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Combining PI Sigma Neural Network with Multiple Offspring Genetic Algorithm for Stock Market Price Prediction

Sipra Sahoo, Saroj Kumar Mohanty, Sateesh Kumar Pradhan

***Abstract:** Accurate and precise prediction of pricing of stock market is a very demanding task because of volatile, chaotic nature of time series data. Artificial Neural Networks played a major role for solving diversified problems for its robustness, strong capability for solving non linear problems and generalization ability. It is a popular choice for researchers for foretelling the financial time series data. In the article Pi Sigma Neural Network (PSNN) is developed for foretelling of stock market pricing in different time horizons. Pricing of stock market is predicted for one, fifteen and thirty days in advance. The parameters of the network are interpreted and optimized by Multiple Offspring Genetic Algorithm (MOGA). The motivation of this study is to achieve global optima with faster convergence rate. Bombay stock Exchange (BSE) data set is used for implementing the proposed model. Performance of the proposed model is evaluated using metrics like Mean Absolute Error (MAE), Root Mean Square Error (RMSE), Median Average Error (MedAE) . The results are compared with Pi Sigma Neural Network with Genetic Algorithm (PSNN-GA) and Pi Sigma Neural Network with Differential Evolution (PSNN-DE). It is concluded that the proposed model outperforms PSNN-GA and PSNN-DE models.*

***Keywords:** Forecast Stock Market, Pi Sigma Neural Network, Genetic Algorithm, Differential Evolution, Multiple Offspring Genetic Algorithm optimization.*

I. INTRODUCTION

Foretelling of stock market pricing is a sizzling field of interest for common investors, corporate personnel, academicians, researchers and speculators. Main motive behind this interesting field is the lucrative benefit which requires accurate information about the stock market and trend prediction. The market has so many affecting parameters such as social and economical conditions, political scenario, condition of other stocks, policies of the companies, investor's psychology towards investment, investor's expectations etc . Forecasting models are developed and applied on historical data to gain insight about the future trend. It has been found that stock market's data is highly dynamic ,chaotic, non linear, non parametric which inspires researchers to develop models for accurate and precise prediction. Beforehand some statistical methods were used for forecasting the price of stock market. Some of them are Kalman separation, autoregressive moving normal (ARMA), exponential smoothing, relapse investigation, and autoregressive moving normal. But the above statistical techniques were not capable for resolving non linearity and dynamic nature of stock market.

Computational intelligence techniques have been tried and tested by many of the researchers for prediction to beat the lacunas of statistical techniques. Among them Artificial Neural Network played a vital role. Many other neural networks like decision tree learning, deep learning, support vector machine (SVM) and functional link artificial neural network (FLANN) have been proposed for foretelling the stock market's price. Prediction of stock market's condition is a very difficult problem due to the non linearity,stochasticity and volatility of problem. However, Pi Sigma which is optimized by Multiple Offspring Genetic Algorithm (PSNN-MOGA) is an example of non linear model which is suitable for discovering the stochasticity , non-linearity, uncertainty and inaccuracy exist in the stock market.

II. RELATED WORK

Stock market forecasting and trend determination is an alluring field for researchers and financial investors who are willing to invest in the stock market [2]. However, the correct forecasting is tough due to the stochasticity and volatile characteristic of the stock market. The non linearity and dynamic nature of stock market depends upon many factors like country's economic condition, price index of products, political scenarios, corporate policies, investor's psychology, and government policies [3]. Many works have been proposed for predicting the pricing of stock market. Parametric, nonparametric and hybrid of both the methods have been employed for prediction. Linear models are easier to be used in comparison to non linear models which are meant for addressing the volatility and non linearity problem of financial time series data [4,5].A lot many numbers of techniques are used for analyzing the stock market scenario which can be divided into two sub categories that is fundamental analysis and technical analysis [6]. Fundamental analysis focuses upon economic condition of industry, corporate management policies and some other parameters for secure investigation and technical analysis focuses upon historical price data for forecasting future price [7].

