What is Independent Components Analysis

• ICA is a family of techniques used to extract independent signals from some source signal.
  – Solves Cocktail Party Problem
  – Major technique for Blind Signal Separation
  – Has advantages from other multivariate techniques like PCA
  – Applications in EEG, fMRI
Cocktail Party Problem

• Problems Specification
  – 2 people talking simultaneously ($s_1(t)$ $s_2(t)$)
  – 2 microphones in different locations (gives us two time signals $x_1(t)$ $x_2(t)$)
    
    $x_1 = a_{12} \star s_1 + a_{12} \star s_2$
    $x_2 = a_{21} \star s_1 + a_{22} \star s_2$
  – $a_{ij}$ are values depending on distance of mic from speakers.
  – Want to estimate $s_1$ and $s_2$ using only $x_1$ and $x_2$
  – ICA solves this problem without knowing $a_{ij}$, the major assumption is that $s_1(t)$ and $s_2(t)$ are independent.
More Details on ICA

• Interested in solving $x=As$
  – $A$ is mixing matrix, $s$ is source vector, $x$ is mixtures
  – Generative model: describes how observed data are generated by a process of mixing components of $s$.

• Two major assumptions
  – Components $s_i$ are statistically independent
  – Independent component must have nongaussian distributions

• Part of Larger Problem Blind Source Separation (BSS)
  – Little known about mixing matrix
  – Little assumed about source signals
PCA vs ICA

• Use ICA or PCA when you want multivariate analysis
  – Definition: methodologies used in the analysis of data taken simultaneously on many variables
• PCA: finds directions of maximal variance in \textit{gaussian} data
• ICA: finds directions of maximal independence in \textit{nongaussian} data “Maximizes joint entropy and minimizes mutual information between output channels” (Bell & Sejnowski, 1995).
Applications of ICA

- **EEG**
  - Separates brain signals from artifacts
  - Allows study of brain activation in noisy conditions

- **fMRI**
  - Identifies concurrent hemodynamic processes
  - One measure of functional connectivity