STAIR CLIMBING MOTION CONTROL FOR PORTABLE MECHANISM

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DECLARATION

I declare that this thesis entitled "STAIR CLIMBING MOTION CONTROL FOR PORTABLE MECHANISM is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have checked this report entitled "STAIR CLIMBING MOTION CONTROL FOR PORTABLE MECHANISM" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATIONS

I wish to give my sincere thanks to the Faculty of Electrical Engineering for providing facilities which required for accomplish this project. Besides, I am also took this opportunity to give my special gratitude to my friends and mostly my beloved parents by giving their encouragement, support, time and idea throughout various phases for the completion of this project.

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ABSTRACT

A wheel-leg mobile robot has the capability to move on flat surfaces and climb the stairs. In this project, a Delta-Wheel stair climbing robot is a purpose to help elderly and disabled people. This is because elderly and disabled people facing difficulties in performing stairs climbing and moving on flat surfaces in daily activities as normal people. These people have required an assistant to help them to climb the stairs. However, the control system of the stair climbing is not a big problem but to maintain stability and smoothness of the stair climbing robot it will become more challenges The main objectives of this project is to design Fuzzy Logic Controller (FLC) by using MATLAB Toolbox in MATLAB software for stair climbing mechanism. The performance of the FLC will be evaluated in term of obstacle detection and obstacles avoidance. The FLC is design by using two inputs and two outputs. The two inputs are left sensor and right sensor that measure distance of obstacles from the robot. The ouputs are speed movement of left motor and right motor that driven by two DC motors. The Infrared sensor are placed at front corners of the robot. The IR sensors can detect up to 0 cm to 27 cm at 90 degrees. The sensors is required to detect the obstacles and it activates the controller to avoid the obstacles. If the robot able to avoid the obstacles, the system will read another sensor input for next process. Based on this signal, the FLC control the speed of the left motor and right motor respectively. The robot able to moving forward with fast speed of left motor and right motor when sensor not detected the obstacle at front of the robot. As the results, the robot able to move forward and reverse but fail to make a turn because the structure of the tires.

ABSTRAK

Robot mudah alih beroda mempunyai keupayaan untuk bergerak di atas permukaan yang rata dan memanjat tangga. Dalam projek ini, robot mendaki tangga yang diberi nama Roda Delta adalah bertujuan untuk membantu golongan warga tua dan golongan orang kurang upaya. Hal ini kerana, orang tua dan orang kurang upaya menghadapi kesukaran untuk aktiviti mendaki tangga dan bergerak diatas permukaan rata dalam kehidupan seharian seperti orang biasa. Golongan ini akan memerlukan seseorang untuk membantu mereka ketika mendaki tangga. Walau bagaimanapun, sistem kawalan pendakian tangga bukanlah satu masalah yang besar tetapi untuk mengekalkan kestabilan dan kelancaran robot ketika menaiki tangga, ia akan menjadi lebih mencabar. Objektif utama untuk projek ini adalah untuk mereka bentuk Pengawal Logik Kabur (PLK)" dengan menggunakan kotak peralatan MATLAB di dalam MATLAB untuk mekanisme pendakian tangga. Prestasi FLC akan dinilai dari segi keberkesanan untuk mengesan halangan dan menghindar halangan. PLK direka dengan menggunakan dua kemasukant dan dua pengeluaran. Kedua-dua kemasukan ialah penderia kiri dan penderia kanan yang mengukur jarak halangan dari robot. Pengeluaran adalah pergerakan kelajuan motor kiri dan motor kanan yang didorong oleh dua motor DC. Penderia inframerah diletakkan di sudut depan robot. Penderia IR boleh mengesan sehingga 0 cm hingga 27 cm pada 90 darjah. Penderia diperlukan untuk mengesan rintangan dan ia mengaktifkan pengawal untuk mengelakkan rintangan. Jika robot dapat mengelakkan rintangan, sistem akan membaca kemasukan penderia lain untuk proses seterusnya. Berdasarkan isyarat ini, PLK mengawal kelajuan motor kiri dan motor kanan masing-masing. Robot mampu bergerak ke hadapan dengan kelajuan pantas motor kiri dan motor kanan apabila penderia tidak mengesan halangan di hadapan robot. Secara keputusannya, robot dapat bergerak ke hadapan dan mengundur tetapi gagal untuk berpusing kerana struktur tayar.

