

MULTI TASKING ROBOTIC ARM WITH LOCOMOTIVES

A Project Report Phase - II

Submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering

By

R.R.SHANKAR (39130424)



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ENGINEERING SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

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Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119
www.sathyabama.ac.in



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ENGINEERING**

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of R.R.Shankar (39130424) who carried out the project entitled “**Multitasking robotic arm with locomotives**” under our supervision June 2022 to April 2023.

INTERNAL GUIDE

Dr.E. ANNA DEVI M.E.,Ph.D.

HEAD OF THE DEPARTMENT

Dr. T. Ravi M.E., Ph.D.

Submitted for Viva Voce Examination held on

Internal Examiner

ii

External Examiner

DECLARATION

R.R.Shankar (39130424) hereby declare that the Project Report entitled **“MULTITASKING ROBOTIC ARM WITH LOCOMOTIVES”** done by us under the guidance of **Dr.E. ANNA DEVI M.E.,Ph.D.** is submitted in partial fulfillment of the requirements for the award of **Bachelor of Engineering degree in Electronics and Communication.**

DATE: 24.04.23

PLACE: Chennai



SIGNATURE OF THE CANDIDATES

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ABSTRACT

Today, technology is developing in the same direction in line with rapidly increasing human needs. The work done to meet these needs makes life easier every day, and these studies are concentrated in robotic arm studies. Robot arms work with an outside user or by performing predetermined commands. Nowadays, the most developed field of robot arms in every field is the industry and medicine sector.

Designed and realized in the project, the robot arm has the ability to move in 4 axis directions with 5 servo motors. Thanks to the holder, you can take the desired material from one place and carry it to another place, and also mix it with the material it receives. While doing this, robot control is provided by connecting to the android application via Bluetooth module connected to Arduino Nano microcontroller.

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CHAPTER 1

INTRODUCTION

These days' people always need additional help systems. With the rapid increase in the flow of information, people are now guided to search for different markets and people have entered the competition to manufacture quality products cheaply. Automation systems are also needed to realize this. Because standardized automation systems are required to minimize errors as well as to have experienced and well-trained employees for quality products. Because of their physical characteristics, people needed to use auxiliary machines in places where their strength was not enough. These machines, which are operated with the need for human assistance in advance, have been made to operate spontaneously without the need of human power with the progress of technology. One of the most used components of automation systems is robots. Robotic systems; Mechatronics Engineering, Mechanical Engineering, Electrical Engineering and Computer Engineering have all come together to work together.

In the project, researchers have been done and implemented in order to have knowledge about mechanics and software during the operations carried out by the robot arm which is designed to fulfill the tasks determined in accordance with predetermined commands.

First, it was determined what function the robot arm would be and what movements it could make. Robotic arm made of Android phone or tablet control; it can carry the desired material, mix it up and perform the commands previously determined by a user. If this project is also a designated task; the robotic arm takes a piece of material and brings it to the desired position and then records its movements and lets it do the same action until we stop it. The servomotor is preferred in order to be able to perform these operations properly since the motor to be selected must operate precisely

and must be at high torque. The robot arm is composed of 5 servo motors and can move in 4 axis directions with these motors.

In the project, an Arduino Nano microcontroller written in Java language is programmed and servo motor control is provided. Thus, it is possible to perform the desired operations by means of the elements located on the Arduino without any circuit construction other than the circuit where the servo motor inputs are located. For the mechanical part, the robot arm is drawn with the SolidWorks program and the dimensions of the robot arm are specified. A 12V power supply is also preferred for the robot to work.

Nowadays, robots are increasingly being integrated into working tasks to replace humans, especially to perform repetitive tasks. In general, robotics can be divided into two areas, industrial and service robotics. These robots are currently used in many fields of applications including office, military tasks, hospital operations, dangerous environment and agriculture. Besides, it might be difficult or dangerous for humans to do some specific tasks like picking up explosive chemicals, defusing bombs or in the worst case scenario to pick and place the bomb somewhere for containment and for repeated pick and place action in industries. Therefore, a robot can be replaced human to do work.

1.2 Robotic arm definition

A robotic arm is a robot manipulator and a mechanical arm, usually programmable, with similar functions to a human arm. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain.

1.3 Type of robots

In this study robots are reviewed according to their structural properties:

1.3.1 Linear Robots

A robot which has linear actuators cooperating with linear motors linked to a linear axis is known as a linear robot (also known as gantry or Cartesian) as shown in figure 1.1. This link can be fixed or flexible connections between the actuators and the robot. The linear motor is attached directly to the linear axis. Robots which use two motors in controlling a linear axis defined gantry robots. Each motor has a limited distance orthogonal to the linear axis. Ballscrews follow the same principles which either use linear motors or rotary motors. These kinds of robots usually achieve tasks such as palletizing, unitizing, and stacking, order grasping, loading, and coordinate measuring. The manipulator (also known as end-effector) of the linear robots is connected in an overhead way that allows the robot to move along the horizontal plane easily, where each of these movements are perpendicular to each.



Fig 1.1 Linear Robots

This type of robot has many advantages like high speed and stiffness, good performance, Good for multiple machines and lines, good handling with large loads. However, it has large structural frame, complex mechanical properties for linear

sliding movements, Energy Inefficiency, large floor space requirement, Limited workspace, Common workspace restriction

1.3.2 Cylindrical Robots

Cylindrical robots have two prismatic joints: one rotary joint for positioning tasks and the end-effector of the robot forms a cylindrical workspace. The main idea of the cylindrical robots is to mount a horizontal arm which moves in forward and backward directions. The Horizontal arm is linked to a carriage which goes up and down and is connected to the rotary base. When the arm of the robot has a revolver and two prismatic joints, it can operate in z-axis and each point that can be reached by this robot can be represented by the cylindrical coordinates. As shown in figure 1.2, the robot can move in and out in direction, can elevate direction and can rotate in direction. The arm can move in directions between the specific upper and lower boundaries.



Fig 1.2 Cylindrical Robots

1.3.3 Parallel Robot

A parallel robot has an end-effector with DOF which is connected to a fixed base. The Connection is done by at least two independent kinematic chains which provide the movements of the robot as shown in figure 1.3. A generalized parallel manipulator has a closed-loop kinematic chain mechanism where the manipulator is linked to the base.



Fig 1.3 Parallel Robot

1.3.4 SCARA Robot

Selective Compliance Assembly Robot Arm (SCARA) was first designed and invented in the early 1960s in Japan. SCARA robots are perfect for the applications which require high speed and repetitive point to point movements. This is why SCARA is used widely in assembly operations. Special end-effector movement makes SCARA ideal for the tasks which require uniform motion and accelerations in a circular form. SCARA consists of two parallel rotary joints and a prismatic joint.



Fig 1.4 SCARA Robot

The rotary joints can move along the horizontal plane and the prismatic joint moves along the vertical plane. One of the special characteristics of SCARA is that the robot is smooth while operating on an x -axis but very strong versus the z -axis. SCARA arm is able to pick up a part vertically from a horizontally placed table and move along the horizontal plane to a desired point and accomplish the assembly task by lowering the arm and placing the part at its proper location as shown in the following figure 1.4.

1.4 Application of Robot

Robotics is becoming almost very popular in today's world and is now applied in several spheres of human life. Robotics is applied in the following areas of life.

1.4.1 Medicine

In the medical field, some robots are used for performing tasks, which are dangerous and unpleasant to humans. Some of these hazardous jobs are handling materials such as blood or urine samples. In addition, some robots are used to transport materials around the hospital. Their main sensor for localization is a camera looking at the ceiling. The camera detects the lamps on the ceiling as landmarks.

1.4.2 Military

Robots in the military are used for detecting enemy equipment, detection and defusing of bombs. In rescue operations, robots are also used for searching buildings for fugitives and deep-water search. Also, during military attacks, guided missiles are used to blast specific locations on the earth.

1.4.3 Education and Research

Some robots are designed for demonstration purposes, which are used for educating the public. For example, the Howard County Sheriff's department of Kokomo Indiana, in 1999 used a motor robot with a cop in it to attract a lot of attention to promote a seat belt program at a fair and they had the robot with the cop with his seat belt on. In space research and the Mars research, robots are usually sent out with the space shuttle for them to obtain samples and bring them back to earth. These robots are usually controlled from a control room on earth.

1.4.4 Entertainment

Some robots are used for entertainment purposes. These robots are designed like puppets and could make some funny moves which amuse people. Olden day robots were mainly like this. They were being used to entertain royalties.

1.4.5 Industry

In the industry, robots are used to perform precise and heavy tasks which are very difficult for humans to perform. Autonomous mobile robots could be used for carrying heavy components from one place to another using custom sensors that help them get their precise positions. Manipulator robots are used to perform certain tasks such as painting, welding, screwing and other activities that would have been difficult to handle using the human hand. Also, manipulator robots are used in assembly lines where each robot takes care of a particular stage of the assembly process

CHAPTER 3

LITERATURE SURVEY

Ruth Anita Shirley.D, Kaviya Sree B, Kavya M, Kishore S and Mohamed Afsal M (2021) et. al. They successfully achieved the proposed aim of making a voice-based arm to pick and place the objects through the user command which are really useful for the handicapped people as it was compact. And the application all we need to include the functions such as pick, place move etc., so as to enable the user to use it regularly. A robot arm with voice recognition is implemented by the use of Arduino to pick out and place items greater appropriately without more damage. The robot arm used right here contains a gripper which thoroughly deals with the item in moving.

