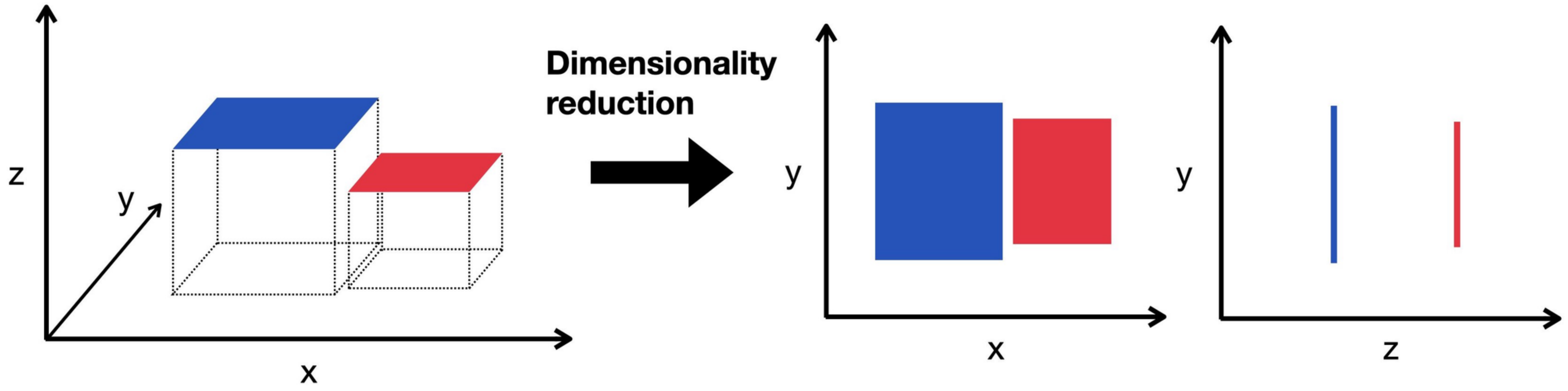
MACHINE LEARNING

INDEPENDENT COMPONENT LEARNING

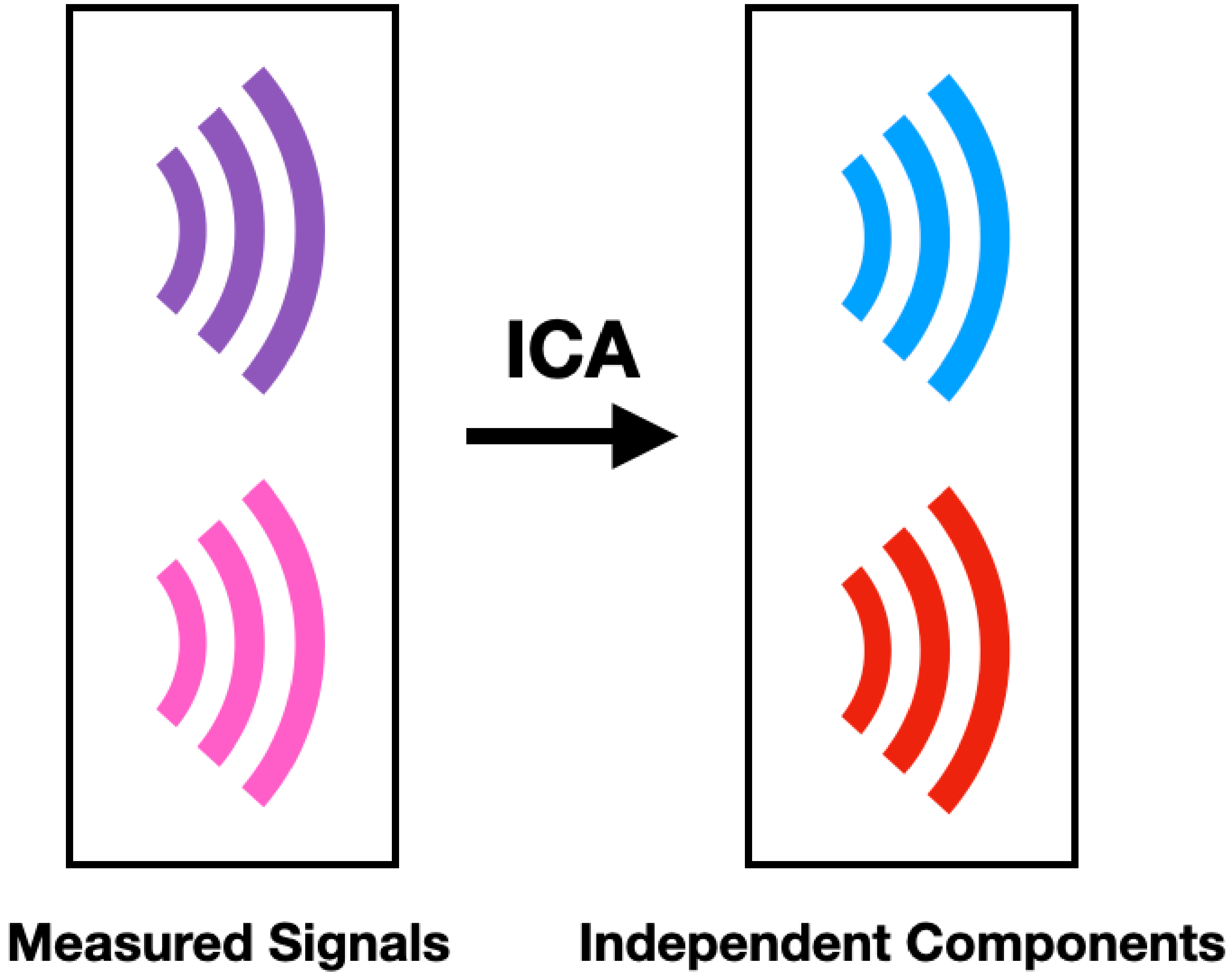
Christian Dzul -Ricardo Hernandez - Javier Hernandez - Ari Quintal

