



**DESIGN AND DEVELOPMENT OF
MULTI-TERRAIN MOBILE ROBOT IN LARGE
SCALE PLANTATION**

by

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In fulfillment of the requirements for the degree of
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**SCHOOL OF MECHATRONIC ENGINEERING
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OKTOBER 2015

For my wife, Shariffah Zarihan and my lovely children Aishah, Arissa and Afiq

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TABLE OF CONTENTS

| | PAGE |
|---|-------------|
| THESIS DECLARATION | i |
| ACKNOWLEDGMENT | ii |
| TABLE OF CONTENT | iii |
| LIST OF TABLES | ix |
| LIST OF FIGURES | x |
| LIST OF ABBREVIATIONS | xiv |
| LIST OF SYMBOLS | xv |
| ABSTRAK | xvi |
| ABSTRACT | xvii |
| | |
| CHAPTER 1 INTRODUCTION | |
| 1.0 Introduction of Thesis | 1 |
| 1.1 Background Research | 1 |
| 1.2 Problem Statement | 2 |
| 1.3 Research Objective | 4 |
| 1.4 Scope of Research | 4 |
| 1.5 Dissertation Layout | 5 |
| | |
| CHAPTER 2 LITERATURE REVIEW | |
| 2.0 Introduction | 7 |
| 2.1 Mobile robot in Agricultural Applications | 9 |
| 2.2 Observations | 26 |

| | | |
|-------|---------------------|----|
| 2.2.1 | Wheel Configuration | 26 |
| 2.2.2 | Steering Technique | 26 |
| 2.2.3 | Sensor System | 26 |
| 2.2.4 | Suspension System | 27 |
| 2.2.5 | Power Supply | 27 |
| 2.2.6 | Transmission | 27 |
| 2.2.7 | Structure Material | 27 |
| 2.2.8 | Robot Application | 27 |
| 2.3 | Summary | 28 |

CHAPTER 3 DEVELOPMENT OF MULTI TERRAIN MOBILE ROBOT

PROTOTYPES

| | | |
|-------|---------------------------------------|----|
| 3.0 | Introduction | 33 |
| 3.1 | Design and Development of Prototype 1 | 34 |
| 3.1.1 | Structure and Wheels | 35 |
| 3.1.2 | Drive System | 35 |
| 3.1.3 | Passive Suspension | 36 |
| 3.1.4 | Power Supply | 36 |
| 3.1.5 | Power Consumption | 37 |
| 3.1.6 | Field Test for Proto 1 | 38 |
| 3.1.7 | Results and Discussions | 38 |
| 3.2 | Design and development of Prototype 2 | 40 |
| 3.2.1 | Structure | 41 |
| 3.2.3 | Speed and Power Requirement | 42 |
| 3.2.2 | The Differential Steering System | 41 |

| | | |
|-------|---------------------------------------|----|
| 3.2.4 | Gearing System | 45 |
| 3.2.5 | Power Consumption | 46 |
| 3.2.6 | Field Test for Proto 2 | 47 |
| 3.2.7 | Results and Discussions | 47 |
| 3.3 | Design and Development of Prototype 3 | 49 |
| 3.3.1 | Wheel Mount | 51 |
| 3.3.2 | Structure | 49 |
| 3.3.3 | Suspension | 52 |
| 3.3.4 | Speed and Power requirement | 52 |
| 3.3.5 | Power Consumption | 54 |
| 3.3.6 | Field Test for Proto 3 | 54 |
| 3.3.7 | Results and Discussions | 55 |
| 3.4 | Summary | 57 |

