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Exchange market algorithm

Naser Ghorbani, Ebrahim Babaei*

Faculty of Electrical and Computer Engineering, University of Tabriz, Tabriz, Iran

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ABSTRACT

This paper proposes a new evolutionary algorithm for continuous non-linear optimization problems. This optimization algorithm is inspired by the procedure of trading the shares on stock market and it is called exchange market algorithm (EMA). Evaluation of how the stocks are traded on the stock market by elites has formed this evolutionary as an optimization algorithm. In the proposed method there are two different modes in EMA. In the first mode, there is no oscillation in the market whereas in the second mode, the market has oscillation. It is noticeable that at the end of each mode, the individuals' finesses are evaluated. For the first mode, the algorithm's duty is to recruit people toward successful individuals, while in the second case the algorithm seeks optimal points. In this algorithm, the generation and organization of random numbers are performed in the best way due to the existence of two absorbent operators and two searching operators leading to high capability in global optimum point extraction. To evaluate the performance of the proposed algorithm, this algorithm has been implemented on 12 different benchmark functions with 10, 20, 30 and 50 dimension variables. The results obtained by 30 dimension variables are compared with the results obtained by the eight new and efficient algorithms. The results indicate the ability of the proposed algorithm in finding the global optimum point of the functions for each run of the program.

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1. Introduction

Optimization is a process of finding the best solution for a problem. In optimization of the problems, the global optimum is the maximum/minimum of a function [1]. In solving optimization problems, the mathematical methods are capable to optimize various problems in comparison with the meta-heuristic algorithms with greater accuracy in less time [2]. The meta-heuristic algorithms, unlike mathematical methods, can obtain the output of a function by selecting random numbers in input regardless of the complexity of the problems and constraints. This advantage has increased the usage of heuristic algorithms in optimization of several complex and applied functions in the real world which cannot be solved by mathematical methods [3–5]. Nowadays, due to the complexity of the engineering problems, the existence of different constraints in these problems and various objective functions in a problem, it is required to use the meta-heuristic algorithms for optimizing these practical problems [6,7]. In this respect, extensive researches have been conducted to improve the algorithms for optimization of engineering and practical problems [8,9].

For all heuristic algorithms, there is a searching operator and an absorbing operator to find out optimal values. The operators inspired by natural or law-based processes are used to produce and organize some random numbers. For instance, the genetic algorithm (GA) uses operators inspired by the natural genetic variation and natural selection [10–12]. The particle swarm optimization (PSO) algorithm uses the operators inspired by social behavior of bird flocking or fish schooling [13–15]. The ant colony optimization (ACO) is another evolutionary optimization algorithm. This stochastic optimization algorithm is inspired by the pheromone trail laying behavior of real ant colonies [16–18]. The imperialistic competitive algorithm (ICA) is one of the optimization algorithms which unlike the above-mentioned algorithms, is inspired by human behaviors in this context [19–21]. All of these algorithms have different searching and absorbent operators resulting in advantages or limitations in comparison with each other. Investigating the results of the functions optimization through the above mentioned approaches, it seems that the trapping in local optimum points and consequently the early convergence (i.e., exploration problem) or insufficient ability in finding adjacent points of the optimum point (i.e., exploitation problem) and convergence to non-similar solutions are some of the problems of these meta-heuristic algorithms.

This paper proposes a new type of evolutionary algorithms with two efficient and powerful searching operators and two absorbent

* Corresponding author. Tel.: +98 411 3300819; fax: +98 411 3300819.
E-mail addresses: naser.ghorbani@yahoo.com (N. Ghorbani), e-babaei@tabrizu.ac.ir, babaeiebrahim@yahoo.com (E. Babaei).

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operators. As a result, the random numbers' generation and organization are performed in a best form in this algorithm leads to highly improvement of the other algorithms' limitations. This algorithm is suitable for continuous nonlinear optimization problems. The proposed algorithm is inspired by shares traded on the stock market and it is called the EMA. In the stock market, the price of a stock is increased by increasing the demand and decreases with declining the demand. Shareholders in the market try to buy and sell stocks in all sorts in order to achieve the most possible benefit. Due to political and economic measures taken by organizations and countries, there are always price oscillations. Buying and selling shares in an oscillated market have higher risk in comparison with no oscillated market which may be highly profitable or harmful [22].

