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OptiVest: An Artificial Intelligence Based Portfolio Optimization and Intelligent Investment Decision Support System

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Abstract

Financial markets are known for their constant fluctuations and uncertainty, which makes the process of making investment decisions quite difficult. Investors often have to deal with unpredictable market movements, changing economic con- ditions, and various external factors that influence stock prices. Traditional portfolio management methods usually depend on historical averages and fixed statistical assumptions. Although these techniques have been widely used for many years, they do not always reflect the real-time behavior of modern financial markets. Because of these limitations, investors may experience problems such as inadequate diversification, higher exposure to volatility, and decisions influenced by emotions rather than data. In this research, we introduce OptiVest, an Artificial Intelligence (AI) based portfolio optimization and investment decision support system. The proposed system combines deep learning techniques, particularly Long Short-Term Memory (LSTM) net- works, with the principles of Modern Portfolio Theory (MPT) to generate more effective asset allocation strategies. OptiVest performs several important tasks including collecting financial data, preparing and preprocessing the data, predicting future trends, optimizing portfolio weights, and presenting the results through visual analytics. The experimental evaluation shows that the proposed system can achieve improved risk-adjusted returns when compared with traditional portfolio construction approaches. The overall objective of this framework is to provide investors, especially retail investors, with a more transparent, practical, and data-driven way to make informed investment decisions.

Index Terms—Artificial Intelligence, Portfolio Optimization, LSTM, Investment Analysis, Financial Forecasting

1. INTRODUCTION

Over the past decade, the financial investment environment has changed considerably with the rapid growth of computing technologies and the increasing availability of large financial datasets. Modern stock markets continuously produce large volumes of time-series data, which are influenced by several factors such as economic indicators, company performance, geopolitical developments, and investor sentiment.

Analyz- ing and interpreting this data manually can be both time- consuming and error-prone, making it difficult for investors to draw reliable conclusions.

Portfolio optimization is a key concept in investment man- agement and focuses on selecting an appropriate mix of assets that can generate higher returns while keeping risk under control. One of the most well-known frameworks for this purpose is Modern Portfolio Theory (MPT), introduced by Harry Markowitz. The theory highlights the importance of diversification and provides a mathematical approach for balancing risk and return. However, MPT is based on certain assumptions, such as linear relationships between assets, nor- mally distributed returns, and stable correlations. In practice, real financial markets often behave in more complex and unpredictable ways, which limits the effectiveness of these assumptions.

With the advancement of Artificial Intelligence, new tech- niques have emerged that can better capture complex patterns within financial data. Machine learning and deep learning models are capable of analyzing large datasets and identifying hidden relationships that may not be easily visible through traditional statistical methods. Among these approaches, Long Short-Term Memory (LSTM) networks have proven particu- larly effective for time-series forecasting because they are able to learn patterns from sequential data and retain important information over longer periods.

The OptiVest system is developed with the goal of combin- ing the strengths of traditional financial theories with modern AI-based predictive techniques. By integrating forecasting models with optimization algorithms, the system supports investors in making more informed and data-driven investment decisions.

2. MOTIVATION

Many retail investors do not have access to the advanced financial analysis tools that are typically available to large financial institutions. Because of this limitation, their invest- ment choices are often influenced by intuition, social media discussions, or short-term market trends rather than systematic analysis. Relying on such informal sources can increase the level of risk in investments and may lead to unstable portfolio performance over the long term.

Although several online investment platforms are available today, most of them either offer only basic statistical informa- tion or rely on proprietary algorithms whose internal workingis not clearly explained to users. As a result, investors often find it difficult to understand how portfolio recommendations are generated. This lack of transparency can create trust issues and may prevent investors from effectively managing the risks associated with their investments.

The development of OptiVest is motivated by the need for a more intelligent and transparent investment support system. The proposed system uses Artificial Intelligence techniques to assist in portfolio optimization while keeping the decision- making process understandable for users. By relying on data-driven analysis rather than emotional judgment, OptiVest aims to encourage better diversification, reduce behavioral bias, and support more stable long-term investment strategies.

3. OBJECTIVES

The objectives of the proposed OptiVest system are as follows:

- To analyze historical stock market data using AI tech- niques
- To predict future stock prices using LSTM neural net- works
- To construct optimized portfolios using Modern Portfolio Theory
- To maximize risk-adjusted returns using Sharpe Ratio optimization

- To provide visual and analytical insights for investors
- To automate the end-to-end investment decision-making process

4. Scope of Work

The scope of this research mainly focuses on equity invest- ments that are analyzed using historical stock price data. The proposed system is designed for long-only portfolios, meaning it considers investments where assets are purchased and held without engaging in short-selling. In addition, the current study does not include derivative instruments such as options or futures, nor does it address intraday trading strategies. Even though the present implementation is limited in scope, the overall design of OptiVest follows a modular architecture. This flexible structure makes it possible to expand the system in the future. For instance, future versions could support multi- asset portfolios that include other financial instruments such as exchange-traded funds, commodities, or cryptocurrencies. The system could also be enhanced to incorporate real-time market data and automated trading integration, allowing investors to make more responsive and dynamic investment decisions.

