" I hereby declare that I have read through this report entitle "Development and Analysis of Obstacle Avoidance Algorithm For Robotic Wheelchair with Shared Control" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)"

Signature : ....

Supervisor"s Name : Mr. Tarmizi Bin Ahmad Izzuddin

Date : ....

DEVELOPMENT AND ANALYSIS OF OBSTACLE AVOIDANCE ALGORITHM FOR ROBOTIC WHEELCHAIR WITH SHARED CONTROL

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A report submitted in partial fulfillment of the requirement for the degree of the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

I declare that this report entitle "Development and Analysis of Obstacle Avoidance Algorithm For Robotic Wheelchair with Shared Control" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : Arif Zaim Bin Zawir Abdulah

Date : ....

To my beloved mother and father

ACKNOWLEDGMENT

First and foremost, I would like to take this oppoturnity to express my greatest gratitude to my supervisor Mr Tarmizi bin Ahmad Izzuddin for his guidance, encouragement, support and advics throughout the project. the valuable and inspirational ideas have very much contributed to the successof this undegraduate project.

During the course of development of this project, several problems have been encountered and from the help of the fellow friends, these problems has been resolved. I would like to take this oppurnity to express my friends for their helps, ideas and informations.

A special thanks to my family who gave me encouragement, support and strength to keep moving on no matter how hard the situation can be ahead

ABSTRACT

Robotic wheelchair technology has been in research for quite number of years. The aim is basically to move an ederly or disable person from one place to another. Some of the genius invention robotic wheelchair was developed by the researcher to ensure the robotic wheelchair will provide safety and comfort to the user. One of the invention is to developmentof an obstacle avoidance algorithm that can be implement to the robotic whelchair. This final project paper objective is to develop an Obstacle Avoidance Algorithm with shared control that can be implemented to the robotic wheelchair. This Algorithm can somehow provide the ability to make decision to switch between controllers from Go-to-Goal controller and Avoid Obstacle controller. The first step is to develop a Go-to-Goal controller followed by Avoid obstacle controller. Then both controllers are either blend or switch between both of them. The analysis is conducted based on the robot simulation result of the final coordinate value of the robot and the difference between the robot heading angle and the reference angle. The analysis also will done based on the gain of the Proportional, Kp, Intergral, Ki, and Derivatives, Kd, of the controller that is crutial to steer the robot to desired angle with a stable and movement.

ABSTRAK

Kajian mengenai teknologi kerusi roda robotik telah dijalankan oleh para pengkaji untuk jangka masa yang lama. Tujuan utama kerusi pintar ini adalah untuk menggerakkan orang kurang berupaya atau orang tua yang tidak mampu untuk bergerak. Kebanyakan inovasi telah direka dan diimplemenkan kepada kerusi roda pintar ke satu tahap yang lebih moden dan canggih. Salah satu inovasi ialah pengelak halangan untuk kerusi roda robotik. Objektif Projek Sarjana Muda adalah berkaitan untuk membangunkan algoritma yang membolehkan kerusi roda robotik ini untuk bergerak tanpa melanggar sebarang objek atau halangan. Algoritma ini juga membolehkan apabila terjadinya keadaan untuk membuat keputusan antara Pengawal Pergi-ke-Gol dan Pengawal Pengelak-Halangan.. Langkah pertama adalah untuk membuat Pengawal Pergi-ke-Gol dan Pengawal Pengelak-Halangan. Kemudian kedua dua Pengawal ini akan di dikisarkan atau di tukarkan kepada pengawal yang lain. Analisa telah dijalankan daripada hasil simulasi berdasarkan maklumat akhir koordinaat robot dan juga perbezaan antara sudut robot dan juga sudut rujukan. Selain itu, analisa juga dijalankan berdasarkan nilai faktor kecerunan Perkadaran,Kp, Kamiran, Ki, dan juga pembezaan, Ki. Yang sangat penting untuk menggerakkan robot ke arah sudut yang dikehendaki.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

In the world of mobile robot one of its application is the Robotic wheelchair. Robotic wheelchair can enhanced the capabilities of traditional powered devices by introducing control and navigational intelligence. The lives of many disabled people can be ease, particularly those with severe impairment, by increasing their range of mobility. It is important for the researcher to develop a high tech and very modern robotic wheelchair to help handicap people. The basic idea of the project comes when there is a situation when the user encounter an obstacle or wall for example. This would be a challenging for the researcher to develop an algorithm to avoid the obstacle either moving or static obstactle.

