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Design, Implementation and Control of a Versatile Mobile Manipulator Using ESP 32 Microcontrollers

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ABSTRACT: In this paper multipurpose mobile manipulator was developed which can be used in many fields. In addition to this feature, a gripper was design which can avoid the extra pressure on the suspected object like bombs for the safety of the army in the military fields. At the transmitting end using android application device, commands are sent to the receiver to control the movement of the robotic arm either to move forward or backward, left or right and also can rotate one full revolution. Four wheels of the manipulator are connected with four motors which are on the base of the robot and separate three motors are used for the movement of the robotic arm. Mobile manipulator was controlled wirelessly with the help of ESP 32 while the receiver end is connected to the wifi device. Remote operation is achieved by the smart phone/laptop with android OS which is based on the touch screen. Special addition to the manipulator is that spying nature and the audio and video is transmitted automatically to the receiver end. For the weight reduction of the mobile manipulator suitable materials are chosen and the fabrications are done. For lifting of objects, the arm was designed and load bearing capacity was calculated in each and every arm.

KEYWORDS: Multipurpose robot, WIFI controller, ESP 32, Android, Spying

I. INTRODUCTION

A robot is a machine designed to execute one or more tasks automatically with speed and precision. Though it may seem like a simple problem robot examining the event closely reveals subtleties that make it much more difficult. Not any robots, robot specially designed to complete a course by to reduce the human power^[1]. A robotic arm is an electromagnetic manipulator usually programmable with similar functions to a human arm. "A robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools or specialized device through variable programmed motions for the performance of the variety of task"^[2]. There are as many different types of robots as there are tasks for them to perform. The advantages of automated process results are faster completion time with lowest error. More than that the robots can perform repeatedly with high accuracy than human operators. Difficult tasks may include welding, grinding, molding and casting. When robots are used to perform these tasks; it enables human workers to partake in more meaningful and creative pursuits. It can be programmed to be fully or semi autonomous depending upon the industrial application required^[3]. In manufacturing, robots often perform tasks which are very dangerous for people. Without risking human life the robot can replace for humans in some hazardous duty servers. A robotic arm means a group of rigidly connected bodies that can be taken different configurations and move between these configurations with speed and speed restrictions^[4]. The mechanical and electrical construction are the components used to build the robotic arm.^[5] The main challenges faced in the area concerned the development of methods for the sensor knowledge data gathering and reproduction of thus data from robots with robustness and accuracy^[6]. And these robots have same number of degree of freedom as human arm. In this modern environment

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everybody uses Smartphone which are part of their day to day life^[7]. They use all their daily uses like newspaper reading, daily updates social networking and all the apps like home automation control, vehicle security, human body anatomy, health maintenance etc....has been designed in the form of applications which can be easily installed and controlled in their hand held smart phones likewise robotic movements also be controlled by smart phones^[7]. Mobile robots are also known as mobots. Mobot must be able to overcome these problems of the performance surface under changing lighting and weather conditions^[1]. Mobile controlled robots are convenient because of their movable platform. Mobile robots are designed to move to a certain area or environment following the controller instruction. Being able to communicate wirelessly with the robot will bring convenient and flexibility^[8]. Wireless also means using Bluetooth however the advancement used here are the most extensive so the wifi comes in to the pictures^[4]. There is no doubt on the importance on the wireless technology in today's life. Controlling robots using wireless technology is one of the applications which have created interest in production lines to create more space and flexibility^[9]. A user friendly robot was developed which can even controlled easily by unskilled labour to skilled professionals. Usually industrials robots were designed with the features of pick and place grippers because humans were unable to meet the demand of the industries in a short period. Because of these repeatable tasks the workers can face with health issues. Likewise electromagnetic grippers and vacuum grippers are used in our robot so, that our robotic arm can pick metal scarps and glass materials without any damage. Development of an adjustable gripper for robotic picking and placing operation in which adjustable gripper for robotic system is designed to identify the shape and size of an object which is needed in many applications especially for the picking and placing operations^[17]. Till now there are specific grippers with specific work which cannot be changed according to its need. But this robotic arm has end effectors which can be removed and replaced according to the work to be done in a particular area. And also a wireless camera is mounted on the robot body for spying purpose even in the complete darkness^[7]. In the project, development of a multipurpose robot with different features which can do various operations like pick and place, spying and metal detecting which can be controlled by ESP 32 micro controller.

