PENERAPAN ALGORITMA *BIDIRECTIONAL GATED RECURRENT UNIT* DAN *STACKED GATED RECURRENT UNIT* UNTUK PREDIKSI HARGA SAHAM

TUGAS AKHIR

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

Oleh:

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UIN SUSKA RIAU

FAKULTAS SAINS DAN TEKNOLOGI
UNIVERSITAS ISLAM NEGERI SULTAN SYARIF KASIM RIAU
PEKANBARU
2025

LEMBAR PERSETUJUAN

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di Pekanbaru, pada tanggal 21 Januari 2025

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Yang membuat pernyataan,

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LEMBAR PERSEMBAHAN

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

Dengan menyebut nama Allah yang maha pengasih lagi maha penyayang

Assalamu'alaikum Warahmatullahi Wabarakaatuh.

Alhamdulillahi 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 semoga selalu tercurah 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 Rabbal 'Alaamiin.* Kupersembahkan hadiah istimewa karya kecil ini sebagai bentuk bakti, rasa terima kasih, dan hormatku kepada orang tuaku tercinta, papa dan mama.

Papa dan mama tersayang, terima kasih untuk setiap perjuangan yang telah diusahakan. *Do'a* yang selalu diberikan disetiap sujud panjang, membimbing, dan mendorong peneliti dalam kebaikan dan selalu ada saat keadaan tersulit sekalipun. Terima kasih untuk segala pengorbanan papa dan mama. Sampai kapanpun tiada rasa dan cara yang dapat membalas semua yang telah diberikan. Untuk itu, peneliti anakmu ini selalu mendoakan yang terbaik untuk papa dan mama agar bahagia dunia dan akhirat, serta diberikan tempat istimewa di sisi-Nya kelak sehingga kita bisa berkumpul kembali bersama-sama di *Jannah*-Nya. Terima kasih juga peneliti ucapkan kepada adik yang sangat peneliti cintai. Terima kasih untuk segala waktu berharga yang telah dilalui bersama, *do'a*, dan dukungan yang tiada hentinya.

Terima kasih juga peneliti ucapkan kepada Bapak dan Ibu Dosen Sistem Informasi yang selama ini sudah mewariskan ilmu, motivasi, dan arahan untuk menyelesaikan studi di Program Studi Sistem Informasi ini. Kemudian untuk teman-teman seperjuangan, terima kasih atas dukungan dan motivasi yang diberikan. Semoga selalu mendapatkan rahmat serta karunia-Nya, dan dilimpahkan kemudahan yang berlipat ganda. *Aamiin*.

Wassalamu'alaikum Warahmatullahi Wabarakaatuh.

KATA PENGANTAR

Alhamdulillahi Rabbil 'Alamin, bersyukur kehadirat Allah *Subhanahu Wa Ta'ala* atas segala rahmat dan karunia-Nya sehingga peneliti dapat menyelesaikan Tugas Akhir ini. *Shalawat* serta salam kita ucapkan kepada Nabi Muhammad *Shallallahu 'Alaihi Wa Sallam* dengan mengucapkan *Allahumma Sholli'Ala Sayyidina Muhammad Wa'Ala Ali Sayyidina Muhammad*. Tugas Akhir ini dibuat sebagai salah satu syarat untuk mendapatkan gelar Sarjana Komputer di Program Studi Sistem Informasi Universitas Islam Negeri Sultan Syarif Kasim Riau.

Pada penulisan Tugas Akhir ini, terdapat beberapa pihak yang sudah berkontribusi dan mendukung peneliti baik berupa materi, moril, dan motivasi. Peneliti ingin mengucapkan banyak terima kasih kepada:

1. Bapak Prof. Dr. Hairunas, M.Ag sebagai Rektor Universitas Islam Negeri Sultan Syarif Kasim Riau.
2. Bapak Dr. Hartono, M.Pd sebagai Dekan Fakultas Sains dan Teknologi.
3. Bapak Eki Saputra, S.Kom., M.Kom sebagai Ketua Program Sistem Informasi.
4. Ibu Siti Monalisa, ST., M.Kom sebagai Sekretaris Prodi Sistem Informasi.
5. Bapak Tengku Khairil Ahsyar, S.Kom., M.Kom sebagai Kepala Laboratorium Program Studi Sistem Informasi.
6. Bapak Nesdi Evrilyan Rozanda, S.Kom., M.Sc sebagai Ketua Sidang peneliti yang telah memberikan arahan dan masukan pada penelitian ini.
7. Bapak Mustakim, ST., M.Kom sebagai Dosen Pembimbing Tugas Akhir yang telah meluangkan waktu dan membimbing hingga peneliti dapat menyelesaikan Laporan Tugas Akhir ini. Motivasi yang diberikan akan selalu peneliti ingat dan dijadikan sebagai pelajaran hidup.
8. Ibu Angraini, S.Kom., M.Eng., Ph.D sebagai Dosen Penguji I yang telah banyak memberikan arahan, masukan, nasihat, dan motivasi dalam penyelesaian Tugas Akhir ini.
9. Bapak M. Afdal, ST., M.Kom sebagai Dosen Penguji II yang telah banyak memberikan arahan, masukan, nasihat, serta motivasi dalam penyelesaian Tugas Akhir ini.
10. Ibu Megawati, S.Kom., MT sebagai Dosen Pembimbing Akademik peneliti yang telah banyak memberikan arahan, masukan, nasihat, dan motivasi selama perkuliahan mulai dari Semester 1 hingga Selesai.
11. Seluruh Pegawai dan *Staff* Fakultas Sains dan Teknologi Universitas Islam Negeri Sultan Syarif Kasim Riau yang telah membantu dan mempermudah

proses administrasi selama perkuliahan ini.

