Principal Component Analysis (PCA) based compressive sensing millimeter wave imaging system

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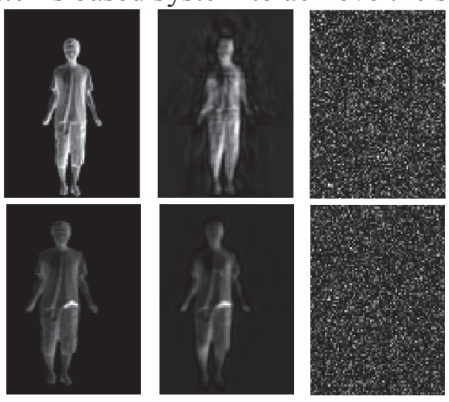
Compressive sensing is a novel sampling/sensing paradigm that enables significant sampling and computation cost reduction for signals with sparse or compressible representation. With compressive sensing technique, the number of measurements needed for accomplishing a specific task can be greatly reduced compared to traditional methods when the signal is sparse in certain basis. The fundamental idea behind compressive sensing is that rather than sampling at high rate first and then compressing the sampled data, it would be much better to directly sample the data in a compressed format.

In this work, a design of Principal Component Analysis (PCA) based millimeter wave imaging system for human body scanning is investigated. PCA algorithm is used to optimize the illumination radiation patterns for compressive sensing and a reflector array is employed to realize the optimized patterns. An iterative beam synthesis process is used to calculate the phase distribution of the reconfigurable array to realize the required radiation patterns obtained from PCA. Figure 1 illustrates the original object images (pixel number 7500) without (top) and with a threat object (bottom) compared to the compressive sensing reconstructed images using ideal PCA generated bases and randomly generated bases. Both images are reconstructed using 200 bases, each base represents a measurement. It can be seen clearly that the reconstructed image using PCA generated bases has better performance than that using randomly generated bases. In other words, fewer numbers of measurements is required for this PCA based compressive sensing system than random patterns based system to achieve the same performance.



(a) (b) (c)

Figure 1. Compressive sensing reconstructed images using 200 numbers of measurements: (a) Original image (b) reconstructed image using ideal PCA generated bases (c) reconstructed image using randomly generated bases.