UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# PROGRAMMING AND INTERFACING OF MASTER SLAVE (PARENT-CHILD) ROBOT FOR PAINTING APPLICATION

Thesis submitted in accordance with the requirements of the University Technical Malaysia Malacca for the Degree of Bachelor of Engineering (Honours) Manufacturing (Robotic and Automation)

By

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# APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotic and Automation). The members of the supervisory committee are as follow:

…………………………………………………

Main Supervisor

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# ABSTRACT

This project demonstrated the master slave robot technology. It has potential for application in hazardous environment harmful for human being such as in painting application. The slave robot is being control by the master arm robot using a suitable programming and interfacing. The designing of this robot consist of selection of hardware component for the robot, programming and interfacing using suitable software and testing the robot. The objective of this project is to understand the case study of building a master slave robotic system especially in programming and interfacing the master slave robot. In this project, the programming of master slave robot has been discussed. It focused on the theory of the master slave robot and the prototype of the robot has been built to get the result by experimental. The best of programming method for master slave robot has been selected in this work.

# ABSTRAK

Projek ini membuktikan teknologi robot 'Tuan-Hamba'. Ia berpotensi untuk diakplikasi di dalam persekitaran yang berbahaya kepada manusia seperti akplikasi untuk proses mengecat. Robot Hamba dikawal oleh robot Tuan yang berbentuk lengan menggunakan atur cara komputer dan hubungkait yang bersesuaian. Proses merekebentuk robot ini melibatkan pemilihan alat-alat logam untuk robot, pemilihan atur cara dan hubungkait perisian yang sesuai serta menguji robot yang telah siap. Objektif utama projek ini ialah untuk memahami sistem dan konsep robot Tuan-Hamba dalam atur cara komputer. Dalam projek ini, atur cara komputer untuk robot Tuan-Hamba dibincangkan secara teori dan prototaip robot dibuat untuk mendapatkan keputusan dan kesimpulan secara eksperimen. Pada akhir projek ini, atur cara komputer yang paling sesuai untuk robot Tuan-Hamba dipilih.

# ACKNOWLEDGEMENTS

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Asru Rozimin Bin Abu Bakar

# DEDICATION

*For my beloved mother and father.*

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# CHAPTER 1

# PROGRAMMING AND INTERFACING OF MASTER SLAVE ROBOT

## 1.1 INTRODUCTION

Now day, the robotic fields have become more expand. New technology being develops and implement in robotic industrial. One of the technologies is master slave robot. The word master slave refers that is two of robot, one is master robot and the other one is slave robot. Master slave mean the slave robot being controlling by the master robot.

The master slave robot can be used for some application such as in nuclear industry, welding, and the industry that involved chemical and poison material to handling by human and so on. For this project, master slave robot is used for painting application. The reason for painting application it is because it easy to implement with UTeM environment.

For this project, the slave robot is developing based on the human arm. The slave robot have three joint related as human arm that is shoulder, elbow and wrist. The slave robot controlled manual by human arm which act as the master to the slave robot.

The concept is, the master give a contact to slave robot which in form of a signal to position of the slave robot. Then the slave robot gives a feedback to the master which move at the desired position.

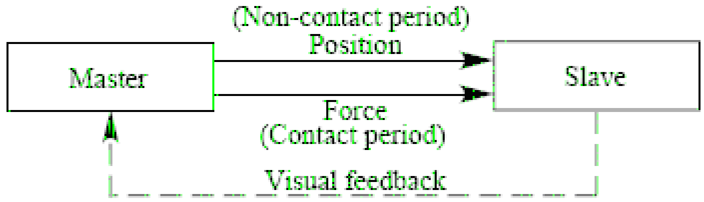


Figure 1: Concept of master slave robot

This project consist of several task. Some of the tasks are

- Design.
- CAD/CAM modeling.
- Simulation.
- Circuit.
- Hardware and software selection.
- Programming and Interfacing
- Physical assembly and testing.

Each of tasks is related to each other, so all the information is shared to make sure the robot working properly.

