ISSN 0735-2727, Radioelectronics and Communications Systems, 2011, Vol. 54, No. 6, pp. 315–324. © Allerton Press, Inc., 2011.
Original Russian Text © S. Mavaddaty, A. Ebrahimzadeh, 2011, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2011, Vol. 54, No. 6, pp. 32–43.

Blind Signals Separation with Genetic Algorithm and Particle Swarm Optimization Based on Mutual Information

S. Mavaddaty and A. Ebrahimzadeh
Babol Noshirvani University of Technology, Babol, Iran
Received in final form September 17, 2010

Abstract—Blind source separation technique separates mixed signals blindly without any information on the mixing system. In this paper, we have used two evolutionary algorithms, genetic algorithm and particle swarm optimization for blind source separation. In these techniques a novel fitness function that is based on the mutual information and high order statistics is proposed. In order to evaluate and compare the performance of these methods, we have focused on separation of noisy and noiseless sources. Simulations results demonstrate that the proposed method for employing fitness function has rapid convergence, simplicity and a more favorable signal to noise ratio for separation tasks based on particle swarm optimization and continuous genetic algorithm than binary genetic algorithm. Also, particle swarm optimization enjoys shorter computation time than the other two algorithms for solving these optimization problems for multiple sources.

DOI: 10.3103/S0735272711060045

1. INTRODUCTION

Blind source separation (BSS) has seen increasing demands nowadays for many areas of signal processing such as medical data processing, speech recognition and radar signal communication [1–4]. In BSS, the source signals and the mixing model parameters are unknown. The unknown original source signals can be separated and estimated using only the observed signals, which are given through unobservable mixture [5]. In the literature, the theory of BSS has been approached in several ways and as a result, various algorithms have been proposed. For example, independent component analysis (ICA), principle component analysis (PCA), high order statistical cumulants and other algorithms may be used [6–8]. The most important and simplest of them is ICA as a statistical method, which purpose is to find components of signal that have the highest statistical independence. ICA is based on random and natural gradient [9]. This algorithm is susceptible to the local minima problem during the learning process and is limited in many practical applications such as BSS that requires a global optimal solution. Also, the neural networks have been proposed. The operation of neural networks depends on the update formula and the activation function that are updated for maximizing the independence between estimated signals [10]. These algorithms depend on the source signals distribution. Since this separation is executed blindly and there is no information about source signals, the source signals distribution function should be estimated in advance. Consequently, it leads to reduced accuracy of the problem's solution. Thus, developing new BSS algorithms on the basis of global optimization algorithms that are independent of gradient techniques is an important issue [11–15]. The BSS problem is identified as a popular topic of study among researchers, because it can work based on evolutionary algorithms such as continuous genetic algorithm (CGA), binary genetic algorithm (BGA), particle swarm optimization (PSO) and so on [16, 17]. It is obvious that GA and PSO are successful evolutionary algorithms, which provide heuristic solutions for combinatorial optimization problems.

In this paper, the BSS approach for linear mixed signals is studied to get the separating matrix coefficients using PSO and both forms of GA. The operation of these algorithms principally depends on the fitness function, which in this paper uses mutual information (MI) as the main criterion in information theory and high order statistics (HOS) of kurtosis [18–20]. MI is the main quantity that measures the mutual dependence of the two variables. Also the kurtosis is a simple and necessary criterion for estimating dependency among signals [21]. This paper proposes the fusion of these important criteria into a suitable fitness function for separation of different sources in linear BSS model. Using this fitness function in