

AIR QUALITY PREDICTION IN JAKARTA USING LSTM AND GRU MODELS FOR INFORMATION DISSEMINATION

SKRIPSI



**PROGRAM STUDI ILMU KOMPUTER (S1)
JURUSAN TEKNIK INFORMATIKA
FAKULTAS TEKNIK DAN KEJURUAN
UNIVERSITAS PENDIDIKAN GANESHA**



- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunakan sertifikat elektronik yang diterbitkan BSR - BSSN, validitas dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSR
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.



- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunakan sertifikat elektronik yang diterbitkan BSR - BSSN, validitas dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSR
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.



**Balai Besar
Sertifikasi
Elektronik**

SKRIPSI

DIAJUKAN UNTUK MELENGKAPI TUGAS DAN MEMENUHI SYARAT-SYARAT UNTUK MENCAPAI GELAR SARJANA KOMPUTER

Menyetujui

Pembimbing I	Ni Putu Novita Puspa Dewi, S.Kom., M.Cs., MIM. NIP.199410032020122015
Pembimbing II	Kadek Yota Ernanda Aryanto, S.Kom., M.T., Ph.D. NIP.197803242005011001

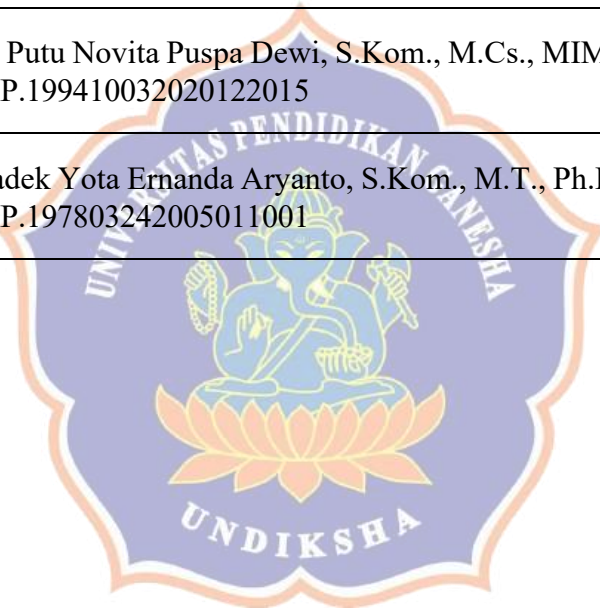


- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunakan sertifikat elektronik yang diterbitkan BSrE - BSSN, validitas dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSrE
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.

Skripsi oleh NI PUTU NITA NATHALIA ini
telah dipertahankan di depan dewan penguji
Pada tanggal 16 Desember 2025

Dewan Penguji

Ketua	Ir. Ketut Agus Seputra, S.ST.,M.T. NIP.199008152019031018
Anggota	I Nyoman Saputra Wahyu Wijaya, S.Kom., M.Cs. NIP.198910262019031004
Anggota	Ni Putu Novita Puspa Dewi, S.Kom., M.Cs., MIM. NIP.199410032020122015
Anggota	Kadek Yota Ernanda Aryanto, S.Kom., M.T., Ph.D. NIP.197803242005011001



- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunakan sertifikat elektronik yang diterbitkan BSR - BSSN, validitas dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSR
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.



Balai Besar
Sertifikasi
Elektronik

Diterima oleh Panitia Ujian Fakultas Teknik dan Kejuruan
Universitas Pendidikan Ganesha
guna memenuhi syarat-syarat untuk mencapai gelar Sarjana Komputer

Menyetujui

Ketua Ujian	Made Windu Antara Kesiman, S.T., M.Sc., Ph.D. NIP.198211112008121001
Sekretaris Ujian	I Nyoman Saputra Wahyu Wijaya, S.Kom., M.Cs. NIP.198910262019031004



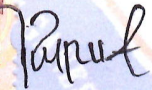
- UU ITE No. 11 Tahun 2008 Pasal 5 Ayat 1 "Informasi Elektronik dan/atau hasil cetaknya merupakan alat bukti hukum yang sah"
- Dokumen ini telah ditandatangani secara elektronik menggunakan sertifikat elektronik yang diterbitkan BSrE - BSSN, validitas dokumen elektronik ini bisa dicek menggunakan aplikasi mobile VeryDS oleh BSrE
- Cetakan dokumen ini merupakan salinan dari file dokumen bertandatangan elektronik yang keabsahannya dapat diakses melalui scan QRCode yang terdapat pada sertifikat ini.

