

Acoustic Echo Canceller with Blind Source Separation

Ekta^{1*}, Shelej Khara¹

¹BRCM College of Engineering and Technology, Department of Electronics and Communication Engineering, Bahal, Haryana 127028, India

Abstract: Acoustic echo cancellation (AEC) aim to suppress the echo picked up by the micro phone in a hand free communication system. There are so many techniques which are used for removing of acoustic echo from original speech signal. We propose to apply a independent component analysis (ICA) technique for separation of near end signal for echoes. Proposed method can be regarded as a optimal coupling of linear echo canceller, multi channel source separation and non linear echo canceller under a proposed blind source separation technique.

Keywords: BSS, ICA, ECHO Canceller

1. Introduction

Echo is the repetition of a waveform due to reflection from points where characteristics of medium through which wave propagate changes. Echo signal are expressed as delayed and distorted version of sound which is reflected back to source of sound[1]. The acoustic echo canceller system is used in hand free system to reduce the undesired echoes which come due to loudspeaker and microphone coupling. There are two types of echoes in communication system.

1. Acoustic Echo
2. Hybrid Echoes

In this paper we will discuss acoustic echoes with BSS. In BSS the word blind source separation refers to fact that we do not know how signal are mixed or how they are generated. We are estimating the original source signal without knowing the parameter of mixing or filtering process. There is no guarantee that estimated or extracted signal have exactly the same waveform as ||Double talk detection is a typical problem that is deeply concerned in AEC implementation to detect the situation in which both sides talk simultaneously. During the double talk period, the residual error increases due to local speech so that the AEC stability bound decreases and the algorithm may start to diverge [3].

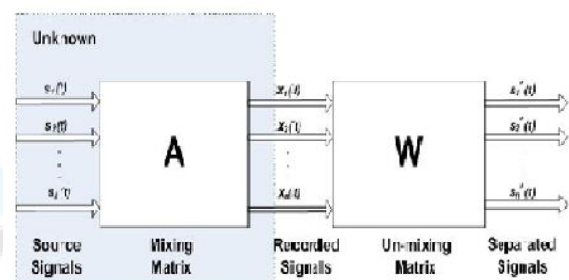
ICA is essentially a method for extracting individual signal from mixture. In this paper independent component analysis is introduced as a widely used technique for solving blind source separation (BSS) problem. Independent component analysis (ICA) is a recently developed method in which the goal is to find a linear representation of nongaussian data so that the components are statistically independent, or as independent as possible [4].

2. Blind Source Separation (BSS)

BSS is a technique in which I have a no. of sources emitting signal which are interfering with another situation in a crowded room with many people speaking at the same time. Interfering the electromagnetic wave from mobile phones or cross talk from brainwave originating from different area of

the brain. In each of their situations of mixed signal are often incomprehensible and it is of interest to separate the individual signal. This is the goal of blind source separation.. ICA the general idea is to separate the signal. Assuming the original underlying source signal are mutually independently distributed and uncorrelated the signal for higher order moment and produce a non orthogonal basis. ICA is very closely related to the method called blind source separation (BSS) or blind signal separation. A “source” means here an original signal, i.e. independent component, like the speaker. “Blind” means that we no very little, if anything, on the mixing matrix, and make little assumptions on the source signals. ICA is one method, perhaps the most widely used, for performing blind source separation.

Block Diagram of BSS



3. Objective

Blind source separation is one of foremost used technique in this era, with its application in variety of sectors. The aim of this technique is to separate the mixed signal which are new to world. Fast ICA algorithm for linear independent analysis in term of accuracy and complexity. Fast ICA algorithm is neural means parallel and distributive. ICA is the extension of PCA. PCA is used as preprocessing step of ICA technique. The main objective is Convergence speed of Fast ICA algorithm is superior from other.

