UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Pick and Place Robotic Arm Controlled By Computer

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By

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DECLARATION

I hereby, declare this thesis entitled "Pick and Place Robotic Arm Controlled By Computer" is the results of my own research except as cited in the reference.

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ABSTRACT

Robot manipulator is an essential motion subsystem component of robotic system for positioning, orientating object so that robot can perform useful task. In the field of robotics, there are five types of robot configurations that are SCARA, articulated, Cartesian, cylindrical and spherical. In this research, the focus is on 5 DOF articulated arm since it mimic to human arm. Articulated arm consists of revolute joints that allowed angular movement between adjacent joint. The arm's rotating base is powered by a single large-scale servo. Mounted to the base is an elevation joint, or shoulder, that can move the arm through 180 degrees, from horizontal to vertical on each side. The shoulder uses two large-scale servos, working together to provide the torque needed to lift the rest of the arm, as well as any object that it may be grasping. Attached to the shoulder piece is an elbow that can move through 180 degrees, also powered by a large-scale servo. The wrist is made up of three standard servos and can move through 180 degrees, as well as rotating the gripper clockwise and counterclockwise. Attached to the wrist is a three-fingered gripper that utilizes a unique design built around a single standard servo. The revolute geometry allows the robot arm to reach any point within a half-sphere, having the shape of an inverted bowl. The radius of the half-sphere should be the length of the arm when its shoulder, elbow, and wrist are straightened out. The robot arm is controlled by a serial servo controller circuit board. The controller circuit board is based on Microchip's popular programmable integrated circuit (PIC) 16F84A flash programmable microcontroller. The serial servo controller board will be connected to the serial port on a PC running the Microsoft Windows operating system. The robot arm control software that runs on the PC will be written in Visual Basic 6. The PIC 16F84A can also be programmed to run robot arm sequences independently. The controller will also be interfaced to a voice recognition circuit.

DEDICATION

To my beloved parents and family.

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In the name of Allah the Beneficent, the Merciful

I would like to take this opportunity to express my sincerest gratitude to Universiti Teknikal Malaysia, Melaka for giving me the opportunity to final year project as part of my degree program and to my project supervisor, Mr. Samsi Md Said who had been there for me giving opinions, suggestions, knowledge in completing this project.

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INTRODUCTION

1.0 Introduction

Robot is an integral part in automating the flexible manufacturing system that one greatly in demand these days. Robots are now more than a machine, as robots have become the solution of the future as cost labour wages and customers' demand. Even though the cost of acquiring robotic system is quite expensive but as today's rapid development and a very high demand in quality with ISO (International Standard Organization) standards, human are no longer capable of such demands. Research and development of future robots is moving at a very rapid pace due to the constantly improving and upgrading of the quality standards of products.

Robot and automation is employed in order to replace human to perform those tasks that are routine, dangerous, dull, and in a hazardous area. In a world of advanced technology today, automation greatly increases production capability, improve product quality and lower production cost. It takes just a few people to program or monitor the computer and carry out routine maintenance.

1.1 Review of Industrial Robotic Arm Development

George Devol received the first patents for robotics in **1954**. The first company to

F. Engelberger in 1956, and was based on Devol's original patents. Unimation robots

transfer objects from one point to another, less than a dozen feet or so apart. They used hydraulic actuators and were programmed in joint coordinates, i.e. the angles of the various joints were stored during a teaching phase and replayed in operation. For some time Unimation's only competitor was Cincinnati Milacron Inc. of Ohio. This changed radically in the late **1970s** when several big Japanese conglomerates began producing similar industrial robots. Unimation had obtained patents in the United States but not in Japan who refused to abide by international patent laws, so their designs were copied.

In **1969 Victor Scheinman at Stanford University** invented the Stanford arm, an all-electric, 6-axis articulated robot designed to permit an arm solution. This allowed the robot to accurately follow arbitrary paths in space and widened the potential use of the robot to more sophisticated applications such as assembly and arc welding. Scheinman then designed a second arm for the MIT AI Lab. called the **"MIT arm."** Sheinman sold his designs to Unimation who further developed it with support from General Motors and later sold it as the **Programmable Universal Machine for Assembly (PUMA).** In **1973 KUKA Robotics** built its first industrial robot, known as **FAMULUS**, this is the first articulated industrial robot to have six electromechanically driven axes.

Interest in industrial robotics swelled in the late 1970s and many companies entered the field, including large firms like General Electric, and General Motors (which formed joint venture FANUC Robotics with FANUC LTD of Japan). US start-ups included Automatix and Adept Technology, Inc. At the height of the robot boom in **1984**. Unimation was acquired by Westinghouse Electric Corporation for 107 million US dollars. Westinghouse sold Unimation to Stäubli Faverges SCA of France in **1988**. Stäubli was still making articulated robots for general industrial and clean room applications as of 2004 and even bought the robotic division of Bosch in late **2004**.

