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Artificial Intelligence Optimization Algorithms in the Finance Sector

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Abstract

Increasing efficiency and security expectations with the technological developments in the financial sector have necessitated more effective solutions in issues such as financial failure prediction, portfolio selection, market analysis, risk assessment, and stock price estimation. At this point, artificial intelligence optimization algorithms come to the fore in terms of lower cost, higher data storage capacity, and transaction volume, performing the same operations in similar problems and creating an effective order to prevent problems that may occur in the future. For this purpose, the use of artificial intelligence optimization algorithms in the finance sector is discussed in this study. To guide their use in decision-making and problem-solving processes, Artificial Bee Colony Algorithm, Tabu Search Algorithm, Flower Pollination Algorithm, Shark Smell Optimization Algorithm, and Differential Evolution Algorithm were explained and examples from their application areas were shared. As a result of the study, the advantages of artificial intelligence optimization algorithms were revealed and their importance in the finance sector was emphasized. This study is especially widely used in the solution of engineering problems; however, it contributes to the literature in terms of explaining algorithms whose applications in the finance sector are still limited.

Keywords:

Finance Sector, Artificial Intelligence, Optimization, Algorithm

Jel Codes:

B26. G20. F30. C60

Finans Sektöründe Yapay Zekâ Optimizasyon Algoritmaları

Özet

Finans sektöründe teknolojik gelişmelerle birlikte artan verimlilik ve güvenlik beklentisi finansal başarısızlık tahmini, portföy seçimi, piyasa analizi, risk değerlendirmesi, hisse senedi fiyat tahmini gibi konularda daha etkin çözümleri gerekli hale getirmiştir. Bu noktada düşük maliyetle daha yüksek veri saklama kapasitesi ve işlem hacmi, benzer sorunlarda aynı işlemleri gerçekleştirme ve ileride oluşabilecek sorunları önlemede etkin bir düzen oluşturması yönleriyle yapay zekâ optimizasyon algoritmaları öne çıkmaktadır. Çalışmada bu amaçla, finans sektöründe yapay zekâ optimizasyon algoritmalarının kullanımı konusu ele alınmıştır. Karar alma ve problem çözme süreçlerinde kullanımlarının yaygınlaştırılmasına rehberlik etmek üzere Yapay Arı Koloni Algoritması, Tabu Arama Algoritması, Çiçek Tozlaşma Algoritması, Köpek Balığı Koku Alma Optimizasyon Algoritması ve Diferansiyel Gelişim Algoritması açıklanarak uygulama alanlarından örnekler paylaşılmıştır. Çalışma sonucunda yapay zekâ optimizasyon algoritmalarının üstünlükleri ortaya konmuş ve finans sektöründeki önemi vurgulanmıştır. Bu çalışma, özellikle mühendislik problemlerinin çözümünde yaygın olarak kullanılan; ancak finans sektöründeki uygulamaları henüz kısıtlı sayıda olan algoritmaları açıklaması yönüyle literatüre katkı sağlamaktadır.

Anahtar Kelimeler:

Finans Sektörü, Yapay Zekâ, Optimizasyon, Algoritma

Jel Kodları:

B26, G20, F30, C60

INTRODUCTION

In the financial sector, artificial intelligence applications are used in issues such as failure prediction, market analysis, portfolio selection, security detection, consultancy, virtual customer assistance, and legal compliance. With the widespread use of e-commerce, there has been a great increase in the level of online fraud. However, banks are required to allocate large budgets to combat financial crimes. Banks, which face heavy penalties if they fail to solve their illegal financing and compliance problems, have turned to artificial intelligence applications to prevent this. It is among the features of these algorithms to prevent detected fraudulent transactions, to reveal transactions performed in the same way, and to prevent possible similar transactions in the future and move them to the investigation point (Buchanan, 2019). The use of digital data volume together with the algorithms used, the possibility of storing large amounts of data, computational processing capacity, and the advantage of low-cost use can be listed as the contributions of artificial intelligence (Fernandez, 2019).

The financial sector is among the areas where the most investment is made in the field of artificial intelligence. Large-scale artificial intelligence investments support public infrastructures. Moreover, small-scale ones provide short and medium-term development opportunities for individual firms and households. Private equity owners have turned their investments towards the development of companies with more physical work intensity in the field of artificial intelligence and technology. The main reason for this is that such companies promise the potential to make a rapid leap, rather than artificial intelligence replacing humans. With this leap, great opportunities are captured in analyzing the interests and needs of customers and determining strategies in this direction (Milana and Ashta, 2021).

