



UNDERGRADUATE THESIS

**BITCOIN PRICE MOVEMENT PREDICTION
BASED ON ON-CHAIN DATA USING THE BILSTM
METHOD**

GAMAR RAMADHANI MALIK
NPM 22081010229

THESIS ADVISORS

Dr. Rizky Parlika, S.Kom., M.Kom.
Dr. Ir. Kartini, S.Kom., M.T.

**MINISTRY OF HIGHER EDUCATION, SCIENCE, AND TECHNOLOGY
UNIVERSITAS PEMBANGUNAN NASIONAL VETERAN JAWA TIMUR
FACULTY OF COMPUTER SCIENCE
INFORMATICS STUDY PROGRAM
SURABAYA
2026**

APPROVAL SHEET

Bitcoin Price Movement Prediction Based on On-Chain Data Using the BiLSTM Method

By:

GAMAR RAMADHANI MALIK

NPM. 22081010229

Has been defended before, and accepted by, the Board of Assessors of the Thesis Examination of the Informatics Study Program, Faculty of Computer Science, Universitas Pembangunan Nasional Veteran Jawa Timur, on June 8, 2026:

Approved,

Dr. Rizky Parluka, S.Kom., M.Kom.

NIP. 19840518 202121 1 003



(Advisor I)

Dr. Ir. Kartini, S.Kom., M.T.

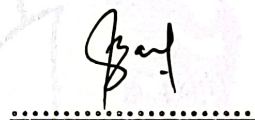
NIP. 19611110 199103 2 001



(Advisor II)

Made Hanindia Prami S, S.Kom., M.Cs.

NIP. 19890205 201803 2 001



(Head Assessor)

Eka Prakarsa Mandyartha, S.T., M.Kom.

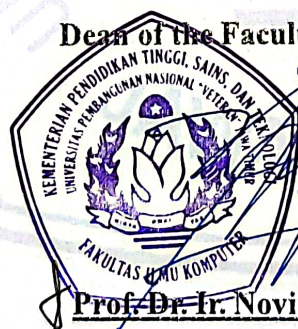
NIP. 19880525 201803 1 001



(Assessor I)

Acknowledge by,

Dean of the Faculty of Computer Science



Prof. Dr. Ir. Novirina Hendrasarie, MT.

NIP. 19681126 199403 2 001

APPROVAL SHEET

**Bitcoin Price Movement Prediction Based on On-Chain Data Using the
BiLSTM Method**

By:

GAMAR RAMADHANI MALIK

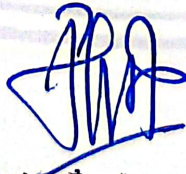
NPM. 22081010229

Approved to proceed to the Thesis

Approved by,

Coordinator of Informatics Study Program

Faculty of Computer Science



Dr. Intan Yuniar Purbasari, S.Kom. MSc.

NIP. 19800602 202521 2 029

STATEMENT OF ORIGINALITY

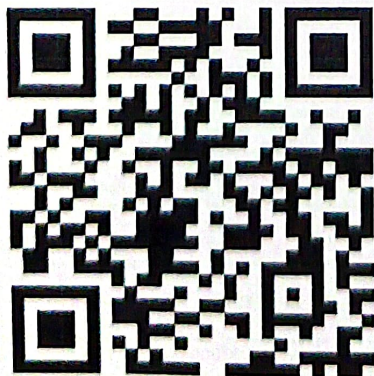
I am the undersigned:

Student Name : Gamar Ramadhani Malik
NPM : 22081010229
Degree Program : Sarjana (S1)
Study Program : Informatika
Faculty : Ilmu Komputer

Hereby declares that this undergraduate thesis contains no part of any other scientific work that has been submitted to obtain an academic degree at any higher education institution. Furthermore, it does not contain any work or opinions previously written or published by others, except for those which are explicitly cited in this thesis and listed completely in references.

And I declare that this scientific document is free from elements of plagiarism. If in the future indications of plagiarism are found in this Thesis, I am willing to accept sanctions in accordance with the applicable laws and regulations.

Thus, I made this statement without any coercion from anyone and to be used as it should.



Surabaya, June 08, 2026
Declarant,



GAMAR RAMADHANI MALIK
NPM. 22081010229

ABSTRACT

Student Name/NPM : Gamar Ramadhani Malik / 22081010229
Thesis Title : Bitcoin Price Movement Prediction Based on On-Chain Data Using the BiLSTM Method
Advisor : 1. Dr. Rizky Parlita, S.Kom., M.Kom.
2. Dr. Ir. Kartini, S.Kom., M.T.

