# Independent Component Analysis (ICA): An Introduction

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# Overview

The following will be introduced:

1. The Cocktail Party Problem
   - also known as *Blind Source Separation* (BSS).
2. Independent Component Analysis (ICA)
   - the model for solving BSS.
3. My interest in ICA and BSS.

# The Cocktail Party Problem

## Picking a voice out of a crowd

- You attend a busy cocktail party...
- Lots of guests speaking - simultaneously.
- You focus on each voice.
- How can a computer do this? (ICA)

# Demonstration

Web demo: Cocktail Party Problem

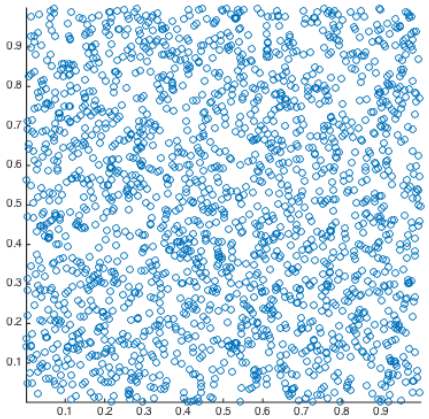
# Independent Component Analysis (ICA)

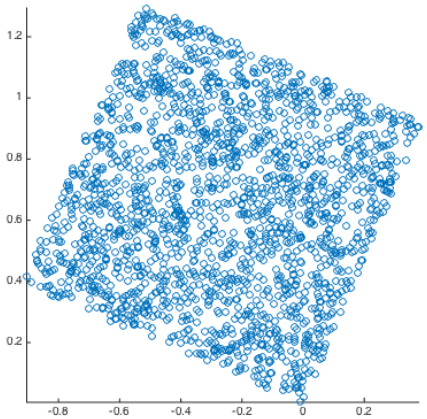
- Latent variable model:

$$\mathbf{x} = \mathbf{A}\mathbf{s} \tag{1}$$

- **s**: source signals.
- **x**: mixtures (observations).
- **A**: mixing matrix.
  Determines how much of each source is in each mixture.

# ICA Principles



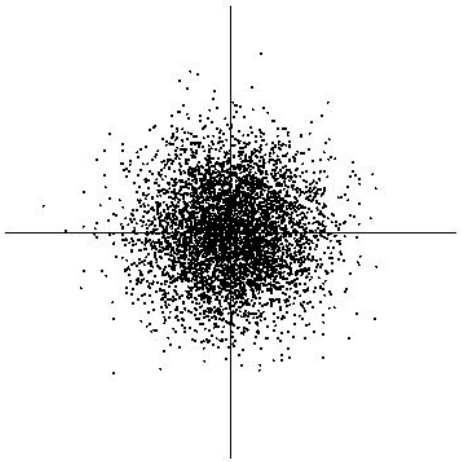

**Assume the sources are...**

- *Statistically independent*.
- *Non-Gaussian* (due to Central Limit Theorem).

**Retrieve sources by...**

- Rotating mixtures to *maximize independence*.

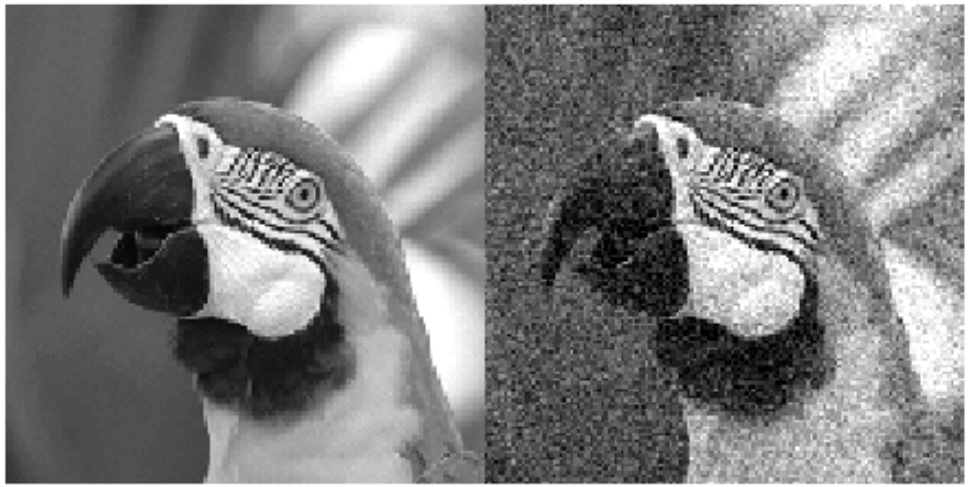
# Problems with ICA



- For Gaussian sources, rotation will not work!
- Linear, noiseless model: what about distortions?

