Adaptive Beamforming and Blind Signal Separation
- are Higher Order Statistics Really Necessary?

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In conventional Adaptive Beamforming (ABF) it is assumed that the direction of the signal of interest (SOI) is known and/or a suitable "look direction" has been chosen. Even assuming the signal lies in the "far field" this requires accurate knowledge of the array geometry. The adaptive algorithm then seeks to minimize the total array output power subject to a linear constraint which ensures that the gain in the look direction is held constant. This means, in effect, that the adaptive algorithm must eliminate all correlation between the combined output signal and the look direction signal. Clearly, this only involves second order statistical measures. Unfortunately, when adapting in the presence of the desired signal, even a slight misalignment of the look direction can lead to cancellation of the desired signal and severe beam distortion. This problem can often be alleviated by using a suitable soft constraint or penalty function.

In blind signal separation (BSS), no knowledge of the array geometry (and hence the mixing matrix) is assumed. The first step of most BSS algorithms is to generate a set of mutually uncorrelated output signals using either the eigenvalue decomposition (EVD) or singular value decomposition (SVD) technique. Then, noting that the unknown mixing matrix could have imposed an arbitrary scaling factor on the decorrelated outputs (possible but a rather fluky accident of propagation), the output signals are all normalized to attain unit power. This is, of course, an accident waiting to happen - unless the noise subspace has been successfully identified and removed, and the desired signal doesn't get thrown out with the "bathwater". None the less, having taken this brave step, the mutually uncorrelated property of the output signals is seen to be invariant to the application of an arbitrary unitary matrix. So the BSS algorithm proceeds by attempting to identify this matrix which, by virtue of its own existence, can't be identified using only second order statistics (SOS) and is therefore termed the "hidden rotation matrix". Consequently, most genuine BSS algorithms resort to using higher order statistics (HOS) for this purpose assuming, of course, that the statistics of the original – and the mixed – signals are sufficiently non-Gaussian. Fortunately, the need for HOS can sometimes be circumvented by introducing some form of prior information embodied in a suitable soft constraint.

In this talk, I will demonstrate how the considerations above can lead to a more unified view of ABF and BSS – one which can also lead to simpler, more robust algorithms.