The needs of obstacle avoidance algorithm in any mobile robot will add the functionality to the robotic wheelchair to move and steer towards the direction of the located goal. A good control of strategy implementation with shared control for obstacle avoiding algorithm can help the robotic wheelchair to avoid the obstacle and help to reach the goal location.

1.2 Motivation

At the end of this project, we will be able to develop an obstacle avoidance algorithm with shared control that can be used for a robotic wheelchair that include switching system that capable in choosing the system priorities between Obstacle Avoidance Controller, Follow Wall Controller, and Go-to-Goal controller in order to reach the goal location by the user. These controllers are guided by the Supervisor controller based on finite state machine system which is basically a system that can switch the controller by their importance respectively according to the situation encounters by the robotic wheelchair.

1.3 Problem Statement

The robotic wheelchair is basically have the function to go to any direction by the signal from the controller. The user is in controlled for the robotic wheelchair. However the user will encounter difficulties in controlling the robotic wheelchair when facing with obstacle. For a robotic wheelchair sytem, one if its basic tasks should be avoiding obstacle. Obstacle avoidance is an important role in the design of self-navigating wheelchair with comfort, safety and smoothness as well. Therefore, the main difficulty is to develop an algorithm and strategy that are able to assist a robot wheelchair to recognise obstacles and to go around it by maintaining an realistic and safe distance.

1.4 Objectives

The objectives of the project are:-

- To develop an obstacle avoidance algorithm with shared control for use in robotic wheelchair using Matlab robot simulator
- To simulate the proposed algorithm in Matlab robot simulator

- To analyse the proposed obstacle avoidance algorithm for robotic wheelchair using Matlab robot simulator

1.5 Scope of Work

The scope of this project are

i. The controller of the obstacle avoidance algorithm in the robot simulator consists of
   a) Go-to-Goal controller
   b) Avoid Obstacle controller
   c) Stop controller
   d) Follow wall controller
   e) Avoid Obstacle and Go-to Goal controller
   f) Supervisor for the all controllers above

ii. The simulation will only use a static obstacle environment as obstacle for the robot.

iii. The tracking of the eye gaze is partial help to guide the direction of the robot. Most of the time the algorithm is taking place to help and navigate the robot towards the goal direction.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In the world of technology, robotic wheelchair has been in research for quite long by many researchers. The aims are basically to improve the current technology and safety to the user in order to make a user friendly wheelchair. This advanced research will help to improvised the robotic wheelchair to the another level of science and technology.

A robotic wheelchair is designed for people with impaired mobility must be able to help the user to navigate to the goal location within a certain workspace. The wheelchair is basically will be intergrated with multiple sensor used for mapping, path planning and obstacle avoidance strategy.[1]

Therefore, various obstacle avoidance algorithm has been designed and implemented to the robotic wheelchair so that the robotic wheelchair can navigate to the goal location and at the same time will avoid the obstacle in

2.1 Basic Concept for Obstacle Avoidance

Imagine a mobile robot with three sensos intergrated and from that we can make a logic gate based avoidance obstacle algorithm. Figure 2.1 shows a simple robot with three sensors.

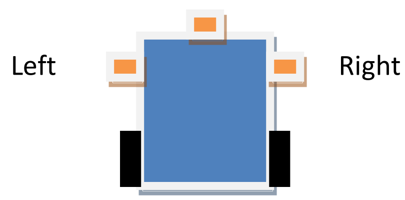

Figure 2.1: A robot integrated with three sensors

Table 2.1: Basic obstacle avoidance with three sensors

Sensor			Direction of the robot	Two DC motors with two pins polarity (+ -)			
Left	Front	Right		Left	Left	Right	Right
0	0	0	Forward	1	0	0	1
0	0	1	Forward	1	0	0	1
0	0	0	Right	1	0	1	0
0	0	1	Left	0	1	0	1
1	1	0	Front	1	0	0	1
1	1	1	Front	1	0	0	1
1	1	0	Right	1	0	1	0
1	1	1	Reverse	0	1	1	1

The most basic algorithm in term of logic gate showed in Table 2.1. It shows the direction of the robot when encounter an obstacle. However this simple logic method cannot be applied when encounter an obstacle with different type of length and angle. Therefore in order to overcome this situation a more advanced algorithm must be made. This will help the robot to navigate through a more complex obstacle.

