Predicting High Volatility Cryptocurrency Prices using Deep Learning

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Abstract

Even if you want to make a profit from cryptocurrency, you are worried that you will lose money, and it is difficult to afford it. There are a vast number of papers that study such unpredictable price fluctuations of cryptocurrency. Currently, it is mainstream to use learning deep to predict the price of cryptocurrency. The goal of this research is to predict the price of cryptocurrency over the long-term using deep learning. The algorithms used are LSTM, GRU, and Bi-LSTM. The targeted cryptocurrencies are Bitcoin, Ethereum, Litecoin, and Cardano. Finally, we will compare it with previous research and verify the performance of our model.

Keywords: Price prediction, Cryptocurrency, LSTM, GRU, Bi-LSTM

1. Introduction

Cryptocurrency is still not very familiar to Japan and may feel like a distant entity, but it is actually something that will affect our lives in the near future. The main uses of Bitcoin are investment and speculative management. Cryptocurrency, which started out as a niche product used by small online groups, has now become mainstream, attracting the attention of both financial professionals and the general public. With a market capitalization reaching billions of dollars, this market has also become a new arena for speculators [1]. Cryptocurrency assets lack intrinsic value, regulatory oversight, lack of fixed-term investment funds, thin order books, short-term investment methods, and collective psychology, causing cryptocurrencies to be highly volatile [2]. Therefore, it is effective to perform technical trading on products with high volatility, and if you trade well, you can generate large profits [3]. Therefore, it is useful to predict the price movements of cryptocurrency using DNN (deep neural network). The goal of this research is to use DNNs such as LSTM, GRU, and Bi-LSTM to predict cryptocurrency such as BTC, ETH, LTC, and ADA with higher accuracy than previous research.

2. Method

2.1. *Cryptocurrency*

Cryptocurrency is a currency that is exchanged only as electronic data, does not have the power of compulsory currency imposed by the state like legal currency, and is primarily used for transactions over the Internet. Since the advent of Bitcoin, which began operations in 2009, derivative cryptocurrency called altcoins have been created one after another, and with the appearance of cryptocurrency exchanges that exchange legal currency and cryptocurrency, holding cryptocurrency has become easier. It spread rapidly [4]. There are various types of cryptocurrencies such as BTC, ETH, LTC, NEM, Ethereum Classic, LISK, etc., and the number is still increasing. The targets to be predicted in this research are

BTC (Bitcoin), ETH (Ethereum), LTC (Litecoin), and ADA (Cardano).

2.2. Algorithm

We will explain the three algorithms used in this research to predict cryptocurrency: LSTM, GRU, and Bi-LSTM. First, I will explain LSTM (Long Short-Term Memory). Although RNN (Recurrent Neural Network), which is a neural network that remembers past states, is suitable for analyzing time-series data, it has not been able to properly process long-term data [5]. LSTM overcomes this weakness and can maintain long context relationships. Data is controlled by three gates centered on the memory cells. The three gates are called forget gate, input gate, and output gate, and each uses a sigmoid function to determine whether or not to pass data. Fig. 1 shows the contents of LSTM.

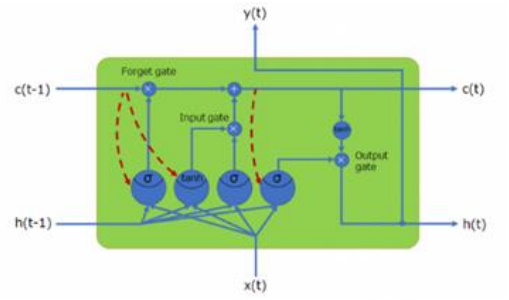

Fig.1. The structure of LSTM [6].

