How Does Artificial Intelligence Synergize to Make Investment Decisions? A Critical Analysis

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ABSTRACK
Artificial Intelligence (AI) has brought about major changes in various fields, including investment decisions. In the context of investment decisions, AI can synergize to provide various advantages, but it also has some challenges that need to be faced. AI can greatly benefit investment decision-making with efficient data analysis, the use of sophisticated algorithms, better risk management, and unemotional decision-making. However, challenges such as data limitations, human interpretation, security and privacy, and the risk of making wrong decisions remain factors that need attention. In the synergy between artificial intelligence and humans, intelligent and informed investment decision-making can result.

Keywords: *Artificial Intelligence, Investment, Big Data, and Machine Learning*

1.1. Introduction

In the last few decades, investment interest in the capital market has grown quite significantly [1]. Therefore, it is not surprising that the total traded every day on the capital market is of great value [2]. Investors as the main actors who act in the market have expectations of achieving high returns on their investment instruments.

In recent years, the capital market has become an attractive place for investors and market participants to carry out stock trading activities. Along with the increasing number of investors participating in stock trading, the higher the need for accurate and effective stock price predictions.

The complexity and volume of data generated is one of the main problems in stock price forecasting for making decisions [4]. While the capital market is a very active market, with millions of shares being traded every day. Hundreds or even thousands of information relevant to investment decision-making also continues to change in real-time, including economic, political and company information [5] Managing and analyzing this large volume of data is a significant challenge in trying to reflect trends and patterns that can be used to make accurate predictions.

Accurate and timely stock price predictions are the main goal of investors in making smart investment decisions to optimize their profits. However, various complex and dynamic factors such as the economic situation, policy changes, publication of company financial reports, and news related to certain industries or companies affect the volatility of stock price movements. Therefore, adaptation is required through traditional to digital transformation in order to be able to analyze complex information [6].

Facing these challenges, the role of information technology is crucial in helping investors and market players to analyze data and make accurate predictions about stock price movements. In recent years, at least two technologies have experienced rapid development, namely *Big Data* and Artificial Intelligence (AI) [7].

Big Data refers to a very large and diverse collection of data, both structured and unstructured, which can be analyzed to obtain valuable information [8]. Big Data has a crucial role in facilitating stock price forecasting. In this context, Big Data is used to collect, manage and analyze data related to stock prices to support a more accurate prediction process. Comprehensive data collection is made possible by using Big Data. Utilization of Big Data which is able to collect unlimited data from

various sources, including historical stock data, financial reports, and non-financial data such as news and market sentiment [9]

Disruption in the financial sector is getting bigger along with the development of AI and Big Data. AI includes a range of techniques that allow computers to mimic human intelligence, such as pattern recognition, decision making and automated learning. In the context of stock price forecasting, AI can be used to analyze historical data, identify patterns and trends, and make accurate predictions. AI allows machines to learn from experience and improve their performance automatically, thereby enabling better predictions in stock trading [10]

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In forecasting stock prices, the integration between Big Data and AI has shown tremendous potential. By using Big Data which is abundant from various sources, such as stock historical data, financial news, company financial reports, and non-financial data such as social media and market sentiment, researchers and financial practitioners can take advantage of AI techniques such as Machine Learning (ML) to identify complex patterns and produce more accurate predictions [11]

Machine Learning is a branch of AI that enables computers to learn from data and improve their performance over time. By using ML techniques, such as neural network algorithms, decision trees, and random forests, researchers and financial practitioners can develop models that can predict stock price movements with a higher degree of accuracy when compared to traditional methods [12]

Many studies have concluded that there is great potential and benefits from the integration of Big Data, AI and ML in stock price forecasting, however there are still a number of challenges that need to be overcome. [13] states in his study, there are challenges in the problems of processing and analyzing large data, data quality and reliability, complexity in developing and validating ML models, and protecting data privacy. Similarly, [14] states that there are limitations in predicting stock prices using the integration of Big Data, AI and ML technology. External factors such as market volatility, policy changes, and unexpected events can affect stock price movements that are difficult to fully predict [15]

