



UNDERGRADUATE THESIS

BITCOIN PRICE PREDICTION USING SVR OPTIMIZED WITH BAYESIAN OPTIMIZATION

WAHYUDI
NPM 21081010100

THESIS ADVISORS

Dr. Rizky Parluka, S.Kom, M.Kom.
Yisti Vita Via, S.ST, M.Kom.

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 PREDICTION USING SVR OPTIMIZED WITH BAYESIAN OPTIMIZATION

By:
WAHYUDI
NPM. 21081010100

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 12, 2026:

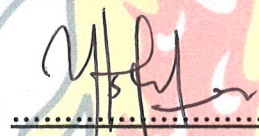
Approved,

Dr. Rizky Parlika, S.Kom, M.Kom
NIP. 19840518 202121 1 003



(Advisor I)

Yisti Vita Via, S.ST., M.Kom.
NIP. 19860425 202121 2 001



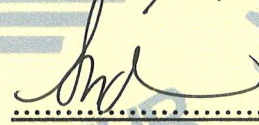
(Advisor II)

Dr. Firza Prima Aditiawan, S.Kom., MTI
NIP. 19860523 202121 1 003



(Head Assessor)

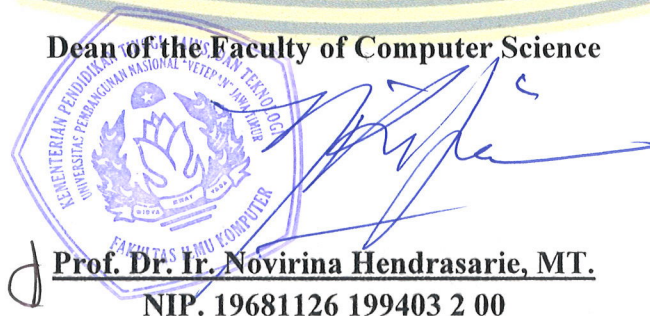
Andreas Nugroho Sihananto, S.Kom., M.Kom.
NIP. 19900412 202406 1 003



(Assessor I)

Acknowledge by,

Dean of the Faculty of Computer Science



Prof. Dr. Ir. Novirina Hendrasarie, MT.
NIP. 19681126 199403 2 00

APPROVAL SHEET

BITCOIN PRICE PREDICTION USING SVR OPTIMIZED WITH BAYESIAN OPTIMIZATION

By:
WAHYUDI
NPM. 21081010100

Approved to proceed to the Thesis Examination



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

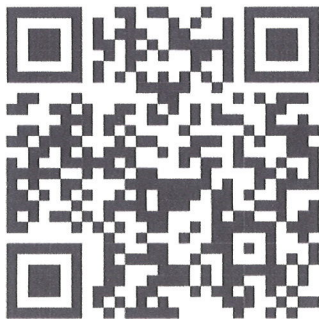
I am the undersigned:

Student Name : Wahyudi
NPM : 21081010100
Degree Program : Bachelor (S1)
Study Program : Informatics
Faculty : Faculty of Computer Science

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, July 17, 2026
Declarant,



WAHYUDI
NPM. 21081010100

ABSTRACT

Student Name / NPM: Wahyudi / 21081010100
Thesis title: Bitcoin Price Prediction Using SVR Optimized with Bayesian Optimization
Supervisor: 1. Dr. Rizky Parlika, S.Kom, M.Kom.
2. Yisti Vita Via, S.ST, M.Kom.

