TARGET DETECTION ABOVE ROUGH SURFACES IN MICROWAVE IMAGING USING COMPRESSIVE SAMPLING

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I. INTRODUCTION

Modeling of electromagnetic scattering of targets above rough surfaces is of interest in recent years because of the need of a model for object detection on the sea surface, remote sensing of vegetation for crop production assessment, and many other applications. In the above mentioned applications the research of interest is the detection of the objects in the clutter background. In the early works of scattering model of vegetation, scattering interaction among the vegetation particles and between vegetation and rough surface are ignored[1]. In [2] the near-field interaction between the target and surface roughness is considered in addition to the other scattering phenomena. There are several existing works to model the electromagnetic scattering from complex targets above the slightly rough surfaces [3-6] . In [3] a hybrid approach combines the four-path model with a quasi-image method to consider the high frequency EM scattering from complex targets above slightly rough surface. In [4-6] are given few works that investigate the scattering from 3-D objects on 2-D surfaces, which is close to practical applications. A study of a light scattering model for a spherical particle above a slightly dielectric rough surface is carried out in [5]. The electromagnetic scattering from 3-D objects on ocean like rough surfaces is analyzed in [6]. Then work in [4] Investigates the EM scattering from a 3-D object above a 2-D random rough surface using FDTD algorithm. All the above mentioned approaches are numerically based methods to model the scattering from the objects above clutter environment. The problem of detection of targets in clutter environment is the main focus of this work. One such method in literature is based on correlation imaging using the angular correlation function [7]. The proposed method in [7] provides finer resolution and suppresses the clutter but it needs larger spectrum domain information. In this paper an approach based on compressive sampling (CS) [8-10] is used for reconstruction of the signal from the minimum number of incoherent projections. Our first attempt for localization of scattering centers on the target in ISAR imaging using compressive sampling is given in [11]. In this work an attempt is made to exploit the sparseness of the rough surface scattering to achieve the finer resolution with minimum number of incoherently projected measurements. Overview of compressive sampling based microwave imaging and experimental validation is provided in the sections II and III respectively.

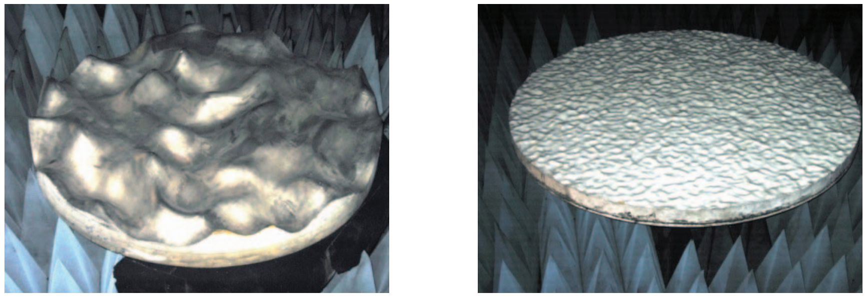
II. COMPRESSIVE SAMPLING BASED MICROWAVE IMAGING

In Inverse Synthetic Aperture Radar (ISAR) imaging, radar cross section scattering measurements are performed for finite frequency spectrum and complete angular window. Measurement data space include the first order term that correspond to scattering centers 'on' target and other higher order components such as windowing effects, multipath scattering. Windowing effects are due to the finiteness of the angular and spectral domain information. All these higher terms shows up as scattering centers in the image domain. Objective of compressive sampling used in microwave imaging is that projection of this higher dimensional measurement space into lower dimensions using a incoherent projections, provided the measurement signal is sparse is certain basis called as 'sparse' basis. Radar scattering measurements are sparse in image domain i.e. Fourier basis. Traditional compressive sampling aims at perfect reconstruction of the signal from minimal number of incoherent measurements. Reconstruction from the reduced linear measurements is possible as long as the measurement matrix has to mix up all the basis vectors of the actual measurement data. Hence it implies measurement basis has to highly incoherent with the sparse basis. In other words it has to satisfy Restricted Isometry Property (RIP) [9]. Random projections serve as measurement basis which is highly incoherent with the Fourier basis. CS principles can be used to solve for signal detection problems from incoherent projected measurements without considering the reconstruction problem [11]. Number of measurements and computations necessary for successful detection will be lower than that needed for perfect reconstruction problem. Objective of this work is to extract the lower dimensional information corresponding to the scattering centers 'on' the target using the fewer number of random projections of the measurements.

III. EXPERIMENTAL VALIDATION

Proposed methodology will be supported with the ISAR measurement data. Surfaces with different roughness are studied in this work. Surface roughness is measured by the standard deviation of the surface height 'σ' variation in wavelengths divided by horizontal correlation length 'L' in wavelengths. Large scale surface (LSS) and intermediate scale surfaces (ISS) with different surface roughness designed at wave scattering research center (WSRC), UTA are used in this work. LSS and ISS are as shown in Figure 1(a) and (b) respectively. The distribution of the surface heights and correlation function of both surfaces considered is Gaussian. More details of the surface statistical parameters will be provided in the full paper. Preliminary results show considerable resolution enhancement with a fewer number of incoherent projections. Sparsity constraint ratio (SCR) is used as a design parameter. Mutual coherence is used as quantitative measure to determine the optimal SCR.

More details of the target configurations above rough surfaces, experimental description and results will be presented in the full paper.



(a) (b)

Figure 1(a) Large Scale Surface (LSS); (b) Intermediate Scale Surface (ISS)

IV. REFERENCES

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