Therefore, more in-depth research and mature technical exploration is needed to overcome this challenge and apply this integration effectively in investment decision making. This article attempts to build a conceptual framework through investigation and exploration to integrate Big Data Engineering, AI, and ML to produce more accurate and effective predictions. This study was conducted using a comprehensive analysis of various techniques and methods used in forecasting stock prices, and looking at how the use of Big Data, AI, and ML techniques can improve model performance. This analysis also aims to provide an overview of the challenges and problems faced in implementing the integration of Big Data, AI and ML Techniques as a decision-making tool. This study also provides recommendations for developing more effective models in the future.

1.2 The Contribution Of Ai In Investment Decision Making

Artificial intelligence (AI) facilitates investment decision making by helping to collect, analyze, and interpret data efficiently. Here are some of the ways in which AI can contribute to investment decision making:

First, complex data analysis: AI can analyze and process financial market data, company financial reports, news, and other relevant factors in a short period of time. With fast processing capabilities and the capacity to pay attention to many variables, AI can identify patterns, trends, and relationships that humans might miss [16].

Second, predictions and Projections: Based on historical data and market trends, AI can provide projections and predictions about future investment performance. Using machine learning algorithms, AI can learn market patterns and behavior, and produce more accurate predictions in making investment decisions [6].

Third, investment Opportunity Discovery: AI can help identify potential investment opportunities. Using pattern recognition algorithms and extensive data, AI can analyze specific markets, industries, and companies to find stocks or assets that might provide future profits [17] .

Fourth, risk Management: AI can help manage risk in investments by predicting possible declines in asset values, market volatility, or changes in economic conditions. This allows investors to take precautions or organize their portfolios to reduce risk and protect their capital.

Fifth, automated Trading: AI can be used in automated trading systems, where AI algorithms can automatically execute trading transactions based on set market conditions [18]. These systems can respond quickly to market changes and take trading decisions without human involvement.

While AI can provide valuable information and insights in investment decision making, it is important to remember that final decisions should still be carefully considered by knowledgeable investors. AI can be a valuable tool, but humans still have an important role to play in evaluating non-quantitative factors and using discretion in investment decision making.

For example, using an Agent Based Model (ABM) to simulate trading patterns. ABM is one approach used to predict trading patterns in an economic context. The model uses computer simulations to describe the interactions and behavior of individual agents who are representations of market participants, such as investors, traders, or other economic entities.

In the agent-based model, each agent has unique attributes and behaviors, and they can interact with each other according to defined rules.

This model considers information available at the micro level (individuals or small groups) and analyzes how those interactions and individual decisions affect overall market patterns. In the context of trading, agent-based models can be used to predict price patterns, trading volume, investor behavior, or other market dynamics [19]. The model takes into account factors such as investor preferences, trading strategies, available information, interactions between agents, and other external factors that can affect the market.

However, it's important to remember that agent-based models have their own limitations and complexity. This model-based prediction is very sensitive to the parameters used, assumptions made, and representations adopted in the model [20]. The results obtained from this model are also highly dependent on the input data used and the precision of modeling agent behavior.

Therefore, the use of agent-based models to predict trading patterns should be done with caution and pay attention to the assumptions used. Careful validation and testing of models with historical data or simulated experiments is essential to evaluate the performance and reliability of those models before they are used in real decision making.

1.3.1 Big data contribution to the Stock Price Estimation process

Big Data is a term that describes the huge and complex volume, speed, and diversity of data generated by various sources such as business transactions, sensors, mobile devices, social media, and so on[21]. When it comes to decision making and stock price forecasting, Big Data has an important role in providing a more in-depth and accurate picture for market participants.