12. Kedua orang tua peneliti, yaitu papa dan mama tercinta yang tanpa lelah selalu memberikan semangat, motivasi, *support*, serta *do'a* terbaiknya, dan selalu menjadi motivasi peneliti dalam menyelesaikan Strata Satu (S1) ini. Terima kasih atas segala keringat, jerih payah pengorbanan, dan kerja keras yang telah kalian berikan dengan penuh keikhlasan demi menuju kesuksesan anakmu ini. Semoga Allah *Subhanahu Wa Ta'ala* selalu menjaga dan melindungi papa dan mama dimanapun kalian berada.
13. Adik-adik peneliti, yaitu Firnalia Amanda dan Muhammad Habib As-syauqie yang selalu memberikan *do'a*, dukungan, dan semangat kepada peneliti.
14. Keluarga besar *Puzzle Research Data Technology* (Predatech) terutama Bapak dan Ibu pembimbing serta teman-teman yang selalu memberikan motivasi, semangat, bantuan, dan kebaikan kepada peneliti.
15. Teman-teman seperjuangan Sistem Informasi Angkatan 2021 khususnya Kelas SIF 21 C yang tidak bisa peneliti sebutkan satu-persatu.
16. Semua pihak yang tidak dapat peneliti sebutkan satu-persatu yang terlibat dalam perjuangan penyelesaian pendidikan Strata Satu (S1) yang telah memberikan bantuan, dukungan, dan semangat kepada peneliti baik dalam pengumpulan data maupun penyusunan Tugas Akhir ini.

Semoga segala *do'a* dan dorongan yang telah diberikan selama ini menjadi amal kebajikan dan mendapat balasan setimpal dari Allah *Subhanahu Wa Ta'ala*. Peneliti menyadari bahwa penulisan Tugas Akhir ini masih terdapat banyak kekurangan dan jauh dari kata sempurna. Untuk itu, kritik dan saran yang membangun sangat diharapkan demi kesempurnaan Tugas Akhir ini yang dapat dikirim melalui *e-mail* 12150323859@students.uin-suska.ac.id. Semoga Laporan Tugas Akhir ini dapat bermanfaat bagi kita semua. Akhir kata peneliti ucapkan terima kasih.

Pekanbaru, 21 Januari 2025

Peneliti,

NASYA AMIRAH MELYANI
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Bandung, 12 Jan 2025

Letter of Acceptance

No: 0008/LoA/ICADEIS/2025

Dear Authors: Nasya Melyani; Mustakim Mustakim; Angraini Angraini; M Afdal;
Id Paper: 1571097772

We are pleased to inform you that your paper, entitled:

Application of Bidirectional Gated Recurrent Unit and Stacked Gated Recurrent Unit Algorithms for Stock Price Prediction

has been **accepted** for oral presentation at 2025 International Conference Advancement in Data Sciences, E-Learning, and Information System (ICADEIS), February 3th – 4th 2025, offline from Bandung and online via Zoom Meetings (**Hybrid Conference**).

We would like your cooperation in double-checking your final paper or a camera-ready version. Please ensure the paper conforms to the standard of the conference manuscript template. Please submit your full paper and pay the registration fee before the deadlines. Visit our website for further information.

Thankyou.

Best Regards,
ICADEIS 2025 Committe

Application of Bidirectional Gated Recurrent Unit and Stacked Gated Recurrent Unit Algorithms for Stock Price Prediction

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***Abstract*— Stocks are financial instruments that provide ownership rights and profits to their holders in public companies, which attract investors because of the potential for high returns despite the risks. Because stock price volatility is difficult to predict, accurate analysis techniques are needed to help investors make the right decisions, especially in the banking sector such as Bank Rakyat Indonesia. This study predicts the stock price of Bank Rakyat Indonesia (BBRI) using deep learning techniques, namely Bidirectional Gated Recurrent Unit (Bi-GRU) and Stacked Gated Recurrent Unit (Stacked GRU), which are chosen because of their ability to capture complex time series data patterns. BBRI stock data from 2018 to 2024 and from 2023 to 2024 were collected, processed, and divided into training and testing data with a ratio of 80:20. The Bi-GRU and Stacked GRU algorithms were optimized with Nadam, Adamax, AdamW, and SGDM, and evaluated using MSE, RMSE, and MAPE. As a result, 7-year data outperforms 2-year data with the best algorithm Bi-GRU with Nadam optimization, batch size 8, and learning rate 0.001 giving the best performance with MSE 7283.1848, RMSE 85.3416, MAE 65.0879, and MAPE 1.2421%. The best prediction shows a decrease in BBRI stock prices in November 2024 which indicates a decrease towards the end of the year, thus providing valuable information for companies and investors in anticipating market behavior and making the right investment decisions.**

***Keywords*— bidirectional gated recurrent unit, predictions, stacked gated recurrent unit, stock price, time series**

I. INTRODUCTION

Investment is the process of investing capital with the aim of gaining profits in the future. Investments are available in various forms, including physical assets such as gold and silver, as well as stocks and cryptocurrencies [1]. Stocks are often chosen because they offer significant returns despite the high risk, following the principle of "high risk, high return" [2]. In the digital era, investment activities have grown rapidly, and stocks and cryptocurrencies have become popular choices [3].