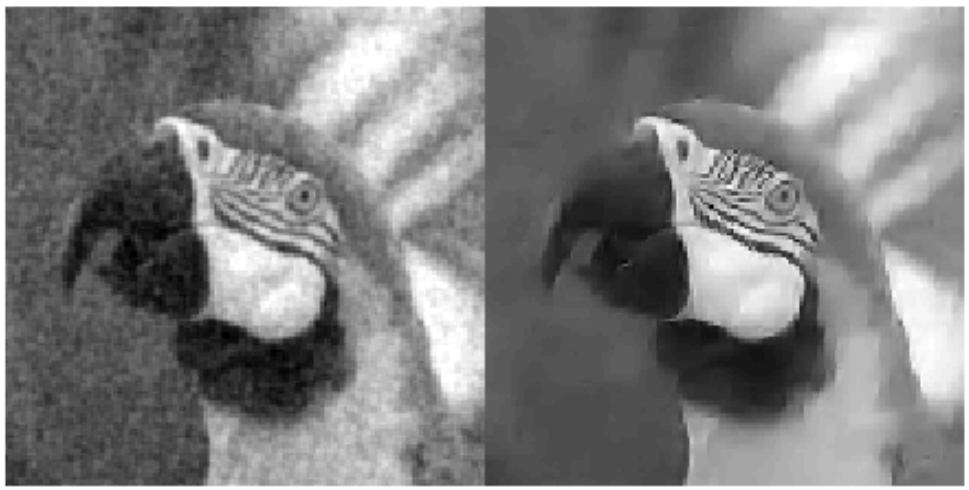
# ICA Applications
## Image denoising

Original



Noisy

Wiener filter



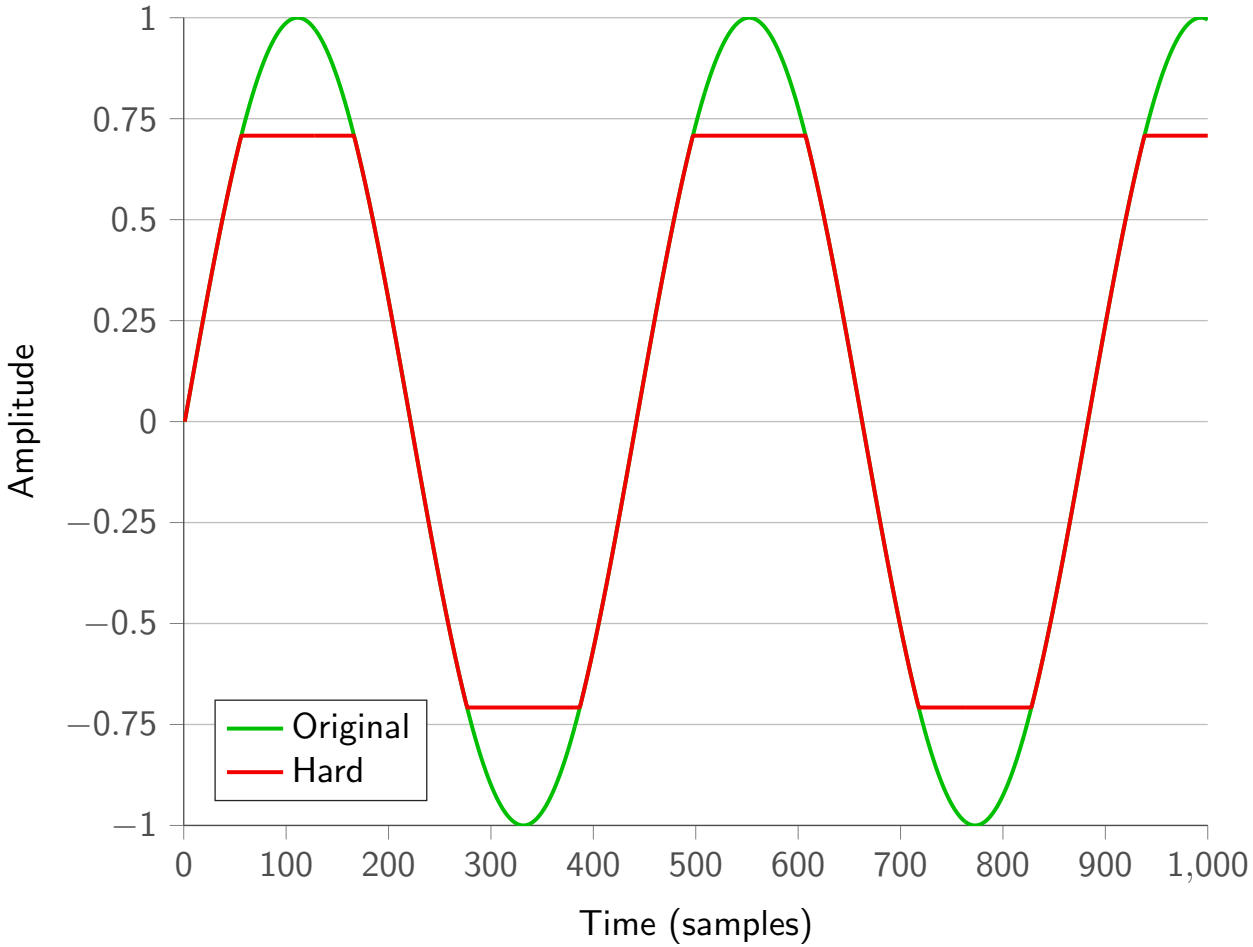
ICA filter

# Distortion

- What if the mixtures are distorted?
- Now, we don't have a linear mixture.
- Peak clipping: a common distortion encountered in signal processing.

