Opposition-based spiral dynamic algorithm with an application to optimize type-2 fuzzy control for an inverted pendulum system

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ABSTRACT
This paper presents two variants of the Opposition-based Spiral Dynamic Algorithm (ObSDA) for an application to optimize a type-2 fuzzy logic controller for an inverted pendulum system. Spiral Dynamic Algorithm (SDA) is a group-based optimization algorithm formulated based on the concept of a natural spiral phenomenon on earth. It has the theory of diversification and intensification in its strategy, which allows the algorithm to present itself as a good deterministic type of optimization tool to solve various engineering problems. Despite the good concept and strategy, the algorithm still suffers from getting trapped in a local optima solution. This is due to the limitation of the deterministic strategy that prevents the search agents from sufficiently exploring the whole feasible search space. The search operation only occurs within the area covered by the search agents, and thus there is a low opportunity to thoroughly diverse outside the covered area. Quasi-reflected and Quasi opposition-based strategies were incorporated into the SDA to overcome the exploration problem of the search agents. It helped the search agents to explore the opposite location of the current location of the agents. The opposition strategy also offered varying step sizes to the agents during the movement. The proposed QR-ObSDA and Q-ObSDA were tested on various benchmark functions comprising multimodal and unimodal fitness landscapes. They are also applied to optimize a type-2 fuzzy logic controller for an inverted pendulum system in comparison to SDA, Spotted Hyena Optimizer, Tunicate Swarm Algorithm, and Sooty Tern Optimization Algorithm. A statistical analysis on the accuracy achievement was conducted using Friedman and Wilcoxon Sign Rank methods. The result had shown that the proposed ObSDA variants had outperformed the original SDA in locating the theoretical optima solution of the benchmark functions. Application of the control problem had shown the accuracy performance of ObSDA variants had significantly improved compared to the existing SDA variants and outperformed the other three optimization algorithms.

KEYWORDS
Spiral dynamics; Type-2 fuzzy control; Inverted pendulum; Opposition learning

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