

Independent Component Analysis (ICA): An Introduction

Alastair Turl

School of Computer Science
University of Birmingham

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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:

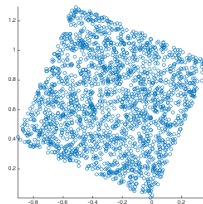
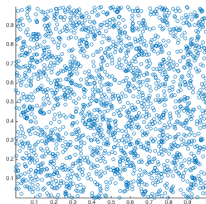
$$\mathbf{x} = \mathbf{A}\mathbf{s} \quad (1)$$

- \mathbf{s} : source signals.
- \mathbf{x} : mixtures (observations).
- \mathbf{A} : mixing matrix.

Determines how much of each **source** is in each **mixture**.



ICA Principles



Assume the sources are. . .

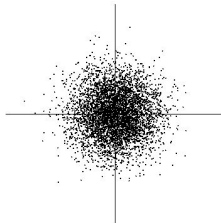
- *Statistically independent.*
- *Non-Gaussian* (due to **Central Limit Theorem**).

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



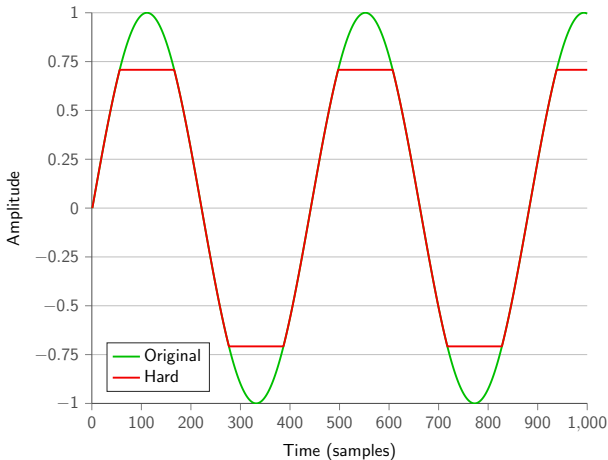
Distortion

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



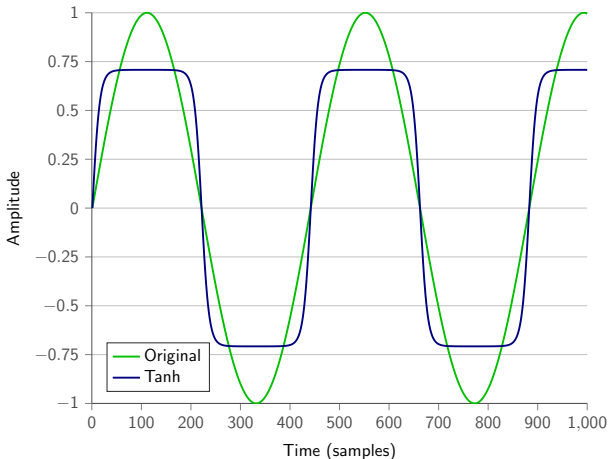
Clipped sine wave

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.

