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Forecasting Stock Market's Performance Based on Grasshopper Optimized Hybrid Neural Network Method

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Abstract: Forecasting stock index prices is a key indicator that helps investors and financial analysts make better decisions that maximize profits while minimizing risks. In order to succeed, a robust engine with the capacity to distribute important information is necessary. In this study, a grasshopper-optimized integrated deep convolutional feedforward neural network (IDCFNN+GOA) is employed to increase stock market forecasting accuracy. Using performance indicator and a hypothesis test (paired t-test), the effect of the IDCFNN+GOA model on forecasting the subsequently day's closing price of several stock indices is examined. By combining data from the COVID-19 epidemic, the stock indexes are taken into account. The efficacy of the suggested strategy is evaluated in comparison to current stock market price prediction systems. The simulation results show that the IDCFNN+GOA model may be used to forecast the next day's finishing price.

Keywords: *Stock market, price prediction, paired t-test, grasshopper optimized integrated deep convolutional feedforward neural network (IDCFNN+GOA)*

1. Introduction

Power system decision-making and guaranteeing the grid's dependable and economical functioning depend heavily on accurate and effective electrical load forecasting. Grid managers and utilities can effectively foresee the demand for power in the future thanks to load forecasting. By anticipating the demand, they can make necessary adjustments to the generating and transmission resources, ensuring grid stability, avoiding blackouts, and maintaining a steady supply of electricity for the general public. Numerous methods, including statistical models, machine learning algorithms, and sophisticated data analytics, are used to provide accurate and effective load forecasts. These techniques provide forecasting models that can identify load trends and anticipate future power demand by using historical load data, meteorological data, economic indicators, and other pertinent aspects [1]. Hybrid models integrate many forecasting methods or models to take use of each one's specific advantages and make up for its shortcomings. The most important and relevant characteristics or variables that affect load fluctuations algorithms for factor and feature selection assist in removing pointless or redundant elements, lowering noise and enhancing load forecasting accuracy. The hybrid model can capture the most significant causes of load fluctuations and provide more precise forecasts by choosing the most important elements [2]. In microgrid energy management systems, short-term load forecasting is essential, especially when renewable resources with intermittent characteristics are included. Energy Savings Microgrid energy management systems may improve energy dispatch and scheduling with precise load predictions. They may optimize the use of renewable energy and reduce dependency on non-renewable sources by predicting demand changes and adjusting the dispatch of renewable resources, storage systems, and conventional generators to guarantee dependable and cost-effective operation. In particular when incorporating intermittent renewable resources. It offers efficient resource allocation, grid stability, energy optimization, and demand response, enabling dependable and sustainable operation inside microgrids [3]. Advancements in wind turbine design, such as bigger rotor diameters, higher towers, and more efficient blade forms, are required to increase wind energy efficiency. Utilizing heat from the Earth's interior produces geothermal energy. Technologies like enhanced geothermal systems (EGS), which include drilling deeper into the Earth's crust and applying cutting-edge reservoir engineering methods to reach higher temperature

