Research paper on Design and Development of gesture controlled Robotic Arm

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Abstract -Now a day's robotic arm is used in various areas such as military, defense, medical surgeries, pick and place function in industrial automation applications. Based on the gesture of human hands the robotic arm moves and performs the task and this system replicates the actions of human hands. The arm is very flexible and can be made suitable in places where the environment is not safe for humans like firework manufacturing industry, bomb diffusing etc. There are various techniques for controlling the robotic arm. This gesture control robotic arm will be mounted on X-Y planes table. So the robotic arm movement is to be control using flex sensor & the final aim will be to position the end effector precisely to the given co-ordinates. Joint movement will be control using the encoder based stepper motor. So this stepper motors will be control using Arduino board. So in this project we are going to create the GUI software for precise movement of end effector.

Key Words: Robotic Arm, Flex Sensor, Wireless Module, Accelerometer

1 . INTRODUCTION

1.1 ROBOT MEANING:

Nowadays, robotics are becoming one of the most advanced in the field of technology. A Robot is an electro-mechanical system that is operated by a computer program. Robots can be autonomous or semi-autonomous. An autonomous robot is not controlled by human and acts on its own decision by sensing its environment. Majority of the industrial robots are autonomous as they are required to operate at high speed and with great accuracy. But some applications require semi-autonomous or human controlled robots. Some of the most commonly used control systems are voice recognition, tactile or touch controlled and motion controlled.

1.2 GESTURE CONTROL TECHNOLOGY

A gesture is an action that has to be seen by someone else and has to convey some piece of information. Gesture is usually considered as a movement of part of the body, esp. a hand or the head, to express an idea or meaning.

An important aspect of a successful robotic system is the Human-Machine interaction. In the early years the only way to communicate with a robot was to program which required extensive hard work. With the development in science and robotics, gesture based recognition came into life. Gestures originate from any bodily motion or state but commonly originate from the face or hand. Gesture recognition can be considered as a way for computer to understand human body language. This has minimized the need for text interfaces and GUIs (Graphical User Interface).

1.2 FUTURE SCOPE:

The end effector, or robotic hand, can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application. For example, robot arms in automotive assembly lines perform a variety of tasks such as welding and parts rotation and placement during assembly. In some circumstances, close emulation of the human hand is desired, as in robots designed to conduct bomb disarmament and disposal. Low-cost anthropomorphic hands with large degrees of freedom have been developed.

2. Problem defination

The traditional wired buttons controlled robot becomes very bulgy and it also limits the distance the robot goes. The wire controlled robots are also facing accuracy problem for their designed task or work, so we are designing a robotic arm with 4 DOF which is used for pick and place operation of an object in any co-ordinate. The aim of this study is to provide Robotic arm for industrial use with high risky task with maximum accuracy.

3. LITERATURE REVIEW :

This chapter deals with research work done in past by various investigation on the performance,

Ankur Bhargava et al. [1] ""A survey on Arduino Controlled Robotic Arm". In this paper Degree of

Freedom (DOF) robotic arm have been developed. It is controlled by an Arduino Uno microcontroller which accepts input signals from a user by means of a set of potentiometers. The arm is made from four rotary joints and end effector also, where rotary motion is provided by a servomotor. Each link has been first designed using Solid works Sheet Metal Working Toolbox and then fabricated using a 2mm thick aluminum sheet. The servomotors and links thus produced assembled with fasteners produced the final shape of the arm. The Arduino has been programmed to provide rotation to each

servo motor corresponding to the amount of rotation of the potentiometer shaft. A robot can be defined according to the nature of the relative movements between the links that constitute. .

Wei Xin Sha, John Iachello, Steven Dow, Yoichiro Serita et al. [2], TAZAMA St. Julien, Julien Fistre Faculty of Literature, Communication, Computer and Culture / GVU Center Georgia Institute of Technology proposed the continuous detection of gestures to control the audiovisual media. They represent how the detection of the incessant movement can be achieved by using low

power remote sensing to improve the expressive control of the age constant of sound and visual supports.

