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# ***LONG SHORT-TERM MEMORY AND GATED RECURRENT UNIT FOR STOCK PRICE PREDICTION***

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Diajukan Sebagai Salah Satu Syarat  
untuk Memperoleh Gelar Sarjana Komputer pada  
Program Studi Sistem Informasi

Oleh:



**AKHAS RAHMADEYAN**

**11950314479**



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**FAKULTAS SAINS DAN TEKNOLOGI  
UNIVERSITAS ISLAM NEGERI SULTAN SYARIF KASIM RIAU  
PEKANBARU**

**2023**

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***LONG SHORT-TERM MEMORY AND GATED RECURRENT  
UNIT FOR STOCK PRICE PREDICTION***

**TUGAS AKHIR**

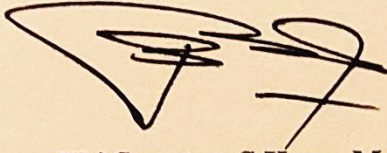
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## LEMBAR PENGESAHAN

### *LONG SHORT-TERM MEMORY AND GATED RECURRENT UNIT FOR STOCK PRICE PREDICTION*

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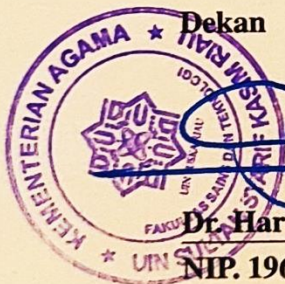
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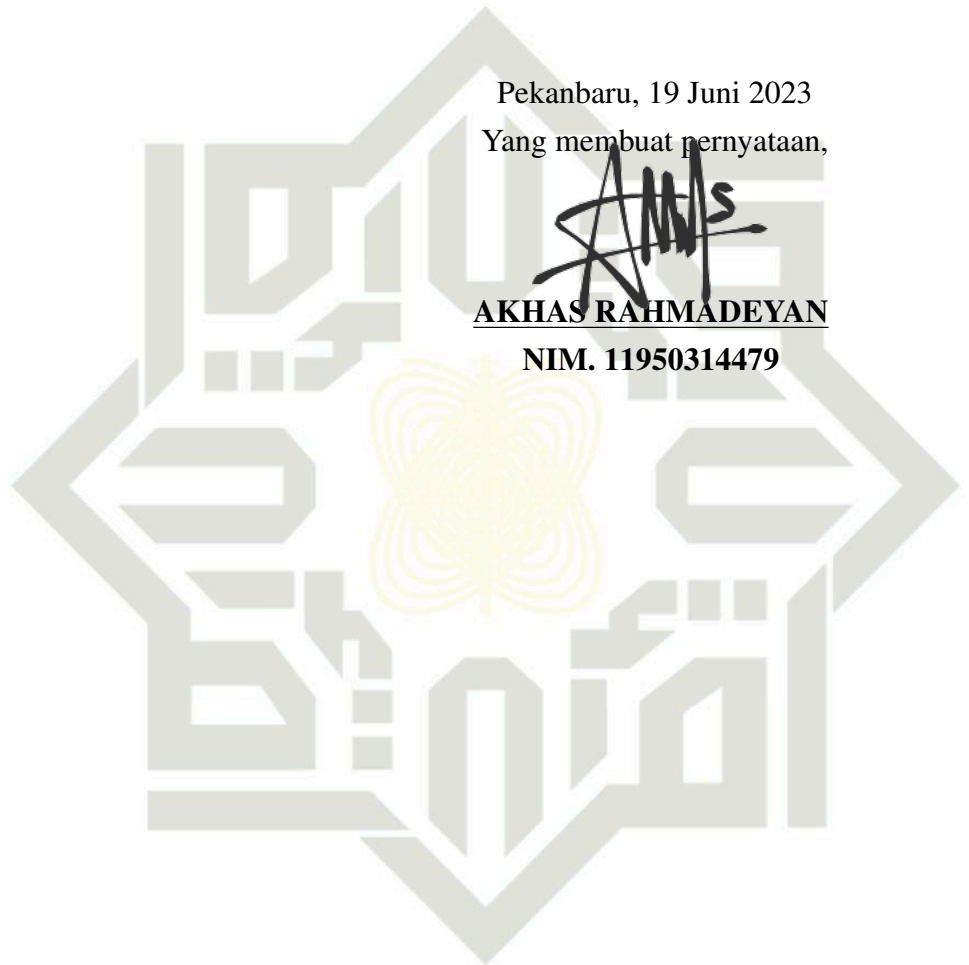
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## LEMBAR PERSEMBAHAN

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

*Dengan menyebut nama Allah yang maha pengasih lagi maha penyayang*

*Assalamu'alaikum Warahmatullahi Wabarakaatuh*

*Alhamdulillah Rabbil 'Alamin, segala puji bagi Allah Subhanahu Wa Ta'ala sebagai bentuk rasa syukur atas segala nikmat yang telah diberikan tanpa ada kekurangan sedikitpun. Shalawat beserta salam tak lupa pula kita ucapkan kepada Nabi Muhammad Shallallahu 'Alaihi Wa Sallam dengan mengucapkan Allahumma Sholli'ala Sayyidina Muhammad Wa'ala Ali Sayyidina Muhammad. Semoga kita semua selalu senantiasa mendapat syafa'at-Nya di dunia maupun di akhirat, aamiin ya rab-bal'alaamiin. Kupersembahkan karya kecil ini sebagai salah satu hadiah istimewa bentuk bakti, rasa terimakasih, dan hormatku kepada orang tuaku tercinta, Ayah dan Ibu.*