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* Correspondence Author
Sipra Sahoo*, Computer Science Department, Siksha O Anusandhan Deemed to be University,Bhubaneswar, India. Email: siprasahoo@soa.ac.in
Saroj Kumar Mohanty,Computer Science and Engineering department, Trident Academy of Technology, Bhubaneswar,India. Email:sarojkumarmohanty@gmail.com
Sateesh Kumar Pradhan, Computer Application department,Utkal University, Bhubaneswar, India. Email:sateesh1960@gmail.com

Some meta heuristic methods over heuristic methods have been used for getting appropriate number of variables. Genetic Algorithm and continuous Ant Colony Optimization algorithms are used to achieve optimal results [8]. For Taiwan stock market price prediction optimized elman recurrent neural network (Elman NN) was developed to get over the lacunas of previous models. A feed forward multilayer Perceptron (MLP) was used for predicting company's stock value and its performance is better than Elman Recurrent Network and Regression Model [9] due to its non linear forecasting ability, accurate mapping and more importantly faster convergence.

Due to many number of advantages like simple optimization models, simultaneously searching method, free derivative nature of genetic algorithms and their hybrids are famous for last three decades. Avoiding the premature convergence to a suboptimal solution is an important issue. This convergence to local optima problem occurs due to the genes of high rated individuals who are dominating population. So better offsprings cannot be reproduced and consequently search process for better solutions slowed down [10]. Preservance of population diversity during the evolution is a method for avoiding local optima problem. Many other heuristic techniques such as restricted selection, application of dynamic mutation, probability of mutation, crossover constraints, assignment of fitness values, grouping method for individuals, mating restriction, universal sampling, elitism, species conserving technique, local search based on diversity [11,12,13,14] .

III. METHODOLOGY ADOPTED

A. Pi Sigma:

Pi Sigma Neural Network (PSNN) is a high ordered simple structured neural network and is developed by Ghosh J and Sinha Y in 1992. It has less variations and faster convergence speed and it is capable of solving complex problems. Conjugate radiant and steepest descent are two training algorithms of pi sigma neural which converges to local optima. It has lesser errors ensuring the capability of the network to solve complex problems. Network complexity can be simplified by employing efficient polynomials for variables of input layer.

The structure of PSNN is similar to a feed forward network having 3 layers: (i) Input layer presenting input variable (ii) Hidden layer presenting summation unit (iii) Output layer presenting product unit.

The potentialities of higher order neural networks are actualized by taking product cells as the output units having insignificant weights. Several domains such as science, finance, and engineering apply PSNN. PSNN overcomes the over fitting problem which is encountered in multi layer perceptron (MLP).It is a fully weighted interconnection between input layer neurons with hidden layer and output layer. Sigmoid activation function is implemented in hidden layer to capture the non-linearity of input and output layer. Significant accuracy achievement is an important feature of this network. It also gives the way to lesser learning time.

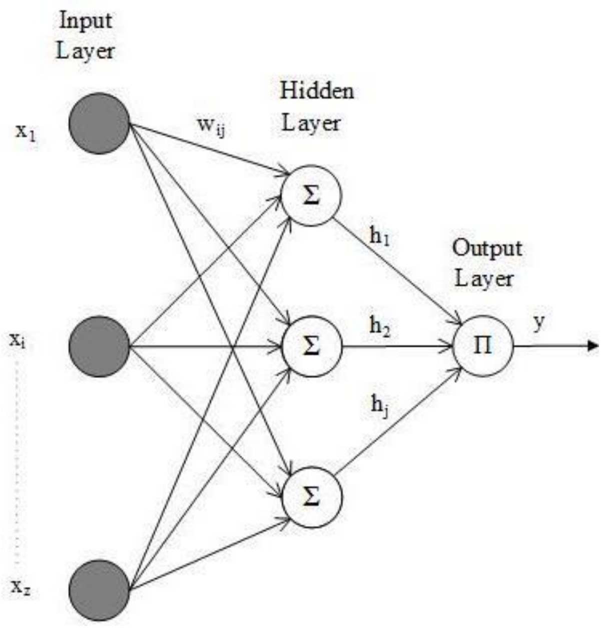

Fig 1.Structure of PSNN

In the above figure of Pi Sigma network the input x is an N dimensional vector.

x_i -ith component of x.

