper has high detection performance and good expansion ability to add new P2P features. It can be easily applied to

an on-line environment in our future planed work [C219]

"Independent navigation and functioning of intelligent agents by social interaction"

The focus of the effort underlying this paper is to evolve a co-operation based navigation scheme and a mechanism for ad hoc task division between members of a socially interactive swarm of intelligent robots that may find application in strategic warfare and in landmine detection and neutralization. A novel approach has been adopted for evolving a vision scheme for the intelligent agents that endows each member of the swarm with a considerable level of autonomy thereby allowing for re-configurability of the swarm. [C220]

"Microstrip antenna for detecting buried land mines"

This paper shows that the finite-difference time-domain (FDTD) simulation method can be used to simulate the electromagnetic performance of mine detection whether they are of metal or dielectric compositions. This is done using proposed two microstrip patch array antennas scaled at UHF frequencies [C221]

"D-D and D-/sup 3/He proton measurements of cylindrical radially convergent beam fusion"

Summary form only given. Radially convergent beam fusion (RCBF) device is a compact fusion neutron/proton source with extremely simple configuration, high controllability, and hence high safety. It has been mainly studied for practical use as a portable neutron source for various applications such as landmine detection, and the results of previous studies indicate that the RCBF device has a high potential as a neutron source. On the other hand, however, the RCBF device as a proton source has not been investigated sufficiently. In this study, not only neutrons but also protons generated by D-D and D-3He reactions in a cylindrical RCBF device were measured for practical proton source. In order to detect protons, a solid-state detector (SSD) was used. However, there is a difficulty in applying the SSD to the RCBF device. The SSD can not discriminate protons from X-rays, which are produced simultaneously in the RCBF device. In addition, it is difficult to stop the X-rays with a metallic foil filter because of its high transmittance. Therefore, a new proton counting system based on magnetic deflection was designed and used to eliminate the X-rays. The system has three magnetic deflectors, which consist of a pair of neodymium magnets. The SSD position in this system was determined by a calculation of the deflected proton trajectory. At first, the cylindrical RCBF device was operated using only deuterium gas. Generated D-D protons of 3.03 MeV were measured with and without this proton counting system, and the count rate was compared with that of D-D neutrons. Then D-3He protons of 14.7 MeV were counted feeding not only deuterium gas but also helium-3 gas. By comparing D-3He proton and D-D neutron count rates, the optimal ratio of helium-3 gas to deuterium gas was obtained [C222]

"Wave-based signal processing"

This paper addresses the problem of adaptive sensing based on multiple sensor modalities. Assuming a multi-modality sensing problem is considered, that physical insight is available, and that a certain quantity of data has been collected thus far from the scene under test. The objective is to optimally choose what new multi-sensor data should be collected, with the objective of maximizing classification performance while minimizing sensing costs (e.g., battery use, time, etc.). It is desirable that the algorithm be non-myopic, in the sense that it accounts for the immediate utility of a given sensor, as well as the properties of sensing over a discounted infinite horizon. For example, a sequence of inexpensive measurements may have the same utility as a single expensive measurement, and the inexpensive measurements are only preferred if the algorithm operates non-myopically (i.e., the algorithm addresses long-term performance, looking ahead, rather than myopically and greedily choosing the sensor that yields the immediate best performance, independent of cost). The problem is solved via a partially observable Markov decision process (POMDP), and this paper explains how the underlying wave physics is employed to improve POMDP sensing performance. The basic framework has been applied successfully to several sensing scenarios, and this paper focuses on the specific problem of multi-modality sensing of buried land mines [C223]

"Determining the Height of Buried Objects Comparing a 1d Transmission Line Method and a 3d GPR Field Simulation"

Within this contribution two different simulation techniques, namely, a 1d transmission line method and a numerical 3d field simulation of a ground penetrating radar including the antenna structure, the soil and the buried object are compared with respect to the achievable accuracy when the height of different buried objects is to be determined [C224]

"Integrated Autonomous System for Exploration and Navigation in Underground Mines"

This paper describes an autonomous platform for exploration and navigation within networks of tunnels, as those typically found in underground mines and caves. In this context, we propose a system allowing two modes of operation: exploration/surveying mode and autonomous navigation mode. In the exploration mode, a remotely located supervisor instructs the platform to move through successive sections of the network, gathering range data that is then concatenated into 2D/3D survey maps of the environment. In the navigation mode, the supervisor specifies high-level missions on the previously acquired survey maps. A motion planner then translates each mission into a set of consecutive navigation actions, separated by natural landmarks. Mission execution consists of autonomously detecting landmarks, self-localizing and performing the planned navigation actions. Advanced and innovative features, mostly related to exploration capabilities, navigation mode switcher, and the integrated aspect of our system distinguish it from the systems described in the literature [C225]

"Multi-Stage Sensor Fusion for Landmine Detection"

This paper proposes a multi-stage approach for landmine detection. It is based on a feature-level data fusion which combines data from several nonspecific sensors. The sensor fusion process is analysed and divided in three stages in order to improve the final result. During the first stage all suspected objects are detected against a background. Then, the detected objects are classified to be a man-made or natural object. And, finally, the landmines are distinguished among the identified manmade objects. The last two stages are described in detail in this paper, demonstrating the advantages for their separation. Classification features, which enable the sensor fusion, are also presented in this work together with an approach for their integration. The proposed ideas are tested using real experimental data obtained from pulsed and continuous metal detectors, infrared camera and ground penetrating radar [C226]

"Environment-Adaptive Antipersonnel Mine Detection System-Advanced Mine Sweeper"

In this paper, we propose an environment-adaptive antipersonnel mine detection system called Advanced Mine Sweeper. Advanced Mine Sweeper is developed based on sensing technologies, access-control technologies and system integration technologies for safe and effective demining procedure after the Level II survey. Advanced Mine Sweeper consists of a sensing vehicle/unit, an access vehicle, and an assist vehicle. The sensing vehicle/unit is composed of an integrated sensor and a small-reaction sensor head manipulator. The access vehicle is parked facing a mine field in order to control the sensing unit position in a global area using its boom. The assist vehicle is parked keeping some distance from a mine field. It controls the sensing vehicle/unit and access vehicle and then displays the processed sensing information for landmine detection, receiving sensing information and sensing position. By using this system, experiments in the field buried dummy landmines were carried out for the utility and performance evaluation [C227]

"The development of a motion-compensated, vehicle mounted, ultrawideband radar for buried landmine detection"

The performance of a vehicle mounted mine detection radar system, developed by QinetiQ, has recently been enhanced by the inclusion of a position and attitude measurement system, using the combination of a differential GPS receiver and an inertial measurement unit. In this paper we present the development of a motion-compensation scheme based upon data from these sensors. Previous to this development, high quality radar images could only be produced from data gathered on relatively flat and even terrain, where uncompensated antenna motion caused by vehicle attitude changes was minimal. However, the new motion compensation scheme has been shown to successfully track the antenna feed positions to within 1 cm accuracy, thus enabling data collection over far more arduous terrain [C228]

"Research on Simulation and Training System for EOD Robots"

Along with the increasing international development, more and more robots have been used in the war field and antiterrorism, so in regard to the development and application of EOD Robots we proposed the researches on simulation and training system for it. The current EOD Robots' configuration has been analyzed, and due to the training requirement the structure of simulation system was designed and the system's implementation was introduced. Then we specifically analyzed the key technologies in the implementation of our simulation and training system-kinematic model collision detection and grade system, as well discussed them particularly. Now this completed simulation and training system based on the police's requirement had been used in the drill. [C229]

"UWB Array-Based Radar for Landmine Detection"

In this paper, the development of an UWB array-based time-domain radar sensor is described. The radar sensor is designed to be used within a vehicle-mounted multi-sensor system for humanitarian demining. The main

novelty of the radar lies in the modular approach, design of the antenna system and waveform of the transmit antenna feeding pulse. The radar has focusing capability via near-field beamforming in cross-scan direction and migration in along-scan direction [C230]

"Normalization of Feature Distributions for Linear-Quadratic Fusion in Landmine Detection Using GPR"

Successful detection of antipersonnel landmines often requires decision making on the basis of more than one decisive feature. The fusion of the available features should be done in a statistically optimal way. Theoretically this might be achieved by Bayesian-based criteria. However application of Bayes' criteria in general form is computationally difficult and may lead to overtraining of classification algorithms. To avoid this situation linear and quadratic fusion rules are often used in practice. However these rules produce optimal results only when the decisive features are normally distributed, which is not always guaranteed in practice. To improve the performance of the linear and quadratic detectors we suggest a normalization of the decisive features by means of Johnson's transform prior to the fusion. We describe the normalization algorithm and demonstrate that it improves performance of the linear and quadratic classifiers. The performance is judged in terms of the ROC curves [C231]

"Solution to Robotic Landmine Detection Through Use of Path Planning and Motor Control"

Low cost robotic detectors are a promising new approach to combat the disturbing landmine crisis. In this paper a low-cost robotic solution is proposed, we present several control techniques used to improve the precision of the robotic motion. A P and PD controller is applied, and it is concluded that a cascaded control system provides a more stable and accurate response. Two search patterns for landmine detection are considered, rectangular and spiral, these are used to analyse the effectiveness of the control system. [C232]

"Multi-Stage Neural Supporting System for Time Domain Metal Detectors"

In this work we propose an end-user supporting system for humanitarian demining tasks to semi-automatically classify signals of time domain metal detectors. Our multi-stage system consists of a first module to smooth the raw signals, followed by a neural feedforward net to classify the received signal's decay curve of the localized object at each sensor position. The resulting output activities of this net are accumulated to spatial vectors, which are propagated to a second feedforward net. Its resulting output activities are visualized in a 3D-end user interface and may be analyzed by different signal processing routines to be sensitive to changing soils and environmental conditions. [C233]

"Moisture Effects in Soils Using a Frequency Domain Metal Detector"

It is reported by experienced deminers that the existence of moisture in soils complicates the detection of buried land mines. In this work we examine the influence of water in two different sample soil types (sand and clay soil) on the magnetic field induced by a mine surrogate and thus on the quality of the detector's audible signal when using a frequency domain metal detector. The results of our studies prove that with increasing moisture content the amplitude of the received response voltage in both operating frequencies is diminished and that the level of diminution depends on the soil type. To investigate the influence of different soils and moisture levels a comprehensive measurement activity has been accomplished. The received signal data have been smoothed and evaluated statistically. For this purpose firstly the voltage intervals defined by the overall extreme values of the pure soil measurements are evaluated, so the intervals include all inhomogeneities of the ground, and compared with other different test scenarios containing mines. The additional obtained result that the extremal intervals of the wet soils converge to the corresponding intervals of dry soils when desiccating underlines the expected influence of moisture content. As a first try to categorize and differentate mines buried in different depths, soil types and moisture levels, a self organizing feature map to merge and categorize the high-dimensional, complex spatial signal vectors obtained when moving the sensor head over a mine buried in the ground has been trained and applied to the test data. [C234]

"Information-theoretic Sensor Management for Multimodal Sensing"

First Page of the Article [C235]

"A novel avalanche-free single photon detector"

A novel single photon infrared detector is presented that is capable of operating at room temperature in principle. Unlike avalanche, this method produces no excess noise, and can potentially cover wavelengths from UV to mid-infrared [C236]

"Automatic Buried Objects Detection in Different Soils Based on Active Contours"

An efficient approach to detect and to localize buried objects using a continuous wave metal detector in different soils is presented. The algorithm can minimize the distracting influence from the soil and localize the buried objects with better precision. This approach used an external force called virtual electric field, to guide the deformation process to active contours boundaries which correspond exactly to the buried objects with and a computed multichannel gradient applied to the obtained metal detector images. The quality of the results can be significantly improved by employing this approach. This can be very useful for higher level vision processing. [C237]

"Detection and Discrimination of Land Mines based on Edge Histogram Descriptors and Fuzzy K-Nearest Neighbors"

This paper describes an algorithm for land mine detection using sensor data generated by a ground penetrating radar (GPR) system. The GPR produces a 3-D array of intensity values, representing a volume below the surface of the ground. First, a computationally inexpensive pre-screening algorithm is used to focus attention and identify regions with subsurface anomalies. The identified regions of interest are then processed by a feature extraction algorithm to capture their salient features. We use translation invariant features that are based on the local edge distribution of the 3-D GPR signatures. Finally, a fuzzy K-nearest neighbor rule is used to assign a confidence value to distinguish true detections from false alarms. The proposed algorithm is applied to data acquired from three outdoor test sites at different geographic locations. [C238]

"Estimation and Decision Fusion: A Survey"

Data fusion has been applied to a large number of fields and the corresponding applications utilize numerous mathematical tools. This survey limits the scope to some aspects of estimation and decision fusion. In estimation fusion our main focus is on the cross-correlation between local estimates from different sources. On the other hand, the problem of decision fusion is discussed with emphasis on the classifier combining techniques [C239]

"Mine information system for the humanitarian demining"

To be effective in mine clearing action applications it is necessary to organize mine related data/geodata and give operators possibility to work with up-to-date topographic data. Quality control procedures have to be established along with the procedures for data collection. Therefore, the new mine information system has been developed for the Croatian Mine Action Centre using sophisticated geoinformation technology. The basis for this new system was existing data, new captured data and international standards dealing with geographic data and mine related data [C240]

"Ridged Horn Antenna for Ground Penetrating Radar"

In this paper dielectric filling is presented as a simple way of adapting ridged horn antenna for ground penetrating radar (GPR). The requirements for GPR antenna were described to justify the choice of dielectric ridged horn as a simple handheld device aimed to landmines finding. An attempt of detection of the buried metal plate is also shown. [C241]

"Microstrip Antenna For Detecting Buried Land Mines"

Two patch array antennas have been proposed for detection of buried land mines using the mutual coupling effect. Mutual coupling among the edges of a patch or among the edges or nearby patches can influence the performance of microstrip antennas and arrays. The finite-difference time-domain method (FDTD) is used. The patch array antennas (sensor) have been simulated to detect various types of targets (nylon plate, stycast plate, and metal plate targets) in different types of soil properties [C242]

"Intelli ent system for the detection of buried ob ects based on hu-Stu tures usin metal detector"

Hybrid classification structures of buried object in different soils using time domain metal detectors are presented in this paper. This approach consists of self organising memories and backpropagation nets combined with the inter-neural whu-structures, whereby special pre-processing methods like DLS and fitting-methods are used to extract the feature specific items. In this work, an end-user supporting system for humanitarian demining tasks to semiautomatic ally classify signals is also proposed. In addition these structures enable to integrate several aspects of a scene into a mega-concept corresponding to the chunking process of the brain. The categorization of concepts will hereby be done by active whu-structures which become dominant since they sum up the

activities of the involved neurons instead of considering one and only one high-active winner neuron. Using the proposed method, results confirm, that the presence of buried objects in land-mine could be localized and some of them classified [C243]

"Anti-personnel Mine Detection and Classification Using GPR Image"

The automated anti-personnel mine (APM) detection and classification is currently a broad issue. The detection success depends on the feature selection that we obtain from the sensors. Ground penetrating radar (GPR) is one of the established sensors for detecting buried APM. In this paper, we introduce a method which improves the accuracy of detecting APM by using GPR imaging. This method adopts a segmentation technique for feature extraction and neural network as a pattern classifier. A seeded region growing algorithm is applied as region based segmentation for pattern construction following the median filtering and threshold of the original GPR image. A feed forward neural network (FFNN) with backpropagation training is employed for classifying the patterns. The FFNN takes the patterns (APM signature) that are constructed from each salient region and generate the classification. This method significantly improves accuracy in the detection and classification of APM [C244]

"Automatic Land-mine Detection System using Adaptive Sensing with Vector GPR"

Ground penetrating radar (GPR) is a promising sensor for landmine detection, but there are two major problems to overcome. One is the non-planer (e.g. rough and/or undulating) ground surface. It remains irremovable clutters on a sub-surface image output from GPR. Geography adaptive scanning is useful to image objects beneath non-planer ground surface. The other problem is the distance between the antennas of GPR. When imaging the small objects such as an anti-personnel landmine close to antennas, it increases the nonlinearity of the relationship between the time for propagation and the depth of a buried object. In this paper, we modify Kirchhoff migration so as to account for not only the variation of height and pose of the sensor head, but also the antennas alignment of the vector radar. The validity of this method is discussed through application to the signals acquired in experiments [C245]

"Application of Ad-hoc sensor networks for localization in underground mines"

Underground mining is a hazardous industrial activity. The harsh physical environment and distinct topology that make mining dangerous act as a hindrance or constraint to the very techniques and technologies that could improve safety and productivity. Workers safety is of paramount importance and is certainly a moral obligation for any business! Wireless sensor networks monitoring is an application that is very crucial for the safety of mine workers. These sensors can monitor vital life signs of workers which may be very useful during emergency situations. Localization and tracking of moving objects is an essential capacity for a sensor network in many applications. This paper studies the problem of localization in underground mines using ad-hoc sensor networks. We use the DV-hop algorithm to estimate the distance between a mobile node and a fixed anchor and we apply the bounding box technique to estimate the location [C246]

"Bomb Detection in Magnetic Soils: AC versus DC Methods"

We compare the performance of eddy-current metal detectors for finding small bombs and other items of unexploded ordnance (UXO) with the potencial of DC gradiometers of scalar and resonant type. Extensive database of results was collected during laboratory measurements and field trials performed by JRC. There are two main obstacles for bomb detection: false alarms caused by metal clutter and effect of magnetic soil and rocks. A number of soil samples were collected at mine fields and UXO affected areas. Magnetic properties of these soils were examined both in time and frequency domain. The results were compared with the detection depths measured both in soil and in air for various targets. In general, the most difficult soils show frequency dependent susceptibility, which creates signal similar to metal object. We show how to compensate such soils. [C247]

"A Rail-mounted UWB SAR Landmines Detection System --- Rail-GPSAR"

A standoff landmine detection system, rail-GPSAR, was built for the purposes to evaluate feasibility and effectiveness of landmine detection using UWB SAR. The system architecture of rail-GPSAR is introduced firstly, and then some new approaches to RFI/coupling suppression; near-field SAR imaging and detection of the buried landmines are proposed. Finally the detection performance of rail-GPSAR is validated by a series of field experiments [C248]

"A Novel KICA Method for Ground Bounce Removal with GPR"

Nowadays ultra wideband ground penetrating radar (GPR) is widely used in landmine detection. For shallowly buried plastic landmines, the ground bounce is usually much stronger than the weak return from landmines and their arrival time is very close with each other, so ground bounce removal is very important for the following detection, imaging and target recognition. In this paper, kernel independent component analysis (KICA) is first introduced to ground bounce removal with GPR. A novel scheme is proposed for the automatic independent component (IC) selection, which is vital for any ICA based ground bounce removal algorithms. Experimental results based on field-test data show that the proposed method has good performance [C249]

"Novel Ground Bounce Removal Algorithms Based on Non-homogeneous Detector"

In this paper, a non-homogeneous detector (NHD) is developed for ground penetrating radar (GPR) for the first time. The homogeneousness of ground bounce (GB) and the number and position of buried targets (or target-like objects) can be determined by the general likelihood based NHD. Combined with NHD, principal components analysis (PCA) based and blind source extraction (BSE) based methods are also presented for GB removal, which are referred to as NHD-PCA and NHD-BSE algorithm, respectively. For NHD-PCA algorithm, PCA is only taken on target areas to avoid leakage of target signals energy and descend of signal noise ratio (SNR) in target areas. For NHD- BSE algorithm, since the number of targets can be priorly determined by NHD, it has much less number of components to be extracted than that needed by independent component analysis (ICA), therefore less computational load is required. Meanwhile, all sources selection strategies needed by ICA are unnecessary for NHD-BSE because of the known number of extracted sources. The experimental results show the good performance of proposed methods [C250]

"Development of Landmine Detection System Using Scintillators by Measuring Radiations from Landmine"

We are trying to establish a landmine detection system by combining the D-D fusion neutron source. The principle idea of the presently developing system is based on the detection of capture gamma-rays from explosive. We are focusing on the detection of 2.22 MeV and 10.83 MeV capture gamma-rays from hydrogen and nitrogen, respectively, since all explosive contain these elements. To detect 10.83 MeV capture gamma-rays, the main detector is employed a BGO scintillator, which is surrounded by annular shaped NaI(T1) scintillator with a hole of 1' in diameter to facilitate the use of anti-coincidence technique to suppress backgrounds and coincidence technique to detect 511 keV escape gamma-rays. To use anti-coincidence technique and coincidence technique, the dual MCA circuit is employed. To examine the performance of this anti-coincidence technique, a preliminary experiment was carried out by using a 60Co gamma-ray source, and it was found that background level of gamma-rays is suppressed. And to examine the performance of this coincidence technique, melamine was irradiated by 252Cf neutron source, and the counts of 10.83 MeV region was increased by 27% than previous system of NIM modules by using only anticoincidence technique. On the basis of these experimental results, a series of experiments by combining with the D-D neutron source was conducted. It was found that the capture gamma-rays of 10.83 MeV from nitrogen could be detected clearly. [C251]

"Computation of Land Mine Signatures using Domain Decomposition with Lagrange Multipliers"

A good knowledge of the electromagnetic fields of metal detectors which are used for mine detection is mandatory for reducing the false alarm rate, originating in the disqualification of the metal detector to decide whether there is a mine or just another metal object. Therefore the comparison of the measured signal from the detector with the pre-calculated signatures of standard mines was proposed. In order to set up a database of mine signatures it is mandatory to use different resolutions in discretising the typically very small metal parts in land mines, the soil and the detector coil. The latter is about two orders magnitudes larger and apart from the mine. Here, a domain decomposition method with Lagrange multipliers is used [C252]

"Recognition of Buried Objects by Their EM Scattering"

Electromagnetic (EM) scattering is effectively used in the detection of buried objects. However, the most challenging problem is represented by the discrimination of targets and clutters. The electromagnetic signature of known objects is often used to this purpose, but generally it is limited either to the r.m.s. value of the scattered field or to one component. In this work a technique based on the analysis of all the components of the EM field is presented and applied to the detection of landmines [C253]

"Ground Response Tracking for Improved Landmine Detection in Ground Penetrating Radar Data"

Recent advances in ground penetrating radar (GPR) fabrication and signal processing have made high fidelity detection of buried anti-tank landmines a practical possibility under field scenarios. However, detection of

subsurface landmines at a low false alarm rate (FAR) requires the effective removal of the response from the air/ground interface (ground-bounce response). This in turn requires accurate and automatic tracking of the time of arrival of the air/ground interface in time-domain GPR data. Such tracking of the ground bounce response can be difficult to perform under certain conditions including the presence of surface-laid landmines, surface vegetation, snow drifts, and multiple subsurface structures like buried roadbeds. In this work, we will explore the application of a low- latency Kalman filter applied to ground bounce tracking in GPR data and resulting performance improvements for pre-screening algorithms under extreme weather conditions. [C254]

"Real-time detection of mines and explosives by laser-induced breakdown spectroscopy"

A fiber coupled LIBS system is used for detection of mines and explosives. Laser excitation at 1.5 mum is preferred to generate LIBS signals using an Er:glass microchip laser as seed laser for an Yb:Er fiber amplifier. [C255]

"A new approach to detecting vegetation-obscured tripwires"

Tripwire-operated fragmentation mines can be a significant hazard for deminers, especially during vegetation clearance. Several different technologies including thermal, acoustic, and electromagnetic have been evaluated as possible candidates for use in a reliable long- range detector which can find tripwires completely obscured by vegetation. An acoustic method has been proposed to detect non-metallic tripwires. The results of some experimental measurements using this approach are presented. Taut, non-metallic wires can be stimulated acoustically so as to generate a characteristic frequency component which may enable detection. [C256]

"A wavelet approach for the discrimination of buried objects"

The detection of buried objects generally requires the discrimination between targets and clutters through the EM signature of the object. However the signature is generally limited to the magnitude or just to a single component of the field, making the detection problem tremendously difficult, especially when dealing with plastic target. The purpose of the present work is to numerically investigate a new detection system, based on both the magnitude and phase of all the components of the E-field at high frequencies, together with a new wavelet post-processing [C257]

"Sensor Management with Uncertain Performance Characteristics"

Previous work has presented an information-theoretic sensor management framework for the detection of static targets. This framework is based on the expected discrimination gain maximization technique of Kastella. The sensor manager searches for N targets within a grid of cells using M sensors, which may be thought of as a reconfigurable sensor array. Sensor probabilities of detection and false alarm are used in the mathematical structure of the sensor manager, and these probabilities have previously been assumed to be certain. Realistic problems, however, will inevitably involve uncertainty. This paper introduces uncertain sensor Pdand Pfvalues into the mathematical framework and allows for their incorporation into the sequential structure of the sensor manager. The performance of the presented sensor management technique is then compared to direct search, where the sensors sweep through the grid in a predefined sampling pattern. The sensor manager is found to be superior to direct search when the uncertainty present in the problem is properly modeled. When uncertainty is present but not modeled, the performance of the sensor manager is severely degraded. This result indicates that uncertainty modeling will be important and necessary for the successful application of the presented sensor manager to real-world problems. Additional simulations examine the robustness of the sensor manager to errors in the assumed densities for Pdand Pf, and the performance of the sensor manager is found to remain strong even when the assumed Pdand Pfdensities differ from the true densities [C258]

"Custom electronic nose with potential homeland security applications"

First Page of the Article [C259]

"GPR Data Processing Using the Component-Separation Methods PCA and ICA"

First Page of the Article [C260]

"Investigation of GPR configurations by ray-tracing methods"

Methods for locating and identifying buried assets are one focus of a large research project entitled 'mapping the underworld'. As of part of the project we are studying novel configurations for ground penetrating radar (GPR). There are two of important specifications for the GPR configurations: the bandwidth and the dynamic range. In

this paper, the bandwidth and dynamic range of a GPR are investigated through simulations. Media that are typical of street environments were modeled is used in the simulations. A 2D ray-tracing model is used to simulate propagation in the ground to identify signal levels, bandwidths and dynamic ranges. A novel In-Pipe deployment and a conventional deployment scheme for GPR are examined using ray-tracing. Comparison of the results shows that the In-Pipe deployment scheme for the GPR has immediate advantages over the conventional one, in terms of having a wider available bandwidth and therefore resolution, and in having a lower dynamic range requirement. [C261]

"Hip Prosthesis Detection based on Complex Natural Resonances"

Resonance based radar target detection has been applied to ground penetrating radar (GPR) applications for the detection and recognition of landmines. Target detection is achieved by searching for certain target dependent complex natural resonances (CNRs), which could be considered as a feature set for identification. In this paper, detection of a hip prosthesis under human tissues using resonance based target detection technique is investigated [C262]

"Classifying dielectric mine-like objects using the Huynen-Fork polarization parameters"

We present a polarimetric approach that can be used to characterize subsurface targets by means of ground-penetrating radar. Several quantities related to the Huynen-Fork parameters are basic to the study. These quantities are all expressible in terms of the elements of Sinclair matrix S, which in turn, can be determined as functions of frequency by an application of the method-of-moment (MoM). The method is applied to a mine-like object buried at various depths in a soil of specified dielectric and moisture properties. The quantities in question are the Stokes parameters, the elevation, azimuth, and polarizability angles, as well as the polarization ratios and the scattering eigenvalues which optimize the backscattered power. Some of these quantities are studied here and displayed in various graphs. These frequency dependent graphs exhibit useful symmetry properties. The plots of the polarizability angle (β) vs. frequency seem to remain invariant with target depth, and exhibit resonance features that are later shown to agree well with other standard methods to estimate resonances such as Prony method. A simple analysis of the early-time resonances thus estimated is used to obtain acceptable mine dimensions. The agreement found implies that polarimetric techniques, such as present one, can also be used in the arsenal of techniques yielding target-ID clues. [C263]