*Ayah dan Ibuku tersayang, terimakasih atas setiap perjuangan, doa, bimbingan, serta dukungan yang kalian berikan kepada saya. Terimakasih atas segala kebaikan dan selalu ada saat keadaan tersulit sekalipun. Terimakasih untuk segala pengorbanan yang kalian lakukan. Sampai kapanpun tiada rasa dan cara yang dapat membalas semuanya. Saya akan selalu mendoakan yang terbaik untuk Ayah dan Ibu agar bahagia dunia dan akhirat, serta diberikan tempat istimewa di sisi-Nya kelak sehingga kita bisa berkumpul kembali bersama-sama di Jannah-Nya.*

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*Wassalamu'alaikum Warahmatullahi Wabarakaatuh*



## KATA PENGANTAR

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banyak memberikan ilmunya kepada peneliti. Semoga ilmu yang diberikan dapat peneliti amalkan dan menjadi amal jariyah.

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Pekanbaru, 26 Juni 2023

Peneliti,

**AKHAS RAHMADEYAN**

**NIM. 11950314479**



# The Seventh Information Systems International Conference (ISICO) 2023

*Breakthrough Information System Innovations Toward Digital Resilience, and  
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Sanur-Bali, 26-28 Juli 2023

## LETTER OF ACCEPTANCE

No. 003/ISICO/VI/2023

Author(s) : Akhas Rahmadeyan; Mustakim  
Paper Title : Long Short-Term Memory and Gated Recurrent Unit for Stock Price Prediction

Dear Author(s),

We are pleased to inform you that your paper entitled above has been **accepted** to be presented in the 7<sup>th</sup> Information Systems International Conference (ISICO 2023) which organized by the Department of Information Systems, Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. The 7<sup>th</sup> Information Systems International Conference (ISICO 2023) will be conducted as a hybrid conference: online (virtual) and onsite (Prima Sanur Beach Bali Hotel, Sanur, Bali, Indonesia) from 26<sup>th</sup> to 28<sup>th</sup> July 2023. The accepted paper has strictly undergone the peer-reviewed process and will be submitted for uploading to the Procedia Computer Science, Elsevier and it will be normally indexed in SCOPUS database if you are attending and presenting your paper at the Seventh Information Systems International Conference (ISICO) 2023 on 26<sup>th</sup>-28<sup>th</sup> July 2023.

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Seventh Information Systems International Conference (ISICO 2023)

# Long Short-Term Memory and Gated Recurrent Unit for Stock Price Prediction

Akhas Rahmadayan\*, Mustakim

*Department of Information Systems, Universitas Islam Negeri Sultan Syarif Kasim Riau, Pekanbaru 28293, Indonesia*

## Abstract

Stocks are a popular investment with high risk due to rapid price fluctuations that are difficult to predict. Many investors do not understand the analysis of buying and selling stocks, making them hesitant to invest. For this reason, an analytical technique is needed that can determine the movement of stock prices in order to carry out planning, risk management, and decision-making. Banking stocks are among the important and popular stock sectors. One of the go public banking stocks is Bank Rakyat Indonesia stock. This research applies Long Short-Term Memory and Gated Recurrent Unit to produce a model that can accurately predict the stock price of Bank Rakyat Indonesia. Based on the implementation, GRU is the best model with MSE value of 4958.9168, RMSE 70.4195, and MAPE 1.1699%. The GRU model predict that there will be a decrease in stock prices in the next month.

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Peer-review under responsibility of the scientific committee of the Seventh Information Systems International Conference.

**Keywords:** Long Short-Term Memory; Gated Recurrent Unit; Stock Price; Prediction; Time Series

## Introduction

The current investment activity has significantly increased, and investing in stocks is one of the investment options in the capital market [1]. Stocks are financial instruments representing company ownership [2], [3]. It gives the investor the right to obtain a share of the prospects or wealth of the organization that issued the securities and various conditions that enable the investor to exercise other rights [4]. The stock price reflects the performance of the company, with higher stock prices indicating better company performance [2].

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Banking stocks are among the most important and popular stock sectors [5]. This is because banking continues to grow over time and its existence will last long. In addition, banking has a strategic position to support economic development [6]. This proves the existence of banking sector stocks and is even included in the most actively traded stocks category. One of the go-public banking stocks listed on the Indonesia Stock Exchange with a rapid price increase is Bank Rakyat Indonesia stock [6], [7].

Bank Rakyat Indonesia is one of the largest state-owned banks in Indonesia [7]. Bank Rakyat Indonesia's stock is the most actively traded stock on the Indonesia Stock Exchange, included in the LQ-45 stock index, and is one of the leading stocks [7], [8]. The LQ-45 index is a stock index of low-risk issuers associated with high-performing and liquid companies with good fundamentals [8], [9]. This indicates that Bank Rakyat Indonesia's stock has investment potential compared to other stocks.

The stock market is one of the most popular investment alternatives because it provides attractive returns [10]. In addition to offering high returns, stock investments are considered to carry high risks [1], [11]. Many investors who do not understand the techniques and analysis for making buying or selling decisions are hesitant to invest in stocks [12]. Furthermore, stock price movements are highly complex as they are influenced by various factors, making it difficult to predict [10], [13]. This causes fluctuations in stock prices to fluctuate very quickly so that it is feared that it will not match expectations [12].

The movement of stock prices can be analyzed using two financial analysis methods, namely technical and fundamental analysis [10], [14]. Technical analysis can be done by observing the movement of stock prices in the past such as opening and closing prices, the volume traded, and price changes at any time. Meanwhile, fundamental analysis can be done by identifying business factors, such as company information, news, business operations, and market or political and economic situations [15]. Technical analysis can be implemented by utilizing time series data of stock prices [14]. Deep Learning techniques such as Long-Short Term Memory (LSTM) and Gated Recurrent Unit (GRU) can be used to process and make predictions on time series data.

