



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**THE 4-DOF PARALLEL ROBOT:  
FABRICATION  
AND DESIGN IMPROVEMENT**

Thesis submitted in accordance with the requirements of the  
Universiti Teknikal Malaysia Melaka (UTeM) for the Degree of  
Bachelor of Engineering (Honors) Manufacturing (Robotics & Automation)

By

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Faculty of Manufacturing Engineering  
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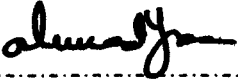
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## **ABSTRACT**

The 4-DOF Zlatanov and Gosselin platform parallel robot is the further invention follows by the Stewart-Gough Platform. The Stewart-Gough Platform is a spatial mechanism in which a moving platform is connected to a fixed base with six extensible limbs by spherical joints. The Zlatanov and Gosselin platform is capable to manipulate the performance as the Stewart-Gough Platform but in fewer axes presented. First, this project report will introduce over view of variety types of robot, especially the parallel robot and the device that are being developed. After that, it is follow by the introduction of the basic of concept for the 4-DOF Zlatanov and Gosselin platform parallel robot. In this section the declaration of the objectives, the scope of the project, some problem statement and the expected outcome will be put. Then the literature review is presented. It wills discuss the study has been done of the 4-DOF Zlatanov and Gosselin platform parallel robot. In this section the mathematical fundamental will also discussion the formula used to solve the design problem. The Methodology used to solve the design and fabrication problem is depending by using the CAD/CAM SolidWorks software. Lastly, some recommendations are made for material selection. Finally, the complete improvement design of 4-DOF Zlatanov and Gosselin platform parallel robot is presented in 3D modeling by using SolidWorks. After that is follow by some suggestion and recommendation for this project.

## ABSTRAK

Robot selari 4 darjah kebebasan Zlatonov dan Gosselin merupakan sesuatu rekaan cipta robot selari yang berlanjutan daripada ciptaan platform Stewart-Gough. Platform Stewart-Gough ini adalah ruang berpandu robot mekanisma ini kerana rekaan platform robot ini adalah bersambungan dengan tapak robot melalui 6 lengan berselari. Platform Zlatonov dan Gosselin, berupaya melakukan pengawalan yang secepat akan platform Stewart-Gough, malahan dengan bilangan lengan yang kurang. Bahagian pertama akan memperkenalkan secara am tentang kepelbagaian teknologi robot, terutamanya robot selari dan alatan yang telah dibangunkan. Selain itu, dinyatakan teliti dengan konsep asas robot selari 4 darjah kebebasan Zlatonov dan Gosselin ini. Bahagian ini juga menerangkan tentang objektif, skop, masalah yang dihadapi serta kaedah yang digunakan untuk mengatasi masalah tersebut. Seterusnya, kajian selidik (ilmiah) akan dipaparkan. Bahagian ini akan membincangkan dengan lebih terperinci mengenai kajian yang telah dilakukan. Pada bahagian ini ia akan menerangkan dengan terperinci mengenai formula yang digunakan untuk mengatasi masalah rekebentuk. Di samping itu, mengenai cara pembinaan yang digunakan untuk menghasilkan robot selari ini dan cara mengatasi masalah rekabentuk. Cara yang digunakan adalah menggunakan perisian 3D SolidWorks. Di samping itu, cadangan tentang pemilihan bahan disertakan dalam bahagian ini. Akhirnya, rekaan siap bagi robot selari 4 darjah kebebasan Zlatonov dan Gosselin yang selepas menambah baik akan dipersembahkan diruangan ini. Diikuti dengan kesimpulan dan cadangan.

## **DEDICATION**

*for my beloved mum and dad.*



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# CHAPTER 1

## INTRODUCTION

### 1.1 Overview

The purpose of this chapter is to provide the reader with an introduction to the research conducted for this project. First, the concept of four degree of freedom parallel robot and the working task of the project will be discussed. In this project report, four degree of freedom will be simply referred as “4-DOF”. The DOF typically refer to the axis or the leg of the robot. For the automation robot generally can be divide to 2 majoring types, one is serial robot another one is the parallel robot. However both of its have a similar point about the more degree of freedom the complexity of the robot will be increase. The further detail can refer to the following contents.

## 1.2 Concept Title of Project

In fact the project is to study the 4-DOF planar Parallel Mechanism and to fabricate the parallel manipulators robot. The 4-DOF is direct to the robot structure which having three rotational and one translational freedom axis of the platform. Each movement is conducted by three main links and joints (sub-chains) then three servo motors are fixed to the links for rotary motions in clockwise and anti-clockwise direction. Parallel robot is the mechanisms which able to perform many tasks that have so far required 6-DOF platforms and achieve lower device and operational costs, due to simplified designs involving fewer links and actuators. With such kinds of advantages the worth to study and develop this kind of technology is necessary.