"Optimal Experiments With Seismic Sensors"

In this paper, we consider the problem of detecting and locating buried land mines and subsurface objects by using seismic waves. We demonstrate an adaptive seismic system that maneuvers an array of receivers, according to an optimal positioning algorithm based on the theory of optimal experiments, to minimize the number of distinct measurements to localize the mine. The adaptive localization algorithm is tested using numerical model data as well as laboratory measurements performed in a facility at Georgia Tech. It is envisioned that the future systems should be able to incorporate this new method into portable mobile mine-location systems [C264]

"Multi-Channel Detection of Narcotics and Explosives using NQR Signals"

A multi-channel detector for narcotics and explosives using nuclear quadrupole resonance (NQR) is developed. Multiple measurement coils are used to estimate the radio frequency interference that is often present. The temperature dependency of the NQR frequencies is incorporated in the detector, allowing for uncertainties in the temperature estimate of the sample. In addition, the detector considers only the frequency bands of the signal of interest [C265]

"Imaging and Detector Framework for Seismic Landmine Detection"

In this paper, we consider the problem of detecting and locating buried landmines and subsurface objects by using seismic waves measured with sources and receivers on the surface. An imaging algorithm is proposed which uses the separated forward and reflected waves obtained via a Prony-based spectrum analysis technique. The imaging algorithm is followed by an energy detector. The resulting algorithms will are verified by using the experimental data containing mines and clutter [C266]

"Locating Subsurface Targets Using Minimal GPR Measurements"

This paper describes a novel approach which finds probable target areas in ground penetrating radars (GPR) with minimal number of measurements. A subsurface GPR target creates a hyperbolic signature in the space-time domain. Conventional algorithms use these signatures to image and detect subsurface targets. Our

approach uses the time delay differences (TDD) in consecutive GPR A-Scan measurements to localize the target. For further reduction of measurement numbers regions of low target probability are determined to eliminate redundant measurements. Results from the experimental data from a model mine field show that the target positions can be found accurately using much fewer measurements than the conventional imaging algorithms [C267]

"A SAR-Based Algorithm for Imaging of Landmines with GPR"

First Page of the Article [C268]

"Towards landmine detection using artificial vision"

One of the main needs for the humanitarian demining procedures in Colombia and in the whole world is to find complementary sensing methods for the metal detectors. This paper presents a study whose main goal is the development of a complementary sensor for a metal detector, based on the analysis of images taken by an on-board camera. The images are processed by developing texture and color analysis of different types of surfaces, composed mainly by grass or small rocks. Based on the color and texture analysis, this paper shows that it is possible to determine the presence of a non-metallic landmine within the image. This is achieved by finding the image regions whose texture features variations and color compositions are considered to be anomalous. It is thought that the texture variations over the image are an indicator that the surface has been intentionally modified. This image processing strategy is being integrated on the robot 'Ursula', designed at Universidad Javeriana in Colombia. [C269]

"Reducing the number of mobile sensors for coverage tasks"

Mobile robots provide new opportunities for research in environment sensing. By combining sensors and robots, we can develop applications to enhance security, search and rescue, and detect hazardous materials. One important problem is to use fewer mobile sensors to cover an area. This paper focuses on two problems in robot sensor deployment: speed management and detouring distance under energy and timing constraints. We determine the robots' traveling speed based on the remaining energy and remaining time before deadline. We use probabilistic models for environments with obstacles and propose an empirical analysis to estimate the extra traveling distance due to detouring. We compute the number of robots (fleet size) needed for cover an area and our approach reduces the fleet size. Compared with two simple heuristics, our method uses 21% fewer robots. [C270]

"3D ground adaptive synthetic aperture radar for landmine detection"

In this paper, we propose a new algorithm which shows a buried landmine clearly in an underground image captured by a ground penetrating radar (GPR). By using GPR, we could extract the buried object signals from a raw underground data of GPR. In addition, we could create a high resolution underground image which focuses on buried objects. The extraction of buried object signals from raw GPR data is achieved by using two methods which are a feature extraction processing method of underground image and a ground adaptive manipulation method which manipulates the sensor head of GPR along a ground surface. Moreover, we propose novel synthetic aperture radar processing, which could be applied to an uneven ground surface of a minefield, for detecting the landmine clearly. The high resolution underground image is obtained by the proposed synthetic aperture radar processing which is referred to as ground adaptive synthetic aperture radar algorithm. We developed a landmine detection robot, in which the proposed methods were implemented. To evaluate the proposed methods, experiments concerning landmine detection are done and experimental results illustrate the validity of the system. [C271]

"Efficient mapping through exploitation of spatial dependencies"

Occupancy grid mapping algorithms assume that grid block values are independently distributed. However, most environments of interest contain spatial patterns that are better characterized by models that capture dependencies among grid blocks. To account for such dependencies, we model the environment as a pairwise Markov random field. We specify a belief propagation-based mapping algorithm that takes these dependencies into account when estimating a map. To demonstrate the potential benefits of this approach, we simulate a simple multi-robot minefield mapping scenario. Minefields contain spatial dependencies since some landmine configurations are more likely than others, and since clutter, which causes false alarms, can be concentrated in certain regions and completely absent in others. Our belief propagation-based approach outperforms conventional occupancy grid mapping algorithms in the sense that better maps can be obtained with significantly fewer robot measurements. The belief propagation algorithm requires a modest amount of increased computation, but we contend that in applications where significant energy and time expenditure is associated

with robot movement and active sensing, the reduction in the required number of samples justified the increased computation. [C272]

"Sensor networks deployment using flip-based sensors"

In this paper, we study the issue of mobility based sensor networks deployment. The distinguishing feature of our work is that the sensors in our model have limited mobilities. More specifically, the mobility in the sensors we consider is restricted to a flip, where the distance of the flip is bounded. Given an initial deployment of sensors in a field, our problem is to determine a movement plan for the sensors in order to maximize the sensor network coverage, and minimize the number of flips. We propose a minimum-cost maximum-flow based solution to this problem. We prove that our solution optimizes both the coverage and the number of flips. We also study the sensitivity of coverage and the number of flips to flip distance under different initial deployment distributions of sensors. We observe that increased flip distance achieves better coverage, and reduces the number of flips required per unit increase in coverage. However, such improvements are constrained by initial deployment distributions of sensors, due to the limitations on sensor mobility [C273]

"Bistatic GPR by using an optical electric field sensor"

In order to apply to land mine detection effectively, bistatic GPR using an optical electric field sensor as a receiver has been developed. The optical electric field sensor is very small and uses optical fiber instead of metallic coaxial cable. With the combination of these advantages and the bistatic radar system, it can be possible for an operator to measure quite flexible and safely. The sensor has been tested in stepped frequency radar system with frequency which consists of a vector network analyzer, a fixed double ridged horn antenna as transmitter and computer controlled receiver-positioner for 2D scanning. For considering effectiveness in real field, we applied impulse radar system, which consist of a digital oscilloscope and an impulse generator to produce the impulse with 250 psec pulse width and the diffraction stacking has been adopted for 3D image reconstruction. Detection of a PMN2 mine model was carried out by the impulse radar system at a sand pit with two modes of data acquisition: the stepped data acquisition and the continuous data acquisition. The PMN2 were detected clearly with sufficiently high resolution in TM mode measurement in both modes, the target contrast was almost the same while the scanning time decreased down to 1/18, 9 min/m2 in case of continuous data acquisition mode which satisfies the requirement for practical use. [C274]

"Temporal analysis for land mine detection"

In this paper the FOI temporal analysis method is presented and tested on images randomly chosen from a diurnal sequence. The method integrates data collection, both sensor images and weather, as well as modelling, with the signal processing detection methods. The detection methods presented show that mines can be detected using optical methods, even when the image sequence show very little contrast. Increasing the number of data collection times affects the detection rate and false alarm rate in a positive way. The result from the test with randomly chosen images show performance better than random for all of the tested cases, excellent for some cases. Using prior knowledge in the choice of time of data collection, the result from testing the method on real mine field data shows interesting result. [C275]

"GPR signals de-noising by using wavelet networks"

The de-noising issue of ground-penetrating radar (GPR) signal is essential GPR's performance on detecting subsurface objects. This paper introduces a wavelet neural networks (WNN) based GPR signal de-noising algorithm. WNNs own the property of time-frequency localization of wavelet transform, as well as the excellent characteristics of artificial neural networks, self-learning and fault-tolerance, which make it a powerful tool for removing noises from noisy ground-penetration radar signals. Experimental results show that the proposed WNN based de-noising algorithm can achieve good de-noising performance and hold the useful detail of GPR signals. [C276]

"Landmine imaging by a hand-held GPR and metal detector sensor (ALIS)"

We are developing a new landmine detection system, namely advanced landmine imaging system (ALIS), which is equipped with metal detector (MD) and ground penetrating radar (GPR). Despite it is a hand-held system, we can record the MD and GPR signals together with the sensor position information acquired by CCD camera. Therefore, MD image and GPR image can be obtained after signal processing. Since ALIS is a hand-held system, the sensor position is random when it is operated in the field. So interpolation processing is needed to provide a gridded data set for both MD and GPR. A good MD image can be achieved after interpolation. Also, interpolation can prepare the gridded data set for migration. 3D Kirchhoff migration is used to enhance the signal-clutter ratio for effective image reconstruction. The ALIS was tested in Afghanistan in December 2004 and

showed a good performance. In particular, the GPR could obtain a good image of anti-personnel (AP) mine buried at more than 20 cm depth. Also images from both sensors could be combined to distinguish a mine from a metal fragment. [C277]

"Enhanced detection and classification of buried mines with an UWB multistatic GPR"

We present a resonance-based classification technique for the identification of plastic-cased antipersonnel (AP) land mines buried in lossy and dispersive soils under rough surfaces by a stepped-frequency ultra-wideband (UWB) downward-looking ground penetrating radar (GPR) with an array of receivers. For this application the multistatic ground probing sensor is positioned just above the ground surface and operates from UHF to C-band frequencies. Novel physics-based models based on the finite difference frequency domain (FDFD) technique simulate the characteristic resonating multi-aspect target frequency responses for several realistic buried land mine detection scenarios. Matched filter detection results are presented which assess the GPR's performance in identifying a simulated mine buried under a rough surface at varying depths in dry sand and a dispersive clay loam soil and distinguishing them from false targets such as buried rocks. [C278]

"On the use of energy density spectra for discriminating between landmines and clutter objects"

The paper studies the use of energy density spectra (EDS) derived from ground penetrating radar (GPR) measurements on a sub-surface target to discriminate between landmines and clutter objects. The GPR used to collect the data is frequency swept and has a bandwidth of 1.4 GHz. Our investigation indicates that the EDS reveals distinct characteristics between landmine targets and many clutter objects, and hence can be exploited for their discrimination. Experimental results based on data measured at a government test site corroborate the effectiveness of the proposed approach. [C279]

"Handheld GPR and MD sensor for landmine detection"

A novel landmine detection sensor system, called ALIS (advanced landmine imaging system), which combines a metal detector and GPR, has been developed. This is a handheld equipment, which has a sensor position tracking system, and the sensor output can be visualized in real time on a head-mounted PC display. A field evaluation test of ALIS was conducted in Afghanistan, and we demonstrated that it can detect buried antipersonnel landmines, and can also discriminate metal fragments from landmines. [C280]

"Special GPR antenna developments for landmine and UXO surveys"

Ground penetrating radar (GPR) is a promising technique for detecting and identifying buried landmines and UXOs. The antenna plays a critical role in determining the performance for tasks and requires to have a broad bandwidth, minimal ground dependency, fast or no antenna ring-down, desirable polarization and pattern characteristics. Three unique UWB dual-polarization GPR antenna designs are discussed. A dielectric rod antenna, covering from 1 GHz to 6 GHz, is suitable for shallow (less than 12 inches) targets, such as landmine detection/identification. The other two antennas, covering frequencies from 20 MHz to 800 MHz, are suitable for general GPR applications, such as the detections of pipes, utility lines, UXOs, AT mines, etc. [C281]

"Detection of buried objects such as landmines using a forward impulse radiating antenna (IRA)"

A novel forward impulse radiating antenna (IRA) is presented. The design of this antenna has been optimized for the detection of buried objects using the 3D field simulator Microwave Studio (MWS). The antenna yields images of subsurface objects with outstanding resolution when an appropriate calibration technique is applied. This technique locates the reference plane inside the ground and therefore allows the air-ground reflection and antenna mismatch and losses to be removed. A prototype of the new forward impulse radiating antenna has already been constructed and preliminary experimental results are presented. [C282]

"Indiscernibility criterion based on rough sets in feature selection and detection of landmines"

Metal detectors currently used by the teams engaged in decontamination of mines, cannot differentiate a mine from metallic debris where the soil contains large quantities of metal scraps and cartridge cases. Landmines are a significant barrier to financial, economic and social development in various parts of this world, so a sensor is required that reliably confirms that the ground being tested does not contain an explosive device, with almost perfect reliability. Human experts are unable to give belief and plausibility to the rules devised from the huge databases. Rough sets can be applied to classify the landmine data because here any prior knowledge of rules is not required, these rules are automatically discovered from the database. Finally, the whole database is divided into mutually exclusive elementary sets. The rough logic classifier uses lower and upper approximations for determining the class of the objects. The paper aims to induce low-dimensionality rule sets from historical

descriptions of domain features which are often of high dimensionality. Moreover, algorithms based on the rough set theory are particularly suited for parallel processing. [C283]

"A simple low cost vision system for small unmanned VTOL vehicles"

Alternative designs of a simple, low cost, effective vision system suitable for small, portable, unmanned vertical take off and landing (VTOL) vehicle based surveillance and landmark recognition are presented. Designs depend mainly on two critical constraints: aerial vehicle payload limitations and power supply limitations; both constraints affect on-board vision system configuration, processing power and flexibility. Hardware and software components are described for both designs. Advantages and disadvantages of both alternatives are compared and an implementation of the chosen system is presented along with experimental results. [C284]

"GPR migration algorithm for landmines buried in inhomogeneous soil"

Accident caused by antipersonnel (AP) landmines remaining from past conflicts have received considerable public exposure in the last several years. Detection of minimum-metal or plastic landmines by conventional metal detectors in a difficult and challenging task. Ground penetrating radar (GPR) can be an effective subsurface imaging tool for solution to landmine detection, because it can detect both the metal and nonmetal objects based on the dielectric properties. However, the detection of buried landmines by GPR normally suffers from very strong clutter that would decrease the signal-clutter ratio and deform the image of the landmine in GPR data. For enhancement of the signal-clutter ratio and improvement of the image quality, we developed a stepped-frequency continuous-wave array antenna ground penetrating radar system, called SAR-GPR. The system can acquire CMP data instead of generic common-offset data. Some data processing techniques have been in use to process CMP data, including velocity analysis, CMP stacking and migration. Also vertical variable velocity model is estimated and applied to normal moveout correction (NMO) and Kirchhoff migration [C285]

"Surface effects on ground penetrating radar imagery"

Ground penetrating radar (GPR) is emerging as viable technology for rapid and accurate landmine detection. Although GPR has been successfully used for land mine and subsurface object detection, the performance of GPR is affected by surface roughness of the soil medium. There have been theoretical studies showing that surface roughness degrades GPR performance, but few empirical studies have been performed. In this paper, we report on an empirical study of the effect of rough, flattened, and smooth surfaces on GPR images of an easily understood target. [C286]

"A validated method to help area reduction in mine action with remote sensing data"

We present here a method to use remote sensing and GIS to help the task of area reduction in mine action. The goal is to synthesize all relevant information in thematic maps, called danger maps, that can be used as basis for area reduction. The information presented in the maps can be extracted from the remote sensing data, coming from the mine action centre mine information system (MIS) or be added after discussion with experts. The blind tests performed on mine-suspected areas in Croatia have shown that the method had a reduction rate of 26% and an error rate of 0.1%. [C287]

"Rough logic for building a landmine classifier"

Landmines are significant barriers to financial, economic and social development in various parts of this world. Metal detectors currently used by teams engaged in the decontamination of mines cannot differentiate a mine from metallic debris where the soil contains large quantities of metal scraps and cartridge cases. So what is required is a sensor that will reliably confirm that the ground being tested does not contain an explosive device with almost perfect reliability. The various sensors provide different attributes about the nature of the soil. Even human experts are unable to give belief and plausibility to their rules. Thus the conventional Dempster-Shafer theory cannot be applied to build an expert system. Thus rough sets are applied to classify the landmine data because here, any prior knowledge of rules is not needed; these rules are automatically discovered from the database. For the application of rough set theory, first, approximation space is to be identified. This can be done by a human expert, otherwise, principal component analysis can be used. In fact the problem of identifying application space is similar to that of identifying redundant attributes (which carry no useful information for the purpose of classification) and throwing them away. It is observed that aspect ratio, blob size, and grayscale are important features for landmine classification. Now, all data tuples which agree on all task relevant attributes, form one elementary set. Thus the whole of the database is divided into mutually exclusive elementary sets. As no crisp rules exist for classification, this essentially implies the decision sets (the sets formed by the presence or absence of landmines) are not definable (cannot be expressed as union or intersection of elementary sets). Thus lower and upper approximations of the decision sets are taken and the boundary set is found. [C288]

"A droplet-based lab-on-a-chip for colorimetric detection of nitroaromatic explosives"

Portable and automated field screening equipment would be very effective in detecting and quantifying explosives at various sites. A droplet-based microfluidic lab-on-a-chip utilizing electrowetting is presented for the colorimetric detection of TNT (trinitrotoluene). The method uses the reaction between nitroaromatics and a strong base which forms the highly colored Jackson-Meisenheimer complex. Microliter-sized droplets of TNT are programmed to transport, mix, and react with potassium hydroxide (KOH) on the microfluidic chip. Colorimetric reactions of TNT are characterized both on a spectrophotometer and on the microfluidic chip. The detection of TNT on the chip is linear in the range of 4-20 μg/mL with a time-to-result of 2.5 minutes. It is also observed that the absorbance peaks of DNT (dinitrotoluene) and TNT are mutually independent and that the presence of DNT does not affect the detection of TNT. Electrowetting also does not seem to influence the colorimetric complex as observed from a comparison of results between a spectrophotometer and on-chip. [C289]

"Affordable gpr technology"

{no data available} [C290]

"International Scientific Review Panel"

{no data available} [C291]

"Adaptive change detection in coherent and noncoherent SAR imagery"

This paper is concerned with change detection in averaged multi-look SAR imagery. Averaged multi-look SAR images are preferable to full aperture SAR reconstructions when the imaging algorithm is approximation based (e.g., polar format processing), or motion data are not accurate over a long full aperture. We study the application of a SAR change detection method, known as signal subspace processing, that is based on the principles of 2D adaptive filtering (M. Soumekh, January 1999) and we use it to recognize the addition of surface landmines to a particular area under surveillance. We identify the change detection problem as a trinary hypotheses testing problem, and identify a change signal and its normalized version to determine whether there is i) no change in the imaged scene; ii) a target has entered the imaged scene; or iii) a target has exited the imaged scene. A statistical analysis of the error signal is provided to show its properties and merits. Results are provided with a realistic X band SAR platform using averaged noncoherent multi-look and coherent single-look SAR imagery. [C292]

"Exploiting temperature dependency in the detection of NQR signals [Cland mine detection applications]"

Nuclear quadrupole resonance (NQR) offers an unequivocal method of detecting and identifying land mines. Unfortunately, the practical use of NQR is restricted by the low signal to noise ratio (SNR), and means to improve the SNR are vital to enable a rapid, reliable and convenient system. In this paper, we develop a non-linear least squares detector exploiting the temperature dependency of the NQR frequencies as a way to enhance the SNR. Numerical simulations on both synthetic and real measured data indicate an excellent performance of the method. [C293]

"Detection of a reflective layer in a random layered medium using time reversal [Cacoustic measurement method]"

We propose a method of detecting a reflective layer in a layered random medium using the time reversal of an acoustic wave. Comparing the refocused signal with the original probing pulse enables us to detect a change it the medium's acoustic properties. The depth of the reflector is pinpointed even in the absence of a direct coherent reflection. We present experimental results validating the proposed algorithm. [C294]

"Imaging of subsurface targets using a 3D quadtree algorithm"

The imaging of subsurface targets using ground penetrating radar (GPR) is becoming an increasingly important area of research. Conventional image formation techniques expend large amounts of computation to resolve a region fully, even a region of clutter. However, by using multi-resolution techniques, e.g, quadtree algorithms, potential targets and clutter can be discriminated in a computationally efficient way. Prior work has focused on the development of 2D quadtree algorithms for surface targets. For mine detection, target depth adds another dimension; thus, we have developed a 3D quadtree algorithm, and applied a multi-stage detector that uses the energy change between quadtree stages to discriminate target and clutter regions. This algorithm is then tested

on computer-generated data, as well as experimental data collected from a model mine field. Results show that target location information can be obtained even under near field and small aperture conditions. [C295]

"Near field imaging of subsurface targets using wide-band multi-static RELAX/CLEAN algorithms"

The paper presents two new imaging algorithms for detecting the positions of subsurface targets, e.g., land mines, using seismic waves. They are based on the CLEAN algorithm and its high resolution version RELAX. The paper shows how the CLEAN and RELAX algorithms can be modified to work in a multi-static active array setup for detecting passive targets. Seismic surface waves reflected from various targets are collected at a receiving array and processed to locate the reflectors. The modified imaging algorithms are demonstrated to work for experimental seismic data that include mines and rocks (clutter). [C296]

"Multiresolution analysis of SAS images"

Detection and classification of underwater mines with Synthetic Aperture Sonar (SAS) images is a challenge that can be performed in studying either the echoes or the shadows of mines. However, SAS images present a strong speckle level due to the construction of the image itself. To reduce this speckle level, filtering methods are generally used but all of them strongly deteriorate either the shadow or the echo of the mine. In this article, we propose a new speckle reduction method which allows enhancing jointly mines echoes and shadows. This new process is based on the marriage between a multiresolution transformation and a filtering method. Results obtained on real SAS data are presented and compared with those obtained using classical processing. [C297]

"Motion control of soil removing operation for teleoperation based demining system"

{no data available} [C298]

"FPGA finite difference time domain solver for thermal simulation"

The use of infrared (IR) images of the soil is an efficient technique to detect shallowly buried landmines. The detection is possible due to the different thermal properties of the soil and the mine. The core of this technique is the simulation of the heat transfer processes in the soil and at the soil-air interface. Simulation of these processes is a very long-time consuming task on ordinary computers. Its execution on dedicated hardware can reduce the computing time. In this paper we show the architecture of a system that simulates the thermal processes onto an FPGA, showing the feasibility of such a realization. [C299]

"New concepts in mine warfare"

With the advent of remote and unmanned vehicles, the mine warfare operations have to be reconsidered. In order to complete the remote mine reconnaissance performed with unmanned vehicles such as SEAKEEPER, DCN proposes a new concept for identification and neutralisation operations. Based on the introduction of the GPS-based long range underwater positioning systems adapted to robotics solutions, these missions could be conducted from a non dedicated ship without any specific requirement neither for low signature nor for shock resistance. Thus, DCN offers a whole mine warfare solution with costs well below the level of classical MCM vessel. [C300]

"Development of electrode polarization controlling sensor for aromatic nitro compounds"

A sensitive landmine detection method with easy operation is demanded, however, sensors satisfied both sensitivity and ease have not been developed yet. The purpose of this study is to develop the high-sensitive chemical sensor that can easily and quickly identify the explosive molecules leaking from landmines. It is conceivable that such technology could be applied to a sensor for security. In this paper, we describe a sensor using a surface polarization controlling method. We improved specificity and sensitivity to aromatic nitro compounds by introducing the modified electrode with Lewis base that has the charge-transfer interaction with aromatic nitro compounds. Furthermore, the modified electrode could be characterized with fluorescence spectroscopy. [C301]

"Background subtraction in the frequency domain for focusing ground-penetrating radar data"

{no data available} [C302]

"Wavelet packets for GPR detection of non-metallic anti-personnel land mines based on higher-order-statistic"

{no data available} [C303]

"Hand-held operational demining system"

The paper presents selected results from theoretical and experimental investigations concerned with radar backscattering from typical antipersonnel land mines (APL) in the frequency range of about 200 MHz to 8 GHz in order to improve the conventional metal detector demining technology presently still widely in use. [C304]

"Clutter reduction and detection of landmine objects in ground penetrating radar data using singular value decomposition (SVD)"

{no data available} [C305]

"Mars Exploration Rover surface operations: driving opportunity at Meridiani Planum"

On January 24, 2004, the Mars Exploration Rover named Opportunity successfully landed in the region of Mars known as Meridiani Planum, a vast plain dotted with craters where orbiting spacecraft had detected the signatures of minerals believed to have formed in liquid water. The first pictures back from Opportunity revealed that the rover had landed in a crater roughly 20 meters in diameter-the only sizeable crater within hundreds of meters-which became known as Eagle Crater. And in the walls of this crater just meters away was the bedrock MER scientists had been hoping to find, which would ultimately prove that this region of Mars did indeed have a watery past. Opportunity explored Eagle Crater for almost two months, then drove more than 700 meters in one month to its next destination, the much larger Endurance Crater. After surveying the outside of Endurance Crater, Opportunity drove into the crater and meticulously studied it for six months. Then it went to examine the heat shield that had protected Opportunity during its descent through the Martian atmosphere. More than a year since landing, Opportunity is still going strong and is currently en route to Victoria Crater-more than six kilometers from Endurance Crater. Opportunity has driven more than four kilometers, examined more than eighty patches of rock and soil with instruments on the robotic arm, excavated four trenches for subsurface sampling, and sent back well over thirty thousand images of Mars-ranging from grand panoramas to up close microscopic views. This paper details the experience of driving Opportunity through this alien landscape from the point of view of the Rover Planners, the people who tell the rover where to drive and how to use its robotic arm. [C306]

"Simulation-based Performance Modeling for War Fighter in Loop Minefield Detection System"

There has been significant recent interest in airborne reconnaissance for target detection using high resolution airborne images collected from an unmanned aerial vehicle (UAV). Even if automatic target recognition (ATR) algorithms are able to produce satisfactory results in terms of probability of detection for certain false alarm rate, there is a need for a warfighter-in-the-loop (WIL) to reduce false alarms further and verify and validate detections to attain the operational performance requirements. We develop a simulation model to assess effectiveness of the warfighter in decision loop for airborne minefield detection. The war-fighter effectiveness is measured in terms of average waiting-time, number of minefield segments in queue, and the expected false alarms, and missed detection. Various parameters which potentially affect the warfighter performance were identified with the help of prior studies with human operator in laboratory settings. Simulation trials were conducted to evaluate the dependence of these parameters on warfighter performance [C307]

"NRC: A Neuro-Rough Classifier for Landmine Detection"

