Orthogonal Permutation Particle Swarm Optimizer with Switching Learning Strategy for Global Optimization

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Abstract: - This paper aims to improve the performance of original particle swarm optimization (PSO) so that the consequent method can be more robust and statistically sound for global optimization. A variation of PSO called the orthogonal permutation particle swarm optimization (OPPSO) is presented. An orthogonal permutation strategy, based on the orthogonal experimental design, is developed as a metabolic mechanism to enhance the diversity of the whole population, where the energetic offspring generated from the superior group will replace the inferior individuals. In addition, a switching learning strategy is introduced to exploit the particles' historical experience and drive individuals more efficiently. Seven state-of-the-art PSO variants were adopted for comparison on fifteen benchmark functions. Experimental results and statistical analyses demonstrate a significant improvement of the proposed algorithm.

Keywords: - Soft Computing; Particle swarm optimization; Orthogonal experimental design; Learning strategy; Global optimization;

1 Introduction

Global optimization problem extensively exists in real-world optimization fields, such as economic and engineering areas [1-3]. Since real-world problems become increasingly complex, superior techniques are always needed.

Particle swarm optimization (PSO), which was first proposed by Kennedy and Eberhart in 1995[4, 5], is a population-based stochastic optimization algorithm. The algorithm is inspired by the social choreography of birds flocking and fish schooling. PSO has been shown to be efficient and effective technique that it has been successfully applied to many practical areas, such as nonlinear constraint problems [6] and system design [7]. These optimization problems can be uniformly formulated as *D*-dimensional minimization problem as follows:

$$\text{minimize } f(x),\ x=[x_1,x_2,\ldots,x_D] \qquad (1)$$

Generally speaking, the advantages of PSO in addressing with global optimization problems include high convergence speed and easy implementation. However, it may easily be premature when solving complex problems. To improve the performance of PSO, many state-of-the-art PSO variants have been proposed [6, 8-16]. Qiao *et al*. [6] redefined personal best and global best to enhance the convergence rate of PSO. Jatmiko *et al*. [8] developed an modified PSO which follows a local gradient of the chemical concentration within a plume. Sabat *et al*. [11] integrated comprehensive learning strategy with hyper spherical manipulation to improve its exploration. A cooperatively coevolutionary algorithm based on the divide-and-conquer strategy has been incorporated into PSO [14], hence proposing two cooperative PSO models which offer remarkable results over the original PSO. Li and Yao [12] combined the cooperative coevolutionary model with random grouping and adaptive weighting schemes to develop a cooperatively coevolving PSO, which is promising on solving high-dimensional problem. What's more, Li and Yao adopted Cauchy and Gaussian distributions to sample new points and adaptively select the coevolving subcomponent sizes [13]. Liang *et al*. developed a comprehensive learning PSO (CLSPO) [9]. In CLSPO, instead of learning from the global and personal best information, a particle employs all the particles' best position to renew its velocity. CLPSO significantly enhances the performance of the original PSO on multimodal problems.

Orthogonal experimental design (OED) [17] is an efficient method to find out the best combination