THE DEVELOPMENT OF AN UNDERWATER PLASTIC WASTE DETECTION PROTOTYPE WITH RASPBERRY PI

Bachelor Thesis

Conducted to fulfill some of the requirements to obtain a Bachelor of Science degree

Muhammad Fajrul Amin
1306620045

PHYSICS DEPARTMENT
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
UNIVERSITAS NEGERI JAKARTA
2024

APPROVAL OF
BACHELOR THESIS

APPROVAL OF BACHELOR THESIS

THE DEVELOPMENT OF AN UNDERWATER PLASTIC WASTE DETECTION PROTOTYPE WITH RASPBERRY PI

Name : Muhammad Fajrul Amin
Registration Number : 1306620045

	Name	Signature	Date
Person in charge			
Dean :	Prof. Dr. Muktiningsih N., M.Si NIP. 196405111989032001		6/8 2024
Deputy in charge			
Vice Dean :	Dr. Esmar Budi, M.T NIP. 197207281999031002		6/8 2024
Chairman :	Dr. Widyaningrum Indrasari, M.Si NIP. 197705102006042001		2/8 2024
Secretary :	Dr. Hadi Nasbey, M.Si NIP.197909162005011001		2/8 2024
Member			
Supervisor :	Dr. Mutia Delina, M.Si NIP. 198011192008012007		2/8 2024
Co-Supervisor :	Taryudi, S.T., M.T., Ph.D NIP. 198008062010121002		5/8 2024
Opponent :	Haris Suhendar, M.Sc NIP. 199404282022031006		2/8 2024

Declared to pass the bachelor thesis defense on 22 July 2024.

STATEMENT OF DECLARATION

STATEMENT OF DECLARATION

I declare the thesis titled "The Development of an Underwater Plastic Waste Detection Prototype with Raspberry Pi" prepared as a requirement to obtain a Bachelor of Science degree from the Physics Department of Universitas Negeri Jakarta, is my scientific work. The sources of information obtained from other published authors mentioned in the thesis have been cited in the Reference section by the norms, rules, and ethics of scientific writing. Suppose a significant portion of this thesis is not my work in certain sections. In that case, I am willing to accept the revocation of my academic degree and other sanctions as per the applicable regulations and laws.

Jakarta, 1 August 2024

Muhammad Fajrul Amin

iii

STATEMENT OF CONSENT TO PUBLICATION

KEMENTERIAN PENDIDIKAN, KEBUDAYAAN, RISET DAN TEKNOLOGI
UNIVERSITAS NEGERI JAKARTA
UPT PERPUSTAKAAN

Jalan Rawamangun Muka Jakarta 13220
Telepon/Faksimili: 021-4894221
Laman: lib.unj.ac.id

LEMBAR PERNYATAAN PERSETUJUAN PUBLIKASI KARYA ILMIAH UNTUK KEPENTINGAN AKADEMIS

Sebagai sivitas akademika Universitas Negeri Jakarta, yang bertanda tangan di bawah ini, saya:

Nama : Muhammad Fajrul Amin
NIM : 1306620095
Fakultas/Prodi : FMIPA / Fisika
Alamat email : m.fajrulamin@gmail.com

Demi pengembangan ilmu pengetahuan, menyetujui untuk memberikan kepada UPT Perpustakaan Universitas Negeri Jakarta, Hak Bebas Royalti Non-Eksklusif atas karya ilmiah:

☑ Skripsi ☐ Tesis ☐ Disertasi ☐ Lain-lain (.....)

yang berjudul :
The Development Of An Underwater Plastic Waste Detection Prototype With Raspberry Pi

Dengan Hak Bebas Royalti Non-Ekslusif ini UPT Perpustakaan Universitas Negeri Jakarta berhak menyimpan, mengalihmediakan, mengelolanya dalam bentuk pangkalan data (*database*), mendistribusikannya, dan menampilkan/mempublikasikannya di internet atau media lain secara ***fulltext*** untuk kepentingan akademis tanpa perlu meminta ijin dari saya selama tetap mencantumkan nama saya sebagai penulis/pencipta dan atau penerbit yang bersangkutan.

Saya bersedia untuk menanggung secara pribadi, tanpa melibatkan pihak Perpustakaan Universitas Negeri Jakarta, segala bentuk tuntutan hukum yang timbul atas pelanggaran Hak Cipta dalam karya ilmiah saya ini.

Demikian pernyataan ini saya buat dengan sebenarnya.