4. Fast ICA Algorithm

- 1) Let Preprocess the data
- 2) Before the Fast ICA algorithm can be applied, the input vector data \mathbf{x} should be centered and whitened.

a) Centering the data

The input data \mathbf{X} is centered by computing the mean of each component of \mathbf{X} and subtracting that mean. This has the effect of making each component have zero mean. Thus:

$$\mathbf{X} \leftarrow \mathbf{X} - \mathbf{E}\{\mathbf{X}\}$$

b) Whitening the data

Whitening the data involves linearly transforming the data so that the new components are uncorrelated and have variance one. If $\tilde{\mathbf{X}}$ is the whitened data, then the covariance of the whitened data is the identity matrix:

$$\mathbf{E}\{\tilde{\mathbf{X}}\tilde{\mathbf{X}}^T\} = \mathbf{I}$$

This can be done using Eigen value decomposition of the covariance matrix of the data: $\mathbf{E}\{\mathbf{X}\mathbf{X}^T\} = \mathbf{E}\mathbf{D}\mathbf{E}^T$ where \mathbf{E} is the matrix of eigenvectors and \mathbf{D} is the diagonal matrix of eigenvalues. Once eigenvalue decomposition is done, the whitened data is:

$$\tilde{\mathbf{X}} \leftarrow \mathbf{E}\mathbf{D}^{-1/2}\mathbf{E}^T\mathbf{X}$$

3) Single component extraction

The iterative algorithm finds the direction for the weight vector \mathbf{W} maximizing the non-Gaussianity of the projection $\mathbf{W}^T\mathbf{X}$ for the data \mathbf{X} . The function is the derivative of a nonquadratic nonlinearity function $f(u)$.

Randomize the initial weight vector \mathbf{W} , Let $\mathbf{W}^+ \leftarrow \mathbf{E}\{\mathbf{X}_g(\mathbf{W}^T\mathbf{X})^T\} - \mathbf{E}\{g'(\mathbf{W}^T)\}$ where means averaging over all column-vectors of matrix \mathbf{X} .

$$\text{Let } \mathbf{W} \leftarrow \mathbf{W}^+ / \|\mathbf{W}^+\|$$

If not converged, go back to 2

4) Multiple Component Extraction

The single unit iterative algorithm only estimates one of the independent components, to estimate more the algorithm must be repeated, and the projection vectors decorrelated. Although Hyvärinen provides several ways of decorrelating results, the simplest multiple unit algorithm follows. $\mathbf{1}$ indicates a column vector of 1's with dimension M .

5. Algorithm

Input: C Number of desired components

Input: $\mathbf{X} \in \mathbb{R}^{N \times M}$ Matrix, where each column represents an N -dimensional sample, where $C < N$

Output: $\mathbf{W} \in \mathbb{R}^{C \times N}$ Un-mixing matrix where each row projects \mathbf{X} onto into independent component.

Output: $\mathbf{S} \in \mathbb{R}^{C \times M}$ Independent components matrix, with M columns representing a sample with C dimensions.

For in 1 to c :
 $\mathbf{W}_P \leftarrow$ Random vector of length N
 while \mathbf{W}_P changes
 $\mathbf{W}_P \leftarrow \frac{1}{M} \sum \mathbf{X}_g(\mathbf{W}_P^T \mathbf{X})$
 $\mathbf{W}_P \leftarrow \mathbf{W}_P - \sum \mathbf{W}_P^T \mathbf{W}_J \mathbf{W}_J$
 $\mathbf{W}_P \leftarrow \mathbf{W}_P / \|\mathbf{W}_P\|$

6. Properties

- [1] The convergence is cubic (or at least quadratic), under the assumption of the ICA data model. This is in contrast to ordinary ICA algorithms based on (stochastic) gradient descent methods, where the convergence is only linear. This means a very fast convergence, as has been confirmed by simulations and experiments on real data.
- [2] Contrary to gradient-based algorithms, there are no steps size parameters to choose. This means that the algorithm is easy to use.
- [3] The algorithm finds directly independent components of (practically) any non-Gaussian distribution using any nonlinearity g . This is in contrast to many algorithms, where some estimate of the probability distribution function has to be first available, and the nonlinearity must be chosen accordingly.
- [4] The performance of the method can be optimized by choosing a suitable nonlinearity g . In particular, one can obtain algorithms that are robust and/or of minimum.

7. Conclusion and Future Work

Blind source separation using independent component analysis is a difficult task when based on the signal. There are many approaches in BSS technique to estimate the signals but FAST ICA ALGORITHM is better because of its accuracy and convergence speed. Example of real world, in CDMA system information sequence of different users remain statistical independent and PN sequence of different users keep uncorrelated each other. So ICA helps to achieve blind estimation of information sequence and PN sequence. Application of ICA is in different areas such as telecommunication, biomedical signal processing, audio processing and image processing etc.