2.2 Reviews of previous related works

The thesis by Marcelo R. Petry, Antonio Paulo Poreira describes on a robust, obstacle avoidance extension of the classic potential field methodology. Their algorithm is specially adapted to share the wheelchair‵s control with the user avoiding situation. The method relies on the idea of virtual forces generated by the user command (attractive forces) and by the objects detected on each ultrasonic sensor (repulsive forces), acting on the wheelchair.[2]

Some of the desired properties of shared control algorithm are:-

i) Avoid obstacles in real-time. Since wheelchairs operate in dynamic environments, it is not feasible to implement popular time-consuming, global path planners. Instead, such application is more suitable to approaches based on fast response like reactive/reflexive controls.

ii) Consuming low memory and processing algorithms are more likely to achieve a real-time reflexive behaviour in controlled systems.

iii) The safety and perception of the user is increase. Shared control approaches may consider qualitative evaluation of the wheelchair‵s overall behaviour in a quantitative reduction in the number of collision.

Summary of some classic obstacle avoidance methodologies developed in robotics.

1) Edge-Detection method

A popular obstacle method is based on edge detection. The algorithm from this method tries to map the position of the vertical edges of the obstacle in the robot surrounding and then move the robot around to the visible edges. There will be disadvantages by implementing this method because the robot will stops in front of the obstacle to gather information from the sensor. This however can be improve by using faster processing computer. Whenever the robot moves, a scanning mode starts taking alternate sonar‵s samples. Once measures are under a certain safety distance, the robot stops, take a panoramic scan, apply the edge-detection methodology and restart the cycle all over again.[3, 4]

2) Certainty Grid

Certainty grid (CG) method is basically a probabilistic representation of obstacles in a grid based world model. It has been developed for mobile robots in Stanford and CMU for more than ten years, and was originally designed to handle sonar‟s inaccuracies shortcomings [5]. In this method, the robot‟s work area is modeled as a 2-D array of square elements, called cells. Each cell of the grid contains a likelihood estimate (certainty value) that indicates confidence that an obstacle is placed within the corresponding region of space. Once readings are more likely to detect objects closer to the acoustic axis of the sonar, a probabilistic function updates more the certainty value in this region than in the other areas enclosed by the sensor [5, 6]. In spite of some improvements presented by CG methodology, some drawbacks can compromise its implementation in real-time applications. Firstly, the accuracy provided is too much dependent of the cell size. Secondly, as the robot moves over large areas, lots of memory and processing power are required, restricting the application of CG especially in some embedded systems. Finally, the subsequent robot‟s path shall be computed off-line, by a global pathplanning.

The next project report is about autonomous robotic wheelchair by Pin-Chun Hsieh. His research discussed on autonomous robotic wheelchair with collision avoidance navigation. The objective of this research is to demonstrate a robotic wheelchair moving in an unknown environment with collision-avoidance navigation. A real-time path-planning algorithm was implemented by detecting the range to obstacles and by tracking specific light sources used as beacons. Infrared sensors were used for range sensing, and light-sensitive resistors were used to track the lights. [7]

He uses three GP2D15 and two GP2D12 infrared distance-measuring sensors as shown in Figure 2.4 , used to detect obstacles. The GP2D15 detects an obstacle at 24-cm range and the GP2D12, from 12 cm to 80 cm. the output voltage signals from the sensors will generate fed to the analog-to-digital converters on the interface board. [7]