5. Literature Survey

A. Traditional Portfolio Optimization Approaches

Modern Portfolio Theory (MPT) introduced the efficient frontier concept, which represents portfolios offering maxi- mum returns for a given level of risk. While MPT is widely adopted, it fails to account for dynamic market conditions and real-time fluctuations.

Machine Learning Techniques in Finance

Machine learning algorithms such as linear regression, de- cision trees, support vector machines, and ensemble methods have been used extensively for financial prediction. These methods, however, struggle with nonlinearity and long-term dependencies.

B. Deep Learning and LSTM Networks

Deep learning models, particularly LSTM networks, are well-suited for financial time-series prediction due to their gated architecture. LSTMs effectively capture temporal depen- dencies and mitigate vanishing gradient problems.

C. Research Gap

From the literature review, the following research gaps are identified:

- Lack of integrated prediction and optimization frame- works
- Limited adaptability to changing market conditions
- Absence of user-centric visualization tools
- High complexity and low accessibility for retail investors

OptiVest addresses these gaps by providing an integrated and intelligent portfolio optimization system.

6. System Architecture

The OptiVest system follows a layered architecture consist- ing of data acquisition, data preprocessing, prediction, opti- mization, and visualization modules. Each module performs a dedicated function while ensuring seamless interaction across the system.

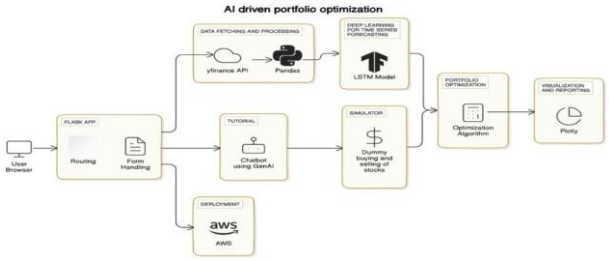

Fig. 1. Overall System Architecture of OptiVest

7. LSTM-Based Prediction Model

The LSTM neural network processes historical stock prices and learns temporal patterns to forecast future price move- ments. The architecture includes input gates, forget gates, and output gates, which regulate the flow of information and preserve long-term dependencies.

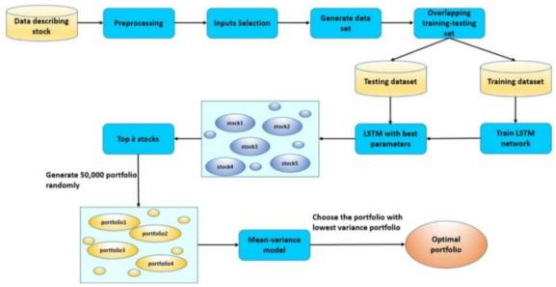

Fig. 2. LSTM Neural Network Architecture

8. Proposed Algorithm

Algorithm 1 OptiVest Portfolio Optimization Algorithm

1: Collect historical stock price data
2: Perform data cleaning and normalization 3: Train LSTM models for individual stocks 4: Predict expected future returns
5: Compute expected return vector
6: Calculate covariance matrix 7: Apply portfolio constraints 8: Optimize using Sharpe Ratio
9: Generate optimal asset weights
10: Display portfolio analytics

9. Mathematical Formulation of Portfolio Optimization

Portfolio optimization in OptiVest is formulated as a con- strained optimization problem where the objective is to max- imize expected returns while minimizing portfolio risk. Let a portfolio consist of n assets, each with an expected return r_i and weight w_i.

A. Expected Portfolio Return

The expected return of a portfolio is calculated as the weighted sum of individual asset returns and is given by:

$$R_p = \sum_{i=1}^{n} w_i r_i \quad (1)$$

where w_i represents the proportion of total capital invested in asset i and r_i denotes its expected return predicted by the LSTM model.

B. Portfolio Risk

Portfolio risk is measured using variance, which accounts for the covariance between asset returns. The portfolio vari- ance is expressed as:

Optimization Constraints

The optimization problem is solved under the following constraints:

$$\sum_{i=1}^{n} w_i = 1 \quad (3)$$

$$0 \leq w_i \leq 1 \quad \forall i \quad (4)$$

These constraints ensure that the portfolio is fully invested and does not involve short-selling.

C. Sharpe Ratio Maximization

To achieve optimal risk-adjusted returns, OptiVest maxi- mizes the Sharpe Ratio, defined as:

$$S = \frac{R_p - R_f}{\sigma_p} \quad (5)$$

where R_f is the risk-free rate. Maximizing the Sharpe Ratio enables selection of portfolios that provide the highest excess return per unit of risk.

I. Risk Analysis and Evaluation Metrics

Effective risk assessment is critical in portfolio manage- ment. OptiVest employs multiple evaluation metrics to assess portfolio performance from different perspectives.