CHAPTER 4 DEVELOPMENT OF FINAL PROTOTYPE (AGROBOT)

| | | |
|-------|--|----|
| 4.0 | Introduction | 58 |
| 4.1 | AGROBOT | 58 |
| 4.1.1 | Suspension | 59 |
| 4.1.2 | The Wheel Mount and Gearing system | 63 |
| 4.1.3 | Speed and Power Requirements | 65 |
| 4.1.4 | Drive system / Transmission | 69 |
| 4.1.5 | The Robot Embedded System | 72 |
| 4.1.6 | Battery | 72 |
| 4.1.7 | Power Consumption | 73 |
| 4.2 | Navigational Aid and Obstacle Avoidance System | 74 |

| | | |
|--------|---|-----|
| 4.2.1 | Ultrasonic Sensor | 74 |
| 4.2.2 | Ultrasonic Sensor Testing | 76 |
| 4.2.3 | Simultaneous Trigger (ST) | 78 |
| 4.2.4 | Daisy Chaining (DC) with Commanded Loop application | 79 |
| 4.2.5 | Indoor Testing | 79 |
| 4.2.6 | Percentage of Error for 25cm Range | 80 |
| 4.2.7 | Percentage of Error for 155 cm Range | 80 |
| 4.2.8 | Percentage of Error for 280 cm Range | 81 |
| 4.2.9 | Percentage of Error for 410 cm Range | 82 |
| 4.2.10 | Percentage of Error for 533 cm Range | 82 |
| 4.2.11 | Outdoor Testing | 83 |
| 4.2.12 | Percentage of Error for 38 cm Range | 84 |
| 4.2.13 | Percentage of Error for 165 cm Range | 84 |
| 4.2.14 | Percentage of Error for 280 cm Range | 85 |
| 4.2.15 | Summary | 86 |
| 4.3 | Compass | 86 |
| 4.4 | Microcontroller | 88 |
| 4.5 | Remote Control | 89 |
| 4.6 | Level Logic Converter | 91 |
| 4.7 | GPS mapping System | 92 |
| 4.8 | Navigation and Course Correction | 94 |
| 4.9 | Obstacle Avoidance and Course Correction | 98 |
| 4.10 | Summary | 101 |

CHAPTER 5 RESULTS AND DISCUSSIONS

| | | |
|-------|---|-----|
| 5.0 | Introduction | 103 |
| 5.1 | AGROBOT on Field Test Result | 103 |
| 5.2 | AGROBOT Localization Test | 103 |
| 5.2.1 | Localization Result at Dense Foliage | 106 |
| 5.2.2 | Localization Result at Moderate Foliage | 107 |
| 5.2.3 | Localization Result at No Foliage | 108 |
| 5.3 | AGROBOT Waypoint Navigational Result | 110 |
| 5.3.1 | GPS Navigation 1 st to 3 rd Row | 111 |
| 5.3.2 | GPS Navigation 3 rd to 1 st Row | 111 |
| 5.3.3 | Navigation Error | 112 |
| 5.4 | Summary | 113 |

CHAPTER 6 CONCLUSION AND RECOMMENDATION

| | | |
|-----|----------------------------------|-----|
| 6.0 | Introduction | 114 |
| 6.1 | Project Finding | 114 |
| 6.2 | Research Contribution | 115 |
| 6.3 | Recommendations and Future Works | 116 |

| | | |
|-------------------|--|-----|
| REFERENCES | | 118 |
|-------------------|--|-----|

| | | |
|-------------------|-----------------------------------|-----|
| APPENDIX A | Power window Motor Characteristic | 121 |
| APPENDIX B | Modulus Rigidity for Spring | 122 |
| APPENDIX C | Wiper Motor Characteristic | 123 |
| APPENDIX D | AGROBOT Source Code Programming | 124 |

| | | |
|-----------------------------|---------------------------------------|-----|
| APPENDIX E | AGROBOT Solid work Design | 136 |
| APPENDIX F | Data Collection for Ultrasonic Sensor | 147 |
| APPENDIX G | Data Collection for GPS Mapping | 150 |
| LIST OF PUBLICATIONS | | 153 |

