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Research Article

Optimization of Virtual Network Mapping Based on Improved Ant Colony Algorithm in Complex Network Environments

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Financial marketing is a method of risky investment, but in a shorter duration, the individual can expect a profit or loss, depending on the current market rate for the organization. Though it has a higher risk of getting a profit, many individuals are ready to take a chance to benefit. In the current era, much research is going on to provide a better prediction rate. Most researchers prefer Ant Colony Optimization (ACO) as a more trustworthy optimization algorithm among the existing optimization algorithms. In this research work, a novel optimization algorithm is proposed; it is a hybrid algorithm with Ant Colony Optimization (ACO) and financial marketing crisis prediction (FMCP) and is termed ACO-FMCP. This hybrid algorithm was applied to the economic sanctions dataset, and the results were generated. The results were compared with ACO and FMCP algorithms and it was found that the hybrid ACO-FMCP shows improved performance than the other two algorithms.

1. Introduction

In everyday life, people require money to make the day successful. Every individual is looking to invest their financial income in different ways. People's interest in investing is growing at a faster rate than their thirst for need. The need for investment can be of various types, such as gold purchase, property purchase, higher education for kids, building a home for themselves, starting a business, and much more. Some of the investment schemes preferred by people are bank deposits, gold purchases, and investment in terms of financial marketing. Most investments necessitate a longer time frame in order to reap greater rewards. However, financial marketing is optional for this longer profit. When a person gets expertise in financial marketing, they can earn a good profit in a short period of time, and hence the profit can be invested in some other sources. Investors prefer less risky methods of investing money. Hence, most people will not take a higher risk in deciding to invest in the financial market. Though there are possibilities to earn a more significant profit in this financial market, the investor should be in a position to take the risk. The current financial market is not stable as it has fluctuations in profit and loss percentage. To overcome losses, investors should exercise caution when purchasing shares and keep up to date on current market conditions [1]. The algorithms proposed by the researchers are to identify a better prediction of the market rate in the future. For the prediction process, algorithms such as machine learning, deep learning, some intelligence algorithms, and meta-heuristics were deployed. It is necessary to find the algorithm that provides an optimal solution in predicting the market rate. To achieve better performance, a machine has to be pretrained with the previous market from opening to closing, various financial marketing companies. In this study, the combination of two algorithms such as ant colony optimization and financial prediction algorithm with AI has been proposed. This hybrid model is used for predicting the market rate in competitive financial markets in order to find a feasible solution in foregoing the financial market.