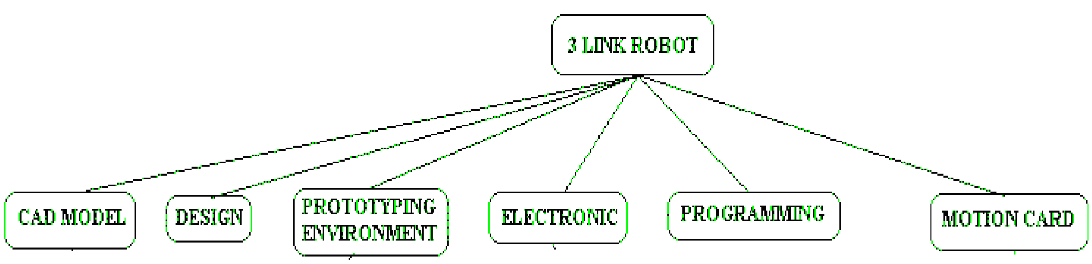


Figure 2**:** Three link of robot

## 1.2 OBJECTIVES

The objective of this project is to understand the framework of the master slave robot, to develop and programming the robot.

## 1.3 THE IMPORTANCE OF PROJECT

- This framework will facilitate the programming and interfacing of robots.
- The prototype robot will be used as an educational tool in the robotics and automatic control classes.
- This project will establish a basis and framework for design automation of robot manipulators.

## 1.4 SCOPE OF PROJECT

1. Research the programming use in master slave robot.
2. Analysis and making the decision of using hardware and software solutions
3. Programming and interfacing a master slave robot.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 WHAT ARE ROBOTS

A robot is an electro-mechanical device that can perform autonomous or preprogrammed tasks. A robot may act under the direct control of a human (e.g. the robotic arm of the space shuttle) or autonomously under the control of a programmed computer. Robots may be used to perform tasks that are too dangerous or difficult for humans to implement directly (e.g. nuclear waste clean up) or may be used to automate repetitive tasks that can be performed with more precision by a robot than by the employment of a human (e.g. automobile production.)

Steven M. LaValle [1], robotics addresses the automation of mechanical systems that have sensing, actuation, and computation capabilities. The word robot is used to refer to a wide range of machines, the common feature of which is that they are all capable of movement and can be used to perform physical tasks. Robots take on many different forms, ranging from humanoid, which mimic the human form and way of moving, to industrial, whose appearance is dictated by the function they are to perform. Robots can be grouped generally as **mobile robots** (e.g. autonomous vehicles), **manipulator robots** (e.g. industrial robots) and self **reconfigurable robots**, which can conform themselves to the task at hand.

Robots may be controlled directly by a human, such as remotely-controlled bomb-disposal robots, robotic arms, or shuttles, or may act according to their own decision making ability, provided by artificial intelligence. However, the majority of robots fall in-between these extremes, being controlled by pre-programmed computers. Such robots may include feedback loops such that they can interact with their environment, but do not display actual intelligence.

Simplify a robot is

1. A mechanical device that sometimes resembles a human and is capable of performing a variety of often complex human tasks on command or by being programmed in advance.
2. A machine or device that operates automatically or by remote control.

Typical applications of robots include welding, painting, ironing, assembly, pick and place, palletizing, product inspection, and testing, all accomplished with high endurance, speed, and precision.

### 2.1.1 Defining Parameters

- Number of axes – two axes is required to reach any point in a plane; three axes are required to reach any point in space. To fully control the orientation of the end of the arm (i.e. the *wrist*) three more axes (roll, pitch and yaw) are required. Some designs (e.g. the SCARA robot) trade limitations in motion possibilities for cost, speed, and accuracy.

- Kinematics – the actual arrangement of rigid members and joints in the robot, which determines the robot's possible motions. Classes of robot kinematics include articulated, Cartesian, parallel and SCARA.
- Working envelope – the region of space a robot can reach.
- Carrying capacity – how much weight a robot can lift.
- Speed – how fast the robot can position the end of its arm.
- Accuracy – how closely a robot can reach a commanded position. Accuracy can vary with speed and position within the working envelope. It can be improved by Robot calibration.
- Motion control – for some applications, such as simple pick-and-place assembly, the robot need merely return repeatably to a limited number of pre-taught positions. For more sophisticated applications, such as arc welding, motion must be continuously controlled to follow a path in space, with controlled orientation and velocity.
- Power source – some robots use electric motors, others use hydraulic actuators. The former are faster, the latter are stronger and advantageous in applications such as spray painting, where a spark could set off an explosion.
- Drive – some robots connect electric motors to the joints via gears; others connect the motor to the joint directly (*direct drive*).