Rafiqul Zaman Khan and Noor Adnn et al. [3], Ibraheem of the Department of Computer Science, A.M.U. Aligarh, India, in the International Journal of Intelligence and Artificial Applications (IJAIA) in July 2012 proposed hand signal recognition: a survey of writing. They said the hand motion recognition framework had an amazing consideration in the couple of years because of their complex applications and the ability to interact with the machine effectively through human collaboration with the PC. They showed a review of the frames of recognition of last-minute movements. The key issues of the hand signal recognition framework are given the difficulties of the structure of the movement.

Mr. Anala Pandit , Mr. Dhirya Dand et al. [4] A simple wearable hand gesture device using institute of medical and early modern studies. In this paper people machine communicating device, most intuitive communicating device , to interacts to the device and the other appliances. In case of communicating to the machine commands are being implemented use of hand gesture. Here accelerometer used to migrate the touchpad to revolve 3D object. Accelerometer changed to wireless communication 3D graphics can be done easily. Effective interaction.

development of industrial robotic arm by Rahul Gautam [5] This selective operation robotic control method is need to be overcome the problem such as placing or picking object that at distant from the worker. The robotic arm has been developed successfully as the movement of the robot can be controls precisely. It is expensive to change the cable and Therefore the designing to reduce the friction on table, is crucial to increase time between maintenance.

4. DESIGN METHODOLOGY:

The most important aspect and backbone of this Thesis is the mechanical design of the Robotic arm. A robotic arm has certain design specifications and certain

parameters are to be taken into the consideration. Since, the design is an area related to thought, many varieties of

designs come to the mind at the initial stages. Everything might not be as we wish and the method cannot be trusted blindly. So, keeping all these things in mind, we have decided to design the robotic arm whose dimensions are loosely based on required we need and using the material as aluminium which will be designed by the software solid works.

The arm should have the ability to lift, move, lower and release an object, seeking all this scenario we are designing an arm with thickness of 3mm max so that the weight should not exceed to do particular task, therefore we have designed the arm with 5 joint. First is base joint, 2nd is shoulder joint, 3rd is the elbow joint, 4th is wrist joint, 5th is gripper joint. . This robotic arm has 5 parts and 5 joints which are pretty much like the human hand. In each joint there will be one servo/stepper motor which allow to move the in particular co-ordinate.

5. WORKING PRINCIPLE:

A small object of low weight is placed near the robotic arm at a distance within the approach of arm. The system is made on. The operator stands at a distance from the robot and moves the finger/hand up, down, left or right. The robotic arm follows the direction. The arm is brought over the object and then lowered. The grabber is fully opened to pick up the object. The robotic arm then is moved up and rotated to another desired position, then lowered. When the arm reaches the ground floor, the grabber is given a command to release the object, which places it at the desired location. This way the robotic arm can be operated and controlled in any manner as deemed necessary by the operator from a distance, usually up to 200 meters.

The robotic arm works on the principle of electrical input energy to perform some mechanical works effectively with the help of some automation and program based operations. The pick and place robotic arm consist of major hardware components such as strips & motors and arm gripper, switches, battery, piece of metal, and other discrete mechanical and electrical components. This project is designed for developing a pick and place robotic arm with a soft catching gripper. This soft catching gripper is used for safely handling an object carefully while catching and placing. The robotic arm consists of servo motor which is used for angular rotations of the arm for catching items (to hold items, to release, to rotate, to place). This servomotor used is works on the principle of Fleming's left-hand rule and is controlled using Arduino circuit board.

6. MODEL:

Fig 1:Cad model

6.1 PART LIST:

Sr. No.	Part Name	Material	Size	Qty
1.	Metal link 1	Aluminum	400mmX 100mmX 3mm	2
2.	Metal link 2	Aluminum	350mmX 78mmX 3mm	2
3.	Base plates L	MS	277.12mmX 172.23mmX 147mm	1
4.	Base plates R	MS	277.12mmX 172.56mmX 80mm	1
5.	Metal shaft A	MS	160mmX Φ 15	1
6.	Shaft B	nylon	160mmX Φ 15	2
7.	Support shaft A	nylon	114mmX Φ 12	2
8.	Support shaft B	nylon	96mmX Φ 12	2
9.	Pulley A	Aluminum	PCD 64.68mm	3
10.	Pulley B	Aluminum	PCD 32.34mm	3
11.	Plumber bearing	CI	Φ 10mm	4
12.	Timing belts	PU material	160xl	1
13.	Timing belts	PU material	130xl	1
14.	Timing belts	PU material	332xl	1
15.	bushes	MS	8mmX Φ16	8
16.	shaft	MS	180mmX Φ 10	1