II. RELATED WORKS

In this research, robots have a wide range of industrial and medical applications such as pick and place and surgical robots and it also use to lift nuclear wastes without humans [2]. This research achieves both wireless communications between the mobile robot android GUI applications. The main task of this work is to make a surveillance robot which can be control by emerging android technology [7]. In this paper, pneumatic actuators with a inexpensive flexible cylinder and microcontroller are chosen for the development of the robot arm [14]. The main aim of this work is to manufacture a prototype of light weight robot arm with a low cost budget, fully functional. This prototype is used to test and fix the elements for driving and controlling [13].

III. MATERIALS AND METHODOLOGY

The materials used in this work are aluminium (Al) and polymer matrix composite. Aluminium was purchased from Ambattur which has a thickness of 3mm. The polymer matrix composite (PMC) was developed by hand layup technique which is shown in the figure1. The matrix used for the PMC is epoxy resin and the reinforcement is glass fiber. The base the mobile manipulator is made of Al which is shown in the figure2, and the arm of the manipulator is made of PMC is shown in the figure 3.

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Figure 1: Hand Layup technique



Figure 2: Base made by Al



Figure 3: Arm made by PMC

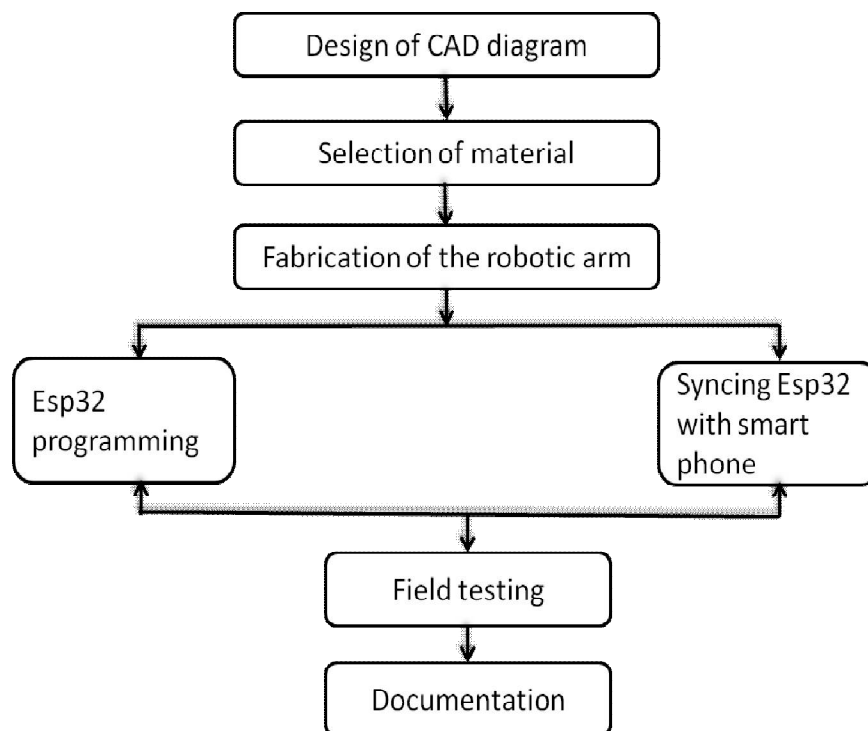
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IV. METHODOLOGY



V. DESIGN OF THE MOBILE MANIPULATOR AND CODING OF ESP 32

The design for the manipulator is shown in the figure 4, which is drawn by CAD Software. The force required to lift the object by the end effector is calculated and the degree of freedom (DOF) is also calculated. ANSYS software was used to calculate the stress in the arms of the manipulator.