The weighted inputs are given into jth summing unit using for the kth output unit y_j .

Then

$$y_j=\sigma(\Pi(w_{ijk}\, x_i+\theta_{jk})) \quad (1)$$

σ=non linear transfer function

w_{ijk},θ_{jk}--adjustable co efficients

Connections from summing unit to an output unit have fixed weights.

In this network fast learning rate can be used and there is no hidden unit. In this network, when an additional summing unit is used the network order increases by one while preserving old connections and maintaining the topological structure of the network.

.Genetic Algorithm

Genetic Algorithms(GAs) are adaptive heuristic search algorithms which is part of evolutionary algorithms. GAs are a group of intelligent exploitation techniques which based on evolutionary ideas of natural selection and genetics that is "Survival of fittest" theory. These are random search techniques which exploit past data and meant for solving optimization problems and significantly perform better than many other conventional optimization techniques. Gas direct the search process towards more significant performance within the search space. In genetic algorithm a population of individuals collectively known as a generation and a point in search space defines an individual. String of character/integer/float present one individual. This string is similar to the chromosome.

B. Differential Evolution

Differential evolution (DE) is one of the population-based stochastic search techniques for getting approximate solutions for some optimization problems where objective functions are non-differentiable, noisy multi-dimensional and has many local minima, constraints or stochasticity. So it is very efficient and powerful. It has been extensively applied in finance, scientific and engineering domains. It is introduced by Storn and Price in 1996 . Selection, mutation and cross over are three operations of evolution process and an optimal solution is found out from a random population. In DE the target vectors are the individuals of the current population of that particular generation. Their fitness function value is estimated using the following eq.(2). Mutant vector is produced for each individual target vector by mutation operation. Trial vector should be chosen carefully as the performance of DE depends upon this and associated control parameter values.

$$m_{ij}=x_{r1j}+F^*(x_{r2j}-x_{r3j}) \qquad (2)$$

Where $r1\neq r2\neq r3\neq i$ (r1,r2,r3 are random and mutually exclusive integers)

The mutant vector and target vector is further passed through the crossover operation to produce a trial vector as follows:

$$t_{ij}=m_{ij} \text{ if rand } [0,1] <=cr \text{ or } j=j_{rand}$$
$$\text{else } x_{ij}$$

Target vector is replaced by trial vector provided that the fitness value is better than target vector. In summary search space selection inspires survival of fittest, crossover recapitulates past successful individuals and search space is enlarged due to mutation. Until some terminating condition is reached the process continues.

C. MOGA

In this paper multiple offspring competition method is applied which is basically based on the reproduction process of Genetic Algorithm. In this method multiple offsprings are generated generation by generation, then competition takes place between the children and the winner of them became the real child. Three generations that is normal, strongly mutated and queen-bee strategies have been used for producing multiple child. At the initial stage winners generate children and they have diversity. Evolution speed can be accelerated due to queen bee generation phase and strongly mutated generation helps the Genetic algorithm to fall into local optimum. Objective of Multiple offspring competition is to help GAs not to fall into local optima leading to premature convergence problem. This method is more efficient than queen bee genetic algorithm because additional parameters and empirical selection of parameters are not needed. In the proposed method three types of offspring are produced according to the three types of generation strategies and amongst the children the winner became the real offspring. Unlike the previous methods, other proposed method reproduce three types of children according to the reproduction methodology. Each parent in our method reproduce three types of children according to the reproduction methodology competing among themselves and the winner become the real offspring. By adopting (i) normal, strongly mutated and queen bee generation of MOGA operates perfectly for the situation of GA. Individuals generated through normal reproduction method strongly affect individuals of next generation, individuals of strongly mutated generation trapped into local optima increasing the diversity of individuals. Children of queen bee generation will accelerate the evolution of GAs without concerning about the premature convergence problem. Some inefficient offsprings which are reproduced by some other means will not affect to the individuals of upcoming generation as they will not be the winner individual. Our multiple offspring competition method causes fast evolution of GAs without negative effects.

