DESIGN AND DEVELOPMENT OF 7 DEGREES OF FREEDOM ROBOTIC ARM FOR INDUSTRIAL APPLICATION

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Abstract

In this research article was to design and develop the 7 Degrees of freedom robotic arm for industrial applications. A seven degrees of freedom articulated motorized robotic arm is designed and assembled in this context along with its Bluetooth control system. The proposed robotic arm consists of 3 sequentially connected modules, i.e., 2 DOF shoulder module, 3DOF elbow module and 2 DOF wrist modules. The robot arm was designed with seven degrees of freedom and talented to accomplish accurately simple tasks, such as light material handling, which will be integrated into a mobile platform that serves as an assistant for industrial workforce. The robot arm is equipped with several gear motors which do links between arms and perform arm movements

Keywords—*Bluetooth module; roboticarm;7 Degrees of freedom ; Gear motors;*

I.INTRODUCTION

This concept of project is to construct a robotic arm system that is able be controlled by Bluetooth module. The background of the project, the problem faced and the solution presented will be discussed. The objective of the project is thereupon stated. The scope and significance of the project will be finally defined

1.1 Background

The term robotics is practically defined as the study, design and use of robot systems for manufacturing. Robots are generally used to perform unsafe, hazardous, highly repetitive, and unpleasant tasks. They have many different functions such as material handling, assembly, arc welding, resistance welding, and machine tool load and unload functions, painting, spraying, etc.

There are mainly two different kinds of robots: a service robot and an industrial robotic. Service robot is a robot that operates semi or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations. Industrial robot, on the other hand, is officially defined by ISO as an automatically controlled and multipurpose manipulator programmable in three or more axis. Industrial robots are designed to move material, parts, tools, or specialized de- vices through variable programmed motions to perform a variety of tasks. An industrial robot system includes not only industrial robots but also any devices and/or sensors required for the robot to perform its tasks as well as sequencing or monitoring communication interfaces.

1.2 Problem Statement

This article is to construct a robotic system with seven degrees of freedom which is controlled by Bluetooth module. There are already many robotic arms with 4 or 5 degrees of freedom but their movements are restricted and cannot achieve smooth or curve motion. So to eliminate this problem in this project we have used 7 degrees of freedom.

1.3 Objectives

The aim of this project is to construct 7 degrees of freedom robotic arm which can be controlled by Bluetooth module, and the objectives are:

- Carryout design and construct a robotic arm with end effectors.
- Develop a program for time delay for each motor separately.
- Develop the communication system between the micro controller and the robotic arm.

1.4 Working principle

- The pick and place action of 7 DOF robotic arm is controlled by an embedded system.
- The action of DC-motors and spur gears enables orientation of the robotic arm.
- BO-motor is used for gripper.
- Embedded system consists of a microcontroller.
- An additional Bluetooth connectivity is used to control robot action via mobile

1.5 Construction

- The mechanical construction in this project is to build and assemble the robotic arm body.
- Seven degrees of freedom manipulator having variable programmed motions to carry out variety of tasks in diverse environments is chosen.
- This is a seven axis articulate manipulator designed to move material like machine parts, tools, specialized devices, etc.

It is driven by seven DC-motors and has a gripper as end-effectors. The gripper has fingers grasping and manipulation of objects.

II.THEORY & CONCEPT

2.1 Concept

In this proposed System, The main aim of a making 7 degrees of freedom is to do complex jobs and movements. If a robot has 3DOF, it cannot tilt or turn. Increase in DOF enhances the working space and to conduct complex operations, robot needs to work with greater flexibility. The arm is to be controlled using Bluetooth module in X, Y, and Z direction. Similarity of human arm with the robotic arm is the basic aim of the project but, due to many problems and disadvantages the arrangement is done in inverse.

2.2 Proposed System

A proper explanation on how the manipulator was chosen is presented. This document contains simulation and experimental results of a project aimed to design and implement an algorithm for motion of a robotic manipulator to accomplish pick-and-place operations. Such operations must be performed avoiding stationary obstacles found in an indoor room environment. The different approaches implemented to achieve the aforementioned tasks in a 7-DOF manipulator are described in this thesis.

