The Research and Simulation of Blind Source Separation Algorithm

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ABSTRACT

When the original source signals and input channel are unknown, blind source separation (BSS) tries decomposing the mixed signals observed to obtain the original source signals, as seems mysterious. BSS has found many applications in biomedicine science, image processing, wireless communication and speech enhancement. In this paper the basic theory of blind source separation is described, which consists of the mathematical model, knowledge, performance evaluation index, and so on. And a further research on blind source separation algorithm has done when the number of source signals is more than (equal) the number of the signals observed, including the traditional ways of BSS—fast independent component analysis (FastICA) algorithm and equivariant adaptive separation via independence (EASI) algorithm, as well as the SOBI algorithm which is based on the joint diagonalization of matrices.

KEYWORDS
Blind Source Separation, EASI, FastICA, MATLAB Simulation, SOBI

1. INTRODUCTION

1.1. Background and Significance

With the rapid development of computer technology in recent years, human society has gradually entered the digital age. Digital signal processing technology, as a “rising star” soon in seismic detection and communication, and other fields have a wide range of applications, and Blind Source Separation (Blind Source Separation, BSS) as a new technology of digital signal processing is gradually developed in the last twenty years. It’s an important research direction that has gradually developed in recent twenty years, and has become the research focus in the neural network and signal processing.

In daily life, we always be surrounded by a variety of signals, but most of these signals are not the message we want to receive, and a small part of the rest is what we want to extract useful signal, blind source separation algorithm is proposed for us to effectively solve this the problem. In the development of society, human life level with the development of science and technology also has improved significantly, the requirements of the new technology is also more than before, for example, digital mobile communication industry has developed rapidly in recent years. With the field of geological exploration in-depth exploration and excavation, research on blind signal processing and deal with the problem for us is very important. Meanwhile in wireless communication, speech recognition, sonar detection, image enhancement and biomedical and other fields, the research of blind source separation still has very important theoretical value and practical significance.

The so-called “blind source separation”, as the name implies, refers to the source signal and transmission channel parameters are unknown, use statistical characteristics of the input signal to separate each independent component of the source signal from the observed signals. The “blind”
has two meanings: first, the concrete mixing process is unknown; secondly, the source signal before mixing is also unknown.

A typical example is the “cocktail party problem,” namely an environment of many speakers exist at the same time, to pick up the speaker voices of mixed signal by a microphone array, use the method of signal processing to separate sound signal form specific speakers or several speakers. Both theory and practice have proved that the solution of this problem can be obtained only by certain assumptions.

Blind source separation problem according to different standards, can be divided into different types:

1. **The Linear Mixed Model and Nonlinear Mixed Models**: According to the characteristics of the hybrid system, the linear mixed model problem has been widely studied, but nonlinear blind source separation model does’t have a universal nonlinear model because of a lot of uncertainty, it needs should be further studied.

2. **Underdetermined, Well-Posed and Overdetermined Three Models**: according to the source signal and the receiving antenna number division, underdetermined refers to the antenna number less than the number of source signals, well-posed refers to the antenna number is equal to the number of source signals, overdetermined refers to the antenna number is greater than the number of sources. At present, most of the algorithms have been studied in overdetermined blind source separation and blind source separation of well-posed, less research on underdetermined blind source separation algorithm. Well-posed and Overdetermined blind source separation algorithm are also the main content of the research in this paper.

3. **The Instantaneous Mixture Model and Convolution Mixture Model**: It is found that the convolution model is more complex than the instantaneous model, but it has more practical application value according to whether exist a delay or not in the mixing process.

### 1.2. The Research Progress of Blind Source Separation

On April 13 to 16, 1986, Herault and Jutten have proposed a feedback neural network model and a learning algorithm based on Hebb at an International Conference on neural network as the theme. Under the condition of the linear mixed channel and the source signals are unknown, the new algorithm only using mixed signal to realize the separation of two independent source signals. Herault and Jutten’s work has opened up a new research topic - the blind source separation. Since then, to the problem of blind source separation research has received the widespread attention at home and abroad, and now study is becoming more and more deep and extensive, theory and practice has made great development. In this field, there are lots of valuable articles published every year.

After Herault and Jutten (1986; 1991) put forward feedback neural network and the learning algorithm based on Hebb learning rule, the signal processing community and the neural network community to research and explore blind source separation positively, and the number of the research about it is very large. Tong et al. (1991) analyzed the uncertainty and separability of blind source separation problem in 1991, and gives a matrix algebra method based on higher order cumulants. In 1992, Cohen and Andreou (1992) in the study pointed out that the Herault and Jutten’s neural network is only suitable for the separation of two sub Gauss source signal, when the source signal containing super Gauss signal, the separation effect will be significantly decreased. Cardoso et al. In 1993, Cardoso et al. (1993) proposed a method for blind separation based on a class of higher order cumulant joint diagonalization, and applied to the beam forming.

Comon (1994) had analyzed in detail the blind source separation problem under instantaneous linear mixture model, clearly put forward the concept of ICA (Independent Component Analysis), defined the objective function of blind source separation problem, namely cost function (Contrast function), and had described its properties, it is proved that the mutual information of the output of the separation system is the cost function of the blind source separation in the Kullback-Leiber
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