MOGA algorithm

$t = time$

$P = population$

$p_1, p_2 = selected\ parents$

$p_q = queen\ bee\ of\ the\ generation$

$p_n, p_m = normal\ and\ strong\ mutation\ probablity$

$c, c_1, c_q = normal, strongly\ mutated\ and\ queen\ bee\ children$

1. t=0
2. Initialization of Population P(t).
3. Evaluation of P(t).
4. While(~terminating condition)
5. do
6 .t =t+1
7. Selection of P(t) from P(t-1)
8. Recombination of P(t)
9. Normal reproduction of children
10. Apply crossover upon parents p1,p2
11. Mutate with pm
12. Evaluate child c_1
13. Strongly mutated generation of children(*)
14. Do crossover with parents p1,p2(*)
15. Do mutation with p_m((*)
16. Evaluate child c_q (*)
17. Queen bee reproduction of children (*)
18. Apply crossover with parents p_1,p_2(*)
19 Mutate with p_m(*)
20. Evaluation of children c_q (*)
21. Compete children with fc,f c_1& f c_q (*)
22. Set the winner children to next children (*)
23. Evaluate P(t)
24. End

IV. EXPERIMENTAL RESULT AND DISCUSSION

A. Experimental setup

The proposed model use MATLAB version R -2014B with Intel I3 processor in operating system Windows 8.1 Professional.

Dataset Description

For every research dataset plays a vital role. Dataset collected from Bombay Stock Exchange (BSE) dataset from 25th August 2004 to 24th October 2018 date. Where 3518 number of days data present.

Opening price, closing price, high price, low price, number of trades and shares, total turnover in Rs, deliverable quantity ,% deli quantity to traded quantity, spread high-low, spread close-open are everyday data. Table I depicts about the dataset.

Table- I: Dataset Discussion

Dataset	Total samples	Data Range	Training Samples	Test Samples
BSE	3518	25/08/ 2004 to 24/10 2018	2518	1000

B. Dataset Description

In Table II it is described what are the parameter setting for PSNN, GA, DE, and MOGA.

Table- II: Parameters for the Model

PSNN	GA	DE	MOGA
No. of input nodes-12	Population size - 50	Population size - 50	Population size - 50
No. of Hidden Layers - 3	Selection operator-Roulette wheel	Crossover rate(Cr)-0.8	Selection operator-Proposed by MOGA
No. of nodes in the each hidden layers-6	Crossover rate-0.25	Mutation scale factor(F)-0.6	Crossover rate-0.25
No. of Iteration-50	Mutation rate-0.1		Mutation rate-0.1

C. Normalization

It is very much required to preprocess and standardize the dataset before giving input to any network. The information to be scaled for retaining the quality of information by applying some normalization methods like min-max, Z-score, decimal scaling, Median standardization etc. Knowledge about the domain is very much required for choosing the right method of normalization process and consequently it increases the network's ability to learn the association between input and output. In our work min-max normalization method is used.

D. Schematic Layout of Proposed Work

The proposed model for stock market prediction is shown in the following figure. This model works step wise. Initially the dataset that is Bombay Stock Exchange dataset is taken. After normalization the data set is divided into two categories (i) Training and (ii) Testing .The ratio is 6:4.Then dataset is trained using Pi Sigma Neural Network and optimized with GA,DE and MOGA. Then performance is evaluated for all the models.