In the modern time manpower is a fundamental constraint for every work. By the usage of our product the economic activities and hazardous activities may be done without problems and safely in a quick span of time. The use of a tender gripper and Wi-Fi conversation approach like Bluetooth makes our device more effective while in comparison to other systems. The proposed machine is capable of lifting simplest small weights, through introducing an excessive torque motor the massive weights may be picked. A wireless camera may also be applied to track the movement of the arm and for that reason it may be used in defense functions also. The variety is likewise a hindrance; it may be more desirable by means of using a wireless conversation.

Robots are examples of programmable automation, and also, they are additionally used in flexible or even constant automation systems. The two motives for deciding on a robot to function in a manufacturing unit are first to decrease labor prices and the second to do the work that is disagreeable or hazardous for human beings. Robots can operate repetitive duties at a constant place and can also program to reap and function-specific hazardous tasks and responses in automation manufacturing operations on a continuous basis.

Ankur Bhargava and Anjani Kumar (2017) et.al. Degree of Freedom (DOF) robotic arm has 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 up of four rotary joints and an end effector, where rotary motion is provided by a servomotor. Each link has been first designed using Solid works Sheet Metal Working Tool Box and then fabricated using a 2mm thick Aluminum sheet. The servo-motors and links thus 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 5 DOF pick & place Robotic arm has been developed. The driver mechanism consisting of an Arduino microcontroller in conjunction with a set of potentiometers has been successfully used to control the arm as per the inputs given by the user.

Navin Kumar Agrawal, Vinay Kumar Singh, Vinay Singh Parmar, Vijay Kumar Sharma, Dipti Singh and Muskan Agrawal (2020) et.al. This paper is presenting the process through which a robotic arm is made with the help of Arduino and Potentiometer for controlling and coordinating the industrial processes. Here, they realize that the robotic arm has the ability to move in four directions with the help of servo motors. The movement of the servo motor, UNO, is responsible for converting the analog signal into the digital signal which is further received by the servo motor. This project discusses the technical imputation, the issue related with the implications and application of robotic arm in the field of automation of industries. It can be used as an artificial arm for a human who has lost his hand in any accident.

They succeeded in this project based on the Internet of Things. The project should be observed and managed by using the Arduino. Robotic arm controller with a potentiometer we are giving four degrees of freedom and it will rotate 180 degrees. This project not only acknowledges the guidance sent but also accounts for the activity and can perform the task which can reduce the human efforts by performing the same task continuously and repeatedly.

L. David William Raj, R. Abinaya, A. Brundha, N. Durga Lakshmi and S. Geethapriya (2022) et.al. The main intention of the paper is to redeem the victim in case of untimely accidents of falling inside the bore well. The system avail in rescuing the child from bore well by the use of Robotic arm controlled by Arduino which includes the additional features such as air quality sensor to detect the toxic gasses, temperature sensors which is used to measure the temperature and a miniature camera that is used to monitor the live status of the child inside the bore well. The proposed system will easily rescue the child without major injury.

The proposed system rescues the victim from the borewell without any major injury in a short span of time. The future enhancements that can be made to this project are a life supporting oxygen supply to the victim if the oxygen level inside is low. The arm control can be automated without the use of a servomotor mechanism. Artificial intelligence can be indulged in different parts of the rescue operation.

Dayanand S Navare, Yogesh R Kapde, Shraddha Maurya, Dr. D. B. Pardeshi and P. William (2022) et.al. A robotic arm is used to securely detect and dispose of a bomb located within a 100-meter radius of the robot. Through the use of a computer and a mouse, the user may manually operate the produced robot. The buzzer goes off when the sensor detects metal. Using a wireless camera, the metal is examined to see whether it is a bomb or not. It is possible to remotely control the robot and detonate the bomb if it has been found. Many components play a vital role in the overall design of the robot. To simulate the first setup, Proteus software is utilized, and then a personal computer is used to handle the whole hardware configuration.

The robot's hardware configuration is built once the rotation of DC motors has been validated using simulation. A wireless camera attached to the robot assesses whether a metal object is harmful when a buzzer sounds. Using a human operator to

control the robotic arm, the explosive is safely disarmed. It's possible that a robot like this may one day replace bomb disposal units in the military and police.

Muhammad Hunain Memon, Muhammad Hammad Memon, Aakash kumar, Syeda Munazza Marium, Jalaluddin Khan (2019) et.al. The robotic arm is a kind of manipulator, used to carry out most difficult tasks, which is the need of today's world and its applications are in vast fields. It can be used for many purposes such as to pick and drop and to work in the environment where a human cannot work i.e. harmful chemicals, high temperature and so on. One needs some skilled personnel to make that robotic arm functional as per requirement and for making some amendments in its functionality, one has to reprogram its parameters which needs an expert. A robotic arm that can learn from its mimicry done by a human which can be easily taught to perform certain operations as per its application by an unskilled person. They have designed a prototype of the robotic arm which can work according to the way one teaches furthermore, robotic arm does not need a skilled person, the mimicry feedback will be recorded in a processing unit i.e. microcontroller (Arduino) and on a single command of play that robotic arm will work continuously to perform that specific task.

They have successfully designed the prototype of a smart trainable robotic arm. The cost of this prototype system is around 250\$. The robotic arm prototype is developed using a micro-controller (Arduino UNO) moreover we have successfully implemented the kinematics algorithm in it. This robotic arm can pick and place an object up to 500- grams. The learning mode will record the data in the processing unit from the controlling unit provided by the user, meanwhile it will show the movements of the robotic arm and its data in the serial monitor. In play mode the robotic arm will start to work continuously as per desired application.

Vikas Varshney, Arvind Kumar, Tushar Saxena, Pranjal Jha, Manish Nath Tiwari and Savita (2022) et.al. In this paper, the implementation of a Design and Development of Intellectual Robotic Arm is presented. The Intellectual Robotic Arm uses Arduino UNO as an interface between Smartphone and Servomotor. The core objective of the model which is to pick and locate the objects to a safer place without incurring much damage has been achieved.

The model is vector controlled as it operates in x-axis, y-axis and z axis. In the x-axis & y-axis, the robot base moves and in the z-axis, the robot arm moves. The execution, testing and the outcome of the model demonstrated in this paper clearly shows that the presented work is proceeding in the specific path. By comparing with other systems, the model is made more effective using low power wireless communication techniques such as Bluetooth. The model has been successfully tested by lifting the light weight articles but not suitable for heavy weight articles.

The limited operating range has been also enhanced by using wireless communication technology. However, the outcomes are preliminary and more testing of the arm with the real-time situations is required. Moreover, the Intellectual Robotic Arm is not enough to carry the heavier load such as unattended parcels, arm weapons, etc. in order to avoid unnecessary human loss. Nowadays, manpower and time are major constraints for the task completion.

The intellectual robotic arm can be used in the industrial activities and hazardous operations which can be executed with an ease and in a safe manner, and also in lesser duration. Therefore, future work will be on designing of the stronger robotic arm and with other possibilities such as harvesting grape bunches in grape vineyards or mangoes, oranges or apples.

Shivam Sharma, Shashwat Sahai, Jaisal Joshi and Hema N (2018) et.al. This paper represents the stage-wise development of a trainable remotely controlled robotic arm based on servo motors. The robot is expected to perform primary pick and place

operations and repeat the recorded actions with error corrections. The arm has four degrees of freedom. The robotic arm is mounted on a base that allows it to traverse between different coordinates. Arduino Mega 2560 is used for controlling functionalities of the robot.

The robot was developed in four stages. In the first stage, the robot was controlled with the help of a potentiometer. In the second stage of development, remote functionality was added. This functionality was achieved using the Bluetooth module. The third stage of development included usage of the real-time remote control over the internet. The robot was controlled using an android application for the stages mentioned above. In the fourth stage, a Unity-3D model was integrated to realize the real-time visual simulation of the robot. This paper discusses the development of the robotic arm capable of repeating the recorded movements. The robot is based on Arduino Mega 2560 board and four servo motors along with the movable base.

The robotic arm has 4 DOF. The 3D model of the arm which is used to control the robotic arm has been developed in UNITY 3D software. Connectors were designed using Blender software that has been integrated into the UNITY 3D model to give a realistic appearance to the 3D model.