Financial intermediation is an important and costly service preferred by people who will invest and choose bank products. By automating the advice and investment management service and reducing its cost, banks aimed to offer their customers privileges with a low budget. This algorithm-based service categorizes a financial portfolio according to opportunities and risks based on user objectives. In addition, these algorithms analyze the income and spending history of customers and make suggestions that will enable them to manage their budgets and invest if possible. In the financial sector, which is not limited to banks, one of the services performed by artificial intelligence algorithms is algorithmic trading. The purposes of this service include performing the trade with the highest profit rate, increasing the accuracy and minimizing the error rate, analyzing and controlling different market conditions, and reviewing the emotional and psychological dimensions of human error (Buchanan, 2019).

When examining the literature, it is seen that the Genetic Algorithm and Ant Colony Algorithm, which are artificial intelligence algorithms, especially in financial subjects such as financial failure prediction and portfolio management, stand out and other algorithms are mostly used in engineering applications (Drake and Marks, 1998; Jiang et al., 2009; Fallahpour and Eram, 2016; Uthayakumar et al., 2020). In this study, Artificial Bee Colony Algorithm, Tabu Search Algorithm, Flower Pollination Algorithm, Shark Smell Optimization Algorithm, and Differential Evolution Algorithm are explained by giving examples from the application to contribute to the expansion of the usage area by increasing the preferability of other algorithms in the finance sector.

Following the introduction part of the study, the studies carried out in the literature on the subject were shared. In the third section, the methodology of the study is explained and the artificial intelligence optimization algorithms determined in the following section are revealed. In the last part, the importance of the study, its results, and limitations are stated and suggestions are made for future studies.

LITERATURE REVIEW

Artificial intelligence applications are gaining more importance in processes such as financial failure prediction, security audit, and portfolio selection. Aktaş (2003) performed statistical methods and artificial neural network comparisons in predicting financial failure. Similarly, Akkaya et al. (2009) revealed that 80% of unsuccessful

businesses were categorized correctly in this model. Çelik (2010), Altınöz (2013), Söylemez and Türkmen (2017) also used artificial neural networks model to predict the financial failure of enterprises.

Lui et al. (2018) discussed the issue of trust in the financial sector with artificial intelligence applications. Fernández (2019) explained the contributions of artificial intelligence to organizations in financial services. Golić (2019), investigating the place of artificial intelligence in the financial sector; examined the contributions of artificial intelligence to the financial sector and its effects on employment. Lin (2019) emphasized that artificial intelligence has risks as well as positive aspects in the finance sector. In line with these risks, it aimed to provide constructive solutions by conducting extensive research at the point where finance and law come together.

Moșteanu (2019) addressed the issue of minimizing human error by keeping up with the digital age in financial markets. Researching the use of artificial intelligence in finance and banking, Gümüş et al. (2020) concluded that the increase in age, income and education levels is directly proportional to the trust in artificial intelligence. Malali and Gopalakrishnan (2020) conducted a study to strengthen the customer experience by examining the artificial intelligence elements in this sector.

Artificial intelligence optimization algorithms play an active role in decision-making processes and in solving problems in the financial sector. Kingdon and Feldman (1995) examined the Genetic Algorithm and its applications in the financial sector. Drake and Marks (1998) with Jiang et al. (2009) in financial forecasting; Lin and Liu (2008) with Chang et al. (2019) used the Genetic Algorithm in portfolio selection. On the other hand, Mustaffa and Yusof (2012) and Kartal (2015) discussed Artificial Bee Colony Algorithm in forecasting and portfolio optimization. Cheeneebash et al. (2009) used Tabu Search Algorithm to predict bankruptcy. Fallahpour and Eram (2016) and Uthayakumar et al. (2020) made the financial failure estimation based on the Ant Colony Algorithm, and Kaleli (2022) performed the portfolio selection according to the return and risk ratio with the example of companies traded in the BIST-30.

METHODOLOGY

Reviews are a foundation that allows for the advancement of existing knowledge. This foundation guides the development of theories by revealing the areas that need research (Webster and Watson, 2002). At this point, a literature review, which is defined as "a comprehensive review of previous research on a particular subject", plays a key role (Denney and Tewksbury, 2013).

