

**CONCEPTUAL DESIGN OF A SEMI AUTONOMOUS MOBILE ROBOT FOR  
PEPPER PLANTATION**

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# Approval Sheet

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To my beloved family

and

Future of Mobile Robot

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# **ABSTRACT**

Pepper is the king of spices and Sarawak in Malaysia is one of the largest producers in the world. In Sarawak, pepper vines are usually planted in secondary forest. The terrains of a pepper plantation can either be hilly or flat. Pepper berries are still manually harvested by human hands and there are no mechanical solutions at the moment. The purpose of conceptualizing the design of this mobile robot is to provide a more effective and fast method of harvesting pepper berries in the future. This mobile robot will be able to reduce the risk of human getting injured from harvesting the pepper berries. Axiomatic design approach is used to conceptualize this mobile robot. By using this approach the designer will be able to point out the limitation, function required and the design parameter by decomposing each function to multiple sub layers. This mobile robot implement two types of mechanism that is the active spoke system and the adjustable wheel support joint mechanism to overcome obstacles and avoid from being overturn on an uneven terrains. The conceptual mobile robot design is hypothesize to be able to adapt to the pepper plantation terrain.

# **ABSTRAK**

Lada Hitam dikenali sebagai raja rempah dan Negeri Sarawak merupakan salah satu pengeluar yang terbesar di dunia. Di Sarawak, pokok lada hitam biasanya di tanam di hutan sekunder yang berbukit atau rata. Penuaian biji lada hitam pada zaman yang serba moden ini masih menggunakan tenaga buruh tanpa bantuan alat mekanikal untuk memudahkan kerja penuaian. Tujuan untuk mereka cipta *Mobile Robot* ini adalah untuk mengurangkan risiko kemalangan semasa proses penuaian lada hitam dijalankan. Konsep *Axiomatic Design* digunakan untuk mereka cipta *Mobile Robot* ini. Pereka akan dapat menentukan fungsi yang diperlukan dan parameter rekaan dengan menggunakan konsep ini kerana fungsi-fungsi utama perlu diuraikan kepada beberapa sub fungsi. *Mobile Robot* ini mempunyai dua jenis mekanisma iaitu *Active Spoke System* dan *Adjustable Wheel Support Joint* untuk mengelakkan daripada terbalik akibat dari permukaan yang tidak rata. *Mobile Robot* ini dihipotesis dapat disesuaikan dengan persekitaran ladang lada hitam.

# CHAPTER 1

## INTRODUCTION

### 1.1 Background of Study

Pepper holds a prime position in the world of spices. The hot pungent produce from the berries of the perennial, climbing vines of *Piper nigrum* L (Family: *Piperaceae*). It is one of the oldest and the most popular spice in the world. The reputation as “King of Spices” is given to pepper because of its versatility uses and most widely used spiced in the world. Figure 1.1 shows the landscape of a pepper plantation. The major growers of pepper are India, Indonesia, Sri Lanka, Brazil, Malaysia, Vietnam and China. Malaysia is the world fifth’s largest pepper supplier and Sarawak produces 95% of the country’s pepper [1].



**FIGURE 1.1 Landscape of Pepper Plantation**

The development in the pepper industry in Malaysia is ongoing as it is one of the main economic sources for Malaysia. One of the recent developments is the building of the world's largest grinding plant in Sarawak to move Malaysia towards the production of a more value added-pepper products while enhancing its competitiveness in the global market [2].

In order to produce a consumable pepper, ripe pepper berries are manually plucked from the climbing vines of *Piper nigrum*, collected and transported by laborer to the factory for processing.

## **1.2 Motivation of Study**

The demand for pepper in the world is increasing and Malaysia as the fifth largest pepper producer is developing ways to increase its production. As a strategic plan to boost the production of peppers The Ministry of Plantation Industries and Commodities have introduce pepper cluster farming. By using this method, the country's annual production could increase from 20000 tonnes to 30000 tonnes by the year 2010 [2].