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LIST OF TABLES

| NO. | PAGE |
|--|------|
| 2.1 (a) Mobile robot summary from reviewed articles. | 30 |
| 2.1 (b) Mobile robot summary from reviewed articles. | 31 |
| 2.1 (c) Mobile robot summary from reviewed articles. | 32 |
| 3.1 Current consumption of Proto 1. | 37 |
| 3.2 Maneuvering test for Proto 1. | 39 |
| 3.3 Current consumption of Proto 2. | 46 |
| 3.4 Maneuvering test for Proto 2. | 48 |
| 3.5 Current consumption of Proto 3. | 54 |
| 3.6 Maneuvering test for Proto 3. | 56 |
| 3.7 Selection of parameters from AGROBOT. | 57 |
| 4.1 Helical spring physical characteristic. | 61 |
| 4.2 Truth table in normal operating condition. | 69 |
| 4.3 Current consumption of AGROBOT. | 74 |
| 4.4 Source code for data heading. | 87 |
| 5.1 Maneuvering test for AGROBOT. | 105 |
| 5.2 Coding for GPRMC data parsing. | 106 |
| A-1 Power window motor characteristic | 121 |
| B-1 Modulus rigidity for spring | 122 |
| C-1 Wiper motor characteristic | 123 |
| F-1 Data collection for ultrasonic sensor | 148 |

LIST OF FIGURES

| NO. | | PAGE |
|------|---|------|
| 2.1 | An Overview of AURORA mobile robot. | 9 |
| 2.2 | A prototype of mobile robot design by K.M Nielsen et al. (2002) | 10 |
| 2.3 | Mobile robot by Astrand & Baerveldt (2002) | 11 |
| 2.4 | Mobile robot by Bak & Jakobsen (2003). | 13 |
| 2.5 | OptoMAIZER by Klose et al. (2004). | 14 |
| 2.6 | Integrated fruit picking mobile robot by Jayanta et al. (2005). | 15 |
| 2.7 | Rear steering tractor for christmas tree weeding by Blackmore et al. (2005). | 16 |
| 2.8 | Mobile robot platform for Cornhoolio. | 17 |
| 2.9 | Slugbot equipped with three degree of freedom robotic arm by Kelly and Melhuish (2007). | 18 |
| 2.10 | Wurking for corn field application by Hofstee et al. (2007). | 19 |
| 2.11 | Front and back steering technique applied by Meinke et al. (2007) on Amaizeing mobile robot. | 20 |
| 2.12 | Helios mechanical structure by Knaup et al (2007). | 21 |
| 2.13 | Three-wheeled mobile robot by Kool et al. (2007). | 22 |
| 2.14 | NAD mechanical structure by Jorg Klever (2007). | 23 |
| 2.15 | Two wheeled mobile robot by Frits et al. (2007). | 24 |
| 2.16 | Mobile robot platform for weed killer by Chocron and Delaleu (2008). | 25 |
| 3.1 | Complete setup of Proto 1 | 34 |
| 3.2 | Proto 1 mobile robot movement. | 35 |
| 3.3 | Complete setup of Proto 2. | 40 |

| | | |
|---------|---|----|
| 3.4 | Welded part of Proto 2. | 41 |
| 3.5 | Differential steering technique. | 42 |
| 3.6 | Free body diagram for multi-terrain mobile robot. | 43 |
| 3.7 | Gearing system for Proto 2. | 45 |
| 3.8 | Proto 3 of mobile robot. | 49 |
| 3.9 | Proto 3 base structure. | 50 |
| 3.10 | 2 nd base structure fit with bolt to hold the wheel mount. | 51 |
| 3.11 | Wheel mount for Proto 3. | 51 |
| 4.1 | Conceptual design of the AGROBOT. | 59 |
| 4.2 | Compression spring parameter. | 60 |
| 4.3 | AGROBOT passive suspension. | 62 |
| 4.4 (a) | Passive suspension layout | 63 |
| 4.4 (b) | Complete assembly of passive suspension. | 63 |
| 4.5 | Wheel mounts structure. | 64 |
| 4.5 (a) | Motor mounting bracket. | 64 |
| 4.5 (b) | Complete layout. | 64 |
| 4.7 | Gear reduction fitted to the wheel mount. | 65 |
| 4.8: | The motor driver motor from Cytron Technology. | 67 |
| 4.9 | Motor driver connection for each side of AGROBOT. | 68 |
| 4.10 | Gearing ratio for AGROBOT. | 69 |
| 4.11 | Gearing system for AGROBOT. | 71 |
| 4.12 | Small and big sprocket for AGROBOT. | 71 |
| 4.13 | Controller box packaging. | 72 |
| 4.14(a) | LiFePO4 battery packaging . | 73 |
| 4.14(b) | Seal lead acid battery. | 73 |
| 4.15 | Principle of ultrasonic sensor. | 75 |

