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Evaluating and Comparing the Performance of Meta-Heuristic Algorithms in Predicting the Stock Price

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Abstract: *Predicting stock price has special importance for shareholders to gain the maximum profit and they have always sought for logical and accurate strategies to predict it. Data mining techniques, in addition to data collection and management, involve analyzing and predicting. Recognizing the current patterns and unknown relationships among the data help us in the predicting. Several models have been developed for predicting by using time series by researchers in the recent years. Given the studies conducted in this regard, it can be realized that one of the important issues in these models is the way of determining the fuzzy intervals to explain the model and to predict. Three models were introduced in this research using combination of fuzzy time series and cuckoo optimization algorithms (FTS-COA), and combination of fuzzy time series and particle swarm algorithm (FTS-PSO), and combination of fuzzy time series and firefly algorithm (FTS-FOA). Finally, to compare the introduced models, findings of these three models are compared. Findings reflect the superiority of the (FTS-COA) model compared to the two models introduced.*

Key words: *Prediction, Strategies, Stock.*

INTRODUCTION

One of the strategies to provide capital for investing is stock market. People are looking for profit in this market. The first and the most important factor for investor to invest in the stock exchange is evaluating and predicting the stock price, and consequently its future price. On the other hand, the stock market is affected not only by macro parameters, but also by other important factors. Great number of unknown factors affecting this market causes uncertainty in investment in this market. It is clear that the uncertainty is unpleasant characteristic. Uncertainty is inevitable for investors, selecting the stock market as an investment place. Naturally, all efforts of the investors are reducing this characteristic. As recognizing the behavior and the stock price movement in the market and predictability in this market are tools to reduce the uncertainty, investors are looking for ways for better evaluating and predicting the stock price and can gain the highest return on their investment.

Theoretical principles and review of literature

The issue of predicting the stock price is one of the classic issues in the financial world. We use the dependent variables of the initial price, the final price, the highest price, and the lowest price, and the independent variable of the last price in this regard. Predicting the time series in different areas, especially in the financial area is remarkable. In this area, they usually use this tool to make decision and to minimize the investment risks. When investors analyze the financial markets, they should be careful in performing their predicting tasks. For this reason, improving the prediction models is very important. Using the methods and models to predict the

future status has always been the main concern of thinkers in different sciences. In this regard, some methods have appropriate application with the minimum possible error in prediction. (Arezki Mellal,et al.2015), conducted a research entitled "cuckoo optimization algorithm for combining the problem of electricity and heat of economic load to minimize the cost of producing systems costs, given the different types of model restrictions". They introduced the bio-heuristic model and it was proven that it is a superior model. In a research entitled "combined model of neural networks to predict stock market price index", (Maharana, et al. 2015) an efficient model was provided to predict stock prices using neural networks, that this model shows more accuracy than other models in producing the output. Using this model, the prediction error is estimated to be 0.753 (Korol T.2014). In a research entitled neural networks and a combined model to predict stock returns (Fang Chang, et al. 2014) used particle swarm optimization algorithm to develop three models, used in the research, in order to manage the business performance, in which error tracking method showed better performance compared to other models. In a paper entitled stocks optimization using Cuckoo search algorithm and colonial competition, (Familian.2015) found that this model is converged to optimal method at less time and it will provide more accurate solutions with fewer errors compared to other algorithms. (Bagheri. 2015) introduced an effective and adaptive algorithm for clustering the Persian texts based on the Cuckoo optimization algorithm and he concluded that the introduced algorithm is able to enhance the clustering quality compared to traditional clustering algorithms. In a study, (Mousavi Shiri, et al. 2015) examined the error of changes in prediction of stock price index in the pharmaceutical products industry by using artificial intelligence algorithms to predict stock price. The findings of the research suggest the superior performance of the colonial competition algorithm compared to other algorithms. In a paper entitled integrating artificial intelligence techniques to provide a model to predict stock price, (Morad Zadeh, et al. 2014) used a combination of artificial intelligence techniques including neural-fuzzy networks and genetic algorithms to predict stock price. This combined model was compared with ARIMA linear model based on the MAE, R2 criteria (Fereydouni, S. 2013). The research findings revealed the superiority of the combined model compared to other models investigated. (Freydooni, S. 2013) presented his second report for the course of meta-heuristic methods and introduced a complete cuckoo optimization algorithm. In his master thesis entitled an expert system to predict stock price and portfolio optimization by using fuzzy neural networks and genetic algorithm, (Zamani.2013) introduced model, in which future stock potential is predicted by fuzzy neural network.