6.2 Detail drawing

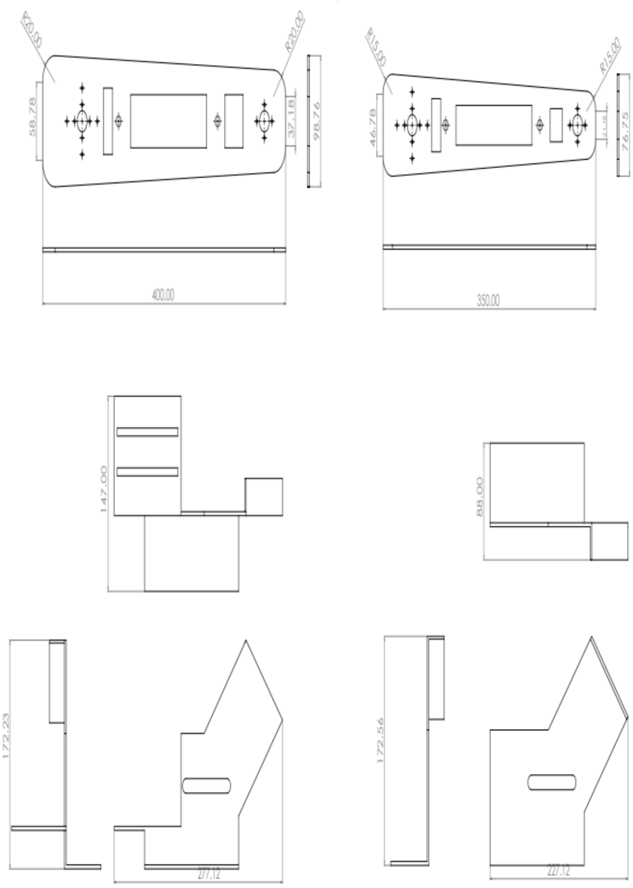

Fig 2: parts drawing

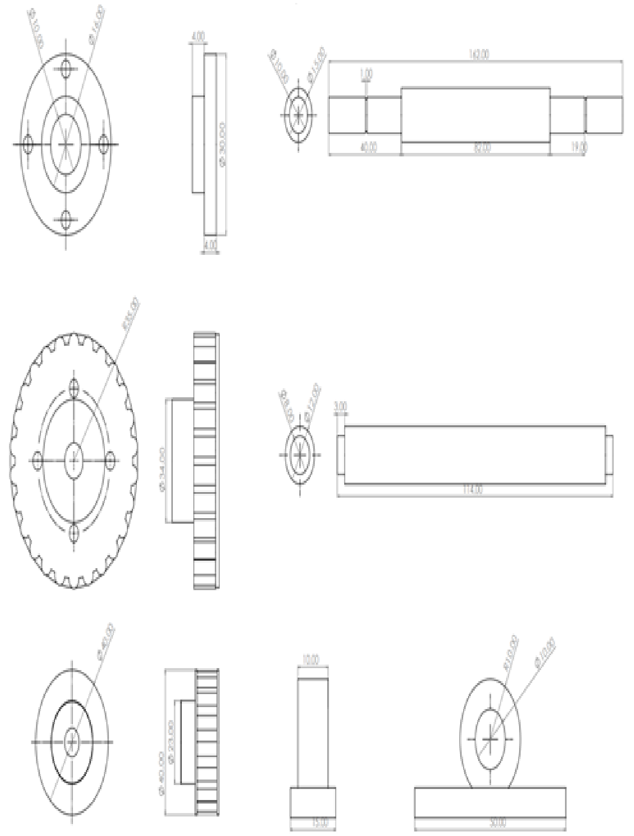

Fig 3: parts drawing

7. Components:

7.1 *Mechanical Gripper:* A mechanical gripper is used to grip the objects and hold it while transferring it from its location to the destination. The gripper has its inbuilt mini servo in it so it can open or close its jaws to grip the objects. The gripper is made from the acrylic by the LASER cutting operation .the shaft of the servo is fixed to the end of first jaw which meshes with the gear on the second jaw. As the motor rotates the gear rotates and this in turn rotates the gear in mesh and the jaws open or close to release or hold the objects. A gear link is attached to a servomotor which is meshes with another geared link to provide a smooth action of gripping of different objects according to their sizes the movement of both of figures of the grippers is synchronize well to hold the object.