In a stock market, the shares trading manner is completely sophisticated, different and unique according to mental conditions of several individuals [23]. In the proposed algorithm, it is assumed that the people who are active in the exchange market act similar to the elite stock dealers such as Warren Buffett [24]. In this algorithm, in each market mode the fitness of each individual is reviewed, ranked and sorted according to their properties values. In the EMA, all of the shareholders try to introduce themselves as the most successful individuals to market and then the individuals have less fitness tend to do greater risks. Similar to real stock market, in this algorithm, each individual carries unique trade and risks. Shareholders in the EMA are arranged according to their rank after each fitness test. After sorting the population, the individuals at the beginning, middle and end of shareholders are known as first, second and third groups. The individuals in the first group as successful people in the market remain unchanged in all stages of the market. The second and third groups trade with separate equations. In a non-oscillated market, the individuals in second and third groups select stocks which are same or close to the shares of the first group. In other words, the algorithm has the duty to recruit members toward the elite members. For an oscillated market, the individuals in second and third groups trade with separate relationship at high risk, in other words, the algorithm searches for unknown points. In the proposed algorithm, the search area or the value of shares traded are easily adjustable, thus this algorithm has the ability to optimize any function in the best possible way.

The proposed algorithm is successfully implemented on 12 different standard benchmark functions with dimension of 10, 20, 30 and 50 variables. The results with dimension of 30 variables are compared with real coded genetic algorithm (RCGA) [25], PSO [25], differential evolution (DE) [26], artificial bee colony (ABC) [27], biogeography-based optimization (BBO) [28], harmony search algorithm (HSA) [29], gravitational search algorithm (GSA) [25] and cuckoo search algorithm (CSA) [30]. The obtained results indicate the high ability of the proposed algorithm in finding the global optimum points in comparison with the other algorithms.

2. Exchange market formation

When some European traders faced with loss in their trades and tried to find a way to prevent or minimize their detriment, the stock formation thought was formed. Therefore, they shared some traders in their trades to divide the probable profit and loss. This successful experience convinced the traders to continue their economic activities through this approach. Over time, this experience was lawful and reformed to establishment of corporations [31].

The first experience of foundation of a corporation flashes back to 1553 AD in Russia, in which some traders provided the required stock and shared in corporation's profit and loss in proportion with their shares in order to decrease the probable loss of the trade. Therefore, by developing the trade in Europe it was necessary to have agencies to establish the relationship between the investors. These types of agencies were established and were called stock markets. The world's first stock market was founded in Amsterdam, Netherlands in the 17th century [31]. Nowadays, the stock markets are considered as one of the economic bases of any country or financial organization, in which people trade several types of shares and try to achieve the maximum possible benefit. In the stock market, there exist the specific numbers of several types of organizations and agencies shares and the shareholders buy and sell shares according to their own experiences and financial policies. In these markets, people usually buy different types of shares in order to gain benefit and decrease the loss risk [32].

In a stock market, sometimes the market faces with non-oscillations and sometimes it faces with oscillations due to the financial and economic policies of organizations and countries. Under balanced conditions, the market is easier to anticipate and people can increase their shares' profit to some extent without doing any unusual risks. Under oscillated conditions, selecting shares to buy and sell holds some risks and it is difficult to anticipate the market status and the activities of shareholders can be profitable or detrimental [22]. However, the stock market has always its own complexity and the behavior of the shareholders in encountering with different conditions is very complex and unique [23].

2.1. Stock market in the proposed algorithm

The proposed algorithm is inspired by the stock market, in which the shareholders buy and sell several types of shares in the virtual stock market under different market conditions. It is assumed that the shareholders compete to introduce themselves as the most successful dealers in the ranking list. In addition, it is assumed that the lower ranked people tend to deal with logical risks to gain more benefit and it is supposed that the intelligent shareholders perform similar to be the successful individuals of stock market such as Warren Buffett, the most successful shareholder of the recent 50 years. The main characteristics of a successful shareholder are as follows [33]:

(a) Capital preservation is always their top priority.
(b) They buy shares as more as they can.
(c) They avoid investing in sectors not match their criteria.
(d) They accept their mistakes and correct them immediately.
(e) They make their mistakes as a learning experience.
(f) They follow the experiences and the performance of the successful shareholders.

In the proposed algorithm, each person of the exchange market is an answer of the problem. Here, there exist a specific number of shares (the variable of the optimization problem), where any person attempts to intelligently buy some of the shares (initializing the problem variables). At the end of each period, they are intelligently proceed to gain the maximum possible profit in the market by calculating the value of their total shares.

The exchange market encounters different market conditions due to the political and financial decisions of organizations and countries. In the proposed algorithm, it is assumed that in the exchange market there are two general market states. In the first state, the market is in its normal condition with no considerable oscillation and the shareholders try to utilize the experiences of the successful shareholders to gain more benefit without performing non-market risks. In the second state, the exchange market encounters different oscillations and the shareholders try to intelligently risk by identifying the market conditions, in order to better use the created conditions in increasing their finance. It is obvious that any additional information about market conditions or the investigated problem can make these risks more targeted and beneficial.

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