If you are using Word, use either the Microsoft Equation Editor or the MathType add-on (<http://www.mathtype.com>) for equations in your paper (Insert | Object | Create New | Microsoft Equation or MathType Equation). "Float over text" should not be selected.

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). First use the equation editor to create the equation. Then select the "Equation" markup style. Press the tab key and write the equation number in parentheses.

References

- [1] L. Zhonghai, Z. Yan, J. Liying, and Q. Xiaoguang, "Application of independent component analysis to the aero-engine fault diagnosis," in 2010 Chinese Control and Decision Conference. IEEE, June 2009, pp. 5330–5333.
- [2] Ganesh R. Naik and Dinesh K Kumar School of Electrical and Computer Engineering RMIT University, Australia. July 2009
- [3] G. R. Naik, D. K. Kumar, and M. Palaniswami, "Multi run ica and surface emg based signal processing system for recognising hand gestures," in Computer and Information Technology, 2008. CIT 2008. 8th IEEE International Conference on, 2008, pp. 700–705.
- [4] F. De Martino, F. Gentile, F. Esposito, M. Balsi, F. Di Salle, R. Goebel, and E. Formisano, "Classification of fmri independent components using ica fingerprints and support vector machine classifiers," *NeuroImage*, vol. 34, pp. 177–194, 2007.
- [5] Q. Zhang, J. Sun, J. Liu, and X. Sun, "A novel ica-based image/video processing method," 2007, pp. 836–842.
- [6] Q. Pu and G.-W. Yang, "Short-text classification based on ica and lsa," *Advances in Neural Networks -ISNN 2006*, pp. 265–270, 2006.
- [7] Y. Zhu, T. L. Chen, W. Zhang, T.-P. Jung, J.-R. Duann, S. Makeig, and C.-K. Cheng, "Noninvasive study of the human heart using independent component analysis," in *BIBE '06: Proceedings of the Sixth IEEE Symposium on BionInformatics and BioEngineering*. IEEE Computer Society, 2006, pp. 340–344.
- [8] C. J. James and C. W. Hesse, "Independent component analysis for biomedical signals," *Physiological Measurement*, vol. 26, no. 1, pp. R15+, 2005.
- [9] C. Jutten and J. Karhunen, "Advances in blind source separation (bss) and independent component analysis (ica) for nonlinear mixtures." *Int J Neural Syst*, vol. 14, no. 5, pp. 267–292, October 2004.
- [10] T. Kumagai and A. Utsugi, "Removal of artifacts and fluctuations from meg data by clustering methods," *Neurocomputing*, vol. 62, pp. 153–160, December 2004.
- [11] B. Azzerboni, M. Carpentieri, F. La Foresta, and F. C. Morabito, "Neural-ica and wavelet transform for artifacts removal in surface emg," in *Neural Networks, 2004. Proceedings. 2004 IEEE International Joint Conference on*, vol. 4, 2004, pp. 3223–3228 vol.4.
- [12] J. V. Stone, *Independent Component Analysis : A Tutorial Introduction* (Bradford Books). The MIT Press, September 2004.
- [13] E. Bingham, J. Kuusisto, and K. Lagus, "Ica and som in text document analysis," in *SIGIR '02: Proceedings of the 25th annual international ACM SIGIR conference on Research and development in information retrieval*. ACM, 2002, pp. 361–362.
- [14] A. Cichocki and S.-I. Amari, *Adaptive Blind Signal and Image Processing: Learning Algorithms and Applications*. John Wiley & Sons, Inc., 2002.
- [15] F. J. Theis, E. W. Lang, T. Westhuber, and C. G. Puntonet, "Overcomplete ica with a geometric algorithm," in *ICANN '02: Proceedings of the International Conference on Artificial Neural Networks*. Springer-Verlag, 2002, pp. 1049–1054.

Author Profile



Ekta is pursuing M.Tech from Department of Electronics and Communication Engineering, BRCM College of Engineering and Technology, Bahal, Haryana 127028, India