DECLARATION

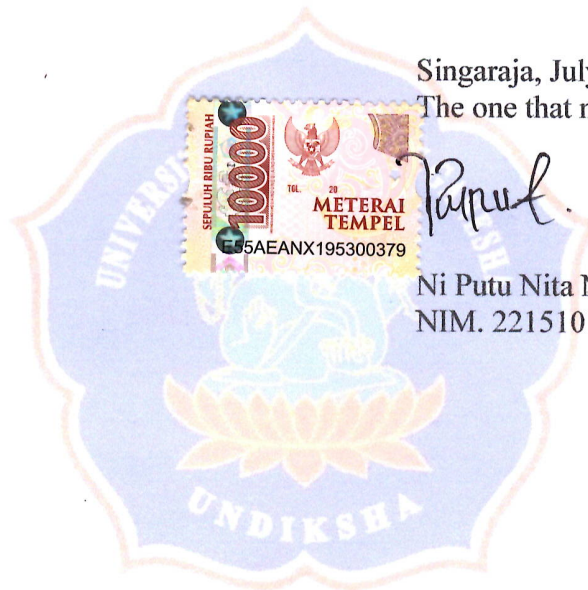
I hereby declare that the written work entitled “Air Quality Prediction in Jakarta Using LSTM and GRU Models for Information Dissemination” and all its contents are genuinely my work and do not plagiarize and quote in ways that are not in accordance with the ethics applicable in the scientific community. With this statement, I am ready to bear the risk of sanctions imposed on me if later there is a violation of scientific ethics in my work or against claims to the authenticity of my work.

Singaraja, July 30th 2025

The one that makes a statement,



Ni Putu Nita Nathalia
NIM. 2215101050



ACKNOWLEDGMENT

All the praise and gratitude the author extends to the Almighty God, for His bless that this undergraduate thesis, entitled "**Air Quality Prediction in Jakarta Using LSTM and GRU Models for Information Dissemination**", could be completed. This undergraduate thesis is submitted as a requirement to obtain the Bachelor's degree in computer science at Ganesha University of Education.

In the process of completing this undergraduate thesis, the author has received significant support. Therefore, the author would like to express sincere gratitude to:

1. Prof. Dr. Kadek Rihendra Dantes, S.T., M.T., Dean of the Faculty of Engineering and Vocational, for his encouragement and the facilities provided, which enabled the author to complete the study as planned.
2. Made Windu Antara Kesiman, S.T., M.Sc., Ph.D., Vice Dean I of the Faculty of Engineering and Vocational Studies, for the motivation and facilities provided, which enabled the author to complete this undergraduate thesis.
3. Prof. Dr. Ketut Agustini, S.Si., M.Si., Vice Dean III of the Faculty of Engineering and Vocational Studies, for the motivation provided.
4. Dr. Putu Hendra Suputra, S.Kom., M.Cs., Head of the Informatics Engineering Department, for the motivation given throughout the completion of this undergraduate thesis.
5. Ir. Ketut Agus Seputra, S.ST., M.T., Coordinator of the Bachelor's Program in Software Engineering Technology and also Examiner 1, for the feedback and evaluation provided on the author's undergraduate thesis.
6. I Nyoman Saputra Wahyu Wijaya, S.Kom., M.Cs., Coordinator of the Bachelor's Program in Computer Science and also Examiner 2, for the feedback and evaluation provided on the author's undergraduate thesis.
7. Ni Putu Novita Puspa Dewi, S.Kom., M.Cs., MIM, as the first academic advisor, for her guidance, direction, advice, and motivation throughout the undergraduate thesis writing process.
8. Kadek Yota Ernanda Aryanto, S.Kom., M.T., Ph.D., as the second academic advisor, for his guidance, direction, advice, and motivation during the completion of this work and also support during study independent and provide better place for

doing my internship at KGEO. Furthermore, the author also extend heartfelt thanks for believe and push me in every project that author doing. So, I could all out doing all the project by my self.

9. The staff members of the Faculty of Engineering and Vocational Studies who assisted in the administrative processes.
10. I Gede Runitha and Ni Luh Sariani, the author's parents, along with the author's siblings Ananda and Adinda, for their unwavering support material, motivational, and spiritual throughout the author's academic journey.
11. The author's close friends, Ananda Adi and Ananda Dharmawati, for their support during both joyful and challenging moments throughout the completion of this undergraduate thesis.
12. My fellow comrades from the IKI Class, members of the Student Executive Board (BEM) of the Faculty of Engineering and Vocational Studies for the 2023/2024 term, and friends whose names cannot be mentioned individually, for their contributions in supporting and encouraging the author during the preparation of this undergraduate thesis.

