Chapter 8
Kinetic Gas Molecule Optimization (KGMO)

ABSTRACT

In this chapter, an optimization algorithm that is based on the kinetic energy of gas molecules, namely kinetic gas molecule optimization (KGMO), is introduced. This algorithm has some agents that are gas molecules, which move in the search space; these agents are subject to the kinetic theory of gases, which defines the rules for gas molecule interactions in the model. This algorithm has a good performance in terms of finding the global minima in 23 nonlinear benchmark functions, and the performance is compared with two other benchmark algorithms, namely particle swarm optimization (PSO) and the recently developed high-performance gravitational search algorithm (GSA).

8.1 INTRODUCTION

There are various types of optimization problems, which change with time in the real-world. Typical examples of optimization problems include recognition of moving objects in changing background; data mining; routing in networks, etc. Finding a solution for optimization problems has been studied by many researchers. It is understood that the classical optimization algorithms do not provide suitable solutions in a high-dimensional search space, because of the exponential increase of the problem size. Therefore, traditional techniques such as exhaustive search are not practical in solving these problems (Arkin, 1998; Beni and Wang; 1989; Bonabeau et al., 1999).

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Many algorithms have been developed for the problem of optimization of objective functions, which is the focus of this chapter. However, they suffer from shortcomings such as getting trapped in local optima, slow convergence and complexity of operations in finding the global optimum point. For example, the standard Particle Swarm Optimization (PSO) algorithm easily gets trapped in the local optima when solving complex multimodal problems (Devi et al., 2011; Idoumghar et al., 2011), while Genetic Algorithm (GA) has no absolute assurance of finding a global optimum. This happens very often when the populations have a large number of subjects. On the other hand, there are various operations such as mutation and crossover in GA that causes the long response time for finding the solution. Evolutionary algorithms (EA) too suffer from slow convergence problem (Devi et al., 2011). In the method proposed in this work, the aim is to gain the best global optima in less number of iterations, thus gaining in convergence time and simplicity of operations.

There are two important aspects in swarm-based heuristic algorithms: exploration and exploitation. The ability of expanding the search space is called exploration, that is an important ability in a swarm-based heuristic algorithm, and the ability of finding the optima around a good solution is called exploitation. Exploring the search space to find new solutions happens in premier iterations in a heuristic search algorithm. This is useful to avoid being trapped in a local optimum. It is necessary that a good balance between exploration and exploitation exists. Extra exploration would cause a pure random search, and extra exploitation would cause trapping in local search (Chun-an, 2008; Rashedi et al. 2009).

Overall, a review of the presented algorithms shows that there is no one superior method for solving optimization problems. The aim of the algorithm proposed in this paper is to optimise the objective functions based on the behaviour of gas molecules. The performance of the proposed Kinetic Gas Molecule Optimization (KGMO) algorithm is evaluated against two optimization algorithms, PSO and the Gravitational Search Algorithm (GSA). GSA is an optimization algorithm based on the law of gravity and mass interactions. It will be shown that the gas molecule behaviour can provide better performance in less number of iterations compared to PSO and GSA benchmark algorithms with high optimization performance.

The next section introduces the fundamentals of the kinetic theory of gas. In Section 8.3, KGMO and its characteristics are described. In Section 8.4, a comparative study is presented, with a demonstration on the experimental

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