LSTM is a type of recurrent neural network designed with a special structure to overcome the vanishing and diverging gradient problems of conventional RNNs [16]. LSTM can learn long-term dependency information and avoid gradient explosion and gradient disappearing during the training period [17]. Meanwhile, GRU is the latest version of LSTM with a simpler and more optimized structure than the LSTM network but still maintains LSTM's performance [18], [19]. The operation of the GRU algorithm is similar to LSTM, but GRU uses a single hidden state that combines the forget gate and input gate into an update gate [20].

The implementation of LSTM and GRU algorithms has been conducted in previous research to predict time series data. The first study compared the LSTM algorithm with SVR to predict stock indices such as S&P 500, NYSE, NSE, NYSE, Dow Jones Industrial Average and NASDAQ, with LSTM producing better prediction accuracy than SVR [21]. Subsequent research compared the SVR, ARIMA, LSTM, and GRU algorithms to predict truck traffic flow, where during peak periods the average prediction accuracy of GRU was higher than LSTM, while during stable periods outside peak times, LSTM performed better than GRU [22]. Another study forecasted the medium to long-term nickel prices using LSTM and GRU, where both LSTM and GRU networks successfully predicted the variation of nickel prices with average MAPE of 7.060% and 6.986% respectively, with the GRU network surpassing LSTM by 33% in terms of average computation time [23].

This research applies and compares the LSTM and GRU algorithms on Bank Rakyat Indonesia stock to produce a model that can accurately predict stock price movements. This research is an original and novel contribution to the field, as no previous research has utilized similar datasets, algorithms, and experiments. With its innovative approach, this research makes a valuable contribution to the understanding and development of knowledge in this field. The resulting model can be used as a recommendation for investors to invest. Each asset invested can be used as additional capital for the company operational business activities. The results of this study are expected to be beneficial for the company as an evaluation material in preparing and planning business strategies to increase the company value and for the community, especially investors, to analyze and support stock trading investment decision-making.



## Methodology

Each stage of this research starts from the data collection stage to analysis and results. The data used is Bank Rakyat Indonesia stock data for the last 5 years, from 1 January 2018 to 30 December 2022 obtained through the yahoo finance website. The data that has been collected is then pre-processed and performs the time steps stage by creating sequences to predict the target value. The time steps set are 10, 20 and 30. After that, the data was separated using a hold-out validation technique with a ratio of 80% as training data and 20% as testing data. The next step is to train the model using LSTM and GRU algorithms. Optimization techniques such as SGD, Adam, and RMSprop are applied during training to improve the model's performance. Additionally, several other experiments were also carried out such as batch size with values of 8, 16, and 32 and learning rate with values of 0.01, 0.001 and 0.0001 to produce an optimal model. Furthermore, the trained model will be tested and evaluated to determine the best model based on the lowest MSE, RMSE and MAPE values. The best model from the testing results will then be implemented to predict the stock price in the next period. The flowchart of the stages of this research can be seen in Fig. 1.

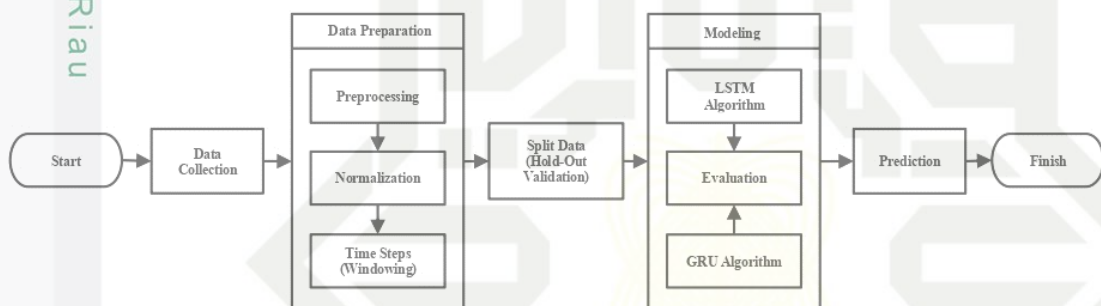


Fig. 1. Research Methodology.

### 1. Stocks

Stocks are financial instruments representing company ownership [2], [3]. It gives the investor the right to obtain share of the prospects or wealth of the organization that issued the securities and various conditions that enable the investor to exercise other rights [4]. Stock prices move very quickly based on market forces of supply and demand in the stock market [24]. In addition, the stock price reflects the company's performance. The stock price reflects the performance of the company, with higher stock prices indicating better company performance [2].

### 2. Data Collection

Data collection was done through Yahoo Finance website using API with Python and yfinance library. Some of the parameters needed to obtain data are the stock code, start date, and end date of the data to be retrieved. This study uses Bank Rakyat Indonesia stock data with the BBRI.JK stock code for the last 5 years, starting from 1 January 2018 to 30 December 2022. Data collection for 5 years was chosen because during this period there were high fluctuations in BRI stock, consisting of the period before the pandemic, during the pandemic, and after the Covid-19 pandemic.

### 2.3. Long Short-Term Memory

LSTM is a type of recurrent neural network designed with a specific structure to overcome the vanishing and diverging gradient problems of conventional RNNs [16]. LSTM can learn long-term dependency information and avoid gradient explosion and gradient disappearing during the training period [17]. These problems arise during training, where the optimizer performs backward propagation and makes the procedure run, while the weights hardly change at all.