The testing and real-world implementation of the robot justifies its applicability in various real-life scenarios. To provide security to the user and to minimize the misuse of the robot, following security features can be included as follows: Facial recognition Fingerprint scanner Iris scanner Voice recognition Other features may include, making it more user-friendly by implementing functions for differently abled users. These may include voice commands and a scheduler

Alex Marnell, Mahmood Shafiee and Amir Hosein Sakhaei (2022) et.al. In this paper, an Android controlled robotic arm was designed and implemented with the ability to be user programmable and run by an automatic algorithm. A Uno R3 was used as the

development board, and a custom Shield PCB contained the operational circuitry. Four MG946R servo motors were used to produce accurate movement of the robotic arm. The robotic arm was fabricated using 3D printing and laser cutting, in PETG and Acrylic respectively. A HC-06 Bluetooth module was used to receive Bluetooth commands from a custom Android controller app, designed by MIT App inventor. By considering the torque generated by the servo motors, the arm was able to pick and place objects up to 80g in weight within its operational range while drawing up to 970mA of current. Several tests were conducted to study the system's performance in terms of lifting capacity, connection range, idle current draw, and reliability. The system was able to achieve real time operations and be manually controlled or be set to run a predefined algorithm.

The robotic arm could be redesigned to allow more efficient transfer of torque from the servo motors to the limbs using a wider application of mechanical levers. This would allow a greater force to be generated on the shorter length of a lever by using a fulcrum, increasing the load that the system can move with the trade-off of losing range of motion. A new detection algorithm can also be developed to enable the system to detect objects within range of the end-effector and allow the automatic reaction for pick and place operations. For example, a Time of Flight (TOF) module could be installed to allow the system to detect how far away an object is and automatically pick it up when at a predefined distance.

Paul Ciprian PATIC, Lucia PASCALE, Marin MAINEA and Gabriela MANTESCU (2017) et.al. The mobile robot that we built was designed for use in hazardous areas. He is equipped with trackers, which gives him the opportunity to more easily access rugged terrain. On the mobile platform we installed two robotic arms that have the ability to catch or cut objects. Robot control is remotely powered by a Bluetooth module, so man is not part of risk areas. This robot can be adapted for use in different situations by adding equipment specializing in the task we want to do. The robot also has drawbacks.

The biggest disadvantage is the short range of action due to the use of a Bluetooth module, which is limited to several tens of meters. In the future we want to change Bluetooth communication with radio or GPS communication, which would allow us to control the robot from far greater distances. We also want to add a camcorder to live video or video recording. In order to improve the performance of the robotic arms, a multifunctional robotic arm could be used, with the ability to change its drive head and perform multiple operations.

2.1 Summary of Survey

There are various ways in which a robotic arm may be controlled. In the past there have been many researchers working to control robotic arm through computer terminals, Joysticks, even interfacing them with the internet so they can be controlled from anywhere in the world. Usually most of the robotic arms are controlled by a central controller which makes use of values taken in from the terminal that are entered by the user at the terminal to move the arm to a particular coordinate in space. This makes the control very difficult as the control values of the motors are very difficult to predict to achieve a particular movement. This is easily achieved by our project. The robot does not require training because the robotic arm is fully controlled by the user. This interfacing is done using wired communication but it can easily be switched to wireless with ease.

- Most of the survey used arduino as their microcontroller.
- Most of them are static which don't have a movable base.
- In the [4] survey they used the robotic arm for child rescue who fell inside of the borewell which was an interesting and innovative idea.
- In the [5] survey they use this technology to detect and diffuse bombs.

This could probably save lives while diffusing as it's a robot.

CHAPTER 3

METHODOLOGY

3.1 Existing Methodology

With the advent of machines, electronics, automation and the incorporation of solid-state transistors instead of vacuum tubes, the evolution of the microcircuit and more rapid computer systems, the stage was set for early modern robotic arm evolution. The first “position controlling apparatus” was patented in 1938 by Willard Pollard. This was a spray finishing robotic arm that had five degrees-of-freedom and an electrical control system. Although Pollard never built his arm, his design and interest in a mechanized application for automated robotic arms would spur on the ingenuity of others. Harold A. Roselund, working for De Vilbiss, developed another sprayer that was indeed manufactured. Both arms were useful and task oriented for their time and every movement at the respective joints in unique ways.

The main design goal of this robotic arm was to present the following functions: Chinese calligraphy, fancy dancing, weightlifting and color classification. Another design goal was to minimize cost and maximize performance. Hence it is designed in a way so as to perform many tasks as a human arm. The simplicity of its design gave it the way to perform motion as good as a human arm with improved values of strength and speed.

This robotic arm controller is using image processing in the field of Human Machine Interaction. There are two methods used to control the robotic arm, the main task of which is to get the hand gesture data without using a tool that helps the system to extract data easier (ex. glove or wrist band). The first method is comparing all pre-stored data in the database at the Template Matching Algorithm, the second method is Signature Signal, distance signal between edge of the hand and center of hand. These necessarily use the gyro-sensors as the computation of change in angular values

shall be obtained at time of operation. The subsequent operations are decided based on these changes.

A typical robotic arm has the following components: A link is considered as a rigid body that defines the relationship between two neighboring joint axes of a manipulator. Manipulators consist of rigid links, which are connected by joints that allow relative motion of neighboring links. The links move to position the end-effector. Actuators play the same role the muscles play in the human arm - they convert stored energy into movement.

Actuators are used to move robot manipulator joints, the actuator can be a pneumatic, hydraulic and electrical actuator but in the project we used electrical actuators (servo motors). The controller is the main device that processes information and carries out instructions in a robot. It is the robot's 'brain' and controls the robot's movements. It is usually a computer of some type which is used to store information about the robot and the work environment and to store and execute programs which operate the robot. It contains programs, data algorithms, logic analysis and various other processing activities which enable the robot to perform its intended function, most robots incorporate computer or microprocessor-based controllers.

These controllers perform computational functions and interface with and control sensors, grippers, tooling, and other peripheral equipment, so the controller that we used in this project is an Arduino Mega microcontroller. In robotics, an end-effector is the device at the end of a robotic arm, designed to interact with the environment. The exact nature of this device depends on the application of the robot. Typical functions of the end effector include grasping, pushing and pulling, twisting, using tools, performing insertions, welding and various types of assembly activities. Thus, the major types of robot end effectors are Grippers, material removal tools, welding torches, tool changers, and there are surgical robots that have end-effectors that are specifically manufactured for performing surgeries.

3.2 Proposed Methodology

This section will detail the chosen design and ensure that it meets all the requirements as stated. The waterproofing of the arm, the interface and the receptacle are also discussed in this section. Simulations, prototype testing plans, finite element analysis, cost analysis, engineering drawings, a manufacturing and installation plan, can all be found below in order to address manufacture.

The Articulated Arm exhibits a max stretch length of 0.7 m (see Appendix J) and will be situated on a rotating base that enables 360 degrees of rotation. The rotating base is powered by Yaskawa's SGMGV-1EA Sigma-5, a medium inertia electric DC servo. This servo is fully enclosed with a rating of continuous operation (YASKAWA AMERICA, Drives and Motion Division). A suitable servo was found after a minimal torque of 82.48Nm was calculated to rotate the entire assembly.

3.2.1 Servo Motors

Servo motors Detects the operation error of a mechanism, provides feedback and corrects faults. The servo motor can have alternating current (AC), direct current (DC) or stepper motors. In addition to these, there are drive and control circuits. Servo motors are the kinds of motors that can fulfill the commands we want. They can operate steadily even at very small or very large speeds. In these motors, the large moment can be obtained from the small size.

Servo motors are used in control systems such as fast operation, excessive axis movement, condition control and so on. Servo motors are the last control element of a mechanism. They are highly sensitive and servo motors are used in conjunction with electronic or programmable circuits. These engines are divided into AC and DC. When the AC servo motors are brushless type motors, the servo motors brush. Servo motors are mostly three cables.

These are a red cable for power, black for grounding and yellow cables for control (data, data). One of the servo motors used in the production phase of the project is shown in Fig.1.



Fig 3.1 Servo Motors

In the project Tower, Pro SG90 Mini servo motor is used. Some features of this servo motor; versatile operation, 10 μ s pulse width control, VP-P: 3-5 V Square wave and working voltage of 4.8-6V. The used servomotor has a working voltage of 0.12 s / 60 ° and a torque of 1.2-1.6 kg/cm at low operating voltage.

Servo motors are controlled according to the signal condition. In doing so, the supplied pulse width modulated (PWM) signal is used with the data bus. Each servo motor is controlled by a PWM signal at 10-20 ms and at 0.5-1.5 ms. the position of the motor shaft is determined according to the duration (t_k) of this signal at logic 1. These;

- When $t_k = 0.5$ ms, the motor shaft rotates to the end,
- When $t_k = 0.5 - 1$ ms, the position of the motor shaft is in the middle,
- When $t_k = 1 - 1.5$ ms, the motor shaft turns to the right,
- When $t_k = 10-20$ ms (when the same signal is given again) it remains in its old position,

The position control of these motors is determined using the required pulses. The servo motors DC used in the project are kept at about 5V during operation.

3.2.2 Arduino Nano Microcontroller

Although microcontroller type PIC is usually used in programming and software fields, Arduino has become very popular in the world in recent times. It is based on Arduino's past wiring and processing projects. Processing is written for non-programming users. Arduino wiring is produced on the basis of the programming language. The common feature of both is that it provides an environment where even the basic knowledge of electronics and programming can easily be designed. Arduino are becoming more and more common nowadays. Even unmanned aerial vehicles made with Arduino, which is used in almost every field, are visible.