A. Standard Deviation

Standard deviation is used as a primary measure of port- folio volatility. A lower standard deviation indicates reduced uncertainty in portfolio returns and improved stability.

B. Sharpe Ratio

The Sharpe Ratio measures excess return per unit of risk and is widely used for comparing portfolios with different risk profiles. OptiVest prioritizes Sharpe Ratio maximization to ensure superior risk-adjusted performance.

C. Maximum Drawdown

Maximum drawdown evaluates the largest peak-to-trough decline in portfolio value over a given period. Lower draw- down values indicate better downside risk protection.

D. Diversification Impact

Diversification effectiveness is analyzed by studying asset correlations. OptiVest dynamically adjusts asset weights to minimize correlated risk exposure.

$$\sigma^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \sigma_{ij} \quad (2)$$

Comparative Performance Evaluation

where σ_{ij} represents the covariance between assets i and j. This formulation ensures that diversification benefits are explicitly considered.

The optimized portfolio generated by OptiVest is bench- marked against traditional equal-weighted and market index- based portfolios. Experimental results show consistent im- provement in returns while maintaining controlled risk levels.

10. Results and Performance Evaluation

The proposed OptiVest system was evaluated using his- torical stock market data. Performance was compared with traditional equal-weighted portfolios.

TABLE I

Performance Comparison of Portfolios

Portfolio Type	Return (%)	Risk (%)	Sharpe Ratio
Traditional	11.8	9.4	1.25
Optimized (OptiVest)	14.2	9.1	1.56

Fig. 3. Efficient Frontier Comparison

The results demonstrate that OptiVest achieves higher re- turns while maintaining lower risk levels, validating the effec- tiveness of AI-driven optimization.

11. Conclusion

This paper introduced OptiVest, an Artificial Intelligence based system designed to assist investors in portfolio optimiza- tion and investment decision-making. The main objective of the proposed framework is to overcome some of the limitations associated with traditional investment strategies. By combining Long Short-Term Memory (LSTM) neural networks with the principles of Modern Portfolio Theory (MPT), the system brings together predictive analytics and mathematical opti- mization to support better portfolio construction.

The LSTM prediction model proved effective in identifying patterns and temporal relationships within financial time-series data. These predictions were then used to estimate expected returns, which served as key inputs for the portfolio optimiza- tion process. By optimizing the Sharpe Ratio while consid- ering realistic investment constraints, the OptiVest framework was able to generate portfolios that provided improved risk- adjusted returns when compared with conventional equal- weighted portfolio strategies.
The experimental results also indicated that the proposed approach contributes to reducing portfolio volatility through improved diversification. By incorporating covariance-based risk analysis, the system ensures that the relationships between different assets are taken into account when allocating portfo- lio

weights. As a result, the generated portfolios demonstrate more balanced and stable performance over time. In addition, the automated and modular structure of the system improves usability and transparency, making it useful for both beginner investors and those with prior market experience.

Overall, the OptiVest framework highlights how Artificial Intelligence can be effectively applied in the domain of financial portfolio management. By connecting theoretical financial models with practical data-driven techniques, the sys- tem provides a structured approach for supporting real-world investment decisions and contributes to ongoing research in intelligent financial systems.

12. Future Scope

Although the current implementation of OptiVest shows encouraging results, there are several opportunities to en- hance the system and extend its capabilities. One possible improvement is the integration of reinforcement learning tech- niques for dynamic portfolio rebalancing. With reinforcement learning, an intelligent agent can continuously adjust portfolio allocations by learning from market feedback and changing conditions. This approach would allow the system to respond more effectively to evolving financial environments.

Another valuable extension would be the incorporation of sentiment analysis based on financial news articles, earnings reports, and discussions on social media platforms. Market sentiment often plays a significant role in influencing stock prices. By combining sentiment information with traditional price-based indicators, the prediction model could better capture external factors that impact market behavior. Tech- niques from Natural Language Processing (NLP), including transformer-based architectures, could be applied to extract meaningful insights from textual financial data.

In future versions, OptiVest could also be expanded to sup- port multi-asset portfolio management. In addition to equities, the system may include other investment instruments such as commodities, exchange-traded funds (ETFs), cryptocurrencies, and fixed-income securities. Incorporating a broader range of assets would enable investors to achieve greater diversification and potentially improve overall risk management. Another direction for development involves integrating real- time market data and brokerage APIs. Such integration would allow the system not only to generate optimized portfolios but also to execute trades automatically in live market en- vironments. This capability could transform OptiVest from a decision-support tool into a fully automated investment platform.

From a deployment standpoint, the system could be imple- mented as a cloud-based or mobile application so that users can access portfolio insights and market updates from any- where. Interactive dashboards, improved visualization tools, and explainable AI features could further increase transparency and help users better understand how investment recommenda- tions are generated. With these future enhancements, OptiVest has the potential to evolve into a scalable and comprehensive intelligent investment advisory system.

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