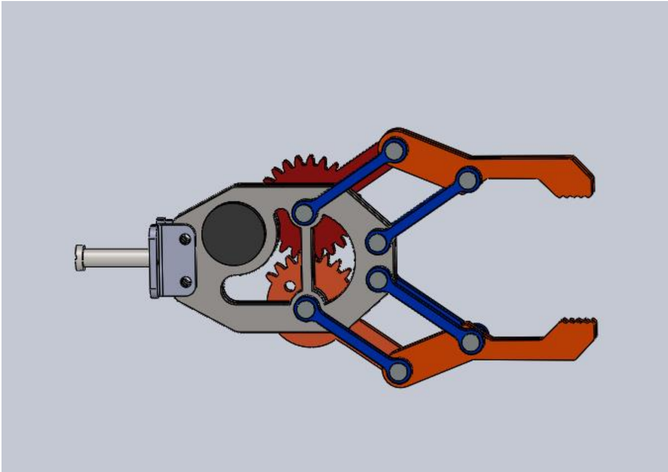

Fig 4:- mechanical gripper

7.2 *Controller:* A device which takes multiple inputs to adjust its output so that the connected gadget operates in a controlled way is called as a controller. By sending a servo signals a servo control can be obtained, a series of repeating pulses of variable width where either the width of the pulse or the duty cycle of a pulse train determines the position to be achieved by the servo. With the help of controller we can upload the programmed regarding the movements of the servos. By using the controller we can control the number of servos at a time and synchronize the operation of the servo. Microcontroller can be operated with more than one control outputs and carry out closed loop control. Choosing a specific controller is important for a final operation of a project because different actuators require differing control methods to achieve stable output. Arduino and Raspberry Pi are the most widely used controllers now a days.

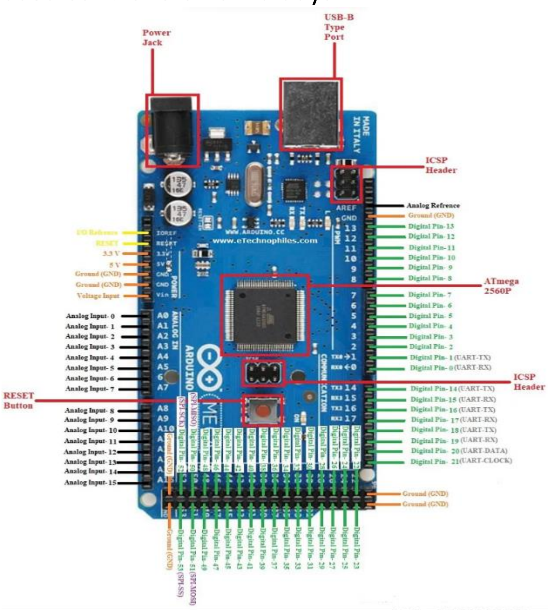

Fig 5:- Arduino board

7.3 *Servo Motor*: The two major servo motors are used in the robotic arm, one for the base movements and one on the side of the base plate two transmit the motion through the various links to the arm. The servo motor is bolted to the base plate it keeps it fixed and it avoids vibrations during the actual operations.

Fig 6:- Servo motor

7.4 *Sensors:* The position of the motor shaft is detected using potentiometer which consists of 3 pins [4], one end of the potentiometer is connected to +5V supply, other end is connected to the ground, middle pin is connected to the analog pin on the Arduino board. Potentiometer are placed at the shoulder joint and the elbow joint. At the shoulder joint, gears are connected to the potentiometers shaft, these gears are connected to the gears placed on the stepper motor. Force sensors are placed at the gripper for detecting the amount of pressure applied on the object. Force sensor consists of 2 pins. A pull-down resistor of 10K [3, 4] is used, one end of the sensor is connected to+5V and other end to the ground as well as the analog pin on the Arduino board.

Programming the force sensor is similar to that of the potentiometer.