| | | |
|------|--|----|
| 4.16 | Maxsonar sensor EZ1. | 76 |
| 4.17 | Experimental setup of ultrasonic sensor of AGROBOT. | 77 |
| 4.18 | Data acquisition tool using PLX-DAQ. | 78 |
| 4.19 | ST circuit connection. | 78 |
| 4.20 | DC circuit connection. | 79 |
| 4.21 | Percentage of error from PLX-DAQ-(DC and ST) for indoor-25 cm. | 80 |
| 4.22 | Percentage of error from PLX-DAQ-(DC and ST) for indoor-155 cm. | 81 |
| 4.23 | Percentage of error from PLX-DAQ-(DC and ST) for indoor-280 cm. | 81 |
| 4.24 | Percentage of error from PLX-DAQ-(DC and ST) for indoor-410 cm. | 82 |
| 4.25 | Percentage of error from PLX-DAQ-(DC and ST) for indoor-533 cm. | 83 |
| 4.26 | Experiment setup for data collection in oil palm plantation | 83 |
| 4.27 | Percentage of error from PLX-DAQ-(DC and ST) for outdoor-38 cm. | 84 |
| 4.28 | Percentage of error from PLX-DAQ-(DC and ST) for outdoor-165 cm. | 85 |
| 4.29 | Percentage of error from PLX-DAQ-(DC and ST) for outdoor-280 cm. | 85 |
| 4.30 | Complete assembly of HMC6352. | 86 |
| 4.31 | Bs2P and BS2 microcontroller. | 88 |
| 4.32 | Block diagram for microcontroller input and outputs. | 89 |
| 4.33 | Four channel radio control. | 90 |
| 4.34 | Receiver unit. | 90 |
| 4.35 | Level logic converter from SGBOTIC.com. | 91 |
| 4.36 | GPS module with integrated antenna. | 92 |
| 4.37 | AGROBOT path mapping. | 93 |
| 4.38 | Bearing to north data extraction. | 94 |
| 4.39 | Complete of Garmin E-Trex Vista GPS module. | 95 |
| 4.40 | Mobile robot navigation using heading and waypoint information. | 95 |

| | | |
|------|---|-----|
| 4.41 | Waypoint navigation in oil palm plantation. | 96 |
| 4.42 | Destination waypoint data. | 97 |
| 4.43 | Sonar sensor placement. | 98 |
| 4.44 | AGROBOT object detection. | 99 |
| 4.45 | AGROBOT obstacle avoidance and course correction path planning. | 100 |
| 4.46 | Obstacle avoidance and course correction flow chart. | 101 |
| 5.1 | Plot for coordinate at dense foliage area. | 107 |
| 5.2 | Plot for coordinate at moderate foliage area. | 108 |
| 5.3 | Plot for coordinate in no foliage area. | 109 |
| 5.4 | Plot of Oil palm tree orientation. | 110 |
| 5.5 | Plot of GPS navigation in first path of AGROBOT. | 111 |
| 5.6 | Plot of GPS navigation in second path of AGROBOT. | 112 |
| 5.7 | Plot of Navigation Error of AGROBOT. | 113 |
| 6.1 | Complete designed of AGROBOT. | 117 |

LIST OF ABBREVIATIONS

| | |
|---------------------|---|
| DC | Direct Current |
| GPS | Global Positioning System |
| RC | Remote Control |
| CMU | Carnegie Mellon University |
| PC | Personal Computer |
| SLA | Sealed lead acid |
| Ni-MH | Nickel–metal hydride battery |
| ICR | Instantaneous center of rotation |
| AC | Alternating Current |
| CW | Clockwise |
| CCW | Counterclockwise |
| LiFePO ₄ | Lithium Ferrum Phosphate |
| NMEA | National Marine Electronics Association |
| AGROBOT | Agriculture Robot |
| DC | Daisy chaining |
| ST | Simultaneous trigger |
| FM | Frequency modulated |
| PWM | Pulse width modulation |
| RPM | Rotation per minute |
| PLX-DAQ | PLX data acquisition |

