MECANUM WHEELS MOBILE ROBOT

TEY SIEW HAI

This Report Is Submitted In Partial Fulfillment Of Requirement For The Degree of Bachelor In Electrical Engineering (Control, Instrumentation, Automation)

Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka

MAY 2008

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

Signature : ………………………………………………………

Name : TEY SIEW HAI

Date : 23 APRIL 2008

To beloved father and mother

ACKNOWLEDGEMENT

Firstly, I would like to take this opportunity to thank En Fariz bin Ali, supervisor of BEKU 4973 Projek Sarjana Muda. I am wishing to express a million thanks for his kind, guidance, and monitoring, constant encouragement through out the development of this project. His knowledge and insights were invaluable in identifying the ways to solve my problems encountered regarding to my project and improves my knowledge on embedded controller and programming skill, but also upgraded my presentation and technical report writing skills.

Hereby, I also would like to thanks my classmates who also having same supervisor for their final year project, for they are always help, guidance and advices given to me time to time in order to help me accomplish my project according to planned schedule.

Lastly, to all my well-wisher who had helped me both directly and indirectly, I virtually fall to short words to express my gratitude. Therefore, I end this acknowledgement with two words "Thank You" in their reminiscence.

ABSTRACT

This project will focus on study an omni-directional mobile platform using four mecanum wheels which is required further capacity being programmed to achieve various motion behavior and intelligence . The main aim of this project is to make a robot to move instantaneously in any direction from any configuration. They are capable performing tasks in environment congested with static and dynamic obstacles and narrow aisles. These environments are commonly found in factory workshop offices, ware house, hospitals and elderly care facilities. In the software part, visual basic will use to control the movement of the robot. For the hardware robot, omni-directional wheels are used to move the robot in any direction because the wheel itself consists of a hub carrying a number of free moving rollers angled at 45 degrees about the hubs circumference.

ABSTRAK

Projek ini akan menumpu kepada kajian tentang platform bergerak omni directional menggunakkan empat roda mecanum, yang mana ini memerlukan keupayaan diaturcara supaya dapat mencapai pelbagai gerakkan yang menpamerkan kepintaran. Tujuan projek ini , adalah untuk menjadikan sesuatu robot dapat bergerak secara spontan ke sebarang arah daripada sebarang konfigurasi. Robot ini dapat merlaksanakan tugasan dalam keadaan yang dipenuhi halangan yang statik atau dinamik atau dalam keadaan ruang yang sempit. Keadaan- keadaan yang dimaksud lazimnya didapati di bengkel ,kilang , pejabat hospaital,dan bangunan-bangunan lama.untuk pembangunan perisian, visual basic akan digunakan untuk mengawal pergerakkan robot .Untuk pembangunan perkakasan , roda omni directional akan digunakan untuk mengerakkan robot dalam sebarang arah.yang mana roda-roda tersebut terdiri daripada satu hub yang memegang sebilangan roda bergerak bebas .Kesemua ini ditempatkan pada permukaan lilitan hub dan menbentuk sudut 45 darjah .

CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

PC	- Personal Computer
I/O	- Input /Output
CPU	- Central Processing Unit
PDIP	- Dual in line package
MCU	- Microcontroller Unit
IC	- Integrated Circuit
AC	- Alternating Current
DC	- Direct Current
PIC	- Programmable Interface Controller
HEX	- Hexagon
MOSFET	- Metal Oxide Semiconductor Field-Effect Transistor

CHAPTER 1

INTRODUCTION

1.0 Overview

Robotics has many different applications that can be pursued. In an omni-directional robot, several aspects of robotics are working together; there is omni-directional movement combined with a closed-loop control system. With both of these applications working in conjunction with each other, holonomic motion is achieved. Holonomic motion means that the robot can move in direction while simultaneously controlling its rotational speed. [1]

Mecanum wheels mobile robot is a kind of omni-directional robot. It can perform important tasks in environments congested with static and dynamic obstacles and narrow aisles, such as those commonly found in nuclear plants, offices, factory workshops and warehouses, eldercare facilities and hospitals.

1.1 Background

Mecanum wheels mobile robot capabilities are best explained by first considering other types of movement. Everyone is exposed to automobiles and the problems that may occur while trying to park or maneuver in tight spaces. A car‟s simple drive capabilities are due to its traditional, four wheel setup. All four wheels face the same direction, and only two of them can actually turn. One step ahead of a car is differential drive, such as an Amgibot.

