Hybrid Deep Learning Framework for Unsupervised Anomaly Detection in DOGE/USD Cryptocurrency Price Movements

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Cryptocurrency markets play a significant role in global finance, impacting international trade. Due to its volatile and nonlinear behavior, anomaly detection has become a critical task for financial risk analysis. Beyond the traditional statistical approaches, this study explores unsupervised machine learning and deep learning techniques to identify abnormal movements in cryptocurrency price data. In this study, the main objective is to develop and evaluate a hybrid anomaly detection framework that combines Isolation Forest and Autoencoder models to detect abnormal price movements in Dogecoin US Dollars Price data. It further compares the effectiveness of individual models with the proposed hybrid approach using quantitative evaluation metrics. The proposed methodology utilizes historical DOGE/USD OHLC (Open, High, Low, Close) data, covering the period from 2017 to 2025, which are normalized using Min-Max scaling. An Isolation Forest model is trained to capture global statistical deviations, while an Autoencoder neural network is trained to capture structural anomalies. A hybrid framework is constructed by combining Isolation Forest and Autoencoder. Since labeled data is unavailable, evaluation is performed using unsupervised metrics. Isolation Forest identified 44 anomalies but showed weaker separation, while the Autoencoder detected 27 anomalies with stronger sensitivity to extreme price changes. The hybrid model detected 38 anomalies and achieved the highest separation score of 0.486, compared to Isolation Forest (-0.198) and Autoencoder (0.046). The results indicate that nonlinear pattern-based anomalies dominate the dataset, and the combination of both models provides a more reliable representation of market behavior. Overall, the proposed hybrid framework provides more reliable and consistent anomaly detection compared to standalone models by integrating statistical and deep learning approaches for cryptocurrency markets. This study contributes to the existing body of knowledge by demonstrating that the integration of Isolation Forest and Autoencoder improves the effectiveness of unsupervised anomaly detection for cryptocurrency price movements.

Keywords: anomaly detection, isolation forest, autoencoder, cryptocurrency, unsupervised learning