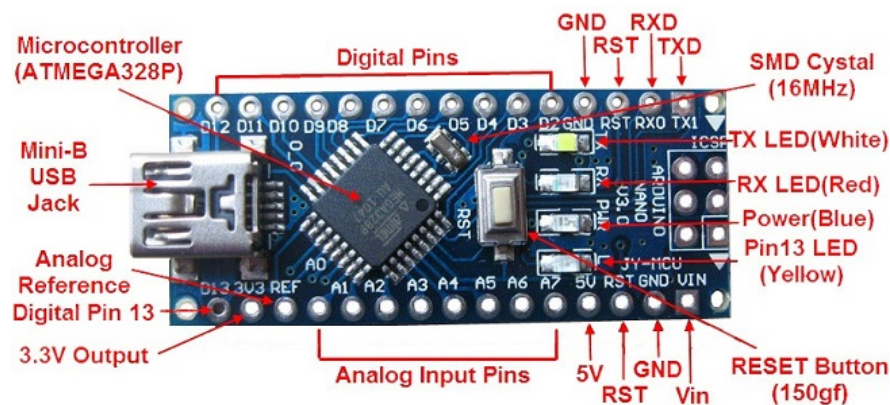


Fig 3.2 Arduino Nano Microcontroller

The causes of the spread of Arduino at such a rapid rate are.

- It can be used on all platforms due to the simplicity of the development environment with driver usage.
- With the help of the advanced library, even complex operations can be easily solved.
- Programs written in Arduino can run fast because they are not run on any other platform.
- There is a lot of hardware support that is compatible with Arduino and can work together.
- Communication with the environment is easy because it is open source.

- If there are any problems due to a large number of Arduino users, the solution can be easily reached.

The Arduino Nano is a small, full and breadboard friendly Arduino card that houses a microcontroller (Arduino Nano 3.x) or Atmega168 (Arduino Nano 2.x) microcontroller. It has almost the same functions as the Arduino Duemilanove. Arduino is designed and used by Nano Gravitech. The Arduino Nano offers a variety of possibilities for communication with a computer, another Arduino, or other microcontrollers.

The ATmega328 and ATmega168 microcontrollers support UART TTL (5V) serial communication, accessible via the RX and TX pins. An FTDI on the card channels the FT232RL serial communications via USB and the FTDI drivers (available in the Arduino software) and the writings on the computer appear as a virtual com port.

The RX and TX LEDs on the card flash on the FTDI chip while the USB den serial cable and the USB den are transmitting data. The Software Serial library allows serial communication over any of the digital pins of the Arduino Nano. The ATmega328 and ATmega168 microcontrollers also support I2C (TWI) and SPI communications.

3.2.3 HC-06 Bluetooth Module

The HC-06 BT module is a slave operating only and uses a serial communication protocol. In Bluetooth communication, master and slave are determined according to the state of connection start. A master module can initiate the connection, but the slave module cannot initiate the connection. In our project, we will provide an external device to connect to a slave PC or an android device. Bi-directional data can be sent and received in a healthy way.



Fig 3.3 HC-05 Bluetooth module

After adding the device to the Bluetooth devices, a virtual com port associated with the module is created on our computer. It is now possible to communicate via Bluetooth via the module. The codes that we send via UART with the microcontroller (PIC18F46K22) can be received via Bluetooth with PC, which is connected to the BT module. Data sent from the PC and COM overreaches the microcontroller.

3.2.4 ESP32-CAM



Fig 3.4 ESP-32 CAM

ESP32-CAM is the latest small size camera module released by Essence. The module can work independently as the smallest system, with a size of only 27*40.5*4.5mm, and a deep sleep current as low as 6mA.

ESP32-CAM can be widely used in various IoT applications, suitable for home smart devices, industrial wireless control, wireless monitoring, QR wireless identification, wireless positioning system signals and other IoT applications. It is an ideal solution for IoT applications .

ESP32-CAM adopts the DIP package and can be used directly by plugging in the bottom plate, realizing the rapid production of products, providing customers with high-reliability connection methods, which is convenient for application in various IoT hardware terminal occasions.

3.2.5 Ultrasonic sensor

The HCSR04 ultrasonic sensor uses sonar to determine distance to an object like bats or dolphins do. It offers excellent noncontact range detection with high accuracy and stable readings in an easy to use package. From 2cm to 400 cm or 1” to 13 feet. Its operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect). It comes complete with an ultrasonic transmitter and receiver module.



Fig 3.5 HCSR04 Ultrasonic Sensor

The timing diagram of HCSR04 is shown. To start measurement, Trig of SR04 must receive a pulse of high (5V) for at least 10us, this will initiate the sensor will

transmit out 8 cycles of ultrasonic burst at 40kHz and wait for the reflected ultrasonic burst. When the sensor detects ultrasonic from the receiver, it will set the Echo pin to high (5V) and delay for a period (width) which is proportional to distance. To obtain the distance, measure the width (Ton) of Echo pin.

3.2.6 Stepper Motor Driver

A Motor Driver is an essential device that provides the required voltage and current to a stepper motor so that it gets a smooth operation. This is a DC type Motor that turns in steps. To design a stepper motor driver, selection of proper power supply, microcontroller, and the motor driver is very important. We know that microcontrollers can be used to rotate the motor, but while designing the driver, we have to focus on voltage and current. A single motor driver board can handle the currents and voltages for a motor. A Stepper motor turns exactly using a controller by synchronizing the pulse signals with the help of a Driver. This motor driver takes the pulse signals from a microcontroller and then changes them into the motion of the stepper motor.



Fig 3.6 Stepper Motor Driver

The working principle of this driver circuit is to control the operation of a stepper motor by sending current using a variety of phases in pulses in the direction of the motor. The designers did not frequently use the wave driving technique due to reasons

like it provides small torque & inefficient because simply 1-phase of the motor uses at a time.

The essential components used to drive stepper motors are controllers like a microprocessor/microcontroller, a driver IC and a PSU (power supply unit)., and other components like switches, potentiometers, heat sink, and connecting wires.

3.2.7 General Characteristics of Robot Arm Mechanics

Kinematics in robotics is the science of motion investigation. Robot arm links can be rotated or offset according to the reference coordinate frame. A systematic and general approach developed by Denavit and Hartenberg establishes the relationship between the robot endpoint and the total displacement of robot arm links. Angular and linear displacements between limbs are called joint coordinates and are defined by limb variables.

In order to determine the amount of rotation and displacement according to the reference coordinate system of the endpoint, the matrices A which represent the amounts of each limb rotation and displacement are multiplied in turn. If the coordinates of the end point are given, limb variables can be obtained by going backward. These operations are called forward and inverse kinematics.

The next section will explain how to determine forward and reverse kinematics. The general transformation matrix can be quite complex even for simple robots. It can be found in standard textbooks such as the Jacobian matrix for standard robots.

3.2.8 Coordinate Frames and Transformation Matrices

An n-dimensional position vector is denoted by an n + 1-dimensional vector and is called a homogeneous coordinate representation. In the following, a matrix of 4 X 4 is shown which shows a position vector in the homogeneous coordinates between the coordinate frames.

$p = p_x i + p_y j + p_z k$ The vector of the origin of the new frame,
 $x = x_1 i + x_2 j + x_3 k$ The contour vector of the x-axis of the new frame, $y = y_1 i + y_2 j + y_3 k$ The contour vector of the y-axis of the new frame,
 $z = z_1 i + z_2 j + z_3 k$ Represents the contouring vector of the z-axis of the new frame.

Column 4 of the transformation matrix has 3 elements corresponding to displacement in the x, y, and z directions.

$$\text{Trans}(p_x, p_y, p_z) = \begin{bmatrix} 1 & 0 & 0 & p_x \\ 0 & 1 & 0 & p_y \\ 0 & 0 & 1 & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Fig 3.7 Displacement of x,y,z Direction

If any of the 3 coordinate axes is possible to rotate, there are 3 rotational transforms corresponding to the rotations in the x, y, and z-axes up to the q angle. The following matrix can be written for x-axis

$$\mathbf{Rot}(x, \theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(\theta) & -\sin(\theta) & 0 \\ 0 & \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{Rot}(z, \theta) = \begin{bmatrix} \cos(\theta) & -\sin(\theta) & 0 & 0 \\ \sin(\theta) & \cos(\theta) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{Rot}(y, \theta) = \begin{bmatrix} \cos(\theta) & 0 & \sin(\theta) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin(\theta) & 0 & \cos(\theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Fig 3.8 Revolutions around the y and z-axes

The elements of the transformation matrix can be found by the arithmetic multiplication of pure rotation and displacement matrices. This can be obtained by a sequence of rotations about the axes of the stationary reference frame if the orientation is desired according to the reference frame of the Cartesian space endpoint. Although there are many ways to do this, one of the best known is the "roll-pitch-yaw" transformation. 3 turns. First turn around the x-axis, then y and then around the z-axis.

$$\text{RPY}(\phi, \theta, \Psi) = \text{Rot}(z, \phi) \text{Rot}(y, \theta) \text{Rot}(x, \Psi)$$

$$= \begin{bmatrix} C(\phi)C(\theta) & C(\phi)S(\theta)S(\Psi) - S(\phi)C(\Psi) & C(\phi)S(\theta)C(\Psi) + S(\phi)S(\Psi) & 0 \\ S(\phi)C(\theta) & S(\phi)S(\theta)S(\Psi) + C(\phi)C(\Psi) & S(\phi)S(\theta)C(\Psi) - C(\phi)S(\Psi) & 0 \\ -S(\theta) & C(\theta)S(\Psi) & C(\theta)C(\Psi) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Fig 3.9 Cartesian space endpoint

Kinematics in robotics is the science of motion investigation. The robot examines the positions of the limb limbs, the relationships between velocities and accelerations, ignoring forces and other factors that affect movement.