LSTM can be applied to time series prediction, which is a very challenging problem due to long-term trends, seasonal and cyclic fluctuations, and random noise [25]. LSTM consists of several components, namely the forget gate decides what to forget from the previous memory unit, the input gate decides what to accept into the neuron, the cell state updates the cell, and the output gate produces a new long-term memory [20]. The following are the equation of the LSTM algorithm.

$$i_t = \sigma(W_i X_t + U_i h_{t-1} + b_i) \quad (1)$$

$$f_t = \sigma(W_f X_t + U_f h_{t-1} + b_f) \quad (2)$$

$$\tilde{c}_t = \tanh(W_c X_t + U_c h_{t-1} + b_c) \quad (3)$$

$$c_t = i_t \cdot \tilde{c}_t + f_t \cdot c_{t-1} \quad (4)$$

$$h_t = i_t \cdot \tanh(c_t) \quad (5)$$

where  $i_t$  is the input gate,  $f_t$  is the forget gate,  $\tilde{c}_t$  denotes the candidate state,  $c_t$  represents the cell state,  $h_t$  is the hidden state,  $W$  and  $U$  are weights,  $b$  is the bias, and  $X_t$  indicates the input value.

#### 4. Gated Recurrent Unit

GRU is the latest version of LSTM with a simple structure and is more optimized than LSTM networks, but still maintains the performance of LSTM [18, 19]. The operation of the GRU algorithm is similar to LSTM, but GRU uses a hidden state that combines the forget gate and the input gate into one, namely the update gate [20].

The reset gate functions to determine how much information will be derived from the previous information and generate a candidate state. The update gate determines how much information from the previous hidden state will be retained. The state candidate then updates the hidden state and updates gate [26]. The following are the equations of the GRU algorithm.

$$r_t = \sigma(W_r X_t + U_r h_{t-1} + b_r) \quad (6)$$

$$z_t = \sigma(W_z X_t + U_z h_{t-1} + b_z) \quad (7)$$

$$\tilde{h}_t = \tanh(W_h X_t + U_h(r_t h_{t-1}) + b_h) \quad (8)$$

$$h_t = z_t \tilde{h}_t + (1 - z_t) h_{t-1} \quad (9)$$

where  $r_t$  is the reset gate,  $z_t$  is forget gate,  $\tilde{h}_t$  denotes the candidate value,  $h_t$  is the output or hidden state,  $W$  and  $U$  are weights,  $b$  is the bias, and  $X_t$  indicates the input value.

#### 5. Time Steps

Time steps are stages used to form a sequence of data that is used as input to predict the target value. This stage is crucial in time series prediction cases. Determining the right time steps in accordance with the characteristics of the data is considered to increase the accuracy of model predictions [27]. Generally, the determination of time steps is done through experiments. Research [14] examined the effect of time step length on model quality resulting in short time steps providing good prediction results. In addition, research [28] found that the use of time steps with a long distance also produced a good model. Based on these findings, this research will conduct tests on time steps with short to long distances, such as 10, 20, and 30 to get the best prediction model.

#### 2.6. Optimizer

There are many optimizations available to improve the performance of the algorithm. For time series prediction cases, optimizations such as Stochastic Gradient Descent (SGD), Adaptive Moment (Adam), and Root Mean Square Propagation (RMSprop) are more commonly used [29]. SGD is a variant of gradient descent optimization that always changes the parameters in every training data. Then Adam is one of the efficient stochastic optimizations that only

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requires a first-order gradient with minimal memory requirements based on combining AdaGrad and RMSprop. RMSprop is an optimization method that calculates the learning rate adaptively for each parameter [30].

## 7. Evaluation

Mean Square Error (MSE) is the average squared difference between the predicted value and the actual value [31]. MSE value can be calculated using Eq. (10).

$$MSE = \frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2 \quad (10)$$

Root Mean Square Error (RMSE) is a parameter of the square root value of MSE to calculate the error value between the prediction and the actual value [3]. RMSE value can be calculated using Eq. (11).

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (y_i - \hat{y}_i)^2} \quad (11)$$

Mean Absolute Percentage Error (MAPE) is the percentage of average absolute differentiation error between the prediction and the true value [3]. MAPE value can be calculated using Eq. (12).

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left| \frac{y_i - \hat{y}_i}{y_i} \right| \times 100\% \quad (12)$$

## Results and Discussion

LSTM and GRU algorithms were modelled for stock price prediction with several experiments to generate an optimal model. The experiments include time steps (10, 20, and 30), optimization (SGD, Adam, and RMSprop), batch sizes (8, 16, and 32), and learning rates (0.01, 0.001 and 0.0001) with 500 epochs. The initial step is to implement LSTM and GRU algorithms with 10 time steps. Based on the experiments conducted, LSTM with Adam optimization in batch size 32 and learning rate 0.0001 resulted in the best model with MSE of 4997.4083, RMSE 70.6923, and MAPE 1.1834%. The results of LSTM and GRU modelling with 10 time steps can be seen in Table 1.

Table 1. Results and evaluation of the LSTM and GRU algorithm modeling with 10 time steps.