Stocks are financial instruments that provide their holders with ownership rights and profits in a public company, which attract investors because of the potential for high returns despite the risks [4]. Stocks provide better stability than cryptocurrencies, which are known for sharp price fluctuations [5]. The stock market is more regulated, while cryptocurrencies still face regulatory challenges. Investors also tend to choose stocks because they offer broader portfolio diversification and better transparency of information, including the potential to receive dividends [6]. One of the stock sectors that is often in demand is banking, which has high liquidity and good performance on the Indonesia Stock Exchange (IDX) [7].

Bank Rakyat Indonesia (BRI) is one of the oldest and biggest banks in Indonesia, with BBRI shares having the highest market capitalization among other state-owned bank shares [8]. BBRI shares are also included in the LQ45 index, recording high performance and becoming a favorite for domestic and foreign investors. In the capital market, BBRI shares attract investors because of their stability and growth potential [9].

To predict stock movements, technical analysis is often used, especially for short-term investments [10]. The other technical, like fundamental analysis, which emphasizes a company's intrinsic value, technical analysis relies on historical data to predict stock price trends [11]. However, many prospective investors do not yet understand the analysis and techniques for making decisions about trading stocks, so prospective investors are hesitant to invest [12]. This is due to the fluctuating nature of stock prices, which are constantly changing and hard to forecast. Therefore, a method is needed to analyze and predict stock prices. To process and predict time series data, you can use deep learning algorithms such as Bidirectional Gated Recurrent Unit (Bi-GRU) and Stacked Gated Recurrent Unit (Stacked-GRU), which are algorithms derived from Gated Recurrent Unit (GRU).

GRU is a variant of the Recurrent Neural Network (RNN) algorithm that simplifies the Long Short-Term Memory (LSTM) architecture but remains effective in capturing temporal patterns [13] [14]. GRU solves the vanishing gradient problem that frequently arises during the training of conventional RNNs, allowing for faster training in various applications [15]. Bi-GRU extends its capabilities of GRU by processing data in two directions, providing more comprehensive context in data sequences and improving accuracy in sentiment analysis and speech recognition [16]. In addition, Stacked GRU, which consists of several GRU layers arranged hierarchically, can capture more complex patterns in sequential data, making it effective for complicated data dynamics and long-term dependencies [17]. With the combination of these features, GRU, Bi-GRU, and Stacked GRU with metrics evaluation such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE), offer powerful solutions to various challenges in data analysis.

Research related to the Bi-GRU algorithm by Chen et al. (2021) in their research found that the multi-scale architecture of the Bi-GRU network allows for the efficient capture of spatial and temporal latency characteristics [18]. Furthermore, research conducted by Duan et al. (2023) produced the Bi-GRU algorithm and compared it to other algorithms. The goodness-of-fit value of the original algorithms increased by an average of 14.4%, which will significantly improve the accuracy of stock price prediction [19].

Similar research on the Stacked GRU algorithm was conducted by Diqi et al. (2023) which showed that Stacked GRU produced low RMSE and MAE values and a high R^2 coefficient, proving the effectiveness of the model in predicting temperature, pressure, humidity, and wind speed [20]. Yang et al. (2022) also found that the Stacked GRU architecture with Adam Optimizer provided optimal results, with MAPE, RMSE, and MAE values of 9.76%, 1.412, and 1.14, respectively, in medium-term and long-term electricity load forecasting in Yunnan Province, surpassing other deep learning methods [17]. In addition, Dutta et al. (2020) showed that the Stacked GRU model produced better classification in predicting breast cancer disease than LSTM and Bidirectional Recurrent Neural Network (BRNN) algorithms [21].

This research fills a gap by directly comparing the performance of Bi-GRU and Stacked GRU in predicting BRI stock price movements, focusing on parameter optimization and in-depth model evaluation. By applying various optimization techniques and model evaluations, the study provides a comprehensive analysis of which model is more effective for stock price prediction.

This research compares two GRU derivative algorithms, Bi-GRU and Stacked GRU, along with four optimizations Nadam, Adamax, AdamW, and Stochastic Gradient Descent with Momentum (SGDM), using hyperparameters and model evaluations not explored in previous studies. It assesses stock price prediction accuracy through metrics like MSE, RMSE, MAE, and MAPE, which help evaluate model error magnitude, accuracy, and the identification of significant prediction inaccuracies. The findings aim to provide reliable stock price predictions, supporting investors in anticipating market trends, managing risks, and optimizing investment strategies in a volatile market. This comprehensive analysis helps investors and market analysts make more informed decisions.