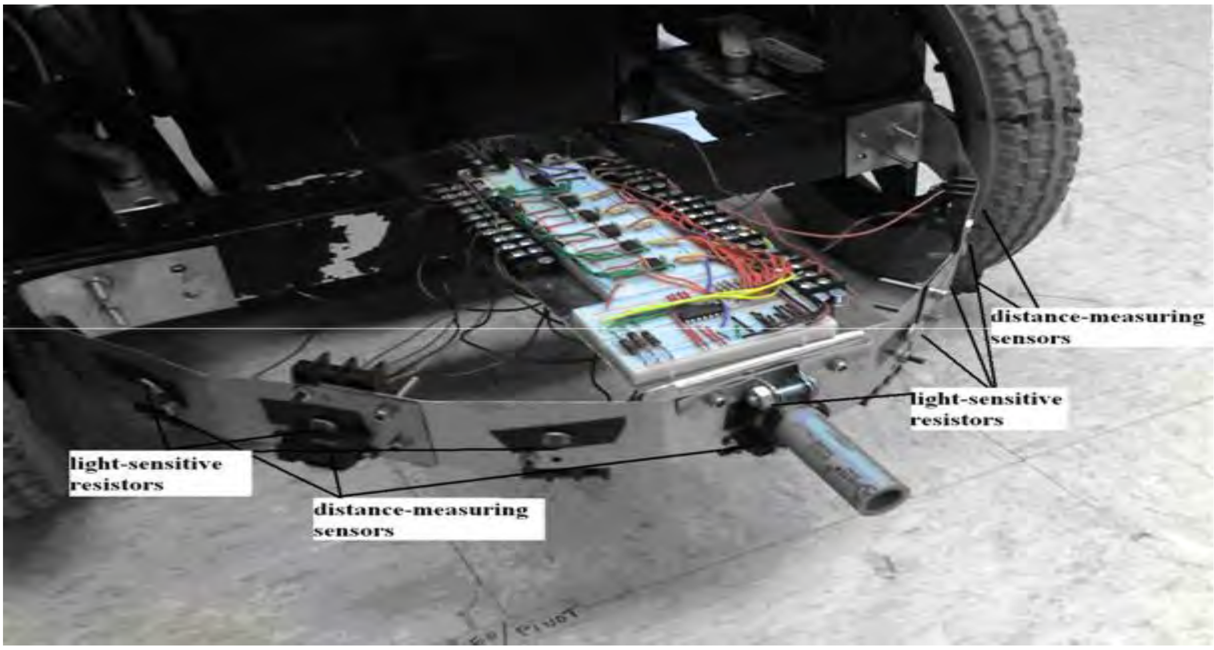

Figure 2.2: Seven light-sensitive resistors and five distance-measuring sensors are mounted on the sensor bracket with interface circuit board.[7]

There are 32 conditions of the signal transmit from these five sensor with the sensors are arranged in the Figure 2.4. Table 2.1 shows the infrared sensor generates logic-high and logic –low to the Digital I/O PCMCIA Card.

Table 2.2: Response of the robotic wheelchair for each condition.[7]

Logic signal from Infrared Sensor				Response of Robot	
Left GP2D12	Left GP2D15	Right GP2D12	Right GPD12	Front GP2D15"s Signal is L	Front GP2D15"s Signal is L
L	L	L	H	Left turn	Left turn
L	L	H	L	Left turn	Left turn
L	L	H	H	Left turn	Left turn
L	H	L	L	Right turn	Right turn
L	H	L	H	Forward	Stop
L	H	H	L	Forward	Stop

L	H	H	H	Left turn	Stop
H	L	L	L	Right turn	Right turn
H	L	L	H	Forward	Stop
H	L	H	L	Forward	Stop
H	L	H	H	Forward	Stop
H	H	L	L	Right turn	Right turn
H	H	L	H	Forward	Stop
H	H	H	L	Right turn	Stop
H	H	H	H	Forward	Stop
L	L	L	L	Forward	Stop

A paper from Ioan Susnea, Viorel Minzu, Grigore Vasilu proposes an algorithm for real time obstacle avoidance, with low cost sonar or infrared sensors that can be implemented on embedded microcontrollers. The algorithm is called “the bubble rebound algorithm”. The obstacle within an area called “sensitivity bubble”around the robot can only be detected by the algorithm. Depending on the kinematics of the robot the sensitivity bubble size and shape are dynamically adjusted. The robot will “rebounds” towards a direction having the lowest density of obstacles, and continues its direction until desired goal becomes visible, or a new obstacle is encountered when detecting an obstacle. [8]

The advantages of this algorithm are

- Uses very low computational load, and can be implemented on low-cost microcontrollers.
- Can avoid any kind of static obstacles, and moving obstacles, like walking humans.
- Require low cost sensors.