This robot has two drive wheels with a third pivotel that creates easier movement. Now instead of turning, the Amigobot can rotate around the third wheel. Movement in any direction can be achieved by driving one wheel and rotating along the third, pivoting wheel. Still, this is not the most efficient way to get around. It is widely known that the shortest distance between two points is a straight line. A mecanum wheels mobile robot utilizes this principle, and gets to the point. By making use of mecanum wheels, more maneuverable robot can move in any direction, having 360 degrees of freedom.

The main concept of mecanum wheels mobile robots is the newly designed wheel which its consists of a hub carrying a number of free moving rollers angled at 45° about the hub's circumference. The rollers are shaped such that the overall side profile of the wheel is circular. [1] *Figure 1.1* is showed the different types of holonomic system. [1]

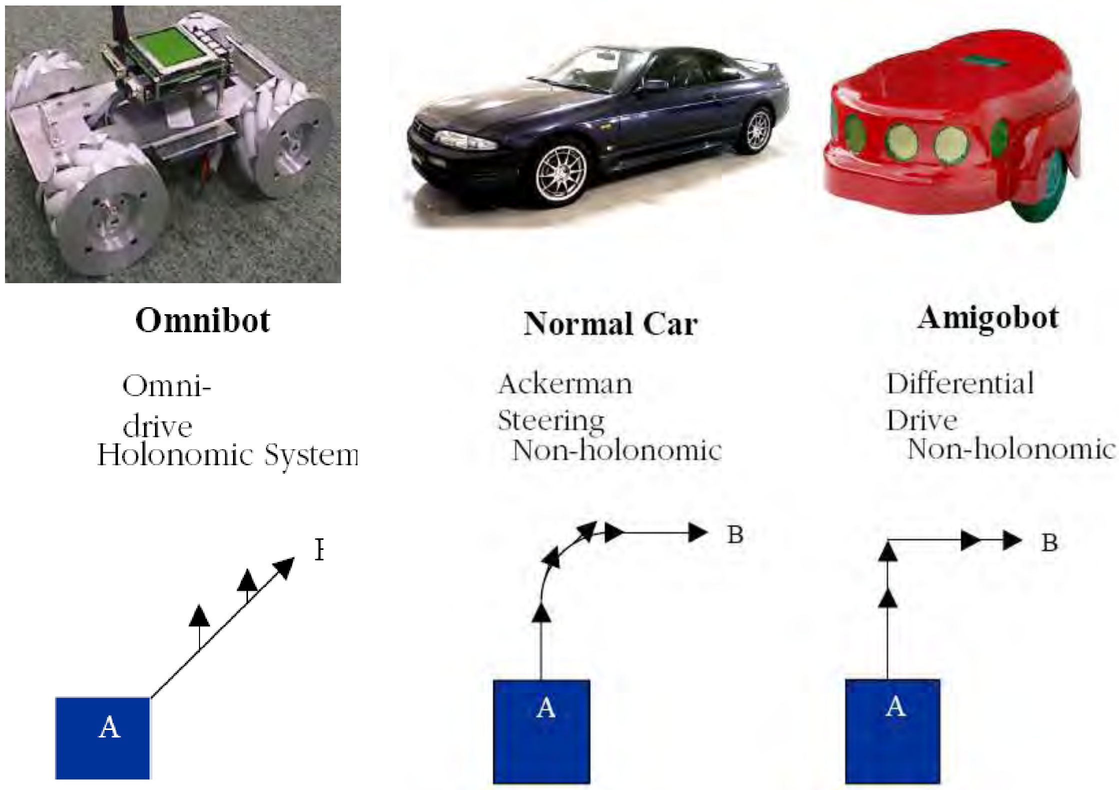

Figure 1.1: Holonomic system

This mecanum wheels built in angled rollers has the ability to roll and slip about 45°. So, robot will move in “vectorarity” to any desired place.