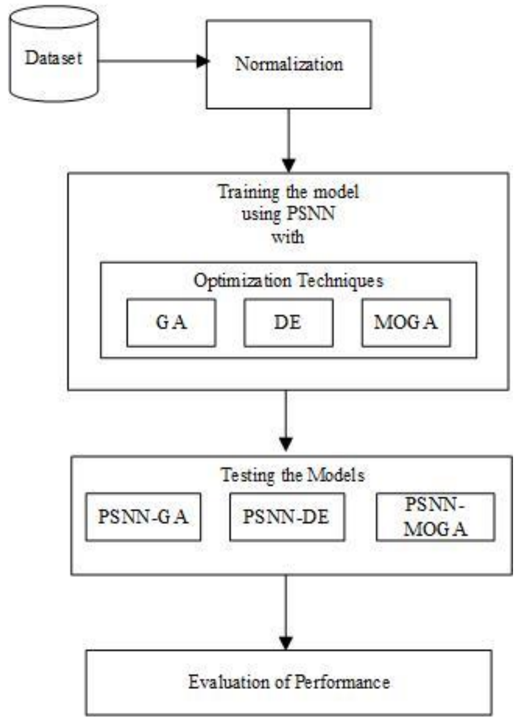

Fig 2.Schematic layout of proposed model

E. Performance Evaluation

PSNN-MOGA performs better than other two models i.e. PSNN-GA and PSNN-DE which is described in the Table 3, Table 4 and Table 5. MAE, MedAE, MSE and RMSE of all the models are explained in Table III, Table IV and Table V.

Table- III: One day ahead performance evaluation measure.

Method	MAE	MedAE	MSE	RMSE
PSNN-GA	0.131167	0.127000	0.018229	0.135015
PSNN-DE	0.121167	0.117000	0.015706	0.125322
PSNN-MOGA	**0.114167**	**0.110000**	**0.014058**	**0.118568**

Table- IV: Fifteen days ahead performance evaluation measure.

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Method	MAE	MedAE	MSE	RMSE
PSNN-GA	0.139167	0.135000	0.020392	0.142799
PSNN-DE	0.134167	0.130000	0.019025	0.137931
PSNN-MOGA	**0.129467**	**0.125300**	**0.017786**	**0.133364**

Table- V: Thirty days ahead performance evaluation measure.

Method	MAE	MedAE	MSE	RMSE
PSNN-GA	0.157167	0.153000	0.025726	0.160392
PSNN-DE	0.154167	0.150000	0.024792	0.157454
PSNN-MOGA	**0.149167**	**0.145000**	**0.023275**	**0.152561**

F. Result Analysis

At the time of testing how the PSNN-MOGA model predicts the future price for one day, fifteen days and thirty days ahead are depicted in the Fig 3, Fig 4 and in Fig 5. RMSE of all the three models are plotted in Fig 6,Fig 7,Fig 8 , where Fig 6 is the training time convergence graph for 1 day advance prediction, where Fig 7 is the training time convergence graph for 15 days advance prediction, and where Fig 8 is the training time convergence graph for 30 days advance prediction.