Jakarta, 18 Agustus 2024

Penulis

(Muhammad Fajrul Amin)
nama dan tanda tangan

FOREWORD

Praise and gratitude are due to Allah SWT for His blessings and guidance, allowing the completion of this thesis titled “The Development of an Underwater Plastic Waste Detection Prototype with Raspberry Pi.” This thesis is submitted as a requirement to obtain a Bachelor of Science degree from the Physics Department of Universitas Negeri Jakarta. This thesis would not have been possible without the support, encouragement, and assistance of many individuals. I would like to extend my deepest gratitude to:

1 Dr. Mutia Delina, M.Si, as the Supervisor for providing guidance, motivation, advice, suggestion, and critiques to the author.
2 Taryudi, S.T., M.T., Ph.D, as the Co-Supervisor for providing guidance, motivation, advice, suggestion, and critiques to the author.
3 Dr. Umiatin, M.Si, as the Coordinator of Physics Department at Universitas Negeri Jakarta.
4 The author’s parents, and Brother for their prayers, advice, and moral support throughout the journey.
5 Fikrul Ihsan Arifin, Michael Setiyanto Silambi, Rian Setiyana, and Sayid Mahmud Ibadirahman Syah, for providing ideas, motivation, suggestion, and critiques.

The author acknowledges that the thesis may not be perfect and acknowledges its shortcomings. Hopefully this thesis be benefical to its readers

Jakarta, 1 August 2024

Muhammad Fajrul Amin

ABSTRACT

MUHAMMAD FAJRUL AMIN. The Development of an Underwater Plastic Waste Detection Prototype with Raspberry Pi. Supervised by MUTIA DELINA, TARYUDI

Underwater plastic waste can caused a serious impact on the environment. A computer algorithm for detecting underwater plastic waste has been developed by applying YOLOv3. For improvement, the study developed a prototype with Raspberry Pi through the Research and Development method. This prototype is like a submarine that operates in the water and integrated with a camera and a computer algorithm to detect plastic waste. The prototype was tested in a water environment with varying turbidity levels from 20 to 120 Nephelometric Turbidity Units (NTU). Turbidity levels were precisely measured using a calibrated turbidity sensor, which had been tested against several known turbidity samples to ensure accuracy. The turbidity sensor used is the TS-300B, which is controlled by an Arduino microcontroller. We use 24 plastic objects with 4 different types: straw, food packaging, bottle, and plastic bag. The result of the study presented the effective threshold for object detection is around 100 NTU. At 100 NTU, The camera can only capture 9 images on the surface, 7 images in the middle, and 5 images at the bottom, with the most frequently detected object is a bottle. The average confidence score for detection at turbidity levels below 100 NTU is 73%.

Keyword. Prototype, raspberry pi, underwater plastic waste

ABSTRAK

MUHAMMAD FAJRUL AMIN. Pengembangan Prototipe Pendeteksi Sampah Plastik di Bawah Air dengan Raspberry Pi. Dibimbing oleh MUTIA DELINA, TARYUDI

Sampah plastik di bawah air dapat menyebabkan dampak serius terhadap lingkungan. Sebuah algoritma komputer untuk mendeteksi sampah plastik di bawah air telah dikembangkan dengan menerapkan YOLOv3. Untuk penyempurnaan, penelitian ini mengembangkan prototipe dengan Raspberry Pi melalui metode Research and Development. Prototipe ini berbentuk seperti kapal selam yang beroperasi di dalam air dan terintegrasi dengan kamera dan algoritma komputer untuk mendeteksi sampah plastik. Prototipe ini diuji coba di lingkungan air dengan tingkat kekeruhan yang bervariasi mulai dari 20 hingga 120 Nephelometric Turbidity Units (NTU). Tingkat kekeruhan diukur dengan tepat menggunakan sensor kekeruhan yang telah dikalibrasi, yang telah diuji terhadap beberapa sampel kekeruhan yang telah diketahui untuk memastikan keakuratannya. Sensor kekeruhan yang digunakan adalah TS-300B, yang dikendalikan oleh mikrokontroler Arduino. Kami menggunakan 24 benda plastik dengan 4 jenis yang berbeda: sedotan, kemasan makanan, botol, dan kantong plastik. Hasil dari penelitian ini menunjukkan bahwa ambang batas yang efektif untuk mendeteksi objek adalah sekitar 100 NTU. Pada ambang batas 100 NTU, kamera hanya dapat menangkap 9 gambar di permukaan, 7 gambar di tengah, dan 5 gambar di bagian bawah, dengan objek yang paling sering terdeteksi adalah botol. Nilai kepercayaan rata-rata untuk deteksi pada tingkat kekeruhan di bawah 100 NTU adalah 73%.

