CS-based SAR and MIMO Radar Imaging of Intra-wall and Through-wall Targets

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The multi-faceted research area of the through-the-wall radar imaging (TWRI) has become of paramount importance in many civilian and defense applications, most notably in the area of detection, imaging, and identification of targets enclosed within building structures. In general, to achieve high imaging resolution a long aperture is synthesized with an ultra-wideband transmitted signal. This becomes impractical and costly in many realistic situations, and it is therefore important to reduce the data volume in TWRI applications, as it accelerates processing and, subsequently, allows prompt actionable intelligence. In recent years, to meet these objectives many research groups have applied Compressive Sensing (CS) to TWRI to reconstruct a sparse radar signal from far fewer non-adaptive measurements. Most of the reported CS works, however, are for targets behind single-layer walls using synthetic aperture radar (SAR).

In this work we present a general approach for radar imaging of targets behind multilayered walls using a combination of CS and multi-input multi-output (MIMO) radar or CS and SAR. To account for all the wall effects, the layered media Green's functions are used in forming the images of targets behind interior walls. The sparseness of the target space is then exploited through the use of CS to achieve a less cluttered and high resolution image with far fewer antennas and/or frequency point measurements. Furthermore, through an efficient evaluation of Green's function of a half-space dielectric medium, this CS-based approach is applied to imaging of objects inside a wall, which is of interest not only in many defense-related operations but also in such civilian applications as non-destructive testing of concrete slabs or walls' interior structures. We are also currently investigating the application of total variance minimization (TVM) to the above generalized Green's function based approach. The standard CS techniques are mainly effective in detecting the presence of targets but they cannot accurately reconstruct the target shape and/or differentiate closely-spaced targets from an extended target. TVM, however, is based on the minimizing the gradient magnitude of the image and can result in better edge preservation and shape reconstruction than standard L1-minimization based CS. Details of the formulation for the above cases together with numerical examples for various wall-target scenarios, using reduced numbers of frequency bins and antenna elements in SAR and MMIO radar cases will be given in the presentation. In addition, in conjunction with sparse image reconstruction of targets, the use of evolutionary techniques in estimation of wall parameters under limited bandwidth and/or randomly selected frequency points will be discussed.