CONTROL OF A NON-HOLONOMIC MOBILE ROBOT

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To my beloved parents, husband and son

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ABSTRACT

Non-holonomic system is a mechanical system that is subject to non-holonomic constraints. They are the constraints on the velocity of the system which can not be integrated into position constraints that can be used to reduce the number of generalized coordinates. Mobile robots constitute a typical example of non-holonomic systems. In this project, the application of two different types of kinematics controller are examined and analysed. Both of the controllers are using Lyapunov method which is the simplest and successful method in kinematics stabilization. The first controller guarantees to be global asymptotically stable tracking control and the second controller guarantees to be asymptotically stable tracking control. Both controllers are able to control a non-holonomic mobile robot to track the desired trajectory. All simulations are performed using SIMULINK/MATLAB.

ABSTRAK

Sistem tidak berholonomi adalah sejenis mekanikal sistem yg mempunyai sekatan tidak berholonomi. Ia adalah sekatan terhadap halaju sistem yang tidak boleh disatukan dengan sekatan kedudukan untuk mengurangkan jumlah koordinat sesuatu sistem. Robot bergerak adalah salah satu contoh sistem tidak berholonomi. Di dalam projek ini, penggunaan dua jenis pengawal kinematik yang berlainan diuji dan dianalisis. Kedua-dua pengawal ini menggunakan kaedah Lyapunov. Pengawal jenis ini adalah kaedah yang paling mudah dan berjaya digunakan di dalam penstabilan kinematik. Kedua-dua pengawal tersebut mampu mengawal robot bergerak tidak berholonomi untuk menjejaki laluan yang dikehendaki. Semua simulasi dilakukan dengan menggunakan SIMULINK/MATLAB

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v	-	Linear velocity
ω	-	Angular velocity
θ	-	Heading angle
ζ	-	Damping ratio
ω_n	-	Natural frequency
v_r	-	Reference velocity

CHAPTER 1

INTRODUCTION

1.1 Project Introduction

Mobile robots are mechanical devices that are equipped with an on-board power source, computational resources, sensors and actuators. They are able to move autonomously and freely to perform their task. These mobile vehicles can be operated in large buildings (such as shopping centre, hospital and warehouse), nuclear waste facility, security and defence industry, transportation sector, inspection process and planetary exploration. The interest in investigating and developing mobile robots has become increasingly relevant and beneficial to human society and industry. There has been active and rapid development in this area pertaining to its research and implementation. Recent advances in computer and sensor technologies have made it feasible and practical to design and develop new and innovative mobile robots that can effectively serve as utility vehicles and material transporters.

Figure 1.1: ASIMO, a humanoid robot manufactured by Honda

One of the important aspects of the mobile robot systems is related to its motion or navigation control. The issue of control problem is not only dependent on the kinematics and dynamics of the mobile robot system but also the actual individual elements of the control itself. Without a good control system, a mobile robot is practically useless and ineffective. Therefore, the development of a mobile robot is significantly influenced by the proper design of the control system. A variety of theoretical and applied control problems of mobile robot system have been studied and proposed such as kinematics control, dynamic control, intelligent control, adaptive control, and robust control.

Meanwhile, substantial research has been devoted to motion planning. The motion planning objective is to transfer a system from a specified initial state to a specified final state while motion control is to solve the three basic navigation problems; tracking a reference trajectory, path following and stabilization about a desired posture.

In this thesis, a study on kinematics modelling and a design of two stable tracking controllers of non-holonomic wheeled mobile robot using Lyapunov, which capable to track a reference trajectory will be presented. Then both controllers will be discussed in terms of their advantages and disadvantages.

1.2 Objectives

The objective of this project is to design two different stable tracking controllers to control the non-holonomic mobile robot to track a reference trajectory. Then, the simulation will be performed using MATLAB/SIMULINK.

1.3 Scopes of Project

This project was carried out within the following frame of work;

(i) The non-holonomic mobile robot considered in this project is a tricycle-type mobile robot.

(ii) This project considered only kinematics model.

(iii) It is assumed that there is no slipping between the wheels and the floor and mobile robot travels at low speed.

(iv) All simulation works are to be conducted using MATLAB/SIMULINK software.

1.4 Methodology

Generally, the method used to accomplish this project is described in Figure 1.1. First of all, understanding on nonholonomic wheeled mobile robot is crucial to start the project. Therefore, the first step is to study on nonholonomic wheeled mobile robot system. Secondly, study on mathematical modelling of the robot. Then, the designs of the tracking controller based on two different types of controller and perform the simulation using MATLAB/SIMULINK. Last but not least, the actual output response is compared with the desired output response.

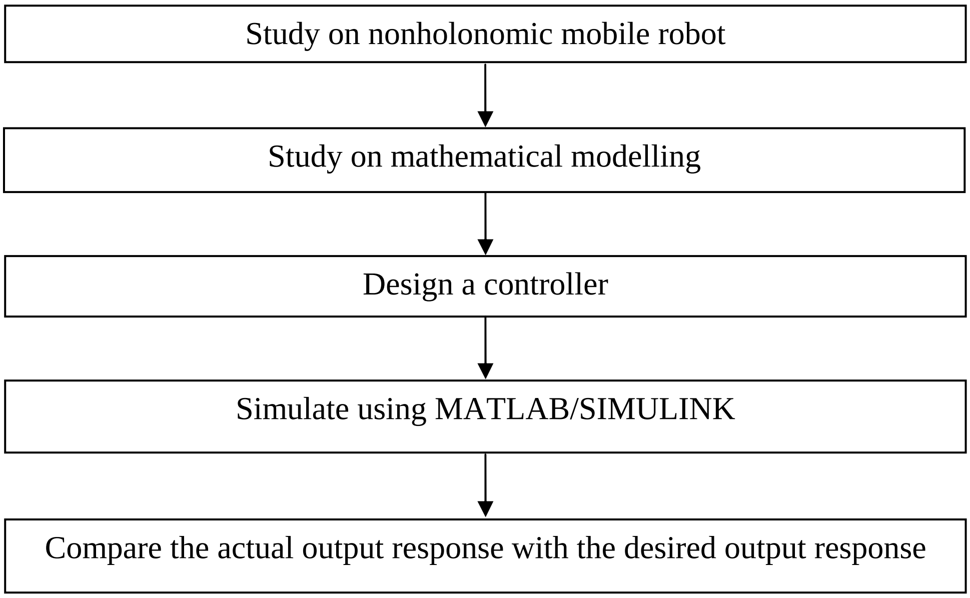

Figure 1.2: Methodology of the project

1.5 Thesis Outline

This thesis consists of six chapters. Chapter I provides some background of the project, the objectives, the scope of studies and the methodologies. Chapter II contains the literature review on non-holonomic system and also on a number of control techniques applied to the mobile robot that were proposed by some researchers. Chapter III entails the kinematic modeling of the nonholonomic wheeled mobile robot system. Chapter IV follows with the design of a stable tracking control using Lyapunov. Simulation results, analysis and discussion of the performance of both the techniques are presented in Chapter V. The work is then concluded in Chapter VI with some suggestions and future works.

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