V. kumar [2] use the term mechanical system to describe a system or a collection of rigid or flexible bodies that may be connected together by joints. A mechanism is a mechanical system that has the main purpose of transferring motion and/or forces from one or more sources to one or more outputs. A linkage is a mechanical system consisting of rigid bodies called *links* that are connected by either pin joints or sliding joints. In this section, we will consider mechanical systems consisting of rigid bodies, but we will also consider other types of joints.

Degrees of freedom of a system

*The number of independent variables (or coordinates) required to completely specify the configuration of the mechanical system.*

While the above definition of the number of degrees of freedom is motivated by the need to describe or analyze a mechanical system, it also is very important for controlling or driving a mechanical system. It is also the number of independent inputs required to drive all the rigid bodies in the mechanical system.

Kinematic chain

*A system of rigid bodies connected together by joints. A chain is called closed if it*
*forms a closed loop. A chain that is not closed is called an open chain.*

Serial chain

*If each link of an open chain except the first and the last link is connected to two other links it is called a serial chain.*

## 2.2 ROBOT PROGRAMMING

The setup or programming of motions and sequences for an industrial robot is typically taught by linking the robot controller via communication cable to the Ethernet, FireWire, USB or serial port of a laptop computer. The computer is installed with corresponding interface software. The use of a computer greatly simplifies the programming process. Robots can also be taught via teach pendant, a handheld control and programming unit.

The teach pendant or PC is usually disconnected after programming and the robot then runs on the program that has been installed in its controller. In addition, machine operators often use human machine interface devices; typically touch screen units, which serve as the operator control panel. The operator can switch from program to program, make adjustments within a program and also operate a host of peripheral devices that may be integrated within the same robotic system. These peripheral devices include robot end effectors which are devices that can grasp an object, usually by vacuum, electromechanical or pneumatic devices. Also emergency stop controls, machine vision systems, safety interlock systems, bar code printers and an almost infinite array of other industrial devices are accessed and controlled via the operator control panel.

Bruce MacDonald et al [3] state that robot programming systems as having three important conceptual

1. The programming component, including designs for programming language/s, libraries and application programming interfaces (APIs), which enable a programmer to describe desired robot behaviour.

2. The underlying infrastructure including designs for architectures that support and execute robot behaviour descriptions, especially in distributed environments.
3. The design of interactive systems that allow the human programmer to interact with the programming component, to create, modify and examine programs and system resources, both statically and during execution. The human programmer may also interact with the infrastructure component, to examine, monitor and configure resources, and directly with robots as they perform tasks.

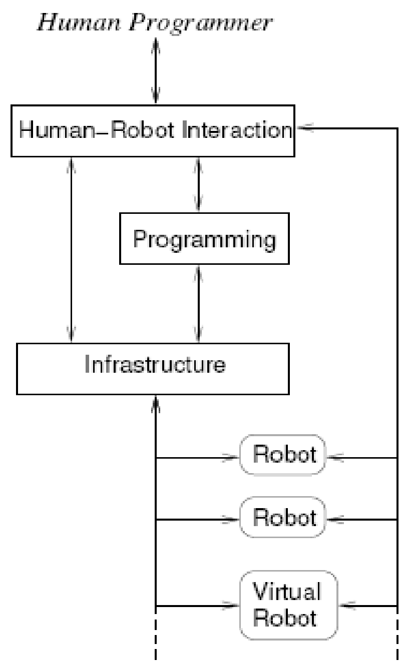


Figure 3: Part of robot programming system

Jean-Paul Meynard [4] said to get a better understanding of programming robot, he make an eXperimental Platform in Robotics (XPROB). XPROB is an open architecture, consisting of four key components: a task level programming environment, a robot program synthesis, a real-time command execution module, and a world model. The task level programming environment provides the end-user with a robot-independent high-level programming language. Specific functions can be added at any time, as the XPROB kernel supports dynamically loadable libraries. A task is specified in a script that is interpreted when the task is run. Each work-cell component, for example, robot, tool, sensor, or manipulated part, has a 3-dimensional description modeled in an object-oriented database - the world model. The database can handle partially identified objects, and it provides a mechanism to express confidence in data. The values of the objects' attributes are updated throughout the execution of the task-level program. In the program synthesis module, a task planner translates the high level commands into low-level robot commands. A motion planner computes the approaching and final gripper position and orientation. Finally, the low-level commands are translated into robot-dependent instructions. The real-time command execution module forwards these instructions to the corresponding hardware and/or graphically displays them. During the execution of the program, sensor data can be requested. Upon reception, a filter adds a symbolic value to the sensor data. Further reasoning about thse symbolic values allows task re-planning at runtime.