Experiments			LSTM			GRU		
Optimizer	Batch Size	Learning Rate	MSE	RMSE	MAPE	MSE	RMSE	MAPE
SGD	8	0,01	9365,6143	96,7761	1,5563	5871,6346	76,6265	1,2593
SGD	8	0,001	14724,6506	121,3451	2,0393	9142,0219	95,6139	1,5690
SGD	8	0,0001	80438,2437	283,6163	5,5157	14687,5030	121,1920	2,0931
SGD	16	0,01	11154,7826	105,6162	1,7293	7271,5389	85,2733	1,3700
SGD	16	0,001	17464,5828	132,1536	2,2316	9498,8353	97,4619	1,6012
SGD	16	0,0001	229603,3553	479,1694	9,8045	36534,9027	191,1410	3,6557
SGD	32	0,01	12351,3836	111,1367	1,9246	8582,6258	92,6424	1,5091
SGD	32	0,001	16999,0387	130,3803	2,2028	9784,2947	98,9155	1,6235
SGD	32	0,0001	364264,0971	603,5429	12,4922	84580,1001	290,8265	5,8071
Adam	8	0,01	5384,6711	73,1346	1,2266	5203,3334	72,1341	1,1914
Adam	8	0,001	5388,9642	73,4095	1,2356	6585,9457	81,1538	1,3773
Adam	8	0,0001	5356,2616	73,1864	1,2051	7950,2971	89,1644	1,5301
Adam	16	0,01	6750,9126	82,1639	1,3556	9586,6835	97,9116	1,8263
Adam	16	0,001	6770,6869	82,2841	1,3605	7520,4181	86,7203	1,5428
Adam	16	0,0001	7028,7536	83,8376	1,4014	6132,9770	78,3133	1,2845
Adam	32	0,01	5947,8721	77,1224	1,2708	7234,6896	85,0569	1,3603
Adam	32	0,001	5606,5059	74,8766	1,2862	5109,9342	71,4838	1,1856
Adam	32	0,0001	4997,4083	70,6923	1,1834	5721,0662	75,6377	1,2474
RMSprop	8	0,01	5775,0131	75,9935	1,3269	7475,6303	86,4617	1,5270

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Experiments			LSTM			GRU		
Optimizer	Batch Size	Learning Rate	MSE	RMSE	MAPE	MSE	RMSE	MAPE
RMSprop	8	0,001	5278,3973	72,6525	1,2028	5346,0230	73,1165	1,2096
RMSprop	8	0,0001	5136,7579	71,6711	1,1891	5388,0529	73,4033	1,2119
RMSprop	16	0,01	6433,0119	80,2060	1,3905	12180,0137	110,3630	2,0276
RMSprop	16	0,001	6633,7220	81,4476	1,3897	9603,0326	97,9950	1,8356
RMSprop	16	0,0001	5257,2108	72,5066	1,2060	6269,8651	79,1824	1,3384
RMSprop	32	0,01	8804,5592	93,9326	1,6582	17665,6359	132,9121	2,4813
RMSprop	32	0,001	6765,1386	82,2504	1,4666	8774,5923	93,6727	1,6259
RMSprop	32	0,0001	6400,1581	80,0009	1,3093	6315,8615	79,4723	1,3873

The next step is to implement the LSTM and GRU algorithms with 20 time steps. At this stage, the GRU model with RMSprop optimization, batch size 16, and learning rate 0.0001 was found to be the best performing model with MSE value of 5038.6143, RMSE 70.9831, and MAPE 1.1726%. The results of LSTM and GRU modelling with 20 time steps can be seen in Table 2.

Table 2. Results and evaluation of the LSTM and GRU algorithm modeling with 20 time steps.

Experiments			LSTM			GRU		
Optimizer	Batch Size	Learning Rate	MSE	RMSE	MAPE	MSE	RMSE	MAPE
SGD	8	0,01	9370,5757	96,8017	1,5301	6745,3684	82,1301	1,3338
SGD	8	0,001	16318,4006	127,7434	2,1955	8762,9462	93,6106	1,5207
SGD	8	0,0001	30198,5635	173,7773	3,1138	13833,6560	117,6165	2,0270
SGD	16	0,01	11195,2025	105,8073	1,6868	6790,1022	82,4020	1,3252
SGD	16	0,001	18865,1918	137,3506	2,4010	9430,7213	97,1119	1,5996
SGD	16	0,0001	73932,2134	271,9047	5,2111	36015,9000	189,7785	3,6083
SGD	32	0,01	15159,5192	123,1239	2,0659	7263,1107	85,2238	1,3740
SGD	32	0,001	21926,2515	148,0751	2,6245	10251,0492	101,2474	1,6710
SGD	32	0,0001	201264,4403	448,6250	9,0219	122939,6971	350,6275	7,1227
Adam	8	0,01	9914,5167	99,5716	1,6488	9315,7337	96,5180	1,8117
Adam	8	0,001	8867,9965	94,1700	1,5892	7564,3104	86,9730	1,4405
Adam	8	0,0001	6173,6597	78,5726	1,2822	5266,3719	72,5697	1,1930
Adam	16	0,01	7567,7445	86,9927	1,4187	5967,8226	77,2516	1,3071
Adam	16	0,001	5353,4443	73,1672	1,2055	5411,6530	73,5639	1,2175
Adam	16	0,0001	6453,8772	80,3360	1,3224	5476,0724	74,0004	1,2184
Adam	32	0,01	6567,6019	81,0407	1,3211	8245,7992	90,8063	1,5096
Adam	32	0,001	6094,2709	78,0658	1,2861	6962,1740	83,4396	1,3976
Adam	32	0,0001	5850,4023	76,4879	1,2554	5735,3266	75,7319	1,2686
RMSprop	8	0,01	7730,7073	87,9244	1,4850	5876,0025	76,6550	1,2625
RMSprop	8	0,001	5416,7627	73,5987	1,2115	5732,5856	75,7138	1,2384
RMSprop	8	0,0001	5147,4587	71,7457	1,1866	5101,8924	71,4275	1,1852
RMSprop	16	0,01	5577,4658	74,6824	1,2296	8031,8723	89,6207	1,5015
RMSprop	16	0,001	6691,2184	81,7998	1,3520	5587,1427	74,7471	1,2284
RMSprop	16	0,0001	5112,6288	71,5026	1,1923	5038,6143	70,9831	1,1726
RMSprop	32	0,01	7560,6397	86,9519	1,4504	12632,1489	112,3928	2,0355
RMSprop	32	0,001	6327,9333	79,5483	1,3893	7077,6380	84,1286	1,4129
RMSprop	32	0,0001	6073,5597	77,9330	1,2950	5218,9542	72,2423	1,1911

