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Design and Kinematic Analysis of Automatic Articulated Robot

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Abstract. Automation in the machine tools has reduced the human's intervention in the machining generation and improved the process efficiency, and product quality, it can be achieved via robots. Therefore, it is very important to study the principle of robots and to learn how to apply them in the automation of a manufacturing system. In this project focus on an automatic robot which an operation of pocking and placing, educational purpose, industrial automation of light assembly. By employment of reprogrammable microcontrollers, it is now easy to add new functions and capabilities to a robot. This robotic arm is controlled by an android. This robotic arm motion is restricted or constrained by using 6 controlled motors. It is a 5-axis robotic arm having 5 DOF like revolute coordinate robot. The robotic arm and android are interconnected wirelessly by using a Bluetooth module. These are programmed through microcontrollers. It is mainly designed for the function of pick and place of objects as guided in the program. This robot gives scope to study, design and fabrication of a robotic arm according to the operations to be performed.
Key words: Wireless, Microcontrollers, Bluetooth module, controller motors, Android.

1. Introduction

Now-a-days automation is necessary to do the works quickly with high efficiency. By using recent technologies, it can be achieved. In these technologies Robots are the first choice. Considering these a robot arm is designed with interchangeable end effectors. In this paper an articulated robot having 5 degrees of freedom is designed. Present robots are made up of hard and rigid materials. These are not suitable for portable works. To overcome this robot is made up of softer material. Acrylonitrile butadiene styrene is used due to its unique properties. The parts are produced by 3-D printing technology. This is the emerging technology in recent days to produce parts. by using this technology accurate and efficient parts can be produced. It runs by using a battery power. Manipulator movements are constrained by using controller motors. These are programmed through an Arduino mega controller. A Bluetooth module is used to interconnect the robot and smart phone. it is programmed by using a computer language of C++.The parts are designed by using CATIA V5 and forward kinematics analysis is done. A smart phone is used as a remote.

2. Review Literature

[1] Ochelle Ashley et.al.,"Arduino Based Robot Arm with Smartphone Control".4-Axis Robotic Arm Which Is Programmed by Using Arduino Microcontroller. And Operated by Using Mobile Phone. Arduino Is Programmed in C++.It Is Easily Operated. The Communication Between Arm and Arduino Is Good. It Can Pick and Place Light Weights. They Faced Some Problems While Operating the Arm Due to Under Power of Servo Motors and Some Mistakes in The Ratio of Mechanical Parts. The Program Reached Its Efficiency Up to 60% Only. [2] alit Swamardhikaet.al. "Design of Mobile Robot with Robotic Arm Utilizing Microcontroller and Wireless Comunicación."it is a movable arm with 6 DOF by using 6-wheel drive mechanism. Controlled wirelessly through remote based on Xebec pro series. Sensor is used to detect the obstacle while the robot moving. it is movable fromone place to another place by using a remote. Arm structure resembles actually like human's arm. The effector can attain wide range of angle. It can detect obstacles while moving. Even though it is wireless it needs separate remote system. Due to more parts cost is high and it needs careful maintenance. [3] prof. Vijay Matta, et.al"Automatic pick and place robotic arm vehicle". The robot consists of an array of IR sensors in order to calculate the reflectance of the block. To control the motion of robot we use DC motor. the whole system is interfaced with Arduino which can be operated with the help of cable.Easily operated for repetitive works. Human efforts will be reduced. Efficiency will be increased. Initial cost may be high. Not fully automated (usage of cable). [4] Catania jambotkaret.al,Pick and place robotic arm using Adriano. The robotic arm placed on a moving vehicle which can be driven with the help of motors. the input signal is given from a wireless which is controlled by a RF receiver module. The programme to the whole mechanism is given in python. The robot will decode the instructions given to it and move or act according to the instructions given by the user. This robot is more versatile and efficient It can be made possibly by image processing tool interfaced with Arduino.This robot is more versatile and efficient It can be made possibly by image processing tool interfaced with Arduino. The gripper used for this arm is vaccume type which is less efficient. Can't work or use in rough or smooth sides. [5] Naga Sudheer rayala et.al,"Pick and place arm robot movement control by using android".This is a four fingered robotic arm this

system has 14 independent commands for all four fingers. The tendering system of the revolute joint mechanism provides the hand the ability to conform object topology with the help of sensors. finally, the result of the experimental work for pick and place application is enumerated. The four fingers will give more grip to pick. Arm actions are faster when compared to manual. Will recognize the position and orientation easily. Expensive due to more parts independent commands may cause gripper failures.

3. Design

Design consideration

- **Functionality:** this paper focused on picking and placing industrial light assemblies, and as a prototype for education purpose to provide knowledge about the trending technology in robotics.
- **Motion Range and Speed:** robots resemble human arm having some joints. The manipulators are joined through these joints. Every joint and manipulator has its own capacity of movement.
- **Payload:** payload is the range of load a robot can offer to lift.
- **Reach:** there are two types of reaches vertical and horizontal reaches. Vertical reach means the length covered by an arm in parallel to the axis. Horizontal reach means the distance covered by robotic arm perpendicular to the axis.
- **Axes:** Higher the axes have high flexibility. Industrial robots have 6-axes in this paper 5-axea robot is designed.

The design and specifications are taken by considering the micro robot, minimover5.

Material Selection: Stands for Acrylonitrile Butadiene Styrene. ABS is an impact-resistant **engineering thermoplastic** & amorphous polymer. ABS is made up of three monomers: acrylonitrile, butadiene and styrene. ABS is one of the most versatile materials available for 3D printing today. ABS comes in the form of a long filament wound around a spool. The 3D Printing process used with ABS is the FDM (Fusion Deposition modeling) process where material is heated and squeezed through a fine nozzle to build yourdesigning250-micron layers. Objects printed with ABS boast slightly higher strength, flexibility, and durability. It is a great material for prototyping and it can be easily machined, sanded, glued and painted.

