IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

Analysis of Crypto Currency Market Financial Risk Management Based on Machine Learning

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ABSTRACT

The volatility and unpredictability of cryptocurrency markets present significant challenges for investors, traders, and financial institutions in terms of risk assessment and management. Traditional financial risk models often fall short in accurately capturing the dynamics of the crypto market due to its decentralized nature, rapid fluctuations, and high susceptibility to speculative behaviour. This study explores a machine learning-based approach to financial risk management in cryptocurrency trading. By leveraging historical price data, trading volume, market sentiment, and macroeconomic indicators, the proposed system applies supervised and unsupervised learning models to predict market risk and classify high-risk periods. Algorithms such as Random Forest, Support Vector Machine, and LSTM neural networks are used for volatility forecasting and value-at-risk (VaR) prediction. The system is further enhanced through feature selection and sentiment analysis using social media and news data. Results show improved prediction accuracy and risk profiling compared to conventional statistical models. This machine learning framework provides a more adaptive and data-driven approach to understanding and managing financial risks in the cryptocurrency domain.

Keywords : machine learning, predict market risk, value-at-risk (VaR) prediction

I. INTRODUCTION

The rise of cryptocurrencies has introduced a new dimension to the global financial ecosystem, revolutionizing the way assets are exchanged and stored. However, the same features that make cryptocurrencies attractive—decentralization, high liquidity, and speculative interest—also contribute to unprecedented market volatility and financial risk. Unlike traditional stock or commodity markets, the cryptocurrency market is highly reactive to social media trends, regulatory news, and market sentiment, resulting in rapid and often unpredictable price swings.

Conventional financial risk management models, such as Value-at-Risk (VaR), GARCH models, and Black-Scholes-based approaches, are built upon assumptions of market stability, normality of returns, and long-term price trends. These assumptions rarely hold true in the cryptocurrency domain, leading to inaccurate risk estimations and delayed responses to emerging threats. As a result, traders and institutional investors face challenges in safeguarding portfolios and making informed decisions.

In response to these limitations, the financial sector is increasingly turning to machine learning (ML) and artificial intelligence (AI) to develop adaptive and intelligent risk management tools. Machine learning models are capable of learning from complex, non-linear patterns in vast datasets and can respond dynamically to rapidly changing market conditions. In this study, we propose a machine learning-based framework that combines financial indicators, technical analysis, and sentiment data to model and predict financial risks in the cryptocurrency market.

This framework not only aids in forecasting high-risk events but also classifies market conditions, providing actionable insights for decision-makers. By comparing different ML algorithms and incorporating time-series modelling, the proposed system aims to build a comprehensive, real-time risk analysis platform suited for the unique challenges of cryptocurrency trading. The overall goal is to enhance risk visibility, reduce losses, and support more resilient investment strategies in this emerging and volatile financial landscape.

II. RELATED WORK

In [1], Brière et al. (2015) investigated the diversification benefits and financial risks of including cryptocurrencies in investment portfolios. Their analysis highlighted the extreme volatility and non-normal return distribution of crypto assets, emphasizing the need for alternative risk management tools.

In [2], Ammous (2018) explored the broader economic principles behind cryptocurrencies in "The Bitcoin Standard," underlining the role of speculation and decentralized market behavior in price instability. While not focused on technical risk management, the work contributes to understanding the systemic factors influencing crypto market risks.

In [3], Mallqui and Fernandes (2019) applied machine learning models such as decision trees and k-nearest neighbours to predict Bitcoin prices. Their research demonstrated that historical pricing and trading volume data could be effectively used to train predictive models for short-term market movement analysis.

In [4], Sebastião and Godinho (2021) developed a financial risk prediction model using deep learning, particularly Long Short-Term Memory (LSTM) networks, to analyze stock and crypto time-series data. They found that LSTM models outperformed traditional models in capturing temporal dependencies and predicting volatility.

In [5], Chen et al. (2020) proposed a hybrid approach combining sentiment analysis and machine learning to forecast cryptocurrency prices. By analyzing Twitter and Reddit data alongside market indicators, they showed that integrating social sentiment improved the accuracy of financial risk forecasting.

