Efficient Field Reconstruction Using Compressive Sensing

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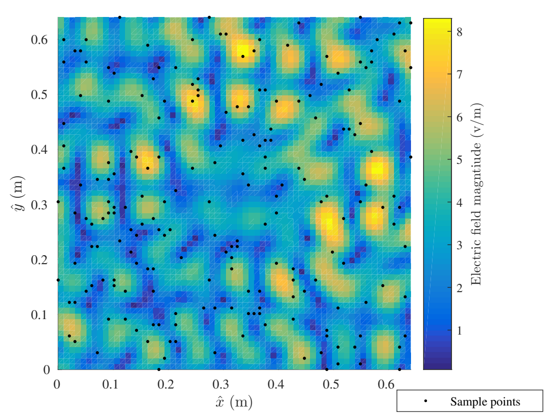
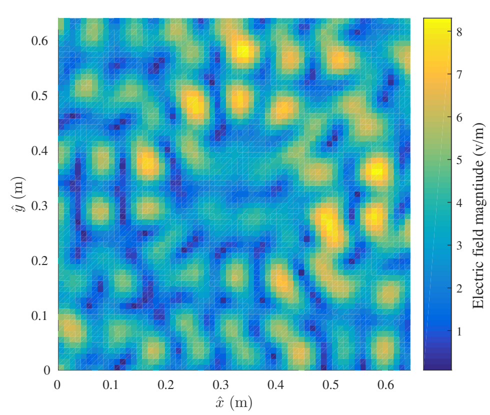
Conclusive identification of the dominant propagation mechanisms is only possible via experimental measurements of the radio channel in the region(s) of interest. Previous research has focused on densely sampling electric fields over a planar or volumetric region to create a synthetic aperture in order to determine the dominant propagation paths, e.g., (A. Kuchar, *et al.*, IEEE T-AP, 48(2), 137–146, 2000). However, these measurements can be time consuming and expensive to perform, as a sufficiently fine sampling grid over a region multiple wavelengths in size is typically required. Accordingly, this paper investigates the use of compressive sensing to reconstruct the spatial electric field distribution over a two-dimensional plane from a limited number of randomly positioned sample points. The resulting image of the radio channel can be used to identify the propagation mechanisms that dominate in the measurement region. Compressive sensing is a recent signal processing technique that can very efficiently reconstruct an under-sampled signal by exploiting sparsity in one or more of the signal domains (E.J. Candès *et al.*, IEEE T-IT, 52(2), 489–509, 2006).

Fig. 1(a) shows the spatial distribution of $|E_z|$ resulting from the superposition of 20 plane waves with arbitrary angle of incidence and magnitude, across a 0.64×0.64 m 2D planar region. The frequency is 2.45 GHz and due to constructive/destructive interference the E_z field is detail-rich in the spatial domain, necessitating a high sampling density. However, in the spatial-frequency domain, the field is sparse, in this case containing only the 20 components representing the plane wave angular spectrum. Fig. 1(a) also shows the 205 randomly selected sample points (representing 5% of the full-grid). The reconstruction of the spatial-domain signal from the spatial-frequency domain coefficients estimated via compressive sensing applied to the 205 sample points is plotted in Fig. 1(b). The signal to error ratio of the reconstruction is 22.1 dB.



(a)



(b)

Figure 1: (a) $|E_z|$ field distribution of the superposition of 20 plane waves with arbitrary angle of incidence; and (b) Compressive sensing reconstruction from the 205 sample points.