The position and orientation of one of the limbs, or the orientation of the limbs between this limb and the end point, will change when the serial limb robot arm is shown in Fig. When the positions and orientations of the limbs change, it is generally desirable to determine the position and orientation of the end point according to the basic reference frame.

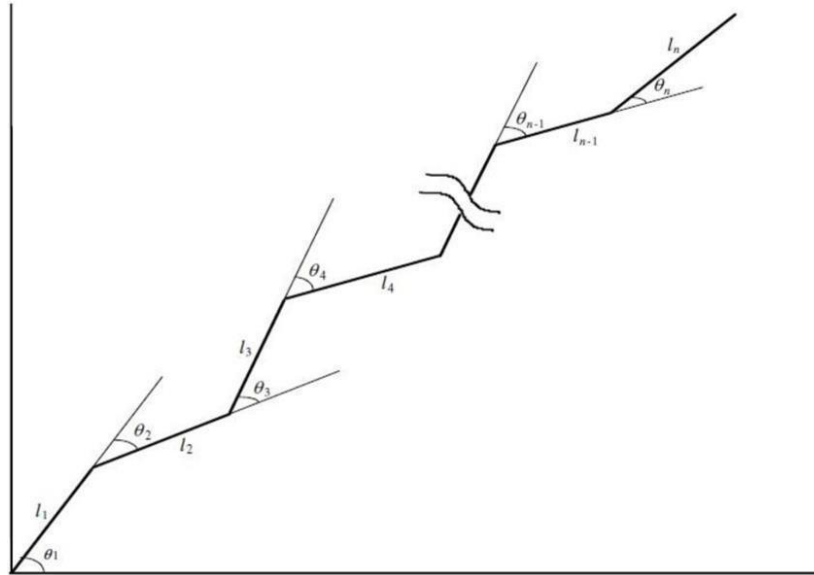


Fig 3.10 Robot arm with n lines showing relative angles

When each mobile station is connected to a coordinate frame, the transformation between both limbs can be defined by a homogeneous transformation matrix, called the matrix A. For example, the first limb is connected to the base frame by 0A_1 , which is the matrix 1A . The transformation matrix RTH of the end point can be expressed according to the reference frame by the arithmetic product of matrices A from the matrices 1A of the matrices A to the matrix A of the endpoints.

When this equation is in closed form, any term can be expressed by another and is very important in the kinematic analysis of the robot arm. Because the robot is used to analyze the forward and inverse kinematics of the arm.

The distances between the limbs and the displacements are called the joint coordinates defined by limb variables. A series of n articulated limb robots with one DOF for each limb has n + 1 joints. Using the D & H parameters, any nonlinear limb, as shown in Figure 6, can be characterized by structural kinematic limb parameters

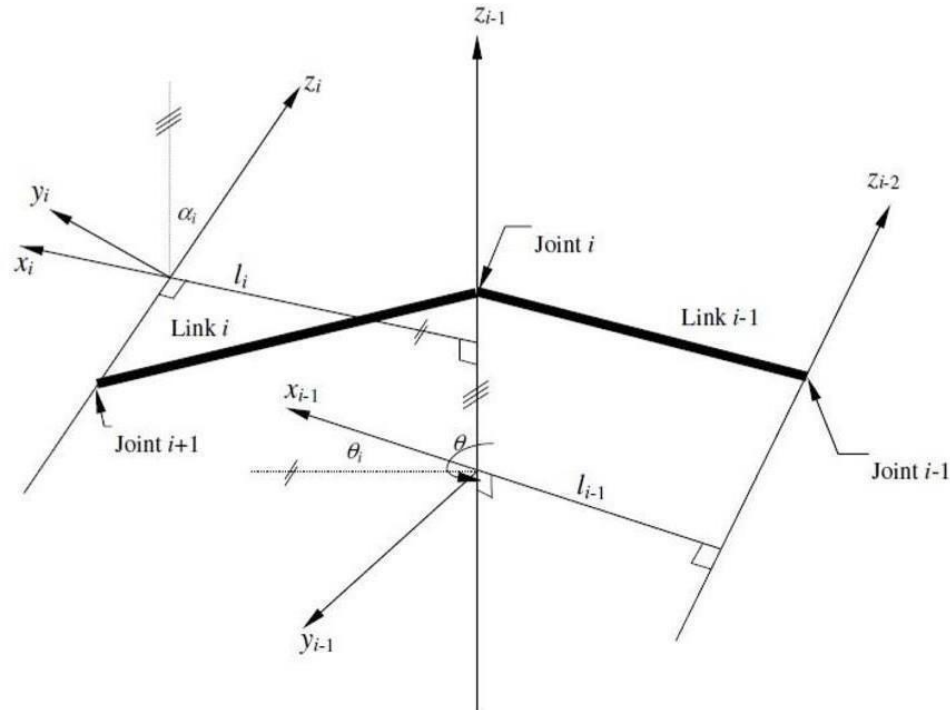


Fig 3.11 6D & H parameters

L_n : the length of the limb is the distance along the common normal between the axes of the joints. Z and Z_{i-1} .

i : is the positive angle of rotation about the positive X -axis from the positive Z_{i-1} axis to the positive Z_i axis.

Θ_i : The positive angle of rotation about the positive Z_{i-1} axis from the positive X_{i-1} axis to the positive Z_i axis.

D_i is the distance to the intersection of the Z_{i-1} and x_i axes along the X_{i-1} axis from the origin of the first coordinate frame.

Some of the structural parameters may change over time during robot arm movements. These parameters are called changing parameters, e.g. Θ_i , i angle in the rotary joint, joint variables.

3.2.10 Advanced Mechanic

The definition of joint space of a robot arm can be related to the definition of Cartesian space. That is, the position and orientation of the endpoint for a given set of joint variables can be determined in Cartesian coordinates. This process is known as forwarding kinematics. Advanced kinematics is the discovery of the RTH transformation matrix, which gives the position and orientation of the end point using the matrices we have already mentioned. The RTH transformation matrix can also be obtained by multiplying by the general displacement matrix and the orientation transform matrix of the RPY axes.

$${}^R\mathbf{T}_H = \begin{bmatrix} x_x & y_x & z_x & p_x \\ x_y & y_y & z_y & p_y \\ x_z & y_z & z_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & p_x \\ 0 & 1 & 0 & p_y \\ 0 & 0 & 1 & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

3.12 Fig ${}^R\mathbf{T}^H$ transformation matrix

3.2.11 Inverse Mechanics

For an endpoint position and orientation given in Cartesian coordinates, the process of finding the values that the joint variables must take is called inverse kinematics. Reverse kinematics can be difficult to solve according to the advanced kinematics. In many cases, it is necessary to use techniques that do not guarantee a solution and include trial and error.

3.2.12 Design Brief

The design part is divided into two parts, the mechanical part design, and the mechanical part installation. In the design of the mechanical part, the millimetric drawings of the parts to be used in the robot arm construction were made through the help program. In the installation of the mechanical part, the naming of the servo motors used in the robot arm and the tasks during the operation of the robot are explained. The construction of the project consists of several steps. These steps are;

- Determination of the mechanical materials required for the production of the project,
- Determination of microcontroller and software to be used in the project,
- Search and selection of servo motors that will run the robot arm in a proper way,
- Proper selection of mechanical parts,
- Implementation of robot arm assembly,
- Testing the system to see if it works properly with the microcontroller we choose,
- Possible faults have been given in the form of restructuring the system by passing through the eye.

These steps have been completed and the design of the robot has been completed.

Arduino and robot arm control are used in the project material are given in the following chart.

Table 1 Material Inventory Chart

Number	Material	Quantity	Price	Amount
1	Tower Pro SG90 Mini Servo Motor	5	120.00	600.00
2	Arduino Nano (AT Mega328)	1	750.00	750.00
3	Robot limbs (made with 3D printer)	5	100.00	500.00
4	Bluetooth module (HC-05)	1	400.00	400.00
5	DC Gear motor (60rpm,12v)	2	190.00	380.00
6	wheels	3	75.00	225.00
7	Battery (12V)-2600mah	1	600.00	600.00
8	Switches and wires	-	100.00	200.00
9	ESP 32 camera	1	800.00	800.00
10	Ultrasonic sensor	2	250.00	500.00
11	Stepper Motor Drivers(Wheel Base)	1	250.00	250.00
12	Stepper Motor Drivers(Mini Servo motor)	5	200.00	1000.00
13	Acrylic Base Board	1	100.00	100.00
	Total	27		6305.00

3.2.13 Mechanical Design

Materials needed for the mechanical part of the robot arm were supplied, and then the materials were drawn on SolidWorks in millimetric form. The mechanical part was assembled with these materials.

