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

by

MOHAMAD HANIF ABD HAMID
0430610021

A thesis submitted
In fulfillment of the requirements for the degree of
Master of Science (Mechatronic Engineering)

SCHOOL OF MECHATRONIC ENGINEERING
UNIVERSITI MALAYSIA PERLIS

OKTOBER 2015

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

UNIVERSITI MALAYSIA PERLIS

DECLARATION OF THESIS

Author's full name : Mohamad Hanif Abd Hamid

Date of birth : 03 Januari 1980

Title : Design and Development of Multi-Terrain in Large Scale Plantation

Academic Session : 2015

I hereby declare that the thesis becomes the property of Universiti Malaysia Perlis (UniMAP) and to be placed at the library of UniMAP. This thesis is classified as :

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*

☐ **RESTRICTED** (Contains restricted information as specified by the organization where research was done)*

☑ **OPEN ACCESS** I agree that my thesis is to be made immediately available as hard copy or on-line open access (full text)

I, the author, give permission to the UniMAP to reproduce this thesis in whole or in part for the purpose of research or academic exchange only (except during a period of _____ years, if so requested above).

	Certified by:
_____	_____
SIGNATURE	**SIGNATURE OF SUPERVISOR**
800103-02-5493	Prof Dr Abdul Hamid Adom
_____	_____
(NEW IC NO. / PASSPORT NO.)	**NAME OF SUPERVISOR**
Date :_____	Date : _____

NOTES : * If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentially or restriction.

ACKNOWLEDGEMENT

Praise to Allah, the most merciful and the most compassionate for blessing me with an abundance of wisdom, patience and health throughout completing this thesis. Firstly, my sincerest appreciation is extended to my supervisor Prof. Dr Abd Hamid Adom for his support, encouragement and guidance in completing this thesis.

My appreciations also go to co-supervisors, Dr. Mohd Hafiz Fazalul Rahiman and Mr. Norasmadi Abd Rahim for their never ending help and support and also fellow staff of PPK Mekatronik UniMAP for their kind helps.

I also would like to express my sincere thanks to my wife, for her understanding, my parent and all in my family.

I gratefully acknowledge the financial support received from FRGS code: 9003-00132, 9003-00025 and the equipment facilities of Mechatronics laboratory of Universiti Malaysia Perlis.

I would like to thank my family, for their kind support, patience and encouragement throughout these years. THANK YOU!

TABLE OF CONTENTS

CHAPTER 5 RESULTS AND DISCUSSIONS

CHAPTER 6 CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

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
LiFePO4	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 pengunaan 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.

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 robotshave been proposed according to required environment. The design can 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 application 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 environmentto help of mobile robot navigation system such as obstacle avoidance system and GPS navigation.

1.2 Problem Statement

One of the main problemsfaced 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 designrobots 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 fourmain 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 obstacleavoidance 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 andimplementation phases.To illustrate each step in the design and development stages, the thesis has beenpresented 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 sensingtechnique 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 testalso 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