1. Introduction

Investors in the stock market can choose between long and short selling positions when deciding on their trading positions to maximize profits. The typical position is long when investors purchase a stock with the expectation that its price will increase. They can also speculate that the stock price will decline by taking a short selling position, which can be profitable [1]. Investors frequently use technical analysis to choose trading positions [2]. The candlestick pattern is one instrument used in technical analysis. In financial time series, Thomas N. Bulkowski identified 103 candlestick patterns that potentially forecast the course of price trends [3]. However, the absence of a thorough definition of a pattern might lead to classification discrepancies, necessitating market investors use of pattern recognition abilities when making judgments based on visual data [4]. According to related studies, Candlestick patterns can predict price changes or make money for participants in the capital markets. However, according to Fock et al., candlestick patterns have no predictive ability. Duvinge et.al also conducted tests to assess the predictive power of Candlestick patterns using 5-minute intervals with DJIA Index data and showed that candlestick patterns do not improve the profit performance of stock market participants [5].

The convolutional neural network (CNN) model is employed in deep learning for image identification because it is suitable for recognizing images that are challenging for the human eye to perceive, such as candlestick patterns. In [6], a Gramian Angular Field (GAF) technique encodes time series data with CNN to detect 10-minute candlestick patterns. The goal is to improve CNN outcomes in candlestick pattern detection. On real-world data, the GAF-CNN model's predictions for identifying candlestick patterns had an average accuracy of 90.7%. However, in earlier studies, GAF was used frequently to encode univariate data. As a result, research [7] aggregated numerous photos using the appending approach. CNN was able to extract and learn from the combined image characteristics to increase CNN classification accuracy. Long Short-Term Memory (LSTM), which can forecast the movement of time series price trends utilizing the open/close feature with an RMSE result of 0.01027, is used in research [8] for the prediction of stock data time series. To aid investors in making future price trend predictions, LSTM is used.

As a result, we compare trading positions obtained using the candlestick pattern alone and with an additional LSTM model to see if candlestick patterns can predict profitable trading. GAF is used to encode time series data as candlestick pattern images to mimic human eyes because identifying candlestick patterns requires expertise. The GAF model is used to detect candlestick patterns in the Nasdaq100 stock price data input, and it detects six out of 103 candlestick patterns. To identify the shape of the candlestick pattern, GAF extract four features from the formed pattern: close, upper-shadow, lower-shadow, and real-body (CULR). Candlestick patterns cannot be detected using a single feature because it does not accurately describe the candlestick in its natural state. This study made an innovative move by combining the four feature images into a single symmetrical image, allowing CNN to learn the patterns formed when the human eye sees candlestick patterns.

This research aims to design a recognition system for candlestick patterns from stock time series data using GAF-based images, which are processed by the CNN method to classify the patterns. The result is then used to predict the trading positions for a given future time. To improve the performance, we involve the LSTM future price prediction combined with the resulting reference from GAF-based CNN and compare it to CNN candlestick recognition alone. Candlestick patterns that are considered successful for predicting profitable trading positions are patterns that are already recognized by CNN and successfully predict the close price trend of 1,2 or 3 hours after the pattern is formed. If the candlestick pattern formed predicts an upward price trend, then the close price afterward is required to be higher than the previous close price, as well as the prediction of a downward price trend. The trading position that is compared for this research is based on the candlestick pattern that was already recognized with CNN and validated by the LSTM close price prediction for 1, 2, or 3 hours, which has a hold scenario after the candlestick pattern is detected to calculate the success of the model so that the position is considered profitable. If the candlestick pattern predicts a bullish price and within 1, 2, or 3 hours after it is predicted by LSTM to have a bullish close price trend, the trading position decision is to buy and hold for the selected period. Vice versa for candlestick patterns that predict a falling price and within a period of 1, 2, or 3 hours after it is predicted by LSTM to have a downward close price trend, the trading position decision is to sell and hold during the selected period. The trading position decision is compared with the real close price data whether the price trend is in accordance with the LSTM results as well as compared to the decision to take a trading position using candlestick patterns only.