GRU (Gated Recurrent Unit) is said to have similar performance to LSTM, and requires less calculation than LSTM, allowing for faster learning. LSTM is a cell that makes it possible to learn long-term features, which was impossible with RNN, but it has the problem of high computational cost. High calculation costs are not desirable, not only in machine learning. The solution is to eliminate memory cells and reduce the number of gates to reduce computational costs. In LSTM, two states, the storage cell, and the output value, are passed on to the next cell, but GRU combines these states into one. In addition,

LSTM requires one gate controller for input gate, forget gate, and output gate, but in GRU, forget gate and input gate are operated by one controller. Fig. 2 shows the contents of the GRU.

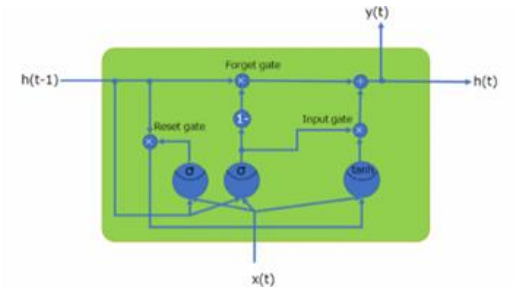

Fig.2. The structure of GRU [6].

The structure of Bi-LSTM (Bidirectional LSTM) ~~has a structure that has~~ with a forward LSTM and a reverse LSTM is shown in Fig. 3. LSTM only flows in the forward direction, but when Bi-LSTM predicts data, for example, given x_n a signal to be predicted, prediction is performed $x_{END} \sim x_{n+1}$ using the Forward Layer in $x_0 \sim x_{n-1}$ the forward direction and the Backward Layer in the reverse direction. It has the characteristic of doing. This allows it to handle more data than LSTM when the same amount of data is used for learning. However, since it handles a large amount of data, it takes longer to process than LSTM [7].

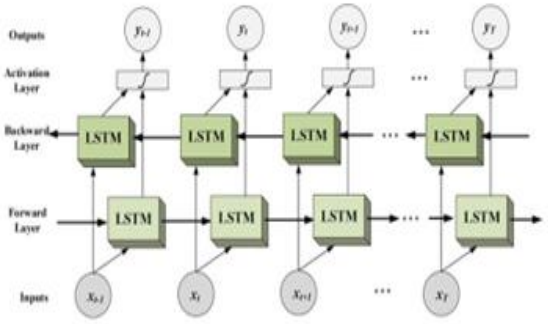

Fig.3. The structure of Bi-LSTM [8].

3. Experiment Content

The conditions for conducting the experiment are described below.

- Three algorithms were used in the experiment: LSTM, GRU, and Bi-LSTM.
- The four cryptocurrencies targeted for prediction are BTC, ETH, LTC, and ADA.
- There are two evaluation indicators: RMSE and M APE.

3.1. *Development environment*

The model was trained and executed using Google Colab, which allows experiments to be performed for free. The number of CPU cores is 2, the number of threads is 4, the RAM is 12.7GB, and the disk is 225.8GB. The deep learning models LSTM, GRU, and Bi-LSTM used in the experiment were implemented in Python version 3.10.12. We used python libraries such as Sklearn and Keras, which are used for deep learning, and numpy and pandas, which are used for numerical calculations and analysis.

3.2. *Data*

The dataset was collected from Yahoo Finance (https://finance.yahoo.com/). We collected the prices of four types of cryptocurrencies on a daily basis: Bitcoin (BTC), Ethereum (ETH), Litecoin (LTC), and Cardano (ADA). The training data consists of January 1, 2018 to June 8, 2022 (80% of the data), and the test data consists of June 9, 2022 to November 30, 2023 (20% of the data). ~~be done. Split the~~ The data proportion of 80:20 for training and testing is designed in this research. The

detailed information of data specifications is listed in Table 1.

Table 1. Data specifications.