As in the previous stage, the LSTM and GRU algorithms were implemented, but this time with 30 time steps. The experiments conducted resulted in the GRU with RMSprop optimization, batch size 32, and learning rate 0.0001 as the best model with an MSE value of 4958.9168, RMSE 70.4195, and MAPE 1.1699%. The modeling results with 30 time steps for each experiment can be seen in Table 3.

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Table 3. Results and evaluation of the LSTM and GRU algorithm modeling with 30 time steps.

Experiments			LSTM			GRU		
Optimizer	Batch Size	Learning Rate	MSE	RMSE	MAPE	MSE	RMSE	MAPE
SGD	8	0,01	11785,4626	108,5608	1,7544	6179,5152	78,6098	1,2641
SGD	8	0,001	15537,3218	124,6487	2,1291	9218,8881	96,0150	1,5708
SGD	8	0,0001	29044,4281	170,4242	3,0635	14406,2042	120,0258	2,0584
SGD	16	0,01	11229,8982	105,9712	1,6909	7526,7878	86,7570	1,4057
SGD	16	0,001	16503,2250	128,4648	2,2269	9382,5800	96,8637	1,5847
SGD	16	0,0001	117693,5057	343,0648	6,7326	38284,2234	195,6635	3,7502
SGD	32	0,01	13317,1138	115,3998	1,8794	8334,3191	91,2924	1,4904
SGD	32	0,001	21227,0772	145,6951	2,5980	9484,6862	97,3893	1,6007
SGD	32	0,0001	230716,6882	480,3297	9,7533	132274,2084	363,6952	7,3696
Adam	8	0,01	6207,9624	78,7906	1,3103	9876,5846	99,3810	1,6629
Adam	8	0,001	5941,3701	77,0802	1,3166	5439,5125	73,7530	1,2250
Adam	8	0,0001	5386,4103	73,3921	1,2535	5630,4682	75,0364	1,2588
Adam	16	0,01	8083,5019	89,9082	1,5583	7466,9084	86,4112	1,4689
Adam	16	0,001	6083,0879	77,9941	1,2792	6204,3981	78,7680	1,2972
Adam	16	0,0001	6026,1209	77,6284	1,2671	6231,7327	78,9413	1,2975
Adam	32	0,01	7733,5104	87,9403	1,4832	11997,4781	109,5330	1,8203
Adam	32	0,001	6583,3154	81,1376	1,3411	7934,3445	89,0749	1,5030
Adam	32	0,0001	6592,3843	81,1934	1,3431	5729,2044	75,6915	1,2516
RMSprop	8	0,01	5740,7798	75,7679	1,2833	8833,4244	93,9862	1,6218
RMSprop	8	0,001	5403,0720	73,5055	1,2127	7152,5659	84,5728	1,4396
RMSprop	8	0,0001	4986,6823	70,6164	1,1785	5461,6996	73,9033	1,2578
RMSprop	16	0,01	5896,8258	76,7907	1,2745	8833,4244	93,9862	1,6218
RMSprop	16	0,001	5642,4104	75,1159	1,2355	7616,5124	88,4110	1,4944
RMSprop	16	0,0001	5086,0117	71,3162	1,1853	5198,6069	72,1013	1,2302
RMSprop	32	0,01	9348,9401	96,6899	1,8466	5397,9464	73,4707	1,2166
RMSprop	32	0,001	5258,5345	72,5157	1,2135	5509,3185	74,2247	1,2223
RMSprop	32	0,0001	5850,2421	76,4868	1,2561	4958,9168	70,4195	1,1699

Through the results of the analysis of the tests carried out, GRU with RMSprop optimization at time steps 30, batch size 32, learning rate 0.0001 is the best model of all experiments conducted with MSE values of 4958.9168, RMSE 70.4195, and MAPE 1.1699%. The prediction results of the GRU model on test data can be seen in Fig. 2.



Fig. 2. Stock price prediction on test data.

GRU as the best model will then be implemented to predict future stock prices in January 2023. The results show that the stock price of Bank Rakyat Indonesia is predicted to decrease. The GRU model prediction graph can be seen in Fig. 3.

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Fig. 3. Stock price prediction in the next month.

The GRU model is more effective than LSTM in predicting the stock price of Bank Rakyat Indonesia. This is because GRU has a simple structure and fewer parameters than LSTM, so the model can learn more efficiently [3]. The SGD optimizer produces an increasingly high error value when the learning rate gets smaller and the batch size gets larger, especially in LSTM. Then, Adam and RMSprop optimizers produce high error values when the learning rate is set higher. However, RMSprop tends to adaptively adjust the learning rate for each model parameter, making RMSprop slightly more effective than Adam. In addition, longer time steps produce more accurate prediction models both LSTM and GRU.

The prediction results show that there will be a decrease in stock prices in January 2023. The information obtained can be used by company in analyzing stock price trends as evaluation material in developing and planning business strategies and making the right decisions, such as managing investment portfolios, managing risks, or planning mitigation measures. This is done to increase the value and prevent a decline in the company stock price.

