ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 3, Issue 8, August 2016

Introduction to Blind Source Separation of Audio Signals using ICA

[1] Mrs. K. Jyothsna Raj Kumari, [2] Sri. T.Vinod Kumar [3] Sri. S.Satish Kumar
[1][2] BITMS-Tirupati [2] NITTTR-Chandigarh [3]CBIT-Proddatur

Abstract: - **One of the requirements in the field of signal processing is to identify an information signal from a mixture of incoming signals. The input signal is assumed to be a mixture of more than one information signals. This paper addresses the blind signal separation (BSS) problem. The case of speech signals was considered. For the efficient separation of speech signals from a mixture of multiple speech signals, a two level signal scheme was proposed. In the first step, a mixture process was modeled. In the second level, a blind source separation algorithm was used to separate the independent source signals. One of the goals of this paper is to provide insight on some advances in algorithms, which are ideally suited for blind signal separation of speech mixtures. More importantly, specific emphasis is given in practical applications of the developed BSS algorithms associated with real-life scenarios.**

Index Terms:— **Blind Source Separation, Independent Component Analysis**

I. INTRODUCTION

Blind signal separation (BSS) is an area of signal processing research that has been extensively over the past years. BSS is defined as the process of retrieving signals from an array of mixtures compromised of the original signals. Although the objective of BSS may be similar to conventional system identification, they are different. Conventional systems identification relies upon a prior knowledge to retrieve signals, while BSS retrieves the solution blindly i.e. without knowledge of the mixing process and only minimal knowledge of the original signals in the mixture. The ability of BSS to separate signals in a mixture without training or a prior knowledge makes it a flexible and powerful framework, suitable for employment with a wide range of potential applications including the De-noising of images, biomedical signal retrieval and the separation of signals in communication systems.

Signal separation has long been a topic of interest in electrical engineering. Many algorithms have been developed to perform separation, but prior to BSS major assumptions were always required on the nature of the source. In signal separation, multiple streams of information are extracted from linear mixtures of these signal streams. This process is blind if examples of the source signals, along with their corresponding mixtures are unavailable for training.BSS is sometimes used interchangeably with independent component analysis (ICA), although technically, BSS and ICA are different tasks. BSS is most appropriate in situations where a linear mixture model is possible. Interest in blind signal separation has recently developed for three reasons:

1. The development of statistical frameworks for understanding the BSS task.
2. Development of several BSS methods, of which one is proposed in this paper.
3. The identification of many potential applications of BSS.

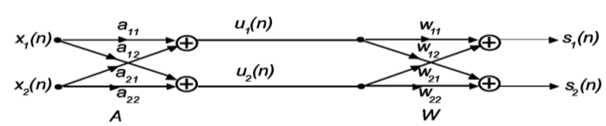
II.METHODS OF BSS

Independent component analysis (ICA) :

ICA is a way to find the independent components of a multivariate random variable. These components are directions in which the elements of the random variable have no dependency. ICA is a fairly new and a generally applicable method to several challenges in signal processing. Successful results in EEG, fMRI, speech recognition and face recognition systems indicate the power and optimistic hope in the new paradigm.

Signal separation

Consider the following mixing model:



Where,

$$u(n) = Ax(n) = \begin{bmatrix} a_{11}x_{11}(n) + a_{12}x_2(n) \\ a_{21}x_1(n) + a_{22}x_2(n) \end{bmatrix}$$

and

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 3, Issue 8, August 2016

In order for the output S(n) be equal to the input X(n), the separating matrix W must be defined as $W=A^{-1}$. Then the mixture U(n) will be separated.There are two inherent ambiguities in the ICA framework. Firstly there

$$s(n) = Wu(n) = \begin{bmatrix} w_{11}u_{11}(n) + w_{12}u_2(n) \\ w_{21}u_1(n) + w_{22}u_2(n) \end{bmatrix}$$

is a scaling ambiguity, secondly, a permutation ambiguity in that the source estimate vector will be an arbitrary permutation of the signals. So, the inverse A^{-1}cannot be found, but the separation of the mixtures can still be done by defining the matrix W so that:

$$W = cDA^{-1}$$

Independent component analysis

The algorithm that performs Blind Source Separation is known as Independent Component Analysis (ICA). ICA technique is a generally applicable method in signal processing. It opens a variety of potential applications.In contrast to other algorithms such as Principal Component Analysis (PCA), ICA can not only decor-relates the signals but also reduces higher-order statistical dependencies, attempting to make the signals as independent as possible.