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resources, are being developed in order to increase efficiency. These developments have the potential to greatly improve system efficiency and energy extraction, efficient energy storage enables greater exploitation of variable renewable energy sources [4]. By offering shares of their firm to the public on the stock market, businesses may generate funds. When a business chooses to go public, it performs an initial public offering (IPO) and sells investors shares of the firm. In addition, corporations may reap a number of advantages from being publicly listed. Additionally, it improves their future access to financing and gives the firm a valuation depending on how the market views its value. This raises its profile and credibility in the industry. Investors who buy stock in these publicly traded businesses become shareholders and have the ability to benefit from the growth in stock value or from dividend payments, which are regular payments made by the business to its shareholders from its earnings [5]. It may be a difficult and time-consuming procedure to upgrade or build new infrastructure because of regulatory restrictions, environmental issues, and financial constraints. Existing electricity infrastructure is deteriorating and needs to be upgraded in many areas. This is a problem since upgrading the infrastructure to make it more effective and robust calls for substantial expenditures and careful planning. The burden on the power system may be reduced by promoting energy saving practices and putting demand response programs into place. In order to lessen systemic stress, these programs manage and reward users to alter their habits of power consumption at times of high demand [6]. The use of enhanced meters, commonly referred to as smart meters, is frequently associated with smart grid technologies. These meters allow for two-way communication between utility companies and customers, giving real-time data on energy use. Smart meters provide for correct invoicing, support programs for demand response, and give customers knowledge on how to efficiently manage their energy use.Smart grids are essential for managing the infrastructure for charging cars and streamlining the charging process as electric vehicles (EVs) gain popularity. They make smart charging possible, allowing EVs to be charged during off-peak hours or dependent on grid circumstances, minimizing the load on the grid and optimizing the use of renewable energy sources [7]. Unconstrained optimization models seek the best answer for a given objective function without placing any restrictions on the decision variables. By modifying the choice variables within their permitted ranges, the objective function in these models is maximized or minimized. Methods for unrestricted optimization Constrained optimization models aim to meet a set of restrictions on the decision variables and find the best solution for a given objective function. The application of constrained optimization methods is necessary to identify the best solutions that fulfill the provided restrictions while maximizing the objective function in many real-world optimization problems since they often combine both constraints and goals [8]. Mid-short-term load forecasting is the process of estimate the quantity of energy needed or the amount of energy that will be used in the next months or weeks. Mid-short-term load forecasting has a tendency to be more precise than long-term load forecasting, which spans years or decades [9]. The accessibility of more current and precise data is advantageous for mid-short-term load forecasting. A greater level of granularity allows for the consideration of historical load data, weather conditions, seasonal trends, and other pertinent aspects, allowing for more accurate projections [10]. The grasshopper optimized hybrid neural network technique is a particular strategy for predicting stock market performance that combines the grasshopper optimization algorithm (GOA) with a neural network.

2. Related Work

The study [11] evaluate the stock market is a difficult task for investor and economic market experts because to the extremely agitated, nonparametric, unstable, difficult, non-linear, active, and disordered personality of accumulation worth time series. The learning method used to train the weight and bias vectors has a big impact on how well ANNs work. The daily TEDPIX as contribution parameter, we have generated 18 technical indicators. As a consequence, the experimental finding demonstrates that grey wolf optimization outperforms MLP training for stock market prediction using metaheuristics. The article [12] examined mining operations and associated businesses, it is crucial to create a precise forecasting sculpt for the instability of level ore prices before making any investments or decisions. Offers a unique model that can be used to predict monthly iron ore price volatility with accuracy. The cluttered GOA, which is worn as a guide to learn the multilayer perceptron neural network, is created using this model by integrated chaotic behavior into a contemporary meta-heuristic approach called GOA. The article [13] replica for mid-term to short-term load forecasting that may be used to predict loads on various days and at various times during the month. Planning for power production and electricity purchases was explored using the mutual MT-STLF model. The anticipated load was clearly impacted by the temperature according to the suggested model. In addition, there were different most and lowest weights in the wintry weather and summer. To ascertain the relationships between the independent factors that impact the load, such as hotness, and the dependent variable (the load), a regressive model was proposed. The credentials regressive model emphasizes the impact of temperature on hourly load. The research [14] describes a reliable carbon pricing market mechanism must include accurate carbon price forecasts. The precise forecasting of carbon pricing is a current area of study. To properly estimate the carbon price series, a hybrid forecasting system that combines error correction technique and divide-conquer approach has been developed. The fundamental structure of this essay is made up of four components specifically. The divide and conquer technique is offered, with each offering advantages over the other benchmark methods taken into consideration. Furthermore, it was shown that the suggested forecasting system offers a novel, workable, and viable alternative for projecting carbon prices. The study [15] determines extraordinary performance of deep neural networks (DNNs) makes them a popular choice for predicting applications. The choice of appropriate hyper-parameter impacts the sensation or malfunction of these models, and the architectural configuration of the DNNs significantly affects their performance. 2 evolutionary operator, opposition-based learning and disorder hypothesis, are added to the optimized progression in a unique evolutionary algorithm that is based on the GOA. Suggested evolutionary algorithm's hyper-parameters have been tuned in an auto-regressive recurrent neural network.

3. Methodology

It is essential to have a powerful engine that has the ability to disseminate crucial information in order to be successful. In order to improve the accuracy of forecasts on the stock market, this research makes use of an IDCFNN+GOA. The impact of the IDCFNN+GOA model on predicting the upcoming day's closing price of numerous stock indices is investigated with the use of a performance indicator and a hypothesis test known as a paired t-test.