## Conclusion

Based on the results and analysis conducted, it can be concluded that LSTM and GRU were successful in predicting the stock price of Bank Rakyat Indonesia. The implementation of LSTM and GRU through various experiments resulted in GRU as the best model with a MSE value of 4958.9168, RMSE 70.4195, and MAPE 1.1699%. RMSprop proved to be an effective optimizer in this research as it could improve the performance of both LSTM and GRU models, outperforming other optimizations such as SGD and Adam. The GRU model as the best was then applied to predict the stock price for the next month. The results showed that the GRU model predicted a decrease in the stock prices of Bank Rakyat Indonesia. That way, the company needs to evaluate and implement the appropriate business strategy to increase the company value and prevent a decrease in stock prices.

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# LAMPIRAN A POSTER KEGIATAN



Seventh Information Systems International Conference (ISICO 2023)

## Long Short-Term Memory and Gated Recurrent Unit for Stock Price Prediction

Akhas Rahmadeyan\*, Mustakim

Department of Information Systems, Universitas Islam Negeri Sultan Syarif Kasim Riau, 28293, Indonesia

### Abstrack

Stocks are one of the popular investments but have a high risk. This was caused by the rapid fluctuation of stock prices so it was feared that it would not meet expectations. For this reason, we need an analysis technique that can determine the movement of stock prices. This research applies LSTM and GRU to produce a model that can accurately predict stock prices. Based on the implementation, GRU is the best model with MSE value of 4958.9168, RMSE 70.4195, and MAPE 1.1699%. The GRU model predict that there will be a decrease in stock prices in the next month.

### 1 Introduction

The current investment activity has significantly increased, and investing in stocks is one of the investment options in the capital market. Banking stocks are among the most important and popular stock sectors. Bank Rakyat Indonesia's stock is the most actively traded stock on the Indonesia Stock Exchange, included in the LQ-45 stock index, and is one of the leading stocks. Many investors who do not understand the techniques and analysis for making buying or selling decisions are hesitant to invest in stocks. Furthermore, stock price movements are highly complex as they are influenced by various factors, making it difficult to predict. This causes fluctuations in stock prices to fluctuate very quickly so that it is feared that it will not match expectations. This study applies and compares the LSTM and GRU algorithms on Bank Rakyat Indonesia's stock to produce a model that can accurately predict stock price movements. The results of this study are expected to be beneficial for the company as an evaluation material in preparing and planning business strategies to increase the company's value and for the community, especially investors, to analyze and support stock trading investment decision-making.

### 2 Methodology

Each stage of this research is illustrated through a flowchart which can be seen in Figure 1.

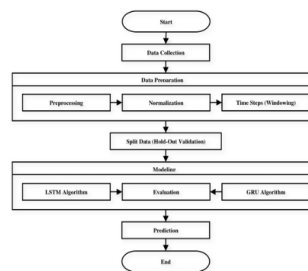


Fig 1. Research Methodology.

### 3 Results and Discussion

Through the results of the analysis of the tests carried out, GRU with RMSprop optimization at time steps 30, batch size 32, learning rate 0.0001 is the best model of all experiments conducted with MSE values of 4958.9168, RMSE 70.4195, and MAPE 1.1699%. GRU as the best model will then be implemented to predict future stock prices in January 2023. The results show that the stock price of Bank Rakyat Indonesia is predicted to decrease.



Fig 2. Stock price prediction on test data.



Fig 3. Stock price prediction in the next month.

### 4 Conclusion

Based on the results and analysis conducted, it can be concluded that LSTM and GRU were successful in predicting the stock price of Bank Rakyat Indonesia. The implementation of LSTM and GRU through various experiments resulted in GRU as the best model with a MSE value of 4958.9168, RMSE 70.4195, and MAPE 1.1699%. RMSprop proved to be an effective optimizer in this research as it could improve the performance of both LSTM and GRU models, outperforming other optimizations such as SGD and Adam. The GRU model as the best was then applied to predict the stock price for the next month. The results showed that the GRU model predicted a decrease in the stock prices of Bank Rakyat Indonesia. That way, the company needs to evaluate and implement the appropriate business strategy to increase the company value and prevent a decrease in stock prices.





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## LAMPIRAN B

### BUKTI KEPUTUSAN EDITOR



AKHAS RAHMADEYAN <11950314479@students.uin-suska.ac.id>

#### ISICO 2023 notification for paper 85

2 pesan

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15 Mei 2023 pukul 12.50

Kepada: Akhas Rahmadeyan <11950314479@students.uin-suska.ac.id>

Dear Akhas Rahmadeyan,

We are pleased to inform you that your manuscript is ACCEPTED WITH REVISION.

All full papers have undergone at least double-blind, developmental reviews by ISICO Scientific Committee.

Final acceptance of approved camera-ready papers will be contingent on incorporating reviewers' feedback to the satisfaction of the Editors-in-chief.

After you have done all the revisions and finalize your registration, we are happy to invite you to present your paper with the following details:

Paper ID : 85

Title : Long Short-Term Memory and Gated Recurrent Unit for Stock Price Prediction

Authors : Akhas Rahmadeyan, Mustakim Mustakim

in Information Systems International Conference (ISICO) 2023 that will be held virtually on July 26-28, 2023. Congratulations!

Thank you for your participation in ISICO 2023 and we look forward to seeing you soon!