Different scenarios to predict stock price

The model used in this research involves using fuzzy community rules and time series along with meta-heuristic optimization algorithms. In order to evaluate the performance of the prediction model, three scenarios were used as follows:

-The first scenario: using time series data of minimum and maximum starting and ending price for each company in the 5-year period since April 2011 to September 2016 and optimizing actual price prediction intervals by particle swarm meta-heuristic algorithm for the week ending to end of September of 2016

-The second scenario: Using the same data in the first scenario and using the Cuckoo optimization algorithm as a meta-heuristic algorithm to optimize the fuzzy intervals and predicting the actual price

-The third scenario: Using the same data of last two scenarios and using the firefly optimization algorithm as a meta-heuristic algorithm to optimize fuzzy intervals and predict the actual price.

Modeling the prediction of stock price using the first scenario

In this scenario, we predict the stock price for the last week of September 2016 for 10 companies' information (odd companies from 20 companies) based on optimization of intervals' length in the particle swarm meta-heuristic algorithm. This algorithm is a meta-heuristic method, so that it considers very few hypotheses on the problem optimized and it can search large spaces of the selective solutions.

MAPE		Symbol of Company	ROW
∪	∩		
0.005116229	**0.003014167**	**Betrans**	1
0.01338	**0.010635**	Khepars	2
0.003889	**0.004438**	Sh**abandar**	3
0.002775	**0.005326**	**Mobin**	4
0.008893	**0.008893**	**Ranfor**	5
0.021131	**0.025553**	**Vasandugh**	6
0.002705	**0.003384**	**Hamrah**	7
0.002994	**0.005689**	**Femli**	8
0.003392	**0.005343**	**Hakashti**	9
0.008194	**0.009887**	**Vamid**	10

Modeling the prediction of stock price using the second scenario

In this scenario, the fuzzification interval is optimized with Cuckoo algorithm. For better understanding, cuckoo optimization algorithm code is described in 11 steps. The steps of cuckoo algorithm are as follows:

First step: Randomly selection of the existing cuckoos habitats (this step is performed to create initial cuckoos and their locations). Now, second step to the eleventh step is defined based on one repetition.

Second step: Determining the number of eggs for each cuckoo (this number is between 5 and 20 eggs)

Third step: Determining the radius of egging of each cuckoo, which this number is a constant value of 5 (ELR = 5)

Fourth step: eliminating of the eggs, which have been identified by host bird (In this step, 10% of the eggs with the minimum optimization (high MAPE) are eliminated

Fifth step: Breeding the eggs, which have not been identified (in this step, the eggs are grown and as adult cuckoos are added to the set of cuckoos).

Sixth step: evaluating the habitant of new cuckoos (the optimal value of all cuckoos is calculated)

Seventh step: Determining the number of cuckoos, living in each habitant (inappropriate cuckoos are eliminated)

Eighth step: Clustering the cuckoos and determining the best group of cuckoos for migration. The cluster, which has the optimal value on average, is returned as the new habitant of the cuckoos.

Ninth step: The new population of cuckoos moves towards a new location. All locations of cuckoos are updated with the alpha coefficient.