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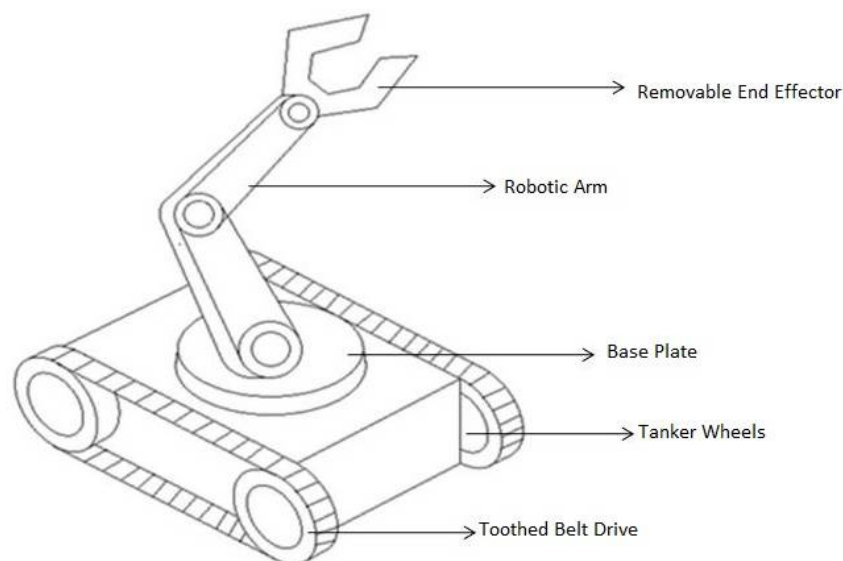


Figure 4: CAD diagram of mobile manipulator

VI. EXPERIMENTAL RESULTS

The degree of freedom of the mobile manipulator is calculated by using kutzbach criteria or theory as given.

$$DOF = 3(L-1) - 2J - H$$

No. of links, $l = 4$

No. of joints, $j = 3$

No. of higher pairs, $h = 1$

$$n = 3(l-1) - 2j - h$$

$$= 3(4-1) - 2(2) - 1$$

$$= 3(3) - 4 - 1$$

$$= 9 - 5$$

$$n = 4$$

FORCE REQUIRED FOR GRIPPING THE OBJECT

$$F = W \mu n g$$

F = Gripping force required

μ = Co-efficient of friction

n = number of fingers

g = acceleration due to gravity

By considering mobile manipulator arm as a cantilever beam, the force experienced by the arm is calculated by using shear stress and bending moment diagrams as shown in figure5.

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Weight of the first arm = $150 \times 10^{-3} \text{ kg}$

Weight of the second arm = $48.8 \times 10^{-3} \text{ kg}$

Weight of the end effector = $150 \times 10^{-3} \text{ kg}$

Weight of the stepper motor = 0.24 kg

Weight of the servo motor = $62.41 \times 10^{-3} \text{ kg}$

- 1) weight of the 1st arm = 1.05 N
- 2) weight of the stepper motor = 1.5 N
- 3) weight of the 2nd arm = 0.5 N
- 4) weight of the (end effector + servo motor + load applied) = 32.1 N

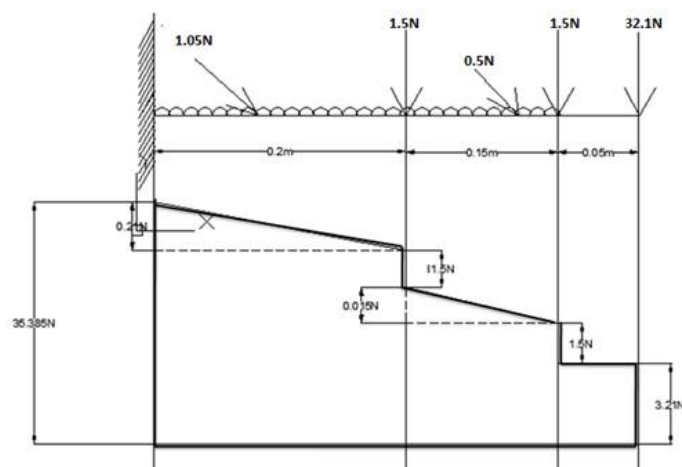


Figure 4: Shear Stress Diagram

The calculated force by using shear stress and bending moment diagram for lifting the objects weighing up to 3 kg for the arm is 35.385N.

- Material of the bolt is MILD STEEL.
- t of MS is 400MPa.
- Shear stress = $0.17t$
 $= 0.17(400)$
 $= 68 \text{ MPa. (Hence the design is safe)}$

Analysis using ANSYS

The figure 6,7,8 shows the ANSYS results of the mobile manipulator. The total deformation is about 3mm and the stress and strain is very low and it is very low.