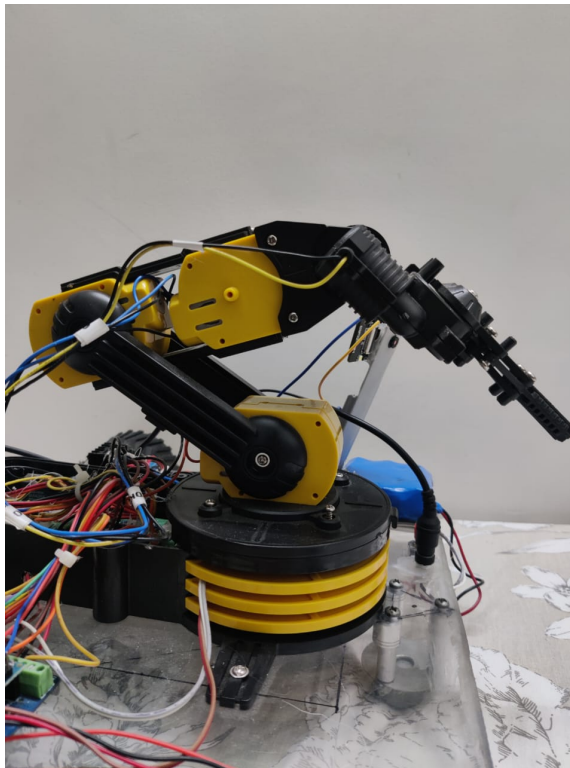


Fig 3.13 Mounting of servo motors

The cut parts are assembled together with the servo motors and assembly of the robot arm is completed. The robot arm moves by 4 axes and performs this movement

with 5 Mini Servo Motors.

After drawing the parts on SolidWorks and making the necessary parts, the design of the mechanical part is started and the robot arm is made of a stationary lower body and movable upper body. There is one servo motor in the stationary lower part of the robot arm and this robot is called axis 1. The 1st axis provides rotation of the robot arm to the right or left. There are 2 servo motors in the moving upper body part. Since these servo motors must operate parallel to each other, both start and end positions are set simultaneously. These two servo motors are named as 2nd axis and 3rd axis respectively.

The tasks of 2nd and 3rd axes are to move the robot arm up and down. Mounting of servo motors in 1st, 2nd, 3rd, 4th and 5th axes is given in Fig.3.14

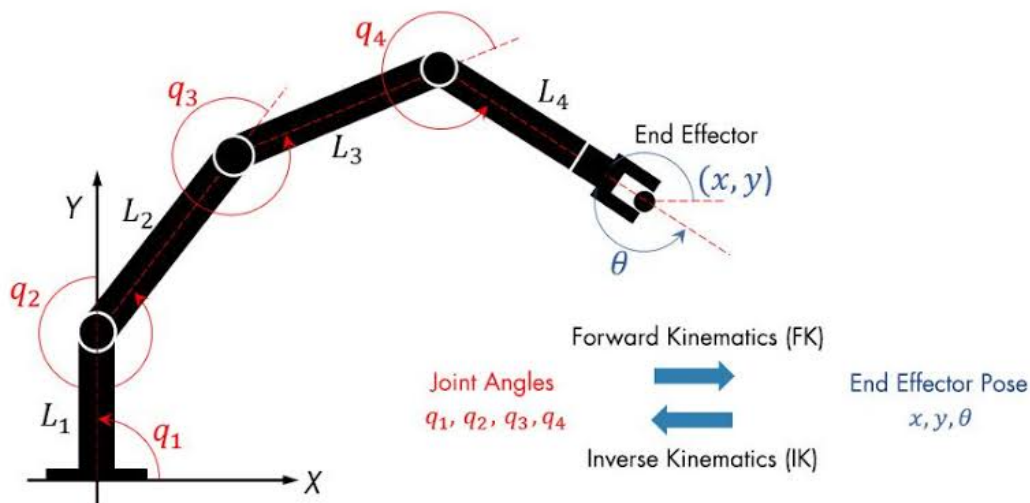


Fig 3.14 Mounting of all Five Servo motors

3.2.14 Android Programming

The Android application we used in this project was done with App Inventor. App Inventor is a free web application developed by Google and later developed by the Massachusetts Institute of Technology (MIT). Other MIT projects use a graphical

interface, such as Scratch and StarLogo TNG, to drag and drop visual objects instead of printing lines of code in mobile applications running on the Android operating system.

App Inventor Design is the part of the application that we will design for visual and active components of the application, from Buttons, Pictures, Text Fields; it can be added to the Media Components such as Audio, Video, etc., besides the GPS, Acceleration and Bluetooth sensor can be added to the device.

In this section, you have a design criterion where many variables like size, color, and position can be controlled. The design of the android application we use in the project is shown in Figure 12

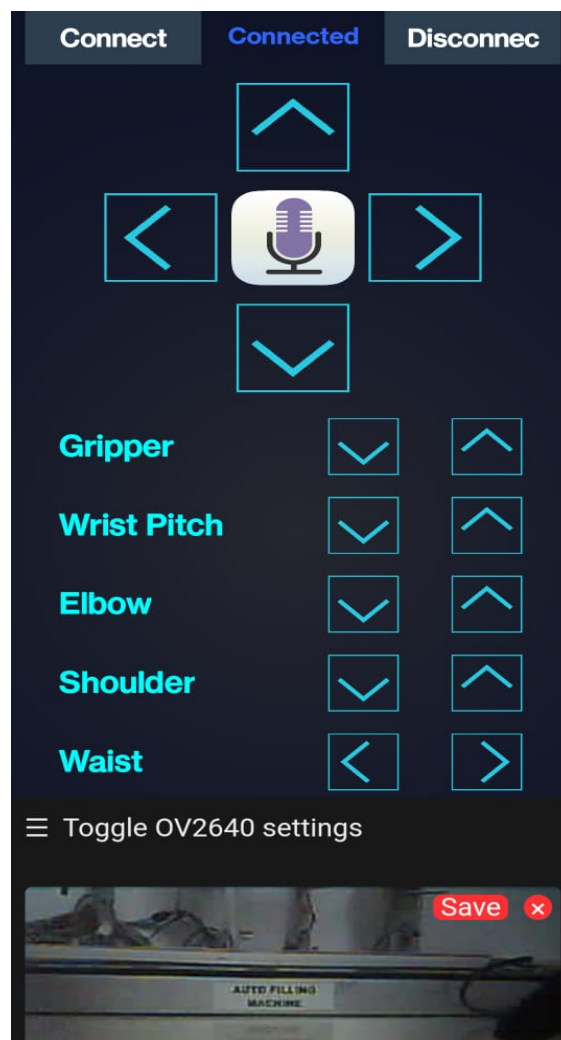
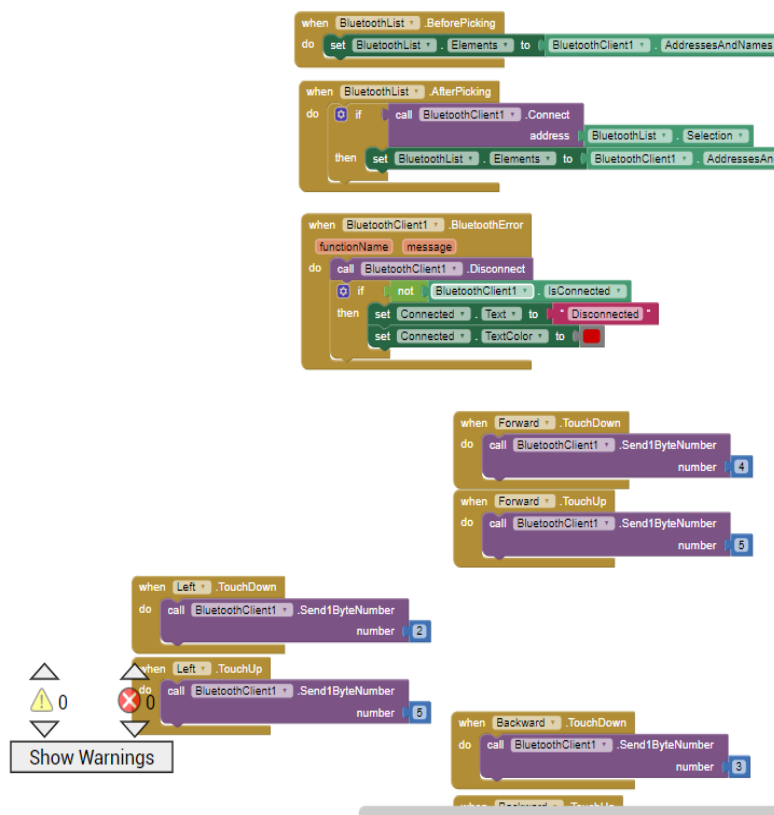


Fig 3.15 The Design of the Android Application

In the App Inventor Block section, we create the code that will work in the background of the application we are doing with the interlocking blocks with code fragments, just like a Lego. We make sure that all the components that I add to my application have all the events/properties that can be used and combine them into the corresponding blokes. In the project we have done, android blocks are shown in Figures 3.16.