II. Research Methodology

The research process begins with collecting data, specifically stock data of Bank Rakyat Indonesia (BRI) for the past seven years, covering the period from January 1, 2018, to October 30, 2024. Additionally, data from January 1, 2023, to October 30, 2024, is utilized. This information is sourced from Yahoo Finance. Once collected, the data undergoes a pre-processing stage, followed by the creation of time steps to generate a sequence for predicting target values. The time steps are configured at intervals of 10, 20, and 30. The data is divided using the hold-out validation method, with 80% assigned for training and 20% for testing [22]. The training phase involves using Bi-GRU and Stacked GRU algorithms. To enhance model performance, various optimization techniques, including Nadam, Adamax, AdamW, and SGDM, are applied [23]. Further experiments are conducted by adjusting batch sizes, such as (8, 16, and 32) and using learning rates (0.01, 0.001, and 0.0001) to identify the best model configuration. The performance of the model is assessed using metrics such as MSE, RMSE, MAE, and MAPE [24]. The results are compared between the two datasets to determine the model with the highest performance that indicates the better algorithm compared to others., based on the lowest error values. This model is subsequently used to predict BRI stock prices for future periods. A flowchart illustrating this research process is displayed in Figure 1.

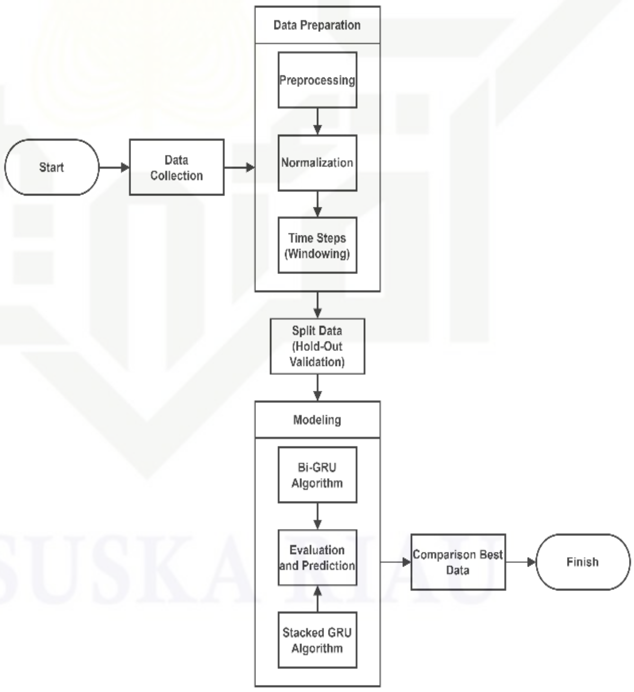

Fig. 1. Research Methodology.

A. Stocks

Stocks are financial instruments that represent a person's ownership in a public company. By purchasing stocks, a person owns a small portion of the company and is entitled to a portion of the profits and potential increase in the company's value [25]. Stocks are traded on the stock market, where the primary goal of market participants is to make a profit. The stock market acts as a key indicator of economic health, showcasing both company performance and the state of the business environment [26].

B. Data Collection

This research analyzes historical stock data of Bank Rakyat Indonesia (BBRI.JK) retrieved from Yahoo Finance using the yfinance library in Python. It examines two data periods: 7 years (2018-2024) and 2 years (2023-2024), chosen to cover market fluctuations before, during, and after the Covid-19 pandemic. The study uses a quantitative approach to validate, process, and analyze the data in a time series format. By comparing long-term and short-term data, the research aims to provide an accurate and in-depth analysis of BBRI stock trends and its resilience to market volatility [9].

C. Bidirectional Gated Recurrent Unit

Bidirectional Gated Recurrent Unit, known as (Bi-GRU) is a variant of Recurrent Neural Networks (RNNs) designed to capture dependencies in sequences by processing information using both directions, such as forward and backward [27]. Sequential data analysis is frequently applied in fields like natural language processing and speech recognition [28]. In the Bi-GRU model, the input sequence is processed by one GRU layer in the forward direction and another in the reverse direction [29]. The architecture used uses the same calculation formulation as the GRU in both directions, the equation is as follows:

$$zt=(Wz\cdot[ht-1,xt]\ ) \quad (1)$$

$$rt=(Wr\cdot[ht-1,xt]) \quad (2)$$

$$h\tilde{t}=\tanh(W\cdot[rt*ht-1,xt] \quad (3)$$

$$ht=(1-zt)*ht-1+zt*h\tilde{t} \quad (4)$$

Where zt represents the update gate, rt denotes the reset gate, $h\tilde{t}$ is the candidate hidden state, ht is the hidden state at time t, xt is the input at time t, and σ refers to the sigmoid function [18].

D. Stacked Gated Recurrent Unit

Stacked GRU is an enhanced version of the GRU model, consisting of multiple GRU layers arranged sequentially [20]. This algorithm, known as the Stacked Gated Recurrent Unit, is another type of artificial neural network designed with multiple GRU layers stacked on top of one another [17]. In this setup, the hidden state from one GRU layer serves as input to the next layer, enabling the model to learn progressively more advanced data representations. Unlike single-layer GRUs, which rely on a single hidden state for final predictions, Stacked GRUs use the hidden states from the final layer for prediction [24].

E. Time Steps

Time steps is an important process in time series analysis, where data is divided into parts or windows. This process allows data to be processed in smaller units, making it easier for machine learning models to understand patterns and trends [21]. By dividing data into windows, we can capture the temporal order of the data, which is key in understanding the dynamics of a system that changes over time [13].

