INVESTIGATION OF KINEMATIC MODEL FOR KHEPERA III MOBILE ROBOT

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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I declare that this report entitled **"Investigation of Kinematic Model for Khepera III Mobile Robot"** is the result of my own work except for quotes as cited in the references.

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Date : 28 May 2018

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : ……

Supervisor Name : Pn. Norhidayah Mohamad Yatim

Date : 28 May 2018

DEDICATION

This humble effort specially to my beloved parents, family, lecturers and friends, whose love can never be forgotten, whose support, guidance and encouragement upon completing this research and thesis.

ABSTRACT

Kinematic model is important for the robot navigation and path planning. However, it is difficult to get an accurate kinematic model for a differential drive robot, due to many reasons such as unequal wheel diameters, misalignment of wheel, limited encoder resolution and others. Thus, the purpose of this research is to investigate the optimum kinematic model for Khepera III mobile robot. The performance of kinematic model was analyzed by comparing the resulting robot's trajectory and ground truth data. Then, the accuracy of the robot trajectory was improved by experimenting with kinematic model's parameter. To achieve this, a controlled environment was set up along with the software to capture the path taken by the robot using SwisTrack software. The collected data were analyzed using the Mean Square Error equation to calculate the sum of error difference between kinematic model and ground truth in order to improve the accuracy of resulting Khepera III robot trajectory.

ABSTRAK

Model Kinematik adalah penting untuk navigasi robot dan perancangan laluan. Walau bagaimanapun, sukar untuk mendapatkan model kinematik yang tepat untuk robot pemacu berbeza, kerana banyak sebab seperti diameter roda yang tidak sama, roda tidak sekata, resolusi pengekod yang terhad dan lain-lain. Oleh itu, tujuan penyelidikan ini adalah untuk mengkaji model kinematik optimum untuk robot Khepera III. Prestasi kinematik model dianalisis dengan membandingkan data trajektori dan data kebenaran robot. Kemudian, ketepatan trajektori robot ditingkatkan dengan bereksperimen dengan parameter model kinematik. Untuk mencapai matlamat ini, persekitaran terkawal didirikan bersama dengan perisian untuk merekod laluan yang diambil oleh robot menggunakan perisian SwisTrack. Data yang dikumpul dianalisiskan dengan menggunakan persamaan 'Mean Square Error' untuk mengira jumlah perbezaan kesalahan antara kinematik model dengan data kebenaran untuk meningkatkan lagi ketepatan trajektori robot Khepera III yang dihasilkan.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

AVI	:	Audio Video Interleaved
ASCII	:	American Standard Code for Information Interchange
BIOS	:	Basic Input/Output System
COM	:	Communication
DB9	:	D-shell Body 9
DISAL	:	Distributed Intelligent Systems and Algorithms Laboratory
EEPROM	:	Electrically Erasable Programmable Read-Only Memory
GigE	:	Gigabit Ethernet
KHIII	:	Khepera III
LED	:	Light-Emitting Diode
MSE	:	Mean Square Error
OpenCV	:	Open Source Computer Vision
PWM	:	Pulse Width Modulation
RS232	:	Recommended Standard-232
TTL	:	Transistor-Transistor logic
UMBmark	:	University of Michigan Benchmark test
USB	:	Universal Serial Bus

θ'	:	Current angle of Khepera III
θ	:	Previous angle of Khepera III
x'	:	Current Coordinate of Khepera III
x	:	Previous Coordinate of Khepera III
y	:	Previous Coordinate of Khepera III
y'	:	Current Coordinate of Khepera III
l	:	Distance travelled by left wheel
r	:	Distance travelled by right wheel
b	:	Distance between two wheels
T	:	Time Sampling

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

The first chapter of this thesis consists of background study, problem statement of project, project objective, scope of the study and lastly project outline.

1.1 Background Study

In mobile robot technology, kinematics is the most basic study of how mechanical systems behave. Additionally, it's necessary to understand the mechanical behavior of the robot both so as to design applicable mobile robots for tasks associated to understand a way to produce control software for an instance of mobile robot hardware.

Kinematics, as a field of study, is commonly stated as the "geometry of motion" and is sometimes seen as a branch of arithmetic. A kinematics problem begins by describing the mathematics of the system and declaring the initial conditions of any

well-known values of position, speed and/or acceleration of points at intervals the system. Then by using arguments from pure mathematics, the position, speed, and acceleration of any unknown elements of the system can be determined.

Geometric transformations also referred to as rigid transformations which are used to describe the motion of parts of a system, simplifying the derivation of the equations of motion. They're in addition central to the dynamic. Kinematic analysis is that the method of measurement of the kinematic quantities used to describe motion. In engineering, as an example, the kinematic analysis could also be used to notice the variety of movement for a given mechanism and dealing in reverse, using kinematic synthesis to design a mechanism for a desired varies of motion. Additionally, kinematic applies algebraical pure mathematics to the study of the ratio of a mechanical system or mechanism.

1.2 Problem Statement

Kinematic model is important for the robot navigation and path planning. However, it is difficult to get an accurate kinematic model for a differential drive robot due to systematic errors and non-systematic errors. Thus, the purpose of this research is to investigate the optimum kinematic model for Khepera III mobile robot to improve the accuracy of the robot trajectory.

1.3 Objective

Below are the objectives of the research:

a) To study the kinematic model for Khepera III mobile robot.
b) To obtain the ground truth trajectory from experimental data using a robot tracking software.

c) To analyze the performance of kinematic model by comparing the resulting robot's trajectory and ground truth trajectory.

d) To improve the accuracy of resulting Khepera III robot trajectory by experimenting with kinematic model's parameter.