With the world's largest market capitalization, Bitcoin exhibits strong heteroscedasticity and sharp price movements. The non-linear relationship between market variables and sharp price movements make conventional methods less effective in generating accurate predictions. Using hourly historical data (OHLCV) obtained from the Binance API from November 27, 2020, to November 26, 2025, this study employed a Support Vector Regression (SVR) approach with a Radial Basis Function (RBF) kernel automatically optimized through Bayesian Optimization. Testing was conducted using a chronological, multilevel data partitioning scheme, with 64% for training data, 16% for validation data, and 20% for test data. Meanwhile, model evaluation was conducted over three prediction horizons: 1 day (24 hours), 3 days (72 hours), and 7 days (168 hours) in the future to assess the model's accuracy and overall performance. Experimental results show that the SVR model optimized with Bayesian Optimization consistently outperforms the conventional Grid Search method across all time horizons. At the 1-day horizon, Bayesian Optimization successfully reduced the Mean Absolute Percentage Error (MAPE) by 34.46% to 1.94% and increased the coefficient of determination (R^2) to 0.9480 compared to Grid Search. The most significant performance improvement in explaining data variability occurred at the 3-day horizon with an 11.97% jump in R^2 to 0.8904.

Keywords: Bitcoin, Support Vector Regression, Bayesian Optimization, Cryptocurrency, Machine Learning, Prediction.

ACKNOWLEDGEMENTS

Praise be to Allah SWT for all His graces, guidance, and gifts to the author so that the thesis proposal with the title **"Bitcoin Price Prediction Using SVR Optimized with Bayesian Optimization "** can be completed properly.

The author would like to thank Mr. Dr. Rizky Parlika, S.Kom, M.Kom. as Supervisor I and Mrs. Yisti Vita Via, S.ST., M.Kom. as Supervisor 2 who are willing to take their time to provide guidance, advice and motivation to the author. In addition, during the preparation of the thesis proposal, the author also received a lot of assistance from various parties. For this the author would like to thank the:

1. Mrs. Prof. Dr. Ir. Novirina Hendrasarie, M.T. as the Dean of the Faculty of Computer Science, UPN "Veteran" Jawa Timur.
2. Dr. Intan Yuniar Purbasari, S.Kom. MSc. as the Coordinator of Informatics Study Program, Faculty of Computer Science, UPN "Veteran" Jawa Timur.
3. Lecturers of the Informatics Departement, UPN "Veteran" Jawa Timur for their guidance during the author's education.
4. My dearest Mother, who has always played an important role in the writer's journey, always provides support, both material and mental. It's always a place to go back when the writer feels tired. Always present with his best prayers, being a source of strength that never goes out, the writer can survive until now.
5. My dearest Father, who taught to be someone who was responsible, worked hard, and did not give up easily. His advice and examples are an important foundation for the author in undergoing each process with determination.

The author realizes that in the preparation of the following thesis there are many shortcomings. For this reason, constructive criticism and suggestions from all parties are highly expected for the perfection of writing the following thesis. Finally, with all the limitations that the author has, hopefully the following report can be useful for all parties in general and the author in particular.

Surabaya, July 17th 2026

LIST OF CONTENTS

APPROVAL SHEET	iii
APPROVAL SHEET	v
STATEMENT OF ORIGINALITY	vii
ABSTRACT	ix
ACKNOWLEDGEMENTS.....	xi
LIST OF CONTENTS	xiii
LIST OF TABLES.....	xvi
LIST OF FIGURES.....	xvii
CHAPTER I INTRODUCTION.....	1
1.1 Background	1
1.2 Problem Formulation	4
1.3 Research Objectives	4
1.4 Benefits of Research	5
1.5 Problem Limitations.....	5
CHAPTER II LITERATURE REVIEW	6
2.1 Previous Research	6
2.2 Bitcoin and Crypto Markets	12
2.3 Prediction	14
2.4 Support Vector Regression (SVR).....	16
2.4.1 Basic Regression Functions	17
2.4.2 Primal Optimization Formulation	17
2.4.3 Dual and Support Vector Formulations	18
2.4.4 Bias Calculation	19
2.4.5 Kernel Functions	19
2.4.6 Slack Variables and ϵ -tubes	20
2.5 Bayesian Optimization	20
2.5.1 Initialization and Initial Evaluation Stage.....	21
2.5.2 Objective Function Modeling Using TPE.....	21
2.5.3 Exploration and Exploitation through Acquisition Function	22
2.5.4 Evaluation of Selected Parameter Points and Model Update.....	23