F. Optimizers

Optimizers are functions used in machine learning and deep learning to optimize the objective or loss function [30]. The objective function is what the algorithm aims to optimize, while the loss function measures the model's prediction error. Optimizers update model parameters in small steps, known as gradients, calculated using mathematical formulas [25]. To enhance the effectiveness of algorithms for forecasting time series data, several optimization methods are commonly used, including Stochastic Gradient Descent with Momentum (SGDM), Adam's derivative algorithm such as Adaptive Moment (Nadam), Adamax, and AdamW. SGDM updates the model parameters after each training example, using momentum to accelerate convergence and smooth out oscillations during optimization [27]. Nadam is an efficient method that combines the advantages of Adam and Nesterov momentum, requiring only the first-order gradient while adapting the learning rate based on the first and second moments of the gradient [19]. Variants such as Adamax and AdamW further improve the optimization by exploiting infinite norms and introducing weight decay, respectively, leading to a more effective training process [23].

G. Metrics Evaluation

MAE, MAPE, RMSE, and MSE are metrics used to assess forecasting model accuracy. MAE measures the average absolute difference between predicted and actual values, while MAPE expresses the error as a percentage of the actual value. RMSE and MSE calculate the mean of squared errors, with RMSE emphasizing larger errors due to its square root transformation. These metrics help evaluate model performance by analyzing prediction bias and accuracy [31]. The formulas for MSE, RMSE, MAE, and MAPE are presented in Equations 8-11.

$$MSE = \frac{1}{n}\sum_{i}^{n}(y_i - y_i{\tilde{}})^2 \quad (8)$$

$$RMSE = \sqrt{MSE} = \sqrt{\frac{1}{n}\sum_{i}^{n}(y_i - y_i{\tilde{}})^2} \quad (9)$$

$$MAE = \frac{1}{n}\sum_{i}^{n}|y_i - y_i{\tilde{}}| \quad (10)$$

$$MAPE = \frac{100\%}{n}\sum_{i}^{n}\left|\frac{y_i - y_i{\tilde{}}}{y_i}\right| \quad (11)$$

III. Results And Discussion

This study models Bi-GRU and Stacked-GRU algorithms to predict stock prices, testing various optimization techniques, batch sizes, time steps, and learning rates over 1000 epochs with callbacks for checkpoints and early stopping. Using hold-out validation (80% training, 20% testing), the analysis of 7 years of data showed that the Bi-GRU model, optimized with Nadam at a batch size of 8, time step of 10, and learning rate of 0.001, performed best. It achieved MSE of 7283.1848, RMSE of 85.3416, MAE of 65.0879, and MAPE of 1.2421%. Table 1 shows the modeling results for both algorithms with 10 time steps.