3.1. Integrated Deep Convolutional Feedforward Neural Networks (IDCFNN)

An IDCFNN can also be applied to stock market analysis and prediction tasks. Representation of Data The input data in the stock market domain often comprises of several characteristics or indications pertaining to a certain stock or the broader market. Among these characteristics are trading volumes, technical indicators (such as moving averages and the relative strength index), news sentiment ratings, and macroeconomic variables. These characteristics may be seen as a time series, where each data point denotes a discrete period of time. The network's convolutional layers may be used to extract pertinent characteristics from the input data. These layers, for instance, may spot particular patterns in the volume data or local trends in the stock price. The model can automatically learn pertinent temporal connections and gather crucial information at various time scales with the aid of the convolutional layers. The feature maps may be down sampled using convolutional layers and pooling layers, which reduce the spatial dimensions while preserving the most crucial data. ReLU (Rectified Linear Unit) and other non-linear institution functions are often employed to bring non-linearity into the network, enabling it to learn intricate correlations between the input data and the goal output. Training deep models that can recognize intricate patterns and correlations in stock market data is made possible by the IDCFNN architecture. With the aim of minimizing a selected loss function, training such a network often entails an iterative process in which the network learns from past data. The weights and biases of the network are often trained using methods like back propagation and gradient descent. The network may also be used to discover anomalies, or out-of-the-ordinary patterns or occurrences, in stock market data. The network may also provide insights based on learnt representations and patterns in the data to aid in decision-making processes such as portfolio optimization, risk assessment, and decision-making. The IDCFNN offers a potent method for analyzing and forecasting stock market behavior by utilizing the integration of convolutional and feedforward neural network components, taking into account both local and global patterns in the data and capturing complex relationships between various features.

3.2. The Grasshopper Optimization Algorithm (GOA)

The GOA may also be used to solve optimization issues in the stock market. The algorithm's goal in this situation is to identify ideal or almost ideal options for decision-making and stock market research. The optimal mix of stocks or portfolio allocations to maximize a set of criteria, such as return, risk-adjusted return, or portfolio diversity, is what is meant by the term "optimization problem" in the context of the stock market. The allocation percentages of various stocks or assets in the portfolio may be included in the decision variables. Various portfolio allocations are represented by the algorithm's "grasshoppers," which stand in for various solutions. The allocation percentages of the stocks in the portfolio are encoded in a position vector that is linked to each grasshopper. The GOA uses both local and international search techniques. By changing the stock allocation percentages, grasshoppers move across the area around their present placements during the local search phase. This local exploration aids in using potentially fruitful search space locations. The grasshoppers communicate throughout the global search phase, sharing knowledge and concepts to investigate various portfolio allocations over the whole search space. This international investigation tries to identify fresh and maybe superior portfolio allocations. Attraction, repulsion, and randomization variables all have an impact on the grasshoppers' motions. These elements replicate the actions seen in a swarm of grasshoppers in their natural environment. Grasshoppers are drawn to positions with greater fitness values because they correlate to better portfolio allocations. Repulsion stimulates exploration of other areas of the search space and prevents congestion of solutions. In order to enable the algorithm to seek new and uncharted territory in the search space, randomization provides unpredictability. A termination condition must be satisfied for the algorithm to stop iterating. Achieving a sufficient portfolio performance, exceeding a predetermined threshold for fitness improvement, or reaching a set maximum number of iterations may all be considered as this requirement. Investors and analysts may effectively explore the universe of prospective portfolio allocations by using the Grasshopper Optimization Algorithm to stock market optimization issues. The method aids in the identification of ideal or nearly ideal stock pairings for a portfolio's goals of maximizing returns, risk-adjusted returns, or portfolio diversification. This may help with decision-making and can be used to create portfolios that are in line with certain investing objectives and risk preferences.

3.3. Research data

Seven stock indices, including the Euronext-100 (N 100), Hang Seng Index (HSI), Russell 2000 (RUT), Dow Jones Industrial Average (DJI), Nifty 50 (NSEI), DAX performance index (GDAXI), and Nasdaq Composite (IXIC) have historical time series prices that are used in this study for SM forecasting. For the purpose of predicting the final price of the subsequently day, the everyday highest, lowest, and open prices of these indices are used as inputs into the IDCFNN-GOA equation (1).

$$T = \frac{v - v_{min}}{v_{max} - v_{min}} \quad (1)$$

Data from training and testing are weighed seven to three, respectively. De-normalizing the ELM output as outlined in equation (2) yields the real finishing price.

$$V = T * (v_{max} - v_{min}) + v_{min} \quad (2)$$

WhereT,v_max, and v_min represent the normalized data, respectively, as well as their highest and lowest values.