The author acknowledges that this thesis is not without its shortcomings and sincerely welcomes constructive feedback. It is hoped that this work may offer meaningful contributions to technology development.

Singaraja, July 30th 2025

Author

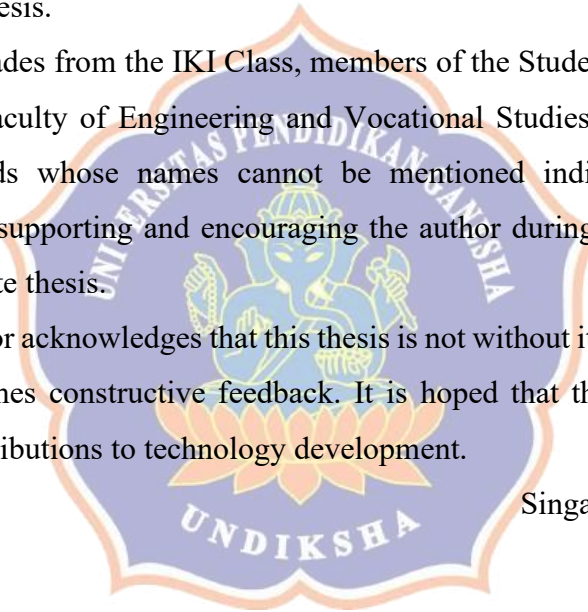


TABLE OF CONTENTS

	PAGE
ACKNOWLEDGMENT.....	i
TABLE OF CONTENTS.....	iii
LIST OF TABLES	vii
LIST OF FIGURES	x
LIST OF THE APPENDIX.....	xiii
ABSTRACT.....	xiii
 CHAPTER I INTRODUCTION.....	 1
1.1 Background.....	1
1.2 Research Problem Identification.....	5
1.3 Problem Formulation.....	6
1.4 Problem Limitations.....	6
1.5 Research Objective.....	7
1.6 Research Benefits.....	7
 CHAPTER II LITERATURE REVIEW.....	 9
2.1 Theoretical Framework.....	9
2.1.1 Introduction to Air Pollution.....	9
2.1.2 Regulation of Air Quality in Indonesia.....	10
2.1.3 Cross Industry Standard Processed for Data Mining (CRISP-DM)	13
2.1.4 Timesteps Forecasting.....	14
2.1.5 Machine Learning	16
2.1.6 Time Series Cross Validation.....	24

2.1.7 Model Evaluation	25
2.2 The review of relevant research	27
2.3 Framework of Thinking	34
2.4 Research Hypothesis	35
 CHAPTER III RESEARCH METHOD	 36
3.1 Data Understanding.....	36
3.2 Data Preparation.....	37
3.3 Modelling	40
3.3.1 Forecasting Model Architecture.....	40
3.4 Evaluation	42
3.4.1 Evaluation Metrics	43
3.4.2 Model Comparison.....	43
3.4.3 Error Analysis	43
3.4.4 Select the Best Model.....	43
3.5 Area of Interest.....	43
 CHAPTER IV EXPERIMENT AND RESULTS	 45
4.1 Environment and Setup	45
4.1.1 Model Learning Parameters	45
4.2 Experimental of Modelling and Result	46
4.2.1 Analysis of Interpolated and Non-Interpolated Datasets	46
4.2.2 Analysis of Early Stop and Without Early Stop for Modelling ...	47
4.2.3 Training and Testing LSTM Model for DKI1-Bundaran HI Station	50

4.2.4 Training and Testing GRU Model for DKI1-Bundaran HI Station	54
4.2.5 Training and Testing LSTM Model for DKI2-Kelapa Gading Station	57
4.2.6 Training and Testing GRU Model for DKI2-Kelapa Gading Station	61
4.2.7 Training and Testing LSTM Model for DKI3-Jagakarsa Station ..	65
4.2.8 Training and Testing GRU Model for DKI3-Jagakarsa Station ..	68
4.2.9 Training and Testing LSTM Model for DKI4-Lubang Buaya Station	72
4.2.10 Training and Testing GRU Model for DKI4-Lubang Buaya Station	76
4.2.11 Training and Testing LSTM Model for DKI5-Kebun Jeruk Station	79
4.2.12 Training and Testing GRU Model for DKI5-Kebun Jeruk Station	83
4.3 Re-train dan Re-test The Overfitting Model	87
4.4 Comparison Performance of LSTM and GRU for All Land Station Monitoring	91
4.5 Error Analysis	95
4.6 Comparison with Previous Research	103
4.7 Discussion	105
CHAPTER V CONCLUSION	109
5.1 Summary	109
5.2 Recommendations	110