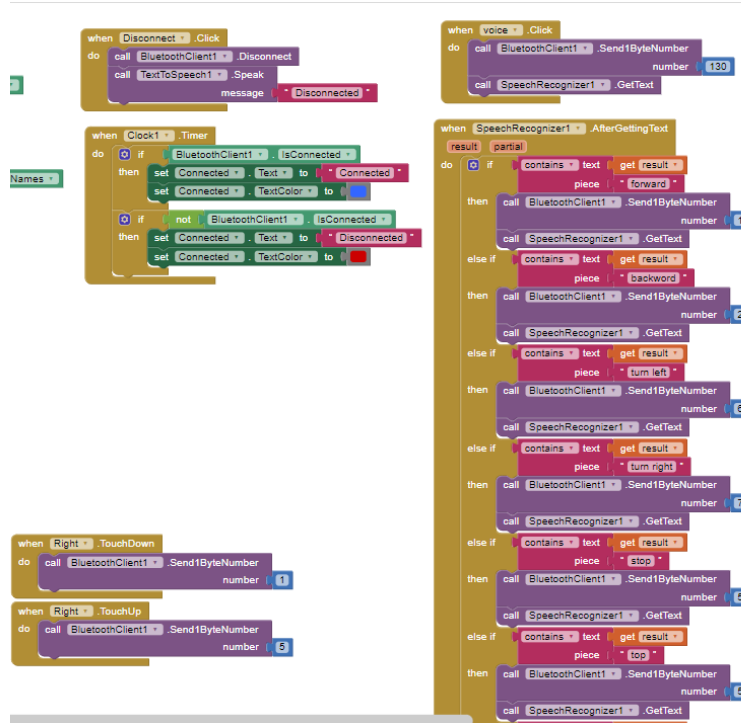


Fig 3.16 MIT Coding Block(Backend)

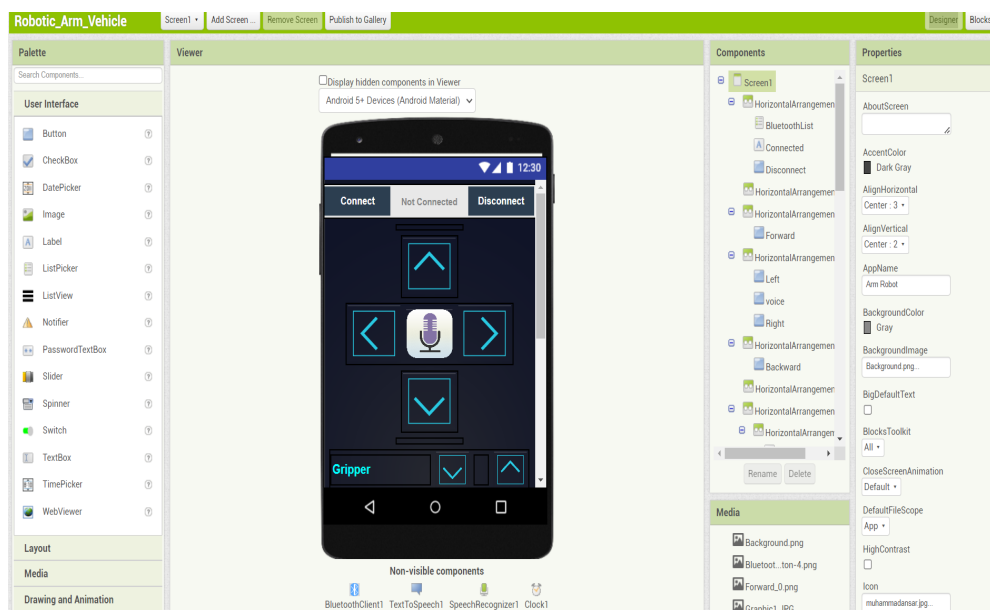


Fig 3.17 MIT Application (Frontend)

CHAPTER 4

VALIDATION

The desired performances outlined in the design brief combined with the knowledge presented in this paper have led to the prototype explained in the previous chapter. To compare the actual performances of the robot arm to the theoretical performances according to this paper, a test program will have to be executed. This test program should test for the performance of accuracy, precision, speed and power, as well as the occurrence of backlash and play in the system, their origins and significant effect on the system. The code used to run these tests can be found in Appendix.

4.1 Test Run

The design brief specifies the robot to be able to 'start, move 100mm and stop in 1 second' By moving diagonally all motors can be moved to achieve maximum acceleration. Place two points 300mm apart on the floor. Program the arm to go from point A to point B and back 10 times. Take a stopwatch and time how long it takes to cycle through 10 movements. Divide this time by 10, when the answer is smaller than 1 second it means the robot arm achieved the required speed performance of the design brief. As can be seen from the screenshots below, The robot manages to take 10 steps of 100 mm in 10 seconds. This was achieved while every side motion was regulated by a button press, adding a software delay every time.

The requirement for power is that the robot arm should be able to lift a load of 150 grm with a stretched arm. According to the specifications of the manufacturer the motors in the prototype arm are rated to 4Nm after the gearbox. To lift 500g at a fully stretched arm of 40 cm roughly 2Nm is needed. The motors should be well within its power reach to lift the specified load. Connect a bottle of water to the end effector of the robot arm. Fill the bottle with 100mL water, lift it up 5cm and bring it down again. Adjust the potmeter on the driver board of the stepper motors to increase the current output if necessary. Add 100mL water to the bottle and lift it up again. Continue adding water in

steps of 100mL and testing the motors until 150mL (150 gram) is reached. If the robot arm can lift a bottle of 150mL the power performance is reached. The power test was also successfully completed. While the arm is stretched out fully it was capable of lifting the fully filled 150mL water bottle, weighing slightly more than 150mL. The arm was also able to lift the bottle without any problems.