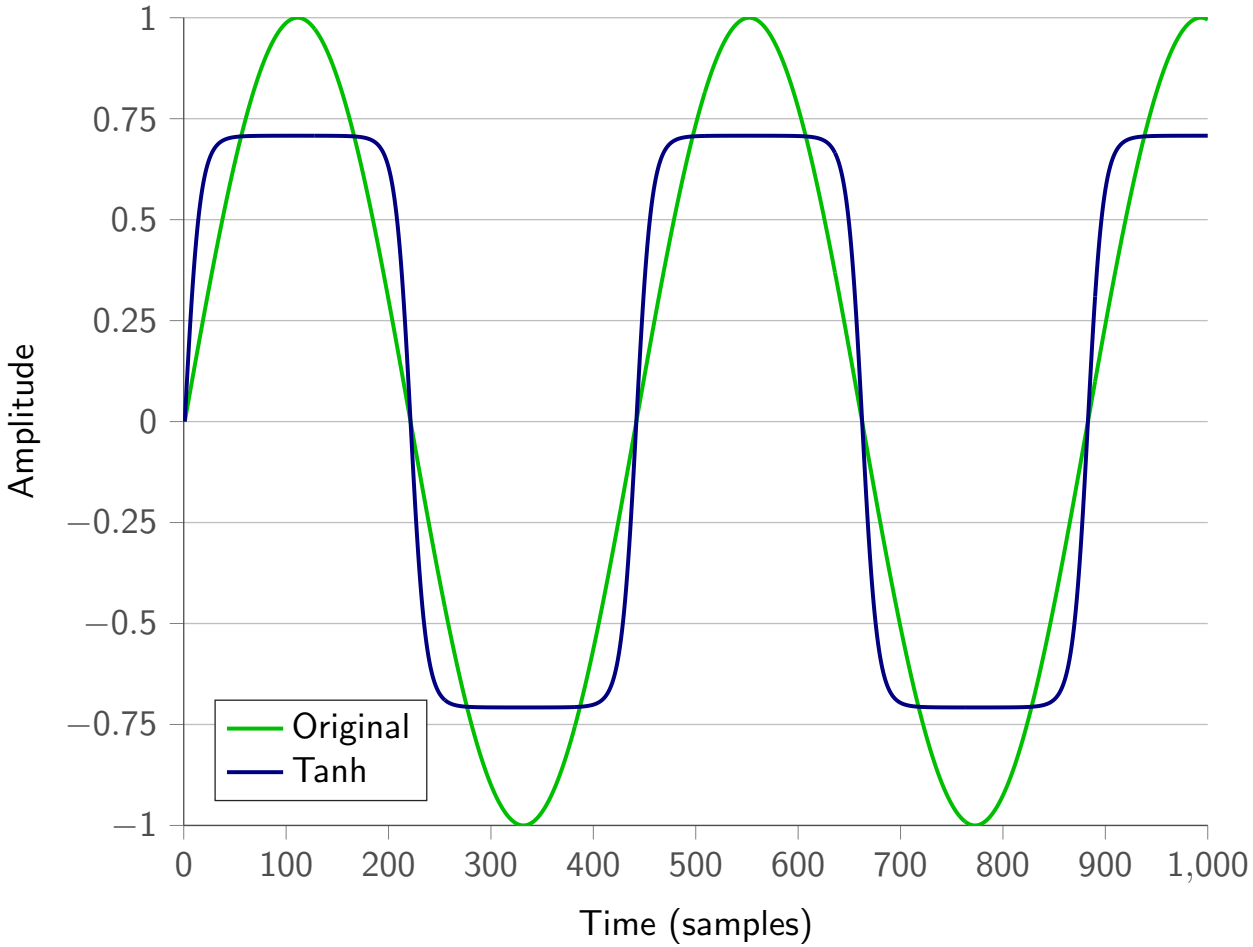
# Clipped sine wave

## Hard clipping example



# Clipped sine wave

## Soft clipping example



# For Further Reading


Hyvärinen, A., Karhunen, J. and Oja, E.
*Independent component analysis*.
New York: J. Wiley, 2001.


Hyvärinen, A., Oja, E.
Independent component analysis: algorithms and applications.
*Neural networks*, 13(4):411–430, 2000.