Tenth step: investigating the stop condition or end of loop

MAPE		Symbol of Company	ROW
∪	∩		
0.003423	0.002329	**Betrans**	1
0.009095	0.011001	Khepars	2
0.003642	0.003981	Sh**abandar**	3
0.00253	0.002515	**Mobin**	4
0.005915	0.005385	**Ranfor**	5
0.029544	0.032356	**Vasandugh**	6
0.002874	0.004992	**Hamrah**	7
0.00235	0.005396	**Femli**	8
0.005789	0.008881	**Hakashti**	9
0.011616	0.016048	**Vamid**	10

Modeling the prediction of stock price by using the third scenario

An evolutionary firefly algorithm in optimizing the intervals is used in this scenario to predict stock prices. Modeling the behavior of a set of fireflies and allocating the value related to fitness of location of each firefly, this model investigates pigments' value of firefly and updates the location of fireflies in sequential repetition to find the optimal solution for the problem.

MAPE		Symbol of company	ROW
∪	∩		
0.508545	0.279175	**Betrans**	1
1.503871	1.114409	Khepars	2
0.34908	0.451925	Sh**abandar**	3
0.305401	0.449631	**Mobin**	4
0.892563	0.892563	**Ranfor**	5
2.400741	2.490461	**Vasandugh**	6
0.393744	0.393744	**Hamrah**	7
0.299159	0.606303	**Femli**	8
0.337012	0.505014	**Hakashti**	9
0.862266	1.045879	**Vamid**	10

