ICA Based Neural Networks for Blind Sources Separation
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ICA (Independent Component Analysis), ISA (Independent Subspace Analysis) and TICA (Topographic Independent Component Analysis) are computational and statistical techniques which attempt to find hidden factors that underlie sets of random variables, measurements, or signals when the known classic methods fail completely. Independent component analysis is a method allowing the finding of underlying components from multivariate statistical data.

ICA is very closely related to the method called blind source separation (BSS). BSS has attracted a lot of research interest in the past decade due to its potential applications in signal processing, telecommunications, and medical imaging. ICA is one method, perhaps the most widely used, for performing blind source separation. “Blind” means that we know very little, if anything, on the mixing matrix, and make little assumptions on the source signals. Blind source separation attempts to recover independent sources which have been linearly mixed to produce observations. Consider, for example, electrical recordings of brain activity as given by an electroencephalogram (EEG). The EEG data consists of recordings of electrical potentials in many different locations on the scalp. These potentials are presumably generated by mixing some underlying components of brain activity.

Blind Source Separation is used to recover source signals from a set of linear mixtures of those signals by finding an un-mixing matrix which maximizes a measure of temporal predictability for each recovered signal. This matrix is obtained as the solution to a generalized eigenvalue problem. Such problems have scaling characteristics of $O(N^3)$, where $N$ is the number of signal mixtures. In contrast to independent component analysis, the temporal predictability method requires minimal assumptions regarding the probability density functions of source signals. It is demonstrated that the method can separate signal mixtures in which each mixture is a linear combination of source signals with Gaussian probability density functions, and on mixtures of voices and music.

The goal of this research is to use a neural network based on Fast Independent Component Analysis (FICA) in order to separate two or more original source signals $s_1(t)$, $s_2(t)$, ..., from their mixtures. For example, the first signal $s_1(t)$ is a zero-mean square wave, and the second signal $s_2(t)$ is uniformly distributed noise in the interval [-1, 1]. The signals were artificially mixed by using the mixing matrix $A = \|a_{ij}\|$. As a result, we generate four observable signals from the equation $X = AS$. From the above mixture of four signals we blindly separate the original two signals. For each of the separated signals, we computed the correlation coefficients with respect to the known (actual) source signals.