LIST OF SYMBOLS

| | |
|----------|--------------------------|
| F | Total Force |
| V | Velocity of mobile robot |
| F_r | Frictional Force |
| ω | Rotation per minute |
| F_w | Downhill Force |
| μ | Friction Coefficient |
| θ | Slope Degree |
| w_b | Weight of Mobile Robot |
| P | Power of motor |
| R | Radius of wheel |
| V | Voltage |
| K | Spring Rate |
| D | Mean Coil Diameter |
| d | Wire diameter |
| G | Modulus Rigidity |
| N | Number of active coil |

Rekabentuk dan Pembangunan Robot Mudah Alih Pelbagai Permukaan untuk Ladang Berskala Besar

ABSTRAK

Aplikasi yang luas bagi penggunaan robot mudah alih boleh dilihat dari penggunaan domestik dan pelaksanaan dalam skala besar. Salah satu aplikasi yang mungkin boleh mendapat manfaat daripada penggunaan robot mudah alih adalah sektor peladangan. Walau bagaimanapun keadaan muka bumi seperti di ladang kelapa sawit boleh bersifat pelbagai permukaan adalah satu cabaran. Tesis ini menerangkan pembangunan robot bergerak pelbagai permukaan untuk perladangan kelapa sawit. Pembangunan robot yang terdiri daripada tiga jenis prototaip yang masing-masing menguji parameter rekabentuk yang berbeza. Analisis dan keputusan yang diperolehi digunakan untuk tujuan rekabentuk dan pembangunan AGROBOT. Beberapa strategi pelaksanaan telah diuji, seperti lokalisasi, penggunaan kuasa dan keupayaan untuk bergerak. Ujian daripada robot mudah alih telah mencapai kejayaan dan mampu bergerak di sepanjang laluan pra-tetap sepanjang pokok-pokok kelapa sawit. Navigasi *waypoint* akan mengikuti jalan yang ditetapkan dan merekod laluan dengan keupayaan untuk mengelakkan halangan. Kejayaan dalam implimentasi sebuah robot pelbagai rupa bumi, AGROBOT akan memberi manfaat kepada industri pertanian dan boleh digunakan untuk aplikasi seperti semburan racun perosak dan merumpai.

Design and Development of Multi-Terrain Mobile Robot in Large Scale Plantation

ABSTRACT

The wide range applications of mobile robots can be seen from domestic appliances to large scale implementation. One of the possible applications that can benefit from the use of mobile robots is large scale plantations. However such applications, say in oil palm plantations, poses real challenge due to the multi-terrain nature of such environment. Described in this thesis is the development of multi-terrain mobile robot for oil palm plantation. The development of the robot consists of three different of prototypes which test the different design parameters of the mobile robots, and the analysis and results used for the design and development of AGROBOT. Several implementation strategies were tested, such as localizations, power consumption and ability to maneuver. The testing of the mobile robot was a success and able to move along desired preset paths along the oil palm trees. The waypoint navigation will follow the path and recorded the desire route with the capability of avoiding the obstacle. The success in the implementation of a multi-terrain mobile robot, AGROBOT, will benefit the agro industry and may be used for application such as pesticide spraying and weeding.

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CHAPTER 1

INTRODUCTION

1.0 Introduction of Thesis

This thesis describes the detailed development of multi-terrain mobile robots for large scale plantation such as oil palm. The thesis is divided into six chapters which are:

- i. Introduction
- ii. Literature Review
- iii. Prototyping of multi-terrain mobile robots
- iv. Final Prototype (AGROBOT)
- v. Result and discussions
- vi. Conclusion

This thesis also discussed the application of navigational system and obstacle avoidance system which aids the mobile robot to maneuver in oil palm plantation autonomously.

1.1 Background Research

Multi-terrain mobile robot is described as a mobile robot that can move in rugged environments such as in plantations with various types of terrains. The mobile robot needsto perform specific movements along the obstacles for example, and may need to climb slopes. Such capabilities give potential to solve a number of challenges in agricultural applications.

