2D Image Fuzzy Deconvolution and Scattering Centre Detection: Model and Real-Time FPGA Implementation for Automotive Application

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***Abstract*— A new non-conventional technique based on fuzzy de-convolution for scattering centre detection (F-SCD) is proposed together with its implementation in FPGA for real-time deployment in automotive collision avoidance application. F-SCD emulates the human being interpretation of radar images using fuzzy measurement of features of the radar Point Spread Function (PSF) differently from other classic detection techniques. The first stage of F-SCD detects signal from noise using image oversampling and binary integration technique. The second stage uses a fuzzy description of the radar PSF in order to discriminate among scatterers and side lobes in the radar image. The method/IP have been implemented in FPGA and tested with a FMCW 77 GHz radar prototype in real automotive benchmarks showing high POD, low FAR and high rejection of ambiguities even with poor time-space variant PSF.**

I. Introduction

Modern imaging systems based on digital beam forming have the relevant feature to be easily re-configurable at run-time. Antenna/modulation scanning scheme (number of angle, range and Doppler bins, modulation period and shape) as well as the whole real-time processing pipelines can be switched on a frame by frame fashion. The technological availability of massive and general purpose parallel processing (FPGA) makes it possible to implement new models of detection, discrimination and localization of targets based on fuzzy techniques normally used by human being during visual analysis and interpretation of images. Performances in detection and localization of targets/scatterers can be greatly improved by oversampling the image in respect to angle and range physical resolution limits. This in order to measure fuzzy features such as shape and location of the point spread function lobes (main and side) which are visual clues intuitively used for localization and discrimination between effective targets (PSF main lobe) and ghosts (PSF side lobes). Operating with oversampled image, large area of the image is used to analyse each single pixel so that localization accuracy is improved and ambiguities reduced.

In fig. 1 the processing pipeline is shown: the image is analysed at different zoom scales in order to identify scatterers. The small area surrounding each pixel is processed by binary integration "M of N" in order to detect signal from noise with very low false alarm rate, FAR, and high probability of detection, POD. At the same time a medium-sized area (7x3 pixels) is also processed by the gradient operator to verify the local flatness of the image intensity. This image shape control applied at medium-sized areas discriminates the small-area detections implementing the heuristic "spot" visual clue: a scatterer produces in the image a region of pixel having more or less smooth intensity.

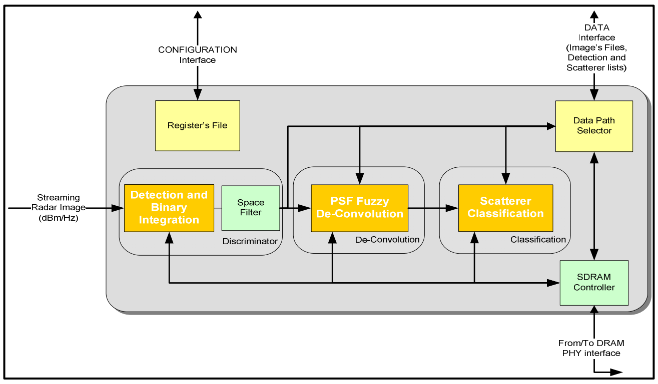

Figure 1. Fuzzy Scattering Centre Detection, F-SCD IP.

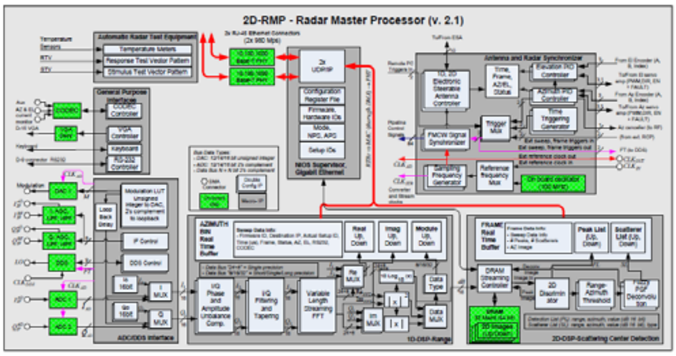

Figure 2. Radar Master Processor. RMP embeds in single FPGA the full set of features required for FMCW control and processing, including: D/A analog and DDS modulation; A/D IQ sampling, filtering and phase/amplitude compensation; DSP processing with FFT (up to 128K) and dBm/Hz conversion; F-SCD; 2 gigabit communication; ESA antenna control; etc. RMP works in streaming with 100% duty cycle of modulation time at the maximum sampling rate of 100 Msps.