2.5.5 Iterative Process and Termination Criteria	23
2.6 SVR Optimization with Bayesian Optimization	24
2.7 Dataset.....	26
2.8 Data Preprocessing	28
2.8.1 Target Shifting	28
2.8.2 Data Cleaning.....	28
2.8.3 Dataset Splitting	29
2.8.4 Data Normalization	29
2.9 Model Evaluation	30
2.9.1 Mean Absolute Error (MAE)	30
2.9.2 Root Mean Squared Error (RMSE).....	31
2.9.3 Mean Absolute Percentage Error (MAPE).....	31
2.9.4 Coefficient of Determination (R^2).....	31
2.9.5 Relevance of Using Evaluation Metrics.....	32
CHAPTER III RESEARCH METHODOLOGY	33
3.1 Research Flow	33
3.2 Dataset Collection	35
3.3 Data Preprocessing	36
3.4 Implementation of Support Vector Regression on Bitcoin Dataset.....	41
3.4.1 Initializing Model Parameters	43
3.4.2 Determination of Support Vector Feature Vectors	43
3.4.3 Kernel Function Calculation	43
3.5 Bayesian Optimization for SVR Parameter Optimization	46
3.5.1 Initial Initialization and Evaluation of Objective Function.....	48
3.5.2 Modeling with TPE and Acquisition Function.....	48
3.6 Model Evaluation	50
3.6.1 Mean Absolute Error (MAE)	51
3.6.2 Root Mean Squared Error (RMSE).....	51
3.6.3 Coefficient of Determination (R^2).....	52
3.6.4 Mean Absolute Percentage Error (MAPE).....	53
3.6.5 Multi-Horizon Prediction Evaluation.....	54
3.7. Testing Scenario	54

3.7.1 Testing Scenario I: Selection of the Best Training Data Proportion	55
3.7.2 Test Scenario II: Coarse-to-Fine Hyperparameter Optimization	56
3.7.3 Test Scenario III: Model Comparison Evaluation.....	57
CHAPTER IV RESULTS AND DISCUSSION	58
4.1 Program Implementation and Data Pre-processing.....	58
4.1.1 Library Calling and Dataset Loading	58
4.1.2 Target Shifting for Multi-Horizon	60
4.1.3 Data Splitting Strategy	61
4.1.4 Min-Max Scaling Normalization	62
4.2 Selecting the Best Split Ratio.....	63
4.3 Hyperparameter Tuning with Grid Search	71
4.3.1 Validation Data Splitting Configuration.....	71
4.3.2 Grid Search Parameter Search Space	72
4.3.3 Results of Selecting the Best Hyperparameters	73
4.4 Optimization with Bayesian Optimization.....	78
4.4.1 Configuration and Iteration Process.....	79
4.4.2 Results of Selecting the Best Hyperparameters	79
4.5 Model Performance Comparison	85
4.5.1 Visual Analysis of Multi-Horizon Prediction Comparison	86
4.5.2 Comparative Synthesis and Practical Implications	88
4.5.3 Inter-Horizon Error Degradation Analysis	89
CHAPTER V CLOSING	93
5.1 Conclusion.....	93
5.2 Suggestions	94
BIBLIOGRAPHY	95
APPENDIX	101

