Maximizing the Shannon Information of Millimeter-wave Computational Imaging systems

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Millimeter-wave imaging is rapidly becoming popular in surveillance systems as it provides an advantageous tradeoff between the high resolution of optical/IR imaging and the good penetration depth that is characteristic of microwaves. Commonly used millimeter-wave imagers that employ Nyquist sampled transceiver arrays (D. M. Sheen et. al., *MTT, IEEE Transactions on,* vol.49, no.9, Sep. 2001) can be uneconomical in terms of cost and complexity. However, the use of compressive sensing techniques that exploit prior information such as target size, sparsity of the scene, radiation pattern of the transmitter/receiver elements, etc. can significantly reduce the number of transceivers needed (G. Lipworth et. al., *JOSA A*, Vol. 30, Issue 8, 2013).

The computational imaging model we employ assigns a linear relationship between a target scattering vector, **f,** and the vector of measurements made by the system, **g**. These are related as **g = H f** by a measurement matrix, **H**, that is pre-constructed through a forward propagation model incorporating the transmitter and receiver fields. This system can be inverted, using various techniques, such as least squares, to reconstruct the target. In the case of compressive imaging, the size of **g** may be much less than **f (**E. J. Candes et. al., *Information Theory, IEEE Transactions on,* vol.52, no.2, Feb. 2006).

In our previous work (S. Venkatesh et. al., *Optics Express*, Vol. 24, Issue 8, 2016), the concept of Shannon information as a metric of assessing the performance of imaging systems was introduced. Here, the framework is extended to include prior information in the form of a correlation among scene voxels that arises due to the extended nature of the scattering cross-section of objects in the target space.

In this work, optimization of transmitter and receiver locations on a sparse, synthetic aperture, is also carried out with the goal of maximizing the total measurement-added Shannon information of the imaging system. Mean squared error in the reconstruction of an ensemble of reflective targets is used to compare the performance of the optimized aperture against conventionally used transmitter/receiver configurations.