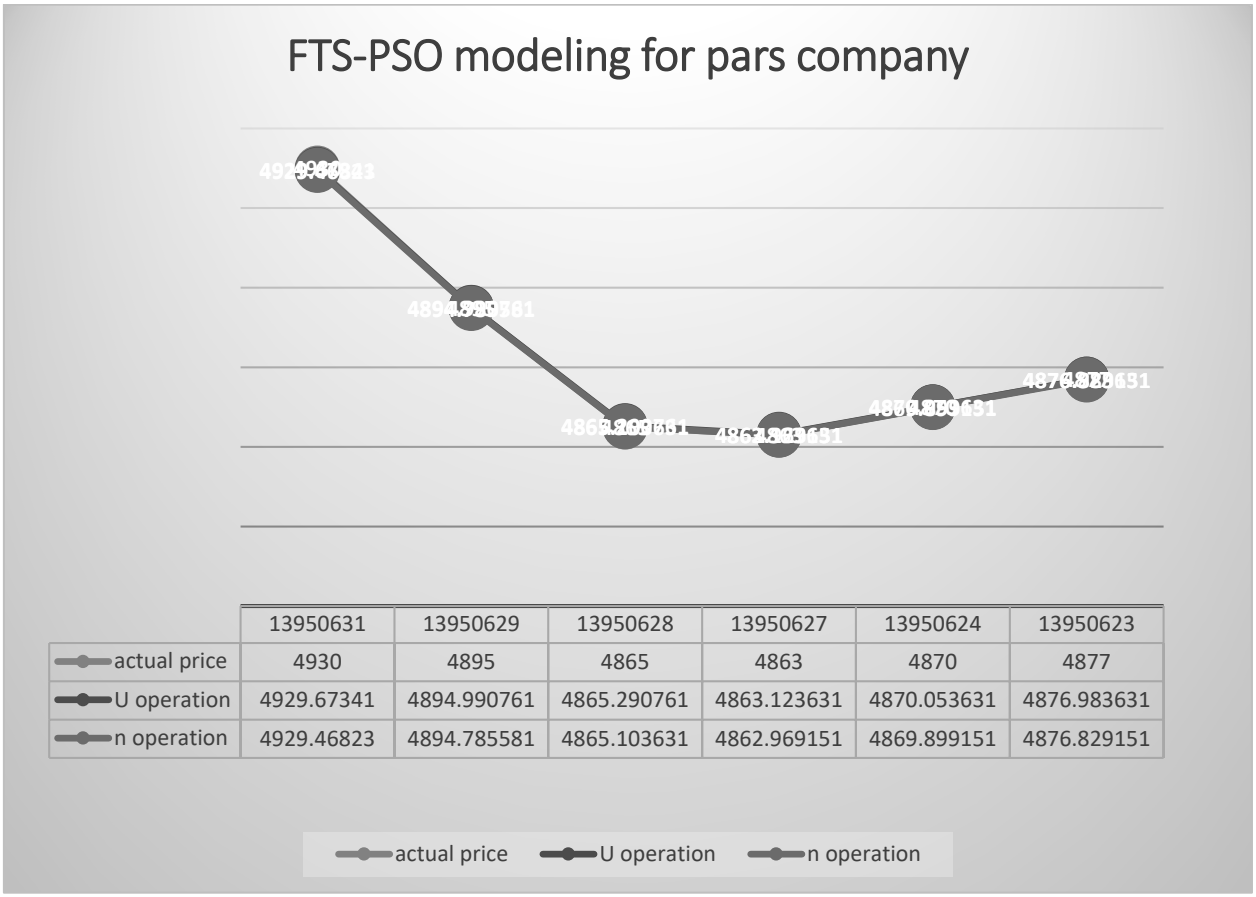
Comparing the scenarios

Optimization algorithms and random and evolutionary searching are innovative and effective methods, used especially for finding the optimal solutions for the problems. The characteristic of being random of these algorithms will prevent their trapping at local optimum points. In practical optimization such as engineering designs, financial management, organizations, and economic systems, the main focus is to achieve the optimal global solutions. Most of these algorithms have been inspired by biological systems, including particle swarm algorithm (PSO), ant colony algorithm (ACO), artificial bee algorithm (ABC) and artificial fish swarm, and firefly and cuckoo algorithms. These methods have been used widely in papers to solve various problems of complex optimization. The common point of these scenarios is the problem investigated by the meta-heuristic algorithms, and in all of the scenarios, the goal was that best classification of the intervals to be in the 50 intervals desired for the problem. The difference point of these scenarios is in fact related to using meta-heuristic algorithms, which this difference in the scenarios and the differences in the obtained solutions can be traced in difference among the methods. The most important difference in these methods is finding the local optimal and global optimal points, where firefly has been diverted from global optimal toward the nearest neighbor of the optimal due to more movement. While it was expected that firefly algorithm provide better solutions due to the type of problem, for which the optimal solution is determining the appropriate interval, it was not achieved. On the other hand, the significant difference between the particle swarm and cuckoo algorithms is the mass populations. As eggs in one nest are relatively close to each other in the cuckoo algorithm, the conditions for local searches in a denser area are more provided, which is unlike the particle swarm

algorithm, in which it is tried that the problem space to be sought with uniform distribution of particles in the whole space. The key difference of particle swarm and firefly can be considered the global optimal, so that the possibility of finding the local optimal solution is higher in the particle swarm due to movement with constant coefficient toward global optimal and the uniform search of the problem space. For better comparison of the models, we investigated the actual prices and predicted prices of Fars Company separately for each of the three scenarios:

First scenario: predicting the stock price by using the FTS_PSO model

In this scenario, we predict stock prices by using fuzzy time series and use the particle swarm optimization algorithm to classify. The particle swarm algorithm is used to optimize the size of intervals for proper prediction of price, which performs the optimization based on the community. The predicted and actual prices related to this method are illustrated in the following chart.