Sincerely,  
ISICO 2023 Committee

SUBMISSION: 85  
TITLE: Long Short-Term Memory and Gated Recurrent Unit for Stock Price Prediction

#### ----- REVIEW 1 -----

SUBMISSION: 85  
TITLE: Long Short-Term Memory and Gated Recurrent Unit for Stock Price Prediction  
AUTHORS: Akhas Rahmadeyan and Mustakim Mustakim

#### ----- Overall evaluation -----

SCORE: 1 (weak accept)

----- TEXT:

This paper compared the use of LSTM and GRU for Bank Rakyat Indonesia (BRI)'s stock value prediction. The topic discussed in this paper is interesting and it has comprehensive experiment and analysis. However, several points below need to be addressed to improve the quality of the paper.

- 1) All abbreviations must be explained the first time it was mentioned, such as LSTM and GRU in the Abstract section, etc.
- 2) Please explain the meaning all of the notation used in the paper, such as  $i$ ,  $W$ ,  $X$  in Eq (1).
- 3) Please explain the full flow of the proposed methodology, from input to output. The use of a flowchart diagram is recommended.
- 4) Did you crawl the data from Yahoo website to acquire the dataset? If so, please also explain the steps to obtain the dataset.
- 5) Please explain the general concept of LSTM and GRU in more detail, such as their architecture, etc.



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6) Please give a more highlight that the contribution of this paper is the use of BRI dataset (that has not been done before) in the Introduction section.

7) Please give a more comprehensive analysis on why GRU gives a better performance than LSTM, why RMSprop gives a better performance than Adam's optimizer and SGD, etc. If you can find some references to support your analysis, it will be better.

### ----- REVIEW 2 -----

SUBMISSION: 85

TITLE: Long Short-Term Memory and Gated Recurrent Unit for Stock Price Prediction

AUTHORS: Akhas Rahmadyan and Mustakim Mustakim

----- Overall evaluation -----

SCORE: 2 (accept)

----- TEXT:

1. The title of this study is intended to ensure that the method is suitable for use in forecasting stock prices in general. However, the paper's contents show that the main objective of this research is to predict the shares of Bank Rakyat Indonesia to make decisions by utilizing both of these methods. Please correct the title of this research.

Abstract:

2. Refine the abstract according to the research focus (referring to the comments in the title)

3. This section has not briefly explained the urgency of predicting stock prices.

4. " This was caused by the rapid fluctuation of stock prices, so it was feared that it would not meet expectations. For this reason, we need an analysis technique that can determine the movement of stock prices. " ==> the relationship between sentences is not in accordance. What is the relationship between rapid stock price fluctuations and expectations? What kind of hope? What is the relationship between knowing stock price movements and expectations with this research? Can't the movement of stock prices be seen directly in historical data?

Introduction:

5. "In addition, banking has a strategic position to support the economic development." --> double sentence.

Methodology:

6. Explain why you use data from the last 5 years?

7. Why do you use time steps set 10, 20, and 30? Explain!

8. Briefly describe the optimizer (Stochastic Gradient Descent (SGD), Adaptive Moment (Adam), and Root Mean Square Propagation (RMSprop)) that you use.

Results and Discussion:

9. In Fig. 2, visualize the forecasting results for the next month only so that stock fluctuations are visible in those months.

10. Interpret the results of your forecasting so that the company can use these results for evaluation material in preparing and planning business strategies, as you expect in this research.

11. Give headers for each advanced table from the previous table.

12. In this section, there is no discussion. There are only results. It does not match the title of the section. Please fix.

Conclusion:

13. " The results showed that the GRU model predicted a decrease in the stock prices of Bank Rakyat Indonesia. That way, the company needs to evaluate and implement the appropriate business strategy to increase the company value and prevent a decrease in stock prices. " ==> There were no interpretations in the results section that could conclude like this.





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# LAMPIRAN C

## BUKTI DITERIMA



AKHAS RAHMADEYAN <11950314479@students.uin-suska.ac.id>

### Registration and Payment Reminder

1 pesan

Information Systems International Conference <isico@its.ac.id>

31 Mei 2023 pukul 10.31

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Saya yang bertanda tangan dibawah ini:

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NIM : 11950314479  
Program Studi : Sistem Informasi  
Judul Tugas Akhir : Long Short-Term Memory and Gated Recurrent Unit for  
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Menyatakan bahwa akan melengkapi seluruh kelengkapan administrasi Tugas Akhir Program Studi Sistem Informasi Fakultas Sains dan Teknologi Universitas Islam Negeri Sultan Syarif Kasim Riau berupa bukti pelaksanaan conference secara lengkap. Demikian yang dapat Saya sampaikan dengan sungguh-sungguh. Kami ucapkan terimakasih.

Pekanbaru, 20 Juni 2023

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## DAFTAR RIWAYAT HIDUP



Akhas Rahmadeyan lahir di Perawang, Kabupaten Siak pada 23 Januari 2001. Peneliti merupakan putra pertama dari Ayahanda Dayang dan Ibunda Mirnawati. Peneliti sebelumnya menempuh pendidikan atas pada SMKS Yayasan Pendidikan Persada Indah (YPPI) Tualang di Jurusan Teknik Komputer dan Jaringan dan melanjutkan pendidikan Strata Satu (S1) di Program Studi Sistem Informasi di Perguruan Tinggi Universitas Islam Negeri Sultan Syarif Kasim Riau. Peneliti tergabung dengan organisasi riset yaitu *Puzzle Research Data Technology* (Predatech). Peneliti cukup aktif dalam menulis artikel ilmiah dan telah menerbitkan beberapa artikel di berbagai Jurnal. Adapun bidang riset peneliti yaitu *Machine Learning*, *Deep Learning*, *Data Mining* dan *Data Science*. Untuk menjalin komunikasi yang baik dengan peneliti dapat menghubungi peneliti melalui email yaitu akhasrahmadeyan101@gmail.com.