TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS i

ABSTRACT ii

TABLE OF CONTENTS iii

LIST OF FIGURES vi

LIST OF TABLES viii

LIST OF SYMBOLS AND ABBREVIATIONS ix

CHAPTER TITLE

1. INTRODUCTION

1.1 Introduction of Adaptive Traffic Signal Control 1

1.2 Statement of the Problem 2

1.3 Introduction to Image Processing 2

1.4 Aim and Objectives 3

1.5 Scope of Thesis 4

1.6 Outlines of Thesis 4

2. LITERATURE REVIEW

2.1 Traffic Light System 5

2.2 Traffic Engineering 7

2.3 Traditional Traffic Light Control System

2.4 Adaptive Traffic Control Systems 2.4.1 InSync Adaptive Traffic Control System 8

2.5 Webster's Method 15

2.5.1. Signal Phases 15

2.5.1.1. Four phases signals 16

2.5.1.2. Passenger car unit (PCU) 18

2.5.2. Vehicle Clearance Interval 19

2.5.3. Minimum Cycle Length 19

2.5.4. Green Splitting

2.6 Image Processing Methods 10

2.6.1. Analogue Image Processing

2.6.2. Digital Image Processing

2.7. Types of Images

2.7.1. Binary Image

2.7.2. Grayscale Image

2.7.3. Colour Image

2.8. Python Programming Language

2.9. OpenCV Library

2.10. Threading

2.10.1. Thread

2.10.2. Thread Control Block

2.10.3. Multithreading

2.11. Real-Time Object Detection with YOLOv3 11

2.11.1. Darknet

2.11.2. YOLOv3

2.12 Arduino 12

2.13 ENC28J60 Ethernet Module

2.14 Categories of Networks

2.14.1 LAN 12

2.14.2 WAN 23

2.14.3 MAN

2.15 Network Protocol 43

2.15.1 Transmission Control Protocol (TCP) 26

2.15.2 User Datagram Protocol 26

2.16 Internet Protocol Camera

2.17 MySQL Database

3. METHODOLGY 14

3.1 System Overview of Adaptive Traffic Control System 14

3.2 Video Live Streaming and Data Collections 14

3.3 Vehicles Detection and Counting with YOLOV3 15

3.4 Cycle Calculation with Webster Method 16

3.5 Arduino Nano 17

3.6 Shift Register (74HC595) 19

3.6.1 Features and Benefits

3.7. Seven-segment Display Construction 20

3.8. 22

3.9. Ethernet Communication with Computer and Arduino 24

3.10. Summary 24

4. HARDWARE DESIGN AND SOFTWARE IMPLEMENTATION OF

HEXAPOD ROBOT CONTROL SYSTEM

4.1 Mechanical Design of Hexapod Body 25

4.2. Defining Parameter of Hexapod Arm 26

4.3. Forward Kinematics of Hexapod Robot 27

4.4. Inverse Kinematic of Hexapod Robot 30

4.5 Coordinate Frame Transformations 34

4.6 Rotational Transformations 35

4.7 Translational Transformations 35

4.8 Euler-Lagrange Formulation 35

4.9. Motor Torque and Force Calculations of Joints  36

4.10. PWM control theory 38

4.11. PWM with Servo control 39

4.12. PID Control Method for Desire Hexapod 42

4.13. Power Supply Unit of the System 42

4.14. Total Power Consumption 43

4.15. Complete Circuit diagram hexapod 45

4.16. Program Flowchart for Hexapod 46

4.17. Program Downloading for Arduino IDE 48

4.18. Summary 49

5. SIMULATION RESULTS AND EXPERIMENTAL RESULTS

5.1. Simulation Results 50

5.1.1. Remote control simulation 52

5.1.2. Calibration and Servos checking GUI with corresponding HEXAPOD motion 54

5.2. Hexapod motions’ experimental results 60

5.3. Gait control diagram of Hexapod 62

5.4. Summary 64

6. DISCUSSIONS AND CONCLUSION

6.1. Discussions 65

6.2. Conclusion 65

6.3. Further Extension 66

REFERENCES 67

APPENDIX A 68

APPENDIX B 71

APPENDIX C 73

APPENDIX D 76