Chapter 10
Conflict Resolution Problem Solving with Bio-Inspired Metaheuristics: A Perspective

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ABSTRACT

This chapter addresses nature and bio-inspired metaheuristics in the context of conflict detection and resolution problems. An approach is presented for a generalization of a population-based bio-inspired search and optimization algorithm, which is depicted for three of the most well-known and firmly established methods: the genetic algorithm, the particle swarm optimization algorithm and the differential evolution algorithm. This integrated approach to a basic general population-based bio-inspired algorithm is presented for single-objective optimization, multi-objective optimization and many-objective optimization. A revision of these three main bio-inspired algorithms is presented for conflict resolution problems in diverse application areas. A bridge between feedback controller design, genetic algorithm, particle swarm optimization and differential evolution is established using a conflict resolution approach. Finally, some perspectives concerning future trends of more recent bio-inspired meta-heuristics is presented.

INTRODUCTION

As there are conflicts in all engineering and computer science fields the conflict resolution range of applications is quite wide. Indeed, as it will be reviewed in this chapter, there are conflict resolution problems in areas as diverse as: air-traffic control, train-scheduling, production systems, water management, legal disputes, among many others. This chapter addresses the use of search and optimization techniques, which can be classified as nature or bio-inspired, in conflict resolution problem solving. While

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the range of nature and bio-inspired metaheuristics is increasing in time, three of the most established techniques are: genetic algorithms, (GAs) (Holland, 1975; Goldberg, 1989), differential evolution, (DE) (Storn and Price, 1997) and particle swarm optimization (PSO) (Kennedy and Eberhart, 1995). Thus, given the application success of the former firmly established techniques, it is not surprising that the same techniques are the most applied within conflict resolution problems.

While there are differences between all bio-inspired search and optimization techniques, population based-bio-inspired algorithm also have many similarities. Three of the most well-known bio-inspired algorithms, which are also the most used in conflict detection and resolution, are reviewed. This revision is based on presenting both the common structures to all methods as well as specific functions and particularities to each algorithm. However, as it will be presented, the different problems diversity and specificity, will always require search and optimization techniques adaptation. The main issues concerning the transition and adaptation of single-objective to multi-objective and many-objective optimization are presented, by using a simplified approach. Which conflict detection and resolution problems have been solved using bio-inspired meta-heuristics? Answer to this question will be provided in this text, focusing in the three main bio-inspired algorithms: GA, PSO and DE. A feedback control design problem, is presented from a conflict resolution perspective, bridging some work done in the last 20 years for proportional integrative and derivative (PID) controller design.

The rest of the chapter is organized sequentially in the following order: Nature and Bio-inspired Search and Optimization techniques- key issues; Applications in Conflict Resolution Problem Solving; Conflict Resolution in Feedback Control Design, Perspectives of Evolution and Conclusion.

NATURE AND BIO-INSPIRED SEARCH AND OPTIMIZATION TECHNIQUES: KEY ISSUES

This section, begins by overviewing three of the most successful bio-inspired search and optimization techniques: genetic algorithm (GA), particle swarm optimization (PSO) and differential evolution (DE). The methodology used to present key issues concerning these algorithms is based in an integrated approach, by focusing firstly in the common issues to all three algorithms and then in the particular differences regarding each meta-heuristic. Due to the huge number of existing variants and refined versions presented in the last decades for all three algorithms, including hybridization techniques, a simplified approach presenting the core of these bio-inspired algorithms is presented here, in order to make it easier their application to solve conflict resolution problems.

Most applications regarding conflict resolution or any other type of problems, require solving an optimization problem with one or more functions, which can be formulated considering the minimization case as follows:

$$\begin{aligned} &\min\ f(x) = \left(f_1(x), f_2(x), \ldots, f_o(x)\right) \\ &\quad s.t.\quad g_i(x) \le 0, \quad i = 1, 2, \ldots, k, \\ &\quad x \in S \subset \Re^n \end{aligned} \tag{1}$$