In this study, a conceptual review of artificial intelligence optimization algorithms in the finance sector was carried out. In this direction, first of all, the place and importance of artificial intelligence optimization in the finance sector are given. Then, the studies in the literature on this subject are presented. When the studies in the literature are examined, it has been determined that Genetic Algorithm and Ant Colony Optimization Algorithm are generally used in financial matters, Artificial Bee Colony Algorithm, Tabu Search Algorithm, Flower Pollination Algorithm, Shark Smell Optimization Algorithm, and Differential Evolution Algorithm are mostly used in solving engineering problems. To increase the use of these algorithms in the field of finance, the emergence and basic features of each algorithm are explained respectively, and examples of usage areas are presented.

ARTIFICIAL INTELLIGENCE OPTIMIZATION ALGORITHMS

In the financial sector, artificial intelligence optimization algorithms are gaining more and more importance in solving complex problems with digitalization and increasing security expectations. To guide its use in this sector, Artificial Bee Colony Algorithm, Tabu Search Algorithm, Flower Pollination Algorithm, Shark Smell Optimization Algorithm, and Differential Evolution Algorithm are explained.

Artificial Bee Colony Algorithm

Valery Tereshko developed an artificial model based on the foraging behavior of a honey-bee colony. This model, which enables the emergence of the collective intelligence of honey bee swarms, consists of the basic elements of "food sources", "working foragers" and "unemployed foragers" (Tereshko, 2000; Tereshko and Lee, 2002):

- **Food sources:** The foraging bee evaluates various characteristics related to the food source, such as proximity to the hive and the richness of its energy, to select a food source.
- **Employee foragers:** Employee foragers are employed at a particular food source that they are currently using. It conveys information about this special source to other bees waiting in the hive, about the distance, the direction of the food source, and its effectiveness.
- **Unemployed foragers:** These are the bees that do not have information about the food sources around the nest. It benefits from bees that randomly research the environment or try to find a food source in line with the information given.

Artificial Bee Colony (ABC) Algorithm was developed by Derviş Karaboğa in 2005, inspired by Tereshko's bee model. This algorithm, it is aimed to reach the most effective solution methods for a problem by considering rich resources (Karaboğa, 2005; Karaboğa and Akay, 2009; Tereshko and Lee, 2002).

It is seen that the ABC Algorithm is widely preferred in areas that can play a role in the classification of data and strengthen predictive ability (Arun and Kumar, 2017; Kaya Keles et al., 2020). Sergeant and Tuncer (2017) used the ABC Algorithm to calculate the most ideal route and reduce the margin of error for unmanned aerial vehicles to make progress on their path full of obstacles without any deviation or disruption. Katyar et al. (2021), on the other hand, applied this algorithm to the delivery of food to customers while preserving its freshness. The main purpose here is to ensure customer satisfaction, not to compromise on quality, and to reduce costs by calculating the correct route within the business.

Tabu Search Algorithm

Tabu Search (TS) Algorithm was developed by Fred Glover in 1989 to find solutions to optimization problems. The main purpose of the TS Algorithm is to prevent the step in the final solution stage from making circular movements. Accordingly, repeating the relevant step in the next cycle is prohibited or penalized. Thus, the necessary research is guided to realize the solutions that are beyond the regional optimum solution (Glover, 1989).

The origin of the TS Algorithm is based on an initial solution. In each iteration of this algorithm, one of the neighbors of the solution and an action that is not tabu is determined and evaluated. For the neighboring solution to be considered the current solution, an improvement in the value of the objective function must have taken place. Although a determined action is a tabu, if it has tabu-breaking criteria, it can be used to create an existing solution. To prevent backward movements, some movements are recorded in the tabu list and the repetition of these movements is prohibited for a certain period. The algorithm continues its search until one or more stop conditions are met. The operation of the algorithm is terminated according to a specified stopping condition. Obstruction of the algorithm in one place, reaching a certain solution value and number of iterations, having no neighbors of a selected neighboring solution, and failure of the algorithm to obtain better results are among the conditions that cause the search to be stopped (Glover, 1990).

TS Algorithm is used in route calculations to reach the determined target in the most accurate order and time with the lowest cost (Archetti, 2006). This algorithm offers opportunities such as obtaining ideas during the selection and categorization of personnel, calculating personnel productivity, and, accordingly, estimating the quality of service and returns that customers will receive. In addition, it plays an active role in the grouping of

products in warehouse organizations and the routing of the collectors and prepares a low-cost production, storage, and distribution process (Gürbüz, 2015; Kulak et al., 2020).