Landmines are a significant barrier to financial, economic and social development in various parts of the world. The demand for dependable, trustworthy intelligent diagnostic systems in the field of landmine detection has been increasing rapidly. Metal detectors used in mine-decontamination, cannot differentiate a mine from metallic debris where the soil contains large quantities of metal scraps and cartridge cases, so a device is required that will reliably confirm that the ground being tested does not contain an explosive device, with almost perfect reliability. Human experts are unable to give belief and plausibility to the rules devised from the huge databases. In this paper a hybrid classifier has been developed that uses rough sets theory and neural networks architecture to classify mines from the non-mines with better results. Rough sets have been applied to classify the landmine data because in this theory no prior knowledge of rules are needed, these rules are automatically discovered from the database. The rough logic classifier uses lower and upper approximations for determining the class of the objects. The neural network is used for training the data, and has been used especially to avoid the boundary rules given by the rough sets that do not classify the data with cent percentage probability. Moreover, the algorithms based on the rough set theory are particularly suited for parallel processing architecture. [C308]

"RF Controlled GPS Based Hovering Mine Detector"

In normal practice, the traditional method used for the detection of mines is by sending a human being into the minefield that carries with him the mine detector. Keeping in view the importance of human life, machines can be used to detect the mines, thus minimizing the casualty rate to zero percent. Due to the advancement in satellite receiver tracking systems, an integrated system employing latest tracking techniques using satellite receiver in the form of GPS integrated with an aerospace vehicle can be used to detect the exact location of mine in the mine field. Radio frequency transmitter controls the aerospace vehicle. The idea of detecting mines by integrating the above-mentioned technologies is implemented on a hovercraft using Global Positioning System as a tracking tool [C309]

"Virtual elastic wall based motion control for teleoperated demining system"

In this paper we proposed a new bilateral teleoperation based soil removing technique for demining system which is supported by geometric virtual wall concept. The virtual wall model was reflected to bilateral telemanipulation system to restrict a motion of the slave manipulator beyond the geometrical virtual wall. The algorithm was experimentally applied to a bilateral telemanipulation system. The experimental results showed that virtual wall can guarantee a generation of smooth surface and dig out the soil without applying too much force to the suspected object in a laboratory environment. [C310]

"Unmanned helicopters applied to humanitarian demining"

This article covers research work about unmanned helicopters that is being developed by the Portuguese SME Introsys, S.A. in the context of a generic project targeting the development of a multi-robot system for landmine detection. As helicopters are complex multivariable nonlinear underactuated systems with strong coupling in some control loops, they are an interesting subject of research for the control and robotic research communities. Therefore, a wide range of techniques have been proposed in the literature to control such vehicles, ranging from classic control to soft-computing methods. The main goal for this article is to present a survey about existing low level control architectures for unmanned helicopters and to discuss which control design criteria (design requirements) are relevant when they are operating in the context of humanitarian demining [C311]

"A multi-robot system for landmine detection"

This paper describes the development of a multi-robot system for area reduction in humanitarian demining. In spite of the specific requirements imposed to the work being carried out by the humanitarian demining domain, the results being achieved can also be used in other domains such as surveillance and remote monitoring. A multi-agent based architecture is responsible for coordinating a progressive stochastic analysis of the terrain. The all-terrain navigation used by the mobile robots is attained by a novel embodied reactive obstacle avoidance method. A control mission software has been developed to plan, configure and supervise the operations. Highly compliant legged and wheeled platforms have been developed accomplishing low-cost all-terrain robots. Digital signal processing algorithms have been applied for landmine detection using the payload sensors [C312]

"Automated selection of fusion parameters through a segmentation of multi-sensor ROC curves"

This research builds upon a mathematically proven optimal decision fusion technique exploiting the Neyman-Pearson (N-P) test. The algorithm requires three parameters for each sensor input, so the number of fusion parameters increases linearly. A new method presented in this paper, relies on two meaningful external parameters defined by an operator. They trigger an automated selection of the remaining internal parameters for all sensory inputs. The outcome is a set of quasi-optimal parameters. The method exploits a segmentation and alignment of individual ROC curves into similar regions of compatible confidence levels. Experimental results are shown for synthetic test data and real-world mine hunting data. This new method allows for an automated dynamic integration of system components into a system, gives consistently better performance, and requires two parameters only regardless of the number of sensor inputs. [C313]

"Information architecture for sensor and mobile robotic systems facing the humanitarian demining problem"

The development of a robotics system not only depends on the technical aspects and modular components allowing the correct design of the remote controlled platforms(s); the application related constraints have also to be carefully analysed in order to achieve the success of the whole system. The constraints related to the humanitarian demining, and more generally to outdoor applications, may be summarised as follows: a high level of protection against the environmental conditions (dust, humidity, temperature, etc), protection and resistance against vibration and mechanical shocks, long and continuous operation time between battery charging/changing or refuelling, wireless communication range depending on the terrain and minefield location, low cost, affordable

prices by use of off-the-shelf components (typical constraint for HUDEM due to the lack of a real commercial market), high reliability, fail-safeness, easy maintenance, easy to use, application of matured technology [C314]

"Alternating-sign windowed energy projection of SAR focused GPR data"

The automated detection of plastic-cased antipersonnel landmines in 3D high-resolution UWB radar images is considered. The 3D images are projected in different ways onto 2D confidence maps, in which the automated APM detection is made by marking local maxima in the maps followed by thresholding. Specifically, we consider the confidence maps of the following types: energy projection (EP), windowed energy projection (WEP) and introduced here alternating sign windowed energy projection (ASWEP). The latter is shown to allow diminishing of the false alarms number in comparison for the other two techniques for most of the considered cases. The advantages of the new technique are described by means of receiver operator curves (ROC). The ROC curves are built for the datasets acquired over several minefield simulation sites under different environmental conditions. [C315]

"Compact High-Voltage Picosecond Generator Used as Pulsar Transient Radar Source"

This article relates to the development of a fast compact pulse generator used as the generation system of an ultra wideband radar device called PULSAR for the French Technical Centre for Armament Electronics (CELAR) [1]. The design, the fabrication and the experimental results of a short pulse generation system are presented in this paper. This system, developed by the LGE (Laboratoire de Genie Electrique), deals with the association of a pulsed source to a coaxial generator in order to realise a peaking circuit. This generation system is able to generate pulses with 25 kV amplitude and 70 ps rise-time through a 50 Omega impedance. It is associated to a radiating structure. So, the IRCOM (Research Institute of Microwave and Optical Communications) has developed a new radiation device (antenna and balun made by Europulse company Cressensac, Lot, France). The antenna, called Dragonfly antenna [2], is able to support high peak voltage (25 kV) and has a very large bandwidth (300 MHz to 3 GHz) as well as a high gain along the axis (up to 12 dB). Main results concerning the new generator associated to the antenna are presented in this paper. [C316]

"Passive remote sensing of a buried object using a 29.9 GHz radiometer"

The use of the radiometer in the passive remote sensing is a very much-established fact now. The present paper explores the possibility of the use of radiometer as a tool to detect a metallic mine. A radiometer tuned to the frequency of 29.9 GHz has been used for the purpose. The experiments were conducted aiming at detecting a mine buried under soil and under plastic envelope. The results in the form of response curve show the ability of the radiometer to detect the metallic mine buried under soil and a plastic envelope. Further experiments have also been conducted to study the temperature variation of the response The results can be used to develop an algorithm for the detection of mine using radiometer. [C317]

"Effect of the data pre-processing on GPR mine detector performance"

The performance of GPR as an anti-personal mine (APM) detector heavily depends on the quality of the acquired data. A scheme of the quantitative evaluation of the quality of the raw GPR data in terms of stability of certain parameters and the set of the procedures, which compensate the instabilities found are presented. We demonstrate the performance of the data pre-processing chain (DPPC), which includes spectral filtering of A-scans, control of the mutual alignment of B-scans, and time and voltage axis's instabilities compensation in the whole C-scan. The performance of the DPPC is judged both in terms of the stabilization of certain statistical parameters of the data, and by its effect on the receiver operation characteristics (ROC) curve [C318]

"Imaging of stepped frequency continuous wave GPR data using the Yule-Walker parametric method"

Ground penetrating radar for humanitarian demining has a large bandwidth. It should discriminate small objects against a complex background. The stepped frequency continuous wave radar of IRCTR has a synthesized bandwidth of 4.5 GHz. Classical methods for generating an image of the subsurface include synthetic aperture processing for cross-range resolution and inverse Fourier transform to generate the range profile. This paper presents a novel scheme, based on Yule-Walker auto regression. This method is widely known as an estimator of the power spectral density based on time domain signals. But here it is interpreted as an estimator of the range profile based on frequency domain signals. The result is a significantly improved detectability and range-resolution if the signal is not too weak. The paper presents some results on the effect of the order of the Yule Walker model and a comparison with the MUSIC method [C319]

"Alternating-sign windowed energy projection of SAR focused GPR data"

The automated detection of plastic-cased antipersonnel landmines in 3-D high-resolution UWB radar images is considered. The 3-D images are projected in different ways onto 2-D confidence maps, in which the automated APM detection is made by marking local maxima in the maps followed by thresholding. Specifically, we consider the confidence maps of the following types: energy projection (EP), windowed energy projection (WEP) and introduced here alternating sign windowed energy projection (ASWEP). The latter is shown to allow diminishing of the false alarms number in comparison for the other two techniques for most of the considered cases. The advantages of the new technique are described by means of receiver operator curves (ROC). The ROC curves are built for the datasets acquired over several minefield simulation sites under different environmental conditions [C320]

"Magnetic field measurements of limpet mines attached to a ship's steel hull"

With the increased threat of terrorist attacks against docked naval and commercial vessels, the use of magnetically attached limpet mines or explosives is of major concern. Detecting limpet mines, or verification of their absence, using magnetic field sensors could be a quick and inexpensive method to determine if a vessel is under attack. Before the design of such a magnetic detection system can begin, the mines' field strength must first be quantified. The field distribution in the proximity of a small, medium, and large limpet mine was measured initially in a magnetically clean laboratory environment. The experiment was then repeated with the mines attached to the steel hull of a destroyer, while measuring the resultant field strengths on the opposite side of the hull. These data can be used in the design of limpet mine detection systems. [C321]

"The application of hyperspectral sensors to the detection of land mines"

Hyperspectral imaging is an important technology for the detection of surface and buried land mines from an airborne platform. For this reason, hyperspectral was included in the three experiments that were executed by the Army RDECOM CERDEC Night Vision and Electronic Sensors Directorate (NVESD) in Fall 2002, Spring 2003 and Summer 2004. The purpose of these experiments was to bring together a wide variety of airborne sensors for the detection of mines, with well ground-truthed targets. The hyperspectral sensors included the airborne hyperspectral imager (AHI), a University of Hawaii LWIR HSI sensor and the compact airborne spectral sensor (COMPASS), an NVESD VNIR/SWIR sensor. These experiments were carried out at sites where extensive arrays of buried and surface mines are deployed. The COMPASS and AHI sensors were both placed on the Twin Otter aircraft, and data was collected with the airplane at a variety of altitudes. In this paper, the data collected on surface mines are reviewed, and specific examples from each background type presented. Spectral detection algorithms are applied to the data and the results of the algorithm processing is presented [C322]

"Facing the challenges of THz quantum cascade laser device development: the relevance of nonequilibrium many body theories"

In this review we summarize current challenges for THz quantum cascade laser development as well as recent theoretical results, which indicate the relevance of nonequilibrium many body effects in the complex scattering and correlation microscopic mechanisms underlying the operation of those devices. The strongly nonthermal nature of the electronic wavefunctions, the fact that the energy difference between the subbands relevant for laser action are of the order of many body effects, and of the resulting level broadening, the Coulomb enhanced cross absorption, as well as the need to account for dephasing in the transport, require our advanced nonequilibrium many body approach for predictive simulations. [C323]

"Ultra-wide band radar using optical synchronized photoconductive generators"

In this paper, we have demonstrated and studied the operation of a photoconductive switch delivering 100 ps to 300 ps electrical pulses with high peak voltage and using low energy for optical gating. The synchronization of 4 generators permitted to develop an ultra wide band radar system for mine detection application. [C324]

"Optimization of antenna spacing in antenna array for ground penetrating radar"

The optimal distance between transmitting and receiving antennas in the array for detecting antipersonnel mines buried at shallow depth has been determined. The scanning method with small step has been proposed [C325]

"Performance of Neutron/Proton Source Based on Ion-Source-Assisted Radially Convergent Beam Fusion"

Summary form only given. Radially convergent beam fusion (RCBF) has been studied for practical use as a portable neutron/proton source for various applications such as landmine detection and medical positron emission tomography. However, some problems remain for the practical use, and the most critical one is the insufficiency of absolute neutron/proton yields. In this study, a new RCBF device was designed and tested to obtain high neutron/proton yields. The key features of the new device are the cylindrical electrode configuration in consideration of better electrostatic confinement of ions and extraction of protons, and an integrated bucket-type ion source which consists of sixteen ferrite magnets and sixteen filaments. To investigate the performance characteristics of the device and the effect of the ion source, three types of experimental setup were used for comparison. At first, the basic RCBF setup was operated. Then a cusp magnetic field was applied by using ferrite magnets, and a thermionic cathode was added. As a result, it was confirmed that the ion source works effectively. At the same discharge condition of voltage and current, the obtained neutron production rate was about one order of magnitude higher than that of the conventional spherical RCBF device. The maximum neutron production rate of 6.8times109n/s was obtained at a pulsed discharge of -70 kV, 10 A [C326]

"MBE grown mid-infrared HgCdTe avalanche photodiodes on Si substrates"

Modern weapon systems need to detect, recognize, and track a variety of targets under a wide spectrum of atmospheric conditions. They include stationary and mobile targets against complex backgrounds and landmines. A number of active systems like hybrid LIDAR-RADAR systems, heterodyne detection as well as passive systems like thermal imagers have been proposed and developed to meet this objective. Most ground-based and air-based systems would operate at long distances. The return laser signal from the target is not only attenuated by absorption, reflection and scattering by air-borne gas, dust and liquid particles, but also by the emissivity and reflectivity variations of the target surface. High bandwidth detectors with internal gain are required. Avalanche photodetectors (APDs) are best suited for this purpose due to their high gain-bandwidth characteristics. Robust silicon-APDs are limited to visible and very near infrared region, while InGaAs works well up to certain wavelengths. On the other hand, it is important to realize that the atmospheric attenuation is wavelength dependent. Local changes in the air density yield random fluctuations in the refractive index, diverging the laser signal. Consequently, longer wavelength (MWIR: 3-5mum and LWIR: 8 -12mu m) source-detector systems are required to overcome the practical and seasonal conditions of the atmosphere. Previous efforts on HgCdTe APDs has been based on expensive CdZnTe substrates . The paper reports on the first HgCdTe based MWIR (3-5mum) APD grown on Si substrates by molecular beam epitaxy(MBE) [C327]

"Doppler radar detection of mechanically resonating objects"

The limitations of existing counter-mine technology have motivated the development of an acousto-electromagnetic technique for detecting landmines and other buried objects (Lawrence, D. and Sarabandi, K., IEEE Trans. on Antennas and Propag., vol.49, p.1382-92, 2001). This hybrid method exploits the acoustic resonance of an object to discriminate it from soil, plant matter, rocks, and other clutter that cause false alarms for GPR. An object is distinguished based on the Doppler signature imparted to radar signals scattering off the object's vibrating surface. We investigated whether small vibrations in objects can be detected by a sensitive Doppler radar. Objects with known acoustic resonant frequencies (tuning forks) were excited (by a speaker), and their Doppler signatures measured using a CW radar system. In the resulting Doppler return, the carrier signal is frequency modulated by a pure tone. Our Doppler radar succeeded in detecting resonant tuning forks even when the vast majority of the receive power was clutter. The primary limitation on our system's performance was not the sensitivity of the radar, but rather the ability to couple acoustic energy into the forks from a remote source. [C328]

"Characterization of a MEMS accelerometer for an underground mine positioning system"

The application of interest involves using accelerometers and an underground mine positioning system. The distance traveled is estimated by double integrating accelerometer measurements. But this calculation can be incorrect due to the presence of bias offset and scaling factor. This paper characterizes MEMS accelerometer and presents measurement results from a test set up. This test set up consists of a custom pendulum test bed, which is described in this paper and was built to test dual axis accelerometer. For a pendulum with small angular distance, calculated bias offsets and scale factors are presented [C329]

"Handheld landmine avoidance system"

The recent miniaturization of GPS receivers has made it possible to design a mobile "personal safety" system to help individuals avoid mapped landmines left over from previous conflicts. The handheld system continually compares the bearer's GPS-reported position with a compressed map of mined danger areas, sounding an alarm on approach. Two kinds of mobile devices are supported: a wearable wristwatch model for general alarm-

only use, and a PDA model that also allows for recording and uploading of discovered mine locations. The mobile devices are integrated into a complete Internet-connected support system, with a central GIS landmine map repository and regional map distributors capable of updating mobile devices in their immediate locales. The data representations allow the mine maps to be stored in compressed form, and the algorithms for real-time proximity calculations are designed to minimize the computation, memory, and power requirements of the wearable mobile device, so as to reduce its cost, without sacrificing accuracy [C330]

"Deployment Strategy for Mobile Robots with Energy and Timing Constraints"

Mobile robots usually carry limited energy and have to accomplish their tasks before deadlines. Examples of these tasks include search and rescue, landmine detection, and carpet cleaning. Many researchers have been studying control, sensing, and coordination for these tasks. However, one major problem has not been fully addressed: the initial deployment of mobile robots. The deployment problem considers the number of robots needed and their initial locations. In this paper, we present a solution for the deployment problem when robots have limited energy and time to collectively accomplish coverage tasks. Simulation results show that our method uses 26% fewer robots comparing with two heuristics for covering the same size of area. [C331]

"Features Selection for Sensor Fusion in a Demining Robot"

Humanitarian demining is a dangerous and time consuming task which leads to more victims among deminers. Thus large efforts are being made worldwide in order to develop autonomous robots able to detect landmines without human participation. Any single sensor currently available for antipersonnel landmine detection can not provide the required detection/false alarm ratio, thus a combination of several sensors together with sensor fusion techniques is used. One of the main problems in the practical implementation of sensor fusion for a demining robot is the lack of experimental data for training the algorithms. Formally using a small training and evaluation set does not allow to take conclusions about the results of sensor fusion. This work presents a sensor fusion strategy which helps to overcome the problem of having few experimental data by creating an unified landmine signatures database. Using this database for sensor fusion in general and for features selection in particular is described. In addition to commonly used statistical features several new features are proposed which reflect the shape and the nature of the object. Moreover the designed ROIs extraction algorithm provides additional information allowing to improve features extraction. The results of features selection using a combination of Mutual information and Hausdorff distance are presented. Preliminary results of sensor fusion for pulsed and continuous metal detectors are also presented. [C332]

"Improvement of Inertial Electrostatic Confinement Device by Magnetron-Discharge-Based Built-in Ion Source"

An inertial electrostatic confinement (IEC) fusion device is studied for a compact fusion neutron/proton source using a magnetron discharge as an external ion source. The addition of ion sources to the IEC device is to enhance the efficiency of fusion reactions by lowering the operating gas pressure and by providing beam-like ion energy distribution. At lower gas pressures, charge exchange collisions are reduced, resulting in longer ion lifetime and enhanced ion re-circulation. An improvement in normalized neutron yield about a factor of ten has been observed with respect to grid current and the operating gas pressure at greatly reduced operation gas pressure of 0.1 Pa [C333]

"Quadruped Walking Robot Centered Demining System-Development of TITAN-IX and its Operation-"

This paper presents a quadruped-walking robot for demining mission. Robot that can adapt any landscape and handle various tasks by utilizing the legs as manipulator is useful one to ensure the safety of local residents and people engaged in the demining mission. However, it is known that mine removing by human workers is progressing slowly because of the risk of their lives. The proposed robot has various features, such as 1) much wider working area than conventional walking robots, 2) unique drive mechanism, 3) high modularity and cooling mechanism and so on. It is expected to give the workers safety to accelerate the demining. [C334]

"Waveform based detection of anti-personnel mines with an UWB radar"

The present paper deals with feature-based landmine detection by means of UWB ground penetrating radar (GPR). A waveform of target response is used as a discriminative feature for two feature-based detection schemes. The output of each DPS is a confidence map obtained by means of energy projection of a 3D distributed feature onto a 2D surface. An automated detection is made over the obtained confidence maps and mines detectability is analyzed on the basis of the receiver operation characteristic curves. Performances of the

feature- and energy-based data processing schemes (DPS) applied to the experimental data are compared. It is shown that suggested waveform based detection is stable to the change of the environment. [C335]

"Radar scattering models for the identification of buried low-metal content landmines"

First Page of the Article [C336]

"Statistical properties of antipersonnel mine signatures in SAR-processed GPR images"

First Page of the Article [C337]

"Buried target signature extraction from ground penetrating radar signal based on the equivalence principle"

First Page of the Article [C338]

"Landmine classification based on high-resolution temporal-spatial GPR template"

First Page of the Article [C339]

"A GPR system using a broadband passive optical sensor for land mine detection"

First Page of the Article [C340]

"Landmine detection and discrimination based on GPR data"

First Page of the Article [C341]

"A genetic-based application oriented approach to optimize RFID-like passive sensor devices for homeland security"

The paper focuses on radio frequency identification devices with improved sensorial abilities and investigates their involvement in homeland and environmental security applications. An application level methodology is suggested which allows the passive device for reducing the total energy required to send the acquired information back to the reader unit. This allows the designer for increasing both reading throughput and reading distance, hence covering a larger acquisition area. The application requirements are cast in an optimization problem which is then solved with a genetic algorithm-based optimization procedure. [C342]

"Landmine detection in high resolution 3D GPR images"

This work describes a novel landmine detection and classification algorithm for high resolution 3D ground penetrating radar (GPR) images. The algorithm was tested on data measured with a video impulse radar (VIR) system developed by the International Research Centre for Telecommunications-transmission and Radar (IRCTR). The algorithm detected all landmines (including the difficult to detect M14 mines) and classified almost all specific landmines features correctly with a reasonably low false alarm rate. The feature on a small height object demonstrates an effective reduction of false alarms. [C343]

"Session C4: Radar Technology 2"

{no data available} [C344]

"Seismic source parameters from InSAR data trough neural networks [Ctrough reads through]"

In the recent years InSAR (Synthetic Aperture Radar Interferometry) technique showed its wide potentialities to detect the surface displacement field due to an earthquake. Of great interest and usefulness in this context is the solution of the inverse problem that means to recover the source parameters from the knowledge of InSAR surface displacement field. In this work a novel approach for the solution of such a problem is presented. [C345]

"IGARSS 2004. 2004 IEEE International Geoscience and Remote Sensing (IEEE Cat. No.04CH37612)"

{no data available} [C346]

"Cooperative control of mobile robots for target search"

Multi-agent teams have the potential to accomplish, some goals more efficiently than single agent systems. The success of the team depends critically on the ability of the agents to coordinate their operations. For this reason, the presence of a robust and reliable control architecture and a cooperation framework is as important as the design of individual agents. In this paper, we present a hierarchical control architecture that provides a methodology to control individual robots and to coordinate the operations of multiple robots. Furthermore, we introduce a multi-robot wireless test bed constructed based on this framework. The effectiveness of the framework is demonstrated by considering an optimal search problem. It is observed that the proposed architecture provides a useful framework to design cooperative control strategies. [C347]

"Navigation of mobile sensors using PSO and embedded PSO in a fuzzy logic controller"

This paper presents novel structures for optimization and communication of a swarm of mobile sensors or robots for maximizing local and global tasks such as firefighting, landmine detection, radioactivity detection, etc. The navigation of the sensors is carried out using two strategies. The first strategy is based on particle swarm optimization (PSO) and the second strategy is based on a swarm of fuzzy logic based controllers. In addition, the membership functions and the rules of the fuzzy logic controller (FLC) are optimized using the PSO algorithm. Navigation of mobile sensors is considered in this paper to locate desirable target sources in a given sensing area. Both approaches presented do not depend on the number of target sources. Results are provided for target locations based on a PSO, a swarm of fuzzy logic controllers and a swarm of optimized fuzzy logic controllers. [C348]

"Landmine detection with GPR using super resolution signal processing algorithm"

First Page of the Article [C349]

"Clutter removal for landmine using different signal processing techniques"

First Page of the Article [C350]

"Wide-area landmine survey and detection system"

First Page of the Article [C351]

"Genetic algorithm for feature extraction in landmine detection"

A feature extraction method based on automatic feature generation and gradual reduction of the feature space using the best search and genetic algorithm is described. Knowledge of the problem domain collected during reduction of the initial set of features is included into the implementation of the genetic algorithm. The fitness function for evaluation of the feature subsets is based on the Bayes classifier. The classifier is constructed for the particular feature subset using the training set of samples, and the classification ability of the particular feature subset is evaluated on samples from the test set. All generated feature subsets are stored, which allows further analysis and extraction of the best feature subsets with a different number of features. The proposed algorithm is tested on acoustic signatures of real landmines and other objects that can be found in a minefield. [C352]

"A novel method for clutter reduction in the FLGPR measurements"

A new method of removing rough-surface clutter in forward looking ground penetrating radar (FLGPR) is proposed based on the physical optics model. The Wigner-Ville distribution (WVD) is proposed to perform a time-frequency analysis. The instantaneous power is worked out to do further processing. By imaging the instantaneous power, we can detect a target more accurately. The treatment comparisons of the experimental data show that the clutter-reduction method presented is better than the conventional method. [C353]

"Research on fast synthetic aperture imaging method for ground penetrating radar in subsurface object detection"

The paper analyzes the received data of shallow subsurface ground penetrating radar (GPR), and proposes to decide the useful information distribution area in the whole received data by the variance characteristic and A-scan energy of the data. A new fast synthetic aperture imaging (SAI) method is achieved by using only those useful GPR data. The results of processing experimental data show that this method is very effective, the effect of the fast synthetic aperture imaging method corresponds with the general synthetic aperture imaging method, and the computational load is reduced greatly compared with the general synthetic aperture imaging method.