LIST OF TABLES

Table 2.1 Comparison of SVR with Other Algorithms	6
Table 2.2 Comparison of Bayesian Optimization with Other Algorithms	8
Table 3.1 Dataset Split Ratio Scenario	39
Table 3.2 Open price data based on trading hours	39
Table 3.3 Normalized Sample Data.....	42
Table 3.4 SVR Prediction.....	44
Table 3.5 SVR Error Calculation	45
Table 3.6 Initialize Initial Values.....	48
Table 3.7 Experimental Scenario for Split Ratio of Dataset	55
Table 3.8 Multi-Horizon Hyperparameter Optimization Search Space Scenarios	56
Table 3.9 Final Comparison Matrix of Prediction Model Performance.....	57
Table 4.1 Comparison of Model Performance in Various Split Ratio Scenarios ..	70
Table 4.2 Best Hyperparameter Configurations for Grid Search Results	78
Table 4.3 Best Hyperparameter Configurations of Bayesian Optimization Results per Horizon.....	85
Table 4.4 Performance Comparison of SVR + Grid Search vs SVR + Bayesian Optimization on Test Set	85
Table 4.5 Summary of Inter-Horizon Error Increase in the SVR + Bayesian Optimization Model (Test Set).....	90
Table 4.6 Results of Slope Analysis of Errors against Prediction Horizon Length	91

LIST OF FIGURES

Figure 2.1 SVR Illustration	16
Figure 3.1 Research Flow	33
Figure 3.2 Bitcoin Dataset.....	35
Figure 3.3 Dataset After Adding Target Variable	37
Figure 3.4 Dataset After Empty Data is Removed	38
Figure 3.5 Dataset After Normalization	40
Figure 3.6 SVR Flow	41
Figure 3.7 Bayesian Optimization Flow	47
Figure 4.1 Load Dataset	59
Figure 4.2 Example of Target Shifting Results	60
Figure 4.3 Subset Size of Data Division Results	62
Figure 4.4 Minmax Scaling Data Results	63
Figure 4.5 Results of 50:50 Data Testing	64
Figure 4.6 Training Data Graph 50:50	64
Figure 4.7 50:50 Testing Data Graph	65
Figure 4.8 Results of 60:40 Data Testing	65
Figure 4.9 Training Data Graph 60:40	66
Figure 4.10 60:40 Testing Data Graph	66
Figure 4.11 Results of 70:30 Data Testing	67
Figure 4.12 Training Data Graph 70:30	67
Figure 4.13 Training Data Graph 70:30	68
Figure 4.14 Results of 80:20 Data Testing	68
Figure 4.15 Training Data Graph 80:20	69
Figure 4.16 80:20 Testing Data Graph	69
Figure 4.17 SVR-Gridsearch Horizon 1 Day	73
Figure 4.18 Graph of SVR-Gridsearch Training Data Horizon 1 Day	74
Figure 4.19 SVR-Gridsearch Testing Data Graph for 1 Day Horizon	74
Figure 4.20 SVR-Gridsearch Horizon 3 Days	75

Figure 4.21 Graph of SVR-Gridsearch Training Data Horizon 3 Days	75
Figure 4.22 SVR-Gridsearch Testing Data Graph for 3-Day Horizon.....	76
Figure 4.23 SVR-Gridsearch Horizon 7 Days	76
Figure 4.24 Graph of SVR-Gridsearch Training Data Horizon 7 Days	77
Figure 4.25 SVR-Gridsearch Data Testing Graph for 7 Days Horizon	77
Figure 4.26 1-day SVR-Bayesian	80
Figure 4.27 SVR-Bayesian Training Data Graph for 1 Day Horizon	81
Figure 4.28 SVR-Bayesian Testing Data Graph for 1 Day Horizon.....	81
Figure 4.29 3-day SVR-Bayesian	82
Figure 4.30 Graph of SVR-Bayesian Training Data for 3-Day Horizon	82
Figure 4.31 SVR-Bayesian Testing Data Graph for 3-Day Horizon.....	83
Figure 4.32 7-day SVR-Bayesian	83
Figure 4.33 Graph of SVR-Bayesian Training Data for 7-Day Horizon	84
Figure 4.34 SVR-Bayesian Testing Data Graph for 7-Day Horizon.....	84
Figure 4.35 1-Day Horizon Comparison Chart.....	86