2. Related Studies

In the article [2], the authors employed the K-Means Clustering Algorithm and Ant Colony Optimization (ACO) to derive portfolio management solutions. In this work, K-Means Clustering is utilized to cluster the stocks based on the financial crisis, whereas the ACO does the weighting of each cluster. The results show that the cluster with the higher weight is considered the solution to the defined problem statement. The authors of [3] have implemented multi-agent stock market prediction for predicting the stock market using the optimal prediction algorithm, ACO. In this research, ants are considered as agents, which aids in finding the least absolute difference between the pheromones generated by the ants. This finding is made by considering two major agent parameters: mean absolute percentage error (MAPE) and mean absolute deviation (MAD). The authors have obtained better forecasting results in comparison with the time series. The Tehran Stock Exchange's total return index (TEDPIX) data is analysed and predicted by the authors of [4]. The authors also analysed some classical algorithms and concluded that ACO had outperformed all the other algorithms concerning time series and robustness. From the previous studies, it can be observed that Ant Colony Optimization (ACO) provides better performance when compared to other optimization algorithms [5]. In [6], long short term memory (LSTM) neural networks and long short term memory (LSTM) neural networks with embedded layer (ELSTM) are proposed, discussed, and analysed. The proposed model is analysed using the Shanghai A-share Composite Index and Sinopec. The Tradinnova-ACO algorithm is applied to the stock market investment application by the authors of [1]. In this model, they have explained the dynamic stock management by proposing a plan to schedule activities. An Ant Colony Optimization (ACO) based financial crisis prediction (FCP) model is proposed by the authors of [7]. In this model, the authors have considered two ACO phases: feature selection and data classification. These two phases of the algorithms are named ACO-FS and ACO-DC. The authors have validated the algorithm with the traditional models and have concluded that the ACO-FCP model is superior to others. In [8], the authors tried to predict the corporate financial crisis rather than the numerical financial ratios. The authors of [5] have created a hybrid algorithm for stock market prediction. In their model, the ACO algorithm is implemented using the selection-based model. Also, the authors have created a hybrid of decision trees and neural networks termed "DT-ANN." The DT-ANN algorithm shows an improved accuracy of 81% when compared to other algorithms used for the analysis. The authors of [9] employed an ANN algorithm for predicting the stock market. The authors use two meta-heuristic algorithms, Social Spider Optimization (SSO) and Bat Algorithm (BA), to train the system, which will aid in the prediction of the stock market price. After system training, feature selection has to be performed for improved prediction accuracy. A genetic algorithm is implemented for the feature selection process. With this model, the analysis is executed on datasets of varying time series. The study proposes ACO-SPP, an ACO-based Stock Price Prediction (SPP) algorithm [10]. This model is designed to forecast stock prices and compare them with traditional models on different parameters. Another research work [11] performs stock market prediction with the K-Nearest Neighbor algorithm (KNN), and a nonlinear regression model and analysis is made on six companies of Jordanian stocks. In [12], a new machine learning (ML) algorithm is deployed for preprocessing of stock market predictions. The results of preprocessing are applied to forecasting stock prices. The authors have used a hybrid algorithm made up of the Bat Algorithm and the XGBoost model to implement the forecasting. This novel hybrid model is called the BA-XGBoost algorithm and is tested with the stocks of Apple and Facebook. For the Japanese stock market, the authors of [13], a hybrid of Genetic Algorithm (GA) and ANN, are made to predict the next day's price for the stocks. The authors of [14] utilise a simple feed-forward neural network model with two measures, normalized mean square error (NMSE) [15] and sign correctness percentage (SCP) [15], for improved performance results. This model is implemented for the Indian Stock Market and the results are updated. The authors of [16] improved on GA by extending the hybrid model with the Harmony Search Algorithm (HSA). The performance analysis is made between HSA-ANN and GA-ANN. The long-short term memory (LSTM) [17] neural network is implemented and analysed with the existing algorithms. As an alternative to these optimization algorithms, the authors of [17] used the Cuckoo Search Algorithm for the prediction process and did statistical analysis. The author of [18] predicted the stock market with the implementation of a machine learning algorithm. In the survey carried out by the authors of [19], the analysis was conducted among various algorithms such as ANN, fuzzy logic, GA, and others. Another hybrid algorithm is given by the authors of [20]. They have proposed a hybrid of Genetic Algorithm and XGBoost named GA-XGBoost. Deep Learning algorithms were focused on by the authors of [21] for the same application. The author of [22] did the analysis of the financial market prediction with an ML algorithm. In [23], the author conducted a detailed survey about the optimization algorithm with different parameters and concluded with results and discussion. There is no accurate predication has made in the existing studies. This study proposed a novel hybrid algorithm for predicting the financial market using artificial intelligence.

3. Proposed Work

Financial market research decisions are usually predicated on using classification techniques for categorising a set of measurements. Various data classification methods are available to determine an organization's overall financial marketing crisis. Identifying suitable parameters (features or organizations) that are critical for developing an accurate financial market crisis prediction (FMCP) method is an essential process. This process is known as an "attribute

selection problem," and it aids in improving the classifier's performance. The purpose of using ACO in this study is to find a optimal solution for predicting the market and tends to solve the computational problems in finding a real route.

The suggested hybrid algorithm with the FMCP model is divided into two parts based on feature extraction and data preprocessing. The novel hybrid algorithm within the information to identify and categorize the suggested work includes some of the following processes. The novel hybrid algorithm goes through a feature extraction process and selects the best subset of attributes.

Step 1. The selected feature subset is used in the classification stage. In this way, the novel hybrid algorithm with the FMCP method categorises financial marketing data and suggests whether an organization will face a financial marketing crisis.