[C354]

"Calibration procedures for antenna footprint measurement of stepped frequency CW radar"

First Page of the Article [C355]

"Ant colony optimization based swarms: implementation for the mine detection application"

Mine detection is a sensitive task confronting the battlefield strategists. There is an ever-increasing demand for proper and sophisticated resources for many issues involved in the task. Traditional practices still involve human force directly in executing the tasks in spite of the advances in technology for tools and implements for the operation [GAO, 2001]. The problem includes various facets inherently: two of the prominent issues are location of mines over a minefield and secondly removal of the mines once located [GAO, 2001]. These two issues are not totally independent as technology used for one can directly or indirectly affect the other. Developments in artificial intelligence, natural heuristics, computational optimization and robotics have endowed us with the ability to realize unmanned robots (or robot like vehicles) that work intelligently on a real time basis in attempting at the problem of mine detection. In this paper we focus on the algorithms developed using ant colony optimization based approaches to the mine detection application and its implementation on a real-time basis. We focus on certain optimization techniques that could be used for effective realization of the algorithm. Generic groundscout robots had been already built at the MABL, RIT [Sahin F. et al., 2003]. These robots have been used to demonstrate the implementation [C356]

"Image processing techniques of landmines: a review"

There are mainly two types of landmines which kill or maim people around the world, are anti-tank mine (ATM) and anti-personnel mine (APM). Much research effort has been devoted in trying to detect and remove APM, because APM is much smaller than ATM and is more difficult to detect. Some of the common mine detection techniques include using sensors, signal processing, image processing and decision processes. In this paper we review the signal processing, image processing and decision processes technique to detect or locate a mine and discuss the possible future techniques. [C357]

"Target detection with texture feature coding method and support vector machines"

A texture analysis approach of using an improved texture feature coding method (TFCM) and the support vector machines (SVM) for target detection is presented. Preliminary tests on mammograms showed over 88% of normal mammograms and 85% of abnormal mammograms were correctly identified. Automatic target detection with a cascade-sliding-window (CSW) technique is also discussed. [C358]

"An artificial immune system approach to mobile sensor networks and mine detection"

The human immune system and its ability to continually develop and learn has been studied for many years. Its capacity to recognize its own cells (self), as well as those that pose a threat to the body's homeostasis (non-self) has lead to the creation of many algorithms that try to mimic this behavior. One of these algorithms is the artificial immune system (AIS). The foundation of AIS depends on the existence of both sensor and communication ranges (assumed circles) with which a single agent can collect and convey information to other agents within the range. It is the purpose of this paper to present a solution to the mine detection problem using cooperative mobile robots equipped with sensory and communication capabilities which allow the AIS approach to be utilized [C359]

"UWB radar improvements by using a several antennas system"

PULSAR is an ultra wide-band radar developed to detect quickly buried mines on a large area. This paper presents briefly the recent development efforts on this system, especially on a new pulse generator (fast high voltage pulse generator) and a new UWB antenna (Dragonfly antenna). It also deals with the possibility to use several scissors antennas in order to build an antenna array. A study was carried out with 2 scissors antennas, one beside the other, in order to evaluate the influence of the distance between them. Other simulations are realised with only one generator connected to 3 antennas. [C360]

"Development of mechanical master-slave hand for demining operation"

A considerable number of landmines and unexploded ordnance (UXO) are buried in many disaster-affected countries. Although some methods to remove them have been proposed, there are still many problems. We propose new mechanical master slave hands to remove landmines and UXOs. At first, we have made a test

model. We have conducted hearing about the first model with expert deminer of Afghanistan. Then we made improved model. Through several basic experiments, the second model is estimated to be practical. [C361]

"Robotic system for humanitarian demining"

This research aims to build a practical mobile robotic system to be used in actual humanitarian demining tasks. The basic system consists of a manipulator mounted on top of a mobile platform. For the purpose of building a practical and versatile mobile platform, the authors have already developed a 4-wheel autonomous buggy system called "Gryphon", as discussed in previous works. This paper addresses the development of an energy-efficient weight-compensated manipulator, which is composed of a 5-node parallel linkage. The manipulator was especially designed for antipersonnel mine detection and removal tasks. The weight-compensation concept and the principle of operation are discussed in detail, and the validity and usefulness of the manipulator, as well as of the whole robotic system, are demonstrated by real experiments. [C362]

"Development of a robot for the detection of plastic dangerous objects"

In this paper, we propose a robot which detects dangerous articles made of plastic. To detect plastic articles, a corona charger is installed on a robot. The corona charger consists of corona wire through which high voltage is charged. The dangerous articles are identified by the detection of different surface potential by the difference of the electrification series when the corona is applied to the object. A vehicle was developed as a prototype machine. This vehicle has two driving systems; one is the mechanism with two motors and four castors, another one is a motor which moves the sensor up and down. [C363]

"Disposal of explosive ordnances by use of a bimanual haptic telepresence system"

The paper outlines a novel approach for performing explosive ordnance disposal by use of a bimanual haptic telepresence system. This system enables an operator to perceive multimodal feedback from a remote environment for proper task execution. The developed experimental setup, comprising a bimanual human system interface and the corresponding bimanual teleoperator for use of both hands, is presented in detail. The teleoperation control architecture is discussed as well as a local model-based impedance control algorithm for manipulator control. Human-system performance is improved by means of stereo visualization of the tele-environment together with overlayed Augmented Reality assistance, and an algorithm for avoidance of dangerous manipulator configurations supported by augmented force feedback. Furthermore, a recently developed UDP communication library is presented for system interconnection taking into account compression of haptic data. Thus efficient and low delay of data transfer is ensured. The usability and effectiveness of the developed bimanual telepresence system are demonstrated by focusing a relevant task scenario, such as demining operations in a remote environment. [C364]

"Active selection of labeled data for target detection"

An information-theoretic approach is developed for target detection, with active training set selection, directly from the site-specific measured data. For the proposed kernel-based algorithm, a set of basis functions to characterize the signature distribution of the site are defined first; then we determine a parsimonious set of data, for which knowledge of the associated labels would be most informative to determine the weights for the basis functions. Both of them utilize the Fisher information criteria. The proposed framework is applied to subsurface target detection, with example results presented for an actual buried unexploded ordnance site. [C365]

"GPR for landmine detection, an invited review paper"

First Page of the Article [C366]

"Technical Review Panel"

{no data available} [C367]

"The measured effect of soils on ground penetrating radar antenna resolution"

First Page of the Article [C368]

"Discrimination of subsurface targets with a plane of symmetry using polarimetric bistatic radar"

First Page of the Article [C369]

"Buried object detection-EMI and IR sensors"

Several sensors have been used to detect buried objects, such as GPR (ground penetrating radar) and EMI (electromagnetic induction) sensors. IR (infrared) and acoustic sensors are supportive sensors which are used with an EMI sensor or GPR. The paper focuses mainly on two sensors, a main EMI sensor and a support IR sensor. The EMI sensor's output signal and IR sensor's output image are determined and also how to get mine detection information from these outputs. Landmine detection, which is important for military and humanitarian purposes, is used as a case study. [C370]

"Landmine detection using fractional Fourier features"

This paper addresses the problem of detecting anti-personnel landmines, in an environment that could contain clutter, using features extracted via the fractional Fourier transform. The focus is on identifying and using fractions of the Fourier transform that lead to better detection performance assuming that the landmine is within a reasonable depth variation below the surface. The performance of the proposed detection scheme is assessed in terms of detection rate and false alarm rate using real landmine signatures. The effects of removing ground clutter are examined, and the effects of knowing the mine depth a priori are also discussed. [C371]

"An experimental setup for the microwave imaging of inhomogeneous dielectric bodies"

A free-space method for the microwave imaging of inhomogeneous dielectric bodies is presented. The proposed technique forms the basis for the active imaging of dielectric bodies in the field of biomedical microwave tomography, and for the detection of anti-personnel plastic mines in the field of remote sensing. The method is based on measuring the complex reflection coefficient data of dielectric objects in free-space, and reconstructing the permittivity profiles of these objects from the measured reflection coefficient data using a recently proposed algorithm. A good agreement between the actual and the reconstructed dielectric images for a number of cases shows the validity of the proposed scheme. [C372]

"Online map building for terrain scanning robots using a hybrid neurofuzzy Kalman filter"

This paper presents a proposed online map building for a terrain-scanning robot that is essentially a mobile manipulator built for landmine detection. Map building of the robot is a generic dynamic modeling process to provide a terrain map in real time. It is expected that the proposed map building process is equally applicable to other autonomous mobile manipulators. Map building provides an a priori terrain model for obstacle free path planning in parallel to other tasks of the robot. Map filtering, as the core of map building, updates the model in real time using the range measurements obtained from laser and ultrasonic rangefinders. Filtering takes place by means of a proposed adaptive neurofuzzy Kalman filter. The filter is capable of dealing with uncertainties associated with sensor data and modeling through the learning capability of artificial neural networks in incorporating real life experiments for more efficient terrain typing. Experimental trials validate the effectiveness of the proposed map building process. [C373]

"Time-domain target detection using a double-sided broadband antenna"

A double-sided broadband antenna with a double-sided feed line is presented. Compared with traditional broadband antennas, it is quite practical to fabricate and use. A mathematical model to simulate the structure and performance of the antenna is established, based on dipole antenna array theory. A formula for the electric field is derived, and the radiation patterns are calculated. It is clear that this antenna works well over a broad frequency range (i.e. from 50 MHz to 10.05 GHz). Specific measurements are carried out to test the performance of the antenna. Finally, a landmine detection system is designed and tested, yielding very encouraging results. [C374]

"Scattering analysis using fractional Fourier with applications in mine detection"

This paper uses the fractional Fourier transform to identify dispersive scatterers in a GPR signature. The motive is that certain dispersive scatterers that uniquely define an object can be better localized in the fractional Fourier spectrum. These scattering features that are extracted via the fraction Fourier transform are then presented to a nonparametric landmine detection scheme. The motive is to detect landmines based on specific scattering mechanisms thus avoiding the use of the significant ground return as a primary feature [C375]

"Unexploded ordnance detection by measuring object symmetry via linear prediction"

Humanitarian demining has become a serious international issue nowadays due to the post-war buried unexploded ordnance (UXO) and land mines. In this research, a new technique based on linear prediction is proposed to discriminate UXO from non-UXO targets. The proposed technique takes into account the symmetry

of the ground penetrating radar (GPR) signal returning from a buried object. We use the GPR data set collected by Battelle company and the Ohio State University from the Jefferson Proving Ground (JPG), U.S.A. in the experiments The results evaluated in terms of receiver operating characteristic (ROC) curves show that our proposed technique has a better detection performance than a traditional detection technique based on energy. The false alarm reductions at 100% detection by the baseline technique and the proposed technique are about 11% and 23%, respectively, compared to a situation where no technique is applied. [C376]

"The challenge of standoff explosives detection"

While there currently are a number of effective technologies and methodologies for explosive screening when close proximity to the person, package, or vehicle being screened is feasible, the problem of detecting explosives at significant standoff distances remains one of the most difficult-and most important-challenges confronting physical security specialists. Among the major detection techniques, trace detection suffers from the fact that available vapor plumes are normally too dilute for detection at appreciable standoff under all but the most favorable conditions, and probing bulk techniques suffer from an intrinsic 1/r4fall-off of the signal intensity with distance. Research into potential means of standoff detection is necessary to try to address this important problem. This paper presents an overview of detection technologies that could prove useful in certain standoff detection applications, along with comments on future research needs. A distinction is made between remote detection, in which the personnel searching for explosives maintain a safe standoff distance from the object being screened but where a sampling and/or detection unit may approach the object closely, and true standoff detection, where both the personnel and the sampling/detection equipment maintain a large standoff distance. [C377]

"Near field imaging of subsurface targets using active arrays and elastic waves"

This paper presents a time-reversal based approach for detecting the positions of subsurface passive targets like landmines. The measurements are made by using sources and sensors placed on the surface. The imaging algorithm uses the seismic waves reflected from the targets, and measured on the surface. A time-reversal based algorithm is used, which utilizes the possible link between the time-reversal matrix and the covariance matrix used in standard array processing. It is shown that the time-reversal matrix can be used to estimate the near field DOA and range parameters using a 2D MUSIC approach. [C378]

"Fusion aspects of the rapid route and area mine neutralisation (RRAMNS) mine detection system"

Rapid route and area mine neutralisation system (RRAMNS) is a capability technology demonstrator (CTD) conducted by the Defence Science and Technology Organisation (DSTO) in Australia and industry partners Tenix Defence Industries and Minelab Electronics Inc. The detection system consists of three sensors: a metal detector array; a ground penetrating radar array (GPR); a forward-looking infrared and visual imaging system. Each sensor in this multisensor platform is targeting to detect different properties of buried and surface landmines. Fusion of detections from all sensors provides a complete automatic target detection system for a wide variety of threat mines. The paper describes the fusion architecture implemented to RRAMNS multisensor system for automatic target detection. [C379]

"Petri net based design of a multi-robot scenario-a case study"

In the paper, we describe the realization of an application scenario with Khepera minirobots. The scenario is a decentralized intersection management, where several Kheperas move trough two intersecting lanes without collisions. The application is realized based on a Petri net based methodology for the seamless design of distributed embedded real-time systems. Hence, the presented work brings together results from two different research areas: robotic applications and embedded system's design. [C380]

"Object detection in 3D UWB subsurface images"

First Page of the Article [C381]

"A concept for hip prosthesis identification using ultra wideband radar"

Ultra wideband (UWB) radar has been extensively investigated both theoretically and practically for the identification buried artifacts. Ground probe radar (GPR) concentrates on the identification of lightly buried land mines, unexploded ordnance (UXO) and archeological targets. The same technology is proposed in a similar context for the rapid identification of in vivo implanted metallic prostheses. The technique is based on resonance based target identification and the paper investigates UWB scattering from a metallic hip prosthesis in free space as a first step in the identification process. [C382]

"Application of swarm intelligence to the mine detection problem"

This paper highlights the important points of swarm intelligence, more specifically the ant algorithm, and illustrate how it can be applied to a real time mine detection problem. The algorithm would be applied using GroundScouts, a modular micro robot that was designed for cooperative robotics applications. An adaptive time division multiple access (ATDMA) communication schemes are also presented that changes the behavior of the network according to the number of robots on the network. This maximizes the efficiency of the communication between the robots. The results show that the real time implementation of the algorithm is successful. [C383]

"Versatile robust Capon beamforming: theory and applications"

The standard Capon beamformer (SCB) has better resolution and much better interference rejection capability than the data-independent beamformer provided that the array steering vector corresponding to the signal-of-interest (SOI) is accurately known. However, whenever the knowledge of the SOI steering vector is imprecise (as is often the case in practice), the performance of the Capon beamformer may become worse than that of the data-independent beamformer. Most of the early suggested robust adaptive methods are rather ad hoc in that the choice of their parameters are not directly related to the uncertainly of the steering vector. In this paper we provide a review of the recently proposed robust Capon beam-former (RCB) and doubly constrained robust Capon beamformer (DCRCB), which directly address the uncertainty of the steering vector and naturally extend the covariance fitting formulation of SCB to the case of uncertain steering vectors by enforcing a double constraint on the steering vector, viz. a constant norm constraint and an uncertainty set constraint. We also present several extensions and applications of RCB including constant-powerwidth RCB (CPRCB) and constant-beamwidth RCB (CBRCB) for acoustic imaging, rank-deficient robust Capon filter-bank (RCF) approach for spectral estimation, and rank-deficient RCB for landmine detection using forward-looking ground penetrating radar (FLGPR) imaging systems. The excellent performances of RCB, DCRCB, and the various extensions of RCB are demonstrated by simulated and experimental examples. [C384]

"The feasibility of searching for contraband materials using a gamma-ray 'radar' system"

A technique for searching for contraband materials that may be hidden behind a barrier is described. This imaging technique is based on the detection of one of the two annihilation photons produced by a positron-emitter that has scattered in the target, in coincidence with the detection of the second photon in a position-sensitive scintillation counter. The results of a feasibility study will be presented in which a 1mCi source was used to illuminate a 1times1 m2area to provide a two dimensional image of the line-of-sight density within this object. The spatial-resolution achievable is -1times1 cm. Details of the detector design envisaged for this application will be described and the images generated through Monte Carlo simulations presented. [C385]

"A Rolling Method for Complete Coverage Path Planning in Uncertain Environments"

Motion planning with obstacles avoidance in uncertain environments is an essential issue in robotics. Complete coverage path planning of a mobile robot requires the robot to pass through every area in the workspace with collision-free, which has many applications, e.g., various cleaning robots, painter robots, automated harvesters, land mine detectors and so on. A novel planning method integrating rolling windows and biologically inspired neural networks is proposed in this paper. The real-time environmental information can be represented by the dynamic activity landscape of the biological neural network. The rolling window approach is used to detect the local environments. Thus, a heuristic planning algorithm is performed on-line in rolling strategy. Three cases on complete coverage path planning in uncertain environments and the comparison of the proposed method and the planning approach based on the biologically inspired neural networks are studied by simulations. Simulation results show that the proposed method is capable of planning collision-free complete coverage robot motion path [C386]

"Antenna footprint measurements of stepped frequency CW radar on the air/ground interface [CGPR for landmine detection]"

This paper presents the antenna footprint measurements of a stepped frequency continuous wave radar. To image a subsurface, a knowledge of the wave fields radiated by the radar below the surface is necessary. Due to the complexity of the system it is hard to compute the emitted wave fields accurately in the ground. A remedy for this problem could be measurement of the antenna footprints on the air/ground interface and then apply synthetic propagation of the wave fields into the subsurface by using the Huygens principle. The footprint of a spiral antenna has been measured by using a 1 cm shielded loop antenna as a probe antenna positioned on the air/ground interface. Subsequently, the same measurement is repeated by positioning the probe in free space at the same elevation as the air/ground interface in order to analyse the correspondence between the

measurements. The footprint patterns obtained after performing calibrations were comparable for both measurements. [C387]

"A new GPR targets feature extraction based on kernel method"

A new ground penetrating radar target feature (GPRTF) extraction method based on kernel method is proposed. This paper also explains that the unsupervised methods (PCA or KPCA) aren't fit for the GPRTF extraction. The conventional GPRTF extraction method is the LDA (also called as FDA).It can minimize the within class scatter and maximize the between class scatter, but it extracts the GPRF in the low dimension GPR data space and the discriminability is limited. The kernel method can map the GPR data to the high dimension space by the non-linear transformation and can so enhance the discriminability. Combine the virtue of the kernel and the LDA and make up for the flaws of them will benefit for the GPRTF extraction. The treatment comparisons of the measurement data show that the method proposed is superior to the others. [C388]

"SIL06: A six-legged robot for humanitarian de-mining tasks"

Detection and removal of antipersonnel landmines in infested fields is an important worldwide problem. Around 100 million landmines have been deployed over the last two decades, and demining can take several more decades, even if no more mines were deployed in future. A high mine-clearance rate can only be accomplished by using new technologies such as improved sensors, efficient manipulators and mobile robots. This paper presents some basic ideas on the configuration and controller of a mobile system for detecting and locating antipersonnel landmines in an efficient and effective way. The whole system has been configured to work in a semi-autonomous mode with a view also to robot mobility and energy efficiency. The paper outlines the main features of the overall system and focuses on some aspects of the controller [C389]

"Preliminary results of a comparative study of fast scintillators for a thermal neutron activation landmine detector"

The improved landmine detector system is a vehicle-mounted multi-sensor landmine detector which uses a thermal neutron activation (TNA) detector to confirm the presence of a mine by detecting the bulk nitrogen in its explosives. The input count rate to the TNA is very high and count rates of future systems could be an order of magnitude higher, allowing correspondingly higher sensitivity or shorter detection times for land mines. The chief bottleneck to achieving the maximum possible performance from the present TNA or a future system is the relatively slow fluorescent decay time of the NaI(Tl) scintillators which are currently used. This paper presents preliminary results from an experimental study into various fast scintillators as potential detector upgrades to the TNA confirmation detector, A number of fast, inorganic scintillators are compared with NaI(Tl) with respect to efficiency, energy resolution, available size and cost in the present application. [C390]

"Thermal neutron backscatter imaging"

Objects of various shapes, with some appreciable hydrogen content, were exposed to fast neutrons from a D-T generator, resulting in a partially-moderated spectrum of backscattered neutrons. The thermal component of the backscatter was used to form images of the objects by means of a coded-aperture thermal-neutron imaging system. Timing signals from the neutron generator were used to gate the detection system so as to record only events consistent with thermal neutrons traveling the distance between the target and the detector. The technique may have application in the detection and shape-determination of land mines, particularly non-metallic types. [C391]

"Walking control of COMET-III using discrete time preview sliding mode controller"

The mine detection hexapod robot COMET-III is driven by hydraulic power. Because of the strong nonlinear characteristic of the oil pressure system, conventional classic methods produce the flattery delay to the target orbit. In the unknown environment of minefield, the robot leg must follow correctly the walking orbit. The sliding mode control has strong robustness to parameter change or disturbance, and the preview control prevents the flattery delay by using a future target value. In this paper, we design a preview sliding mode controller, which incorporate the advantages of both control theory, and so improves control performance. [C392]

"Improving landmine detection using frequency domain features from ground penetrating radar"

Landmine detection is an important and yet challenging problem remains to be solved. Ground penetrating radar (GPR) is an effective sensor to detect landmines that are made of plastic or have low metal content. Most GPR signal processing algorithms apply processing in the time (depth) domain. This paper proposes to use the frequency domain features from the GPR signal to improve the detection of weak plastic mines and to reduce the

number false alarms due to clutter objects. The motivation comes from the fact that the energy density spectrum may be different between mine targets and clutter objects, although both may have strong GPR signal return in the time domain. Experimental results based on clutter lane data collected at a test site corroborate the effectiveness of the proposed spectral features to increase the accuracy for landmine detection [C393]

"Application of texture feature classification methods to landmine/clutter discrimination in off-lane GPR data"

Recent advances in ground penetrating radar (GPR) fabrication and algorithm development have yielded significant performance improvements for anti-tank landmine detection in government sponsored blind tests. However, these blind tests are typically conducted over well-maintained homogeneous testing lanes specifically designed to test landmine detection performance in low-clutter population situations. New GPR data collections over targets emplaced in un-maintained off-lane soils have much higher GPR anomaly populations and provide more stringent tests of landmine detection algorithms. In this work, we focus on the application of feature-based class separation techniques to lower false alarm rates in heterogeneous off-road soils. In particular, we explore the application of texture feature coding methods (TFCM), which have previously shown promise in fields like tumor detection [C394]

"Landmine detection with ground penetrating radar using fuzzy k-nearest neighbors"

This paper introduces a system for landmine detection using the sensor data generated by a ground penetrating radar (GPR). The GPR produces a three-dimensional array of intensity values, representing a volume below the surface of the ground. First, a constant false alarm rate (CFAR) detector is used to focus the attention and identify the candidates that resemble mines. Next, we apply a feature extraction algorithm based on projecting the data onto the dominant eigenvectors in the training data. The training signatures are then clustered to identify a few representatives, and a fuzzy k-nearest neighbor rule is used to distinguish true detections from false alarms. [C395]

"Combined seismic, radar, and induction sensor for landmine detection"

An experimental system to collect co-located ground penetrating radar (GPR), electromagnetic induction (EMI), and seismic data was developed to investigate the possibility of using the sensors in a cooperative manner and to investigate the benefits of the fusion of the sensors. These sensors were chosen because they can sense a wide range of physical properties. The seismic sensor is sensitive to the differences between the mechanical properties of a landmine and the soil while the GPR is sensitive to the dielectric properties, and the EMI sensor is sensitive to the conductivity [C396]

"Analysis of infrared polarization signatures for backgrounds and objects"

Recent investigations into the use of new electro-optical sensing modalities for the detection of landmines and other objects in complex backgrounds have led to the need to understand the optical properties of background materials (e.g., soils) in more detail. In particular, the use of polarimetric signatures in the optical and infrared domains has been the subject of much study; an understanding of soil optical properties and their variations is critical to evaluating the utility of these signatures. Our research examined polarimetric signatures and corresponding metrics in the context of a real world environment; specifically, we examined the spectral polarization characteristics of landmines and soils within a complex radiative environment. Our initial results indicate that the optical properties of sand dominate the resultant signature for the buried and flush-buried cases. Therefore, a spectral phenomenological model for the polarization signature of the combined sand-landmine system was developed for the infrared band (mid-wave and long-wave infrared) to study these issues in more detail; this model included the effects of various environmental factors such as solar insolation and atmosphere. The modeling paradigm centered on a radiative transfer approach coupled with heat transfer results to account for incident and emitted radiation simultaneously; the Hapke emission model served as a basis for the current investigations. This paper presents a description of the physics-based model for the spectral polarization signatures of buried, flush, and surface land mines and soil features along with signature effects arising from changes in the atmosphere and other environmental processes [C397]

"Detection of surface mines using hyperspectral sensors"

Hyperspectral imaging is an important technology for the detection of surface and buried land mines from an airborne platform. For this reason, hyperspectral was included in the two experiments that were executed by the Army RDECOM Night Vision and Electronic Sensors Directorate (NVESD) in Fall 2002 and in Spring 2003. The purpose of these experiments was to bring together a wide variety of airborne sensors for the detection of mines, with well ground-truthed targets. The hyperspectral sensors included the Airborne Hyperspectral Imager (AHI), a

University of Hawaii LWIR HSI sensor and the Compact Airborne Spectral Sensor (COMPASS), an NVESD VNIR/SWIR sensor. These experiments were carried out at sites where an extensive array of buried and surface mines were deployed. At the first experiment called Forest Fusion I, the mines were deployed against several different backgrounds ranging from bare dirt to long grass. For the second experiment, called Desert Fusion, the mines were placed on backgrounds ranging from loose sand to mixed sand and vegetation. The COMPASS and AHI sensors were both placed on the Twin Otter aircraft, and data was collected with the airplane at a variety of altitudes. In this paper, the data collected on surface mines are reviewed, and specific examples from each background type presented. Spectral detection algorithms are applied to the data and the results of the algorithm processing are presented [C398]

"Multi-sensor and algorithm fusion with the Choquet integral: applications to landmine detection"

We discuss the application of Choquet integrals to multi-algorithm and multi-sensor fusion in landmine detection. Choquet integrals are defined. Specific classes of measures, the full and Sugeno measures, are described. Full measures are optimized via quadratic programming. A steepest descent algorithm for optimizing Sugeno measures is derived by applying implicit differentiation. Multiple detection algorithms are applied to hyper-spectral and synthetic aperture radar imagery. In addition, a LWIR vegetation index is computed using statistics of apparent emissivity. The detection algorithms are combined using an OR operator and Choquet integrals with respect to full and Sugeno measures. The Choquet integral with respect to the full measure achieves lower false alarm rates [C399]

"Finding organized structures in 3-D ladar data"

In this paper, we address the problem of finding organized thin structures in three-dimensional (3-D) data. Linear and planar structures segmentation received much attention but thin structures organized in complex patterns remain a challenge for segmentation algorithms. We are interested especially in the problems posed by repetitive and symmetric structures acquired with a laser range finder. The method relies on 3-D data projections along specific directions and 2-D histograms comparison. The sensitivity of the classification algorithm to the parameter settings is evaluated and a segmentation method proposed. We illustrate our approach with data from a concertina wire in terrain with vegetation. [C400]

"Locating underground chemical sources by tracking chemical gradients in 3 dimensions"

This paper describes current progress in a project to develop a robot for locating underground chemical sources. There are important economic, environmental and humanitarian applications for systems that can find the source of an odor or volatile chemical located beneath the ground. These applications cover the spectrum from harvesting truffles, to finding the location of leaking gas pipes and land mines. In previous work the feasibility of detecting vapor percolating through the ground was demonstrated. An algorithm was then developed to control a robot enabling it to gather information about the location of the source and to guide the robot towards it. This algorithm was limited to searching in two dimensions (depth was held constant). In this paper the original algorithm is extended to 3-dimensions allowing variations in depth to be included. The 3-dimensional search algorithm involves following a path through the ground that corresponds to the edges of closely packed dodecahedra. Simulations and physical experiments both confirm the capabilities of this search algorithm. [C401]

"Hand posture detection by neural network and grasp mapping for a master slave hand system"

This article is proposing a grasp recognition and grasp mapping method for a land mine clearance master-slave system. The system consists of a data glove and a powerful hydraulic hand. Because of the different structure of the master and slave hand a mapping from master grasp to slave grasp has to be implemented. The paper presents a grasp recognition method by neural network (NN) and a mapping method. The introduced mapping method allows the operator more intuitive grasping. [C402]

"Toward practical implementation of sensor fusion for a demining robot"

This paper presents a pre-processing method to allow the implementation of landmine sensor fusion techniques in a pneumatic demining robot. The proposed method is based on a two-level strategy for the sensor fusion. This strategy allows separating two different classification tasks: object/background and mine/another object. This work is focused in the first stage of the process, particularly in the identification of regions-of-interest (ROI). The proposed ROI extraction algorithm decreases the number of parameters, is reliable in different environmental conditions and can be implemented online. Results of experimental implementation and conclusions are presented. [C403]

"GPR-based adaptive sensing: GPR manipulation according to terrain configurations"