The increasing productions in pepper require better accessibility in order to transport the pepper berries to be processed. Even now in the modern world, manual labor is used to pluck the pepper berries. The task of plucking pepper berries is quite dangerous as farmers need to climb up the climbing vines of *Piper nigrum L* using a ladder on a sloppy and uneven hill.

Therefore, the purpose of this study is to design a semi autonomous mobile robot that is able to pluck the pepper berries and transport it to the process center. This will eventually help to increase the production rate of pepper.

### **1.3 Issues Regarding Mobile Robot Efficiency**

Issues regarding mobile robots usually depend on where the mobile robot is being used. The design of the mobile robot must be suitable with the environment and terrain in which the mobile robot will perform its operations. Flaws that occur on a mobile robot will cause inefficiency when performing a task. The following issues are as follows:-

#### **a. Slippage**

Wheeled mobile robot that moves on uneven terrain usually experience slips at the wheel-terrain contact point. These slip leads to large wastage of power which is a premium in mission like planetary exploration. It is also a big problem for autonomous wheeled mobile robot that uses odometry technique to localize their position during navigation. Odometry is the study of position estimation during wheeled vehicle navigation and are sometimes used to describe the distance traveled by the wheeled vehicle. It is very sensitive to error and requires rapid and accurate data collection, equipment calibration, and processing are required in most cases for odometry to be used effectively. Therefore slippage must not occur for wheeled mobile robot that uses odometry as it will cause accumulation in localization error [3].

### **b. Mobility**

The limitation of mobile robot mobility causes inefficiency in performing the operation and became a major issue in the current robotic technology [7]. Therefore, in a complex unstructured environment a mobile robot must have high flexibility, strong environment perception ability and fast feedback ability to overcome all the obstacles for the success of an operation.

### **c. Stability**

The other issue on mobile robots is the stability where some task on rough and uneven terrain can result in loss of stability which will lead to tip over and loss of wheel traction [7]. A tip over can cause the mission to fail and in some cases when the robot irretrievable a lot of money and hard work in making the mobile robot would be loss.

## **1.4 The Aim and Objectives**

The aim of this project is to propose a conceptual design of a semi-autonomous mobile robot for pepper plantation. This thesis should accomplish the following objectives:

1. To study of the characteristic of semi autonomous mobile robot on uneven surfaces.
2. To proposed the conceptual design of semi autonomous mobile robot that have a mobility to avoid obstacles and stability to move on uneven terrains and also have the flexibility of performing different types of task.

# **CHAPTER 2**

## **LITERATURE REVIEW**

### **2.1. INTRODUCTION**

The purpose of this chapter is to study the basic process of harvesting pepper berries and the available design of mobile robot that involves in this project respectively. The study of this chapter is based on the objectives that have been mentioned in chapter 1. The information here will be analyzed and evaluated for solution in the design process in the following chapter. The related topics in this chapter are:

The Cultivation of Pepper Berries

The Design Approach

The Application of Mobile Robots

Basic Analysis of Mobile Robots

Mobile Robot Navigational System

## **2.2 THE CULTIVATION OF PEPPER BERRIES**

The pepper berries grow on bushes that are cultivated to the height of about 4 meters. Fully ripe berries usually turn red, but they are harvested when they are green or just begin to turn red. These days there are still no mechanical equipment used in harvesting the pepper berries. Manual labor will pick the unripe berries and transport them in a wicker basket to a drying platform. There are two options in making the pepper berries turn black or dried. The first option is to spread the green berries on a large platform and let it to dry under the sun for about a week and a half. The second option is to take the berries that just turn red and boil in them in boiling water for approximately 10 minutes and the berries will turn black or brown in about an hour. It is then spread on a drying platform for about three to four days. The dried berries are then taken to the factory to be cleaned, grind and package [1].