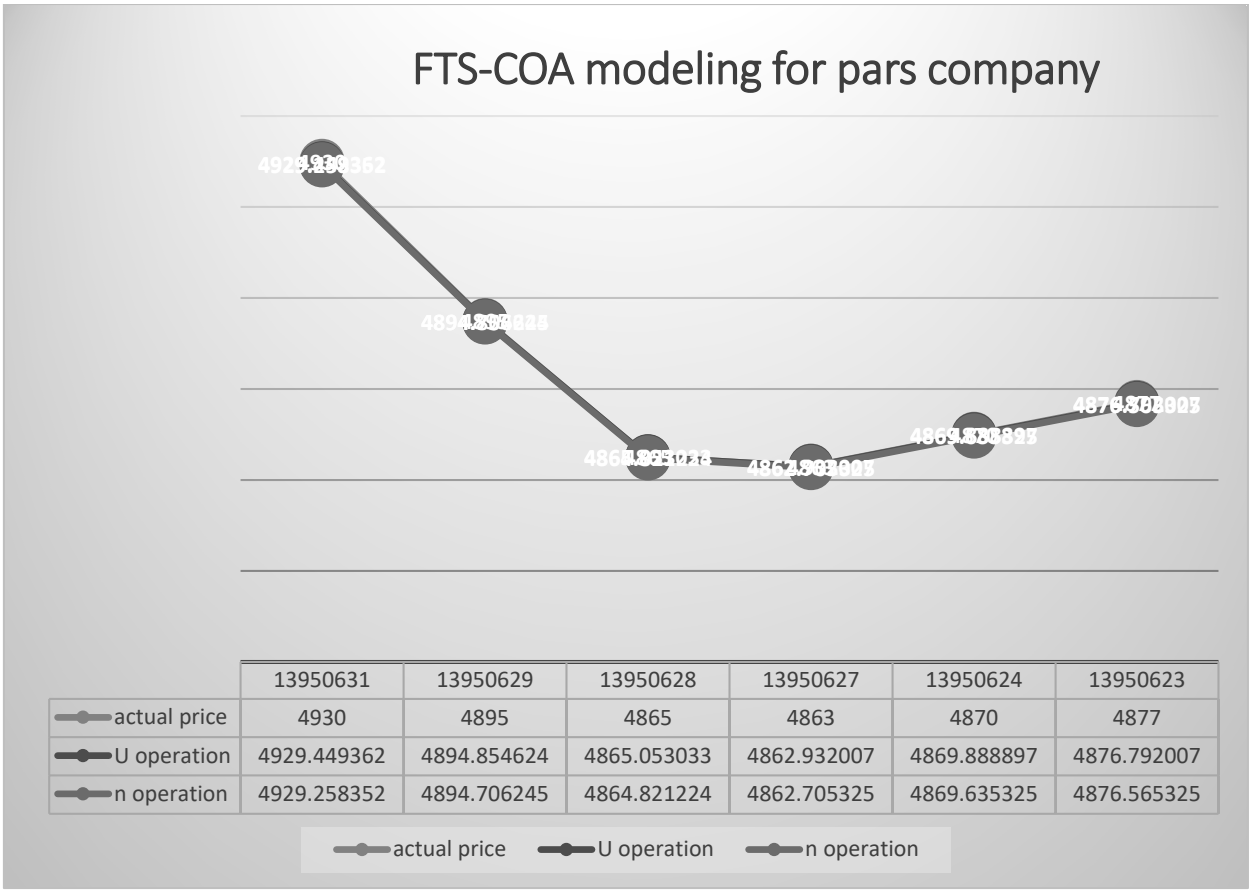


	13950631	13950629	13950628	13950627	13950624	13950623
actual price	4930	4895	4865	4863	4870	4877
U operation	4929.67341	4894.990761	4865.290761	4863.123631	4870.053631	4876.983631
n operation	4929.46823	4894.785581	4865.103631	4862.969151	4869.899151	4876.829151

Second scenario: predicting the stock price by using the FTS-COA model

In this scenario, our approach is the same as previous scenario, but we use cuckoo algorithm as meta-heuristic algorithm for optimizing fuzzy data intervals and predicting the actual price in the present scenario.

