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"HYBRID MODEL FOR STOCK PRICE PREDICTION: COMBINING MACHINE LEARNING AND FINANCIAL INDICATORS"

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Abstract:

Investors have always wanted to spot potential opportunities or risks in the stock market ahead of time. This skill became even more important during the Covid-19 pandemic, as the market became very unpredictable, and good risk management was essential for staying afloat. While there are many traditional strategies for analyzing the market, investors now need a smart system that can accurately predict stock prices to guide their investment decisions. Currently, a lot of research focuses on predicting stock price trends, mostly using deep learning methods. Although these studies have produced good results, few papers summarize the deep learning techniques used in stock prediction.

This paper aims to fill that gap by summarizing the machine learning methods used for stock prediction, reviewing the field's progress, and analyzing recent trends. It categorizes papers by their deep learning methods, including Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), Recurrent Neural Networks (RNN), and hybrid deep learning models. Additionally, this paper identifies key datasets, variables, models, and results from each study, using popular performance metrics like Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE), and Mean Square Error (MSE) to evaluate outcomes.

Keywords: Stock Price Prediction, Hybrid Model, Machine Learning Financial Indicators

1. Introduction:

Stock prices often reflect the state of the global economy—showing whether it's doing well or facing a downturn. Traditional stock traders sometimes doubt the reliability of modern machine learning methods for predicting stock prices, arguing that the market's complexity makes accurate predictions impossible. However, research has shown that these machine learning models can be practical. In fact, some researchers have developed hybrid models to predict stock trends, like the patterns in candlestick charts, to help investors make timely buying or selling decisions. Since machine learning has worked well in other areas of time-series forecasting, it seems promising for stock market analysis, too.

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Previous studies have widely used techniques like Support Vector Machines (SVM) and neural networks to predict stock trends. A key factor in making accurate predictions is choosing the right features, and much past research has focused on historical stock data. To get a fuller picture, researchers have also been gathering information from sources like social media, news, and company announcements, feeding this data into machine learning systems.

Deep learning models, however, can go beyond traditional methods by using an end-to-end approach that doesn't require separate steps for feature selection. In recent years, deep learning has achieved impressive results in fields like computer vision and natural language processing, and it's now being used for a wide range of tasks, including stock prediction. Early machine learning methods required manually selected features, but deep learning can learn important features automatically, thanks to large datasets and powerful networks. This ability has drawn significant attention to deep learning, highlighting its potential as a powerful tool across many areas.

Although methods like Graph Neural Networks (GNN), Gated Recurrent Units (GRU), and Long Short-Term Memory (LSTM) networks have shown promising results in stock forecasting, a thorough review summarizing the latest research is still missing. This article aims to fill that gap by first providing background on stock price prediction, including the main tasks and types of data used. We'll then review recent deep learning models, explain how they work, and look at the main issues they address. Finally, we'll outline some ongoing challenges based on past studies. This review serves as a helpful guide for newcomers to the field.

2. Methods of Stock Price Prediction:

Predicting stock prices can be broadly divided into traditional and computational approaches.

2.1 Fundamental Analysis:

Fundamental analysis is a method of evaluating a company's stock by examining its overall health and value based on its business and financial fundamentals. It involves studying financial statements like income statements, balance sheets, and cash flow reports to assess the company's profitability, assets, debts, and cash management. Beyond the company itself, analysts consider the performance of the industry it operates in and broader economic factors such as interest rates, inflation, and market trends. The ultimate goal is to calculate the intrinsic value of the stock, which reflects what the stock should be worth based on the company's potential, rather than its current market price. For example, if a company has growing sales, innovative products, but also rising debt, an analyst would weigh these factors to determine whether the stock is undervalued (a good investment) or overvalued (a risky choice). In essence, fundamental analysis provides a logical, evidence-based approach to stock valuation, helping investors make informed decisions.

2.2 Technical Analysis:

Technical analysis is a method used to predict stock prices by studying past market data, mainly the stock's price and trading volume. The idea is that patterns and trends