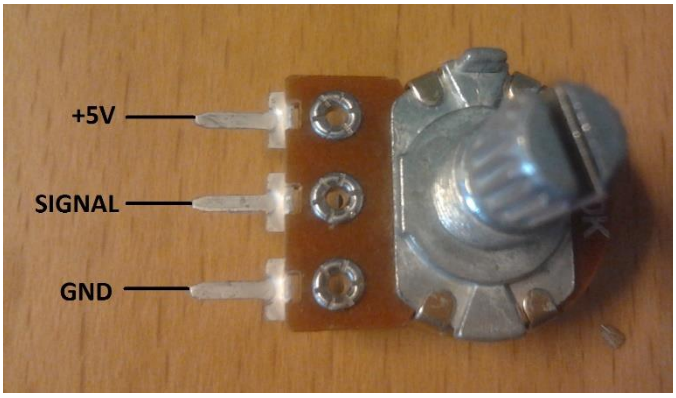

Fig 7:- Potentiometer

8. Communications and programming :

8.1 Communications:

To get the most out of the system, it was better to transfer the data wirelessly. This was done with the help of RF module communication between the Robotic Arm and glove. The APC-220 Module was used in the process, which is highly integrated semi-duplex low power transceiver module with high speed MCU and capability RF IC. It has high sensitivity and strong interference circumstance as well.

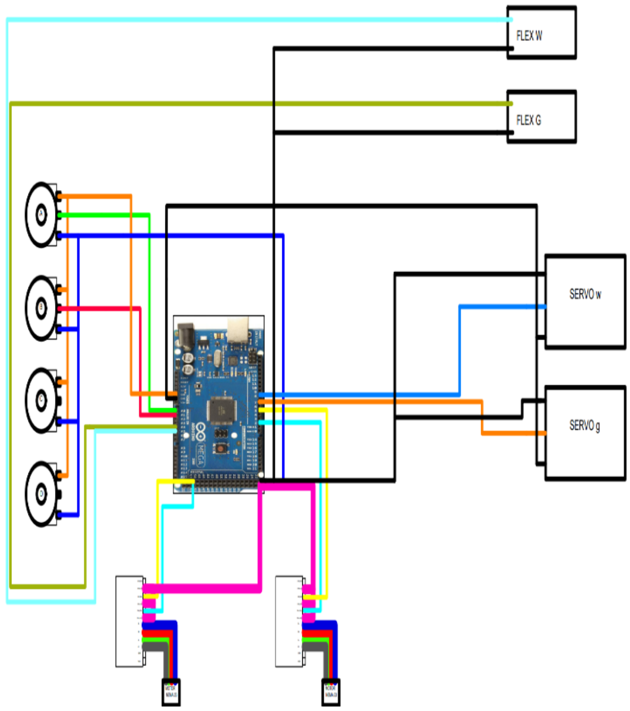

Fig 8:Circuit diagram:

8.2Programming:

Program on Arduino Mega Board will be performed in offline mode using Integrated Development Environment (IDE). the Arduino programming language is a modified version of c/c++. A program written in Arduino programming language is called sketch and saved with .ino extension. You can even use python to write an Arduino program. Arduino is cross-platform which makes it easy to run on any sort of device compared to another microcontroller which can only run on windows. USB connection with PC help to do work which assigns in code like the movement of angles, direction of Motors, etc. Also, by using angles values, we can restrict the motion of the robotic arm in the particular moment that we want.

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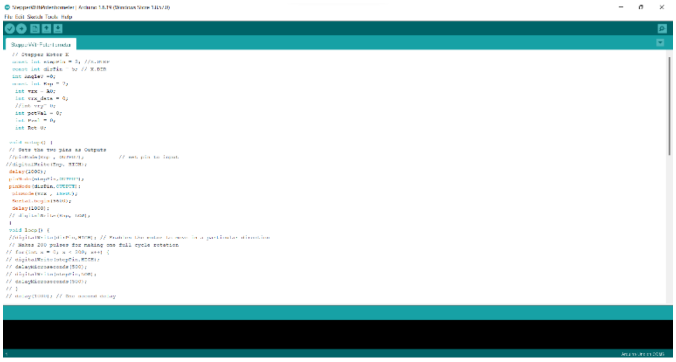
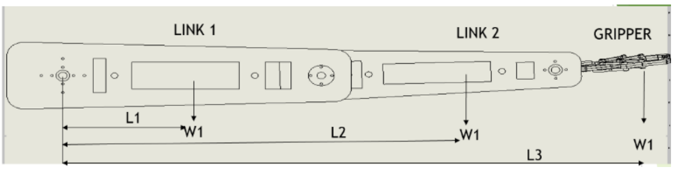