DIMENSIONALITY REDUCTION

Dimensionality reduction refers to techniques that reduce the number of input variables in a dataset. More input features often make a predictive modeling task more challenging to model, more generally referred to as the curse of dimensionality.



INDEPENDENT COMPONENT ANALYSIS



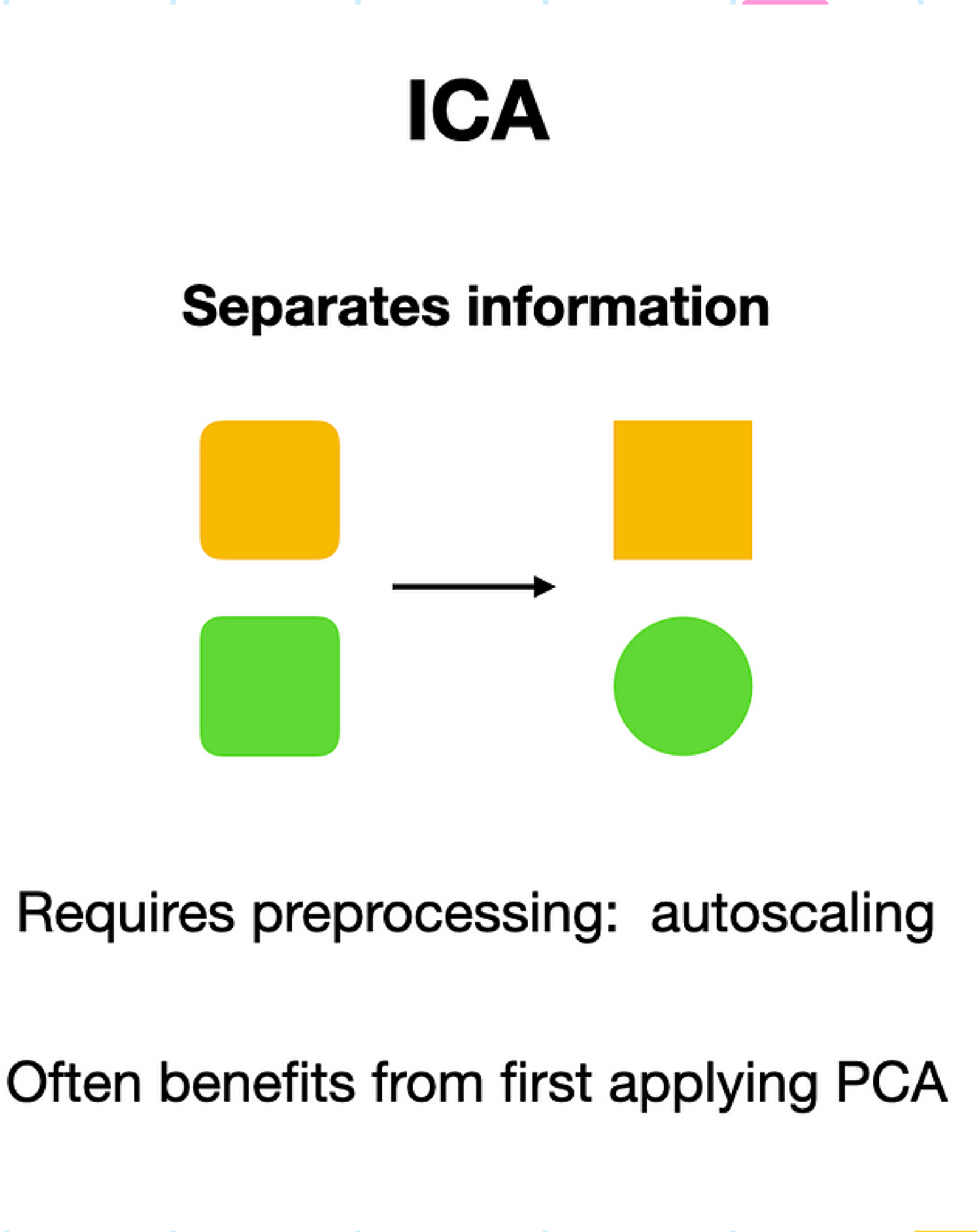
Independent Component Analysis (ICA) is a statistical and computational technique used in machine learning to separate a multivariate signal into its independent non-Gaussian components. It is a powerful technique used for a variety of applications, such as signal processing, image analysis, and data compression. ICA has been used in a wide range of fields, including finance, biology, and neuroscience.