In this paper, we introduce an adaptive sensing method to a landform using a ground reflection of a ground penetrating radar (GPR). When GPR scans a ground surface, an antenna of GPR should be put on a ground as an ideal condition. The farther an antenna is put away from a ground, the shallower the sensing depth becomes, because a ground surface reflects most of the electromagnetic wave radiated by the antenna. Practically an antenna should be manipulated, keeping a small distance from a ground in order to avoid a collision with a ground. Besides, the distance should be controlled so as to observe the ground reflection at a constant position in B-scan image, which is eliminated by a simple algorithm. There are many sensors to measure a ground configuration, but we propose an adaptive sensing which does not require any additional sensors such as laser range finder. In addition, the ground reflection in B-scan image is precisely eliminated by manipulating the sensor head according to GPR sensor information. We show some experimental results to confirm its effectiveness and its performance. [C404]

"Continuous Choquet integrals with respect to random sets with applications to landmine detection"

A hit-miss transform is defined using Choquet integrals with respect to random sets. In this context, random sets represent random shapes defined on the plane. Random sets are characterised by their capacity functional. Capacity functional is fuzzy measures. Choquet integrals with respect to random sets are interpreted as stochastic morphological operations. Specifically, the integrals represent the average probability that sets either intersect or are contained in the random sets. Formulas are defined for random erosions and dilations of disks and annuli with Gaussian radii. Applications to landmine detection are given. [C405]

"Renyi entropy with respect to Choquet capacities"

Entropy terms are analyzed for use in a heterogeneous network involving ordered weighted averaging (OWA) operators and feed-forward neural networks, referred to as FOWA networks. The OWA operators are used to aggregate feature information and were previously used successfully in a landmine application. Weight vectors of OWA operators are special cases of Choquet capacities for which the Shannon entropy has been defined. One can also consider the quadratic Renyi entropy for OWA weight vectors. A term is added to the objective function of the FOWA network involving these entropy terms. An analysis of the derivatives used in gradient descent is conducted. [C406]

"Fusion of polarimetric infrared features and GPR features for landmine detection"

Currently no single sensor reaches the performance requirements for humanitarian landmine detection. Using sensor-fusion methods multiple sensors can be combined for improved detection performance. This paper focuses on the feature-level; fusion procedure for a sensor combination consisting of a polarimetric infrared imaging sensor developed by TNO and a video impulse GPR developed by Delft University of Technology. Feature-level sensor-fusion is the process where specific information (i.e. features) from objects detected by different sensors are combined and classified. The single sensor detection methods and the feature-level sensor-fusion methods are evaluated using a leave-one-out evaluation method. This evaluation method provides an independent evaluation set while retaining the largest possible training set. The detection results of both single sensors and the sensor-fusion methods are both presented in receiver operator characteristics (ROC) curves. They show that on the training set feature-level sensor-fusion always outperforms the best single sensor. Furthermore, on the independent evaluation set, there are ROC points of the feature-level sensor-fusion methods that are better than the best sensor. [C407]

"Processing of polarimetric infrared images for landmine detection"

Infrared (IR) cameras are often used in a vehicle-based multi-sensor platform for landmine detection. Additional to thermal contrasts, an IR polarimetric sensor also measures surface properties and therefore has the potential of increased detection performance. We have developed a polarimetric IR setup, which has to be used in a forward-looking manner. This paper describes all the steps to reach detection performance. The first step is the acquisition of the polarimetric IR image data. The next step is the pre-processing to (re)construct polarimetric images. A subsequent segmentation step is made to identify objects. Features, like intensity, reflectivity and shape, of these objects are measured. For independent performance analyses, the data set is divided into a training and evaluation section. A classifier is trained on the training section and evaluated on the classification section. The detection performance of the forward-looking IR camera is shown in receiver operator characteristics (ROC) curves. [C408]

"Semi-analytical calculation of Jacobian in the electromagnetic inverse scattering problem"

Discrimination of unexploded ordinance (UXO) from widespread metallic clutter remains a very urgent environmental remote sensing problem. One of the most promising technologies for such discrimination is ultra-wideband low frequency electromagnetic induction (EMI), operating from a few Hz up to a few hundred kHz. The numerical hybrid of the full method of auxiliary sources (MAS) and the MAS-thin skin approximation (MAS-TSA) (Shubitidze, F. et al., Proc, ACES, 2003; IEEE Trans. Geosc. & Remote Sens., vol.40, no.4, p.928-42, 2002) solves the forward governing equations very efficiently. Solving the inverse problem numerically requires calculation of the gradient of the system Jacobian. In the hybrid full MAS/MAS-TSA method, one obtains an analytical form of this gradient, producing an overall semi-analytical system for inferring a metallic object's electromagnetic parameters. We illustrate our main ideas with a simple body of revolution problem, and results are compared with measured data. The method can readily be extended to general inverse electromagnetic scattering problems at higher frequencies. [C409]

"Camera based motion tracking for data fusion in a landmine detection system"

First Page of the Article [C410]

"Stepped frequency continuous wave radar-data preprocessing"

Radar systems have been paid a lot of attention since the end of WWII. Along with performances improvement one has witnessed a diversification of their applications, which range from target detection and parameter measuring to navigation systems, anti-collision systems and subsurface sensing. The last application has had a great importance for humanitarian demining purposes taken into account the number of landmines spread across the world and the danger they pose to humans. Both, continuous wave and pulse radar have been employed for landmine detection. This paper deals with stepped frequency continuous wave (SFCW) radar that operates from 400 MHz to 4845 MHz, in steps of 35 MHz. The novelty of the system, built at International Research Center for Telecommunication-transmission and Radar (IRCTR), consists in the fact that 8 frequencies are transmitted simultaneously, which drastically decreases the data acquisition time. Because of the strong reflection from the air-ground interface one may face some difficulties to "see" the landmines, which are lying on, or just below of the surface. If the antenna system footprint is much more larger than the size of the mine, this is even more difficult as the signal from the mine will be buried in the clutter signal. In order to remove the clutter signal and to improve signal to clutter ratio, average clutter subtraction and synthetic aperture radar have been investigated. [C411]

"Subsurface imaging using measured antenna footprints"

For the detection of landmines, images of the subsurface are made using a bistatic stepped frequency continuous wave radar system. During the measurements, the system moves along the surface and due to the presence of objects in the subsurface changes in measured voltages are observed. These changes are formulated as a convolution of a complex contrast function with a sensitivity function. In fact, this sensitivity function is the vectorial inner product of the incident and the total electric wavefield. Using the Born approximation, the sensitivity function is obtained as the inner product of the field emitted by the transmitter and the field from the receiver operating in transmitting mode. For imaging purposes, knowledge of the wavefields in the subsurface is needed. Since it is difficult to model the radiation characteristics very accurately, we measure the footprints of the antennas at one level and propagate the emitted wavefields using Huygen's principle. After we verify the usability of this principle, we create synthetic data using measured patterns and apply back-propagation on the data to localize objects. [C412]

"Multistatic antennas and non-linear inversion for mine-detection GPR"

This paper deals with the utilization of "angular diversity" in GPR, an approach, which in comparison to the widespread "fixed-offset" GPR helps to improve clutter robustness as well as image resolution. The latter can be achieved by means of enhanced processing techniques-compared to the widely used SAR or tomographic approaches-which rely on the availability of angular diversity data. The paper discusses data acquisition by means of multistatic measurement setups and numerical MoM simulations. The "factorization method" is proposed as an image formation scheme, which, amongst other advantages, requires only low computational effort. 3-D imaging results from numerical datasets in free-space and a stratified background are presented and discussed. [C413]

"Application of microwave radiometry for buried landmine detection"

In this paper we illustrate the phenomenological background, the design, and some experimental results of a multi-spectral low frequency microwave radiometer as a part of a multi-sensor mine detection system. The overall system is intended to work in a hand-held operation allowing the use in areas of difficult access without

excluding missions in more friendly environments. Thus the radiometer antenna is operated in an extreme near-field mode to achieve a corresponding ground resolution in the order of the active antenna aperture size. In particular, the radiometer receiver is swept in low-bandwidth steps through a broad microwave (MW) frequency range to vary the penetration depth and the reflectivity properties of the actually observed ground part. This can provide significantly increased information about the location and shape of buried objects for discrimination purposes. The relevant theoretical aspects of this interference based effects are illustrated and attempts to interpret the spectrum for specific layered arrangements as in the case of buried objects are presented. [C414]

"Scattering by partially buried cylinders at the rough surface interface between two media"

The prediction of electromagnetic scattering from rough surface and subsurface targets has been a problem of long-term interest, as the targets above or below the rough surface are affected by the surrounding medium. The fact that a combined object and rough surface scattering mode can be applied to studies of landmine detection, foliage and surface remote sensing, or target detection and signal processing problems provides further motivation for model development. The contribution from the rough surface can significantly modify the scattering from the target, as compared to that from a flat surface. Some approximate analytical solutions can only be found in the case of small roughness limit The development of numerical models is therefore of interest since these models avoid unnecessary approximations and thus can clarify important scattering effects where analytical methods failed. However, to the authors' knowledge, the electromagnetic scattering by partially buried cylinders at the dielectric rough surface interface between two media was not investigated. This problem will be discussed here, by means of the method of moments with point-matching and pulse basis functions. [C415]

"Dielectric wedge antenna for ground penetrating radars"

This paper introduces a new GPR antenna: the dielectric wedge antenna. This antenna is based on a dielectric wedge and has a number of similarities with dielectric-filled TEM horns. The main constructional difference of the proposed antenna from a dielectric-filled TEM horn is the tapering of the antenna flairs. An additional difference is that the dielectric base of this antenna does not have a pyramidal shape as in TEM horns but a wedge shape. [C416]

"FDTD simulations of multiple GPR systems"

In this work, a multiple-GPR detection system has been simulated. The main advantage of such a system is that it saves time by detecting both the transverse and the longitudinal positions of the target by a B-scan measurement, whereas the same detection can be achieved by a C-scan with a single-GPR system. FDTD method is employed to perform the simulations, in which the ground is homogeneous and the target is perfectly conducting. [C417]

"Ground penetrating radar (GPR) studies at the ElectroScience Laboratory (ESL)"

There are a number of factors to be considered in making many GPR measurements. These include (a) electronic hardware (b) antenna systems (c) electromagnetic properties of the ground (d) target identification arid remote sensing concepts and (e) use of numerical simulations. The purpose of this paper is to review the contributions made at the ESL for these factors and to discuss future potential advances in the state of the art. [C418]

"High-order extended Born approximations for EM scattering by buried dielectric objects"

Finding fast solutions for the electromagnetic (EM) scattering by dielectric objects buried in lossy earth is very important in near-surface geophysical exploration and landmine detection. Although conjugate gradient fast Fourier transform (CG-FFT) algorithms are much more efficient than the conventional method of moments (MoM), they are still not fast enough because many iterations are required. Consequently, some approximate methods, like the Born approximation and the extended Born (ExBorn) approximation, are usually used in the detection of buried objects. The ExBorn approximation is the more accurate, but it requires O(N2) computational complexity (N is the number of unknowns). Recently, we proposed a fast ExBorn method using the FFT technique (Cui, T.J. et al., IEEE APS Int. Symp., vol.II, p.570-3, 2002), where the computational complexity is proportional to CN log N with a small coefficient C. Hence, ExBorn is much more efficient than the CG-FFT algorithm. However, the ExBorn approximation is less accurate when the target contrast is high. We derive high-order ExBorn approximations, all of which have closed-form expressions. Using the FFT technique, these approximations can be evaluated at a cost of O(N log N). Compared with full-wave analysis, high-order ExBorn approximations are more accurate than ExBorn. [C419]

"Application of Bayesian inversion for scatterer shape from EMI data"

Bayesian inversion approaches may be useful for inferring metallic scatterer shapes, and thereby assist in discriminating buried unexploded ordnance (UXO). The fundamental feature of Bayesian inversion is its attempt at rational incorporation of prior information in the inference algorithm. In UXO detection and classification, the model is a set of parameters corresponding to a particular object in a particular disposition. Prior information about the target sought and the randomness of noise and clutter from different sources warrant the application of a Bayesian approach. Broadband electromagnetic induction (EMI) responses at different locations, in terms of scattered magnetic field components in-phase and out-of-phase with the transmitted primary field, form the data vector. Here a fast forward model, in which we successfully represent a steel cylinder by a spheroid, is exploited for inversion computations. The validated model produces synthetic data, for which Bayesian inversion is compared to simple least squares (SLS), i.e. without weighting or damping. The Bayesian approach can provide more accurate results, if we can provide reasonable prior information. [C420]

"Bistatic GPR system for landmine detection using optical electric field"

Ground penetrating radar (GPR) is one promising technique for land mine detection, and many researches have been carried out. Most of the ideas for landmine detection by GPR use a monostatic type radar system, which is suitable for detecting land mines buried in shallow soil, which is normally less than 10 cm. On the other hand, bistatic type radar will be suitable for stand-off detection. In this paper, we propose a novel bistatic radar system, which uses an optical electric field sensor as a receiver. Some fundamental field test results are shown in this report. [C421]

"Clutter suppression and feature extraction for land mine detection using ground penetrating radar"

In this paper, we discuss approaches for processing ground penetrating radar (GPR) data for land mine detection. We discuss two methods of clutter suppression using ARMA modeling and also examine feature extraction using both ARMA modeling and complex natural resonance (CNR) modeling. The algorithms presented have been tested on laboratory GPR data and been found to be promising techniques. In future work, the feature vectors produced by these techniques will be processed through appropriate detection algorithms. [C422]

"Antenna development and a stepped-frequency GPR system for landmine detection"

A project for developing a compact size GPR system for landmine detection was started. It will be based on stepped-frequency radar system for wider application in various kinds of soil conditions. We have developed a prototype stepped-frequency for fundamental evaluation of the system. This system uses a broadband Vivalidi antenna and operates at 2-6 GHz. The system was tested in laboratory and could be used for imaging buried mine-like targets by high resolution. Series of tests were carried out by using sand with rough surface and inhomogeneous soil. We discuss the ability of GPR for landmine detection. [C423]

"STW project "Advanced relocatable multisensor system for buried landmine detection""

Delft University of Technology has just finished its major efforts in a most challenging project, supported by the Dutch Technology Foundation STW. This four-year project entitled "Advanced relocatable multi-sensor system for buried landmine detection" was the largest project in STW history. Within the scope of this project we have built up a unique expertise and knowledge in the whole GPR chain starting from all aspects in GPR technology and finishing with target classification and soil characterization. The paper describes the goals and results within this project. [C424]

"Proceedings of the 2nd International Workshop on Advanced Ground Penetrating Radar (IEEE Cat. No.03EX680)"

First Page of the Article [C425]

"Studies of ground penetrating radar antennas"

Virtually all systems that have been developed in recent years to detect landmines and buried unexploded ordinance (UXO), have included the ground-penetrating radar (GPR) as one of the principal subsystems. Much of the effort reported to date in evaluating these GPRs has focused on obtaining overall end-to-end detection performance metrics (Pd, Pfa). These studies have been useful but they provide little insight into the functioning of individual GPR components and the limitations they may impose on system performance. By contrast, this project concentrates on investigating performance characteristics of the GPR antenna, which is perhaps the

most critical component in determining GPR system performance. Some of the antenna issues that remain unresolved are: determination of the most useful bandwidths, defining the role of polarization and polarization diversity, minimizing the effects of self-clutter (also known as "ringdown" or "reverberation"). Over the course of this ongoing program, we plan to investigate a variety of GPR antenna subsystems, including the spiral, the sinuous log-periodic, various dipoles, the TEM horn, the TEM rhombus, tapered slots and forms of the impulse radiating antenna (IRA). In this paper, we report some initial experiments carried out on a transmit-receive pair of Archimedean spiral antennas. To characterize these antennas, we carried out measurements in a conventional radio frequency (RF) laboratory using a vector network analyzer to synthesize waveforms covering the frequency range from 500 MHz to 5.5 GHz. Transformation of these data to the time domain allows us to gate out extraneous laboratory clutter beyond a 1.5-m (10 nsec) range. The principal measurements reported here are: the gain and phase properties, noise and clutter levels, and the antenna system spatial response footprint. The spatial patterns were measured by raster-scanning a stainless steel sphere through a two dimensional grid located 17 cm (a range typical of GPR applications) from the aperture of the transmit/receive antenna pair. [C426]

"System description of a stepped frequency CW radar for humanitarian demining"

A multiple frequency stepped frequency continuous wave radar for detecting flush buried and surface laid antipersonnel landmines was designed and built. The system covers a frequency band from 400 MHz up to 4845 MHz. The range resolution is 3.4 cm and the maximum unambiguous range is 4.3 m. The antenna configuration is a bistatic one with two Archimedean spirals with opposite sense of rotation. The instrumented dynamic range is 40-50 dB per frequency channel. After synthesis of the range profile the dynamic range is significantly higher. The system parameters are aimed at imaging algorithms exploiting the phase evolution over the antenna footprint in particular. One example of the results achieved with and without synthetic aperture radar processing is presented. [C427]

"Array signal processing in the known waveform and steering vector case"

The amplitude estimation of a signal whose waveform is known (up to an unknown scaling factor) in the presence of interference and noise is of interest in several applications including using the emerging quadrupole resonance (QR) technology for explosive detection. In such applications a sensor array is often deployed for interference suppression. This paper considers the complex amplitude estimation of a known waveform signal whose array response is also known a priori. We study a practical scenario where the interference and noise is both spatially and temporally correlated. We model the interference and noise vector as a multichannel autoregressive (AR) random process. A cyclic iterative ML (IML) method is presented. We show that in most cases the IML method is superior to its simple ML counterpart that ignores the temporal correlation of the interference and noise. [C428]

"Linguistic hidden Markov models"

In this paper we develop a hidden Markov model (HMM), called the linguistic HMM (LHMM), suitable for processing sequences of fuzzy vectors. A fuzzy vector B is an n-tuple of fuzzy numbers. Since fuzzy numbers are often associated with linguistic terms, such as "small," "medium," etc., a fuzzy vector can also be called a linguistic vector. The derivation of the linguistic HMM (LHMM) from the numeric HMM is done using the extension principle and the decomposition theorem. We show that the LHMM behaves in the same way as the HMM in the degenerate linguistic case when the fuzzy numbers are singletons (real numbers). We also derive the related algorithms for LHMM training (linguistic Baum-Welch) and for LHMM recognition (linguistic Viterbi). Several examples of LHMM training and recognition are given. [C429]

"Detection of land mines using fuzzy and possibilistic membership functions"

This paper introduces a new system for real-time land mine detection using sensor data generated by a Ground Penetrating Radar (GPR). The GPR produces a three-dimensional array of intensity values, representing a volume below the surface of the ground. Features are computed from this array and two types of membership degrees are assigned to each location. A fuzzy membership value provides a degree of belongingness of a given observation in the classes of mines, false alarms, and background, while a possibilistic membership value provides a degree of typicality. Both membership degrees are combined using simple rules to assign a confidence value. The parameters of the membership functions are obtained by clustering the training data and using the statistics of each partition. Our preliminary results show that the proposed approach is simple, efficient, and yet, yields results comparable to more complex detection systems. [C430]

"A new approach for near-field wideband synthetic aperture beamforming"

A coarray-based synthetic aperture beamformer using stepped-frequency signal synthesis and post-data acquisition processing is presented for wideband imaging of near-field scenes. The proposed beamformer formulation and implementation finds key applications in through-the-wall microwave imaging and landmine detection problems. While coarray techniques offer significant reduction in array elements for a given angular resolution, stepped-frequency realization of wideband systems simplifies implementation and offers flexibility in beamforming. Proof of concept is provided using real data collected in an anechoic chamber. [C431]

"Landmine detection technology research programme at TNO"

This presentation gives an overview of most of the activities on research and development in the technology area for landmine detection at TNO in the Netherlands. The projects cover the range from military applications to humanitarian demining. In the "conventional" detection systems area the activities on an instrumented prodder, metal detection, ground penetrating radar thermal infrared are covered. Signal processing and sensor fusion are key activities in this area. The focus for these techniques is on vehicle mounted and airborne multi-sensor systems. The activities are supported by more fundamental modelling of the interaction of sensors with the landmines. Especially the effects of the environment of the mines (background clutter, scenario) on this interaction are taken into account. [C432]

"Results of, measurements, processing and modelling of GPR data showing the effect of soil moisture content on land-mine detection"

Summary form only given. To be able to predict the performance of a ground penetrating radar system (GPR) under certain environmental conditions, one needs to relate the parameters that predominantly determine the environment, to parameters that directly govern GPR performance. Soil type and soil water content are such environmental parameters. The latter is determined by prevailing (and historic) weather conditions and has a large effect on the electrical permittivity and conductivity of the soil medium. Thus, by relating soil water content to electrical permittivity and conductivity one can gain a better understanding of GPR performance and in principle could even predict GPR performance. For the purpose of land-mine detection it is advantageous to be able to have some idea of GPR performance under given circumstances. Knowledge about the environment will influence the choice of sensor and the moment in time, the de-miner wishes to deploy the GPR as mine detection sensor. In the summer of 2002 detailed GPR measurements were taken at the TNO Physics and Electronics Laboratory (TNO-FEL), mine-detection test-facilities. These measurements were executed under relatively dry as well as moderately wet conditions, in both sand and grassy soils. Data acquisition was done on a high-density grid with several GPR systems. The test facility contains a number of moisture conditions to GPR measurements. In this paper we will illustrate the effect of soil moisture content of different soil types, on the detection of buried land-mines, and compare this with the outcome of a numerical GPR model which takes moisture level and soil type into account. [C433]

"A new bistatic GPR system using a passive optical sensor for landmine detection"

A novel GPR system for stand off landmine detection is discussed. This is a bistatic GPR system, which use a TEM horn antenna for a transmitter and a passive optical electrical field sensor as a receiver. A small size passive optical sensor scans on the ground surface and the acquired signal is used for synthetic aperture processing. Since the receiver is very small, it is suitable for scanning near the ground surface, where landmines can be buried. Fundamental laboratory test shows its capability of imaging of buried objects. [C434]

"Full-polametric video impulse radar for landmine detection: experimental verification of main design ideas"

A full-polarimetric ultra wideband GPR front-end has been developed in IRCTR especially for landmine detection application. A number of new ideas have been implemented in the design. A principally new antenna system design and an ability to perform quasi-simultaneous measurements with two transmit polarizations and in two different frequency bands are main novelty aspects of the radar. Additionally in comparison with commercial available video impulse GPR systems the front-end has considerably larger bandwidth, ability to measure polarimetric structure of the scattered field and very high precision of scattered field measurements. Experimental verification of these new design ideas is discussed in this paper. [C435]

"Analysis of target responses and clutter based on measurements at test facility for landmine detection systems located at TNO-FEL"

Target responses and natural clutter have been analyzed based on GPR measurements performed in July 2002 at the test facilities for landmine detection systems located at TNO-FEL. The object responses of four different

types of antipersonnel mines (surface laid and buried at depths of one, five and six centimeters) in three different types of ground have been analyzed for different polarizations of incident and scattered wave, for different pulse durations and for different antenna configurations. Clutter levels have been defined for two different presentations of raw data and have been determined for three different types of ground. It is shown that detectability of targets by GPR is limited not by the sensitivity or the dynamic range of the radar, but by the clutter. It is demonstrated that it is possible to detect targets below clutter level using the statistical data analysis. [C436]

"Processing and analysis of polarimetric ground penetrating radar landmine signatures"

The paper presents an analysis of landmine signatures acquired with a polarimetric ground penetrating radar (GPR). First, preprocessing was applied to isolate the target signatures from other reflection events. This included a frequency-wavenumber (f-k) filter to remove unwanted side reflections, followed by background subtraction to remove the direct wave and the ground reflection. The obtained polarimetric signatures of the landmines indicated that these can contain significant cross-polar components, which is in contrast to expectation for a target with a cylindrical casing and most likely a result of internal structure. Making use of the reciprocity property of the scattering matrix, the polarimetric signatures were transformed into the target frame, yielding signatures that are independent of target orientation. From the transformed signatures target impulse responses were estimated using a newly developed deconvolution algorithm. The novelty of the deconvolution algorithm lies in the fact that it computes impulse responses, which adhere to a physical model. Accordingly, the computed impulse responses can be related to mine properties such as size and dielectric permittivity. An interesting application of this is the estimation of a mine's permittivity from its impulse response and the impulse response of a calibration target, of which an example is given. [C437]

"MINETECT"

This paper describes the MINETECT, combined MD and GPR mine detector, sponsored by the UK Department for International Development and developed by ERA Technology. Using a radically different patented approach from conventional GPR designs, in terms of the man machine interface, MINETECT offers simplicity of use and affordability, both key factors in humanitarian demining operations. The ground penetrating radar employs novel operator audio interface techniques embodied in European patent number 99306164.7. This paper describes the design concept, summarises the trials carried out and provides the conclusions as to requirements for GPR performance. [C438]

"Phase-based detection of small 3-D dielectric objects beneath rough surfaces"

This paper discusses the detection of small three-dimensional (3-D) dielectric objects with low contrast (relative to their surrounding media) buried near the 3-D rough ground surface by means of stand-off ground penetrating radar. This case scenario was derived from the requirements on detecting small non-metallic anti-personnel (AP) mines in realistic minefields, where AP mines are buried a few centimeters beneath rough ground surfaces. If the dielectric contrast between the objects and their surrounding media is low, and if the objects are small and buried just beneath rough ground surfaces, then scattering from the rough ground surfaces will dominate and hence mask the weaker scattering from these buried objects. Various analyses and numerical simulations have shown the considerable complexity of scattering from rough surfaces and/or the targets buried beneath rough surfaces. In this paper, we present the methodology using measured GPR phase data to deal with this complex problem without using a-priori knowledge about the target and/or ground characteristics. [C439]

"Buried land mine detection using complex natural resonances on GPR data"

In this paper, we discuss a modified Prony's algorithm for use in buried land mine detection from ground penetrating radar (GPR) data. The algorithm finds the dominant complex natural resonances (CNRs) for vectors of time-domain GPR data. We consider the identification of objects present in two-dimensional images. The CNR features of an unknown image are processed through distance-based detectors with the CNR features of known objects from an object library. We analyze our algorithm performance versus SNR and also analyze performance for different distance detectors. [C440]

"Effective clutter removal for detecting non-metallic mines in various soil fields"

In this paper, an effective method for removing the clutter effects from the data collected using a stand-off impulse GPR with a small electromagnetic probe is presented. The method requires no a priori knowledge about the target and/or ground characteristics. Essentially, it combines successive processing and spatial variable moving averaging (SVMA) to eliminate the clutter and to enhance the detection of small land mines shallowly buried in different soils. In addition, this method can use measured GPR data to infer the effective soil permittivity. [C441]

"Host medium transformation of the early-time radar response of a buried dielectric target"

This paper addresses the problem of predicting the early-time radar response of a low-metal content landmine buried in a lossy soil given its response in a lossless soil. To make the problem tractable, we consider plane wave scattering from a homogeneous dielectric target embedded in a layered host medium with a global loss model. Using similarity analysis and the Born approximation, a transformation law for the scattered field is derived which relates the early-time target response in the lossy host medium to that in a corresponding lossless host medium. We also present a transformation law for the target impulse response, which follows directly from the transformation for the scattered field. The derived transformation law is tested using early-time responses of a mine-like target obtained from 3D finite-difference time-domain (FDTD) simulations. Based on these tests, the ability of the transformation law to predict changes in the early-time response of a non-metallic landmine as a result of changes in the electromagnetic properties of the host medium is discussed. [C442]