TABLE I. RESULTS AND EVALUATION OF BI-GRU AND STACKED GRU ALGORITHM MODELLING WITH 10 TIME STEPS

			Bi-GRU				**Stacked GRU**			
Optimizer	**Batch Size**	**Learning Rate**	**MSE**	**RMSE**	**MAE**	**MAPE**	**MSE**	**RMSE**	**MAE**	**MAPE**
Nadam	8	0.01	9371.3424	96.8057	75.6273	1.4374	10158.7727	100.7907	74.5000	1.4196
Nadam	8	0.001	7283.1848	85.3416	65.0879	1.2421	8012.7697	89.5141	67.0970	1.2800
Nadam	8	0.0001	11168.4273	105.6808	82.0030	1.5564	14852.7758	121.8720	97.0364	1.8371
Nadam	16	0.01	10005.0303	100.0251	75.8000	1.4456	15273.8636	123.5875	96.3667	1.8233
Nadam	16	0.001	9296.0697	96.4161	72.2758	1.3844	7719.4424	87.8604	66.2182	1.2638
Nadam	16	0.0001	13016.8788	114.0915	86.6303	1.6567	14400.9333	120.0039	91.4303	1.7480
Nadam	32	0.01	8908.4848	94.3848	72.2545	1.3728	8650.8606	93.0100	71.9939	1.3665
Nadam	32	0.001	10099.3212	100.4954	77.2788	1.4690	10218.7758	101.0880	77.9333	1.4795
Nadam	32	0.0001	17901.3606	133.7960	103.1545	1.9709	16486.8818	128.4013	99.1424	1.8918
Adamax	8	0.01	8593.5818	92.7016	71.4667	1.3545	10565.7545	102.7899	75.8394	1.4509
Adamax	8	0.001	9987.2152	99.9361	78.6636	1.4844	8242.4303	90.7878	68.8545	1.3151
Adamax	8	0.0001	14498.5909	120.4101	91.3909	1.7487	15435.3030	124.2389	96.2364	1.8353
Adamax	16	0.01	8342.4455	91.3370	67.9970	1.2986	9046.1000	95.1110	72.0212	1.3723
Adamax	16	0.001	13135.9788	114.6123	88.9182	1.6923	15722.0061	125.3874	99.1879	1.8803
Adamax	16	0.0001	23084.9818	151.9374	116.4000	2.2313	19390.2000	139.2487	106.9333	2.0452
Adamax	32	0.01	11309.9667	106.3483	82.3061	1.5666	10606.9333	102.9900	76.3030	1.4575
Adamax	32	0.001	14363.5424	119.8480	92.6879	1.7668	16741.1121	129.3874	101.7606	1.9336
Adamax	32	0.0001	342725.7121	585.4278	544.4879	10.0292	24641.9242	156.9775	126.5788	2.3880
AdamW	8	0.01	11780.1515	108.5365	86.7879	1.6205	18877.5485	137.3956	105.8879	1.9838
AdamW	8	0.001	9935.6818	99.6779	78.9848	1.4906	9708.5030	98.5317	78.0242	1.4729
AdamW	8	0.0001	10511.2061	102.5242	79.2848	1.5029	111749.6485	108.3958	82.7152	1.5783
AdamW	16	0.01	9853.5667	99.2651	73.6333	1.4079	8582.7455	92.6431	68.5636	1.3078
AdamW	16	0.001	9623.2970	98.0984	76.8303	1.4517	8651.5212	93.0136	70.7879	1.3492
AdamW	16	0.0001	19856.1364	140.9118	105.8152	2.0349	14462.1424	120.2586	93.1182	1.7755
AdamW	32	0.01	8362.6061	91.4473	69.7394	1.3273	9341.6333	96.6521	71.1970	1.3564
AdamW	32	0.001	9870.0879	99.3483	78.0030	1.4751	13344.0667	115.5165	86.9515	1.6640
AdamW	32	0.0001	41188.7848	202.9502	169.2091	3.1406	17059.7242	130.6129	100.4273	1.9188
SGDM	8	0.01	18153.6485	134.7355	104.3515	1.9892	16110.4273	126.9269	99.9545	1.8965
SGDM	8	0.001	25702.3455	160.3195	124.7273	2.3732	17448.8848	132.0942	104.8242	1.9841
SGDM	8	0.0001	1085769.9273	1042.0028	1001.6788	18.5655	1922369.5242	136.4954	137.1242	24.8014
SGDM	16	0.01	22057.3485	148.5172	114.9121	2.1920	15759.8727	125.5383	98.6788	1.8723
SGDM	16	0.001	39541.5242	198.8505	164.7121	3.0833	125879.1667	354.7945	326.1727	6.0293
SGDM	16	0.0001	143033.9636	1114.9143	1072.3212	19.8778	265666.7758	137.2428	187.1636	25.7362
SGDM	32	0.01	20824.1667	144.3058	112.1121	2.1364	16645.3727	129.0169	100.1970	1.9083
SGDM	32	0.001	1450273.1303	1204.2729	1143.6818	21.1030	1409221.8091	187.1065	130.7000	20.8837
SGDM	32	0.0001	157644.2273	1399.1584	1348.7303	25.0139	280607.8727	137.2562	181.2121	29.3420

The next step involves applying the Bi-GRU and Stacked GRU algorithms to 2 years of data. According to the experiments, the Bi-GRU model with Adamax optimization, a batch size of 8, a time step of 30, and a learning rate of 0.01 achieved the best performance. It achieved MSE of 7739.0222, RMSE of 87.9717, MAE of 69.4, and MAPE of 1.4021%.

Based on the analysis of the experiments conducted, the Bi-GRU model with Nadam optimization and time steps of 10, using a batch size of 8 and a learning rate of 0.001, produces the best performance. This is observed when using 7 years of data compared to 2 years of data. This model achieves an MSE of 7283.1848, RMSE of 85.3416, MAE of 65.0879, and MAPE of 1.2421%. Figure 2 shows the predicted outcomes of the Bi-GRU model on the test data. The Bi-GRU model is selected as the optimal model for forecasting stock prices in November 2024. The prediction chart for the Bi-GRU model is presented in Figure 3.

Fig. 2. Stock Price Prediction on Test Data.

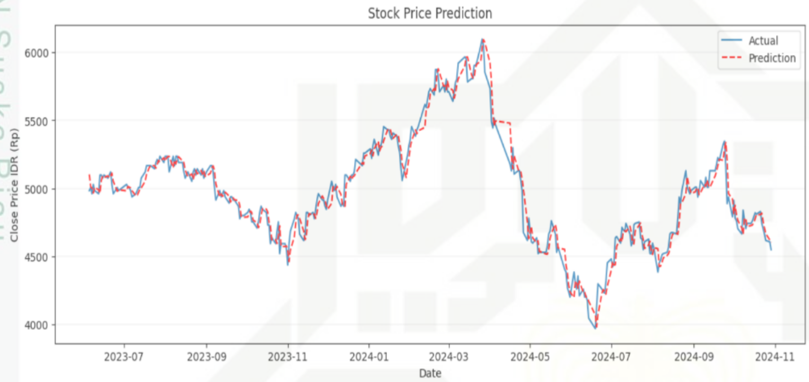

Fig. 3. Stock Price Predictions for Next Month.

The Bi-GRU model surpasses Stacked GRU in stock price prediction due to its bidirectional structure, effectively capturing past and future data dependencies. Optimized with Nadam, batch sizes of 8, 10 timesteps, and a learning rate of 0.001, it balances accuracy, speed, and training stability. Predictions for November 2024, depicted in Figure 3, show a significant downward trend in stock prices toward the year's end, as indicated by the red dotted line.