### 1.3 Problem Statement

The previous design of this parallel robot has a lot of designing problems (after some study about the title) with this project. Just like say, the mechanism which resample universal joint is used in the original design will be replace with another simpler mechanism, but this will lead to the some negative reaction effect to happen (during the running mode). Besides, I also realize that, one of the free translation axes joint is shorted. This will restricted the flexibly of the robot during rotation motion is carry out.

Other form that, the part of the robot is so difficult to fabricate according to the dimension is given. Due to the shape of the parts (lower base plate and the upper platform) applying the design in hexagon shape, this will make the fabrication work become complicated indeed to get the similar length for every side and produce a symmetry outlook. To overcome this problem, the designs of the robot have to review and make some change to improve the design. Therefore, we can make the fabrication task can be done in more easy way and make the project successful.

## 1.4 Scope of Project

The main purpose of this project is fabricating a 4-DOF parallel manipulator robot base on the concept which introduced Zlatanov and Gosselin. In fact, the Zlatanov and Gosselin platform is the further invention follows the Stewart-Gough Platform. Stewart-Gough Platform is the early parallel manipulator robot which creator by Stewart. The Stewart-Gough Platform is a spatial mechanism in which a moving platform is connected to a fixed base with six extensible limbs by spherical joints. However the Zlatanov and Gosselin platform is a parallel manipulator just has three freedoms rotational sub-chains and one translation axes. Although it has less sub-chains but theoretically, it still able to perform well like the 6-axes Zlatanov and Gosselin platform and other serial robot too. For this project many constraint have to overcome, just like the things have mention in the problem statement previously. On the other hand, many technical testing and improvement have to carry out indeed to make the robot perform well like the predicted outcome.

## **1.5 Objective**

The main objectives of this research are to:

- i. Study the conceptual design of the parallel robot.
- ii. Improve the present design to reduce the robot geometry problem.
- iii. To fabricate and install a parallel mechanism.

## **1.6 Expected Result**

For the expectation for this project, the replicate parallel robot is able to run smoothly as the predicted movement it can be. To achieve this goal there are many improvements should be done indeed to make this manipulator able to function; and there is the need to solve the project limits like the complicate structure of the mechanism and complexity of kinematic singularities. After this robot is finished, then it will be able attach to their working station for functioning purpose. This can be done by installing the servo motor to the sub-chains of the robot, because the servo motor is a high accuracy position control actuator. So the parallel robot will be executed under a very high accuracy and persistence condition.

## **CHAPTER 2**

### **Literature Review**

#### **2.1 Overview**

This chapter will provide an overview of the robot in the manufacturing industrial field; especially about the Parallel Robot and the robot mechanism which related for better explain for this project. Here will begin with brief characteristics of Industrial Robot. This section also introduces different type of industrial robot that have commercialized for industrial application. It also will provided summary of the past studies, researches about the concept, designs and implementation of many types of parallel robots that have been conducted. The source of the literature reviews usually refer to the information obtained from valid sources such as books, articles of relevance, published paper or any other source deemed appropriate. Through the literature reviews we able to learn the concept to doing the project and adapt the suitable element to the project during we replicate and improve it.

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## 2.2 Robot

What is robot? The sentence we always have to ask. There is a definition sound like:-

“A machine able to extract information from its environment and uses knowledge about its world to perform non trivial tasks such as moving safely in a meaningful and purposeful manner. A robot is a system which exists in physical world and autonomously senses its environment and acts in it [14].”

Another definition is that:-

“A robot is a re-programmable, multi-functional manipulator designed to move material, parts, or specialized devices through variable programmed motions for the performance of a task (Robotics Industry Association). And robotics is the intelligent connection of perception to action [1].”

Robots come in many shape and sizes and have many different abilities. Basically, a robot is simply a computer with some sort of mechanical body designed to do a particular job. It is able to move and has one or more electronic senses. These senses are not nearly as powerful as human senses of sight and hearing. However, scientists and engineers are working hard to improve robots. They are constantly coming up with ways to make them see, hear and respond to the environment around them.

First, they are hardworking and reliable. They can do dangerous work or work that is very boring or tiring for humans. They can work around the clock without complaining and without needing rest, food or vacations. A robot can go places that humans cannot, such as the surface of Mars, deep under the ocean or inside the radioactive parts of a nuclear power plant.