Bitcoin is a decentralized cryptocurrency built on Blockchain technology that exhibits extremely high price volatility, making it difficult for investors to make sound investment decisions. This study aims to develop a Bitcoin price prediction model using the Bidirectional Long Short-Term Memory (BiLSTM) method based on on-chain data, including transaction volume, tx_count, active_spending_addresses, and fee_btc. The BiLSTM approach was chosen for its ability to process time series data bidirectionally, making it more effective at capturing extreme volatility patterns compared to conventional LSTM. The dataset was obtained from BigQuery and underwent preprocessing stages including data transformation, normalization, data splitting, and sequence formation. Experiments were conducted by varying the data split ratio, learning rate, and number of hidden layers. The optimal model was achieved using a 2-hidden-layer architecture, a learning rate of 0.0001, and a 90:10 data split, yielding MAE of 932.61, RMSE of 1,257.07, and MAPE of 0.97% classified as a highly accurate prediction. The model was subsequently deployed as a Flask-based web application in the form of an interactive single-page dashboard, enabling users to upload datasets, execute price forecasts, and visualize market analysis results in a unified interface.

Keyword: Bitcoin, BiLSTM, Data On-Chain, Forecasting, Deep Learning

ACKNOWLEDGEMENTS

All praise and gratitude be to Allah SWT for His endless blessings, guidance, and mercy, which have enabled the author to successfully complete this undergraduate thesis titled "Bitcoin Price Movement Prediction Based on On-Chain Data Using the BiLSTM Method".

Within the pages of this thesis, the author wishes to deeply embed a sense of utmost gratitude for the support, guidance, life lessons, and love provided by those who have contributed to the author's journey, rendering their impact timeless within this foreword. Therefore, on this profound occasion, the author proudly dedicates this work to:

1. Prof. Dr. Ir. Novirina Hendrasarie, M.T., as the Dean of the Faculty of Computer Science, Universitas Pembangunan Nasional "Veteran" Jawa Timur.
2. Dr. Intan Yuniar Purbasari, S.Kom., MSc., as the Head of the Informatics Study Program, Faculty of Computer Science, Universitas Pembangunan Nasional "Veteran" Jawa Timur.
3. Dr. Rizky Parluka, S.Kom., M.Kom., as the First Advisor, who has generously spared his time to provide invaluable guidance, direction, and motivation throughout this research.
4. Dr. Ir. Kartini, S.Kom., M.T., as the Second Advisor, who has provided incredible mentorship, constructive feedback, and relentless motivation during the preparation of this thesis.
5. Made Hanindia Prami Swari, S.Kom., M.Cs., as the Head Assessor, for her valuable direction and evaluation toward the perfection of this manuscript.
6. Eka Prakarsa Mandyartha, S.T., M.Kom., as a Assessor, for providing significant inputs and guiding the author through the finalization of this thesis.
7. All Lecturers and Staff of the Informatics Study Program, Faculty of Computer Science, Universitas Pembangunan Nasional "Veteran" Jawa

Timur, who have equipped the author with knowledge, experience, and extraordinary learning opportunities throughout his academic years.

8. The author's beloved family, my Father and Mother, who have unconditionally poured out their prayers, affection, and immense moral as well as material support debts of love that are far too vast to ever be repaid. Deepest thanks also go to my older sister, Ghina Malikah Malik, for providing the foundational direction at the start of this thesis-writing journey, as well as for her constant support through prayers and words of encouragement before every examination.
9. My college friends found midway through my studies, Achmad Yusuf, Alief Putra, Pramudya Kumala, Rafie Anjasmara, and Rangga Agni, who heavily accompanied the author during the remainder of my university life, and crucially helped the author maintain my sanity throughout the compilation of this thesis. The author is deeply grateful to walk alongside you all, and hopes your paths are always eased by his grace.
10. Denanera Imana Unsa, whose presence held immense importance in the author's writing process. Thank you for contributing your energy, time, companionship, support, and for comforting the author whenever exhaustion kicked in, as well as for constantly convincing the author to never give up until this thesis finally came to fruition.
11. Agung Sukmaazi and Dimas Aswito, the author's steadfast best friends from the very beginning until the completion of this thesis. Thank you for the shared stories and for braving the dynamic tides of life together. The author holds only one true wish: to go on a vacation together as a trio for the very first time and last time. Thank you, because the presence of both of you is profoundly essential in the author's life.
12. Heaven, Silvi, Evando, Diva, Khaela, and Aulia, who have been present since the very beginning of the author's educational journey up to the completion of this work. Thank you to one of you, because of a book by the purple squid author, we were able to know each other deeply. Thank you for once being physically present to sit together, for

accompanying me in complete silence, and for ensuring the author never had to walk alone. And thank you, for your souls have never truly departed, even when your physical forms can no longer be reached. There are things that do not need to be spoken to be felt. And the author, to this very day, still feels them deeply.

