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Novel Heuristic Algorithm for Large-scale Complex Optimization

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Abstract
Research in finance and lots of other areas often encounter large-scale complex optimization problems that are hard to find solutions. Classic heuristic algorithms often have limitations from the objectives that they are trying to mimic, leading to drawbacks such as lacking memory-efficiency, trapping in local optimal solutions, unstable performances, etc. This work considers imitating market competition behavior (MCB) and develops a novel heuristic algorithm accordingly, which combines characteristics of searching-efficiency, memory-efficiency, conflict avoidance, recombination, mutation and elimination mechanism. In searching space, the MCB algorithm updates solution dots according to the inertia and gravity rule, avoids falling into local optimal solution by introducing new enterprises while ruling out of the old enterprises at each iteration, and recombines velocity vector to speed up solution searching efficiency. This algorithm is capable of solving large-scale complex optimization model of large input dimension, including Over Lapping Generation Models, and can be easily applied to solve for other complex financial models. As a sample case, MCB algorithm is applied to a hybrid investment optimization model on R&D, riskless and risky assets over a continuous time period.

Keywords: Large-Scale Complex Optimization, Heuristic Algorithm, Market Behavior, Investment Decision

1 Introduction

Complex modeling technique is widely used in applications of finance, operations research and other areas. As the complexity of computation soars up, many intelligent heuristic algorithms are developed to improve efficiency. J Holland came up with Genetic Algorithm in his work Adaptation in Natural and Artificial Systems (J Holland, 1988) that can approach optimal solutions. Later in 1995, Particle Swarm Optimization algorithm (RC Eberhart, 1995) was put forward as another heuristic algorithm to achieve high computation efficiency by group's mutual imitations. Intelligent algorithm research was divided to deterministic and nondeterministic algorithms after 1990s, and Simulated

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Annealing algorithm (WL Goffe, 1994) as a popular probability based nondeterministic algorithm helped in solving problems in complex solution searching space. Later heuristic algorithms focuses on solving specific problems, for example, the harmony search algorithm (ZW Geem, 2001) for traveling salesman problem. More recent heuristic algorithms works on fundamental computer system control such as assigning Internet files (R Kolisch, 2015) and system state prediction (L Dong, 2015).

However, the above works have their limitations respectively due to the restrictions of objects that they are trying to imitate. Some intelligent algorithms like GA do not have the memory of past searching history, while some other algorithms like PSO often stuck in local optimal solutions (JW Zhuo, 2011). And some nondeterministic algorithms such as SA are not efficient and fast enough in situations where the solution searching space is large and complex. If we apply Monte Carlo Method in such situations aiming to speed up searching process, we lose stability of the searching results. Recent works often try to combine these methods and create hybrid algorithms such as hybrid genetic algorithm, while many of them are till restricted by the original objects that their algorithms are trying to imitate.

This paper focuses on finding another imitation object to build a new intelligent algorithm that could be capable of solving large-scale complex optimization problems with efficiency, stability and accuracy. We find out the Market Competition Behavior is a object that have comprehensive favorable characteristics to imitate in intelligent algorithm, and this algorithm can achieve efficiency, stability and accuracy that we want in complex searching space while avoiding local optimal solutions. We then use a novel investment decision case from financial engineering research to test and prove this algorithm.

2 The Market Competition Behavior (MCB) Algorithm

2.1 The Idea

The objective of Market Competition Behavior is to make decisions within restrictions based on past information over a series of time to develop optimal product of best return (in a certain industry), which is very similar to the process of finding optimal solution in a complex system. Market players compete under certain rules, steadily and effectively develop their products toward the optimal point. Different market competition behaviors provide comprehensive characteristics for our intelligent algorithm to imitate and aggregates to overcome past algorithms' drawbacks.

2.2 Main Features for Imitation

1. Dispersion: As many players are competing in a market and constantly updating products over time, we assume a dispersion of players in the market at the very beginning.
2. Identification: Identification can be categorized into individual identification and group identification. If one player in the market develops a successful product, then very likely it will capture some features leading to success in market and develop product with similar features in the next release. This is individual identification. At the same time, other players in this market will also notice and learn from those successful features and try to incorporate those features into their next product release, which is group identification.
3. Memory: The historical best selling product of the firm and historical best selling product of the market provides guidance for players in the market and allows them to develop better product faster. In other words, they keep their memory of historical product release and never produce products that are worse than before, which improves efficiency of developing toward the best product.