There is an initial estimate of the most significant characteristics available. As a result, the features which it occurs in the $L_i^p(s)$ optimal solution have been acknowledged, and each feature is balanced depending on the number of times it appears in the $|\tau_i(s)^{\infty}|.|i|^{\beta}$ optimal solution. The characteristics that appear more frequently with in set of best approaches are given higher i value. If a feature i is enabled in all $\sum_{v\epsilon j_p}|\tau_v(s)^{\infty}|.|\eta_v|^{\beta}$ best approaches, then $v\epsilon J_p$. If, but at the other hand, a feature is not enabled at all, then $i=0$. A novel hybrid algorithm with in feature j decides whether or not feature i is chosen, using the probability $L_i^p(s)$.

$$L_i^p(s) = \begin{cases} \dfrac{|\tau_i(s)^{\infty}|.|i|^{\beta}}{\sum_{v\epsilon j_p}|\tau_v(s)^{\infty}|.|\eta_v|^{\beta}} & if\ v\epsilon J_p, \\ 0 & \text{otherwise}, \end{cases} \tag{1}$$

where J_p denotes the number of attributes that can have been included in the temporary solution; τ_i and τ_v denote the analysis value as well as methodology attractiveness of feature τ_i are the parameters that govern the relative value of secretion value as well as optimization algorithm.

Step 2. When all of the novel hybrid algorithm have found their own first solution, the analysis disappearance among all modules begins, and each ant p investments the quantity of analysis given by (2),

$$\Delta\tau_i^p(s) = \begin{cases} \varnothing.\gamma\left(D^p(s)\right) + \dfrac{\varnothing\left(r-1D^p(s)i\right)}{r}, & if\ i \in D^p(s), \\ 0 & \text{otherwise}, \end{cases} \tag{2}$$

Step 3. $S(r)k$ is the feature subset produced by ant p iteration and $|s^r|r$ represents the length, ϕ is the parameter which controls the relative weight of feature subset length and it ranges between 0 and 1 is represented in (3).

$$\tau_i(s+1) = (1-\rho 1)\tau_i(t) + \sum_{p=1}^{q}\Delta_i^k(s) + \Delta\tau_i^a(s). \tag{3}$$

IF <Condition> THEN <classes>. (4)

Step 4

(i) Whatever values less than the prespecified value could indeed be included in rule, which is referred to as the minimal level instances for every rule as in (4).

(ii) The rule based process would be discharged that once ants have exploited all the attributes. To create rules, the ants are using a probabilistic model E_{ij} as shown in (5) to can choose a parameter value.

$$E_{ij} = \frac{\eta_{ij}.\tau_{ij}}{\sum_{i=1}^{b}(U_i).\sum_{j=1}^{a}\left(\eta_{ij}.\tau_{ij}(s)\right)}. \tag{5}$$

Step 5. For each term ij that can be introduced to the current rule, the Ant colony optimization method specifies the amount ij of an optimizer that represents the performance of this time frame in terms of its ability to improve the rule's predictive performance. The significance of ij for time frame ij is a measure of an electron density associated with that time frame. The result is approximated for each time frame ij as shown in (6).

$$A\left(MA_i = U_{ij}\right) = -\sum_{m=1}^{p}\left(M\left(A|A_i = U_{ij}\right).\log_2 K\left(m|A_i = U_{ij}\right)\right). \tag{6}$$

Step 6. It improves the rule's simplicity, as a smaller rule is easier to understand than just a lengthy one. After the ants have completed the rule design process, the rule replanting process is initiated. This process eliminates unnecessary rules generated by ants within every step, thereby improving rule quality. In (7), the valuation of F is calculated.

$$F = f\frac{SK}{(SK+HR)} * \frac{DR}{(HK+SR)}. \tag{7}$$

Step 7. The ants use this method to discover simplified as well as stronger classification rules. Initially, those routes are administered with same quantity of analysis as specified in (8).

$$\tau_{ij}(s=0) = \frac{1}{\sum_{i=1}^{b}a_i}. \tag{8}$$

Step 8. Since the artificial ant transactions substance all through path investigation, the nodes that were utilized by the current rule would be updated. Simulating analysis

evaporation at the same time is required. As a result, the recursive operative is carried out in accordance with (9).

$$\tau_{ij}(s) = (1-\rho)\tau_{ij}(s-1) + \left(1 - \frac{1}{1+M}\right)\tau_{ij}(s-1). \quad (9)$$

