

## TABLE OF CONTENTS

<b>UNDERGRADUATE THESIS.....</b>	<b>i</b>
<b>PREFACE .....</b>	<b>ii</b>
<b>TABLE OF CONTENTS.....</b>	<b>iv</b>
<b>LIST OF FIGURES.....</b>	<b>vi</b>
<b>LIST OF TABLES.....</b>	<b>vii</b>
<b>LIST OF EQUATIONS .....</b>	<b>viii</b>
<b>INTISARI.....</b>	<b>ix</b>
<b>CHAPTER I INTRODUCTION .....</b>	<b>1</b>
1.1 Background.....	1
1.2 Problem Statement.....	2
1.3 Problem Limitation .....	2
1.4 Research Purpose .....	3
1.5 Research Benefits.....	3
1.6 Research Methodology .....	3
1.7 Thesis Structure .....	4
<b>CHAPTER II LITERATURE REVIEW .....</b>	<b>5</b>
<b>CHAPTER III THEORETICAL BASIS.....</b>	<b>12</b>
3.1. Object Detection .....	12
3.2. You Only Look Once version 9 (YOLOv9).....	12
3.3 Performace Metrics .....	15
3.3.1. Confusion Matrix.....	15
3.3.2. Intersection over Union.....	15
3.3.3. Precision.....	17
3.3.4. Recall .....	17
3.3.5. F1 Score .....	17
3.3.6. Average Precision (AP) .....	17
3.3.7. Latency.....	18
3.3.8. FPS (Frame per Second) .....	19
<b>CHAPTER IV RESEARCH METHODOLOGY .....</b>	<b>20</b>
4.1 Research Procedure.....	20

4.2 Tools and Materials .....	21
4.3 System Design .....	22
4.3.1 Software Design .....	22
4.3.2 Hardware design .....	23
4.3.3 Detection Model Design .....	24
4.4 System Testing and Evaluation .....	26
<b>CHAPTER V IMPLEMENTATION.....</b>	<b>29</b>
5.1 Dataset Pre-processing.....	29
5.2 YOLOv9 training .....	29
<b>CHAPTER VI RESULT AND DISCUSSION .....</b>	<b>47</b>
6.1. Object Detection Training .....	47
6.2. Object Detection Testing .....	54
6.2.1. YOLOv9 Model Object Detection Testing.....	55
<b>CHAPTER VII CONCLUSION.....</b>	<b>59</b>
7.1. Conclusion .....	59
7.2. Suggestion.....	60
<b>REFERENCES .....</b>	<b>xi</b>

## LIST OF FIGURES

Figure 3. 1 Confusion Matrix Table ( <a href="http://surl.li/hoztni">http://surl.li/hoztni</a> ).....	15
Figure 3. 2 IoU Treshold Illustration ( <a href="http://surl.li/zxxpfg">http://surl.li/zxxpfg</a> ).....	16
Figure 3. 3 Precision-Recall (PR) Curve ( <a href="http://surl.li/calkvu">http://surl.li/calkvu</a> ) .....	18
Figure 4. 1 Research Flow Diagram.....	21
Figure 4. 2 Program Flow.....	23
Figure 4. 3 Block Diagram of Hardware.....	24
Figure 4. 4 GPS Schematic.....	24
Figure 4. 5 Training Phase.....	25
Figure 4. 6 Testing Phase .....	26
Figure 5. 1 Pretrained model YOLOv9 .....	30
Figure 5. 2 training model program.....	31
Figure 5. 3 The code that makes the output folder .....	43
Figure 5. 4 The output folder.....	44
Figure 5. 5 the code that saves the video and filling name.....	44
Figure 5. 6 the video output saved in the video folder .....	45
Figure 5. 7 the code that saves the pinpoint map and filling name .....	45
Figure 5. 8 the pinpoint map saved in map folder.....	46
Figure 6. 1 Detection output using sample image .....	48
Figure 6. 2 Precision-recall curve.....	49
Figure 6. 3 Latency and FPS comparison graph.....	56
Figure 6. 4 jtop monitoring.....	58

## LIST OF TABLES

Table 2. 1 Preview Study Comparison .....	6
Table 4. 1 Tool List .....	21
Table 4. 2 Material List .....	22
Table 4. 3 System Classes .....	25
Table 4. 4 System Testing Plant .....	26
Table 4. 5 Performance Metrics List .....	27
Table 4. 6 Success Parameters.....	28

## LIST OF EQUATIONS

Equation (1).....	16
Equation (2).....	17
Equation_ (3).....	17
Equation_ (4).....	17
Equation_ (5).....	18
Equation_ (6).....	19