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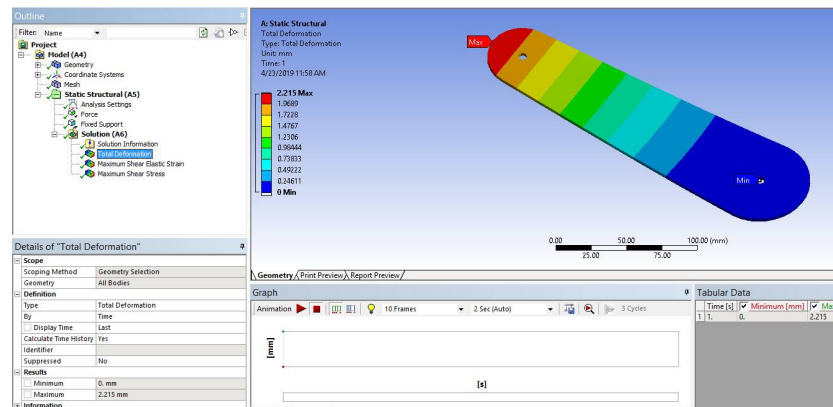


Figure 6 Total Deformation

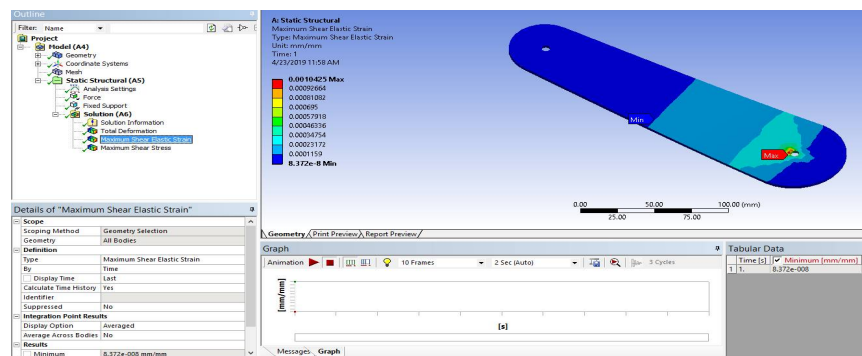


Figure 7 Maximum shear strain

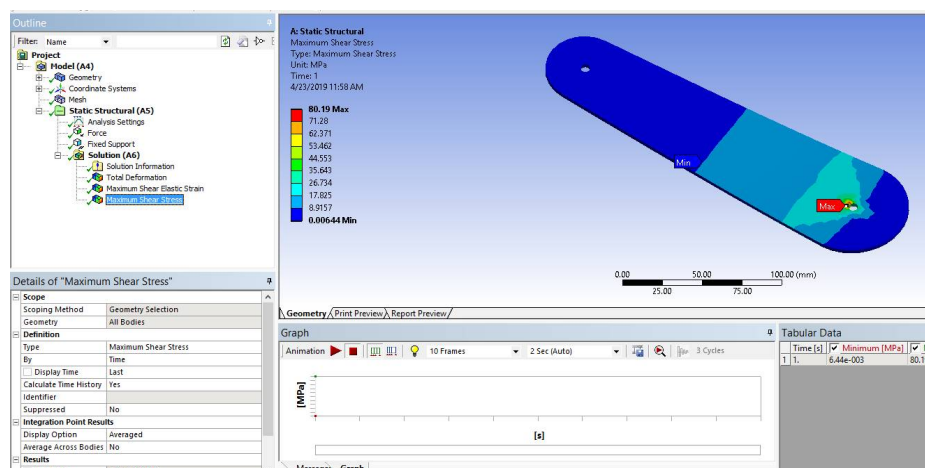


Figure 8 Maximum shear strain

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Overview of the mobile manipulator:

Figure 9 shows the over view of the mobile manipulator

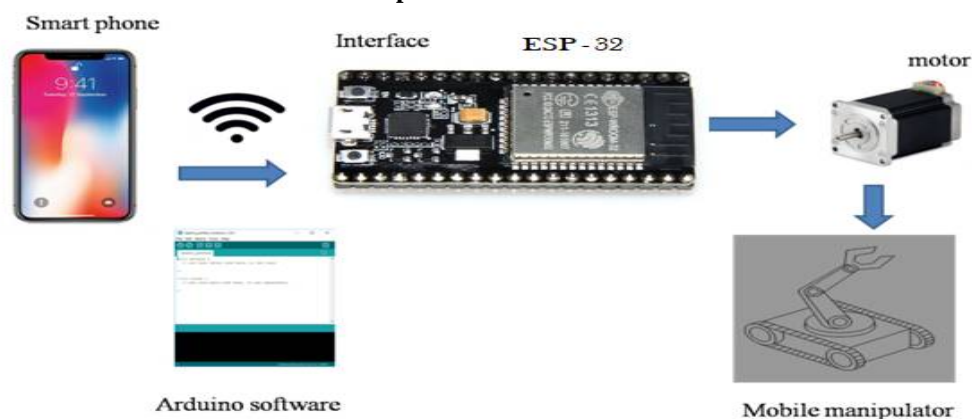


Figure 9 Overview of the mobile manipulator.

VII. CODING OF THE MOBILE MANIPULATOR

```
#include <ESP8266WiFi.h>
WiFiClient client;
WiFiServer server(80);
const char* ssid = "YOUR SSID";
const char* password = "YOUR PASSWORD";
String data = "";
int leftMotorForward = 2;
int rightMotorForward = 15;
int leftMotorBackward = 0;
int rightMotorBackward = 13;
int rightMotorENB = 14;
int leftMotorENB = 12;
void setup()
{
  pinMode(leftMotorForward, OUTPUT);
  pinMode(rightMotorForward, OUTPUT);
  pinMode(leftMotorBackward, OUTPUT);
  pinMode(rightMotorBackward, OUTPUT);
  pinMode(rightMotorENB, OUTPUT);
  pinMode(leftMotorENB, OUTPUT);
  server.begin();
}
void loop()
{
  if (client.available())
  {
    if (!client) return;
    data = checkClient ();
    if (data == "forward") MotorForward();
    else if (data == "backward") MotorBackward();
    else if (data == "left") TurnLeft();
    else if (data == "right") TurnRight();
    else if (data == "stop") MotorStop();
  }
}

void MotorForward(void)
{
  digitalWrite(leftMotorENB, HIGH);
  digitalWrite(rightMotorENB, HIGH);
  digitalWrite(leftMotorForward, HIGH);
  digitalWrite(rightMotorForward, LOW);
  digitalWrite(rightMotorBackward, LOW);
}

void MotorBackward(void)
{
  digitalWrite(leftMotorENB, HIGH);
  digitalWrite(rightMotorENB, HIGH);
  digitalWrite(leftMotorBackward, HIGH);
  digitalWrite(rightMotorBackward, HIGH);
  digitalWrite(leftMotorForward, LOW);
  digitalWrite(rightMotorForward, LOW);
}

void TurnLeft(void)
{
  digitalWrite(leftMotorENB, HIGH);
  digitalWrite(rightMotorENB, HIGH);
  digitalWrite(leftMotorForward, LOW);
  digitalWrite(rightMotorForward, HIGH);
  digitalWrite(rightMotorBackward, LOW);
  digitalWrite(leftMotorBackward, HIGH);
}

void TurnRight(void)
{
  digitalWrite(leftMotorENB, HIGH);
  digitalWrite(rightMotorENB, HIGH);
  digitalWrite(leftMotorForward, HIGH);
  digitalWrite(rightMotorForward, LOW);
  digitalWrite(rightMotorBackward, HIGH);
  digitalWrite(leftMotorBackward, LOW);
}

String checkClient (void)
{
  while(!client.available()) delay(1);
  String request = client.readStringUntil('\n');
  request.remove(0, 5);
  request.remove(request.length()-9, 9);
  return request;
}
```

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VIII. CONCLUSION

- In this work a pick and place mobile manipulator was developed and controlled by an Android application.
- The arm of the mobile manipulator was analyzed using ANSYS and the result was discussed.
- The weight handling capacity of the robot is determined by the motor and materials used.
- The hardware model which was designed can handle up to a maximum weight of 3kg above which the arm of the robot tends to bend and break.

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