Step 9. So, the analysis rate of evaporation, F is the attribute as defined in (7), as well as t is the iterative process unique identifier. The endpoints that have not yet been used by current rule, on the other hand, will only have analysis evaporation, as associated in (10).

$$\tau_{ij}(s) = \frac{\tau_{ij}(s-1)}{\sum_{i=1}^{b}\sum_{j=1}^{a_i}\tau_{ij}(s-1)}. \quad (10)$$

Figure 1 describes the distributive environment of the share price market environment, in which a number of attribute, class, and instance from various stock financial institutions engage in share market under strict regulation and supervision is considered. The adaptability of Ant Colony Optimization in trying to solve decentralized control problems, the stochastic optimization technology can be implemented in addressing the capital market challenges with an Ant Colony Optimization (novel hybrid algorithm) predicated FMCP method.

Table 1 provides the details of the economic sanctions dataset which is utilized in this research work.

In Figure 2, we can see the financial transactions can be subjected to technical analysis is represented. This includes feature selection techniques and other financial instruments. Analysis will be performed based on iteration over stocks as illustrated in the figure. These constructs can be categorized by the type of protection. Trading strategy is more common in commodity and future currency markets, where traders are concerned with relatively brief market instability. From this figure it can be observed that when the iteration increases, the feature selected from the total number of available features. But the feature selection starts fluctuating after fourth iteration. So the feature selection is unstable; also it can be observed that there is no variation when the cost increases. Only at the third iteration, the cost of all the products dataset has faced a shortfall and restored to normal in the very next iteration.

For the selected number of iterations from Table 2, it can be observed that the feature no. 8 is selected in maximum number of iterations; also for each iteration, certain features are selected and the cost for the selected feature is calculated. Cost calculation can be provided as, at a given time number of features selected from the total available features and variation in the rate at that simulated time.

In Figure 3, we can observe the substance associated for each solution fraction is degraded during the atomization step, where its flow rate is given by τ. The rate of evaporation is critical in controlling the novel hybrid algorithm stability of exploration and production. If τ is close to 1, then the analysed value is used within next iteration step and are heavily reliant on the reasonable alternatives from the previous iteration. This process results in a search algorithm around these solutions. Relatively small quantities of τ

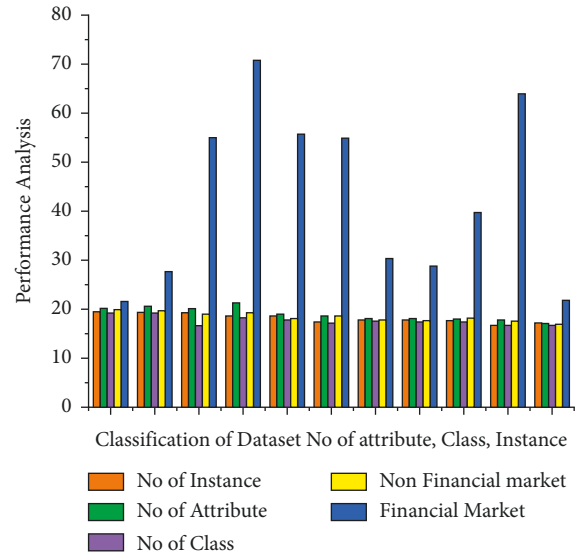

Figure 1: Classification of Dataset No of attribute, Class, Instance using novel hybrid algorithm.

enabled in earlier iterations of novel hybrid algorithm may affect the searching strategy. In this figure though the market rate is maintained static for the given time, decline in the feature selection is observed. So, there might be reduced number of features having variation at the given time.

Similar to Tables 2 and 3 provides the results for the modified ACO-FMCP algorithms.

Figure 4 and Table 4 shows the classification performance again for economic sanctions dataset using various feature selection methods. The modified hybrid ACO-FMCP method outperforms the other methods in classifier performance. It is guaranteed by the best prediction performance, which has a sensitivity of 100%, the specificity of 100%, as well as an accuracy of 100%.