13. Lastly, to myself though I am writing this at the very end, it by no means carries the least significance. Rather, it is precisely here that I uncovered the most profound lesson: that loving myself is a truth that I must never neglect. This realization was gifted to me by someone who once stepped into my life and gently taught me to make peace with myself, a grace for which I remain boundlessly grateful. Therefore, with all my heart, I wish to deeply thank myself for enduring, for relentlessly fighting, and for finally arriving at this monumental milestone. This is not the ultimate end, but rather the threshold and opening gateway to my true journey ahead. And to anyone who has ever crossed paths along my journey to those who once stood as my companions, even if our roads have now drifted apart thank you. For every single encounter, no matter how small, has unalterably guided and shaped me into the person I am today.

The author fully realizes that this thesis is still far from perfection and inherently contains limitations. Therefore, constructive criticism and structural suggestions from all parties are highly anticipated for future improvements. Ultimately, despite all limitations, the author sincerely hopes that this thesis will yield genuine benefits for the readers in general and for the author in particular.

Surabaya, June 08th 2026

Author

TABLE OF CONTENTS

APPROVAL SHEET	ii
APPROVAL SHEET	iii
STATEMENT OF ORIGINALITY	iv
ABSTRACT	v
ACKNOWLEDGEMENTS.....	vi
TABLE OF CONTENTS.....	ix
LIST OF FIGURES	xiii
LIST OF TABLES.....	xv
LIST OF SOURCE CODES.....	xvi
LIST OF ATTACHMENTS.....	xvii
1.1 Backgroud of the Study.....	1
1.2 Problem Formulation	4
1.3 Objective of the Research	4
1.4 Significance of the Study	4
1.5 Scope and Limitations.....	5
CHAPTER II LITERATURE REVIEW	6
2.1 Previous Research	6
2.2 Blockchain.....	7
2.3 Bitcoin.....	7
2.4 Forecasting	8
2.5 Time Series.....	8
2.6 TensorFlow.....	9
2.7 Long Short-Term Memory	9
2.7.1 Forget Gate.....	11

2.7.2 Input Gate	11
2.7.3 Output Gate	12
2.7.4 Cell Gate.....	13
2.8 BiLSTM.....	14
2.9 Optimizer.....	15
2.10 Measurement of Error Values	16
2.10.1 Mean Absolute Error (MAE).....	16
2.10.2 Root Mean Square Error (RMSE)	17
2.10.3 Mean Absolute Percentage Error (MAPE)	17
2.11 Flask.....	18
2.12 Research Gap Penelitian.....	19
CHAPTER III METHODOLOGY	21
3.1 Case Study Description and Its Urgency	21
3.2 Research Stages	22
3.3 Literature Study	24
3.4 Analysis and Design	24
3.5 Dataset Collection	26
3.6 Data Preprocessing	27
3.6.1 Data Transformation.....	28
3.6.2 Split Data	29
3.6.3 Data Normalization.....	30
3.6.4 Data Sequences.....	31
3.7 BiLSTM Model Development.....	32
3.7.1 BiLSTM Layer Configuration	32
3.7.2 Baseline Hyperparameter Settings.....	34
3.7.3 Trainig Model	37

3.7.4 Model Prediction	39
3.7.5 Model Evaluation	40
3.7.6 Plotting Results	40
3.8 Experimental Scenarios.....	41
3.9 Trading Backtesting Strategy	42
3.10 System Design.....	44
CHAPTER IV RESULTS AND DISCUSSION	48
4.1 Import Package.....	48
4.2 Dataset Collection	49
4.3 Data Preprocessing.....	51
4.3.1 Data Transformation	51
4.3.2 Split Data.....	54
4.3.3 Data Normalization	55
4.3.4 Data Sequences	57
4.4 BiLSTM Model Development	59
4.4.1 Set Layer BiLSTM and Baseline Hyperparameter	60
4.4.2 BiLSTM Model Training	61
4.4.3 Model Prediction.....	63
4.4.4 Evaluation of Results	65
4.4.5 Plotting Results	67
4.5 Experimental Results and Analysis	69
4.5.1 Split Data Experiments	69
4.5.2 Learning Rate Experiments.....	73
4.5.3 Hidden Layer Experiments	78
4.6 Final Experimental Results and Model Comparison	83
4.7 Trading Backtesting Performance Analysis	84

4.8 Web Based Application Implementation	87
CHAPTER V CONCLUSION AND RECOMMENDATION	91
5.1 Conclusion.....	91
5.2 Recommendations	92
REFERENCES	93
ATTACHMENTS	98