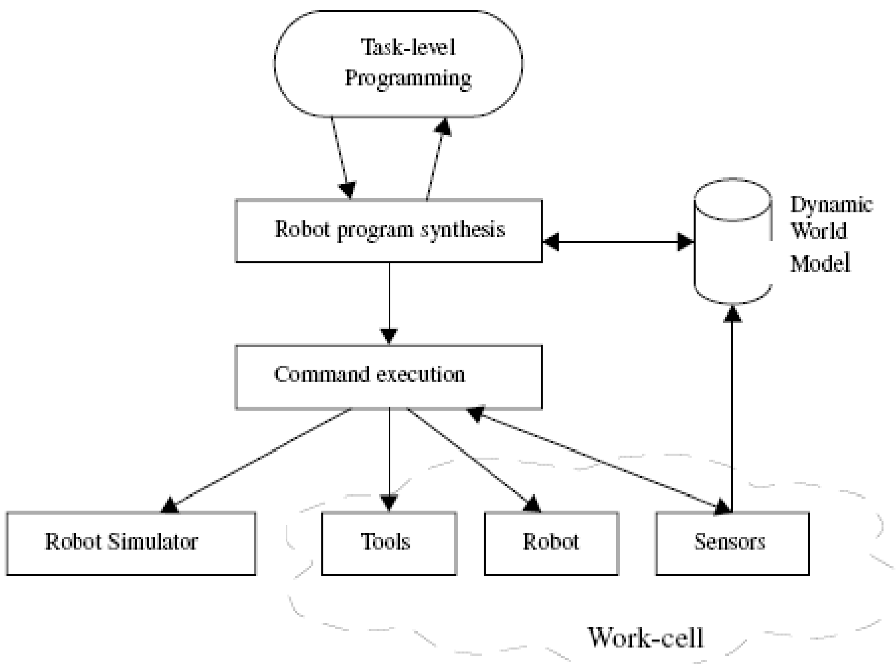


Figure 4: eXperimental Platform in Robotics (XPROB) architecture

## 2.3 MICROCONTROLLER

A microcontroller (or MCU) is a computer-on-a-chip used to control electronic devices. It is a type of microprocessor emphasizing self-sufficiency and cost-effectiveness, in contrast to a general-purpose microprocessor (the kind used in a PC). A typical microcontroller contains all the memory and interfaces needed for a simple application, whereas a general purpose microprocessor requires additional chips to provide these functions. A microcontroller is a single integrated circuit, commonly with the following features:

- central processing unit - ranging from small and simple 4-bit processors to sophisticated 32- or 64-bit processors
- input/output interfaces such as serial ports
- peripherals such as timers and watchdog circuits and signal conversion circuits.
- RAM for data storage
- ROM, EPROM, EEPROM or Flash memory for program storage
- clock generator - often an oscillator for a quartz timing crystal, resonator or RC circuit

## 2.4 PIC MICROCONTROLLER

PIC is a family of microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division.

Microchip Technology does not use PIC as an acronym; in fact the brand name is PICmicro. It is generally regarded that PIC stands for Peripheral Interface Controller, although General Instruments' original acronym for the PIC1650 was "Programmable Intergrated Circuit". The original PIC was built to be used with GI's new 16-bit CPU, the CP1600. While generally a good CPU, the CP1600 had poor I/O performance, and the 8-bit PIC was developed in 1975 to improve performance of the overall system by offloading I/O tasks from the CPU. The PIC used simple microcode stored in ROM to perform its tasks, and although the term wasn't used at the time, it is a design that runs one instruction per cycle (4 oscillator cycles).

In 1985 General Instruments spun off their microelectronics division, and the new ownership cancelled almost everything — which by this time was mostly out-of-date. The PIC, however, was upgraded with EPROM to produce a programmable channel controller, and today a huge variety of PICs are available with various on-board peripherals (serial communication modules, UARTs, motor control kernels, etc.) and program memory from 512 words to 32k words and more (a "word" is one assembly language instruction, varying from 12, 14 or 16 bits depending on the specific PICmicro family

Today, the PIC is a complete computer on a chip. Such chips can be built into a device to make the product more intelligent and easier to use.

PlC chips are programmed to perform only one very specific task, e.g. - a microwave oven may use a single micro-controller to process information from the keypads, display user information on the seven segment display, and control the output devices (turntable motor, light, bell and magnetron).