Theoretically, on stock price movements, variables such as technical indicators, financial variables, and macroeconomic variables are considered to be the most influential variables ([22]. In making investment decisions, this variable is crucial. Through the utilization of Big Data, these variables can be collected quickly and accurately [23].

Therefore, through Big Data, a broader and more comprehensive process of collecting and analyzing data can be carried out to make decisions. Historical data on stock prices, company financial reports, market news, social media sentiment, and several other factors that affect stock prices can be collected and integrated into a system that can process large volumes of data [24]. As a result of this process, investors and analysts obtain data that describes comprehensively and completely the factors that influence stock price movements.

Big data is able to collect and analyze data on a large scale thereby increasing investor accuracy and analysis in estimating stock prices and making decisions. They get a deeper picture of the stock market, identify trends and make more accurate predictions. It can be said that Big Data has great potential to improve the accuracy of decision-making and investment forecasting in complex capital markets.

1.3.2 Artificial Intelligence in the Stock Price Estimation process

The progress of learning modelling the function of the human brain or Artificial Intelligence has shifted the focus of computing, learning from the development of computational abilities. The theoretical framework of an artificial neural network is based on the simulation of the biological central nervous system. Through tight integration, networks containing a large number of computing components (neurons) work together to solve complex problems in real-time. [25] emphasized that one of the main functions of a neural network is to handle and process incomplete, missing, or noisy data.

Meanwhile, [26] confirms that in stock price forecasting, Artificial Intelligence (AI) and *Fuzzy* Logic techniques have a close relationship. AI utilizes the concepts and techniques of Fuzzy Logic to increase the accuracy and effectiveness of forecasting stock prices. Fuzzy Logic is a means to model human reasoning to manage and process unpredictable and dynamic data. Studies show that various functional problems that cannot be handled effectively by traditional models can be handled effectively by fuzzy logic [27].

Fuzzy Logic Process stimulates stock price forecasting on the Stock Exchange to be more effective and predictive. Uncertainty and ambiguity in data which are common characteristics in financial market predictions can be handled accurately by Fuzzy logic. Meanwhile, uncertainty in the movement of stock prices in the future can be predicted through the membership concept of fuzzy logic. In contrast to the traditional approach of having binary logic that only has the values 0 and 1, fuzzy logic introduces the concept of partial membership, where variables can have membership levels between 0 and 1. For example, terms such as "high", "medium", or "low" to describe the price level of the stock. [28] nemphasized that through Fuzzy logic, these variables can be operated and analyzed better, producing more accurate predictions and having high predictive value.

In some cases, the data available for stock price forecasting may be incomplete or uncontrollable.

Fuzzy logic fills in data gaps and makes predictions using implication-based rules. For example, if trading volume data is not available, Fuzzy Logic can use a rule such as "If stock prices are rising and volatility is high, then trading volume is likely to be high" to generate a reasonable estimate of trading volume [29].

Developing a risk control model in stock trading is also one of the benefits of using Fuzzy logic. Systems based on Fuzzy Logic can generate trading recommendations that help investors manage risk more effectively with predictive analysis. Considering factors such as market volatility, expected profit, and acceptable risk level, fuzzy logic extracts data to produce risk value output [30].

While stock prices and the factors that influence them often have complex and nonlinear relationships, Fuzzy Logic can model this relationship by combining Fuzzy rules that reflect the interactions between relevant variables. Through these nonlinear interactions, Fuzzy logic can provide more accurate predictions than the traditional linear approach [31].

Stock prices are affected by a variety of complex factors and are often difficult to predict with absolute accuracy. Big Data and AI synergize with the Fuzzy logic approach enabling the handling of uncertainty and ambiguity in stock price forecasting. This synergy contributes to reflecting the level of certainty or uncertainty in predictions, and can incorporate the subjective knowledge of financiers via Fuzzy rules. This helps produce more realistic and reliable predictions.