Automation is termed as use of different control systems such as numerical control, programmable logic control or other industrial control systems in concern with computer applications or information technology(such as Computer Aided Design or Computer Aided Machining) to manipulate all the industrial machinery and processes, thus reducing the need for human intervention. As always said, for growth of

industries, automation is must and should supersede the mechanical growth. Where mechanization provides human operators with machinery to assist them along with the muscular requirements of work, automation decreases the involvement for human sensory and mental requirements as well. Automation plays a dominant role in the world economy these days and in daily application in industries.

2.3 Selection

2.3.1 Selection of Degree of freedom

The number of independents movements that an object can perform in 3D space is termed as the number of degree of freedom (DOF). Thus, a rigid body free in space has six degree of freedom – three for positions and three for orientations. For our application 7 DOF are suitable.

2.3.2Selection of material

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.

2.4 Arrangement of 7 degrees of freedom

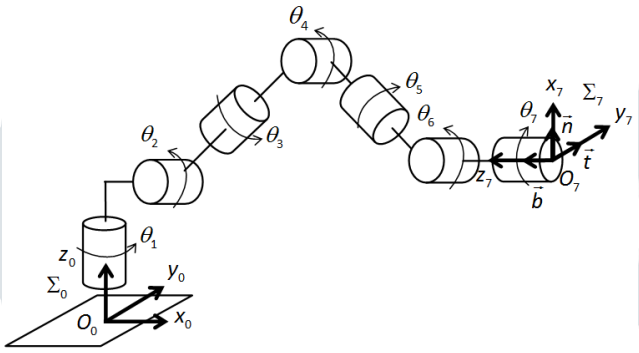


Fig 1 Schematic Arrangement of 7 DOF

The above shown is the arrangement of 7 degrees of freedom in a robotic arm. This is the first arrangement decided to be designed.

2.5 PIC CONTROLLER

We can broadly define an embedded system as a microcontroller-based, software-driven, reliable, real-time control system, designed to perform a specific task. It can be thought of as a computer hardware system having software embedded in it. An embedded system can be either an independent system or a part of a large system. In this tutorial, we will explain all the steps necessary to design an embedded system and use it.

As its name suggests, Embedded means something that is attached to another thing. An embedded system can be thought of as a computer hardware system having software embedded in it. An embedded system can be an independent system or it can be a part of a large system.

An embedded system is a microcontroller or microprocessor based system which is designed to perform a specific task. For example, a fire alarm is an embedded system; it will sense only smoke. An embedded system has three components:

- It has hardware.

• It has application software.

It has Real Time Operating system (RTOS) that supervises the application software and provide mechanism to let the processor run a process as per scheduling by following a plan to control the latencies. RTOS defines the way the system works. It sets the rules during the execution of application program. A small scale embedded system may not have RTOS.

So we can define an embedded system as a Microcontroller based, software driven, and reliable, real-time control system.

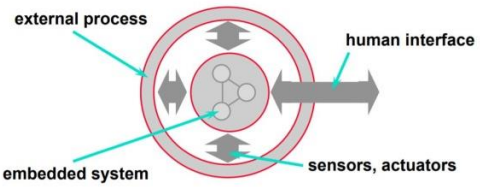


Fig 2 Embedded system

2.5.1 Basic structure of an embedded system

- **Sensor** – It measures the physical quantity and converts it to an electrical signal which can be read by an observer or by any electronic instrument like an A2D converter. A sensor stores the measured quantity to the memory.
- **A-D Converter** – An analog-to-digital converter converts the analog signal sent by the sensor into a digital signal.
- **Processor & ASICs –** Processors process the data to measure the output and store it to the memory.
- **D-A Converter** – A digital-to-analog converter converts the digital data fed by the processor to analog data.
- **Actuator** – An actuator compares the output given by the D-A Converter to the actual (expected) output stored in it and stores the approved output

