Improved Target Detection in Urban Sensing Using Distributed Sensing and Fast Acquisition Techniques

Principal Investigator: Dr. Moeness Amin

Project Summary

The objective of the proposed research is to enhance detection of targets behind walls and in enclosed structures using fast data acquisition techniques. New detection techniques applied in the data-domain and in the image-domain are developed and shown to outperform conversional approaches for detection and parameter estimation. Data-domain target detection techniques provide optimal waveforms based on the matched illumination and mutual information approaches. Both approaches employ signature exploitation in which waveform shaping is optimized to yield maximum signal-to-clutter-and-noise-ratio (SCNR) or mutual information at the output of the receiver. The data-domain detection techniques are applied to distributed sensing and utilize mono-static, bi-static, and multi-static configurations. Our proposed image-domain detection, on the other hand, does not assume any a priori knowledge of target statistics or impulse response. Rather, we we aim at developing a robust target detection approach that iteratively adapts to varying statistics of the target images. The argument for using an iterative learning detection scheme is supported by the fact that the target image statistics depend on the target three-dimensional orientation and position, and can also vary with the standoff of the imaging system which causes a corresponding change in the scene image resolution. The proposed iterative detector is derived for one-, two- and three-dimensional data, and applied to through-the-wall imaging problem using synthetic and physical aperture radars. At the core of the detector in an image processing step which aims at separating target and noise images. The proposed research also implements fast data acquisition which is an important requirement for systems deploying wideband signals and large array apertures for achieving high resolution imaging. In the proposed research, we accelerate image acquisition using compressive sensing (CS) which is an attractive approach for reducing the number of data samples, without a significant degradation of the original image that is generated using the full array aperture and frequency band. The CS applicability to urban and through the wall sensing stems from the fact that for indoor imaging, the number of targets, or the population area of target, is very small compared to the whole scene of interest, rendering the sparsity property necessary for compressed implementation. We apply CS to reduce both antenna elements and frequency subbands and examines the results using computer simulations, EM modeling, and real data. The state-of-the art radar imaging lab of the Center for Advanced Communications, Villanova University will be used to provide different sets of data supporting the two main aspects of the proposed research, namely detection and compressive sensing.