1.3.3 Machine Learning Techniques in Describing Patterns and Trends

Extracting data to become a source of knowledge is the philosophy behind machine learning. Data extraction to predict market movements through several machine learning techniques has been constructed and implemented concretely. Some examples are Artificial Neural Networks (ANN), Support Vector Machine (SVM), and Random Forest (RF) which are the most frequently applied techniques because they have shown promising results in predictions [32].

The machine learning approach, using models such as Artificial Neural Networks (ANN), Support Vector Machine (SVM), and Random Forest (RF), has become a popular method for predicting the stock market. These models have their respective advantages in dealing with the complexity and nonlinearity of stock market data.

Artificial Neural Network (ANN) is a machine learning model inspired by how the human brain works. ANN can recognize complex patterns in stock market data and capture nonlinear relationships between various factors that affect stock prices. Investors and analysts can predict stock price predictions based on patterns that have been studied through models generated from training ANNs using historical data [33]

Furthermore, Support Vector Machine (SVM) can deal effectively with classification and regression problems through machine learning algorithms. Data classes in multidimensional space are separated by hyperplanes built by SV. In the context of stock market predictions, SVM reconstructs a model that contains a number of relevant features or variables to predict whether stock prices will increase or decrease [34]

Moreover, the Random Forest (RF) is an ensemble model that combines several decision trees to make predictions. Dependence and complex interactions between variables in stock market data can be managed effectively and accurately by RF. Working by activating a group of independent decision trees, RF can produce careful, precise and stable estimates (Misra, 2020).

The level of effectiveness of stock price prediction methods such as Artificial Neural Networks (ANN), Support Vector Machine (SVM), and Random Forest (RF) varies depending on the characteristics of the data and the context used. However, it certainly exceeds the accuracy of the traditional approach. ANN has the advantage in responding to complex and non-linear data patterns. In addition, it has a flexible ability to model complex relationships between input and output. However, optimal ANN training requires time and computation which is quite intensive, as well as a tendency to overfitting if not properly controlled.

Meanwhile, SVM has advantages in processing data that has high dimensions and non-linear dependencies. In addition, SVM has a good tolerance for overfitting. But on the other hand, SVM is less effective at handling data that has a lot of noise or overlap.

Furthermore, RF excels in solving overfitting problems, is reliable in managing important variables and produces estimates of predictive reliability. On the other hand, in other aspects, RF is less effective in handling data with complex and non-linear relationships.

Big Data Integration Model and Machine Learning Technologies

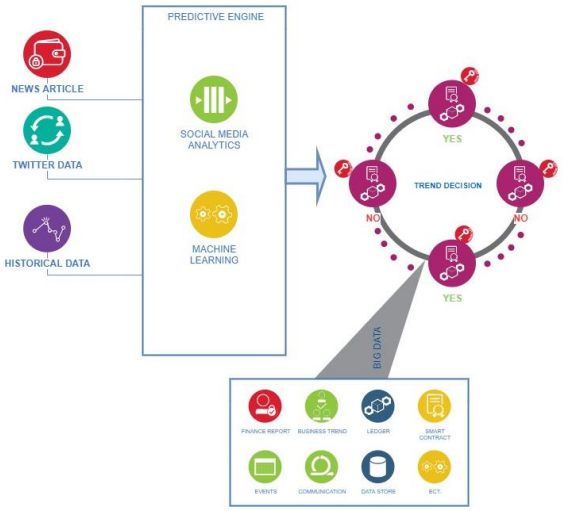

Figure 1. Hadoop Big Data Platform

Figure 1 exhibits how Machine Learning Techniques build predictive models in analyzing patterns and trends to make investment decisions. Information processed comes from various sources such as electronic media, websites, articles, raw data which will be processed from Historical Data and others. Thus, there are plenty of them, unstructured and generated every second. Therefore, it requires the existence of technology to process and analyze this data in real-time so as to produce market sentiment output, investment prospects, and risk in a faster and more complex manner.

