Chapter 2
Local Best Particle Swarm Optimization Using Crown Jewel Defense Strategy

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ABSTRACT

Particle swarm optimization (PSO) is a swarm intelligence algorithm well known for its simplicity and high efficiency on various problems. Conventional PSO suffers from premature convergence due to the rapid convergence speed and lack of population diversity. It is easy to get trapped in local optima. For this reason, improvements are made to detect stagnation during the optimization and reactivate the swarm to search towards the global optimum. This chapter imposes the reflecting bound-handling scheme and von Neumann topology on PSO to increase the population diversity. A novel crown jewel defense (CJD) strategy is introduced to restart the swarm when it is trapped in a local optimum region. The resultant algorithm named LCJDPSO-rfl is tested on a group of unimodal and multimodal benchmark functions with rotation and shifting. Experimental results suggest that the LCJDPSO-rfl outperforms state-of-the-art PSO variants on most of the functions.

INTRODUCTION

Particle swarm optimization (PSO) was first introduced by Kennedy and Eberhart (Eberhart & Kennedy, 1995) based on a social-psychological model of social influence and learning. Like most swarm intelligence algorithms, PSO is a population-based stochastic search technique. Each member of the PSO swarm, called a particle, represents a candidate solution in the search space. During the optimization, each particle iteratively adjusts its position and flying direction according to the velocity, which is dependent on the best experiences of the swarm and the particle itself. A fitness value is used to estimate the quality of the particle's position. The subsequent flying direction is determined accordingly.

PSO is easy to implement while highly effective in searching the solution space. It has been successfully applied to various optimization problems such as spam detection (Tan, 2010), breast cancer diagnosis (Sheikhpour, Sarram, & Sheikhpour, 2016), building energy performance simulation (Delgarm, Sajadi, Kowsary, & Delgarm, 2016), log-periodic antenna design (Zaharis et al., 2017), and radiotherapy planning (Modiri, Gu, Hagan, & Sawant, 2017). However, the conventional PSO commonly gets trapped in local optima when solving complex multimodal problems. It converges quickly in that information transmits throughout the swarm rapidly, while the search scope is also shrinking fast, which usually leads to the lack of population diversity and premature convergence. If the particles are initialized in proper areas, PSO can quickly reach a superior solution. However, in more common cases it is likely to converge to an inferior solution and result in mediocre performance.

Many PSO improvements have been proposed to address this problem by increasing the population diversity. For instance, Qin *et al.* improved PSO with an inter-swarm interactive learning strategy (Qin, Cheng, Zhang, Li, & Shi, 2016); Wang *et al.* introduced the idea of hybrid Krill herd and quantum-behaved in PSO to increase the local search ability and individual diversity (Wang, Gandomi, Alavi, & Deb, 2016); Dong *et al.* used supervised learning and control method to optimize the parameters and to maintain diversity for PSO (Dong & Zhou, 2017); Du *et al.* proposed a novel heterogeneous strategy PSO, which enhances the converging speed while prevents premature convergence (Du, Ying, Yan, Zhu, & Cao, 2017).

In this paper, we impose the reflecting bound-handling scheme and von Neumann topological neighborhood on a local best PSO (LPSO), which helps to achieve a better balance between diversity and convergence speed. Moreover, a novel Crown Jewel Defense (CJD) strategy is proposed to direct the algorithm toward a better solution when the particles are trapped in a local optimum region. We evaluate the performance of the proposed algorithm, namely LCJDPSO-rfl, through a series of experiments on both unimodal and multimodal benchmark functions. The experimental results demonstrate the stability and efficiency of LCJDPSO-rfl on most of the functions.

BACKGROUND

Global Optimization

Global optimization is the process for seeking variables that minimize or maximize the result of the target function. It's an important research area in the field of artificial intelligence and machine learning. Conventional deterministic optimization methods, e.g., Quasi-Newton methods and gradient descent achieve promising performance on unimodal and low dimensional problems. However, these "greedy"

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