Keyword. Prototipe, raspberry pi, sampah plastik bawah air

TABLE OF CONTENT

APPROVAL OF BACHELOR THESIS ii
STATEMENT OF DECLARATION iii
STATEMENT OF CONSENT TO PUBLICATION iv
FOREWORD v
ABSTRACT vi
ABSTRAK vii
TABLE OF CONTENT viii
LIST OF TABLE x
LIST OF FIGURE xi
LIST OF ABBREVIATIONS xii
LIST OF APPENDIX xiii
CHAPTER I INTRODUCTION 1
A. Background 1
B. Researh Questions 3
C. Research Aim 3
D. Research Benefit 3
CHAPTER II LITERATURE REVIEW 4
A. Digital Image Processing 4
B. Light and Optic 6
C. Water Turbidity 8
D. Plastic Waste 9
E. Deep Learning 10
F. Convolutional Neural Network (CNN) 10
G.You Only Look Once (YOLO) 11
H. Raspberry Pi 13
I. Relevant Research 14
CHAPTER III RESEARCH METODOLOGY 17

A. Research Setting 17
B. Research Method 18
1. Tools and Materials 18
2. Research Procedure 19
C. Data Collection and Analysis Techniques 23
CHAPTER IV RESULT AND DISCUSSION 24
A. The Prototype Structure 24
B. Prototype Integration with raspberry pi 25
C. Deployinh model YOLOv3 to raspberry pi 25
D. Prototype Testing 26
CHAPTER V CONCLUSION AND SUGGESTION 57
A. Conclusion 57
B. Suggestion 57
REFERENCE 58
APPENDIX 63
CURRICULUM VITAE 74

LIST OF TABLE

Table 3.1 Research Schedule Activity 12
Table 4.1 Prototype Specification 26
Table 4.2 Sensor Readings for Various Turbidity Levels 29
Table 4.3 Prototype Test Results: Detection of Object Types on the Surface 31
Table 4.4 Prototype Test Results: Detection of Object Color Types on the Surface 32
Table 4.5 Prototype Test Results: Detection of Object Types in the Middle 40
Table 4.6 Prototype Test Results:Detection of Object Color Types in the Middle 41
Table 4.7 Prototype Test Results: Detection of Object Types at the Bottom 49
Table 4.8 Prototype Test Results: Detection of Object Color Types at the Bottom 50

LIST OF FIGURE

Figure 2.1 Coordinates in digital images 4
Figure 2.2 CNN layer model 10
Figure 2.3 YOLO Architercture 11
Figure 2.4 Darknet-53 Architecture 13
Figure 2.5 Raspberry Pi 14
Figure 3.1 Research flowchart 19
Figure 3.2 Design control circuit 20
Figure 3.5 Illustration water environment 23
Figure 4.1 Turbidity sensor with arduino 28
Figure 4.2 Exponential Regession of Sensor Value vs NTU 29
Figure 4.3 Controlled water environment for testing the prototype 30
Figure 4.4 four types of plastic waste (a) Straw (b) Bottle (c) Food packaging (d) Plastic bag 31
Figure 4.5 Prototype test result at turbidity level 20 NTU on the surface 35
Figure 4.6 Prototype test result at turbidity level 40 NTU on the surface 36
Figure 4.7 Prototype test result at turbidity level 60 NTU on the surface 37
Figure 4.8 Prototype test result at turbidity level 80 NTU on the surface 38
Figure 4.9 Prototype test result at turbidity level 100 NTU on the surface 39
Figure 4.10 Prototype test result at turbidity level 120 NTU on the surface 40
Figure 4.11 Prototype test result at turbidity level 20 NTU in the middle 43
Figure 4.12 Prototype test result at turbidity level 40 NTU in the middle 44
Figure 4.13 Prototype test result at turbidity level 60 NTU in the middle 45
Figure 4.14 Prototype test result at turbidity level 80 NTU in the middle 46
Figure 4.15 Prototype test result at turbidity level 100 NTU in the middle 47
Figure 4.16 Prototype test result at turbidity level 120 NTU in the middle 48
Figure 4.17 Prototype test result at turbidity level 20 NTU at the bottom 52
Figure 4.18 Prototype test result at turbidity level 40 NTU at the bottom 53
Figure 4.19 Prototype test result at turbidity level 60 NTU at the bottom 54
Figure 4.20 Prototype test result at turbidity level 80 NTU at the bottom 55
Figure 4.21 Prototype test result at turbidity level 100 NTU at the bottom 56
Figure 4.22 Prototype test result at turbidity level 120 NTU at the bottom 57

LIST OF ABBREVIATIONS

PET	: Polyethylene Terephthalate
HDPE	: High-Density Polyethylene
PVC	: Polyvinyl Chloride
LDPE	: Low-Density Polyethylene
PP	: Poly Propylene
PS	: Poly Styrene
AUV	: Autonomous Underwater Vehicle
ROV	: Remotely Operated Vehicle
YOLO	: You Only Look Once
CNN	: Convolutional Neural Network
MLP	: Multi Layer Perceptron
NTU	: Nephelometric Turbidity Units
PWM	: Pulse width Modulation
CPU	: Central Processing Unit
RAM	: Random-Access Memory
USB	: Universal Serial Bus
SSD	: Single Shot Detector

LIST OF APPENDIX

Appendix 1 Straw object sample..... 66
Appendix 2 Bottles object sample..... 68
Appendix 3 Food packaging object sample 70
Appendix 4 Plastic bag object sample 72
Appendix 5 Source code for underwater plastic waste detecion real-time 74
Appendix 6 Sample NTU..... 75
Appendix 7 Photo during data collection..... 75