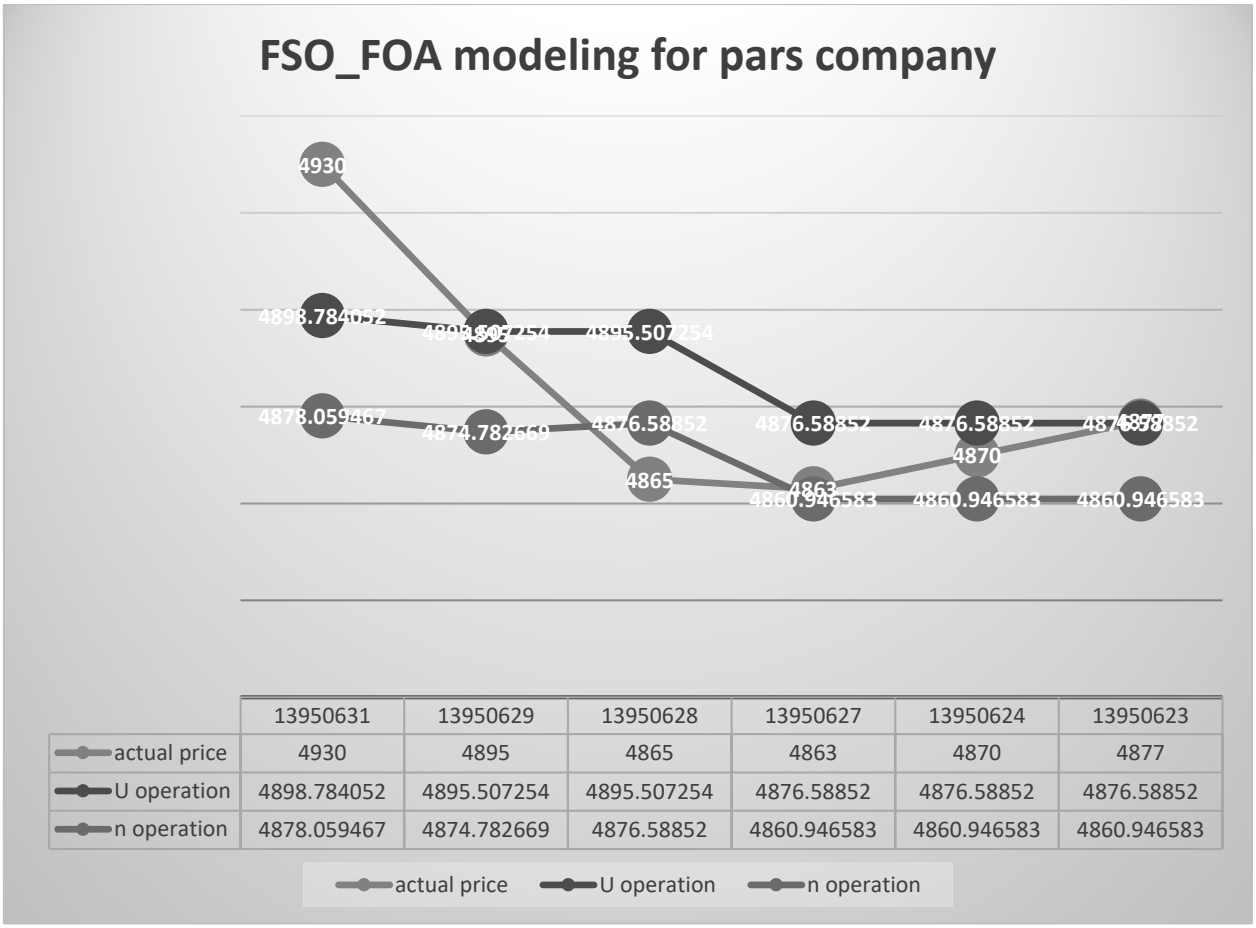
Results related to predicted and actual prices are illustrated in the following chart.



	13950631	13950629	13950628	13950627	13950624	13950623
actual price	4930	4895	4865	4863	4870	4877
U operation	4929.449362	4894.854624	4865.053033	4862.932007	4869.888897	4876.792007
n operation	4929.258352	4894.706245	4864.821224	4862.705325	4869.635325	4876.565325

Third scenario: predicting the stock price by using FTS_FOA model

In this scenario, we use the fuzzy time series to predict the stock price and use the firefly optimization algorithm to classify. Modeling the behavior of a set of fireflies and allocating the value related to fitness of location of each firefly, this model investigates pigments' value of firefly and updates the location of fireflies in sequential repetition to find the optimal solution for the problem. The results obtained from difference of the predicted price and actual price are illustrated in the following chart. As shown in this chart, this algorithm was not so successful in predicting the prices.