REFERENCES.....	112
APPENDIX.....	115



LIST OF TABLES

Table	Page
Table 2. 1 Conversion of ISPU Parameter Concentration Values	10
Table 4. 1 Parameter Set of Each Model.....	45
Table 4. 2 The Result of Interpolated and Non-Interpolated Implementation.....	46
Table 4. 3 Comparison of DKI1-LSTM Models Performance With and Without the Early Stopping.....	47
Table 4. 4 Comparison of DKI1-GRU Models Performance With and Without Early Stopping.....	48
Table 4. 5 Comparison Between Timesteps 1-24 DKI1 Station LSTM Model...	51
Table 4. 6 Criteria for Selecting The Timesteps for The DKI1 Station LSTM Model	52
Table 4. 7 The Error Matrix Results Were Obtained during The Testing Process Using 2024 Data and New Data from January 2025 by The DKI1-LSTM Model	52
Table 4. 8 Comparison Between Timesteps 1-24 DKI1 Station GRU Model.....	54
Table 4. 9 Criteria for Selecting The Timesteps for The DKI1 Station GRU Model	55
Table 4. 10 Best Timesteps Based on The Given Criteria	55
Table 4. 11 The Error Matrix Results Were Obtained during The Testing Process Using 2024 Data and New Data from January 2025 by The DKI1-GRU Model.	56
Table 4. 12 Comparison Between Timesteps 1-24 DKI2 Station LSTM Model.	57
Table 4. 13 Criteria for Selecting The Timesteps for The DKI2 Station LSTM Model	58
Table 4. 14 The Best Selected Timesteps Comply with The Established Criteria	59
Table 4. 15 The Error Matrix Results were Obtained during The Testing Process using 2024 Data and New Data from January 2025 by the DKI2-LSTM Model.	59
Table 4. 16 Comparison Between Timesteps 1-24 DKI2 Station GRU Model...	61
Table 4. 17 Criteria for Selecting The Timesteps for The DKI2 Station GRU Model	62

Table 4. 18 The Best Selected Timesteps Comply with The Established Criteria of DKI2-GRU Model	62
Table 4. 19 The Error Matrix Results were Obtained during The Testing Process using 2024 Data and New Data from January 2025 by the DKI2-GRU Model ...	63
Table 4. 20 Comparison Between Timesteps 1-24 DKI3 Station LSTM Model.	65
Table 4. 21 Criteria for Selecting The Timesteps for The DKI3 Station LSTM Model	66
Table 4. 22 The Best Selected Timesteps Comply with The Established Criteria for DKI3 Station LSTM model.....	66
Table 4. 23 The Error Matrix Results were Obtained during The Testing Process using 2024 Data and New Data from January 2025 by the DKI3-LSTM Model.	67
Table 4. 24 Comparison Between Timesteps 1-24 in DKI3 Station using GRU Model	68
Table 4. 25 Criteria for Selecting The Timesteps for The DKI3 Station GRU Model	69
Table 4. 26 The Best Selected Timesteps Comply with The Established Criteria for DKI3 Station GRU Model	70
Table 4. 27 The Error Matrix Results were Obtained during The Testing Process using 2024 Data and New Data from January 2025 by the DKI3-GRU Model. ...	70
Table 4. 28 Comparison Between Timesteps 1-24 in DKI4 Station using LSTM Model	72
Table 4. 29 Criteria for Selecting The Timesteps for The DKI4 Station using LSTM Model	73
Table 4. 30 The Best Selected Timesteps Comply with The Established Criteria for DKI4 Station LSTM Model	73
Table 4. 31 The Error Matrix Results were Obtained during The Testing Process using 2024 Data and New Data from January 2025 by the DKI4-LSTM Model.	74
Table 4. 32 Comparison Between Timesteps 1-24 DKI4 Station GRU Model...	76
Table 4. 33 Criteria for selecting the timesteps for the DKI4 station GRU model	77
Table 4. 34 The Best Selected Timesteps Comply with The Established Criteria for DKI4 Station GRU Model	77

