Blind Source Separation Research Based on the Feature Distance Using Evolutionary Algorithms

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Without any information on the mixing system, the blind source separation (BSS) technique efficiently separates mixed signals. The approach called evolutionary algorithms was used for the BSS problem in this paper. The fitness function based on the feature distance and kurtosis was proposed to measure the degree of the separated signals in this paper. Compared with the traditional algorithm in the BSS problem, the mathematical calculation and the physical significance of the separated signals are both taken into consideration in the proposed method. Therefore, the separated signals could have great correlation with the original individual signal and could be used in the additional signal processing step with good signal property. Experimental results on mixed spoken signals indicated that the established evolutionary algorithm of particle swarm optimization (PSO) and genetic algorithm (GA) could effectively solve the BSS problem from the signal feature distance and independence measurement. The study in this paper was implemented with MATLAB language.

1. INTRODUCTION

Without knowing the mixing processing and sources, blind source separation (BSS) deals with recovering a set of underlying sources from observations. The BSS problem is widely used in the fields of: image processing, acoustics signal separation, vibration signal separation, medical signal processing, biomedical data analysis, telecommunications, stock analysis and fault recognition.[1–3]

In the literature, the theory of BSS has been approached in several ways and various algorithms have been proposed. For example, the methods were originally introduced in the context of neural network (NN) modelling, independent component analysis (ICA), principle component analysis (PCA), singular value decomposition (SVD), high order statistical cumulants and others. The most important and simplest of the methods mentioned above is ICA which has the goal of finding a suitable representation of non-Gaussian sources with all the most independent components as possible. Lots of ICA algorithms for BSS problems are proposed, including the minimization (or maximization) of a contrast function (for example Mutual Information and non-Gaussianity). ICA works with different algorithms, including FastICA algorithm, JADE (Joint Angle and Delay Estimation) algorithm, extended Infomax algorithm, and mean field approach ICA. The ICA method differs from other similar methods in that the components are both statistically independent and non-Gaussian. BSS is used for recovering unobserved signals from a known set of mixtures. Therefore, ICA and BSS are equivalent when the mixtures are assumed to be linear up until possible permutations and invertible scalings.[2–7]

In the past, the NN model was the popular architecture for separation, but its performance depends strongly on the initiation of weight. In a previous study, the authors used the genetic algorithm (GA) for optimizing the weights of the NN system in order to enhance global convergence.[8] In another study, a support vector machine (SVM) methodology is applied to ICA in the search for the separating matrix.[5]

According to a previous paper, through finding optimum and accurate coefficients of the separating matrix, the evolutionary algorithms can be the best solution for solving BSS problems. In this approach, the new population can be created where independence among its components is maximized if a suitable fitness function is used. There are two types of contrast functions of BSS: information theory and high order statistics. In this paper, the authors used two evolutionary algorithms, GA and PSO, for BSS, and the novel fitness function is based on the mutual information and high order statistics.[2]

In another paper the authors present a novel GA-ICA method which converges to the optimum.[9] The new method uses GA to find the separating matrices, which are based onthe contrast function to minimize a cumulant. In reference 10 the authors used the kurtosis of the mixed signal to the target function, by modifying PSO to replace the steepest gradient descent method. In reference 11 the learning rate of the BSS method is selected adaptively by using PSO. In reference 12 the authors introduce the evolution speed and the aggregation degree to update the dynamic inertia weight in PSO. In refer-