In the above Table 4 performance metrics is used to display the performance of the algorithms. FPR is the False Positive Rate, FNR is the False Negative Rate. Sensitivity defines the correct prediction of stock market price for the products on the other Specificity is the correctness in prediction of no changes in the stock market price for the given product at the given time. With this definition, modified algorithm outperforms the other algorithm by providing exact prediction percentage.

In Figure 5, the novel hybrid algorithm or the modified hybrid algorithm is used for effective feature selection and data categorization. From this figure it can be seen that the wrong prediction of the data is less than the accuracy and the specificity. The suggested novel hybrid algorithm is validated to use a sequence of data sets, as well as the results have been compared to state-of-the-art method. The overall research and testing results show that novel hybrid algorithm with FMCP method enhances accuracy of classification known as feature selection techniques significantly (Table 5).

The recommended novel hybrid algorithm with ACO-FMCP method rules are applied to every financial market to determine its financial activity in real time.

Table 1: Classification of dataset no. of attribute, and class instance using novel hybrid algorithm.

Dataset	Source	Number of instance	Number of attribute	Number of class	Financial market/nonfinancial market
Economic sanctions	UCI	54678	128	3	3695/54724

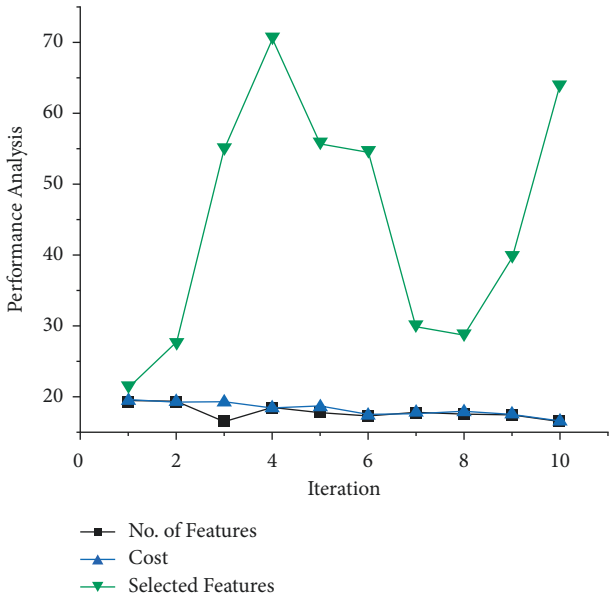

Figure 2: To Analysis for on the qualitative economic sanctions dataset, feature selection techniques is used.

Table 2: To Analysis for on the Qualitative Economic Sanctions Dataset, feature selection techniques is used.

No of iteration	No. of features	Selected features	Cost
1	8	4,5,1,2	0.002122
2	8	3,4,5,1	0.002212
3	8	8,4,5,3	4.8737e-10
4	8	8,4,5,3	4.8737e-10
5	8	8,4,5,3	4.8737e-10
6	8	8,4,5,3	4.8737e-10
7	8	8,4,5,3	4.8737e-10
8	8	8,4,5,3	4.8737e-10
9	8	8,4,5,3	4.8737e-10
10	8	8,4,5,3	4.8737e-10

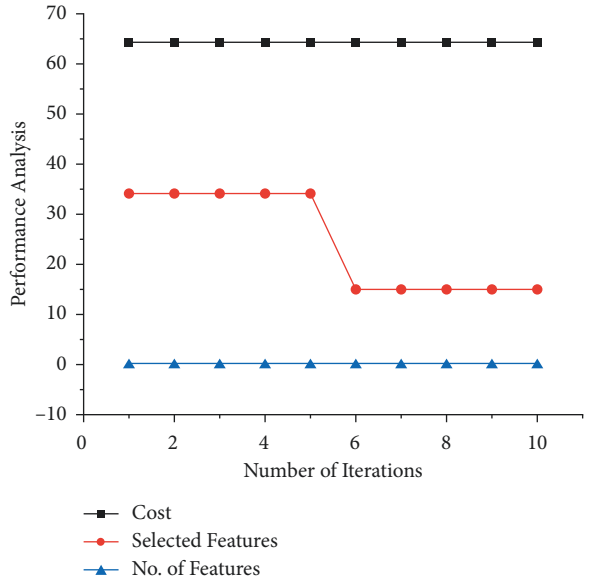

Figure 3: Performance Analysis the novel hybrid algorithm with FMCP on the Economic Sanctions Dataset.