**FIGURE 2.1 Pepper Berries**

## **2.3 THE DESIGN APPROACH**

Design is defined as relationship between what we want to accomplish and how we want to accomplish it. Firstly, before designing designers must understand their customer's needs. Next, problem that needs to be solved must be defined. Conceptualizing the solution by synthesizing is the next step. Then analysis need to be performed to optimized the proposed solution and lastly the design solution needs to be check to see whether it meets what the customer needs [4].

### **2.3.1 Axiomatic Design**

Axiomatic design was developed by Nam Pyo Suh which is based on the generalization of good design decisions and processes. Axiom is defined as the self-evident truth or fundamental truth for which there are no contradicting examples or exceptions. An axiom cannot be derived from other laws or principles of nature. The axiomatic design framework consists of [4]:-

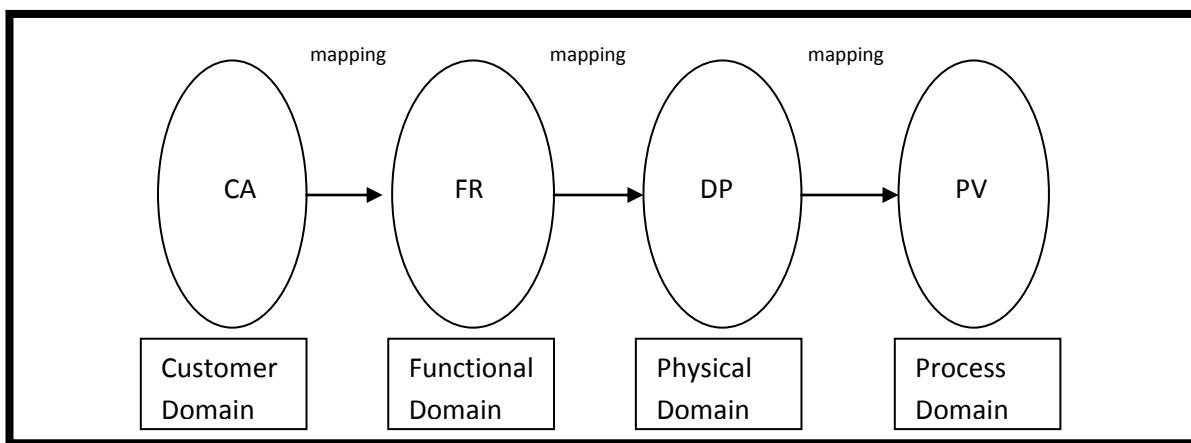
2.3.1.1 Domains

2.3.1.2 Zig-zagging

2.3.1.3 Hierarchies

### 2.3.1.1 Domains

There are all together four domain that we must consider that which is shown in Figure 2.2.

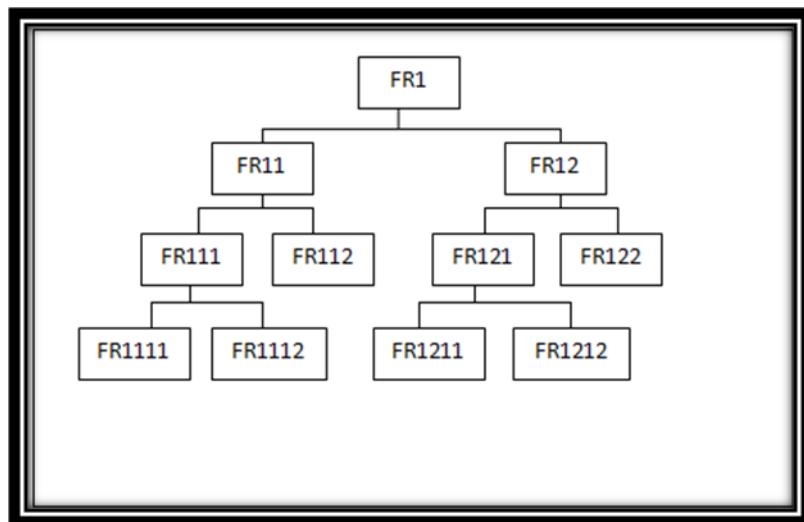


**FIGURE 2.2 Four Domains of the Design World [4]**

The customer domain is characterized by the customer needs or attribute (CAs) in a product or process or systems. The functional domain is where the customer's needs are specified in terms of functional requirement (FR) and constraint (Cs). In order to fulfill the specified functional domain, we must consider the design parameters (DP) in the physical domain. Lastly we need to develop a process that is characterized by process variables (PVs) in the process domain.