Eventually the myopic vision of American industry was superseded by the financial resources and strong domestic market enjoyed by the Japanese manufacturers. Only a few non-Japanese companies managed to survive in this market, including Adept Technology, Stäubli-Unimation, the Swedish-Swiss company ABB (ASEA Brown-Boveri), the Austrian manufacturer igm [illegible]
company KUKA Robotics.

1.2 Project Background

The robot arm for this final project is the revolute type that closely resembles the human arm. The arm's rotating base is powered by a single large-scale servo that rotates the rest of the arm in a half-circle (180 degree) arc. Mounted to the base is an elevation joint, or shoulder, that can move the arm through 180 degrees, from horizontal to vertical on each side. The shoulder uses two large-scale servos, working together to provide the torque needed to lift the rest of the arm, as well as any object that it may be grasping. Attached to the shoulder piece is an elbow that can move through 180 degrees, also powered by a large-scale servo. The wrist is made up of three standard servos and can move through 180 degrees, from a straight position to doubled back, as well as rotating the gripper clockwise and counterclockwise. Attached to the wrist is a three-fingered gripper that utilizes a unique design built around a single standard servo. The revolute geometry allows the robot arm to reach any point within a half-sphere, having the shape of an inverted bowl. The radius of the half-sphere should be the length of the arm when its shoulder, elbow, and wrist are straightened out.

The robot arm is controlled by a serial servo controller circuit board. The controller circuit board is based on Microchip's popular programmable integrated circuit (PIC) 16F84A flash programmable microcontroller, and it receives servo position commands from any device using a 2400-baud serial connection. This means that the arm can be used with any of the popular microcontroller systems available on the market or with a PC. The serial servo controller board will be connected to the serial port on a PC running the Microsoft Windows operating system. The robot arm control software that runs on the PC will be written in Visual Basic 6.0. The PIC 16F84A can also be programmed to run robot arm sequences independently.

1.3 Problem Statement

The main intention of this project is to design and implemented a 5 DOF revolute type robot arm that is capable to grasp and carry objects. Several problems on this project have been defined to simplify the development process. The problems are:

1.3.1 Material Selection and Considerations

The most suitable material to fabricate the structure of the arm has to be light and strong. Otherwise, the servo motor will not be able to pull up the arm and to perform the desired turning degree. Among the materials that can be considered to fabricate the structure are aluminum, perspex, plastic polymer and carbon fiber. In choosing the fabrication materials, the aspect of availability of the materials, the overall cost and the flexibility to be shaped, should also be taken into consideration. Thus among the four materials considered, the aluminum is the most ideal material to be chosen as fabrication material.

1.3.2 Design The Mechanism and Fabrication of the Robot Arm

The mechanical structure of shoulder, elbow and wrist form the main part of the robot arm. The main problem in this part is on how to attach the servo motor onto the section or joint to achieve the desired turning degree level. Besides, the way on how to combine the arm component should also be considered in order to achieve the intended degree of freedom. Autodesk Inventor and Autodesk AutoCAD are used to draw and to simulate the mechanical design of the robot arm. The accuracy of the mechanical design dimensions is consider as part of the main problem since minor error in the dimension will cause major problem in the fabrication of the arm structure.

1.3.3 Electronic Circuit Design and Software Programming

The electronic part is used to control the movement of the arm component. For this purpose, the PIC microchip or microcontroller is used. The PIC needs to have its own electronic circuit and needs to be programmed to enable it to control the arm movement and interface with the software to control the arm. Problem occurs in order to program the Visual Basic in PC to interface or communicate with the circuit through PIC.

1.4 Objectives

The main objective in completing the project is to achieve the standards that have been set. The objectives are as follows:

1.4.1 Design and Fabrication the 5 DOF Robot Arm

The main objective of this project is to design the 5 DOF revolute robotic arms that able to carry out certain task. The revolute robotic arm is able to move similar to human arm. The arm is designed so it is able to rotate clockwise and counter clockwise (180 degrees) and able to pick and place objects. The arm needs to be as light as possible in order to maximize payload. The material for the arm structure also needs to be strong and rigid. One possible material is the aluminum.

1.4.2 Design and Fabrication Serial Servo Controller Circuit Board

The second main objective is to design and fabricate the serial servo controller circuit board that will be used to control the robot arm servo via a serial connection to a Personal Computer (PC). The most important components that are used in the controller are the PIC 16F84 microcontroller. The circuit board will be connected to the serial port of a PC via DB9 serial connector.

1.4.3 Robot Software and Interfacing with the Robot Arm

The next main objective is to design robot interface application using Microsoft's Visual Basic 6.0 to control the servo controller circuit board to run the robot arm. The Visual Basic program sent servo position to the PIC on the controller circuit.

CHAPTER 2

LITERATURE REVIEW

2.1 Components of a Robot Manipulator

A robot manipulator system often consists of links, joints, actuators, and controllers [Robotics Second Edition, Man Zhihong, 2004].