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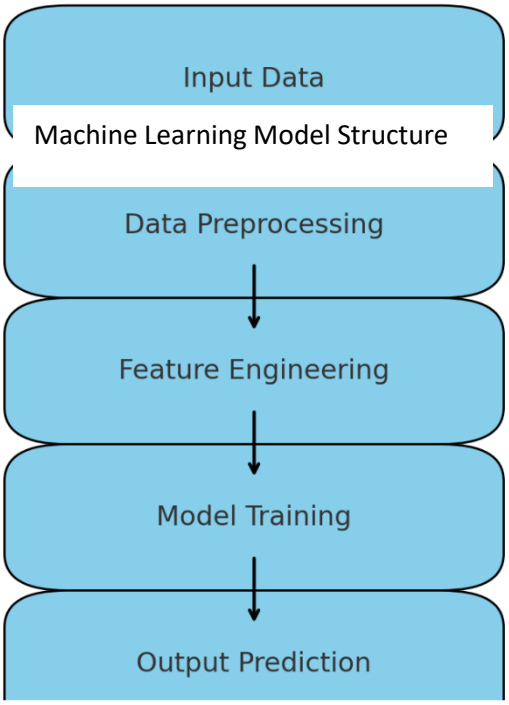
in this historical data often repeat themselves because they reflect human behavior in the market. For example, if a stock's price consistently increases after reaching a specific low point, analysts might expect a similar reaction in the future. Tools like moving averages help smooth out price fluctua tions to show trends more clearly. Indicators like the Relative Strength Index (RSI) measure whether a stock is overbought or oversold, signaling potential price reversals. While technical analysis is popular for its simplicity and quick insights, it assumes the past will predict the future, which isn't always true, especially during unexpected market events or news.

2.3 Machine Learning (ML) Approaches:

Machine learning (ML) is a branch of artificial intelligence that enables computers to learn patterns from data and make predictions without being explicitly programmed. In stock price prediction, ML models are trained on historical stock data, such as past prices, trading volumes, and other financial indicators, to identify trends and patterns. For example, a linear regression model might look for a relationship between a stock's price and its moving average, while more advanced models like support vector machines (SVM) or decision trees can uncover complex, non-linear relationships. ML models are valuable because they can process large datasets and identify insights that might not be apparent to human analysts. However, they have limitations—ML models can overfit the data, meaning they perform well on the training data but poorly on new, unseen data. Additionally, these models require clean, high-quality data and careful tuning to achieve accurate predictions. Despite these challenges, ML has become a popular tool for investors looking to make data-driven decisions.



2.4 Deep Learning Models:

Deep learning models are a type of artificial intelligence (AI) designed to learn patterns from data, especially when the data is complex and has many layers. In stock price prediction, two popular deep learning techniques are Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks. These models are particularly good at handling time-series data, like stock prices, because they can remember past information and use it to predict the future. For example, LSTMs are like a memory system that understands trends over time, such as how a stock's price might respond to changes in the market. While deep learning models can make accurate predictions when trained on large datasets, they require a lot of computational power and can be difficult to understand. This means while they can predict prices,

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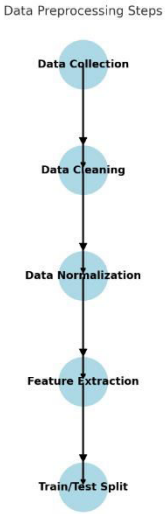
it's often unclear how they arrived at the prediction.

2.5 Hybrid Models:

Hybrid models blend different methods to improve stock price prediction accuracy by leveraging the strengths of each approach. For example, they may combine technical analysis, which focuses on patterns in past stock prices, with machine learning techniques, which can identify hidden trends in data. Similarly, fundamental analysis, which examines a company's financial health and market conditions, can be paired with deep learning models that process large datasets for more precise predictions. By merging these methods, hybrid models aim to provide a more comprehensive view of what influences stock prices. However, while they often outperform individual techniques, these models are more complex and require advanced expertise and resources to develop and implement effectively. Despite the challenges, hybrid models hold significant potential for making stock price prediction more accurate and reliable.

3. Data Sources and Preprocessing:

For stock price prediction, the quality of data is extremely important. Models use various types of data, including past stock prices, economic reports, company financial statements, news articles, and even social media trends. However, raw data often contains problems like missing information, irrelevant details, or inconsistencies that can confuse prediction models. Preprocessing is the step where we clean and prepare this data for analysis. It involves organizing the data into a useful format, filling in missing values, removing unnecessary details, and normalizing numbers so they're easier for the model to interpret. Good preprocessing helps ensure the model learns from the right patterns, making predictions more accurate and reliable.



4. Challenges in Stock Price Prediction:

Predicting stock prices is tough because many unpredictable and complex factors influence them. Let's break down the main challenges:

1. Market Volatility

Stock prices can change rapidly due to unexpected events like political changes, economic crises, or even a single company's news (e.g., a CEO resigning). These events are hard to predict in advance.

Models struggle to handle such sudden and extreme price movements because they rely on patterns that may not apply during chaotic times.

2. Data Quality and Volume

Prediction models need accurate and complete data (like historical prices, news,

or economic indicators) to learn how the stock market behaves.

If the data has errors, missing information, or is too limited, the model will make poor predictions. For example, if a company's past stock data is incomplete, the model won't fully understand its behavior.

3. Overfitting

When a model learns from the training data too well, it picks up even the minor details and "noise" that don't actually matter.

This makes the model great at predicting the data it trained on but terrible at predicting real-world stock prices. It's like memorizing answers for one test but failing when the questions change.