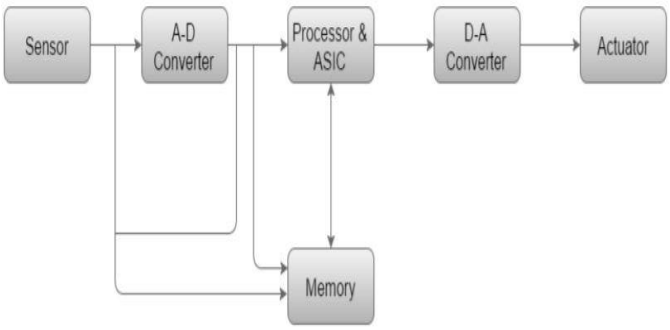


Fig 3 .Structure of embedded system

2.5.2Microcontroller

Microcontroller is a single chip micro computer made through VLSI fabrication. A microcontroller also called an embedded controller because the microcontroller and its support circuits are often built into, or embedded in, the devices they control. A microcontroller is available in different word lengths like microprocessors (4bit,8bit,16bit,32bit,64bit and 128 bit microcontrollers are available today). Microcontroller called microchip also.

Fig 4 Microcontroller chosen

2.6 Hardware Requirements

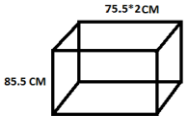
- Bluetooth module
- Microcontroller
- The Robotic arm

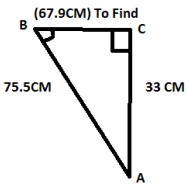
2.7 Robotic System

The Robotic System consists of 3 main components,

- D.C gear Motors
- Relays
- Power Supply

2.8 Robotic Arm Workspace





To calculate work volume,

1) when vertical it gives = 85.5cm (y)

When horizontal = 75.5×2 (x)

Also other axis = 75.5×2 (z)