9 Calculation:

9.1 Torque:

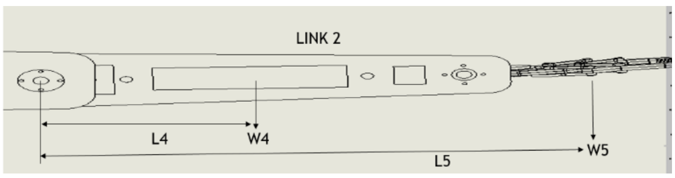
(1) calculation for motor 1



W1=567 grams	**0.567 Kg**
W2=395 grams	**0.395 Kg**
W3=200 grams	**0.200 kg**
L1 =150 mm	**0.15 m**
L2 =438 mm	**0.438 m**
L3 =607 mm	**0.607 m**

T =(0.567*0.15)+(0.395*438)+(0.2*0.607)
T =(0.085050)+(0.17301)+(0.1214)
T = 0.37946 kgm
T = 3.8 NM

(2) calculation for motor 2



W4 =395 grams	**0.395 kg**
W5 =200 grams	**0.2 Kg**
L4 = 136 mm	**0.136 m**
L5 = 330 mm	**0.33 m**

T = (0.395*0.136) + (0.2*0.33)
T = (0.05372+0.066)
T = 0.11972 Kgm
T = 1.1972 NM

9.2 Kinematic Calculations

Here are the forward kinematics calculations for the two link assembly

x= $L_1 \cos(\theta_1) + L_2 \cos(\theta_1 + \theta_2)$

Y= $L_1 \sin(\theta_1) + L_2 \sin(\theta_1 + \theta_2)$

$$x^2 + y^2 = L^2_1 + L^2_2 + 2 L_1 L_2 \cos(\theta_2)$$

$$\cos(\theta_2) = \frac{x^2 + y^2 - L^2_1 - L^2_2}{2L_1L_2}$$

$$x = L_1 \cos(\theta_1) + L_2(\cos(\theta_1)\cos(\theta_2) - \sin(\theta_1)\sin(\theta_2))$$

$$x = \cos(\theta_1)(L_1 + L_2\cos(\theta_2)) - \sin(\theta_1)L_2\sin(\theta_2))$$

$$y = \cos(\theta_1)(L_2\sin(\theta_2)) + \sin(\theta_1)(L_1 + L_2\cos(\theta_2))$$

$$\cos(\theta_1) = \frac{x + \sin(\theta_1)L_2\sin(\theta_2)}{L_1 + L_2\cos(\theta_2)}$$

$$\sin(\theta_1) = \frac{(L_1 + L_2\cos(\theta_2))y - L_2\sin(\theta_2)x}{L^2_1 + L^2_2 + 2L_1L_2\cos(\theta_2)}$$

Inverse kinematics calculations are also presented to validate the right positioning of the robotic arm. Here is the equation carried out for 2 links, L1 and L2 as an example.

$$\theta_2 = 180^0 - \cos^{-1}\left(\frac{L^2_1 + L^2_2 - x^2 - z^2}{2L_1L_2}\right)$$

$$\theta_1 = \tan^{-1}\frac{z}{x} + \cos^{-1}\left(\frac{L^2_1 + L^2_2 + x^2 + z^2}{2L_1\sqrt{x^2 + z^2}}\right)$$

$$\theta_0 = \tan^{-1}\frac{y}{x}$$

Control of the robotic arm is rather simple for the case of a 1-link (L1) manipulator - where the end effector is attached directly to the shoulder (base). Only the θ1 angle gets the value according the coordinates of the moved arm.

10 Conclusion:

As robotic applications have started to be used in daily life, the 20th Century science fiction fantasy of the human-robot interaction may be in fact the common practice in near future. In this manner, the re-configurability and self-adaptability for a robotic arm has great potential in the future of the robotics. This paper illustrates a simple and low-cost solution to this kind of a robotic application. Further work for this application consists of the production of the robotic manipulator using a 3D printer and its control using different motion control algorithms to test its performance and functionality. Afterwards, it will be implemented for a user-friendly mobile application as a personalized assistant robot

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