APPLICATIONS

- Applied in signal processing, image analysis, and data compression, with diverse applications in fields like finance, biology, and neuroscience.

- ICA's core concept is to discover a set of basis functions that are statistically independent and non-Gaussian to represent observed data, facilitating the separation of data into independent components.

- Commonly combined with other machine learning methods, such as clustering and classification. It can preprocess data before clustering/classification or extract features that enhance the performance of these tasks.



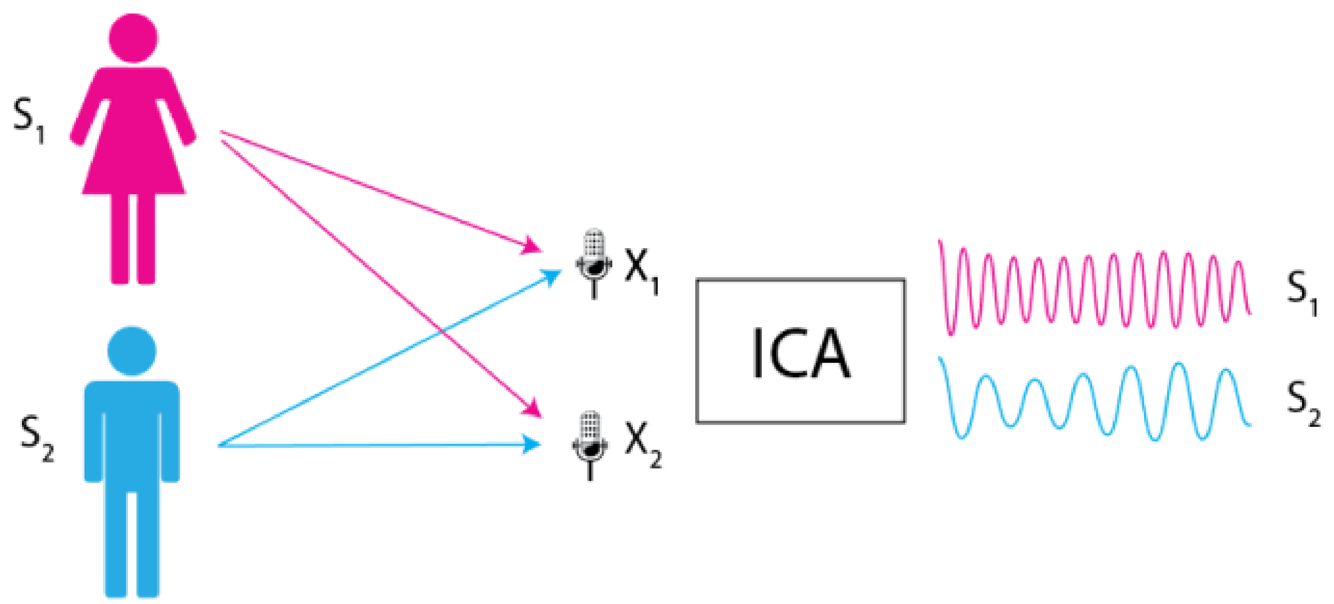
WE MUST CONSIDER:

To successfully apply ICA, we need to consider:

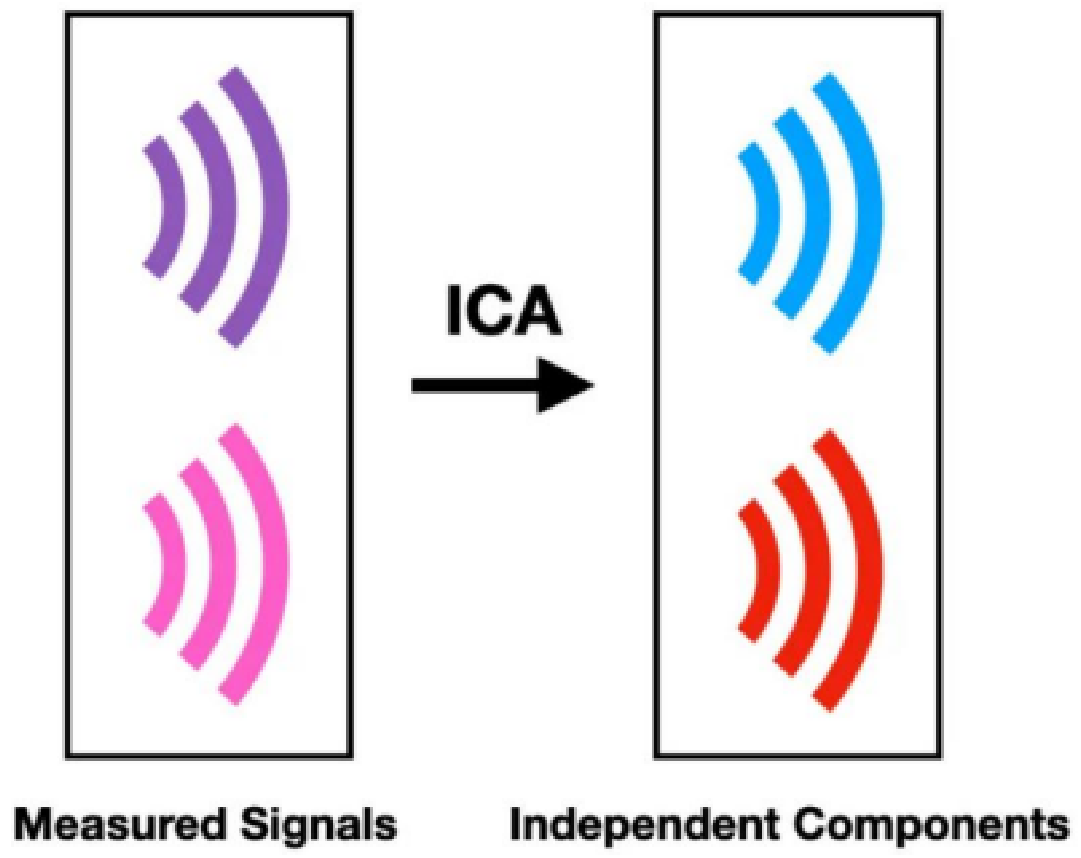
- Presumption of statistical independence
- Choice of ICA algorithm
- Component interpretation
- Results validation