"Landmine detection by a broadband GPR system"

Most of the landmine detection techniques by GPR use a monostatic type radar system, which is suitable for detecting landmines buried in shallow soil, which is normally less than 10 cm. The shallow target is difficult to detect by conventional GPR due to its low range resolution. We developed a broadband Vivaldi type antenna, which operates at 1GHz-10GHz. Using this antenna, we made a prototype of a GPR system, which operates at 2GHz-5GHz. By scanning the antenna on a 2D plane, we could obtain clear 3-D images of mine-like targets buried in dry sand. We proposed an array signal processing technique using CMP method, and found it is effective for rejection of the ground surface clutter, even if the ground surface has roughness. [C443]

"Multi-waveform full-polarimetric GPR for landmine detection"

A full-polarimetric ultra wideband GPR front-end has been developed in IRCTR especially for landmine detection application. A number of new ideas have been implemented in the design. A principally new antenna system design and an ability to perform quasi-simultaneous measurements with two transmit polarization and in two different frequency bands are main novelty aspects of the radar. Additionally in comparison with commercially available video impulse GPR systems the front-end has considerably larger bandwidth, ability to measure polarimetric structure of the scattered field and very high precision of scattered field measurements. [C444]

"Ultra wideband endfire synthetic aperture radar for landmine detection"

The detection of landmines is an important and challenging application for remote sensing technologies. The use of ground penetrating radar is an established technique but requires close coupling between the antennae and the ground and generally suffers from a poor area coverage rate. In order to clear mines rapidly along a route using a vehicle mounted system, a forward looking sensor is required that can operate effectively in a stand off configuration and detect surface laid, flush and buried mines. Reliable detection is required against a background of vegetation and other, surface and buried mines. Reliable detection is required against a background of vegetation and other, surface and buried, clutter. The Remote Minefield Detection System (REMIDS) is a technology demonstration programme funded by the UK Ministry of Defence designed to use an Ultra Wideband Synthetic Aperture Radar (UWBSAR) and a polarimetric infrared camera. The UWBSAR is a 3GHz bandwidth impulse radar with onboard data collection and offline image processing. The UWBSAR has been successfully trialled against landmines. Previous trials have mounted the radar on an airship and employed a conventional side-looking imaging geometry. In contrast, for the trials reported in this paper, the radar was amounted on a trolley to simulate a ground vehicle and operated in a forward-looking mode. The resulting use of an endfire synthetic aperture radar rather than the more conventional broadside aperture is the principal development reported in this paper. This coarsens the resolution and introduces a left-right ambiguity into the data. Previous trials have also highlighted the lack of a comprehensive data set containing controlled targets and a range of clutter conditions. The current trials were therefore conducted on a purpose built 80m test track which contained five different soil types, a range of surface conditions and over 200 targets of varying types and burial depth. The trials campaign collected over 500 data sets by varying the conditions of data collection in terms of polarisation, antenna height, antenna separation, incidence angle, power levels and pulse repetition frequency. The experimental configuration allowed the track of the platform to be repeated to sufficient accuracy to allo- w the synthesis of multiple baselines in the vertical and horizontal. The principal conclusions from the trials analysis are 1) that the data set collected is of good quality and comprehensive in terms of targets and background; 2) the endfire synthetic aperture configuration worked as anticipated; and 3) the left-right ambiguity can be resolved if a suitable antenna configuration is used. [C445]

"Impact of ground clutter on buried object detection by ground pentertaing radar [Cpentertaing read

penetrating]"

We performed careful analysis of the measure data to determine the clutter level and responses of different targets in different types of soils under different environmental conditions. We found that even in a dry sand ground clutter level is higher than responses of many types of antipersonnel mines. As a result, the signal-to-clutter ratio for GPR targets becomes nonsufficient for reliable detection by widely used detection procedures. A new detection algorithm, which should partly overcome this problem, has been developed. The performance of the algorithm on real GPR data is encouraging. [C446]

"Characterization of shallow underground targets using wideband microwave reflectometry"

In this paper, the use of a combined signal processing technique of target discrimination for the step-frequency ground penetrating radar is investigated. To construct the radar range profile from the backscattered signal, a real part of the inverse discrete Fourier transform is multiplied by the pseudospectrum obtained from the same data via eigenvector method. The signatures of small underground objects can be subdivided in four categories designated conditionally as front wall; back wall; inclusion of high density; inclusion of low density. Experimental studies have shown that the technique is valid for both strong and weak scatterers. The approach can be extended to the discrimination of complex targets such as landmines by creating a set of templates. [C447]

"Transient ultra wide band measurement applications: radar cross section, synthetic aperture radar, electromagnetic compatibility"

The Electronic Armament Centre (CELAR: Centre d'Electronique de L'Armement) and the Research Institute of Microwave and Optical Communications (IRCOM: Institut de Recherches en Communications Optiques et Micro-ondes) has evaluated the use of ultra-wide-band (UWB) short pulse measurement facilities to characterize target electromagnetic signatures. A first device is capable of determining the radar cross section (RCS) within a 200 MHz to 1.2 GHz frequency band. A second device, an UWB synthetic aperture radar (SAR), is dedicated to pulse measurements on outdoor targets (buried mines) and low frequency clutter. These transient techniques are soon used for EM coupling applications on various systems. [C448]

"Timed-neutron detection for land mines"

We describe a new and novel means for detecting nonmetallic land mines. Timed neutron detection (TND) utilizes the unique neutron-moderating properties common to most explosives and all polymers and incorporates timing aspects to improve the measurement process. TND offers the possibility of a low-cost detector for non-metallic land mines with small radiation exposure. Experimental results with actual land mines and simulants are described. Computer simulations provide an understanding of how the performance of detectors based on this approach will be affected by environmental and operator parameter variations. [C449]

"Reconstruction algorithm for object determination from ultra-wideband field data"

An inverse obstacle scattering method is presented for reconstructing the shape and effective constituent material parameters of a buried dielectric object from measured scattered field data collected above the surface of an air/ground interface. A forward model is developed based upon the linearised Born approximation and the dyadic Green's function for a single homogeneous medium. The forward model is filtered for noise using the Tikhonov regularization operator and then inverted and back propagated. Experimental results are provided to illustrate the steps involved and the performance of the inverse scheme to extract constituent material parameters. [C450]

"Fuzzy C-means and mathematical morphology for mine detection in IR image"

Detection and clearance of a buried are difficult problems with lots of environmental and economical implication. In this work, the mine detection is tackled in a broader context of preprocessing and texture segmentation for the data associated with infrared sensor. Principal component analysis is used to enhance the contrast by extracting the whole dynamic information contained in a sequence of images. Texture parameters, and fuzzy C-means clustering method are proposed to segment background and mine like objects. For the residual clutter in a segmented image, a post-processing step is employed based on morphological reconstruction filter that yields accurate detection result [C451]

"High resolution image reconstruction by GPR using MUSIC and SAR processing method for landmine detection"

Landmine detection is a difficult and very sensitive task as it may cost a human life even with a slight mistake or

misdetection. In addition, the invention of non-metallic landmines made the scenario much more complicated and difficult. Various landmine detection techniques have been proposed, such as a metal detector, an electromagnetic induction (EMI), and so on. However, the probability of false alarm is very high in such techniques, which is considered as a sever problem. In this paper, ground penetrating radar, which has the capability to detect the non metal and the plastic mines, has been proposed to detect landmines. In addition, super resolution technique MUSIC algorithm and SAR (Synthetic Aperture Radar) has been implemented for the signal processing and image reconstruction of a GPR signal. [C452]

"Multi-Waveform SFCW radar"

A Stepped Frequency Continuous Wave radar for detecting flush buried and surface laid anti personnel landmines was designed and built. The system covers a frequency band from 400 MHz up to 4845 MHz. The range resolution is 3.4 cm and the maximum unambiguous range is 4.3 m. The antenna set up is a bi-static one with two Archimedean spirals with opposite sense of rotation. A particular property of the radar is that it transmits and receives a set of eight frequencies at the same time. The system parameters are particularly aimed at imaging algorithms exploiting the phase evolution over the antenna footprint. An example of the result achieved after Synthetic Aperture Radar processing is presented. [C453]

"Multi-Waveform Full-Polarimetric Video Impulse Radar for Landmine Detection"

A principally new multi-waveform full-polarimetric front-end of a Ground Penetrating Radar has been developed. In comparison with commercially available video impulse GPR systems the key advantages of the front-end are considerably larger bandwidth, ability to measure the polarimetric structure of the scattered field and very high precision of scattered field measurements. A principally new antenna system design and an ability to perform quasi-simultaneous measurements in two different frequency bands with two transmit polarizations are main novelty aspects of the radar. [C454]

"Gambit MCM AUV: overview and system performance"

The Marine and Acoustics Centre (MAC) at QinetiQ Bincleaves is currently pioneering MCM research and development in support of the UK MoD by undertaking a programme of work focussed on developing and demonstrating MCM surveillance and reconnaissance from an AUV. It is recognised that MCM operations impose key demands on vehicle and sensor performance levels, with recent analysis highlighting four main areas of essential capability, which form the main focus of the research programme. These areas are: the ability to correctly detect and classify targets; the ability to accurately determine the location of targets; the ability to cope with unexpected events, obstacles and environments, whilst still delivering the required mission level performance; the ability to communicate findings/provide suitable connectivity with other military assets. To meet these needs the following major technologies have been integrated onto the vehicle platform: Wideband high frequency Synthetic aperture sonar (SAS) offering near photographic imagery of the seabed at long ranges; Nonacoustic sensors in the form of a 9-axis magnetic gradiometer for buried mine detection; Advanced navigation combining high-grade INS and MCM sensor data to improve the accuracy and robustness of the overall navigation solution; On-board computer aided detection and classification algorithms to provide a high probability of detection and low false alarm rates; 3-dimensional forward looking sonar; High data rate acoustic communications optimised for operation in shallow water; Vehicle autonomy for sensor optimisation, collision avoidance, communications scheduling and run-time mission replanning; Network enabled capability for inclusion of the threat information into the wider battlespace picture. Forming part of a joint UK/US collaborative programme these sensors and processing techniques are currently being integrated in a phased approach onto the Gambit AUV, a vehicle based on the Bluefin Odyssey III platform. Supporting the procurement of a future UK MCM capability, the overall aim of the Gambit AUV is to demonstrate the completion of a high performance MCM reconnaissance mission. This paper will present an overview of vehi- cle, the key technology areas being addressed in the programme with examples of data gathered during sea trials. [C455]

"Cognitive maps in swarm robots for the mine detection application"

Navigation based on cognition is seen in many instances in the animal community. Maps are very useful for navigation in unknown and complex environments. User defined and preinstalled maps can be very useful in navigation in complex environments, while adaptively built maps become very essential in unknown environments. Intelligence is bestowed in the effective utilization of data to produce decisions. In the case of navigation, intelligence is seen when information collected en-route from a source to a destination is used judiciously in reaching the destination. In this paper we deal with the foraging of a piece of terrain as a process of navigation. The application here is on mine detection. Mines are placed over a field at unknown locations and swarm intelligence based agents are deployed for demining them. The efficiency of the demining process is

measured in terms of the quickness with which they can clear the mines and the assurance that the minefield is clear of all of the mines at the end of the process. Simulation results acknowledging the performance under different working conditions of the swarm robots are presented. In an endeavor to substantiate our claims in simulation we decided to build swarm robots performing the task on an artificially developed environment. [C456]

"The current opinion on the use of robots for landmine detection"

Anti-Personal landmines are a significant barrier to economic and social development in a number of countries. Several sensors have been developed but each one will probably have to find, if it exists, a specific area of applicability, determined by technological as well as economical or even social factors, and possibly other sensors to work with using some form of sensor fusion. A significant issue concerns the safety of the deminer. For every 5000 mines removed, one deminer is killed. The design of an accurate sensor may reduce the amount of time needed to determine whether a landmine exists, but does not increase the safety of the deminer. Since the safety issues during the eradication process are of great concern, the use and integration of cheap and simple robots and sensors in humanitarian demining has been raised. This removes the deminer from close contact with mines. This paper is concerned mainly with the work that has been done in the area of robotics and landmine detection, the problems involved, the issues that have been overlooked and the future of robots in the field. [C457]

"3-D image reconstruction from near-field coherently scattered waves"

This work presents a rigorous mathematical derivation of an effective approximate solution to the near-field 3-D inverse scattering/imaging problem for a system where the coherent signals are transmitted, and the scattered signals are subsequently received at individual transmitters and receivers. Potential applications of this technology include a variety of sub-surface imaging modalities such as: UHF foliage penetrating SAR, ground penetrating radar for land mine detection, and electromagnetic millimeter-wave scanning for concealed weapon detection. [C458]

"Robust recruitment near the edge of chaos and an application to mine sweeping"

The field of robotics is in rapid development. As robots become cheaper to build, new applications involving many robots systems can be envisioned. One reason for using many robots is to achieve robustness. Having many robots, however, does not ensure robustness. A control strategy and robot behaviors must be engineered to incorporate robustness into the system. Swarm intelligence based approaches are popular for developing optimal and robust control strategies for systems of robots. Here we analyze the behavior of a swarm of robots modeled after a swarm of ants, where tasks are spatially distributed in the environment and robots/ants are recruited through short-range recruitment. For ants that move probabilistically in response to the short range signal and who adjust their probabilities such that they are near a phase change boundary, or edge-of-chaos, in the mean field analysis of their motions, we find a significant improvement in the robustness of the system. [C459]

"Foraging in ant colonies applied to the mine detection problem"

This paper focuses on the application of swarm intelligence to the problem of mine detection. Swarm intelligence concepts have captured the interest of research mainly in collective robotics, optimization problem and communication network routing (Bonabeau et al., 1999). In the mine detection problem we are faced with subproblems such as searching for mines over the minefield, defusing then effectively and assuring that the field is clear of mines within the least possible time. In this paper, we study the ant colony system applied to the mine detection problem. We highlight a certain formulation that the ants (the agents in our case involved in mine detection) are given for executing the task effectively. Heuristics based on cognitive maps in ants are used to achieve this. The agents do the task effectively when they are able to assure that the minefield is clear of the mines within the least possible time. [C460]

"Area-covering operation of a cleaning robot in a dynamic environment with unforeseen obstacles"

Area-covering operation is a special kind of path planning, which requires the robot path to cover every part of the workspace. Area covering is an essential issue for cleaning robots and many other robotic applications such as painter robots, land mine detectors, lawn mowers, and windows cleaners. In this paper, a novel biologically inspired neural network approach to area-covering operation with avoidance of unforeseen obstacles is proposed for a cleaning robot in a dynamic environment. The dynamics of each neuron in the topologically organized neural network is characterized by a shunting equation derived from a biological membrane model. There are only local lateral connections among neurons, thus the computational complexity depends linearly on the neural network size. The proposed approach is compared to fuzzy logic based, rule based and re-planning

based models. It shows that the proposed model is capable of planning more reasonable and shorter area-covering path with obstacle avoidance. The proposed model algorithm is computationally efficient, and can also deal with changing environments. [C461]

"Local exploration: online algorithms and a probabilistic framework"

Mapping an environment with an imaging sensor becomes very challenging if the environment to be mapped is unknown and has to be explored. Exploration involves the planning of views so that the entire environment is covered. The majority of implemented mapping systems use a heuristic planning while theoretical approaches regard only the traveled distance as cost. However, practical range acquisition systems spend a considerable amount of time for acquisition. In this paper, we address the problem of minimizing the cost of looking around a corner, involving the time spent in traveling as well as the time spent for reconstruction. Such a local exploration can be used as a subroutine for global algorithms. We prove competitive ratios for two online algorithms. Then, we provide two representations of local exploration as a Markov Decision Process and apply a known policy iteration algorithm. Simulation results show that for some distributions the probabilistic approach outperforms deterministic strategies. [C462]

"Detection of land mines using hyperspectral sensom"

First Page of the Article [C463]

"Multi-waveform SFCW radar"

A stepped frequency continuous wave radar for detecting flush buried and surface laid anti personnel landmines was designed and built. The system covers a frequency band from 400 MHz up to 4845 MHz. The range resolution is 3.4 cm and the maximum unambiguous range is 4.3 m. The antenna set up is a bi-static one with two Archimedean spirals with opposite sense of rotation. A particular property of the radar is that it transmits and receives a set of eight frequencies at the same time. The system parameters are particularly aimed at imaging algorithms exploiting the phase evolution over the antenna footprint. An example of the result achieved after synthetic aperture radar processing is presented. [C464]

"Multi-waveform full-polarimetric video impulse radar for landmine detection"

A principally new multi-waveform full-polarimetric front-end of a Ground Penetrating Radar has been developed. In comparison with commercially available video impulse GPR systems the key advantages of the front-end are considerably larger bandwidth, ability to measure the polarimetric structure of the scattered field and very high precision of scattered field measurements. A principally new antenna system design and an ability to perform quasi-simultaneous measurements in two different frequency bands with two transmit polarizations are main novelty aspects of the radar. [C465]

"Calibration procedures of a stepped frequency continuous wave radar for landmines detection"

This paper deals with the calibration procedures for stepped frequency continuous wave radar, which operates from 400 MHz to 4845 MHz and transmits 128 frequencies in steps of 35 MHz. Because it is a continuous wave radar the information about distance is included in the phase variation of the received signal, so the behavior of the antenna is a very important issue. Two Archimedean spiral antennas have been employed for this radar. As it is known, spiral antennas show a dispersive behavior, thus, in the time domain, a "chirp" pulse will be displayed at the output. The calibration of the system has to correct the phase dispersion produced within the system. In order to identify the phase dispersion given by the antenna, a reference metallic plate is placed at a certain distance. The received signal is passed in the time domain by applying an IFFT, the multiple reflections are removed and the phase variation due to the time propagation is subtracted. After phase correction, the time domain response, as well as the side lobes level, are decreased. [C466]

"Some experience with the use of spiral antennas for a GPR for landmine detection"

Ground penetrating radars for detection of antipersonnel landmines operate in a UWB domain from 400 MHz up to 5 GHz. One of the radar concepts for this kind of application is a stepped frequency CW radar. The requirements on the antenna for this radar is, that it shall have a stable phase centre, frequency independent gain, ultra-wide band, high isolation between the two antennas in a bi-static arrangement and other more common requirements like a low VSWR. The antenna selected for the application is an Archimedean spiral. Such an antenna has a wide beam width and a radiation pattern only slightly dependent on frequency. A basic problem to the use of a spiral antenna when it is elevated above the ground is that the small contribution of the anti personnel mine is surged by the strong reflection off the air/ground interface. This paper is addressing this

effect by analysing the impact of the size of the antenna footprint on the SAR-synthesised three dimensional image of the subsurface. Experimental results like the ones presented here are not available to the authors' knowledge elsewhere in the open literature. [C467]

"Non-uniform information dissemination for sensor networks"

Future smart environments are characterized by multiple nodes that sense, collect, and disseminate information about environmental phenomena through a wireless network. In this paper, we define a set of applications that require a new form of distributed knowledge about the environment, referred to as non-uniform information granularity. By non-uniform information granularity we mean that the required accuracy or precision of information is proportional to the distance between a source node (information producer) and current sink node (information consumer). That is, as the distance between the source node and sink node increases, loss in information precision is acceptable. Applications that can benefit from this type of knowledge range from battlefield scenarios to rescue operations. The main objectives of this paper are two-fold: first, we precisely define non-uniform information granularity, and second we describe the different protocols that achieve non-uniform information dissemination and analyze these protocols based on complexity, energy consumption, and accuracy of information. [C468]

"Evaluation on effect of errors on haptic information in wireless communication system"

In recent years, haptics, robotic and networking technology advancements bas brought about networking of various systems. As a result, the spotlight was placed on humanitarian assistance using networks, for example, remote robotic manipulation, which allows for remote surgery and removal of hazardous materials such as landmines and explosives. Most of the research done on robotic manipulation had been carried out using a wired system. Although, there are few researches done with wireless systems, they are not developed for complicated systems such as a robot hand simulating human hand. Using a bilateral robot hand, we have simulated a wireless network through introduction of errors. The bilateral robot hand is compliance-controlled, in which position information is transmitted from the master robot hand to slave robot hand, while force information is transmitted back from the slave robot hand to the master robot hand. Errors were inserted into each of the transmitted information. By evaluating the position trace of simulation and experimental results, we have concluded the effect of errors on haptic information. [C469]

"Proposal for automation of humanitarian demining with buggy robots"

Landmines represent a clear threat to the civilian population in war-ravaged countries, and hamper peacekeeping and reconstruction efforts. The seriousness of this issue demands immediate automation of the mine detection and removal tasks, but until now only partial mechanization has been available. This paper proposes a versatile and feasible automated system based on mobile platforms to improve humanitarian demining, taking into account field requirements. Details of the development of the mobile platforms are presented, as well as experimental results. Special tools and components, also briefly described, are under development in order to maximize the range of applications of this system. [C470]

"Evaluation of approximate analytical solutions for EMI scattering from finite objects of different shapes and properties"

UWB electromagnetic induction (EMI) sensing, from 10s of Hz up to 100s of kHz, is emerging as one of the most promising remote sensing technologies for discrimination of subsurface metallic objects. Progress is urgently needed to distinguish dangerous objects, such as unexploded ordnance, from innocuous clutter. Development of EMI signal calibration, interpretation, processing, and inversion have all been impeded by the lack of rigorous, reliable analytical solutions for any scatterer shape other than the sphere. Here we test a number of new approximate solutions and determine that most canonical geometries and common, homogeneous material compositions can be treated adequately by the simple formulations proposed. [C471]

"Detection and identification of landmines using electromagnetic induction spectroscopy"

Reducing the false alarm rate is one of the most outstanding problems in clearing landmines. A broadband EMI sensor combined with a spectral matching method, known as Electromagnetic Induction Spectroscopy (EMIS), has shown great potential to address this complex problem. The common EMIS discrimination approach is to match the spectrum of an unknown target to a library of known spectra. A broadband EM sensor works like a metal detector, but it can operate at multiple programmable frequencies suitable to a given geologic environment. Once it detects a potential target, the sensor will interrogate the target and measure its spectral responses over the entire operating bandwidth. The sensor will then compare the measured spectrum with a library of spectra stored for mines that are known or presumed to occur in the area. The process will generate a rank-ordered list

of spectral matches. We have developed and field-tested several spectral matching algorithms for detecting and identifying buried landmines. Recent EMIS test surveys at a controlled military site have produced a high detection rate at a very low false alarm rate. This paper will present results from the surveys including the spectral matching algorithms employed for the identification process. [C472]

"Model-based statistical sensor fusion for unexploded ordnance detection"

Detection and remediation of unexploded ordnance (UXO) represents a major challenge on closed, closing, and transferred military ranges as well as on active installations. The detection problem is exacerbated by the fact that on sites contaminated with UXO, extensive surface and sub-surface clutter and shrapnel is also present. Traditional methods used for UXO remediation have difficulty distinguishing buried UXO from these anthropic clutter items as well as from naturally occurring magnetic geologic noise, and thus incur prohibitively high false alarm rates. The reduction of the false alarm rate has proven to be the greatest challenge for UXO remediation. In this paper, sensor fusion techniques are applied to field data from magnetometer and electromagnetic induction (EMI) sensors in order to determine to what degree such an approach results in false alarm mitigation. The adoption of a model consisting of multiple non-colocated dipoles is shown to improve our ability to predict measured signatures. The results indicate that performance can be improved by limiting the processing bandwidth to those frequencies that are the most robust to naturally occurring geological noise. [C473]

"Optimization of migration method to locate buried object in lossy medium"

We present an optimized frequency-wavenumber (F-K) migration method to localize buried objects such as landmines in lossy medium. F-K migration has been proposed to find the location of a buried object using ground penetrating radar (GPR) data. This approach makes use of a wave equation in the Fourier domain to back-propagate the received wavefield. For GPR applications however, standard F-K migration assumes that the ground surface is flat and the medium is loss-free which are not true in reality. When implemented in the Fourier domain, the wave equation becomes the Helmholtz equation. It is then straightforward to incorporate a complex index of refraction in the Helmholtz equation to describe wave phenomenon in lossy medium. We generalize F-K migration to the case of rough ground surface and lossy medium. In the framework of Tikhonov regularization, we develop an algorithm that optimally alters the wave propagation velocity and the complex index of refraction to take into account of the ground roughness and lossy medium. In the process of searching the optimal velocity and complex index of refraction, the algorithm is constrained to produce an image of minimum entropy. By minimizing the entropy of the resulting image, better results are obtained in terms of enhanced mainlobe, suppressed sidelobes, and reduced noise. We use examples from field data to demonstrate the performance of our method. [C474]

"Application of broadband EMI responses to infer buried object's aspect ratio"

A new broadband electromagnetic (EMI) sensor, operating as lows as 10s of Hz and as high as 100s of kHz, has shown significant improvement for classification of buried metallic objects. EMI responses ("secondary" or scattered magnetic field) are characterized by two components, one inphase and another in phase quadrature with the primary field. Numerical and experimental investigations show that the frequency location of the quadrature peak in EMI scattered fields from metallic objects depends strongly on the major axis length ratio and on the object's orientation relative to the transmitted field. To illustrate potentially useful processing of EMI sensor data, this paper presents results of high fidelity numerical simulations to verify a theory for simple estimation of an object's aspect ratio based on the frequency location of the quadrature peak (permeable case). Results are shown for a permeable cylinder and spheroid. [C475]

"Treatment of broadband and multi-object electromagnetic induction scattering using high frequency approximations"

Wideband electromagnetic induction (EMI) sensing shows increasing capability and promise for characterizing subsurface metallic objects, such as UXO. While EMI has some advantages over radar, such as superior penetration of moist soil, the field problem is still difficult due to the frequent occurrence of multiple targets in close proximity. The numerical modeling problem, even for a single object, is complicated by the fact that transmitted ("primary") fields typically penetrate the target, but will often only do so slightly. In most of the established numerical treatments, the scale of discretization is dominated either by the dimensions of the thin subsurface layer of electrical activity, or, more or less equivalently, by the range over which a Green's function decays, based on the characteristics of the metal. Resolution at this scale is often computationally prohibitive, particularly for magnetic materials, even though external fields of interest have only mild gradients. We approach the problem using the Thin Skin Depth Approximation (TSA). The TSA assumes an exponential form for the internal normal magnetic field component, as a function of distance inwards from the object surface. Despite the

fact that it is designed to treat a state of affairs characteristic of relatively high EMI frequencies, results based on the TSA turn out to be accurate across the entire EMI band when the relative permeability of the scatterer material is high (e.g. as for steel). [C476]

"The inversion of subsurface VETEM data-theory and practice"

Very early time electromagnetic system (VETEM) is an efficient tool for the detection of buried targets in very lossy medium. In this paper, we will discuss the inversion of VETEM data using a combination of one-dimensional (1D) and three-dimensional (3D) inverse scattering techniques, where the Born iterative method and distorted Born iterative method have been applied. In order to expedite the 3D inversion, an extended Born-type approximation is made in the forward solver, together with FFT acceleration technique. The 1D inversion provides a gross image of the subsurface, but the 3D inversion helps to resolve the subsurface image better. [C477]

"Detection and imaging of small buried 3D non-metallic objects with multistatic phase-based GPR signatures"