Stock price prediction faces challenges such as market volatility influenced by external factors, incomplete or anomalous historical data, and the difficulty of selecting models capable of handling the stock market's non-linear complexity. Accurate predictions are crucial for informed decision-making and risk management in financial markets.

This research has successfully compared Bi-GRU and Stacked GRU algorithms for predicting BRI stock price movements, addressing challenges posed by market volatility. By leveraging their ability to handle sequence data and temporal patterns, the study aims to improve prediction accuracy in the banking sector, which is known for its liquidity and stability. The results of this study indicate that Bi-GRU outperforms Stacked GRU in terms of prediction accuracy.

This research builds upon the previous work of Rahmadeyan and Mustakim (2023), which utilized LSTM and GRU algorithms for stock price prediction. In their study, they implemented optimizers such as Stochastic Gradient Descent (SGD), Adaptive Moment Estimation (Adam), and Root Mean Square Propagation (RMSprop) to improve model performance [26]. By extending their work, this research explores the potential of Bi-GRU and Stacked GRU, providing a comparative perspective on their effectiveness in handling market volatility and delivering accurate predictions. Additionally, this study incorporates advanced Adam-based optimizers, including Nadam, Adamax, AdamW, and SGDM, to further refine model performance. This continuation aims to enhance deep learning-based approaches, contributing to stock market prediction and supporting informed financial decision-making.

IV. Conclusion

This research addresses a gap in stock price prediction literature by comparing the performance of Bi-GRU and Stacked GRU algorithms in predicting Bank Rakyat Indonesia (BRI) stock price movements, specifically in the Indonesian banking sector. While Bi-GRU and Stacked GRU have been applied in various domains, this study uniquely focuses on their comparative effectiveness in financial forecasting. The results demonstrate that Bi-GRU, optimized with Nadam, batch size 8, time step 10, and learning rate 0.001, outperforms Stacked GRU in MSE, RMSE, MAE, and MAPE evaluations, confirming its superiority in capturing complex temporal patterns. Additionally, the study highlights the critical role of data range, showing that longer datasets (7 years) result more accurate predictions than shorter ones (2 years). Predictions for November 2024 indicate a significant stock price decline toward the year's end. By offering data-driven recommendations for efficient model selection and emphasizing parameter optimization, this research provides valuable insights for investors and market analysts, contributing to the development of more reliable stock price prediction systems and supporting informed investment decisions in volatile markets.

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LAMPIRAN A

POSTER KEGIATAN

IEEE INDONESIA SECTION ICADEIS

Application of Bidirectional Gated Recurrent Unit and Stacked Gated Recurrent Unit Algorithms for Stock Price Prediction

Stocks offer ownership rights and profits, attracting investors despite their risks. This study predicts BBRI stock prices using deep learning models—Bi-GRU and Stacked GRU—known for analyzing complex time series patterns. Data from 2018–2024 and 2023–2024 were processed and split (80:20) for training and testing. Bi-GRU optimized with Nadam (batch size 8, learning rate 0.001) delivered the best results (MSE: 7283.18, RMSE: 85.34, MAE: 65.09, MAPE: 1.24%). Predictions show a decline in November 2024, offering insights for better market decisions.

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Introduction

Investments, including stocks, offer significant returns but come with high risks. Stocks are preferred over cryptocurrencies due to better stability, regulation, and transparency. Among stock sectors, banking, especially Bank Rakyat Indonesia (BRI), is favored for its high liquidity and growth potential.

BBRI shares, with the highest market capitalization among state-owned banks, attract investors due to their inclusion in the LQ45 index and performance stability. Predicting stock prices is challenging due to volatility, requiring advanced methods like deep learning. This study employs Bidirectional Gated Recurrent Unit (Bi-GRU) and Stacked Gated Recurrent Unit (Stacked GRU) to process time-series data, addressing the complexities of stock price forecasting.

Evaluation Metrics Analysis

The Bi-GRU model demonstrated superior performance across various metrics, emphasizing its ability to handle time-series data effectively. Key evaluation results include:

- MSE: Measures the average squared error, with Bi-GRU achieving the lowest at 7283.18.
- RMSE: Highlights significant prediction deviations, where Bi-GRU recorded 85.34.
- MAE: Indicates the average error magnitude, with Bi-GRU scoring 65.08.
- MAPE: Expresses error as a percentage of actual values, showing Bi-GRU's accuracy at 1.24%.

Objective

This study aims to predict the stock prices of Bank Rakyat Indonesia (BBRI) using Bidirectional Gated Recurrent Unit (Bi-GRU) and Stacked Gated Recurrent Unit (Stacked GRU) algorithms. The research evaluates the performance of these models using optimization techniques (Nadam, Adamax, AdamW, SGDM) and metrics like MSE, RMSE, MAE, and MAPE, focusing on datasets spanning 2 and 7 years to identify the best-performing algorithm and configuration for accurate stock price forecasting.

Methodology

This research employs the following steps:

1.Data Collection: Stock price data of Bank Rakyat Indonesia (BBRI) from 2018–2024 and 2023–2024, sourced via Yahoo Finance, processed into time-series format.

2.Data Preprocessing: Creating time steps (10, 20, 30) and splitting the dataset using an 80:20 train-test ratio.