Flower Pollination Algorithm

The Flower Pollination (FP) Algorithm was developed by Xin-She Yang in 2012, inspired by the reproduction of plant flowers in nature by pollination by insects and bees. Pollination in terms of biological order; is based on the process of optimizing the reproduction of plants by determining the most suitable flower to survive with the contribution of animals such as insects, bees, birds, and bats. Biologically, each plant can have more than one flower, and each flower can often release billions of pollen gametes. However, to simplify the algorithm, it is assumed that each plant has only one flower and that the flower gives only one pollen gamete (Yang, 2012).

It is seen that FP Algorithm plays an active role in solving optimization problems and developing prediction models (Yang et al., 2014; Lukasik and Kowalski, 2015). Niğdeli et al. (2016) used it to optimize safety and applicability in structural engineering. Preventing safety deficiencies in the design of buildings and optimizing the degree of conformity contribute to the use of the right materials in the right designs and places. Korkmaz and Akgüngör (2018) applied the FP Algorithm to estimate the number of vehicles per capita in the coming years.

Shark Smell Optimization Algorithm

The Shark Smell Optimization (SSO) Algorithm was developed by Oveis Abedinia, Nima Amjady, and Ali Ghasemi in 2014, based on the olfactory characteristics of sharks. Sharks start to move in a target-oriented manner by smelling their prey from a distance with a small drop of blood. The most important element here is the ability to locate the prey in a short time and a wide search area, based on its strong sense of smell. The first of the application steps of the SSO Algorithm is to find the scent parts. Then the move toward the hunt takes place. Here, the location of the prey is determined by reaching more blood particles and it is examined that it can be reached faster (Abedinia et al., 2014).

There are studies in which the SSO Algorithm is carried out in engineering fields such as dam construction, and construction of water reservoirs, especially to minimize the absolute difference between water demand and water release (Ehteram et al., 2017; Allawi et al., 2018; Ehteram et al., 2019; Cuevas et al., 2022).

Differential Evolution Algorithm

The Differential Evolution (DE) Algorithm is an optimization technique based on Genetic Algorithm. This algorithm, which allows searching at more than one point simultaneously, aims to search for better results for solving the problem throughout the iterations with the help of operators (Price, 1996; Storn and Price, 1997; Hrstka and Kucerova, 2004; Mayer et al., 2005; Price et al., 2006; Storn, 2008).

There are similarities and differences with the Genetic Algorithm. The crossover method used in the Genetic Algorithm is also included in the application stages of the mutation and selection operators in the DE Algorithm. On the other hand, each operator discussed in this algorithm is not applied to the whole population in turn. All chromosomes are evaluated separately and a new individual is formed by randomly selecting three chromosomes from among them. Compatibility degrees of the chromosome obtained with the existing chromosome are compared. The one with the highest fitness is then transferred to the next population. In this way, the selection operator is also used. The quality of the solutions developed by the value they produce for the objective function is measured (Mayer et al., 2005).

DE Algorithm is frequently used in production processes and in determining the most accurate path. In this context, studies were carried out to find the most accurate solutions to possible problems that may be encountered in production, and transportation network designs were made to reduce the density that may occur

at intersections in traffic and to save time for drivers (Terzi, 2009; Gürarslan, 2011; Tsai et al., 2013; Tang et al., 2013; President et al., 2014; Farrell et al., 2000; Çakıcı et al., 2021).

CONCLUSION

In solving problems such as portfolio selection, failure estimation, market analysis, and fraud detection that arise in the financial sector, practices to be developed with traditional methods and measures to be taken are insufficient. At this stage, artificial intelligence optimization algorithms create an effective system to find and prevent problems that an employee may find in a very long time, to perform the same operations in similar problems, and to prevent derivative problems that may occur in the future. Artificial intelligence optimization algorithms are superior to traditional methods in terms of lower cost, higher transaction volume, and data storage capacity.

In this study, the use of artificial intelligence optimization algorithms in the finance sector has been evaluated. Artificial Bee Colony Algorithm, Tabu Search Algorithm, Flower Pollination Algorithm, Shark Smell Optimization Algorithm, and Differential Evolution Algorithm were shared to guide the applications in the finance sector and examples from the application areas were given. As a result of the study, the importance of artificial intelligence optimization algorithms in the finance sector has been revealed by emphasizing the efficiency difference compared to traditional methods.

This study contributes to the literature in terms of explaining the algorithms whose applications in the finance sector are still in the development stage, but which are frequently preferred in the solution of engineering problems. In future studies, it is expected that different artificial intelligence optimization algorithms will be evaluated within the scope of the finance sector.

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