3.4. Low Resolution performance measures

A performance metric is a calculation that expresses quantitatively how well projected data matches actual data. The terms "mean squared error" (MSE), "mean absolute error" (MAE), and "mean absolute percent error" (MAPE) are worn to denote error measured from the origin and accuracy in proportion, respectively. Less is preferable when it comes to MSE, MAE, and MAPE values. Performance measurements MSE, MAE, and MAPE are, respectively, stated in Equations (3) through (6).

$$MSE = \frac{1}{M_{test}} \sum_{j=1}^{M_{test}} \left(t_j - \hat{t_j}\right)^2 \quad (3)$$

$$MAE = \frac{1}{M_{test}} \sum_{j=1}^{M_{test}} \left(t_j - \hat{t_j}\right) \quad (4)$$

$$MAPE = \frac{1}{M_{test}} \sum_{j=1}^{M_{test}} \left| \frac{t_j - \hat{t_j}}{\hat{t_j}} \right| \times 100 \quad (5)$$

Where M_test is the number of testable data points. The closing prices are t_j and (t_j)̂ (predicted), correspondingly. In this study, MSE is employed as a practical value to be reduced by enhancing the assumptions and weights.

3.5. Hypothesis testing (paired t-test)

To speculatively evaluate the precision of forecasted final cost, paired t-test is performed. The 2 sample of explanation needed for the paired t-test are the projected price ((t_j)̂) and the actual price (t_j), both having n samples. The t-test is used to determine whether the legal (H0) and unconventional (H1) hypothesis are accepted.

$$dif = t_j - \hat{t_j} \quad (6)$$

$$\overline{dif} = \frac{\sum dif}{m} \quad (7)$$

$$TC = \sqrt{\frac{\sum (dif - \overline{dif})^2}{m-1}} \quad (8)$$

$$s - value = \sqrt{m_{TC}^{dif}} \quad (9)$$

Wheredif,$\overline{dif}$, and TC are the distinction, mean of difference, and sample standard deviation, respectively. By allowing a significant threshold of 5% (0.05), the null hypothesis is accepted or rejected.

4. Result and Discussion

4.1 Mean Squared Error (MSE)

MSE is a frequently used indicator in the forecasting and prediction of the stock market. It calculates the average squared difference between an index and stock price's expected and real values. Enhanced prediction accuracy is shown by lower MSE values. The standard of the square discrepancies between the predictable and actual values is used to decide mean square error. It is often used to assess how well financial models or stock market forecasting techniques function. A lower MSE suggests more accuracy since the forecasts or estimations are closer to the real values.

Table 1. Numerical outcomes of MSE

	MSE (%)
ANN [17]	42

CNN [16]	39
DNN [18]	46
IDCFNN+GOA [Proposed]	31

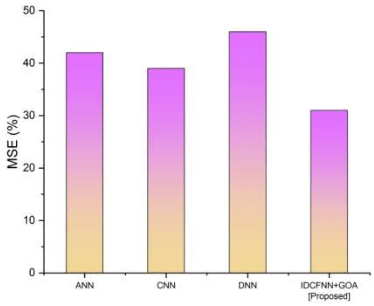

Fig. 1. Comparison of MSE

Figure 1 and Table 1 displays the associated MSE values. The proposed method's IDCFNN+GOA value is 31%, which is less error-prone than existing techniques like CNN, which has a 39% error rate, ANN, which has a 42% accuracy rate, and DNN, which has a 46% error margin. Forecasting stock markets is made possible by the suggested IDCFNN+GOA, which is also more successful than other methods.

4.2 Mean Absolute Error (MAE)

The average amount of mistakes and the discrepancies between expected and observed values are measured statistically using the MAE metric for a collection of data. Regression models and forecasting techniques are often assessed using this technique. A lower MAE suggests higher accuracy since the forecasts or estimations are more likely to match the measured data. Given that it gives a measurement of average absolute deviation from the real values, it is a simple and uncomplicated statistic.