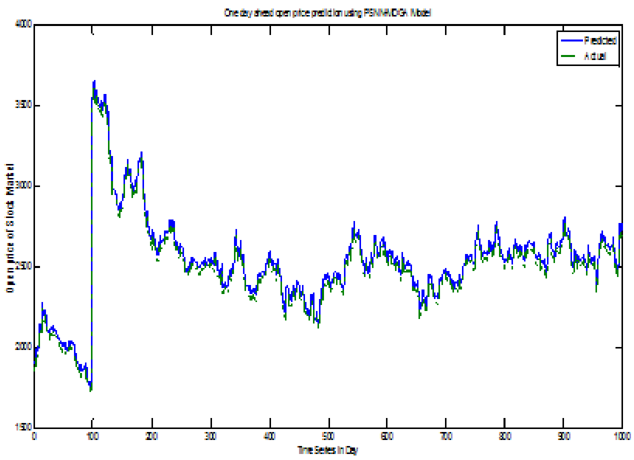

Fig 3. One Day in advance prediction

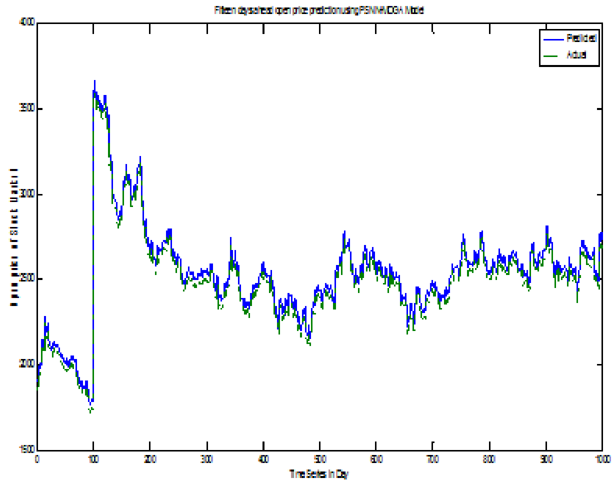

Fig 4.Fifteen Days in advance prediction

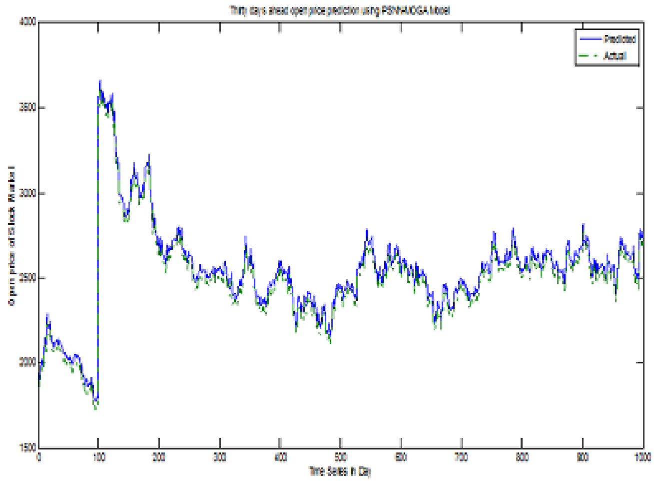

Fig 5.Thirty Days in advance prediction

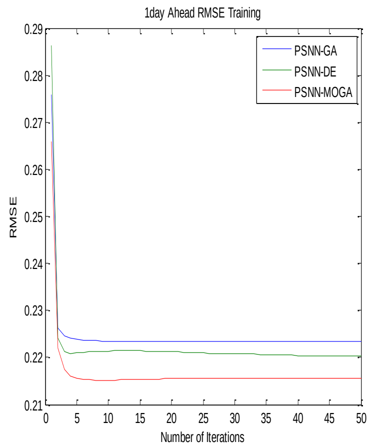

Fig 6.RMSE of training data one day in advance

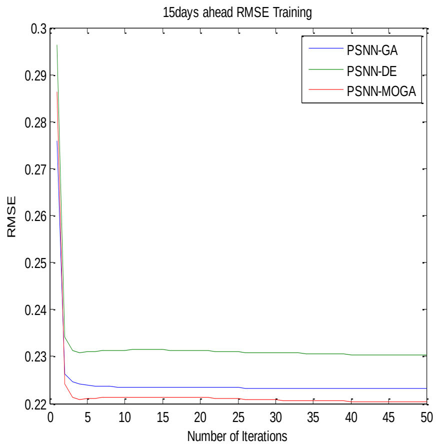

Fig 7.RMSE of training data 15 days in advance

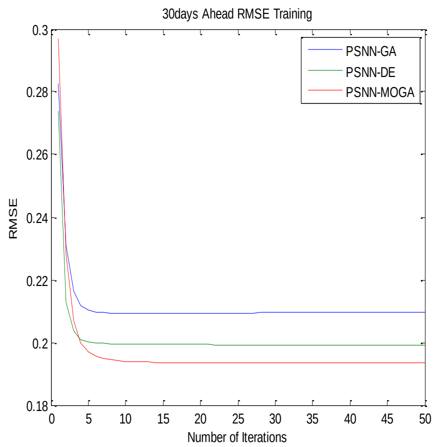

Fig 8. RMSE of training data 30 days in advance

V. CONCLUSION

In this article, the efficacy of Multiple Offspring Genetic Algorithm in evaluating the unrevealed parameters of Pi Sigma Neural Network for forecasting the pricing of stock market is explored. The proposed method has been compared with PSNN-GA, PSNN-DE taking into account various performance evaluation measures .From the experiment it is found that the proposed method outperforms other conventional methodologies.