As an example, historical data refers to the company's historical fundamental data. Machine Learning will analyze the company's fundamental historical trends and patterns, so that investors can identify patterns of growth, changes in strategy, or performance that have an impact on future stock price movements.

1.3.4 Integration and Transformation in Big Data, AI, and Machine Learning Technologies

Integrated and transformative ways of working between Big Data, Artificial Intelligence (AI), and Machine Learning Techniques provide enormous support in improving the analysis and forecasting of stock prices. In the context of stock prices, Big Data can provide broad access to market data, including historical data, company financial information, and the latest market news. AI and Machine Learning Techniques are then used to analyze and extract patterns from the data.

Furthermore, it is possible to develop complex and sophisticated predictive models by leveraging the integration and transformation of AI and Machine Learning Techniques. The predictive model also involves analyzing various factors that affect stock prices by utilizing Machine Learning algorithms such as Artificial Neural Networks (ANN), Support Vector Machine (SVM), and Random Forest (RF). In this context, hidden patterns and complex relationships between variables such as economic conditions, company performance, and global market factors are identified and analyzed by AI and Machine Learning Techniques [32]

Meanwhile, Big Data plays an important role in this integration and transformation process by providing large, diverse and complex data volumes [35]. For example, historical data, market data, and company fundamental data as materials that are trained by Machine Learning models in order to produce more accurate and efficient predictions. In addition, Big Data also allows the use of advanced statistical and data analysis techniques to identify market trends, volatility, and other risk factors that can affect stock prices.

In practice, the transformative integration between Big Data, AI, and Machine Learning Techniques also makes it possible to use natural language processing (NLP) techniques to analyze news, financial reports, and market sentiment that can affect stock prices. The way it works includes measuring market sentiment automatically, keywords are identified and information can be extracted. Through this process, more accurate and robust estimates can be generated that will assist investors and traders in making investment decisions.

The transformative integration between Big Data, Artificial Intelligence, and Machine Learning Techniques in the process of stock price analysis and forecasting has great potential to improve market understanding, identify investment opportunities, and manage risk. A more comprehensive view and deeper analytical materials and more accurate predictions are the contributions of the integration and transformation of advanced AI and Machine Learning techniques.

1.3.5 Traditional methods VS Integration & Transformation

Big Data, Artificial Intelligence (AI), and Machine Learning Techniques have several advantages in performing stock price forecasting analysis compared to traditional methods. The weakness of traditional methods besides the limited capacity to calculate and measure is also limited in accessing historical data. In contrast, a systemic and

integrated way of working on Big Data, Artificial Intelligence (AI), and Machine Learning Techniques provides very significant benefits. Starting with a large and diverse volume of data, Big Data can access unlimited amounts of it. Furthermore, AI and Machine Learning Techniques analyze all sources of information in Big Data in the form of the latest market data, company financial information, latest news, and other relevant factors in a fast and up-to-date manner. This allows for more accurate stock price predictions and is responsive to market dynamics

Complex patterns and relationships in stock price data can be easily identified by the integration of AI and Machine Learning Techniques.[34] confirmed that this integration pattern is able to mix all hidden patterns, perform multivariate analysis, and overcome the limitations of traditional, more linear methods. Various factors that influence the movement of stock prices in the capital market are analyzed comprehensively and in detail so as to produce in-depth insights for investors and analysts.

Machine Learning Techniques enable the development of predictive models that are adaptive and able to learn from new data [6]. These models can be continuously updated and improved over time, so that they are able to capture changing market trends and changes in the factors that influence stock prices. In this case, this integration exhibits greater flexibility and robustness compared to traditional methods which may require updating manually.