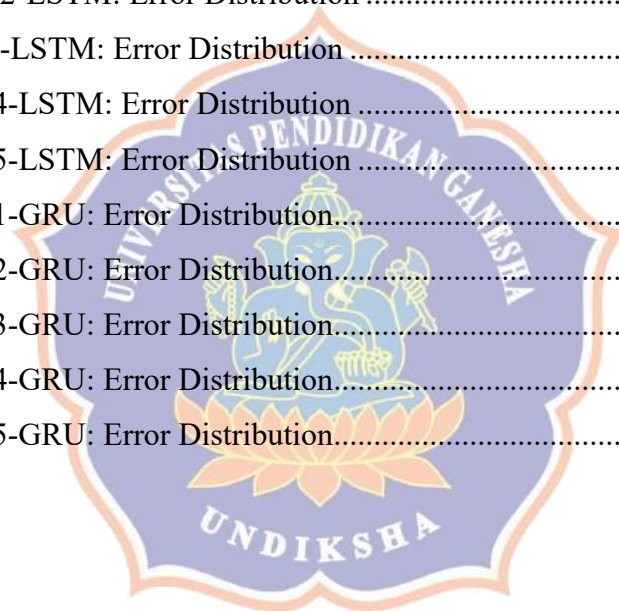
Table 4. 35 The Error Matrix Results were Obtained during The Testing Process using 2024 Data and New Data from January 2025 by The DKI4-GRU Model..	78
Table 4. 36 Comparison Between Timesteps 1-24 in DKI5 Station using LSTM Model	80
Table 4. 37 Criteria for Selecting the Timesteps for The DKI5 Station LSTM Model	81
Table 4. 38 The Best Selected Timesteps Comply with The Established Criteria for DKI5 Station LSTM model.....	81
Table 4. 39 The Error Matrix Results were Obtained during The Testing Process using 2024 Data and New Data from January 2025 by The DKI5-LSTM Model	82
Table 4. 40 Comparison Between Timesteps 1-24 in DKI5 Station using GRU Model	83
Table 4. 41 Criteria for selecting the timesteps for the DKI5 station GRU model	84
Table 4. 42 The Best Selected Timesteps Comply with The Established Criteria for DKI5 Station GRU Model	85
Table 4. 43 The Error Matrix Results were Obtained during The Testing Process using 2024 Data and New Data from January 2025 by The DKI5-GRU Model..	85
Table 4. 44 Re-training Process for Lower Performance Model	88
Table 4. 45 Re-testing Process for Lower Performance Model	89
Table 4. 46 Comparison of LSTM and GRU Model Based on The Value of <i>RMSE</i> on Testing Performance	92
Table 4. 47 Comparison of LSTM and GRU Model Based on The Value of <i>R2</i> on Testing Performance	93
Table 4. 48 Comparison Between LSTM and GRU in DKI1	94
Table 4. 49 Comparison Between LSTM and GRU in DKI2	94
Table 4. 50 Comparison Between LSTM and GRU in DKI3	94
Table 4. 51 Comparison Between LSTM and GRU in DKI4	94
Table 4. 52 Comparison Between LSTM and GRU in DKI5	95

LIST OF FIGURES

Figure	Page
Figure 2. 1 CRISP-DM Example Implementation.....	14
Figure 2. 2 Example of Multi-step Forecasting	15
Figure 2. 3 Basic Architecture of RNN.....	17
Figure 2. 4 Structure of LSTM Model	18
Figure 2. 5 Forget Gate Layer	19
Figure 2. 6 Input Gate Layer	20
Figure 2. 7 Update Gate Layer.....	20
Figure 2. 8 Output Layer Structure	21
Figure 2. 9 GRU Architecture	22
Figure 2. 10 Time Series One-step Cross Validation using Expanding Windows	24
Figure 2. 11 Framework of Thinking	34
Figure 3. 1 Data Before Interpolation	38
Figure 3. 2 Data After Interpolation.....	38
Figure 3. 3 Data After Scaler to Range 0-1.....	39
Figure 3. 4 Shape of Reframing Data.....	40
Figure 3. 5 Modified Architecture for LSTM and GRU Model	41
Figure 3. 6 Research Method Overview	42
Figure 4. 1 DKII-LSTM Without Early Stopping.....	49
Figure 4. 2 DKII-LSTM With Early Stopping	49
Figure 4. 3 DKII-GRU Model Without Early Stopping.....	50
Figure 4. 4 DKII-GRU With Early Stopping	50
Figure 4. 5 Graphic Visualization of Actual Value with Prediction Value by DKII-LSTM Model, during Testing Process with The Same Data as Training	53
Figure 4. 6 Graphic Visualization of Actual Value with Prediction Value by DKII-LSTM Model, during Testing Process Using New Data	53
Figure 4. 7 Graphic Visualization of Actual Value with Prediction Value by DKII-GRU Model, during Testing Process with The Same Data as Training	56