Table 3: Results of the modified hybrid algorithm of ACO-FMCP on the economic sanctions dataset.

No of iteration	No of features	Selected features	Cost
1	64	34	0.03070
2	64	34	0.03070
3	64	34	0.03070
4	64	34	0.03070
5	64	34	0.03070
6	64	15	0.02360
7	64	15	0.02360
8	64	15	0.02360
9	64	15	0.02360
10	64	15	0.02360

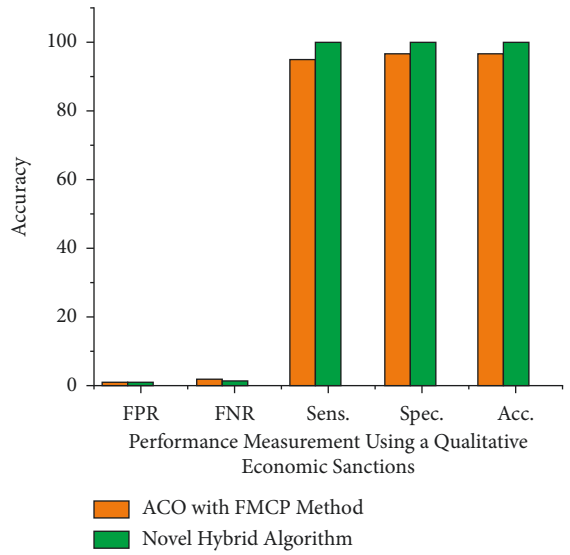

Figure 4: Performance measurement using a qualitative economic sanctions dataset.

Table 4: Classifier performance measurement using a qualitative economic sanctions dataset.

Dataset	Method	FPR	FNR	Sensitivity	Specificity	Accuracy
Economic sanctions	ACO-FMCP	2.98	1	100	99.78	99.8
	Modified ACO-FMCM hybrid algorithm	0	0	100	100	100

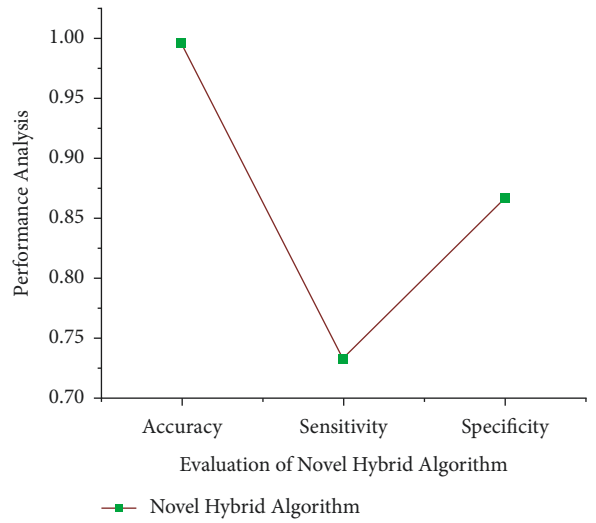

Figure 5: Evaluation of novel hybrid algorithm with FMCP Method.

Table 5: Evaluation of result analysis in novel hybrid algorithm with FMCP method.

Modified hybrid algorithm: ACO-FMCP method	
Accuracy	0.995426
Sensitivity	0.732540
Specificity	0.866570

4. Conclusions

Investment has become mandatory for the peaceful future life. However, investment with no or minimum loss have to be considered for any investment plan. Financial Marketing Crisis prediction is considered for this research work. In this study, ACO-FMCP algorithm and a modified ACO-FMCP algorithm has been proposed. These two algorithms have been used for evaluating the best performance and accuracy. Though the first algorithm provides better results, when a deviation occurs there will be reversal of results, whereas in the modified algorithm, strict rules will be made to avoid deviations. As the deviation in the algorithm is reduced, higher the accuracy rate is observed over the ACO-FMCP algorithm. The study found that FMCP has deviation issues. Hence, the modified hybrid algorithm with novel rules can be suggested for financial market crisis prediction.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Ran Zhang and Jie Sheng contributed equally to this work.

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