2.1.1 Joints

The rotary joints and the sliding of prismatic joints allow the links to move in the robot work space. In robot system, the number of degrees-of-freedom is determined by the number of independent joint variables [Man Zhihong, 2004]. "CRS Robotics", the automation laboratory robot has 3 DOF. It's inexpensive, easy to program and limited load capacity [Handbook of Industrial Robotics, Shimon Y.Nof, 1999]. "IVAX SCARA" robotic arm produced by FEEDBACK has 4 DOF, it is primarily used in industrial areas such as pick & place and automated palletizing [Darryl Wai, 2004]. "Teleoperate Anthropomorphic Robotic Arms" has 5 DOF and the concept is similar to the industrial robotic arm in the factory. It is suitable for pick and place object with limited load capacity [Karl Williams, 2004]. Through all the research that I've done I have chose 5 DOF for my robotic arm because 5 DOF has the similar movement and features like human arm. But the more number of DOF the more complex the robotic arm.

2.1.2 Actuators

Actuators are devices that cause rotary joints to rotate or drive prismatic joints to slide along their motion axes. The most used robot drivers are stepper motor and DC servo motor. The stepper motor movements can be very precise but stepper motor is open loop type that is the control computer computes the number of pulses required for the desired movement and dispatches the command to the robot without checking whether the robot actually completes the motion commanded [Robots and Manufacturing Automation, C.Ray Asfahl,1992]. "IR Transreceiver Robotic Arm" used 4 stepper motor to control the direction and generate a Pulse Width Modulation [Neremal Singh, UNN, 2004]. "Robotic Arm Control System" used 4 unit of DC motor to drive each joint of the robotic arm used for speed and position control application [Mohd. Badrul bin Abd. Rahman, UNN, 2004]. The second type of robot actuator is dc servo. These robots invariably incorporate feedback loops from the driven components back to the driver. Thus the control system continuously monitors the positions of the robot components, compares these positions with the position desired by the controller and check any differences or error conditions [C.Ray Asfahl, 1985]. "Teleoperate Anthropomorphic Robotic Arm" used 8 servo motors overall to control the arm. That is 2 large scale servos to control shoulder to provide torque needed to lift the rest of the arm as well as any object that it may be grasping, 1 large scale servo to control the rotating base and another one large scale servo to control elbow. While 3 standard servos used to control the wrist and one more standard servo to control the gripper [Karl Williams, 2004]. As a conclusion on the actuators, I'm going to use servo motor as my robotic arm driver since servo motor is a continuous device, thereby making possible a smoother and continuously controllable movement.

2.1.3 Controllers

Controllers are the most important components in a robot system. If a robot has *n* joints, *n* controllers are needed to control all joint actuators. Robot controllers used to solve the problem how robot actuators are driven to achieve a desired performance. A robot control system is actually the integration of electronic hardware and software.

The task of software is to use some control algorithms to compute the control signals while the control hardware can then provide the control signals to the actuators [Man Zhihong, 2004]. "IR Transreceiver Robotic Arm" applied stepper motor controller to control the direction and generate a PWM. The direction of and the PWM output is then sent to the stepper motor driver. In this controller design, the programmable PIC16F84 is use to generate the desired signals. UCN5804 IC is used to drive the stepper motors. By incorporating stepper motor controller into the design, the PIC can control multiple stepper motor [Neremal Singh, UNN, 2004]. "Teleoperate Anthropomorphic Robotic Arm" used serial servo controller to control robot arm via serial connection to a PC or directly from the onboard PIC 16F84 microcontroller. The PIC is programmed to listen for any incoming serial communication from the host computer then set the servos to the positions received and update the servos with their positional information so that the servos will hold their positions [Karl Williams, 2004]. I'm going to choose servo motor controller for my robotic arm since I'll use servo motor to drive my robotic arm and the advantage of using servo motor already explain under actuators topic above.

2.2 Robot Geometry

In the field of robotics, there are five types of commonly used robot arm configurations, each named according to the combination of shoulder, elbow and wrist joints. Each of the commonly used types employs simple revolute or prismatic joints. The five types are the rectangular coordinate (this includes both floor and gantry mounts), spherical coordinate (polar), cylindrical coordinate, revolute coordinate and the Self Compliance Automatic Robot Assembly (SCARA).

Cartesian robots have three prismatic joints, whose axes are coincident with a Cartesian coordinate system. "Gantry robots (GCA Corporation)" are widely used for handling tasks such as palletizing, warehousing, and order picking or special machining task such as water jet or laser cutting where robot motions cover large surfaces [Shimon Y. Nof, 1999]. A cylindrical robot's arm forms a cylindrical coordinate. This kind of robotic arm preferably used for palletizing, loading, and unloading of machines. "Optimal Design for Laparoscopic Positioning Stands"