EXAMPLE

The standard problem used to describe ICA is the "Cocktail Party Problem". let's imagine that two people have a conversation at a cocktail party. Let's assume that there are two microphones near both people. Microphones record both people as they are talking but at different volumes because of the distance between them. In addition to that, microphones record all noise from the crowded party. The question arises, how we can separate two voices from noisy recordings and is it even possible?



This problem is solved easily with Independent Component Analysis (ICA) which transforms a set of vectors into a maximally independent set. For this problem, ICA will convert the two mixed audio recordings (represented by purple and pink waveforms) into two unmixed recordings of each individual speaker (represented by blue and red waveforms)



Continuing with the problem, we can define the measured signals as a linear combination:

$$X_i = a_{i1}S_1 + a_{i2}S_2 = \sum_j a_{ij}S_j,$$

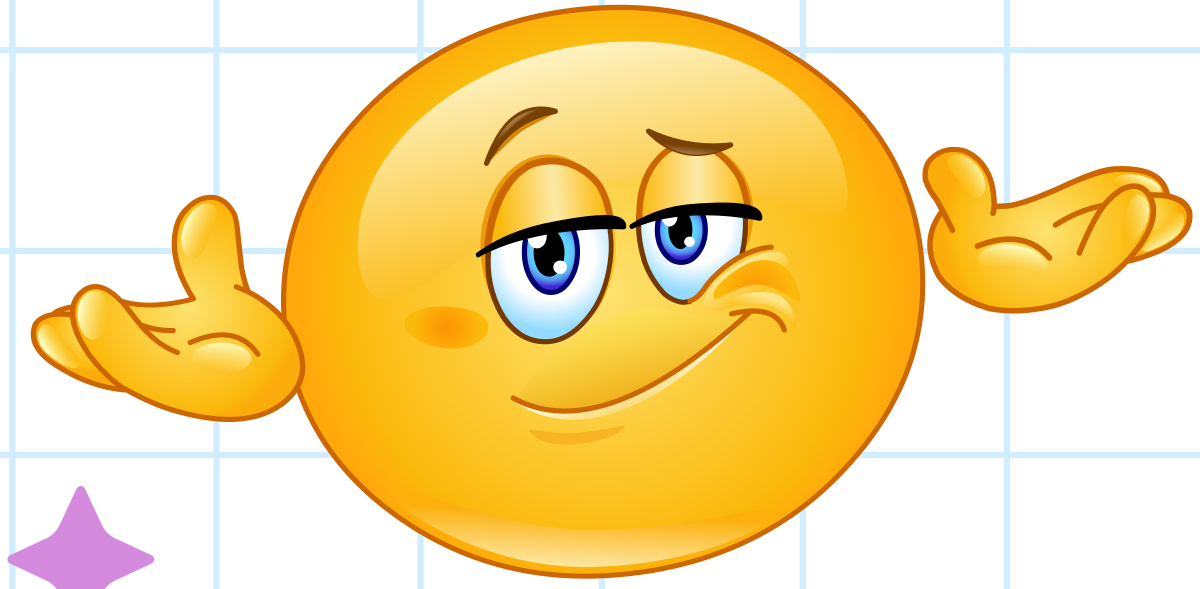
where Sj are independent components or sources and "aij" are some weights. Similarly, we can express sources as a linear combination of signals Xi:

$$S_i = \sum_j w_{ij}X_j,$$

where **Wij** are weights.

Using matrix notation, source signals S would be equal to $S=WX$ where W is a weight matrix, and X are measured signals. Values from X are something that we already have and the goal is to find a matrix W such that source signals S_i are maximally independent. Maximal independence means that we need to:

- Minimize mutual information between independent components or
- Maximize non-Gaussianity between independent components



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THANKS FOR YOUR ATTENTION!