4. Interpretability

Many advanced models (like neural networks) make predictions, but they don't explain why they make those predictions. These models are often called "black boxes."

Investors and analysts need to trust these models before using them. If a model can't explain how it predicts prices, people might hesitate to rely on it, especially when large amounts of money are involved.

5. Emerging Trends in Stock Price Prediction:

Stock price prediction is evolving as new technologies and methods are developed. Here are some exciting trends that are shaping this field:

1. Sentiment Analysis

Sentiment analysis uses computers to understand the emotions and opinions expressed in text, such as news articles, tweets, or financial blogs. For example:

Positive news about a company may mean its stock price will go up.

Negative news might predict a drop in the price.

Machine learning models analyze large amounts of text to determine whether the general sentiment is positive, negative, or neutral.

This approach helps investors understand the mood of the market and predict short-term price changes based on public opinion.

2. Explainable AI (XAI)

Many advanced models, like deep learning, are often called "black boxes" because they make predictions without explaining how they got the answer. Explainable AI is about building systems that not only predict stock prices but also provide clear reasons for their predictions.

Example: Imagine a model predicts a stock will go up. An explainable AI model might tell you:

It noticed strong quarterly earnings.

It observed positive news coverage.

It saw a rise in social media mentions.

Investors and analysts want to trust and understand the predictions before acting on them.

3. Quantum Computing

Quantum computing is a new kind of computing that processes information faster and solves problems that are too complex for regular computers.

Stock markets generate enormous amounts of data that are hard to analyze. Quantum computers can process this data quickly, finding patterns and making predictions much faster than traditional methods.

While still in its early stages, quantum computing has the potential to revolutionize how stock predictions are made, especially for large and complex markets.

These trends aim to make stock prediction more accurate, transparent, and responsive to the fast-paced nature of financial markets. As technology improves, combining these innovations will likely change how we approach investing and trading.

6. Future Directions:

This section talks about what can be done in the future to make stock price prediction better. Here are the key ideas explained in simple words:

1. Data Integration

Stock prices don't just depend on one thing—they're influenced by many factors like company performance, news, global events, and even social media. In the future, we can combine all these different types of data into one system. For example:

Use financial numbers (like profits or debts) from company reports.

Check news and social media to see what people think about the company.

Add global economic data, like inflation or interest rates.

By putting all this together, prediction systems can get a more complete picture, making them more accurate.

2. Model Explainability

Some modern prediction methods, like deep learning, work like a "black box." This means they give results, but we don't really understand how they got those results. For example:

A machine might predict that a stock price will go up, but it won't explain why it thinks so.

In the future, we need models that are not only accurate but can also explain their predictions in simple terms. For instance:

If a system predicts a price increase, it should also say, "This is because the company announced a new product, and people are reacting positively."

This will help people trust these models more and use them confidently.

3. Ethical Considerations

As technology becomes better at predicting stock prices, it could also be misused. For example:

Someone might use a highly accurate model to manipulate markets or spread false information.

In the future, it's important to set rules and guidelines to make sure these technologies are used in fair and ethical ways. This will prevent misuse and protect regular investors.

Why These Directions Are Important

These steps will make stock price prediction:

More Reliable: By using better data and models.

More Trustworthy: Because people will understand how predictions are made.

Fair: By ensuring everyone plays by the rules.

By focusing on these areas, stock prediction can become more useful and safer for everyone.

7. Conclusion:

In the conclusion, the paper emphasizes that predicting stock prices is a difficult but valuable task, which has a big impact on investors and the financial markets. It acknowledges that traditional methods, like fundamental and technical analysis, have been around for a long time and provide useful insights. However, the real focus is on the advancements made in machine learning (ML) and deep learning, which are newer technologies that offer greater potential for making more accurate predictions.

These modern techniques, especially deep learning models like recurrent neural networks (RNNs) and long short-term memory (LSTM) networks, have been successful in recognizing complex patterns in stock prices over time. Still, they come with their own challenges, such as requiring large amounts of data and being difficult to understand, which can limit their use in practical applications.

Looking forward, the paper suggests a few key areas for improvement:

Hybrid Models: Combining different prediction methods (like technical analysis and machine learning) could improve prediction accuracy by using the strengths of each.

Explainable AI: One of the main challenges with deep learning is that the models are like "black boxes"—you get a prediction but don't always know why the model made that decision. Developing models that are easier to interpret and explain would help make them more trustworthy and usable.

Ethical Use: With the power of AI to predict and influence stock prices, it's important to use these models ethically and ensure they're not being used to manipulate the market unfairly.

In short, while predicting stock prices is challenging, the progress in new technologies, particularly AI and machine learning, shows promise for improving accuracy. Future research should focus on improving how these models work, making them easier to understand, and ensuring that they're used responsibly.

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