Many designs of multi-terrain mobile robots have been proposed according to required environment. The design can be divided into three approaches, namely the modifications of existing vehicle (small tractor), modifications of remote control truck and new design of the multi terrain mobile robot.

The project focuses on the new design of the multi terrain mobile robot. It is also intended to be the founding development platform for future research in an agricultural application and development within this field at the University Malaysia Perlis.

The application in agriculture, such as fruit picking, crop registration, weed killer and other applications are cost intensive and also high labor demand. By introducing the mobile robot higher efficiency work can be done and low cost by reducing human capital thus increase the productivity.

The current research applied on large scale plantation such as grape and corn plantation. The AURORA designed by Antony Mandow (1996) use in green house application for chemical spraying. The project can be form of development of mobile robot, development of mobile robot navigation and mobile robot application. AURORA is discussed in Chapter 2, Section 2.2.

The mobile robot design parameters covered in the project include:

- i. Mobile robot drive configuration, i.e. four wheel, two wheels and tricycle,
- ii. Steering technique,
- iii. Suspension system,
- iv. Batteries and
- v. Wheel types selection

The mobile robot navigation uses various types of sensor such as:

- i. Global Positioning System (GPS)
- ii. Laser range finder
- iii. Stereo vision
- iv. Sonar sensor
- v. Infrared sensor

The system designed according to this parameter will give the mobility of mobile robot to perform a specific task in a required environment to help of mobile robot navigation system such as obstacle avoidance system and GPS navigation.

1.2 Problem Statement

One of the main problems faced in plantations of multi-terrain nature is the mobility of mobile robots. The focus of this research is the oil palm plantation, which by nature has such multi-terrain environment, and should provide a good test-bed in which the robots will be tested.

The design robots for such condition need many considerations such as mobile robot stability, which discussed in Chapters 3 and 4. The rugged environment consists of different element, such as dirt, sand and rock are considered as an obstacle to mobile robot. The mobile robot also needs to climb the slope which is the main mobility in rugged environment.

1.3 Research Objective

There are four main objectives to be achieved in this research. The objectives are as follows.

- i. To design less complex multi terrain mobile robot suitable for oil palm plantation
- ii. To fabricate multi terrain mobile robot using out-the-shelf material which reduce development cost.
- iii. To navigate multi terrain mobile robot in oil palm plantation using GPS, compass.
- iv. To test obstacle avoidance system using sonar sensor by implementing Daisy chaining application method and map required multi terrain path .

1.4 Scope of Research

The project covered several areas as listed below:

- i. Development of a series of mobile robot prototypes to test several design parameters separately.
- ii. To develop multi-terrain mobile robot using different parameters described in Chapter 2 and electronics design for motor driver and input output interfacing for various types of sensors.
- iii. To test the prototypes on site to validate the choice of the design parameters.
- iv. To use the findings of the prototype testing parameters and build the last mobile robot combining all the finding.

- v. Data collection from the GPS and ultrasonic sensors for mapping and data acquisition to perform obstacle avoidance system and waypoint navigation.

1.5 Dissertation Layout

The key objectives for this project include the evaluation, and selection of a drivesystem, the mechanical design and development, through to the electronic design and implementation phases. To illustrate each step in the design and development stages, the thesis has been presented in the following manner:

- i. Chapter One: Gives a general introduction to the project requirements, background of research, application, motivation, objective and scope of research.
- ii. Chapter Two: Discusses the conceptual designs of previous agricultural mobile robot covering the sensing technique and drive configurations and others parameter in determining the best systems for the intended applications.
- iii. Chapter Three: Prototyping of multi terrain mobile robot. This section will discuss the design of first, second and third prototype. The advantages and the disadvantages that have been observe during maneuvering test also being discussed in this chapter.
- iv. Chapter Four: The development of the final prototype is described based on three different prototypes in the previous chapter. The comparison between sonar sensor using daisy chaining application method and simultaneous trigger sonar sensor also been discussed. The waypoint navigation