In this paper the bistatic and monostatic phase-based ground-penetrating radar (GPR) technique for ingenious detection of poor-contrast scattering objects hidden just beneath the air-ground interface is discussed. This technique neither requires a priori knowledge about the background medium nor needs any pure background measurement. It was developed to deal with one of the worst-case scenarios in terms of landmine detection. The method was tested with the data measured from the L-band and S-band stepped-frequency continuous-wave GPR over the compound soil where small non-metallic mines are shallowly buried. The results demonstrate that it is feasible to detect small buried poor-contrast objects by using coherent phase processing and imaging. [C478]

"CNN-based 3D thermal modeling of the soil for antipersonnel mine detection"

The inherent analogies between the defining equation of CNN and that of heat transfer are well known. In this paper, we explore the projection of a 3D thermal model of the soil on this kind of structure. In so doing, reliable and fast prediction of the thermodynamic behavior of soil subject to known boundary conditions can be obtained. That way, it is possible to characterize different kinds of soil in terms of its thermal signature. Based on that knowledge, and using an inverse approach, we perform the detection of buried land mines. [C479]

"Adaptive difference of Gaussians to improve subsurface imagery"

In detection of landmines using ground penetrating radar (GPR), the most significant interference is the specular reflection. Compared with the specular reflection, landmine scattered signals are of small amplitude and difficult to observe. Better detection results can be obtained if the specular reflection can be well separated from the landmine scattered signals. Difference of Gaussians (DOG) is an operation that generates a sharp image from an original image, i.e. in the case of a GPR image, it keeps the specular reflection intact. Therefore by subtracting the DOG output from an original GPR image, we are able to remove the specular reflection and enhance the landmine scattered signals. The DOG takes the difference between two Gaussian curves of zero means and different standard deviations and convolves with the original image. One advantage of the DOG is that the two standard deviations can be chosen properly to suit different applications. We develop an adaptive DOG (ADOG) to process GPR images to improve detection of buried landmines. In the ADOG, the two standard deviations of Gaussians are computed adaptively as a GPR image is scanned from the top to the bottom row. At each row, two windows are used to calculate the two standard deviations and the current row is convolved with the DOG. The output has an unchanged specular reflection while there is a reduced landmine scattered signal. The final image is obtained by subtracting the ADOG output from the original image to remove the specular reflection. The landmine scattered signal is greatly enhanced, allowing more accurate detection. [C480]

"Advanced classification of buried UXO using a broadband, fully polarimetric ground penetrating radar"

A broadband, fully polarimetric ground penetrating radar (GPR) system has been applied for classification of buried unexploded ordnance (UXO) for the past few years. It utilizes both late-time and early-time signatures extracted from GPR data collected with multiple antenna positions and multiple scan orientations. Various field measurements were conducted from 1999 to 2001 at UXO sites that have quite different environmental conditions. Lessons learned from these tests have led to significant system improvements. [C481]

"A numerical study of the effects of realistic GPR antennas on the scattering characteristics from

unexploded ordnances"

The detection and classification of unexploded ordnances (UXOs) is a difficult task, and it is even further complicated by the fact that the ground penetrating radar (GPR) antenna can significantly distort the scattering signal from the UXO. We consider the model of the real antenna which will be used in the numerical study of scattering from UXOs. We consider a rigorous finite difference time domain (FDTD) model of a fully polarimetric horn-fed bowtie (HFB) antenna and study how various modifications of the parameters of the antenna can affect it performance. [C482]

"Landmine detection with nuclear quadrupole resonance"

Nuclear quadrupole resonance (NQR) technology for the detection of explosives is of crucial importance in an increasing number of applications. For landmine detection, NQR has proven to be highly effective if the NQR sensor is not exposed to radio frequency interference (RFI). Since strong nonstationary RFI in the field is unavoidable, a robust detection method is required. With the aid of reference antennas, a frequency domain LMS algorithm is applied to cancel the RFI in field data. An average power detector based on power spectral estimation algorithms is proposed and performance using both the periodogram and MUSIC algorithms is evaluated. The detection performance has been compared with that of a non-adaptive Bayesian detector. The experimental results show that, unlike the non-adaptive Bayesian detector, the average power detector provides perfect detection capability if the data segments involved in the collection process are sufficiently long. [C483]

"The planar near field antenna system for underground investigation"

This paper is concerned with the detection of underground objects, especially mines. They threaten civil life in many countries and are a serious problem for innocent people far from the hot-war. This work considers objects in the size range of 5-30 cm diameter, and the frequency band is selected to determine this size of mine. We investigate the antenna system and synthesis of the field pattern required. [C484]

"Quasi-ray Gaussian beam algorithms for subsurface sensing in the presence of a moderately rough air-soil interface"

A major source of variability in ground penetrating radar (GPR) interrogating signals is related to reflection from, and (double) transmission through, the rough unknown air-soil interface which obscures the useful target-scattered signals. These considerations motivated our recent investigations toward a more robust, physics-based, adaptive approach to subsurface imaging in the presence of a moderately (both in height and slope) rough air-soil interface. The proposed approach entails prior estimation of the deterministic gross features of the rough interface and subsequent exploitation of this information to enhance underground target imaging. So far, this approach has been applied to two-dimensional (2D) frequency-stepped and pulsed GPR configurations, for slightly lossy soils and low-contrast mine-like targets, yielding encouraging results. In this paper, we briefly review the proposed framework and discuss some representative results. [C485]

"Airborne sensor concept to image shallow-buried targets"

This paper develops an airborne sensor concept to detect and image shallow-buried targets with a focus on the remote sensing of landmines. Our ongoing ground-based bistatic ground-penetrating radar (GPR) experiments have demonstrated deep penetration and subwavelength resolution. Simulation software (ground penetrating radar processing-GPRP) was developed and validated using experimental results. Extrapolation of the experimental results to higher frequencies using the simulation software indicates the ability to provide high-quality images of shallow-buried targets. [C486]

"Mobile pneumatic robot for demining"

The enormous amount of anti-personal land mines scattered over many countries worldwide is a major humanitarian problem asking for an efficient solution at an affordable cost. The article describes a robust and low cost mobile robot that can transport equipment of about 1.5 times its own weight over natural terrains with inclinations superior to 40 degrees. The robot mechanical structure is optimised for precisely scanning large areas of natural environments with land mine detection sensors. The paper also describes the control architecture of the robot with the possibility to correct the motion direction. The land mine sensing system of the robot is presented. [C487]

"Design, implementation and testing of a prototype 1.1-2.1 GHz SFCW GPR for use in landmine detection"

The problem of undetected anti-personnel landmines is both of major political concern and a formidable engineering problem. Currently, no affordable, accurate method for detecting such mines exists. As a solution to the landmine problem this paper gives an account of the design, implementation and testing of an inexpensive, prototype 1.1-2.1 GHz stepped frequency continuous wave (SFCW) ground penetrating radar (GPR) for landmine detection. Initial tests performed in a laboratory based environment using a homogenous Styrofoam ground medium have shown that the design has the potential to accurately detect landmines in a field test situation. [C488]

"Near field analysis of a wideband log-spiral antenna for 1-2 GHz GPR"

A log-spiral antenna is described. It is part of the ultra-wideband stepped frequency ground penetrating radar (GPR) for subsurface landmine detection currently being developed at the University of Manitoba. Log-spiral antennas possess many features that are desirable in such a radar system: low profile, high bandwidth, and circular polarization. The design and construction of the antenna are described. The antenna is fitted with a wideband balun to balance the current between the two arms of the spiral. An absorber loaded cavity is used behind the antenna to help direct the energy into the ground and keep it from radiating into the air. A study of the far and near fields of the antenna, via simulations and measurements, is presented. The near fields are measured using short coaxial E-field probes at an electrically short distances from the antenna and agree well with simulations. [C489]

"An effective algorithm for subsurface SAR imaging"

For many applications in subsurface sensing (e.g., landmine detection or road inspection), it is important to make images of the shallow subsurface from the data acquired by a GPR with antennas slightly elevated above the ground. Classical SAR algorithms are not well suited to this purpose. A new SAR algorithm in the space-time domain for a multi-media propagation environment is proposed. In comparison with known algorithms, this algorithm is significantly simplified without loss of accuracy. The simplifications are based on a physical analysis of the sensing wave propagation. We also show that, for a multi-media background, it is not possible to determine correctly the depth of a scatterer and the speed of light in the ground from only one B-scan without additional information about the transverse position of the scatterer. [C490]

"Mapping of land mines using air borne radars"

The detection of land mines using an air borne radar is investigated. The relation between the height of the radar and the separation distance between regular linear distributed mines is obtained. Bistatic and monostatic radars are employed with different operating frequencies to detect the number of mines and their locations. An E-plane or H-plane horn antenna can be used during the simulation. [C491]

"Stand off detection of buried anti-personnel landmines"

A small, low powered, ultra wideband radar using a picosecond switching system has demonstrated the ability to produce radar images of surface laid landmines using an experimental rail SAR setup at a stand off range of 30 feet. [C492]

"Model-based principal component techniques for detection of buried landmines in multiframe synthetic aperture radar images"

Here we consider the use of model-based methods for the detection of buried objects from a sequence of synthetic aperture images obtained by a radar sensor moving linearly down a track. The scattering physics of the underlying sensing modality cause the relevant target signatures to change in a complex yet predictable manner from one image to the next. To arrive at a tractable processing scheme that exploits these motion-induced changes, we develop a flexible parametric model capable of capturing the full variation of these signatures. A detection scheme based on a principal components analysis of estimated model vectors is then derived. Results are demonstrated using field data from a forward-looking sensor. [C493]

"Detection of variable depth nonmetallic mines using ground penetrating radar"

First Page of the Article [C494]

"Voting fusion adaptation for landmine detection"

This paper presents a voting fusion application for use with a remotely controlled multisensor vehicle platform for antitank landmine detection. Data from three landmine detection sensors mounted at the front of the vehicle

enhance the probability of detection and, when combined via data fusion, limit the false alarm density to practical levels. The performance of the voting fusion scheme presented in this paper is contrasted with a heuristic data fusion approach developed by General Dynamics Canada. [C495]

"Entire region filling in indoor environments using neural networks"

Entire region filling is a special type of robot path planning strategy that requires the mobile robot to cover every part of the whole workspace, which has many applications such as cleaning robots, vacuum cleaners, painter robots, land mine detectors, lawn mowers, and window cleaners. In this paper, a novel biologically inspired neural network approach is proposed for entire region filling with obstacle avoidance of a mobile cleaning robot in a nonstationary environment. The dynamics of each neuron in the topologically organized neural network is characterized by a shunting equation or an additive equation derived from Hodgkin and Huxley's (1952) membrane equation. There are only local lateral connections among neurons. Thus the computational complexity linearly depends on the neural network size. The robot path is autonomously generated from the dynamic activity landscape of the neural network and the previous robot location. The proposed model algorithm is computationally efficient. It can deal with an unstructured environment with irregular obstacles. The effectiveness of the proposed model is demonstrated by simulation results. [C496]

"Application of artificial immune system based intelligent multi agent model to a mine detection problem"

Biological systems are sophisticated and intelligent information processing systems. They have inspired scientists and engineers to solve complex computational and information processing tasks. This paper presents a novel artificial immune system based intelligent multi agent model named AISIMAM. The model involves the behavioral management of artificial intelligence, namely multi agent systems and artificial immune systems. This paper outlines AISIMAM, concentrates on the mine detection application and discusses the results. [C497]

"Object detection for surface landmine with mobile robot"

Most landmine detection problems using mobile robots have been solved as a standard navigation and target identification problem implemented for the application of landmine detection. This paper solves the problem of landmine detection using low cost mobile robot from a direct perspective. Locating the object is solved using a grid based map and exhaustive search strategy that is effective in terms of accuracy. The advantage of this method is that the data reduction and analysis is done in real time. [C498]

"Wavelet based UXO detection"

The detection and classification of unexploded ordnance (UXO) is considered a multidimensional pattern recognition problem. Standard techniques in solving multidimensional detection and classification problems involve using large sets of templates or libraries. This paper shows that by using wavelet transformation a single library will allow a particular class of ordnance to be classified over a range of depths. [C499]

"Adaptive antenna for ground penetrating radar applications"

A concept of adaptive antenna for ground penetrating radar applications is presented. The adaptation is achieved with respect to the antenna footprint in the ground. The shape and size of the subsurface footprint of the antenna can be changed to improve detection and localization of buried targets. The adaptive antenna is based on a wire bow-tie structure since this structure makes it possible to switch on/off its wire elements in order to form a bow-tie antenna with certain flare angle. By adjusting the flare angle in this way, the shape and size of the subsurface footprint can be varied. [C500]

"Ultra wide band synthetic aperture radar for the detection of mined areas"

This article begins with a presentation of the concept of the ultra wide band (UWB) low frequency short pulse radar, its potential applications, advantages and limitations. To illustrate this, the article describes the work undertaken by the Centre Electronique de l'Armement (Defence Electronics Centre-CELAR) on the experimental UWB PULSAR radar for the detection of targets masked by vegetation and the measurement of clutter at low frequencies. Results of detection of mined areas are presented. [C501]

"A swarm intelligence based approach to the mine detection problem"

In this paper, we have applied a swarm intelligence based technique to a mine detection problem. Swarm intelligence techniques are used to model robotic agents to solve the problem. Studies made on the ant

colonies, which is a typical member of the family of swarms, are applied in devising the techniques for the agents. Ant colony models bestow intelligence not only at the individual level, but more at the collective level (the interactions produced by the individual members in trying to solve a common problem). An analysis of the results obtained with a computer simulation of the mine detection is also presented. [C502]

"Gryphon-I-buggy robot for field applications on uneven terrain"

The demand for mobile robots for hazardous field tasks, such as rescue operations in disaster scenes or landmine detection and removal has been increasing in recent years. Since electrical infrastructure is seldom available in such situations, robots that rely on chemical batteries or/and tethered connections to external electric generators suffer severe limitations in operation time and mobility. This paper presents a new approach, involving the use of a combustion engine for on-board electric energy generation. For practical purposes, the authors used a commercial 4-wheel buggy as the base platform. Mechanical adaptations in the steering, throttle, gearshift and brakes mechanisms were performed, and the developed mobile platform (Gryphon-I) can be computer controlled. This paper introduces new strategies for the control of Gryphon-I over uneven terrain, and the effectiveness of the proposed methods is evaluated experimentally. [C503]

"Image and signal classification for a buried object scanning sonar"

As US expeditionary forces address the threat of asymmetric weapons, greater efforts are being made toward development of mine countermeasure technologies. To locate stealthy buried mines, a unique adaptive acoustic system is being developed that combines image and signal classification algorithms using data collected with a broadband, multiaspect sediment volume imaging sonar. Initial testing of a joint Gaussian Bayesian image classification method is described, for which scalar and statistical features calculated from a selected image region are combined to optimize correct classification probabilities and minimize false alarm rates. Potential targets are identified in the acoustic image and passed to biomimetic signal classification algorithms that map time-frequency patterns into object class declarations. Two-category classification results are reported for a buried mine shape and clutter objects. [C504]

"Active broadband electromagnetic detection and classification of buried naval mines"

We present a new active broadband electromagnetic (EM) sensor to detect and classify buried naval mines. The sensor operates at multiple programmable frequencies suitable to a given littoral environment. Once the sensor detects a potential target, it measures the target's spectral responses over the entire operating bandwidth. The sensor then compares the measured spectrum with a library of spectra stored in mines that are known or presumed to occur in the area. Target classification based on the spectral fingerprints is called electromagnetic induction spectroscopy or EMIS. It is known that an EMIS spectrum depends on the object's shape and metal compositions in terms of electrical conductivity and magnetic permeability. Apart from detecting explosives, EMIS is the only rigorous, physics-based phenomenology for identifying buried mines. A major drawback of an active EMI sensor is its relatively short detection range. We have recently found, however, that we may able to significantly increase the range for a metallic mine embedded in a conductive medium (e.g. mines in saturated sediments), in comparison with the range for the same mine placed in the ground. We describe this potential range extension in terms of "current channeling" that occurs in the vicinity of a mine in a conductive medium. The current channeling response can be quite strong and, under some conditions, can exceed the eddy current response by nearly an order of magnitude, which can significantly increase the range for underwater mine hunting. [C505]

"Geo-location of detected landmines via mobile robots equipped with multiple sensors"

In the process of landmine remediation, it is necessary to determine the ground coordinates of the mines. This is needed for data association in the case of multiple looks by a single sensor as well as in the case of multiple sensors. It is also required for neutralizing the mine or marking it for avoidance. Earlier the work in this area treated the use of a single radar sensor. This has now been extended to include multiple sensors, forward-looking radar and infrared. It treats the process of combining these measurements for optimal estimation of the mine's ground coordinates as well as tracking the status of each mine with respect to each sensor's field of view. Results of simulations show significant benefits achieved by the use of the multiple sensors. [C506]

"Total variation regularized velocity estimation to image subsurface reflectivity"

We propose a modified frequency-wavenumber migration method to enhance subsurface imagery obtained by ground penetrating radar (GPR) array to localize buried landmines and other objects. The method aims to minimize the entropy of processed image by introducing different wave propagation velocity for each array element. The different wave propagation velocity is organized to form a velocity vector. On the other hand, by

constraining the total variation of the velocity vector, the method satisfies physics requirement that the velocity shall not change abruptly. The optimization scheme is built in the framework of Tikhonov regularization by selecting proper regularization parameter. We use examples obtained from 2-D GPR images. The frequency-wavenumber method and its optimization can be generalized to 3-D in a straight-forward manner. [C507]

"Development of mine detection robot COMET-II and COMET-III"

The present paper proposes two types of mine detection robots which are six-legged walking robot with two manipulators based on the added stability, mobility, and functionality. The COMET-II is a medium size, electric power driven robot. The COMET-III is a full autonomous robot which is driven by hydraulic power. The COMET-III has a crawler and six legs and its weight is 900 Kg, These improved robots will soon be engaged in the mine detection job in Afghanistan. [C508]

"Adaptive difference of Gaussians to improve subsurface object detection using GPR imagery"

We present an adaptive difference of Gaussians (ADOG) method to improve landmine detection from ground penetrating radar (GPR) imagery. GPR is widely used for a variety of subsurface sensing problems including landmine detection and localization. In most all applications, specular reflection from the air-ground interface is the most significant source of interference often eclipsing the returns from the buried object. From an image processing viewpoint, the specular reflection constitutes a sharp edge and the landmine reflected signals are more smooth and of low spatial frequency. As an edge-preserving method, the ADOG keeps the specular reflection intact and removes the object reflected signals. Then by subtracting the ADOG output from the original image, we eliminate the specular reflection and obtain an image with enhanced object reflected signals. Using the difference image, we can obtain better result in detecting buried objects. Results from applying our algorithm on a landmine detection application are used to demonstrate the performance of the method. [C509]

"Entropy optimized contrast stretch to enhance remote sensing imagery"

This paper presents a contrast stretch (CS) method based on minimum entropy constraint to enhance images obtained in remote sensing applications such as ground penetrating radar (GPR), synthetic aperture radar, and infra-red imagery. The CS enhances contrast of the low-contrast part of an image. In remote sensing, it is usually the desirable signals that are of low contrast while interference of high contrast. The CS modifies the original image such that pixel values above and below preset boundaries are set to Zero and the maximum possible pixel value and the pixel values falling between the boundaries are stretched out to enhance the contrast of the image. Using the CS we can enhance the contrast of desirable signals from, for example, a buried landmine or an object obscured by some interference. On the other hand, the CS inevitably enhances other parts of a remote sensing images, such as clutter and measurement noise. Therefore there is a trade-off in using the CS. It is beneficial to find the correct "cut-off" boundaries in the CS in some optimal sense. We propose using minimum entropy as a criterion of looking for the optimal CS parameter Using field data from GPR application, we show that improved image can be obtained which makes further processing such as detection more accurate. [C510]

"Pattern recognition for humanitarian de-mining"

Landmine detection has become a humanitarian problem of great magnitude. It is estimated that there are between 60 and 100 million landmines buried around the world and that someone is killed or injured by landmines every 20 minutes. Pattern recognition problems in this area are discussed. A brief overview of sensors used to collect data is given. Current pattern recognition methodologies in use are described. Future challenges are outlined. [C511]

"Probabilistic hierarchical spatial model for mine locations and its application in robotic landmine search"

One way to improve the efficiency of mine search, compared with a complete coverage algorithm, is to direct the search based on the spatial pattern of the minefield. This paper extends our original statistical approach (2001) to identify the regular pattern of a minefield at the beginning of the searching process. The extracted pattern parameters are used to build a probability distribution map of the configuration of the minefield. The map then can be used to guide the search for more mines efficiently. The new approach can efficiently capture the systematic and accumulated random departure of the actual mine locations from the grid pattern caused by the inaccuracy of the translational and rotational motion of the mine layer. Online implementation of our approach on a mobile robot is feasible. [C512]

"Development and control of a buggy robot for operations on unstructured terrain"

The demand for mobile robots for hazardous field tasks, such as rescue operations in disaster scenes or landmine detection and removal has been increasing in recent years. Since electrical infrastructure is seldom available in such situations, robots that rely on chemical batteries or/and tethered connections to external electric generators suffer severe limitations in operation time and mobility. A different approach is being sought in this research, which involves the use of a combustion engine for on-board electric generation. For practical purposes, the authors used a commercial 4-wheel buggy as the base platform. Some mechanical adaptations in the steering, throttle, gearshift and brake mechanisms were performed, and the developed mobile platform (Gryphon-I) can be computer controlled. This paper introduces new strategies for the control of Gryphon-I over uneven terrain, and the effectiveness of the proposed methods is evaluated experimentally. [C513]

"Real-time area-covering operations with obstacle avoidance for cleaning robots"

An area-covering operation is a kind of complete coverage path planning, which requires the robot path to cover every part of the workspace, which is an essential issue in cleaning robots and many other robotic applications such as vacuum, robots, painter robots, land mine detectors, lawn mowers, and windows cleaners. In this paper, a novel biologically inspired neural network approach is proposed for complete coverage path planning with obstacle avoidance of a cleaning robot in a nonstationary environment. The dynamics of each neuron in the topologically organized neural network is characterized by a shunting equation or an additive equation derived from Hodgkin and Huxley's (1952) membrane equation. There are only local lateral connections among neurons. Thus the computational complexity linearly depends on the neural network size. The proposed model algorithm is computationally efficient, and can also deal with changing environment. Simulation results show that the proposed model is capable of planning collision-free complete coverage robot path. [C514]

"UWB multi-static SAR with image stackng for land mine detection"

We investigate techniques for improving the signal to clutter ratio of an ultra wide-band SAR designed to detect small mine-like objects in the surface of the ground. In particular we collected images using different bistatic antenna configurations in an attempt to decorrelate the clutter with respect to the targets. The images were converted to a reference depression angle, summed, and then converted to ground coordinates. The resulting target strengths were then compared with the amplitude distribution of the ground clutter to show the improvement obtained. Use of the bipolar response to further enhance target to clutter ratios was also considered. Whilst some improvement was demonstrated, this was for the relatively easy scenario of targets on the surface partially obscured by grass. [C515]

"A multifrequency SFCW radar for humanitarian demining"

IRCTR has developed and built a novel design of a stepped frequency continuous wave radar for humanitarian demining. The radar has the important property that it transmits signals at eight frequencies at the same time. Due to this fact and the use of a DDS for the basic signal generation, the total data acquisition time for collecting a set of data sufficient for one synthesized range profile is only 3.3 msec. The total bandwidth of the system is 4445 MHz. The electrical performance allows for sidelobes in the synthesized range profile of better than -50 dB RMS. The bistatic antennas are Archimedean spirals with dual arms. They are balanced and symmetrically fed. The paper shows the diagram of the prototype of the antenna. [C516]

"Wide swathe multi-channel GPR systems for mine detection"

Many national and international programmes are underway to develop more effective detection and clearance system for buried mines. Results from the US national programmes on mine detection suggest that radar can outperform conventional metal detectors, which only respond to the metal content of a mine and hence are insensitive to minimum metal mines. Radar, and in particular ground penetrating radar, used in conjunction with other sensor arrays can result in a improved fused performance in terms of reduced false alarm rate. This paper reviews some key aspects of the performance of radar as a wide swathe sensor, in particular the system design, antenna characteristics, signal and image processing as well as detection performance. Examples of the radar images of mines and the factors that influence the image quality are presented. Current demonstrator radar systems can detect buried AT mines with some confidence, but the reliable detection of AP mines will require further development of antennas, clutter rejection algorithms and target detection methods. [C517]

"High-resolution full-polarimetric video impulse radar for landmine detection"

A full-polarimetric ultra wideband GPR front-end has been developed. The front-end is suitable for subsurface imaging with resolution sufficient for antipersonnel mine detection and recognition. In comparison with

commercially available video impulse GPR systems the key advantages of the front-end are considerably larger bandwidth, ability to measure the polarimetric structure of the scattered field and very high precision of scattered field measurements. A principally new antenna system design and an ability to perform quasi-simultaneous measurements with two transmit polarizations and in two different frequency bands are main novelty aspects of the radar. [C518]

"Radar 2002 (IEE Conf. Publ. No.490)"

First Page of the Article [C519]

"A real-time cooperative sweeping strategy for multiple cleaning robots"

In this paper, a cooperative sweeping strategy of complete coverage path planning for multiple cleaning robots in a time-varying and unstructured environment is proposed using biologically inspired neural networks. Cleaning tasks require a special kind of trajectory being able to cover every unoccupied area in specified cleaning environments, which is an essential issue for cleaning robots and many other robotic applications. Multiple robots can improve the work capacity, share the cleaning tasks, and reduce the time to complete sweeping tasks. In the proposed model, the dynamics of each neuron in the topologically organized neural network is characterized by a shunting neural equation. Each cleaning robot treats the other robots as moving obstacles. Multiple cleaning robots can cooperate to achieve a common sweeping goal effectively. The robot path is autonomously generated from the dynamic activity landscape of the neural network, the previous robot location and the other robot locations. The proposed model algorithm is computationally efficient. The feasibility is validated by simulation studies on three cases of two cooperating cleaning robots. [C520]

"Laser Doppler vibrometer-based anti-personnel mine detection"

Acoustic-to-seismic (A/S) coupling has been used successfully to locate anti-tank (AT) mines with a high probability of detection and a low false alarm rate. Due to the generally smaller size and large variability in the shapes and sizes of anti-personnel (AP) mines, AP mine detection is more challenging than AT mine detection. This paper discusses the analysis results of A/S coupling mine detection data for AP mines collected using a laser Doppler vibrometer-based mine detection system at test minefields during two years. Important data features indicating the presence of a mine include the ratio of the velocity magnitude of the ground surface over and away from the target, and the presence of wave-like or scattering phenomena. The analysis reveals the relationship between the wavelength of the excitation and the target size as well as between the scanning spatial resolution and the target size and shape [C521]

"Multistatic GPR for antipersonnel mine detection"

Todays ground penetrating radar (GPR) systems encounter a variety of difficulties when applied to the detection of buried antipersonnel mines, e.g., a high clutter level and strong surface scattering. Angular diversity or "multistatic" data acquisition promises for the cost of additional hard- and processing effort high potential to overcome some of the problems. The paper explains the basic idea, illustrates a hardware realization and processing strategies and presents first results [C522]

"Applications of RADARSAT-2-polarimetric data"

Expected applications improvements provided by dual- and quad-polarised data from Radarsat-2 are identified. Dual-polarised data is expected to have a wide range of applications. More detailed information is provided by quad-polarised data but here applications are limited by the narrow swath width. A specific study on sea ice monitoring is focussed on as an example application. The effect of system noise on polarimetric data analysis is considered as is the potential for polarimetric interferometry. The latter will be limited by temporal decorrelation [C523]

