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Soccer game optimization with substitute players

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HIGHLIGHTS

- Player substitution mechanism is proposed to enhance the Soccer Games Optimization.
- The proposed method is compared to SGO without substitution.
- The experiment results confirm the proposed method is better.
- We investigate the method sensitivity for unimodal and multimodal functions.

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ABSTRACT

Metaheuristic methods are powerful optimization methods to solve various problems and have been used widely. In this paper, a player substitution mechanism to enhance the performance of the Soccer Game Optimization (SGO) is proposed. The substitution mechanism refers to the competition concept existing in the evolutionary algorithm. The substitute players are continuously updated to keep up with a set of best solutions so far. This paper discusses the sensitivity of its parameters as well as assesses the performance of the proposed method using unconstraint continuous problems. The proposed method is compared to the SGO without player substitution, Biogeography-based optimization (BBO), Ant Colony Optimization (ACO), Differential Evolution (DE), Evolutionary Strategies (ES), Genetic Algorithm (GA) and Particle Swarm Optimization (PSO). The experiment results show that the proposed method performs better than other algorithms used in this paper.

1. Introduction

Metaheuristic methods are widely used to solve various optimization problems. In the last two decades, there has been significant development of metaheuristics. The metaheuristic methods have developed into powerful optimization algorithm [1,2] since the term was introduced by Glover [3]. The methods have gained popularity in both the academics and the industrial practices due to their effectiveness and general applicability.

Metaheuristic method exploits randomness and a set of rules to produce solutions [4]. Compared to the exact solution, metaheuristic algorithms are more flexible in their adaptability to fit the need of various optimization problems. However, the algorithms need considerable problem specific adaptation in order to achieve a good performance [5].

The metaheuristic has two important elements: intensification and diversification [4,6–8]. Intensification is the ability to investigate the neighborhood of a potential solution to improve the potential solution during the search. It exploits solution

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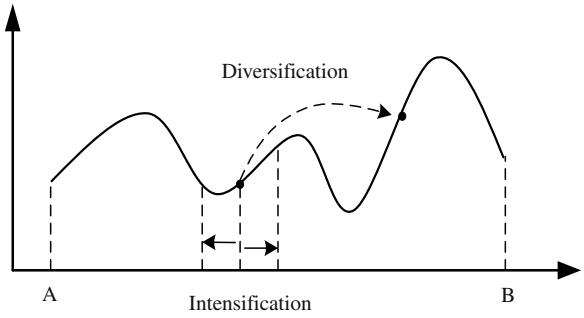

Fig. 1. Intensification and diversification [9].

space nearby a potential solution which is found during the search and is often called local search. On the other hand, diversification is the ability to explore the whole solution space and is often called global search. Diversification is important to avoid being trapped in local optimal solution. The intensification and diversification should be laid in balance in order to achieve a high performance (see Fig. 1).

There are various strategies in balancing the intensification and diversification, depending on their conceptual model of metaheuristic methods. However, there are common similarities among the metaheuristic methods: initialization, solution's manipulation and solution update [4]. The initialization consists of problem representation and generation of the first population of candidate solution. Commonly, the first population of candidate solution is generated randomly. The solution's manipulation is the most important element of metaheuristic algorithms. There are various manipulation approaches to balance the intensification and diversification, depend on the philosophy used in each metaheuristic algorithm. This distinguishes a metaheuristic algorithm from other metaheuristic algorithms. Most metaheuristic algorithms will keep their current best solution during the search process and update it when necessary. The update strategy is important because it will drive the next search process. The elitism concept is commonly used to update the current best solution, where the best solution so far is replaced when the new candidate solution is better than the current best solution.

Recently, a new metaheuristic method called Soccer Games Optimization (SGO), has been proposed by Purnomo and Wee [9]. The method is inspired by the movement behavior of soccer players. In a soccer game, a player moves to a good position to dribble the ball and to score a goal. The cooperation among players in a team is important. The ball moves among the players and the ball position will become the main consideration of a player's movement. A player who do not dribble the ball will move into better positions in order to become a ball dribbler. Some of the players will move closer to the ball (called *move forward*) and some other move on to explore the soccer field (called *move off*). Besides the ball position, a player's movement is also influenced by nearby players as well as their own experience.

The SGO [9] is a simplification of soccer player movement. It focuses on the movement behavior of soccer player during a game and does not considering the opponent players. In this paper, we proposed a players substitution mechanism to replace a player during a game. The rest of the paper is organized as follows: Section 2 explains the proposed player substitution; Section 3 provides the numerical example, experimental setup and discussion. Conclusion and further study are given in Section 4.

2. The proposed player substitution

2.1. Soccer games optimization

SGO is a new metaheuristic method that transforms the basic movement behavior of soccer players into an optimization method by simplifying its environment and rules [9]. A team represents a simultaneous set of vector solutions and each vector solution is called a player. Each player encodes a set of decision variables. The quality of a player is evaluated using its objective function. The ball dribbler represents the best solution obtained during the search process. The team, players, and decision variables can be illustrated in Fig. 2.

In the SGO, a player with the most advantageous position will dribble the ball (called ball dribbler), and this player represents the best solution so far. The ball dribbler position is shared globally, so that all players can access this information (knowing which player has the best solution). This is similar to the real soccer game where all players consider the ball dribbler position in their movements. As the game continues, the ball dribbler can pass the ball to another player or remain holding the ball.

In order to control the player's movement, two main movements, called '*move off*' and '*move forward*', are introduced to balance the diversification and intensification. The '*move off*' is mainly used to explore the solution space and it involves randomness. The movement minimizes the chance of premature convergence. The '*move forward*' is mainly used to explore the solution space nearby a player. The movement is determined by the cooperation or interaction between the player and other players. The interaction describes the information sharing among them. The information sharing is divided into two