LIST OF FIGURES

Figure 2. 1 RNN and LSTM Architecture[3]	10
Figure 2. 2 Architecture LSTM[3], [30].....	10
Figure 2. 3 BiLSTM Architecture Model[38]	14
Figure 3. 1 Research Stages	21
Figure 3. 2 Analysis and Design	25
Figure 3. 3 Data Preprocessing Flowchart	27
Figure 3. 4 Flowchart BiLSTM Devoplment.....	32
Figure 3. 5 Example of Resulting Plotting.....	41
Figure 3. 6 System Design Wireframe	45
Figure 4. 1 Dataset Acquisition Results	51
Figure 4. 2 Data Transformation	53
Figure 4. 3 Data Type Verification Change.....	53
Figure 4. 4 Data Splitting Results	55
Figure 4. 5 Data Sequences Output Results.....	59
Figure 4. 6 BiLSTM Model Training Terminal Output	63
Figure 4. 7 Model Prediction Computational Process	64
Figure 4. 8 BiLSTM Model Evaluation Metric Output	66
Figure 4. 9 BiLSTM Actual vs Predicted Price Chart.....	68
Figure 4. 10 Evaluation Results for the 70:20 Data Split	70
Figure 4. 11 Evaluation Results for the 80:20 Split Data.....	71
Figure 4. 12 Evaluation Results for the 90:10 Split Data	71
Figure 4. 13 Actual Price vs. Predicted Price Chart under a 90:10 Split Data.....	73
Figure 4. 14 Evaluation Results for Learning Rate 0.01	74
Figure 4. 15 Evaluation Results for Learning Rate 0.001	75
Figure 4. 16 Evaluation Results for Learning Rate 0.0001	76
Figure 4. 17 Actual Price vs. Predicted Price Chart under a 0.0001 Learning Rate	78
Figure 4. 18 Evaluation Results for 2 Hidden Layers.....	79
Figure 4. 19 Evaluation Results for 3 Hidden Layers	80
Figure 4. 20 Evaluation Results for 4 Hidden Layers.....	81

Figure 4. 21 Actual Price vs. Predicted Price Chart under 2 Hidden Layers Configuration.....	82
Figure 4. 22 Portfolio Cumulative Returns Comparison in the Backtesting Simulation.....	86
Figure 4. 23 Comprehensive System Dashboard Web Interface	87
Figure 4. 24 Header Section and Primary Indicator Panel	88
Figure 4. 25 Dataset Upload Gateway Component	88
Figure 4. 26 Interactive Market Analysis Charting Panel	89
Figure 4. 27 Model Evaluation Metrics Display Panel	90

LIST OF TABLES

Table 2. 1 Criteria for MAPE Values[44].....	18
Table 3. 1 Dataset On-Chain	27
Table 3. 2 Data Transformation.....	28
Table 3. 3 Number of Data Training and Test	30
Table 3. 4 Data Before and After Normalization	30
Table 3. 5 Sequence Data	31
Table 3. 6 BiLSTM Layers Sturcture	33
Table 3. 7 Optimization Components.....	34
Table 3. 8 Learning Rate Settings	35
Table 3. 9 Hidden Layer Settings	36
Table 3. 10 Hyperparameter Matrix Overview	37
Table 3. 11 Baseline Hyperparameter Experimental Scenarios	41
Table 3. 12 Metric Measurements for Backtesting	43
Table 4. 1 Dataset Before Normalization	56
Table 4. 2 Dataset After Normalization.....	56
Table 4. 3 Split Data Experimental Scenarios.....	69
Table 4. 4 Summary of Experimental Results for Split Data.....	72
Table 4. 5 Learning Rate Experimental Scenarios	74
Table 4. 6 Summary of Experimental Results for Learning Rate	76
Table 4. 7 Hidden Layer Experimental Scenarios.....	79
Table 4. 8 Summary of Experimental Results for Hidden Layer.....	81
Table 4. 9 Comparative Training Results under the Optimal Configuration Framework	83
Table 4. 10 Financial Performance Metrics for Simulated Trading Strategies	85

LIST OF SOURCE CODES

Program Code 1: Import Package.....	48
Program Code 2: Dataset Acquisition	50
Program Code 3: Data Transformation.....	52
Program Code 4: Split Data.....	54
Program Code 5: Data Normalization	55
Program Code 6: Data Sequences	57
Program Code 7: BiLSTM Architecture Configuration	60
Program Code 8: BiLSTM Model Training Execution	62
Program Code 9: BiLSTM Model Prediction Execution	64
Program Code 10: BILSTM Performance Evaluation Metric.....	65
Program Code 11: Visualization Plotting	67

LIST OF ATTACHMENTS

Attachemt 1. LoA and article SINTA 4.....	98
Attachment 2. Article SANTIKA.....	100

