A Bayesian Approach to Single Measurement Blind Source Separation

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A common problem in taking radio science measurements is dealing with a pervasive radio frequency interference (RFI) environment. This environment stems from many man made systems including radio stations, cell phones, and broadcast television. These and other sources of noise can mask low amplitude signals and make the collection of weak RF signals of scientific interest difficult if not impossible. One way to combat a strong RFI environment is through identifying, modeling, and subtracting the sources of noise from a measurement. By eliminating sources of noise any signals of scientific interest in the measurement receive an effective signal to noise ratio (SnR) boost. Modeling unknown sources of noise given a single sensor reading can be classified as a blind source separation (BSS) problem.

The field of blind source separation (BSS) deals with identifying source signals from observations of their mixtures. When the number of observations or mixtures is less than the number of source signals in the mixtures the problem is referred to as under-determined. Under-determined BSS problems cannot be solved exactly, but different heuristic approaches can be used to generate probable solutions. By leveraging often over looked prior knowledge of extraneous signals in a mixture, sources of noise can be modeled in a probabilistic fashion utilizing Baye's Rule. A general framework can be constructed to perform source separation of a single sensor reading containing an unknown number of component signals using intensive and iterative optimization routines. This methodology was applied to synthetic and experimental radio science data sets to assess its effectiveness and ability to accurately model sources of noise. It was found that these algorithms were able to concisely model signals in an observation and subtract them while still maintaining the integrity of the remaining signals in the observation. Through the use of this methodology previously hidden signals of scientific value were able to be isolated in antenna readings after they received an increase in their SnRs by subtracting the modeled sources of noise.