Table 2. Numerical outcomes of MAE

	MAE (%)
ANN [17]	41
CNN [16]	35
DNN [18]	33
IDCFNN+GOA [Proposed]	29

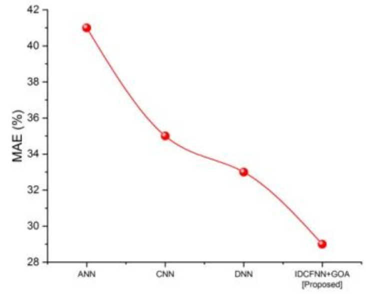

Fig.2. Comparison of MAE

The accompanying MAE values are shown in Figure 2 and Table 2. The IDCFNN+GOA value of the suggested approach is 29%, which is less error-prone than the IDCFNN+GOA values of CNN (35% error rate), ANN (41% accuracy rate), and DNN (33% error margin). The recommended IDCFNN+GOA, which is also more effective than previous approaches, enable stock market forecasting.

4.3 Mean Absolute Percentage Error (MAPE)

MAPE is a statistical metric used to evaluate the precision of a forecast and prediction model. It calculates the typical percentage difference between values that were anticipated and those that were actually obtained. The standard percentage of the deviation connecting the forecasts and the concrete data is provided by MAPE. The accuracy of models is often evaluated in forecasting and demand planning.

Table 3. Numerical outcomes of MAPE

	MAPE (%)
ANN [17]	39
CNN [16]	36
DNN [18]	33
IDCFNN+GOA [Proposed]	27

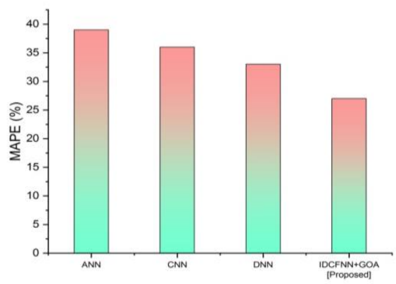

Fig.3. Comparison of MAPE

The corresponding MAPE values are shown in Figure 3 and Table 3. The IDCFNN+GOA value of the suggested approach is 27%, which is less error-prone than the current methods CNN, ANN, and DNN, which have error rates of 36%, 39%, and 33% respectively. The recommended IDCFNN+GOA, which is also more effective than previous approaches, allows for the prediction of stock market movements.

4.4 The paired t-test result

To compare the means of several samples associated, statisticians employ the paired t-test. By comparing the means of paired observations within the same group, it establishes if there is a significant difference. To accept the paired t-test, a significance threshold of 5% (0.05) is applied. It is evident from Table 4 that for all 4 markets, > 0.05. When compared to IDC FNN+GOA with ANN, CNN, and DNN models, the suggested algorithm's contribution to the absolute value of the t-value is lower.

Table 4. Numerical outcomes of Paired t-test

Prediction model	*Markets*	*P-value*	*t-value*
IDC FNN+GOA	N100	0.9985	0.0155
ANN		0.9971	0.0168
CNN		0.9939	0.0205
DNN		0.9837	0.0211
IDC FNN+GOA	IXIC	0.9637	-0.0591
ANN		0.9545	-0.0592
CNN		0.9555	-0.0588
DNN		0.9655	-0.0590
IDC FNN+GOA	HIS	0.9968	0.0168
ANN		0.9961	0.179
CNN		0.9945	0.0199
DNN		0.9949	0.0200
IDC FNN+GOA	DJI	0.9765	-0.0299
ANN		0.9765	-0.0301
CNN		0.9855	-0.0309
DNN		0.9958	-0.0311

5. Conclusion and Future Work

An IDCFNN-GOA may perform better when deep convolutional layers are added, which might help with tasks like pattern recognition, computer vision, and image analysis. The input data's spatial patterns and properties may be successfully captured by the convolutional layers, producing predictions or classifications that are more accurate. Depending on the particular application and situation, this integration may enhance performance, decrease the number of parameters, promote transfer learning, and provide some interpretability. The integrated network has the ability to automatically learn feature representations in hierarchical order from the input data. While higher-level, more abstract convolutional layers capture low-level characteristics like edges and textures, lower-level features are extracted from lower-level layers via convolutional algorithms. The network is able to comprehend the fundamental structure and properties of the data thanks to its feature extraction capacity. Although the grasshopper optimized hybrid neural network technique shows potential, it is important to proceed with care and see it as a supplementary tool rather than a surefire predictor when making stock market predictions. Unexpected occurrences have the power to derail even the most precise forecasts, thus past performance may not necessarily be a reliable predictor of future outcomes.

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