4. Components

- BODY
- ARM BODY-1
- ARMBODY-2
- ARM BODY-3
- GRIPPER LINK
- GRIIPER BASE
- GRIPPER TEETH
- WAIST
- GRIPPER GEAR

Specifications for Components

S.no	Name of the part	No. Of parts	Length	Width	Thickness
1	BODY	1	90.2	59.1	16.2
2	ARM BODY-1	1	638	165	75
3	ARM BODY-2	1	453	150	106
4	ARM BODY-3	1	181	110	155
5	GRIPPER LINK	1	153	20	16
6	GRIPPER BASE	1	303	175	31
7	GRIPPER TEET	2	132	20	33

S.no	Name of the part	No. Of parts	Diameter	Height	Length	Thickness
8	WAIST	2	290	239	-	67
9	GRIPPER GEAR-1	1	116	-	194	16
10	GRIPPER GEAR-2	1	116	-	179	16

5. Analysis

Denavit–Hartenberg Parameters: In mechanical engineering, the Denavit–Hartenberg parameters (also called DH parameters) are the four parameters associated with a particular convention for attaching reference frames to the links of a spatial kinematic chain, or robot manipulator. Jacques Denavit and Richard Hartenberg introduced this convention in 1955 in order to standardize the coordinate frames for spatial linkages. Richard Paul demonstrated its value for the kinematic analysis of robotic systems in 1981. While many conventions for attaching reference frames have been developed, the Denavit–Hartenberg convention remains a popular approach. Forward Kinematic Analysis

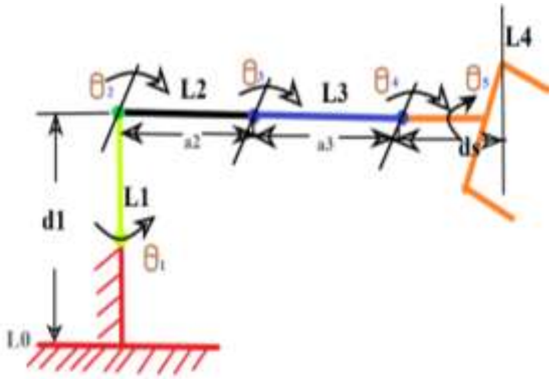

FIGURE 1. Freebody diagram of 5-DOF Articulated robot

- α_{i-1}=The angle from Z_{i-1} to Z_i measured about X_{i-1}
- α_{i-1}=The distance from Z_{i-1} to Z_i measured along X_{i-1}
- θ_{i}=the angle from X_{i-1} to X_i measured about Zi
- d_{i}=the distance from X_{i-1} to X_i measured along Zi

Table:5.2.1 Proximal variant D-H parameters of articulated robot

Frame (i)	α_{i-1} (deg.`)	α_{i-1} (deg.)	di (mm)	θ_i (deg.)	Home
1	0	0	4	θ_1	0
2	0	-90	0	θ_2	0
3	a_2	0	0	θ_3	0
4	a_3	0	0	θ_4	-90
5	0	-90	0	θ_5	0
6	0	0	d_6	-	-

Transformations: ${}^{0}T6={}^{0}T_1\,{}^{1}T_2\,{}^{2}T_3\,{}^{3}T_4\,{}^{4}T_5\,{}^{5}T_6$

$${}^{0}T_1=\begin{bmatrix} C1 & -S1 & 0 & 0 \\ S2 & C1 & 0 & 0 \\ 0 & 0 & 1 & d1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^{1}T_2=\begin{bmatrix} C1 & -S1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -S1 & -C2 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^{2}T_3=\begin{bmatrix} C3 & -S3 & 0 & a2 \\ 0 & 0 & 1 & 0 \\ -S1 & -C2 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^{3}T_4=\begin{bmatrix} C4 & -S4 & 0 & a3 \\ S4 & C4 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^{4}T_5=\begin{bmatrix} C5 & -S5 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -S5 & -C5 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^{5}T_4=\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d6 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^{i-1}T_i=\begin{bmatrix} c\theta i & -S\theta i & 0 & ai-1 \\ S\theta iC\alpha i-1 & C\theta iC\alpha i-1 & -S\alpha i-1 & -S\alpha i-1di \\ S\theta iS\alpha i-1 & C\theta iS\alpha i-1 & C\alpha i-1 & C\alpha i-1di \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Table:5.2.2 Proximal variant D-H parameters of articulated robot

Frame (i)	**α_{i-1} (deg.`)**	**α_{i-1} (deg.)**	**di (mm)**	**θ_i (deg.)**	**Home**
1	a_0=0	a_0= -90	d_1	θ_1	0
2	a_1=0	a_1=0	d_2=0	θ_2	0
3	a_2	a_2=0	d_3=0	θ_3	0
4	a_3	a_3=0	d_4=0	θ_4	-90
5	a_4=0	a_4=0	d_5=0	θ_5	0
6	a_5=0	a_5=0	d_6	-	-

6. Conclusion

The aim of this project is to design the articulated robot for the function of picking and placing. it will provide a knowledge about the designing, working and construction of a pick and place articulated robot which is easily controlled by an android. It is reprogrammable through a computer language. Because of this, it is easy to change the instructions. And user friendly while working. By the use softer materials it is portable and damage percentage is reduced. Finally it can meet the requiremets of the users.

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