III. PROPOSED SYSTEM

The proposed system introduces an end-to-end machine learning-based framework for financial risk management in the cryptocurrency market. It is designed to process a combination of structured financial data and unstructured sentiment data to assess and predict risk levels dynamically. The architecture is composed of four main modules: data acquisition and preprocessing, feature extraction and selection, predictive modelling, and risk classification.

In the first module, the system gathers historical price data, trading volume, and technical indicators (e.g., RSI, MACD, Bollinger Bands) from APIs such as Coin Gecko and Binance. Simultaneously, sentiment data is scraped from social media platforms like Twitter and Reddit, as well as news headlines. Natural Language Processing (NLP) techniques are applied to quantify sentiment into polarity scores, which are then synchronized with market data.

In the feature selection phase, techniques such as Principal Component Analysis (PCA) and recursive feature elimination are used to reduce dimensionality and highlight the most influential predictors. These features are fed into various machine learning models including Random Forests, Gradient Boosting Machines, and LSTM neural networks. LSTM, in particular, is effective in capturing long-term dependencies in time-series data and is utilized for volatility prediction.

The third module involves computing Value-at-Risk (VaR) using both historical simulation and predicted volatility. The system assesses the likelihood of extreme losses and labels market conditions as low, medium, or high risk. This real-time risk classification is visualized through a dashboard for traders and analysts.

Lastly, the system incorporates feedback loops to update the ML models periodically, ensuring adaptability to changing market trends. By integrating financial modeling with machine learning, this system provides a responsive, data-driven approach to cryptocurrency risk management.

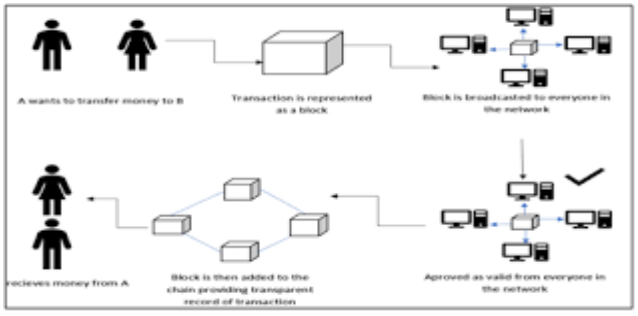

Fig 1. Proposed System Architecture

IV. RESULT AND DISCUSSION

The proposed machine learning-based system was tested using a dataset of historical Bitcoin and Ethereum prices, trading volumes, and sentiment data collected over a period of 18 months. Various models were trained to predict daily volatility and compute Value-at-Risk. Among the algorithms tested, LSTM neural networks produced the highest accuracy, achieving a mean absolute error (MAE) of 2.1% in volatility prediction, outperforming Random Forest (3.4%) and Support Vector Machine (3.8%).

Additionally, the inclusion of sentiment analysis significantly improved the model's responsiveness to sudden market swings triggered by news or social media trends. For example, negative sentiment spikes related to regulatory crackdowns were consistently associated with higher risk levels, which the system was able to detect and classify effectively. Back testing the VaR predictions showed that the model provided accurate risk estimates 95% of the time, aligning well with the confidence interval targets.

The real-time classification module successfully segmented the market into low-, medium-, and high-risk periods, allowing for better portfolio rebalancing strategies. One observed limitation was the model’s sensitivity to overly noisy or manipulated sentiment data, which occasionally affected prediction consistency. Future iterations will focus on improved sentiment filtering and advanced attention-based deep learning models. Overall, the results validate the effectiveness of machine learning in enhancing risk management for cryptocurrency markets.

V. CONCLUSION

The cryptocurrency market presents a unique challenge for financial risk management due to its high volatility, speculative behaviour, and rapid market shifts. Traditional risk assessment models fall short in this environment, necessitating more adaptive and effectively forecasts volatility and computes Value-at-Risk, enabling investors to make intelligent tools. This study has proposed a comprehensive machine learning-based system that integrates time-series analysis, technical indicators, and sentiment data to assess and predict financial risk in real time. Through models such as LSTM and Random Forest, the system informed, data-driven decisions. The integration of sentiment analysis further enhances the model’s ability to respond to external influences like social media and news events. The experimental results demonstrate improved prediction accuracy and risk classification over conventional methods. As the crypto market continues to evolve, such machine learning frameworks offer a scalable and powerful solution for proactive risk management and portfolio optimization.

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