### 2.3.1.3 Hierarchy

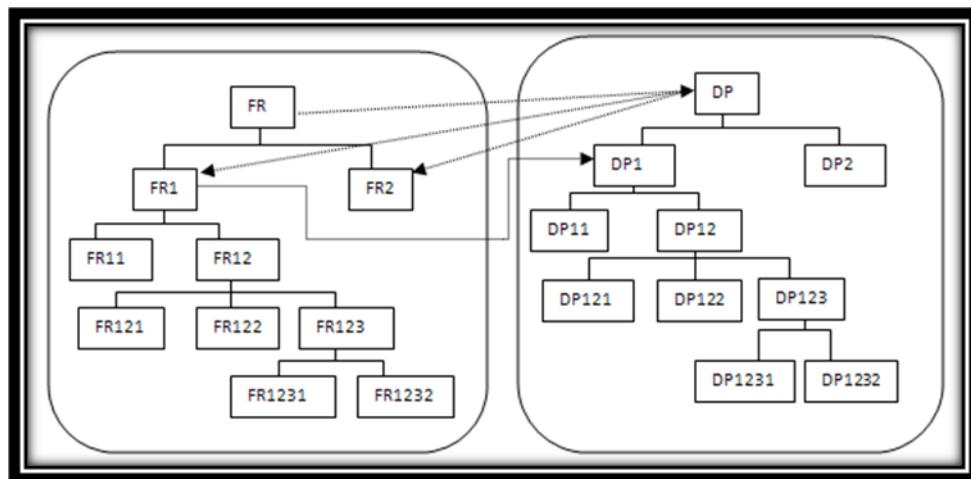
In the beginning of designing process, the designer often has to specify the input constraints because the design must satisfy the external boundary conditions. A hierarchy will be generated because some constraints are generated because of design decisions made as the design proceeds. Therefore, all higher levels constraints act as constraints at lower level [4].



**FIGURE 2.3 Functional Domains Hierarchies [4]**

### 2.3.1.4 Zig-Zagging

Zig-zagging is an important part of axiomatic design because it is used to decompose FRs, DPs, and PVs. The FRs, DPs, and PVs are decomposed into the hierarchy to get a product design specifications [4].



**FIGURE 2.4** Zig-Zagging Mapping between Domains [4]

## **2.4 THE APPLICATION OF MOBILE ROBOTS**

Mobile robots are increasingly being used to accomplish tasks. There are basically two types of working environment that differentiate the type of mobile robot to be used and they are the indoor and outdoor mobile robot.

### **2.4.1 Indoor Mobile Robot**

Indoor mobile robots are usually used in plant or factories to move materials from one station to another station. These types of mobile robot are called Automated Guided Vehicles (AGV). It is a self propelled vehicle that moves along defined pathways and is powered by on-board batteries that allow many hours of operations. There are a few types of vehicle guidance technology that AGV uses which are imbedded guide wires, paint strips and combination of dead reckoning and beacons [5].

### **2.4.2 Outdoor Mobile Robot**

Outdoor mobile robots are usually used for rough environment operations. The terrains in outdoor environment are usually uneven and full of obstacles. Therefore, these types of mobile robots require good maneuverability and stability to overcome the obstacles in order to perform the operation successfully. Outdoor mobile robots are increasingly being used in high risk, rough terrains situations such as planetary exploration, environmental monitoring and protection, anti-terror response, and search and rescue. Such tasks require high maneuverability and stability for the success of each mission [7].