Upper part alone (above base) = (75.5×2) × (75.5×2) ×85.6

$= 1.9495m^3$

2) Work volume below the base = $\sin\theta = \frac{33}{75.5}$

$$\theta = \sin^{-1}\left(\frac{33}{75.5}\right)$$

$\theta = 25.918^c$

BC = AB $\cos\theta$ = 75.5×cos 25.918

BC = 67.9cm

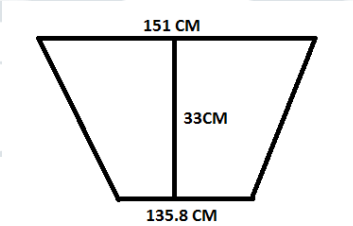


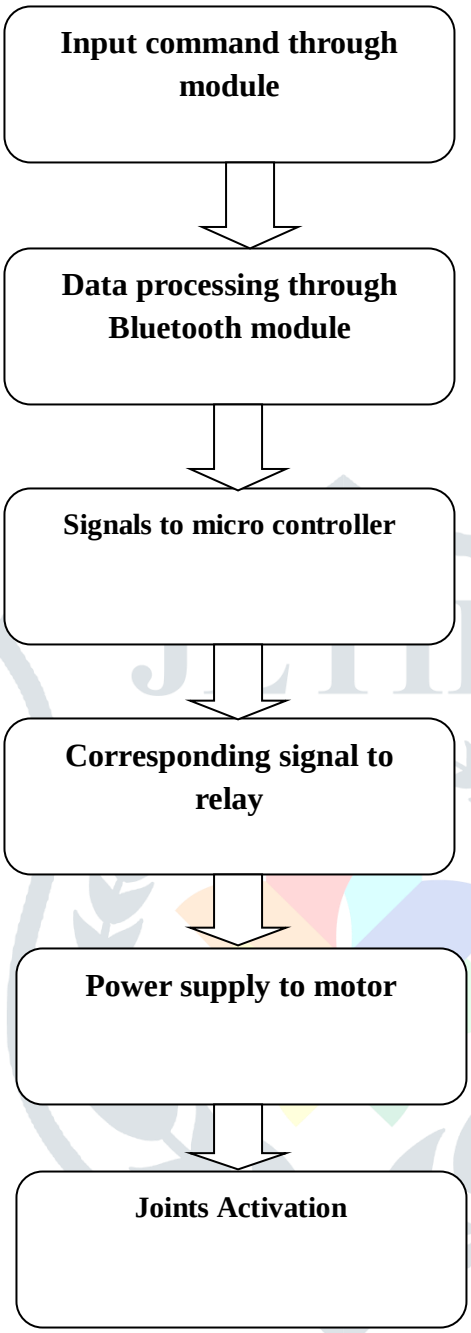
Fig 5 Robotic Arm Workspace

Robot Work Space V= $4/3\pi r^3 = 4/3\pi (0.12)^3$

$= 7.24\times10^{-3}mm^3 = 7.24\times10^{-3}/4$

$= 1.81\times10^{-3}mm^3$

I.PROCESS METHODOLOGY



IV DESIN OF ROBOTIC ARM

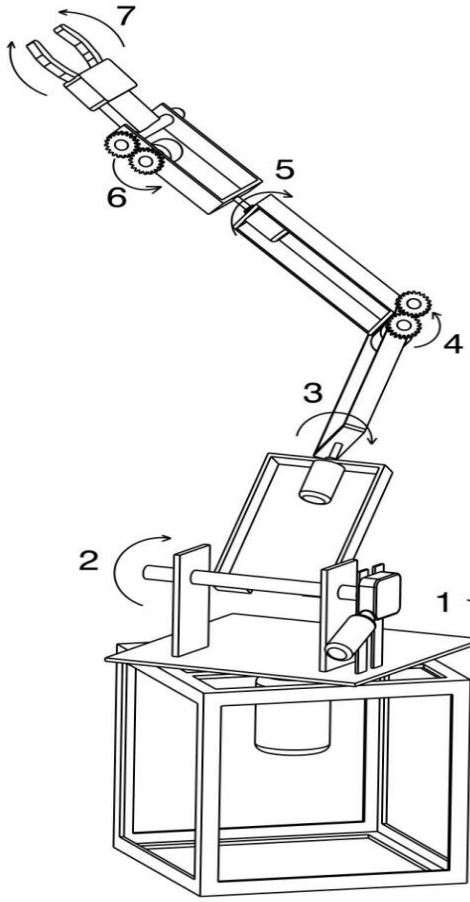
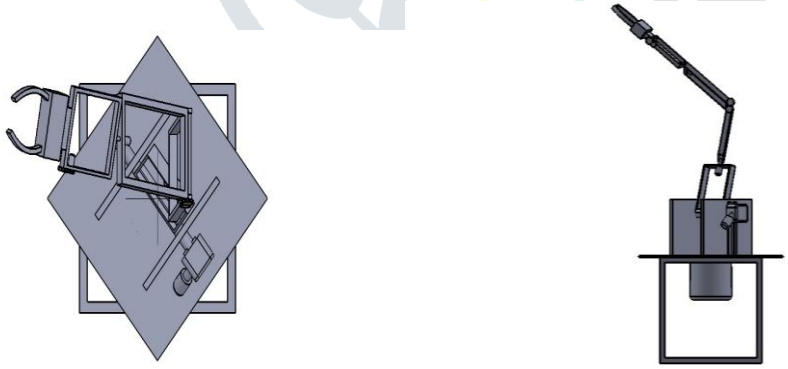


Fig 6 .Graphical representation in 3D View



Top view **Side view**

Fig 7 2D View

V. RESULTS AND DISCUSSION

5.1 Proposed setup

The Robotic Arm has been designed in Solid works software and successfully constructed as a working model.

Bluetooth module is connected and the Keys for actuation of motors are noted then it is successfully controlled by the microcontroller.

Fig 8 Schematic diagram of Proposed Setup

The signals are sent through the relays to the motors which are fixed in the robotic arm Setup and the response of the motors is good and the joints are moving properly.

5.2 Conclusion

Finally the 7 degrees of freedom robotic arm is good and enhances more movements compared to 3 and 4 degrees of freedom robots. The main objective of this study is to introduce a simple robotic arm manipulation in order to enable the incorporation of robotic systems into the home environment, to enhance the independence and autonomy of individuals with severe mobility impairments, and to allow at the same the monitoring and prevention of accidents which may occur while handling the robot physically.

So we can believe that the 7 degrees of freedom robotic arm would be undoubtedly benefit and enable the realization of various application in the field of AI, due to its compact size, enhanced precision, and low purchase cost.

5.3 Future Scope

The future scope is by using the same design of robotic arm and just instead of Bluetooth control if gesture control is used then all the motors can be actuated at the same time and a smooth motion is achieved. This will have a vast application like handling materials of small sizes and handling hazardous materials easily without any fear and more. As the number of degrees of freedom increases the smoother will be the movement.

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