III. MIXING PROCESS

In this mixing process three assumptions were taken in account:

- The sources are statistically independent
- The independent components have non-Gaussian distribution
- The mixing matrix is invertible

In order to implement the design, three microphones and a processing computer with audio output capabilities was required. Then three independent signal sources were recorded using the microphones. The following steps illustrate the mixing process:

1. Three signal sources$S_1(t)$,$S_2(t)$,$S_3(t)$ are considered and were imported in matlab program using "waveread".

2. These signals were combined into one signal vector S(t). The signal vector is then multiplied by some unknown mixing matrix B(NxN), where N is the number of signals recorded. The model for these mixed signals can be represented in matrix notation by:

$$X(t) = BS(t)$$

3. The resulting X(t) contains the mixed signals$X_1(t)$,$X_2(t)$ and X_3 (t).

IV.SEPARATION PROCESS

The objective is to recover the original signal vector, S(t) from only the observed vectorX(t). An estimate for the sources was obtained by first obtaining the unmixing matrix W, where

$W = B^{-1}$

This enables an estimate, S(t) of the independent sources to be obtained, where

S(t) = WX(t) --- **(1)**

The following steps illustrate the process:

- The mixed signals inputs obtained from the mixing process were imported into the ICA code. Each signal with specific sample and frequency.
- The unmixing matrix W was initiated to the identity matrix (NxN), where N is the number of signals observed.
- The output was calculated using equation **(1)**
- Then W was updated according to following equation

$$W^{(K+1)} = W^{(K)} + \alpha[I - 2\tanh(Y)Y^T]W^{(K)} \quad \text{--(2)}$$

And the next output was calculated, and so on until the maximum iteration. Then the separated signals were observed. This iteration will guess a row of the unmixing matrix W and then run through a loop until it finds a projection that agrees with the statistical analysis behind the decoding.

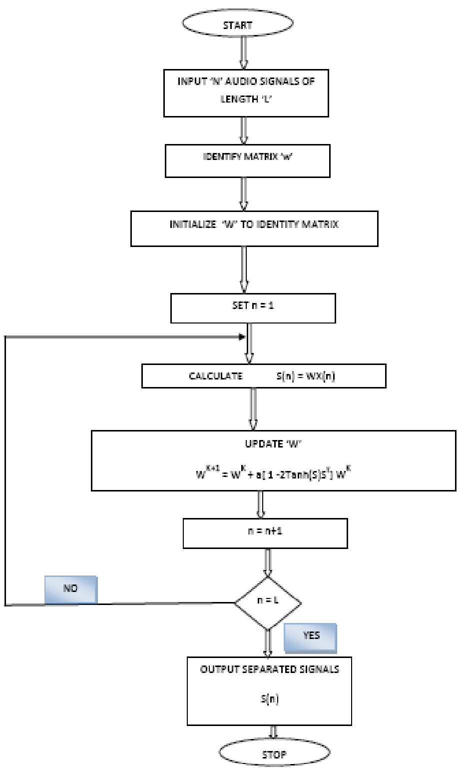
5. The coefficient "α" in equation (2) is used to ensure fine separation between the signals, and its value varies from one mixture to another.

IFERP
connecting engineers... developing research

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 3, Issue 8, August 2016

V.ICA ALGORITHM FLOWCHART



VI.CONCLUSION

The topic of Blind Source Separation, focusing on the mathematical foundations of BSS techniques.The objective of this paper was to achieve separation of set of signals from a set of mixed signals blindly. The obtained simulated results were in a good agreement with the expected theoretical study, thus the required goal was achieved. The algorithm used results in successful separation of mixed signals. But due to the long computations involved in the procedure the system encountered a significant delay in receiving the extracted signal, thus makes it too inefficient for practical use in a real time environment. In order to overcome this problem, the algorithm can be improved by implementing a frame by frame technique.

REFERENCES

1) 1.Blind Signal Separation, *Wikipedia*. [Online] 2011. [Cited:May 24,2011.] http://en.wikipedia.org/wiki/Blind_signal_separation

2) **David Knezevic**,"*Blind Source Separation for Signal Processing Applications*", University of Western Australia, 1st November 2004.

3) Fast ICA, *Legacy.ics.tkk*. [Online] 2011. [Cited: Jul 2,2011] http://cis.legacy.ics.tkk.fi/aapo/papers/IJCNN99_tutorialweb/node32.html.

4) Introduction, *Makafi*. [Online] 2011.[Cited: Feb 4, 2011.] http://www.makhfi.com/tutorial/introduction.htm

VII.BIBLIOGRAPHY

Jyothsna Raj Kumari .K
Received her M.Sc., (Computer Science) from SV University. Presently she is pursuing PhD., program at SVU – Tirupati, A.P, India.

Vinod Kumar Tummalur
Pursuing M.E., in ECE from NITTTR Chandigarh.

Satish Kumar Soma
Received his M.Tech (Elcetronics Instrumentation & Communication Systems) from Sri VenkateswaraUniversity,Tirupati. Presently he is working as Assistant Professor in Electronics &Commnication Engineering, **CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY**, Proddatur,Kadapadist, A.P,India.