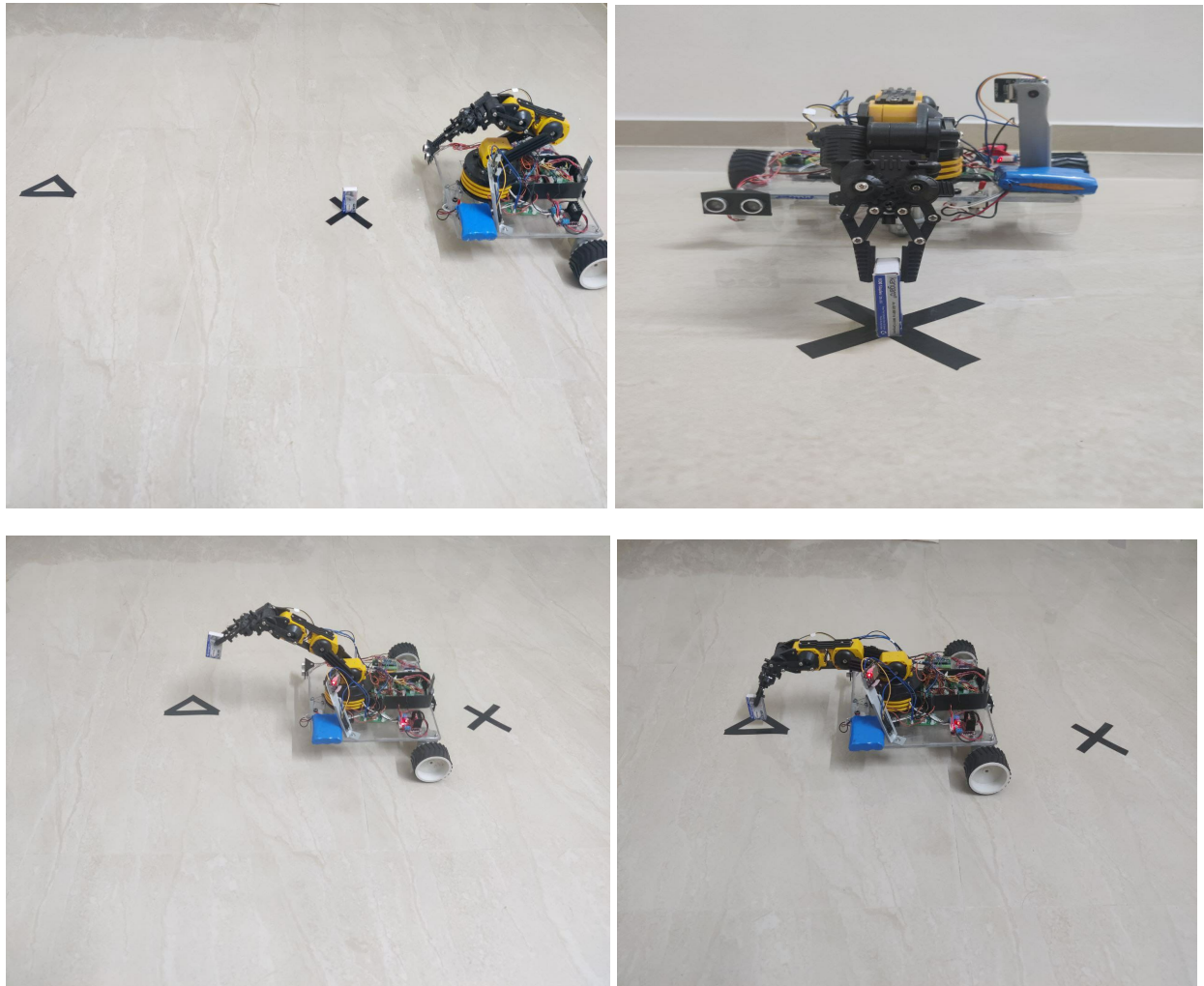


Fig 4.1 Precision and Speed testing

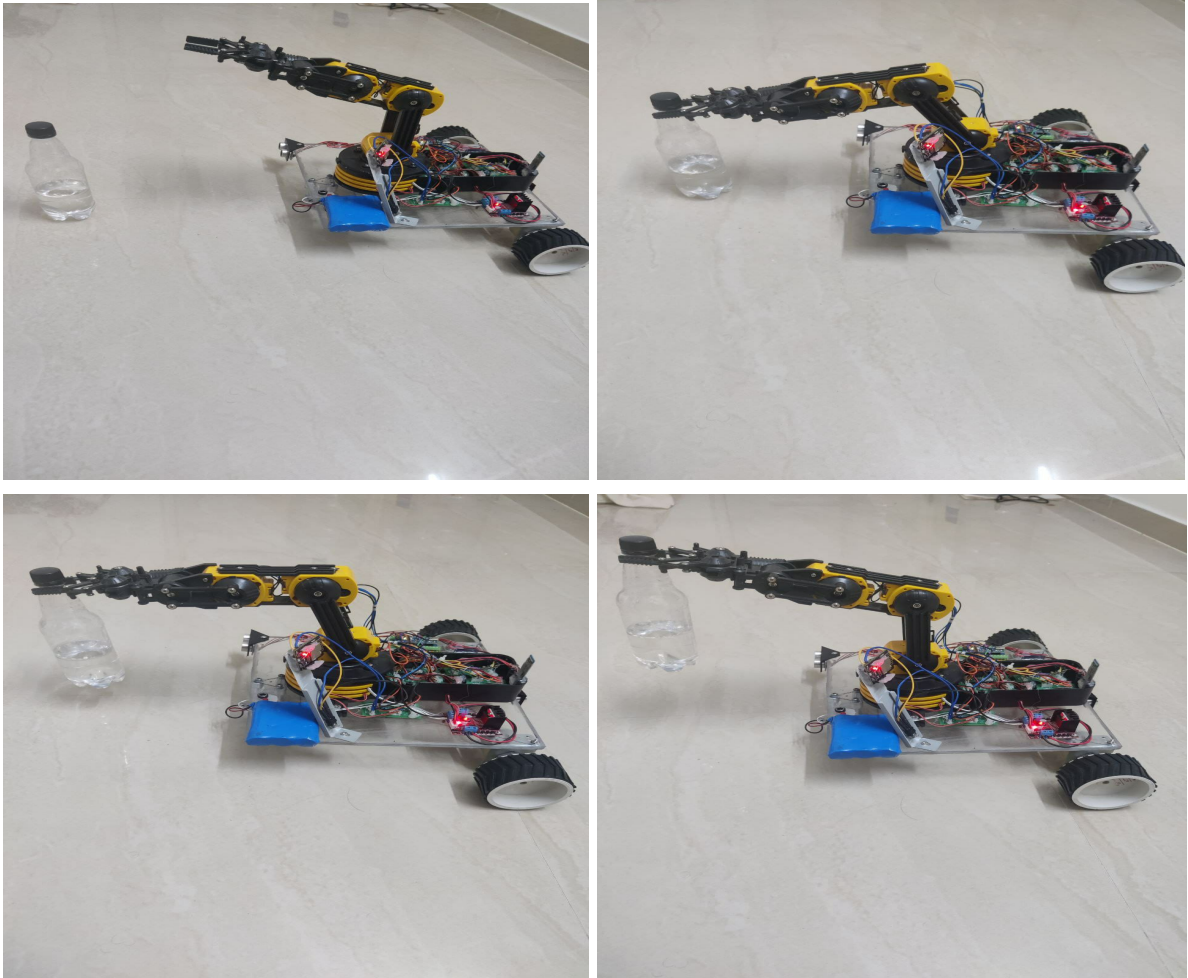


Fig 4.2 Weight Testing

4.2 Recommendation(improvements)

The first recommendation of improvement on this prototype would be the end effector. At the moment this is a ballpoint pen top, with the insides of a fine-liner pen wedged inside, being held into place because the pen was forced. When redesigning a pen holding end effector it should be noted that the pen should be kept stable at different heights to keep it from tilting.

Another recommendation is a rotation stopper to keep the robot arm from turning more than 180° in both directions. The way the arm is setup now, it could rotate too far and pull the wires out of the driver boards or the motors. This could be resolved by adding a stopping plate to the basis and the rotating shoulder assembly.

To get more use out of the robotic arm it may be necessary to swap out the arduino for a more advanced micro controller with a higher clock speed. That way it is possible to drive all motors at once without losing speed.

Another problem that should be addressed is the end effector stabilizer rod system. The way the stabilizer is installed now results in it reaching its top dead center when the arm is fully stretched and losing much of the stabilizing ability. To make full use of the robot arm, the motors should be able to run at the same time. By doing this the robot could draw shapes, laser engrave or 3D print. It is possible to do this with this setup by having a better programmer or team of programmers and an upgrade to the arduino.

CHAPTER 5

CONCLUSION AND FUTURE IMPLEMENTATION

5.1 Conclusion

Robotic arms, many areas are developable. Thanks to the robotic arms, many tasks are made easier and the resulting error level has been reduced to a minimum. For example; some pharmacy-based drug-giving robots and a projected robot arm have been developed. In addition to this, the ability to move the robot arm is further increased, and when the camera is placed in the finger area and the sensitivity is increased, it can be used in a wide range of applications from the medical sector to the automation systems. With the robotic arms developed in this way, the risk of infecting the patient in the medical sector is minimized, while the human errors are minimized during the surgical intervention. Despite the fact that the robotic arm made by this project is of prototype quality, it has a quality that can be improved for more robotic systems. Besides these, the robotic arm sector, which is open to development, will keep its importance in the future.

The purpose of the project is to provide control of 4 axes moving robot arm design and this robot arm with a suitable microcontroller and Bluetooth module with android application. The necessary theoretical and practical information for this purpose has been obtained and the necessary infrastructure has been established for the project. During the process of making and developing the project, a lot of theoretical knowledge has been transferred to the practice and it has been ensured that it is suitable for the purpose of the project.

This paper presents our study on early research and developments in robotic arms. The objective of the project has been achieved which was developing the hardware and software for a controlled robotic arm. The main aim of our project is to

build a robotic arm that can pick things. Even after many years of research, the applications of robotic arms are restricted to the industries and primarily used in manufacturing units for increasing productivity. These arms are very sophisticated and can manage to make extremely precise movements. The robotic arms have a wide variety of general purpose and domestic applications too, which are not much explored. The robotic arms will be available everywhere to serve as a “helping hand”. From observations that have been made, it clearly shows that its movement is precise, accurate and easy to control and user friendly to use. The robotic arms develop successfully as the movement of the robotic arm can be controlled precisely. The robotic arm controlled method is accepted to overcome problems such as placing or picking objects away from the user, and picking and placing objects in a very fast and easy manner.

The purpose of this paper was to analyze the different components that go into making a robotic arm, how they work and how they influence the performance of the entire system. While at the same time making a model to predict and relate desired performances to required components, their composition and their cost and also to explore the possibilities for designing and producing high quality robotic arms at the right cost. The information required to build the prototype arm can all be found in this paper, like the type of frame structure to use, the types of bearings and the types of motors best suited. This lead to the successful build of a robotic arm. The purpose of analyzing the different components, how and why they work and their influence on the performance of the robot arm was therefore successful. The model presented in this paper to calculate the required motor torque was put to the test and proved to be correct. This paper also presented a model to predict the precision of a robot arm, based on the worst case scenario for play in bearings, motor resolution, backlash and frame deflection. The model predicted the worst case imprecision to be 1.59mm while the real precision was 1.5mm. These results seem to prove the model to be true for this test. However, the model does not include the imprecision's caused by the tolerances in the fit of the lower arm on the elbow axel and the upper arm on the shoulder axel. Were

these to be included, the prediction would be higher and the real precision would still be within the boundaries.

5.2 Future Implementation

Robotic Arms has a wide scope of development. In the near future the arms will be able to perform every task as humans and in a much better way. Imagination is the limit for its future applications.

- It can be a real boon for handicapped people, who are paralyzed or lost their hands in some accident.
- The arm can be trained to listen to the command from a human and perform that task.
- A Precise gesture controlled system is also possible. Wearable devices can be used to send the command and control the movements of the arm.
-
- Brain Computer Interface (BCI) is an emerging field of research. BCI can be used to acquire signals from the human brain and control the arm.
- The system can work in the same way as a human arm. A person who may have lost his hand in any accident can resume his life like before with such artificial arms. Robotic arms are versatile and have enormous ways of implementation.

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