3.Modeling: Implementing Bi-GRU and Stacked GRU algorithms with variations in optimizers (Nadam, Adamax, AdamW, SGDM), batch sizes (8, 16, 32), and learning rates (0.01, 0.001, 0.0001).

4.Evaluation: Performance evaluated using MSE, RMSE, MAE, and MAPE metrics to determine the best model.

Conclusion

This research successfully compares the performance of Bidirectional Gated Recurrent Unit (Bi-GRU) and Stacked Gated Recurrent Unit (Stacked GRU) algorithms in predicting the stock prices of Bank Rakyat Indonesia (BBRI). The Bi-GRU model, optimized with Nadam, batch size 8, time step 10, and learning rate 0.001, outperformed Stacked GRU, achieving the best metrics with MSE 7283.18, RMSE 85.34, MAE 65.08, and MAPE 1.24%.

The study highlights the importance of using longer datasets (7 years) for improved prediction accuracy. These findings provide valuable insights for investors and market analysts, enabling more informed investment decisions and better risk management strategies.

Related Literature

1. Effectiveness of GRU Variants
Bidirectional Gated Recurrent Unit (Bi-GRU) and Stacked Gated Recurrent Unit (Stacked GRU) have shown significant performance in handling sequential data. Research by Chen et al. (2021) demonstrated Bi-GRU's capability to capture spatial and temporal features efficiently, while studies by Yang et al. (2022) and Diqi et al. (2023) highlighted Stacked GRU's ability to produce low RMSE and MAE values in applications such as weather and electricity load forecasting.
2. Algorithm Optimization
Optimization techniques such as Nadam, Adamax, AdamW, and SGDM have been widely applied to improve the performance of deep learning algorithms. Sharma et al. (2022) found Nadam effective in enhancing convergence, while Adamax and AdamW showed robustness in various time-series forecasting tasks.
3. Metrics Evaluation
MSE, RMSE, MAE, and MAPE are crucial metrics for assessing model performance. Studies such as those by Dong et al. (2021) and Priyatno et al. (2024) emphasize these metrics' role in ensuring model reliability and accuracy, particularly in predicting complex stock price trends.
4. Applications in Stock Prediction
Previous research has applied GRU variants in financial forecasting. Duan et al. (2023) compared Bi-GRU with other algorithms, highlighting its superiority in stock price prediction. Similarly, Yang et al. (2022) demonstrated the advantages of Stacked GRU in capturing long-term dependencies in sequential data

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Congratulations - your paper #1571097772 ('Application of Bidirectional Gated Recurrent Unit and Stacked Gated Recurrent Unit Algorithms for Stock Price Prediction') for ICADEIS 2025 has been **accepted** and will be presented in the session titled __.

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4. Please clarify the data collection method used
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Relevancy to Scope:: Is the paper relevant to the conference's scope and themes?

Yes (1)

Methodology: Is the methodology appropriate and well-documented?

Good (3)

Results and Discussion: Are the results clear and the discussion insightful?

Average (2)

Recommendation: Do you recommend this paper for acceptance?

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Regards,
The conference chairs

LAMPIRAN D

INSTRUKSI PENYERAHAN MAKALAH AKHIR

NASYA AMIRAH MELYANI SISTEM INFORMASI <12150323859@students.uin-suska.ac.id>

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Best regards,

DAFTAR RIWAYAT HIDUP

Nasya Amirah Melyani, lahir di Pekanbaru pada tanggal 30 April 2003. Peneliti merupakan anak pertama dari Papa Nasrul dan Mama Firda Yanti. Peneliti bertempat tinggal di Kelurahan Pematang Reba, Kecamatan Rengat Barat, Kabupaten Indragiri Hulu, Provinsi Riau. Pada tahun 2015 peneliti berhasil menyelesaikan pendidikan di SDN 026 Pematang Reba, kemudian melanjutkan pendidikan ke SMPN 1 Rengat Barat dan lulus pada tahun 2018. Setelah tamat dari tingkatan sebelumnya, peneliti langsung memutuskan untuk melanjutkan ke SMAN Plus Provinsi Riau dan berhasil lulus pada tahun 2021. Setelah menyelesaikan pendidikan dibangku sekolah, peneliti melanjutkan pendidikan Strata Satu (S1) di Universitas Islam Negeri Sultan Syarif Kasim Riau, tepatnya Fakultas Sains dan Teknologi, Program Studi Sistem Informasi pada tahun 2021. Peneliti tergabung dengan organisasi riset yaitu *Puzzle Research Data Technology* (Predatech). Saat menempuh masa perkuliahan, peneliti melakukan Kuliah Kerja Nyata (KKN) di Desa Titian Resak, Kecamatan Rengat Barat, Kabupaten Indragiri Hulu, Provinsi Riau. Peneliti berhasil menyelesaikan pendidikan Strata Satu (S1) dengan judul penelitian "Penerapan Algoritma *Bidirectional Gated Recurrent Unit* dan *Stacked Gated Recurrent Unit* Untuk Prediksi Harga Saham". Untuk menjalin komunikasi yang baik dengan peneliti, dapat menghubungi peneliti melalui *e-mail* 12150323859@students.uin-suska.ac.id.