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LIST OF SYMBOLS AND ABBREVIATIONS

IR	-	InfraRed
FLC	-	Fuzzy Logic Controller
MISO	-	Multiple Input Single Output
MIMO	-	Multiple Input Multiple Output
US	-	United States
PID	-	Proportional Integral Derivative
LRF	-	Laser range finder
ANN	-	Artificial neural network
ANFIS	-	Adaptive neuro fuzzy inference system
DC	-	Direct current
PI	-	Proportional Integral
PD	-	Proportional Derivative
PB	-	Positive Big
PS	-	Positive Small
Z	-	Zero
NB	-	Negative Big
NS	-	Negative Small
Kp	-	Proportional term
Kd	-	Derivative term
Ki	-	Integral term
PWM	-	Pulse Width Modulation
ZMF	-	Z-Shaped Membership Functions
SIGMF	-	Sigmoidal Membership Functions
SMF	-	S-Shaped Membership Functions

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CHAPTER 1

INTRODUCTION

1.1 Background

A stairway is a kind of building structure and consider as an obstacle and challenging for vehicles and mobile robots when an emergency occurs such as disaster, fire, and earthquake, especially for wheelchair users. Elderly and disabled people have used the wheelchair in their daily life to move from one destination to another destination. Unfortunately, the number of disabled people are increasing day by day due to some issues such as road accident or disease as well as a number of wheelchair users. Elderly and disabled people are facing difficulties in performing stairs climbing in daily activities as normal people. Nowadays, there are various type of stair climbing mechanism are presented for wheelchair and the design are depending on adaptability on stair climbing and traverse obstacle or slope. Furthermore, the stair climbing robot also can be useful where the stair climbing robot can replace human assistant in the stair climbing operation for wheelchair users.

Generally, stair climbing robot having different locomotive mechanisms based on their performance such as wheeled, legged, tracked and hybrid locomotion. The wheeled locomotive mechanism having the simplest design and able to move faster on flat terrain and provided high energy efficiency. However, in the different unstructured environment their movement is very difficult because it depends on surroundings and different sizes of obstacles during mobility.

A robot with a legged locomotive mechanism capable to climb the stairs and traverse obstacle on different terrain and make it stable with that locomotive mechanisms. Design of legged robot is quite complex and not provide smooth motion on flat terrain compared to wheeled robots. The operation of the legged robots is considering as human legs during up and down stairs.

Furthermore, stair climbing robot with wheel-leg locomotive mechanism has better performance because it will able to moving on flat surfaces and climb the stairs properly. In this project, Delta-Wheel structure is used based on a wheel-leg mechanism in order to move on different structure environment by changing their locomotion based on requirement. Even though, the leg-wheel mechanisms able to adapt in many kind environments it also shows the complex structure and required control algorithm to perform the movement.

Then, Fuzzy Logic Controller (FLC) by using multiple input multiple output (MIMO) was designed in this stair climbing robot to control the complex system and improve the system performance in term of stability and smooth motion. All the system performance of the stair climbing robot are examined.

1.2 Motivation

In recent years, the researcher has involved the attention of people around the world by replacing the manual wheelchair with an automatic wheelchair which able to climb the stairs. The stair climbing robot can be used not only for stair climbing, but it also can be implemented on flat surfaces. Furthermore, the stair climbing robot also play an important role for disabled people in term of healthcare to make their daily life more comfortable.

