Frequency Modulation Sound Parameter Identification using Shuffled Particle Swarm Optimization

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ABSTRACT

The frequency modulation sound parameter identification is a complex multimodal optimization problem. This problem is modeled in the form of a cost function that is the sum-squared error between the samples of estimated wave and the samples of real wave. In this research, the authors propose a shuffled particle swarm optimization algorithm to solve this problem. In the shuffled particle swarm optimization proposed here, population such as shuffled frog leaping algorithm is divided to several memeplexes and each memeplex is improved by the particle swarm optimization algorithm. A comparison among the obtained results of the authors’ proposed algorithm with the results reported in the literature confirms a better performance of the authors’ proposed algorithm.

Keywords: Frequency Modulation, Memeplex, Parameter Identification, Particle Swarm Optimization, Shuffled

INTRODUCTION

The frequency modulation sound parameter identification (FMSPI) is a complex multimodal problem having strong epistasis. In order to solve this problem, it is firstly modeled in the form of an optimization problem and then an optimization method is employed to extract its parameters. The methods used for solving optimization problem can be divided into two main groups: analytical and non-analytical methods. Analytical optimization methods such as linear and non-linear programming require to apply some limitations and initial
assumptions on objective function, e.g. to be differentiable and convex, so they cannot be applied on a variety of optimization problems. The non-analytical optimization methods do not have these limitations. They require little or no additional assumptions on the structure of optimization problems. One of the most applicable methods are evolutionary algorithms (EAs).

The EAs can be applied to search the complex, discrete or continuous, linear or non-linear, and convex or non-convex spaces. So those are recognized as all-propose and direct search optimization methods. Existence of a criterion to evaluate a candidate solution is unique necessary and enough limitation to apply the EAs on each problem. The particle swarm optimization (PSO) (Kennedy & Eberhart, 1995) is an EA which has been attracted many researchers in different engineering fields (Yu & Xiong, 2004; He & Wang, 2007; Kwok et al., 2006; Feng et al., 2007).

The PSO simulates the movement of organisms and social behaviour in a flock of birds or school of fishes. This algorithm updates its members using the particle’s previous best position and using the previous best position of the particle’s neighbors or whole swarm. To improve the performance of original PSO, various concepts have been proposed in the literature.

Feng et al. (2007) developed an evolutional fuzzy PSO learning algorithm to self extract the near optimum codebook of vector quantization for carrying on image compression. The fuzzy PSO vector quantization learning schemes, combined advantages of the adaptive fuzzy inference method, the simple VQ concept and the efficient PSO, were considered at the same time to automatically create near optimum codebook to achieve the application of image compression. Fan and Zahara (2007) proposed a hybrid NM-PSO algorithm based on the Nelder–Mead (NM) simplex search method and PSO to produce faster and more accurate convergence on unconstrained optimization. Lee and Chen (2007) presented an iteration PSO algorithm for solving the optimal contract capacities of a time-of-use (TOU) rates industrial customer.

A new index, called iteration best was incorporated into PSO to improve solution quality and computation efficiency.

Arumugam and Rao (2007) embedded the concepts of the popular genetic algorithm (GA) operator, cross-over and root mean square variants into PSO algorithm to make the convergence faster. The experimental results illustrated the advantage of PSO with cross-over operator, which sharpened the convergence and tunes to the best solution.

Beside of aforementioned concepts, the authors propose a novel approach to improve the performance of PSO. This research employs the partitioning and shuffling concepts to give the parallel search ability to the PSO. The partitioning and shuffling concepts have been borrowed from the shuffled frog leaping (SFL) algorithm (Eusuff & Lansey, 2003).

The paper is organized as follows: the second section describes a formulation of the FMSPI problem. In the third section, the PSO is briefly described. The utilized strategy to improve the PSO is explained in the fourth section. The obtained computational results are presented and discussed in the fifth section. Conclusions are given in the sixth section.

FREQUENCY MODULATION SOUND PARAMETER IDENTIFICATION

A global optimization problem can be considered as:

$$\min f(X), \; X = (x_1, x_2, ..., x_n)$$

Subject to $X \in \Omega \subseteq \mathbb{R}^n$

where $X$ is a set of variables and $f : \Omega \rightarrow \mathbb{R}$ is the objective function. A vector $X^*$ that satisfies $f(X^*) < f(X)$ for all $X \in \Omega$ is a global minimizer of $f(X)$ over $\Omega$ and the corresponding value of $f(X^*)$ is called a global minimum.