Figure 4. 8 Graphic Visualization of Actual Value with Prediction Value by DKI1-GRU Model, during Testing Process Using New Data	57
Figure 4. 9 Graphic Visualization of Actual Value with Prediction Value by DKI2-LSTM Model, during Testing Process with The Same Data as Training	60
Figure 4. 10 Graphic Visualization of Actual Value with Prediction Value by DKI2-LSTM Model, during Testing Process using New Data.....	60
Figure 4. 11 Graphic Visualization of Actual Value with Prediction Value by DKI2-GRU Model, during Testing Process with The Same Data as Training.....	64
Figure 4. 12 Graphic Visualization of Actual Value with Prediction Value by DKI2-GRU Model, during Testing Process using New Data	64
Figure 4. 13 Graphic Visualization of Actual Value with Prediction Value by DKI3-LSTM Model, during Testing Process with The Same Data as Training...	67
Figure 4. 14 Graphic Visualization of Actual Value with Prediction Value by DKI3-LSTM Model, during Testing Process using New Data.....	68
Figure 4. 15 Graphic Visualization of Actual Value with Prediction Value by DKI3-GRU Model, during Testing Process with The Same Data as Training.....	71
Figure 4. 16 Graphic Visualization of Actual Value with Prediction Value by DKI3-GRU Model, during Testing Process using New Data	71
Figure 4. 17 Graphic Visualization of Actual Value with Prediction Value by DKI4-LSTM Model, during Testing Process with The Same Data as Training...	75
Figure 4. 18 Graphic Visualization of Actual Value with Prediction Value by DKI4-LSTM Model, during Testing Process using New Data.....	75
Figure 4. 19 Graphic Visualization of Actual Value with Prediction Value by DKI4-GRU Model, during Testing Process with The Same Data as Training.....	78
Figure 4. 20 Graphic Visualization of Actual Value with Prediction Value by DKI4-GRU Model, during Testing Process using New Data	79
Figure 4. 21 Graphic Visualization of Actual Value with Prediction Value by DKI5-LSTM Model, during Testing Process with The Same Data as Training...	82
Figure 4. 22 Graphic Visualization of Actual Value with Prediction Value by DKI5-LSTM Model, during Testing Process using New Data.....	83
Figure 4. 23 Graphic Visualization of Actual Value with Prediction Value by DKI5-GRU Model, during Testing Process with The Same Data as Training.....	86

Figure 4. 24 Graphic Visualization of Actual Value with Prediction Value by DKI5-GRU Model, during Testing Process using New Data	86
Figure 4. 25 DKI2-LSTM : Graphic After Re-testing Process – SO ₂ Particle	89
Figure 4. 26 DKI2-GRU : Graphic After Re-testing Process – SO ₂ Particle.....	90
Figure 4. 27 DKI3-LSTM : Graphic After Re-testing Process – CO Particle	90
Figure 4. 28 DKI3-GRU : Graphic After Re-testing Process – CO particle.....	90
Figure 4. 29 DKI5-LSTM : Graphic After Re-testing Process– PM ₁₀ Particle ...	90
Figure 4. 30 DKI5-GRU : Graphic After Re-testing Process – PM ₁₀ Particle.....	91
Figure 4. 31 DKI1-LSTM: Error Distribution	95
Figure 4. 32 DKI2-LSTM: Error Distribution	96
Figure 4. 33 DKI3-LSTM: Error Distribution	97
Figure 4. 34 DKI4-LSTM: Error Distribution	98
Figure 4. 35 DKI5-LSTM: Error Distribution	99
Figure 4. 36 DKI1-GRU: Error Distribution.....	100
Figure 4. 37 DKI2-GRU: Error Distribution.....	100
Figure 4. 38 DKI3-GRU: Error Distribution.....	101
Figure 4. 39 DKI4-GRU: Error Distribution.....	102
Figure 4. 40 DKI5-GRU: Error Distribution.....	102



LIST OF THE APPENDIX

Appendix	Page
Appendix 1. Biography	115
Appendix 2. Architecture of DKI1-LSTM Model	116
Appendix 3. Architecture of DKI1-GRU Model	117

