

## TABLE OF CONTENTS

<b>UNDERGRADUATE THESIS.....</b>	<b>I</b>
<b>APPROVAL PAGE.....</b>	<b>II</b>
<b>ACKNOWLEDGEMENTS.....</b>	<b>IV</b>
<b>ABSTRACT.....</b>	<b>V</b>
<b>ABSTRAK.....</b>	<b>VI</b>
<b>TABLE OF CONTENTS.....</b>	<b>VII</b>
<b>LIST OF FIGURES.....</b>	<b>VIII</b>
<b>LIST OF TABLES.....</b>	<b>X</b>
<b>LIST OF EQUATIONS.....</b>	<b>XI</b>
<b>CHAPTER I.....</b>	<b>1</b>
<b>INTRODUCTION.....</b>	<b>1</b>
1.1 Research Background.....	1
1.2 Research Problem.....	3
1.3 Research Scope.....	3
1.4 Research Objective.....	4
1.5 Research Advantage.....	5
1.6 Writing System.....	5
<b>CHAPTER II.....</b>	<b>7</b>
<b>LITERATURE REVIEW.....</b>	<b>7</b>
2.1 General Overview of Literature Review.....	7
2.2 Literature Review Comparison.....	15
2.3 Literature Review Conclusion.....	21
<b>CHAPTER III.....</b>	<b>22</b>
<b>THEORETICAL BASIS.....</b>	<b>22</b>
3.1 Basketball Travelling Violation.....	22
3.2 Spatio-Temporal Action Verification.....	23
3.3 Convolutional Neural Network (CNN).....	24
3.4 Frame Preprocessing and Frame Iteration.....	25
3.5 Mediapipe Pose for Pose Estimation`.....	26
3.6 You Only Look Once Algorithm (YOLO) for Object Tracking.....	28
3.7 Recurrent Neural Network (RNN) and Long Short-Term Memory (LSTM).....	29
3.8 Model Testing and Evaluation.....	34
<b>CHAPTER IV.....</b>	<b>36</b>
<b>RESEARCH METHODOLOGY.....</b>	<b>36</b>
4.1 Research Description.....	36
4.2 Data Collection.....	37
4.3 Algorithm and Model Design.....	38
4.3.1 Algorithm Overview.....	38
4.3.2 Frame Iteration.....	41
Figure 4.4 - OpenCV for Frame Iteration and Mediapipe Pose Estimation.....	42
4.3.3 Mediapipe Pose Estimation.....	42

4.3.4 Object Detection using YOLOv7.....	44
4.3.5 Feature Extraction, Processing and Labelling.....	48
4.3.6 Modelling using LSTM.....	49
4.3.7 Model Testing and Evaluation.....	50
4.4 Validation and Evaluation Design.....	51
4.4.1 Validation.....	51
4.4.2 Evaluation.....	52
<b>CHAPTER V.....</b>	<b>53</b>
<b>RESEARCH IMPLEMENTATION.....</b>	<b>53</b>
5.1 Data Collection.....	53
5.2 Mediapipe Pose Estimation.....	53
5.3 Object Detection using YOLOv7.....	54
5.4 Feature Extraction, Processing and Labelling.....	56
5.5 Modelling using LSTM.....	61
5.6 Live Testing.....	64
<b>CHAPTER VI.....</b>	<b>66</b>
<b>RESULTS &amp; ANALYSIS.....</b>	<b>66</b>
6.1 Feature Extractor (Mediapipe Pose Estimation and YOLOv7) Performance.....	66
6.1.1 Mediapipe Pose Estimation Inference Time.....	67
6.1.2 YOLOv7 Model mAP Scores.....	69
6.1.3 YOLOv7 Inference Time.....	70
6.1.4 Feature Extractor Inference Time.....	72
6.2 LSTM Binary Classifier Performance.....	73
6.2.1 Inference Time.....	73
6.2.2 Model Accuracy.....	73
6.3 Limitations.....	79
6.4 Summary.....	81
<b>CHAPTER VII.....</b>	<b>83</b>
<b>CONCLUSION &amp; SUGGESTIONS.....</b>	<b>83</b>
7.1 Conclusion.....	83
7.2 Suggestion.....	83
<b>REFERENCES.....</b>	<b>86</b>