Attribute	Explanation	Type
Date	Date of transaction	Date
Open	First traded price	Continuous
High	Highest traded price	Continuous
Low	Lowest traded price	Continuous
Close	Last traded price	Continuous
Adj Close	The closing price before the split is the adjusted price after the split.	Continuous
Volume	Quantity of trades completed during the period	Continuous

3.3. *Evaluation index*

Root-Mean-Square Error (RMSE) and Mean-Absolute-Percentage error (MAPE) are used to evaluate the algorithm in this study. The smaller the RMSE and MAPE values, the better the prediction model performance. In Eq. (1) and Eq. (2), n is the number of elements, y_i is the correct value, and $\hat{y}_i$ is the predicted value.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2} \quad (1)$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - \hat{y}_i}{y_i}\right| \quad (2)$$

4. Experimental result

Table 2 shows the results predicted according to the conditions in Chapter 3. Evaluation values are rounded down to the fifth decimal place. Bold letters in the evaluation value indicate the lowest value (the highest value in terms of accuracy). The results showed that the accuracy of Bi-LSTM was better than other algorithms for all cryptocurrencies.

Table 2. Performance results of this research model.

Currencies	Methods	RMSE	MAPE
BTC	LSTM	807.7135	0.0332
	GRU	873.7594	0.0362
	Bi-LSTM	**770.3047**	**0.0314**
ETH	LSTM	21.0737	0.0123
	GRU	33.0912	0.0192
	Bi-LSTM	**15.1817**	**0.0092**
LTC	LSTM	1.5991	0.0188
	GRU	1.7605	0.0207
	Bi-LSTM	**1.1928**	**0.0130**
ADA	LSTM	0.0203	0.0578
	GRU	0.0236	0.0695
	Bi-LSTM	**0.0172**	**0.0526**

5. Comparative verification

In the comparative verification, we compare the performance of the model for predicting the price of cryptocurrency in this study with other models in previous studies [9], [10]. Here, we will verify whether the model proposed in this study is effective. When making comparisons, we will verify that the period of experimentation is consistent with previous research. Table 3 is a comparison between this research model and the previous study [9] model, and Table 4 is a comparison between this study and the previous study [10]. The accuracy of Bi-LSTM in this study was good in all comparisons, indicating that the model in this study is effective.

Table 3 Comparison of this study and previous study [9] .

Currency	Studies	Methods	RMSE	MAPE
BTC	Our model	LSTM	1184.7059	0.0426
		GRU	1094.3126	0.0422
		Bi-LSTM	**647.2073**	**0.0221**
	[9]	LSTM	1447.648	0.03059
		ARIMA	1288.5	0.03479
		SARIMA	1802.31	0.04665

Table 4 Comparison of this study and previous study [10] .

Currency	Studies	Methods	RMSE	MAPE
BTC	Our model	LSTM	836.2219	0.0318
		GRU	901.6092	0.0312
		Bi-LSTM	**752.4224**	**0.0290**
	[10]	LSTM	1031.340	0.0397
		GRU	1274.171	0.057
		Bi-LSTM	1029.362	0.036
ETH	Our model	LSTM	59.4498	0.0339
		GRU	51.6724	0.0293
		Bi-LSTM	**45.7691**	**0.0253**
	[10]	LSTM	148.522	0.297
		GRU	98.314	0.148
		Bi-LSTM	83.953	0.124
LTC	Our model	LSTM	3.620	0.049
		GRU	5.453	0.078
		Bi-LSTM	**1.988**	**0.020**
	[10]	LSTM	9.668	0.064
		GRU	8.122	0.046
		Bi-LSTM	8.025	0.041

6. Conclusion

In this study, we used three algorithms, LSTM, GRU, and Bi-LSTM, to predict the prices of four cryptocurrency: BTC, ETH, LTC, and ADA. The model was evaluated using the evaluation indicators RMSE and MAPE. The research results showed that Bi-LSTM made the most accurate predictions for all cryptocurrency, followed by LSTM and GRU. Finally, we conducted a comparative verification with previous studies and showed that this study is more effective than previous studies. Future works could include applying reinforcement learning to previous studies [11] and predicting price fluctuations based on the number of tweets [12].

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