1.4 Scope of Study

In this project, the scope of the project will focus entirely on mobile robot kinematics for robots operating in planar environments. The main goal of this project is able to analyze the kinematic models of Khepera III robot.

To do this, a controlled environment will be set up along with the software to capture the path taken by the robot using SwisTrack software. In general, SwisTrack is a tool for trailing humans, robots, animals, and objects using a recorded video or camera as an input source. However, in this project, SwisTrack is used specifically to track the Khepera III and used Intel's OpenCV library for fast image processing and contains interfaces for USB, FireWire, and GigE cameras, also as AVI files.

After that, the collected data from wheel encoder of Khepera III will be analyzed by using MATLAB software to determine and measure that data in order to get the characteristics of the kinematic model with related mathematical formula. Then, the kinematic model and ground truth data that obtained from capturing the robot paths will be compared and analyzed

At the end of the project, the kinematic model's parameter was experimented in order to improve the accuracy of resulting Khepera III robot trajectory.

Figure 1.1 below show that the scope of study which is divided by two scopes: Hardware and Software.

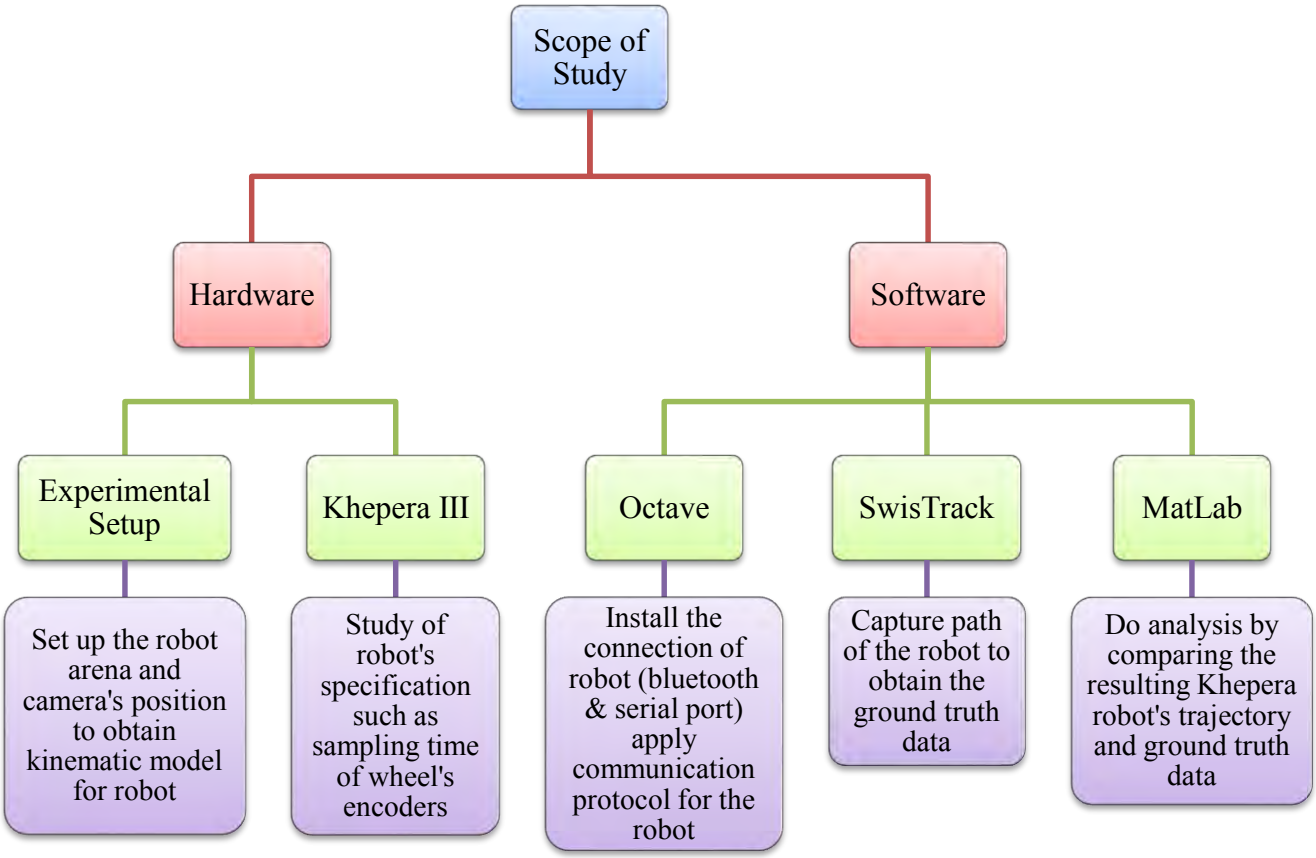

Figure 1.1: Scope of Study

1.5 Project Outline

In Chapter I, the chapter introduces the project background, the problem statement of the project, the objectives of the project, the scope of the project as well as the project outlines. This chapter purposely gives the readers a clear view on the purpose of the project and brief version of this thesis is all about.

Next, Chapter II is about literature review of the project. This chapter is actually covers the previous works completed by other researchers. The previous works done by the researchers includes kinematic model, odometry based model and ground truth measurement.

Chapter III describes thoroughly the methodology used in completing the project and the process flow of the project. The method of connection regarding the system software and hardware will be shown and clarified in this Chapter III.

Finally yet importantly, Chapter IV presents the result on simulation as well as the experiment. The results obtained, later, discussed and analyzed for the performance done and the expenses for the project also presented briefly.

Finally, Chapter V deduces project conclusions based on the result achieved and objectives desired. Recommendation on future works or improvements that can be made for the project are also suggested as one of the part in the chapter.