"A Kalman filter-based approach to detect landmines from metal detector data"

Metal detectors play a significant role in landmine detection. Automatic sensor fusion is required to improve the performance of ground penetrating radar (GPR)-metal detector multi-sensor systems. The existing version of the Kalman filter-based detection algorithm has been adapted for automatic detection and discrimination of landmines in metal detector data. In this algorithm, multi-channel metal detector output data are fused to produce a distribution of probabilities of the presence or absence of a target. Performance of this algorithm has been assessed using data obtained by burying a number of simulant landmines, canonical targets and shrapnel in different soil types [C524]

"IGARSS 2001. Scanning the Present and Resolving the Future. Proceedings. IEEE 2001 International Geoscience and Remote Sensing Symposium (Cat. No.01CH37217)"

The following topics were dealt with: soil moisture remote sensing; archaeology; global clouds and aerosols; remote sensing; data compression and coding; SAR; floods and disasters; Antarctica; Arctic; classification, labelling and inference; visualization; advanced sensors and measurement techniques; missions and programs; skin sea surface temperature; agriculture, coastal lakes and rivers; hyperspectral environment; geoscience; Global Change Observation Mission; environmental degradation and Earth systems; student prize paper competition; processing and analysis methods; interferometry; Africa; Radarsat 1; sensor calibration; oceans; Australian applications; aquatic and submerged ecosystems; hyperspectral and multispectral mineral exploration; advanced lidar systems; Tropical Rainfall Mapping Mission; clouds and precipitation data fusion; thermal remote sensing; biophysical modelling; Shuttle Radar Topography Mission; forestry; fires; passive remote sensing; state communities; active remote sensing; snow; local communities; geospatial data fusion; multisource vision; knowledge based systems and unmixing; tropospheric refractivity estimation; radar polarimetry; ocean color; sea ice, snow and glaciers; short wind waves; topography, DTM and cartography; arid zone; rangelands; lidar technology; ozone; clouds and precipitation; inverse problems; spaceborne scatterometers; differential SAR interferometry; antipersonnel landmine detection and classification; landcover change; air-sea interaction; knowledge based systems and unmixing; Bayesian techniques; data formats, archiving and retrieval; EOS-Terra mission; ocean waves; agriculture; salinity; urban studies; hydrology; soils; geoscience; atmosphere; climate; large scale thematric products; emission and scattering; image processing and enhancement; GPS reflection; electromagnetics; AIRSAR and PACRIM; synthetic aperture techniques; processing systems; policy, education and societal issues; GPR; ocean winds; disaster assessment; target detection; environmental degradation; coastal landscapes and fisheries; biophysical modelling; neural networks, expert system systems; inverse problems [C525]

"Detecting regime changes with a mobile robot using multiple models"

We present an approach to the detection of global environmental regime changes by a mobile robot performing a task. The approach is based on the use of augmented Markov models (AMMs), a variation of semi-Markov process. We have developed an algorithm that constructs AMMs online and in real-time with little overhead. AMMs are a general tool for capturing the interaction dynamics between a robot and its environment using the history of behavior executed by the robot. We extend AMMs to regime detection, using multiple models to monitor events at different time scales and provide statistics to detect regime changes at those time scales. This approach has been successfully implemented using a physical mobile robot performing a land mine collection task. In the context of this task we present experimental results, first validating our approach, then demonstrating a more complex proportion-maintaining scenario of the land mine collection task. Finally, we present results using an alternative reward maximization decision criterion in the same task [C526]

"Landmine detection using stimulated infrared imaging"

As part of a continuing evaluation of new technologies for landmine detection, work has been carried out at the Joint Research Centre of the European Commission to determine the effectiveness of stimulated infrared imaging in locating buried mines and minelike objects. This paper reports on part of this work, which attempts to compare passive (that is, solar radiation-produced) images with those obtained using artificial stimulation: in particular, high-power microwave (HPM) radiation. The advantages of HPM, and some practical difficulties, are discussed. Results from both laboratory and field measurements are described. Images are compared in terms of the temperature contrast between the image and the surrounding area. Microwave stimulation appears to be capable of providing a thermal contrast at times of day when solar radiation alone gives none. The paper also describes results of infrared measurements made over buried mines containing explosive material and surrogates containing a filler in order to evaluate the apparent differences in the thermal image obtained. First results show that the surrogates exhibit a similar behavior to that of the real mine under the same conditions [C527]

"Probabilistic methods for robotic landmine search"

One way to improve the efficiency of mine search, compared with a complete coverage algorithm, is to direct the search based on the spatial distribution of the minefield. The key for the success of this probabilistic approach is to efficiently extract the spatial distribution of the minefield during the process of the search. In our research, we assume that a minefield follows a regular pattern, which belongs to a family of known patterns. A Bayesian approach to the pattern extraction is developed to extract the underlying pattern of the minefield. The algorithm performs well in its ability to catch the "actual" pattern in the situation where placement and detector errors exist, and the algorithm is efficient, therefore, online implement of the algorithm on a mobile robot is possible.

Compared to the likelihood approach, the advantage of using a Bayesian approach is that this approach provides information about the uncertainty of the extracted "actual" pattern [C528]

"Use of elastic waves for the detection of buried land mines"

A prototype system that employs seismic surface (Rayleigh) waves and non-contact displacement sensors for the detection of buried landmines is being developed. The operating principle of this system is to interrogate the ground surface motion, resulting from a remote seismic source, in a region surrounding, and immediately above, a mine using a two-dimensional array of non-contact sensors. The data from this array are then processed in the space and time domains to form images. These images emphasize specific features of the ground motion, which have been linked empirically, through both numerical modeling and experimental studies, to the presence of landmines. The images formed in this way show a large contrast (~30 dB) between mines and background reverberation and a large contrast (>20 dB) between mines and mine-sized clutter objects. They also appear to be robust in simulations of realistic burial scenarios involving a variety of mine sizes and depths along with clutter objects in close proximity [C529]

"Smart sensing for mine detection studies with IR cameras"

Because of the high risks involved, it is necessary to conduct mine detection remotely. By making use of infrared (IR) cameras, scattered mines can be detected from remote locations. In the case of mines buried in the ground, detection is possible if the peripheral temperature difference is large enough between the ground and mine weapon. As one of the world's advanced nations in sensor technology, Japan should promote surveys and studies for detecting mines safely by using its advanced remote sensing technologies. [C530]

"A multi frequency radar for detecting landmines: design aspects and electrical performance"

A radar has been designed and built for application in the problem of anti-personnel landmine detection. The radar is based on the principle of a Stepped Frequency Continuous Wave (SFCW) transmission scheme. The novelty of the system is, that it transmits 8 frequencies at the same time through one antenna and that it repeats this procedure 16 times with shifted frequency offsets in order to collect a set of 128 frequency samples. The resolution in the synthesized range profile in air is just over 3cm, while the total frequency coverage is from 400MHz upto 4845 MHz, so ultra wide band. The architecture of the radar however is based on Commercial Off The Shelf narrow band technology. The acquisition time for collection of a full set of 128 frequencies covering the ultra wide band is less than 2 msec. This short time was achieved by simultaneously transmitting 8 frequencies and using Direct Digital Synthesis for signal generation. The concept of SFCW radar is prone to errors in phase. Therefore a calibration facility is built in. First results of the system while it is still in the setting-to-work phase are encouraging. [C531]

"A comparison of the linguistic Choquet and Sugeno fuzzy integrals"

One of the popular fuzzy set theoretic technologies is the fuzzy integral. It combines numeric confidence from information sources with the worth of subsets of those sources. But sometimes, we encounter data that has a higher order of uncertainty, e.g., confidence values, locations, etc., that can only be expressed in linguistic terms. It is our belief that dealing with this type of data through the extended version of the regular algorithms produces meaningful analyses. The regular algorithms are extended using the extension principle. While we have reported success in applying the extended Choquet integral on landmine detection problems, there is a need to study the behavior of the linguistic fuzzy integrals. In this paper, we examine the extended version of the Choquet and Sugeno fuzzy integrals on a synthetic data set to gain insight into the effect of varying conditions on the final results [C532]

"A portable landmine detector based on the combination of electromagnetic induction and neutron backscattering"

A new portable, ergonomic landmine detector was constructed that combines electromagnetic induction and neutron backscattering. The latter technique uses the moderation of high energy neutrons from a californium source in the soil. When a hydrogen-rich anomaly is present, the number of low energy neutrons that return from the soil increases. This makes the method especially suitable for the detection of plastic landmines. By combining this technique with a metal detector, it is possible to locate both metal and plastic landmines. Preliminary results with this detector, the Delft University Neutron Backscattering LAndmine Detector (DUNBLAD), are presented and future developments are discussed. [C533]

"Applications of Passive Microwave Devices for Imaging System Designed for Detecting Objects in

Soils"

The paper deals with some grounding in theory of a passive radiometric complex designed to detect from a helicopter metal and non-metal objects in the soil at the depth of several metres. Experimental results obtained during tests of a complex prototype are presented as well. The complex can be applied in construction and repair works to detect underground utility systems. The complex is of particular interest for the detection of land mines which armed conflicts are left after their completion. [C534]

"The effect of phase noise in a stepped frequency continuous wave ground penetrating radar"

In the application of stepped frequency continuous wave for a ground penetrating radar, the required range resolution is very high, in the order of a few centimetres. Because weak echoes of landmines must be detected against the strong background of the surface reflection, particular attention must be paid to the phase noise of the generated frequencies. The paper evaluates the effect of phase noise based on a frequency modulation approach. It is shown that due to the very short delay between transmission and reception, the requirements on the phase noise can be met using commercial off the shelf components [C535]

"Investigations on anti-personnel mine detection using microwave radiometers"

Many million anti-personnel mines are polluting the environment in about 60 countries and cause a considerable limitation of the living space for agricultural purposes. The present mine clearance operations are much slower than the mine laying operations. Therefore the principal goals of a mine detection system designer must be focused on the following key requirements: 1) The system should be capable of detecting small surface and subsurface plastic mines with very low metal content under most environmental conditions, 2) the detection probability should be maximised and the false alarm rate minimised, 3) the hardware expense should be as most cost-effective as possible. The optimum solution is the use of multiple sensors, e.g. metal detectors, ground penetrating radars, microwave radiometers, based on different physical phenomena and on data fusion. In this paper we give an overview on relevant physical phenomenology and on our past work in investigating passive microwave sensors for mine detection purposes as a possible contribution to a multi-sensor system. We present experimental equipment and corresponding illustrative measurements results [C536]

"Improved Landmine Detection System for the Canadian Army"

This paper outlines the key characteristics of the Improved Landmine Detection System being procured by the Canadian Army. The system uses multiple detection sensors in order to provide a high probability of detection, and fuses the multiple sensor data in order to maintain a practical false alarm rate. Standoff detection, for operator safety, is achieved by remotely controlling the vehicle platforms. [C537]

"Anti-Personnel Landmine detection using depth fusion"

Detection of Anti-Personnel Landmines is a challenging task for any sensor currently available. Using sensor fusion allows combining individual sensor results such that for each sensor its advantages remain while compensating for its disadvantages by using other sensor types. This paper provides an overview of sensor-fusion results obtained within the EU funded projects GEODE and LOTUS. These projects aim toward a vehicle mounted sensor suite consisting of Ground Penetrating Radar, Metal Detector, and Thermal Infra-Red. [C538]

"Infrared land mine detection by parametric modeling"

A parametric model for the infrared signature caused by a buried land mine is presented. Further, a detector is calculated for the case where the background noise can be described by an autoregressive process. The detector separately estimates the parameters of the mine and the noise in an alternating fashion. The estimates are then used in the likelihood ratio test. Simulations show that significant gains in performance can be achieved as compared to the standard detector used, which correlates the infrared image with the known mine shape and thresholds the square of the output [C539]

"Detection and identification of odorants using an electronic nose"

Gas sensing systems for detection and identification of odorant molecules are of crucial importance in an increasing number of applications. Such applications include environmental monitoring, food quality assessment, airport security, and detection of hazardous gases. We describe a gas sensing system for detecting and identifying volatile organic compounds (VOC), and discuss the unique problems associated with the separability of signal patterns obtained by using such a system. We then present solutions for enhancing the separability of VOC patterns to enable classification. A new incremental learning algorithm that allows new odorants to be learned is also introduced [C540]

"Novel inverse methods in land mine imaging"

The imaging of buried land mines continues to present significant signal-processing challenges in the development of inverse methods for the detection of plastic mines buried in soil. To address this difficult problem, mathematical advances in the development of the elliptic systems method are used to generate images of the buried land mines. The-proposed approach adapts earlier methods, successfully applied in laser tomography of breast tumors using the diffusion equation, to the present problem of land mine imaging using the Helmholtz equation. The images generated by the new method represent electromagnetic properties of underground regions, providing effective differentiation of plastic land mines from surrounding soil. Experimental results are presented to demonstrate the new method [C541]

"Comparison of PCA and ICA based clutter reduction in GPR systems for anti-personal landmine detection"

This paper presents statistical signal processing approaches for clutter reduction in stepped-frequency ground penetrating radar (SF-GPR) data. In particular, we suggest clutter/signal separation techniques based on principal and independent component analysis (PCA/ICA). The approaches are successfully evaluated and compared on a real SF-GPR time-series. Field-test data are acquired using a monostatic S-band rectangular waveguide antenna [C542]

"Proceedings of the 11th IEEE Signal Processing Workshop on Statistical Signal Processing (Cat. No.01TH8563)"

The following topics are dealt with: statistical signal processing; resampling methods; Monte Carlo methods; self-similarity, long range dependence and heavy tails; multi-access communication systems; radar signal processing; signal processing for landmine detection; signal detection; sensor array processing; biomedical signal processing; blind system identification; nonstationary signal analysis; filter design; signal processing applications; multi-carrier communications systems; parameter estimation; blind source separation; speech processing; multidimensional signal processing; audio processing; DOA estimation and source localization; channel estimation; equalization; multirate signal processing [C543]

"Adaptive fuzzy force control of an anti-personnel (AP) mine detector robot"

At present, there are approximately 110 million land mines scattered around the world in 64 countries. The clearing of these mines takes place manually. Unfortunately, on average, for every 5000 mines to be cleared, one mine clearer is killed. A mine detector robot (MDR) is under development at the Electronic Research Center. The robot arm imitates a manual hand-prodding technique for mine detection. It inserts a sharp metal bar (probe) into the soil whose parameters, such as stiffness are unknown and vary depending on the type of soil. An explicit force control scheme is applied as the main control scheme, while an adaptive fuzzy controller is designed to deal with uncertainties and varying environment parameters. Simulation and experimental results are presented to validate the proposed control scheme [C544]

"High sensitive pulse inductive eddy current measurement for mine detection systems"

Due to military conflicts, more than 100 million landmines are scattered all over the world. Besides the unbelievable human suffering these mines cause, mines are a strong economic and environmental problem and prevent industrial and agricultural use of land. State of the art mine detection is mainly based on metal detectors (MD). Due to military and urban metal parts like shrapnel, nails, etc., a huge number of “false alarms” make mine clearance a very time consuming and expensive task. Different MD technologies are compared, and the high sensitivity pulse inductive eddy current measurement method is presented. Measurement of low level magnetic fields immediately after high-energy magnetic pulses is presented, including the application of a high-resolution DAQ system with sample rates higher than 106. Test results and data analyses are presented for the time domain and the frequency domain [C545]

"Implementation of a dispersive matched layer RBC within an FDTD framework, and its application to impulse GPR studies"

The problem of excessive computational resource requirements for modelling of dispersive and lossy materials is addressed with the development of high performance boundary conditions that can operate in such media. The work reports two innovations, firstly the investigation of conductivity profiles using genetic algorithm optimisation methods, and secondly the use of variable permittivity and permeability within the PML layer for effective

absorption of evanescent waves. It is demonstrated that such methods can provide order of magnitude improvements in reflection coefficients over analytically derived profiles in both lossless and lossy dispersive materials. The effectiveness of the RBC is illustrated in the application of transient ground penetrating radar in soils with conductive loss using a full 3D model of an impulse GPR system, including antennas and feeds. Results are compared to published measurements [C546]

"Inductive and capacitive sensor arrays for in situ composition sensors"

Advances in electromagnetic sensor design provide the potential for high resolution imaging of subsurface objects and material properties at the microscopic (micrometer) and mesoscopic (meter) scales. With quasi-static, capacitive and inductive sensor arrays, objects are detected, identified, and imaged via their perturbations to the applied electric and magnetic fields, rather than through time delays of reflected electromagnetic waves as in ground penetrating radar. Building on the successful application as nondestructive quality assessment and monitoring tools as well as land mine detectors, several subsurface in situ sensors are enabled by this technology. Examples include: an electronic 3D microscope, enabling examination of cell level structures and composition; examination of near surface structures such as soil moisture, permafrost dynamics, soil properties with depth, root growth carbon sequestration, Martian surface aquifers, and buried deposits of carbon dioxide or methyl hydrides [C547]

"Map building for a terrain scanning robot"

Presents the application of an image registration method for a mobile manipulator. The robot is used for scanning natural terrain and detecting metal objects hidden beneath the terrain surface (e.g., landmines) using a metal detector. The range image may be interpreted for visual servoing, map building and path planning, or object recognition. In the work, the image is used to build a terrain map for obstacle free path planning. Because the working area of the robot is extremely dynamic (i.e., not only the robot travels but also the environment is also subject to change) an active range sensing method is selected to provide the range image. The range values are acquired using a laser range finder with a rotating mirror for scanning so that sensor fusion in the form of collecting sensor readings over an extended period of time is required. In addition, range readings of two ultrasonic range finders are fused at signal level to tackle both sensor imperfection and environmental illumination that induce uncertainty at the system. We explain the use of a real-time programming platform that executes an online map-building process in parallel for robot manipulation and control. [C548]

"Optimal line-sweep-based decompositions for coverage algorithms"

Robotic coverage is the problem of moving a sensor or actuator over all points in given region. Ultimately, we want a coverage path that minimizes some cost such as time. We take the approach of decomposing the coverage region into subregions, selecting a sequence of those subregions, and then generating a path that covers each subregion in turn. We focus on generating decompositions based upon the planar line sweep. After a general overview of the coverage problem, we describe how our assumptions lead to the optimality criterion of minimizing the sum of subregion altitudes (which are measured relative to the sweep direction assigned to that subregion). For a line-sweep decomposition, the sweep direction is the same for all subregions. We describe how to find the optimal sweep direction for convex polygonal worlds. We then introduce the minimal sum of altitudes (MSA) decomposition in which we may assign a different sweep direction to each subregion. This decomposition is better for generating an optimal coverage path. We describe a method based on multiple line sweeps and dynamic programming to generate the MSA decomposition. [C549]

"Environmental influence on microwave radiometry for buried object detection"

Microwave radiometers have been shown to be effective sensors for monitoring soil moisture and other geophysical data. Recent studies have begun to consider the use of microwave radiometers for detecting shallow, sub-surface objects such as anti-personnel landmines. However, previous buried object detection models have neglected variations in medium temperature and soil moisture with depth. Since these factors can significantly impact soil moisture remote sensing, their effect on buried object detection requires consideration as well. A multi-layer horizontally stratified emission model is coupled with it numerical solution of the heat equation and a model for water transport in the presence of a sub-surface object to estimate the importance of temperature and soil moisture variations. Results show that these factors can impact overall brightness temperatures, but that the concept of using oscillatory features in frequency swept data as an indicator of a sub-surface object remains valid [C550]

"Artifical neural network based buried land mine imaging"

Our buried land mine imaging system is based on transmitting and receiving antennas mounted within a

cylindrical auger, a stepped frequency CW transmitter/receiver, and three artificial neural network (ANN) imaging processors, all controlled by a small computer. Stepped frequency, CW microwave signals reflected from objects within the view of the transmitter and receive antennas are used as inputs to the first ANN processor. This paper briefly describes the design of broad RF bandwidth cylindrical waveguide antennas that are mounted in the opposite spades of a dual spaded auger, the training patterns used for ANN land mine imaging and experimental land mine images using data recorded in April 1999 at the USA army's A.P.Hill test site [C551]

"A remote electronic olfactory sensor"

This paper overviews the implementation of an automatic and portable electronic olfactory sensor unit suitable for remote operation. This unit is capable of complex odor identification [C552]

"Mine detection and sensing technologies-new development potentials in the context of humanitarian demining"

Humanitarian demining aims for a total clearance of all types of landmines from infected areas and infrastructures as efficiently and as safely and as rapidly as possible while keeping cost to minimum. It requires that each individual mine in an area to be located, uncovered and removed or destroyed. The focus is to make these areas economically viable and usable by the people for different activities and to allow people to use their land without fear. The targets of mine detection and sensing technologies are to achieve a high probability of detection rate while maintaining low probability of false alarm. This paper presents the landmine problems, the problems facing humanitarian demining, priorities and an evaluation of mine detection techniques and technologies along with their new development potential in the context of humanitarian demining [C553]

"Autonomous control of an engine-driven mobile platform for field robotic systems"

Currently, most of the robotic systems use electric actuators and depend on chemical batteries as source of energy. However, this results in severe limitations to their range and time of autonomous operation, making it difficult to employ those robotic systems in remote areas or fields. In order to solve this problem, the authors have developed a mobile platform with energy-generation capability and mechanisms to drive it automatically. In this paper, a new autonomous control for the mobile platform is proposed, including telemetry features, especially focused on hyper-tether applications Those applications may include landmine detection/removal and forestry works in environments where the currently available systems cannot operate uninterruptedly for long periods of time [C554]

"Linearized multi-frequency inversion of ground penetrating radar data"

Although inverse scattering methods have reached a level of considerable sophistication in the past decades, their testing and verification remains predominantly numerical. By inverse scattering methods we understand those mathematical techniques that go beyond the trivial time-domain backpropagation or frequency-domain migration algorithms (sometimes called SAR imaging). The present study is concerned with the application of such inverse scattering methods to a practical problem of landmine detection using commercial ground penetrating radar (GPR) equipment. In particular, we investigate the performance of the so-called linearized inversion, i.e. the one where the description of the scattering process is subject to the Born approximation [C555]

"Signal processing techniques for clutter parameters estimation and clutter removal in GPR data for landmine detection"

Ground penetrating radar (GPR) has become widely accepted as a major technique for subsurface investigations, mainly in civil engineering. Considerable efforts are put in the development of GPR systems for the detection of shallow buried landmines. However, the GPR performs inadequately due to clutter, which dominates the data and obscures the mine information. The clutter varies with surface roughness and soil conditions and lead to uncertainty in the measurements. It is therefore necessary to overcome these surrounding effects when processing GPR data for detecting small, shallow buried objects. We present improved signal processing techniques which can be used to reduce the clutter through data preprocessing. Several approaches are proposed for the GPR clutter reduction techniques, most of them model the clutter statistically. The proposed clutter reduction technique models the clutter using parametric modeling. The clutter contained in the measurements is treated as an ARMA model. The advantage of such approach lies therein that once the clutter is satisfactorily known, any target will show up as a small anomaly in against the known clutter background. This method suggests that the clutter shows a certain amount of correlation. Experimentally it is shown that the dominant interference in GPR data is correlated clutter, i.e., interference, which has a large correlation coefficient

for tags greater than zero. However, the clutter environment cannot be considered completely stationary. An ideal filter would then be an adaptive filter, which estimates the slowly varying local clutter parameters, all the time ignoring the small parameter jumps caused by the buried targets to be detected. Kalman filtering is used for the estimation of the clutter parameters in the presence of random noise, detects jumps that occur at unknown points in time, and provides estimates of the new parameter values, without altering the target return [C556]

"Towards real-time detection of landmines in FLIR imagery"

A pipelined algorithm and parallel architecture is under development for real time detection of landmines. Our previous work has dealt with monochromatic images from airborne active infrared scanners and images from a low-altitude aircraft-mounted multi-spectral scanner. Because of the nature of the sensors and the aerial observation platform, the landmines were treated as small, sparse, discrete objects in a large clutter field. Our current work deals with passive infrared imagery obtained from cameras mounted on ground vehicle. In contrast to the previous work, although the targets are still relatively sparse, they are no longer small in the sense of occupying just a few pixels and the signal to noise ratio is considerably worse than in for the airborne active infrared and multi-spectral scanner problems. So significant changes to our detection algorithm are needed. The paper describes the overall algorithm and the particular issues, such as irregular shapes, that need to be dealt with in FLIR imagery. Some early results are presented. In addition, changes in computer processing power and interprocessor communications has led to a rethink of the real-time hardware implementations of the system and these issues are discussed [C557]

"Model-based statistical signal processing using electromagnetic induction data for landmine detection and classification"

Traditionally, electromagnetic induction (EMI) sensors are operated in the time-domain and the response strength is related to the amount of metal present in the object. These sensors have been used almost exclusively for landmine detection. Unfortunately, there is often a significant amount of metallic clutter in the environment that also induces an EMI response. Consequently, EMI sensors employing detection algorithms based solely on metal content suffer from large false alarm rates. A second issue regarding processing of data collected on highly cluttered sites is that anomalies are often in close proximity, and the measured EMI signal consists of a weighted sum of responses from each anomaly. To mitigate the false alarm problem, statistical algorithms have been developed which exploit models of the underlying physics for mines with substantial metal content. In such models it is commonly assumed that the soil has a negligible effect on the sensor response, thus the object is modeled in "free space". To date, such advanced algorithms have not been applied specifically to the problem of detecting low-metal mines in a cluttered environment. Addressing this problem requires considering the effects of soil on signatures, separating the multiple signatures constituting the measured EMI response as well as discriminating between landmine signatures and clutter signatures. In this paper, we consider statistically based approaches to the landmine detection and classification problem for frequency-domain EMI sensors. We also develop a preliminary statistical approach based on independent components analysis (ICA) for separating the signals of multiple objects that are within the field of view of the sensor and illustrate the performance of this approach on measured data [C558]

"Land mine detection in rotationally invariant noise fields"

This paper proposes a method to detect infrared land mine signatures embedded in rotationally invariant colored noise. A common problem in statistical image processing is high dimensionality. This causes a need for large sets of training data. To overcome this, an alternative formulation of the generalized likelihood ratio test (GLRT) is presented. This formulation makes it possible to utilize the circular-symmetry, rendering a substantial decrease in model dimensionality and consequently, in the amount of training data needed. Simulations indicate that a significant gain in performance can be achieved compared to both the non-parameterized detector and the matched filter [C559]

"Polynomial phase signal based detection of buried landmines using ground penetrating radar"

Put simply, the global landmine problem is massive. Ground penetrating radar (GPR) is just one engineering solution currently being investigated. A polynomial amplitude-polynomial phase model is fitted to GPR returns. It is observed that the second order phase coefficient shows deviations from background-only levels when a buried target is present. A bootstrap-based detection scheme is proposed that tests for this change. The technique is applied to real GPR data, with encouraging results [C560]

"Landmine detection using single sensor metal detectors"

Historically, metal detectors have been essential tools for demining. However they have been unable to keep

pace with developments that made landmines more difficult to find. Here, techniques for the detection of buried objects using a metal detector are presented, evaluated and compared. The findings highlight a number of deficiencies, as well as a number of strengths, in the proposed detectors. Of particular interest are the parameters found using Prony's method, as well as the difference operator, reverse arrangements test and the median filter. Suggestions are made for the improvement of a number of detectors. [C561]

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