Comparison of the Time-Reversal and SEABED Imaging Algorithms Applied on Ultra-Wideband Experimental SPR Data

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***Abstract*— This paper presents a comparison study between a simple time-reversal algorithm (designed at LEAT) and the SEABED algorithm (designed at Kyoto University) with their application to multiple-target experiments. Data are collected with an eight element ultra-wideband antenna linear array connected to an eight port vector network analyzer, working in a frequency bandwidth starting from 1.5 GHz up to 8 GHz. Several target configurations demonstrate the advantages and disadvantages of both algorithms.**

I. Introduction

In Surface-Penetrating Radar (SPR) applications, such as security or landmine detection for instance, signal processing plays a key role in obtaining images of targets. Different algorithms have been developed for that purpose, combining preprocessing methods and microwave imaging [1]. Among these, two algorithms, time-reversal [2] and the Shape Estimation Algorithm based on BST and Extraction of Directly scattered waves (SEABED) [3], are promising algorithms for the detection of the location of multiple scatterers. The efficiency of time-reversal has already been shown in the case of embedded targets [4], [5] and also in telecommunication applications, taking advantages of the multipath environment [6], [7], while SEABED has been seen as a promising candidate due to its high-speed processing property.

Here we compare time-reversal and correlation (in effect an adjoint method) and the SEABED algorithms applied on experimental data, obtained in a multiple-target SPR measurement configuration. The measurement configurations (radar and geometric configuration of radar scenes) are presented in Section II while the algorithms are presented in Section III and IV. In section V we discuss the results and advantages of each method. Section VI contains a final discussion and conclusion.

II. Measurement Setup

A. Measurement system

The antennas used to build the array are ETS (Exponentially Tapered Slot) antennas based on Vivaldi type antennas [8]. These antennas have been employed in array experiment by Chatelée [9] and have a flat S_{11} response from 1.4 to 20 GHz. For the experiments we present hereafter, the antenna array is an 8-element linear array with a spacing of 8 cm between each antenna. It is connected to an 8-port Rohde & Schwarz ZVT multi-port vector network analyzer which is employed over the frequency range from 1.5 to 8 GHz with 2001 frequency points. In this configuration we can have access up to 64 measured S parameters in a short time.

B. Configuration of radar scenes

Several data acquisitions were used in order to obtain the results presented in section V. Targets were dielectric or metal scatterers, placed on a grid for easier location, as we can see in Fig. 1. Measurements were made in free space and we assume a two-dimensional reconstruction for simplicity. For all the experiments, multiple-target configurations were studied.

For the two-target case, we use a metallic cylinder with a radius of 2.5 cm and a plastic bottle with a radius of 4 cm filled with saline to approximate human's body permittivity. The second configuration corresponds to four aligned plastic bottles filled with water except for the second one from the