According to the Disabilities Statistics Annual Report for United State (US) 2016 [1], there are 12.6% of the population in the US are disabled people. Every year the number of disabled people are increasing due to various issue from various age. Figure 1.1 shows the statistics of disabled people from 2008 to 2015 based on several types of questions during a community survey. One of the question from six disability question, it is difficult for disabled people with physically disabled to walking and climbing stairs in daily life.

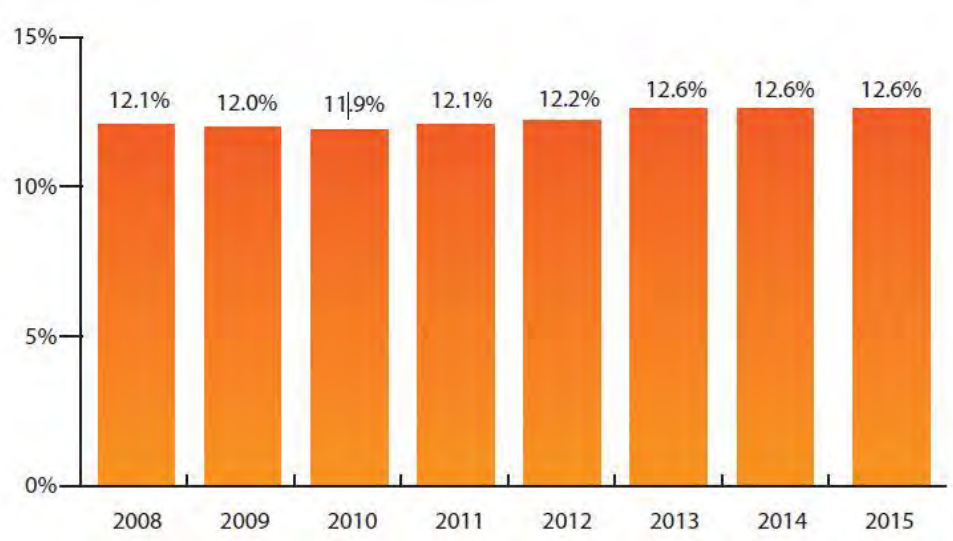

Figure 1.1: Percentage of People in the US with Disabilities, 2008-2015 [1]

On the other hand, the most disabled people being reported is ambulatory with 6.6% and closely followed by cognitive with 4.8% and independent living with 4.5%. Table 1.1 shows the most common type of disabilities in the United State from 2008 to 2015 in percentage

Table 1.1: People with Disabilities by Type and Year, 2008-2015 [1]

Type of disabilities	Percentage (%)							
	2008	2009	2010	2011	2012	2013	2014	2015
Hearing	3.5	3.4	3.4	3.4	3.4	3.6	3.6	3.6
Vision	2.3	2.1	2.1	2.2	2.2	2.3	2.3	2.3
Cognitive	4.5	4.5	4.5	4.6	4.6	4.7	4.8	4.8
Ambulatory	6.4	6.4	6.4	6.5	6.5	6.6	6.7	6.6
Self-care	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.5
Independent living	4.3	4.2	4.3	4.4	4.4	4.4	4.5	4.5

So, the best solution in order to decrease the number of human assistant during climbing stairs for disabled people especially for physically disabled is by replacing the human assistant with a stair-climbing wheelchair. Nowadays, there are various type of wheelchairs, for example, manual wheelchair and automatic wheelchair. However, wheelchair out there is not affordable for poverty wheelchair users and some wheelchair are not suitable for other purposes. Furthermore, the stair climbing wheelchair that able to adapt with different unstructured of environment likes stairs, curb and zebra crossing give an advantage for wheelchair users in daily life.

1.3 Problem Statement

Stairs represent a dangerous component in building structure compared to slopes. These stairs are considering as an obstacle to the mobile robot to perform their movement, especially on stair climbing. Hence, stairs will become a major problem for disabled people and elderly who use the wheelchair in daily life.