1.2 Project Objective And Aims

This project has the main objective as to establish whether the project is technically and financially feasible, which means whether it fulfils the criteria of being cost effective and are practical enough in all terms. This project will also be important as to state the awareness in terms of money or commercial value in its development. As a whole, the project aims to expose the students to the processes of Engineering design management and practice through the appropriate use of skills and knowledge learned throughout the program. This project will include details such as a time plan; work undertaken for developing the project, risk assessment as well as resources checklist. This project has the objectives in the view of the whole course as follows:

1. To apply a range of techniques for generating, evaluating and selecting design concepts to meet specified requirements in produce mecanum wheels mobile robot.
2. To investigate about the operation in mobile robot system by makes decision of program and hardware to use in completes the task.
3. To learn the Micro- C programming to control robot to perform certain tasks. E.g. moving forward, backward, left , right ,rotate clockwise and rotate anticlockwise

4. To acquire a range of interpersonal skills throughout meetings, interviews, questionnaires, group meetings and lecturer‟s supervision during projects development.
5. To be critical in term of evaluating time concepts and material resources throughout the development of the project.

1.3 Scope of Project

The scope of this project is to design a prototype robot that enables to perform the following tasks:

1. Understanding the basic function of PIC microcontroller (16F877A) and driver L293B.
2. To design a prototype of a robot which can perform 6 rotation motor sequence automatically.

1.4 Problem statement of Project

- Some type of the movement robot cannot move instantaneously in any direction from any configuration.

- A system cannot performing tasks in congested with static and dynamic obstacles and narrow aisles.

1.5 Project Basic Requirement

Multiple tools as below are needed to complete the mecanum wheels mobile robot;

1. Software design and development
   - Micro-C
     - It is a low cost PC based C language compiler optimized for the restricted and specialized environment of embedded microcontrollers. It might be very similar to a C language program with some special functions for moves, loops and palletizing routines. Robot is programmed by moving the robot to the desired position

2. PIC Microcontroller implementation and interfacing

   -It is very important for me to understand the port number of the PIC microcontroller in order to let the Digital I/O interfacing that to switch for an expected result and output.

3. H-bridge characteristic

   - By understand the H-bridge characteristic, we can control the robot by rotate the motor to the desired polarity.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Robots have been a subject of philosophical and a source of literary inspiration for hundreds of years. It is only since this century that robots have emerged out of fiction and philosophy into the real world. Today robots are common-place, for instance mobile robots have the capability to move around in their environment and are not fixed to one physical location. However, robots still have significant limitations. Specifically, most industrial robots require they operate in a congested with static and dynamic condition to moving directly in any direction.

Clearly, there is a need for a more advanced generation of robots that can ensure robot moving in holonomic. To facilitate the advancement, systems must be developed that enable robots to perform that required task.

2.2 Background

Autonomous mobile robots are machines that are able to move around freely in a manner appropriate for their environment, with respect to some general goals. Control of the robot‟s movement in an environment is generally referred to as navigation. The earliest autonomous mobile robot was built by Dr. Grey Walter in the 1940‟s. [2] However, research in developing mobile robots as an end in itself began in earnest in the late 1960‟s. [3]

2.3 Wheel mobile robot

Locomotion is the process of causing an autonomous robot to move, which is Combination of various physical (hardware) and computational (software) components. This movement process is included locomotion, sensor, control and communication. Locomotion ensures the robot moving through its desired environment. Sensor will help robots to measure properties of itself and its environment .Control is a part for robot to generate physical actions. Communication allows robots communicate with each other or with an outside operator.

2.4 Omni-directional wheels mobile robot

Omni-directional mobile robot or automated vehicles could perform tasks in environment with congested with static and dynamic the main concept of omni-directional robots is the newly designed wheel which it‟s built in rollers is 90 degree. This wheel has the ability to roll and slip about two perpendicular axes simultaneously. This is accomplished by the use of free moving cylinders, which encompass the perimeter of the wheel.

A variety of designs of omni-directional or near omni-directional vehicles have been developed. These can be broken into two approaches: special wheel designs and conventional wheel designs. An omni-directional vehicle is usually formed using three or more of such wheels.