	13950631	13950629	13950628	13950627	13950624	13950623
actual price	4930	4895	4865	4863	4870	4877
U operation	4898.784052	4895.507254	4895.507254	4876.58852	4876.58852	4876.58852
n operation	4878.059467	4874.782669	4876.58852	4860.946583	4860.946583	4860.946583

As seen, the difference of these scenarios is the different using of meta-heuristic algorithms, and difference in scenarios and difference in the obtained solutions can be sought in the difference among the methods. The most important difference in these methods is finding the local optimal and global optimal points, where firefly has been diverted from global optimal toward the nearest neighbor of the optimal due to more movement. While it was expected that firefly algorithm to provide better solutions due to the type of problem, for which the optimal solution is determining the appropriate interval, it was not achieved. On the other hand, the significant difference between the particle swarm and cuckoo algorithms is the mass populations. As eggs in one nest are relatively close to each other in the cuckoo algorithm, the conditions for local searches in a denser area are more provided, which is unlike to the particle swarm algorithm, in which it is tried that the problem space to be sought with uniform distribution of particles in the whole space. The key difference of particle swarm and firefly can be considered the global optimal, so that the possibility of finding the local optimal solution is higher in the particle swarm due to movement with constant coefficient toward global optimal and the uniform search of the problem space.

Discussion and conclusion

One of the important and effective factors in predicting the fuzzy time series is the problem of determining of the intervals. Several models have been developed and introduced by researchers in this regard to find the appropriate intervals. This research tried to use cuckoo optimization algorithm, particle swarm algorithm, and firefly algorithm and new approach to classify the problem to provide new model for predicting the fuzzy time series. This type of classification has a good sensitivity to distribution and dispersion and it provides intervals appropriate to various distributions and dispersions. By reviewing the findings of the previous chapter, it can

be observed that the cuckoo meta-heuristic algorithm provides better solution compared to particle swarm algorithm and particle swarm algorithm also provides better results compared to firefly algorithm. Its reason can be found by examining the problem and the characteristics of meta-heuristic algorithms. In this problem, based on what was described in the previous chapter, the important point in the process of problem solving and finding the prediction of stock price value was optimizing or finding the best intervals to create fuzzy rules in predicting the stock price value. As meta-heuristic algorithms need to change the boundaries of the intervals to achieve the appropriate solution, it was expected that firefly optimization algorithm to be more accessible, given its nature, in which each firefly moves towards the most luminous firefly around itself, since interpretation of this issue guides us to the problem of small changes in prediction intervals. However, results suggest that this expectation was wrong and the best solution is obtained when the intervals are completely heterogeneous, and intervals had the lowest value at the time of high changes in the stock price, and they had the largest value at a time of lack of significant change in prices, and this solution is achieved by global investigation of the problem space. It is clear that particle swarm algorithm and cuckoo algorithm are the best meta-heuristic methods in this regard, due to the homogeneous distribution of elements in the whole search space and moving with specified weight towards the global optimal. Given the nature of the cuckoo egging in nests, cuckoo algorithm moves in mass and examines the whole space by moving the masses, while the firefly algorithm moves locally and based on the and neighbors. These characteristics completely justify the findings. Findings obtained by model implementation on the actual data of 10 companies out of 50 companies operating in stock market (the odd companies) suggest the superiority of the FTS-COA model to FTS_PSO and FTS_FOA models in fuzzy time series space. However, the reason that cuckoo algorithm could achieve the best results is that nests are uniformly distributed throughout the search space, so it has the strength and characteristic of the particle swarm algorithm. In addition, the possibility of local optimal search after the global search is provided in one nest with having several eggs. Hence, it is clear that the best results are obtained by using the FTS-COA model given the type of problem.

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