Exploiting Inter Voxel Correlation in Compressed Computational Imaging

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Compressed sensing based computational imaging techniques that exploit prior information such as target size, scene sparsity, transceiver radiation pattern, etc. are rapidly gaining popularity in applications such as medical and security imaging, remote sensing, and automotive radar as they can significantly reduce SWAP-C (Size, Weight, Power, and Cost) of hardware modules (G. Lipworth et. al., *JOSA A*, Vol. 30, Issue 8, 2013).

In our previous work (S. Venkatesh et. al., *Optics Express*, Vol. 24, Issue 8, 2016), the linear computational model that relates the target scattering vector, **f**, and the vector of measurements made, **g**, through the system matrix, **H**, was outlined. The inversion of this system using techniques such as least squares or matched filter reconstructs the image. 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 this work, covariance among the target voxels, obtained through a large ensemble of representative targets that act as training data, is used as prior information to reduce the number of voxels to be reconstructed. This is achieved by using the eigenvectors of the voxel covariance matrix as a diagonalizing basis. In this new basis, the transformed image components are uncorrelated and the eigenvalues provide the variances. By then applying a suitable threshold on the eigenvalues, it is shown that the number of significantly contributing image components is much smaller than the size of **f**, leading to faster reconstructions. As this is an orthogonal basis, transformation back into the scene voxels is straightforward.

Two dimensional polygon targets are reconstructed using the thresholded eigenvalue method, and it is shown that when least squares techniques are used, reconstruction time can be expedited by about an order of magnitude for comparable Mean Squared Errors. The large size of **f** prohibits the use of least squares, and the more poorly performing matched filter reconstruction is preferred for 3D targets. In this work, it is also shown that a significant reduction in the dimension of the vector to reconstruct with the thresholded eigenvalue technique can enable the usage of least squares techniques, potentially leading to improved reconstructions.