Most special wheel designs are based on a concept that achieves traction in one direction and allow passive motion in another. The universal wheel is an example of the special wheel design that has a number of small passive rollers mounted on the periphery of a normal wheel. The axes of the rollers are perpendicular to that of the wheel. The wheel is driven in a normal fashion, while the rollers allow for a free motion in the perpendicular direction. The Mecanum wheel design is based on similar concept. It has angled passive rollers around the periphery of the wheel. By controlling the four wheels attached to a platform, omnidirectional mobility can be achieved

Conventional wheels are inherently simple, have high load capacity and high tolerance to floor irregularities such as bumps, cracks, dirt and debris. However, due to their nonholonomic nature, they are not omni-directional. Designs have been proposed to achieve near omni-directional mobility for vehicle using conventional wheels. The most common designs are those using steered wheels. Vehicles based on this design have at least two active wheels, each of which has both driving and steering actuators. They can move in any direction from any configurations. [4]

However, this type of system is not truly omni-directional because it needs to stop and re-orient its wheels to the desired direction whenever it needs to travel in a trajectory with non-continuous curvatures. One technique to use the conventional wheel for omni-directional mobility is to use the active castor wheel. With two or more such wheels omni-directional mobility can be achieved for a vehicle.

2.4.1 The advantages of an Omni-directional robot compared to conventional vehicles.

- Omni unique technology provides the ability to move in any direction and rotate within footprint of vehicle.

- Mechanically, an omni-directional robot is simpler than other types of highly maneuverable or "multi-directional" or "all-wheel steered" vehicles.

- With the exception of omni-directional wheel and controls, an omni-directional robot is extremely simple and is fabricated using conventional, off-the-shelf hardware. This feature reduces acquisition and maintenance costs. Modular designs for controls drive, and omni wheels further reduce development and operating costs.

- Existing designs for wheels, drive, and control systems can often be adapted for the client's specific application at minimum cost.

- For many applications, an omni-directional robot reduces manpower while increasing productivity (throughput) compared to conventional vehicles.

- An omni-directional robot reduces operating space as well as the time to complete an operation, plus increases storage space for materials. [5]

2.5 Control

From a systems engineering point of view, the control of the robot was fairly straight forward. A user input was taken, run through a microprocessor, which sent a Pulse Width Modulation (PWM) signal to the motors and in turn ran the wheels. The result of this process was relative closed looped control. The encoders, attached to the motors, supplied real-time feedback creating a closed-loop system allowing velocity control to be achieved.

2.5.1 Open-Loop Timer Based

Open-loop timer based control would work through user interface, most likely with a laptop resting on top of the robot. The user would specify a distance and an angle for the robot to travel, and the program would run based on already determined distances. For example, the robot would know it takes three seconds to travel a total of one meter. So if a drive distance of two feet were desired, the program would turn the motors on for six seconds. This type of interface allows a little more precision control than the above systems, but it is still fairly inaccurate. Also, traveling at varying velocities is impossible due to the pre-set distances. [1]

2.5.2 Relative Closed-Loop

Relative closed-loop control can be integrated with a variety of other interfaces, such as a computer or a joystick. The term "closed-loop" stands for a continuous status feedback given to the microprocessor. The microcontroller communicates with the laptop or joystick, which allows it to figure out the current speed and direction of the robot, and in turn make changes to the robot‟s current state. This is the type of program needed to implement the velocity control.

The code for this type of interface is much more complex, but it allows increased accuracy when dealing with distance and velocity. This accuracy is achieved by comparing continual data feedback with the user input, changing the state of the robot based on this comparison.

However, relative closed-loop control does not have position memory, so global coordinate positioning would not be possible. Position memory would allow the robot to record the distance it has traveled and use this information to map its movements. [1]

2.5.3 Absolute Closed-Loop

Absolute closed-loop control works exactly like relative closed-loop control, only it has position memory. Position memory, also known as global coordinates positioning, means the robot stores the total distance it has traveled in each direction, so the robot‟s current position is always given relative to its known starting point. This would allow the user to travel with respect to global North-South/East-West rather than arrangement of the robot. This code can be fairly complex, but it gives the most accurate results compared to all the other control options.

After weighing the pros and cons of each type of interface, a relative closed-loop control run from a laptop mounted to the top of the robot was initially chosen. This type of control would prove to be challenging on the programming side, but it would provide the precision and usability desired. However, as the design process progressed, the team realized the computer interface was not very user-friendly, so a vehicle joystick was incorporated into the system. This made the robot much more interactive and increased its maneuverability, but it limited the team‟s precision of distance and velocity. [1]

CHAPTER 3

THEORETICAL