REFERENCES

1. Sahoo, S., & Mohanty, M. N. (2020). Stock Market Price Prediction Employing Artificial Neural Network Optimized by Gray Wolf Optimization. In New Paradigm in Decision Science and Management (pp. 77-87). Springer, Singapore.
2. Sahin, U., & Ozbayoglu, A. M. (2014). TN-RSI: Trend-normalized RSI indicator for stock trading systems with evolutionary computation. Procedia Computer Science, 36, 240-245.
3. Majhi, B., Rout, M., & Baghel, V. (2014). On the development and performance evaluation of a multiobjective GA-based RBF adaptive model for the prediction of stock indices. Journal of King Saud University-Computer and Information Sciences, 26(3), 319-331..
4. AmirAskari, M., & Menhaj, M. B. (2016, January). A modified fuzzy relational model approach to prediction of Foreign Exchange rates. In 2016 4th International Conference on Control, Instrumentation, and Automation (ICCIA) (pp. 457-461). IEEE.
5. Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econometrica: Journal of the Econometric Society, 987-1007.
6. Anbalagan, T., & Maheswari, S. U. (2015). Classification and prediction of stock market index based on fuzzy metagraph. Procedia Computer Science, 47, 214-221.
7. Hong, W. C., Dong, Y., Zheng, F., & Lai, C. Y. (2011). Forecasting urban traffic flow by SVR with continuous ACO. Applied Mathematical Modelling, 35(3), 1282-1291.
8. Naeini, M. P., Taremian, H., & Hashemi, H. B. (2010, October). Stock market value prediction using neural networks. In 2010 international conference on computer information systems and industrial management applications (CISIM) (pp. 132-136). IEEE.
9. Karimi, H., & Yousefi, F. (2012). Application of artificial neural network–genetic algorithm (ANN–GA) to correlation of density in nanofluids. Fluid Phase Equilibria, 336, 79-83.
10. Sankar, C. P., Vidyaraj, R., & Kumar, K. S. (2015). Trust based stock recommendation system–a social network analysis approach. Procedia Computer Science, 46, 299-305.
11. Yu, S., Zhu, K., & Zhang, X. (2012). Energy demand projection of China using a path-coefficient analysis and PSO–GA approach. Energy Conversion and Management, 53(1), 142-153.
12. Xiao-qin, W. (2012). Research on Prediction Model of Time Series Based on Fuzzy Theory and Genetic Algorithm. Physics Procedia, 33, 1241-1247.
13. Mohanty,A.,&Mishra,D.(2019). Exploring the use of Water Cycle Optimization Algorithm for Foreign Exchange Prediction. International Journal of Innovative Technology and Exploring Engineering .8(10)
14. Mohanty,A.,&Mishra,D.(2019). Optimal Prediction of Foreign Exchange Market Exploring the Effect of Water Cycle Algorithm Strategy on Data Segregation. International Journal of Recent Technology and Journal of Innovative Technology and Exploring Engineering .8(2)

AUTHORS PROFILE

Sipra Sahoo is working as an assistant professor in ITER, SOA (Deemed to be). She was born on 6th May 1984. She has completed her B.E (Information Technology) from BPUT in 2005 and M.E.(Computer Science and Engineering) in 2008 from Utkal University. and currently pursing Ph.D in Utkal University. Her areas on interest include data mining, recommendation systems, soft computing, web personalization and sentiment analysis. She is a member of Institute of Engineers (India).

Saroj Kumar Mohanty is working as an assistant professor in Trident Academy of Technology, Bhubaneswar, Odisha. He was born on 6th May 1983. He has completed his B.E (Computer Science and Engineering) from BPUT in 2005 and M.E. (Computer Science and Engineering) in 2008 from Utkal University. His areas of interest include data mining and artificial intelligence.

Sateesh Kumar Pradhan is working as professor in Utkal University, Bhubaneswar, Odisha. He earned his Ph.D. from Berhampur university. He has teaching experience over 25 years in several programmes like B.E., MCA, MSc, ME, M.Tech in different universities and institutes. Dr. Sateesh has worked as a senior lecturer in King Khalid University from 2006 to 2011. He has published more than 50 research papers and delivered many talks on different areas of computer science. His research interests include neural Computing, Language Processing, Computer Architecture & Parallel Computing, Cloud Computing, Wireless Sensor Network, Mobile Computing and Data Mining.