1.3.6 Integration and transformation challenges in Big Data, Artificial Intelligence, and Machine Learning Techniques

An important factor in estimating stock prices is data quality. So even though Big Data provides access to large volumes of data, data quality must still be considered. Problems such as inaccurate, incomplete, or noisy data are disturbing enough to result in inaccurate predictions. Therefore, it is important before using it in predictive models, it must carry out careful data processing, filter out irrelevant data, and accurate data validation

Meanwhile, integration and transformation between Big Data, AI and Machine Learning Techniques require complex and complicated data processing. The right technology and infrastructure must be built before carrying out the integration and transformation. It is a big challenge for organizations to prepare effective resources with relevant expertise. Deep and proficient technical skills in the use of highly adaptive technology [13]. In-depth technical skills and adequate resources are required to tackle the tasks.

One of the risks of using Machine Learning Techniques is overfitting, which is when the model is too complex and fits the training data well, but is unable to generalize well to new data. This causes excessive complexity in the model so that the predictive output is unstable or inaccurate. Therefore, the model must be selected and adjusted according to the objectives appropriately and evaluate the model to mitigate this risk.

In addition to unstable and inaccurate outputs, model complexity and predictive results that are difficult to interpret are further obstacles to the integration and transformation processes. AI models and Machine Learning Techniques often work in a "black box" where the mechanism behind the predicted output is not always clear making it difficult to understand the factors that influence the predicted outcome. Therefore, developing good interpretation methods and the ability to explain predictive results clearly so that they can be used effectively is another important aspect that must be considered.

Although Big Data and AI can help improve the accuracy of forecasting stock prices, financial markets are still complex and full of uncertainties. External factors such as policy changes, global economic conditions, or political events can affect stock prices in ways that are difficult to predict. This transformative integration cannot completely eliminate investment risks and market uncertainties.

CONCLUSION

Integration and transformation between Big Data, Artificial Intelligence (AI), and Machine Learning (ML) Techniques in forecasting stock prices in the capital market has had a significant impact in increasing the accuracy and effectiveness of forecasting. The use of Big Data allows access to large and diverse volumes of data, including the latest market data, company financial information, and breaking news. AI and ML Techniques approaches can identify complex patterns and relationships in stock price data, resulting in an in-depth picture of the factors that influence stock prices.

Through the utilization of *Fuzzy* Logic techniques in AI, this integration can handle uncertainty and ambiguity in stock price forecasting. The level of certainty or uncertainty in predictions can be described, and the subjective knowledge of financial experts can be integrated through Fuzzy rules. This results in more realistic and reliable predictions, helping investors and decision makers in the stock market.

Fuzzy theory can be used as an approach to model uncertainty and ambiguity in input and output variables, which can then be processed by ANN, SVM, or RF to study patterns and produce predictions or decisions. Combining and merging these approaches can result in stronger and more adaptive methods of data processing and decision making.

1.4.2 Suggestions

Following are some suggestions for further research that can be explored regarding the transformative integration of Big Data, Artificial Intelligence (AI), and Machine Learning (ML) techniques in forecasting stock prices:

1. Comparison and evaluation of various Machine Learning methods: Comparing and evaluating the performance of various Machine Learning methods, such as Artificial Neural Networks (ANN), Support Vector Machine (SVM), Random Forest (RF), and other methods to predict stock prices. Future research may involve selecting the most suitable model, establishing optimal parameters, and validating it using historical data sets.
2. Integration of market data and fundamental data: Testing the integration and merging of market data (such as historical stock price data, trading volume and technical indicators) with company fundamental data (such as financial statements and financial ratios) in stock price forecasting. Future research can explore how best to combine and effectively utilize the information from these two data sources.
3. Use of Deep Learning Techniques: Exploring the use of Deep Learning techniques, such as Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN), in stock price forecasting. Future research can study Deep Learning's ability to handle temporal data and understand long-term patterns in stock price data.
4. Use of innovative algorithms and techniques: Future research may focus on using new and innovative algorithms and techniques in the integration of Big Data, AI, and ML Techniques in stock price forecasting. An example is the use of Reinforcement Learning techniques, AutoML, or Generative Adversarial Networks (GAN).

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