Optimal Layouts for Large RF Arrays

G.N. Newsam

School of Computer Science, University of Adelaide
email: garry.newsam@adelaide.edu.au

Abstract

Next generation RF sensors for the detection of far-field signals, *e.g.* over-the-horizon radars or radio telescopes, will use large multi-dimensional arrays. Deciding on optimal layouts for such arrays raises questions as to what might be appropriate definitions and metrics for "optimal". This talk will propose an approach to these questions based on modelling the far-field signals impinging on the array as a spatial random process and identifying an optimal array as being one the collects the maximum amount of information about this process under specified constraints on the extent of the array and number of antennae in it.

More specifically, the approach starts by modelling the far-field signals as a random field of uncorrelated point sources at infinity of varying strengths and indexed by their frequency ω and direction $\mathbf{n}$. On the array the plane waves generated by these sources then form a stationary spatial Gaussian random process whose covariance function $\gamma(\mathbf{x})$ is the Fourier transform of the energy envelope $\mu(\omega\mathbf{n})$ of the original point sources. Sampling this process by an array of ideal antennae at locations $\mathbf{x}_i$ yields a Gaussian random vector $\mathbf{c}$ with covariance matrix $C_{ij} = \gamma(\mathbf{x}_i - \mathbf{x}_j)$. The standard measure of the information in a random vector is its entropy; here this is the log of the determinant of C. Thus under this model the optimal layout will be a set of points $\mathbf{x}_i$ that maximise $\log |C|$ subject to the specified constraints.

The talk will present a short derivation of this measure, show how noise, interference and clutter are naturally accommodated within it, and sketch out some further insights and implications. In particular some illustrative numerical results on optimal layouts will be presented. These have structures that are surprisingly close to uniform lattices: we shall use some theory on Fourier transforms to explain why this might be expected and what form these lattices are likely to take in two or more dimensions.