Elderly and disabled people have required an assistant to help them to climb the stairs, however, this technique is not efficient in term of safety. For example, by carrying disabled or older people on backs, this technique is very good and less cost required but the risk to injure for both people is very high. On the other hand, it is not suitable for the long-term because it can injure the backbone. Another technique is by lifting a wheelchair user but it will require more assistant especially if the weight of a wheelchair user is more than the weight of assistant. Then, it will require from three to four assistant to help wheelchair users for ascending and descending stairs.

However, a suitable type of mechanisms will become a serious issue in order to design a stair climbing robot that able to move on flat surfaces and able to adapt in any kind of unstructured environment as well as traverse obstacle. A stair climbing robot is very useful for wheelchairs users which the stair climbing robots can be used instead of using the human assistant. The control system of the stair climbing is not a big problem but to maintain stability and smoothness of the stair climbing robot it will become more challenges. Hence, it required a good controller so that the stair climbing robot can maintain stability and provide smooth motion during movement.

1.4 Objectives

The objectives of this project are: -

i. To develop open loop test for obstacle detection, obstacle avoidance and stair climbing..
ii. To design Fuzzy Logic Controller for stair climbing mechanism.
iii. To analyze performance of the mechanism in terms of obstacles avoidance.

1.5 Scope and Limitations

The scope of this project are: -

i. The Fuzzy Logic Controller of the stair climbing robot is developed using Arduino.
ii. Infrared sensor is used for obstacle detection and it only able to detect from range 0 – 27 cm.
iii. The stair climbing robot has limitation about two-step during climb the stairs with the diameter of wheel 16 cm.
iv. The stair climbing robot is not designed for carrying the load during climb the stairs.
v. Developing an obstacle detection and obstacle avoidance system occur at the frontal part of the mechanism to assist a user to control the mechanism.

1.6 Thesis Outline

This project is focusing on the design of motion control for stair climbing robot for portable mechanism. This research is to help disabled people and elderly people when traveling. Chapter 1 is an introduction of the stair climbing robot and in these chapters also included why the stairs are very important especially for disabled people. It is also discussed how the wheels will react when traversing obstacles like stairs.

Chapter 2 described the literature review based on past research related to stair climbing robot. The most important thing in this chapter is the type of mechanism, type of sensors and type of controller. In order to design the motion control for a stair climbing robot, the right controller need to consider

Chapter 3 described in details the method used in this project. In this chapter, all of the method for every experiment and process to design Fuzzy Logic Controller was described. In addition, the list of component used in this project also stated in this chapter.

Chapter 4 described the result and discussion for the overall project. All the data from three open-loop experiment were discussed in details in this chapter. The result of the designing Fuzzy Logic Controller also described in this section

Chapter 5 described the conclusion and recommendation for the whole project. The overall conclusion of the whole project was discussed either it achieved objective or not. For the recommendation part, the improvement for this project was suggested based on the previous result in order to get a better result

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Stair Climbing

The stair represents the most dangerous building structure due to its challenging structure for a various vehicle and mobile robot, especially for wheelchair users. A few decades ago, there are many scientists and researcher are presented stair climbing mechanisms for disabled people. This idea is come out when a number of wheelchairs user become increase every year.

The main goal of developing this stair climbing robot is to provide disabled people with a smooth and safe motion during stair climbing and to be independent. There is various type of stair climbing which had been done by scientist and researcher such as a wheelchair. q, Zero Carrier, Shrimp, iBOT, Rocky, and TopChair [2].

2.2 Type of Mechanism

Generally, the design and functionality of the stair climbing robot are depending on their locomotion. There are three main type of locomotive mechanism for stair climbing which are wheeled, legged, tracked and hybrid locomotion [2][3].

2.2.1 Wheeled Mechanism

Wheeled mechanisms are the most popular locomotive mechanism used for mobility because with a simple design it easy to control and provide fast motion with