Chapter 4
Parameter Settings in Particle Swarm Optimization

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ABSTRACT

The issue of parameter setting of an algorithm is one of the most promising areas of research. Particle Swarm Optimization (PSO) is population based method. The performance of PSO is sensitive to the parameter settings. In the literature of evolutionary computation there are two types of parameter settings - parameter tuning and parameter control. Static parameter tuning may lead to poor performance as optimal values of parameters may be different at different stages of run. This leads to parameter control. This chapter has two-fold objectives to provide a comprehensive discussion on parameter settings and on parameter settings of PSO. The objectives are to study parameter tuning and control, to get the insight of PSO and impact of parameters settings for particles of PSO.

INTRODUCTION

Research in optimization is very active and different optimization algorithms are being proposed regularly. Kennedy and Eberhart (Kennedy & Eberhart, 1995; Eberhart & Kennedy, 1995) introduced an optimization technique named Particle Swarm Optimization (PSO) in 1995. PSO is from the category of algorithms named Swarm Intelligence and is motivated by social behavior patterns of organisms living and interacting within large groups. In particular, it incorporates swarming behavior observed in bird flocks and fish schools. Social sharing of information among individuals of a population is the core idea behind PSO.

The performance of PSO is sensitive to the parameter settings. The computational behavior of PSO is significantly affected by initialization of particles, velocity threshold, inertia weight, constriction coefficient, acceleration coefficient, neighborhood typologies and swarm size. The algorithm finds a solution which is near optimum efficiently depending on the values of these parameters. Assigning the

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proper values to these parameters needs much effort. Hence it is necessary to analyze the PSO theoretically to tune the parameters. Particles change their position dynamically based on socio-cognition model.

MAIN FOCUS OF THE CHAPTER

The chapter has two-fold objectives, to provide an insight of PSO and to present a comprehensive discussion on the impact of parameters settings on the performance of PSO. The chapter provides a broad view in the field to help researchers. Particle swarm optimization algorithm is formulated and the parameters of PSO are listed down in the first section. Parameter settings for PSO algorithm influence the performance of the algorithm. The second section focuses on parameter tuning and control. The parameter tuning in PSO is based on the theoretical and empirical analysis. Theoretical analysis of PSO and the states of PSO are discussed in the third section. Parameters may or may not be independent and trying all combinations is practically impossible. In essence, tuning parameter values before the optimization process does not guarantee an optimal performance of the algorithm. Parameters can be controlled based on evidence such as generation number, fitness values or convergence and diversity of the population by fixed control without feedback or by adaptive control with feedback mechanism. Feedback can be fitness value or state of the swarm. PSO is a population based method and the evolutionary state reflects current population and fitness diversity. The search process can be accelerated by finding out the state of the swarm. The fourth section focuses on parameter tuning and control in PSO.

PARTICLE SWARM OPTIMIZATION

Swarm Intelligence (SI) is collective intelligence. It is simulation of social interaction between individuals. In SI, metaphors from successful behavior of animal or human societies are applied to problem solving. The social behavior of fish and birds has influenced scientists. Various interpretations of the movement of organisms in a bird flock or fish school are simulated by number of scientists. Natural flocks seem to consist of two balanced, opposing behaviors: a desire to stay close to the flock and a desire to avoid collisions within the flock.

The PSO is a population based approach (Engelbrecht, 2005) and follows swarm intelligence principles. The swarm consists of particles. These particles fly through the problem space. The velocity directs flying of the particles. The particles fly by following the current optimum of objective function. Social sharing of information among individuals of a population is the core idea behind PSO. The first version of the PSO was published by Kennedy and Eberhart (1995) and has rapidly progressed in recent years since then. Swarm of N particles is represented as

$$S = X_1 , X_2 , \ldots , X_N \tag{1}$$

Depending on the problem at hand each particle has d-dimensions. For a d-dimensional search space, the position of the i^{th} particle is represented as-