IoT Based Pick and Place Robot

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Declaration

"No portion of the work referred to in the dissertation has been submitted in support of an application for another degree or qualification of this or any other university/institute or other institution of learning".

SIGNATURES

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ABSTRACT

In a highly competitive situation, manufacturing high quality products with time and cost saving and by ensuring proper safety in the production process is a basic need of industry operators. Therefore, it is necessary to employ a Robotic system to assist in manufacturing. Robots are now an essential component of many industries and manufacturing processes due to their accuracy, flexibility and ability to operate for extended periods without getting tired. A significant and vital part of industrial automation is robotics.

In this modern day, automation and robotics are changing several sectors. Although it was formerly more theoretical than practical in many industries, including healthcare and agriculture, automation is now widely used in these sectors. Pick and Place Operation in manufacturing industries are mostly performed by these pick and place robots. As human intervention causes some mistakes thus this system offers consistency and removes human error. This robot that we are going to built is highly effective and it is controlled completely by Android Mobile or Pc using internet, the commands are then received by the controller to perform actions. The wireless video camera captures the video and then transmit it thus it can be viewed over the windows.

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Chapter 1

Introduction

1.1 Introduction

Replacing Human work with machine has been a common practice. In today's rapidly changing world Human can't match the speed and efficiency of Robotic Machines. In practice, robotics refers to the research, design, and application of robot systems in manufacturing. Robots are used to carry out tasks that are unsafe, risky and repetitive. They perform a variety of jobs that includes picking and placing of material, welding, assembling and are also involve in many medical processes. You might picture humanoid automata from science fiction when you think about robots. There are many other kinds of robots in existence today, but these ones are still mainly science fiction. But, what are robots? How will they alter the world, exactly? The idea of a robot is one that most of us are familiar with, yet it can be challenging to clearly identify a robot as a unique machine from other kinds of machines. Study the nature of robots in Open Step; they vary from other devices by interacting with their environment. By acting and responding to the world around them, they can alter their surroundings. Robots are machines that carry out jobs that would typically be done by people. Robots vary in their levels of automation, but they should all be able to independently accomplish a set of duties.[1]

1.1.1 Types of Robots

The major categories into which robots, ranging from chatbots to humanoids, fall are given below,

- **Humanoid Robot**

  Robots that resemble humans in terms of appearance and even facial emotions are called humanoids. They are suited for service positions that demand face to face, personal engagement due of their resemblance to humans as shown in figure 1.1.

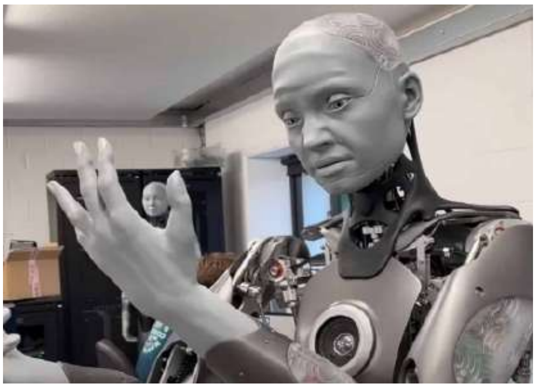

Figure 1.1: Humanoid Robot

- **Autonomous Mobile Robots:**

  All types of businesses, warehouses, and healthcare facilities are searching for fresh, inventive approaches to boost productivity, speed and accuracy. Many people seek assistance from autonomous mobile robots (AMRs). A robot type that can autonomously comprehend its surroundings and move around is an autonomous mobile robot as shown in figure 1.2. AMR is distinct from Automatic Guided Vehicle, which it replaced (AGV). AGVs frequently need human monitoring and rely on rails or predetermined courses. AMR interprets the environment using sensors, artificial intelligence, machine learning, and path-planning computers. AMRs have cameras and sensors, so if they run into unforeseen impediments while exploring their surroundings, they apply navigation strategies like collision avoidance. A fallen box or crowd slows their path and stops or redirects the object before continuing with the task.

Figure 1.2: Autonomous Mobile Robot

- **Teleoperated Robots**

  They can be operated remotely by a person. The remote control signals may be transmitted through satellite, over the Internet, a local wireless network (like Wi-Fi), or a wire.

- **Software Bot**

  A software bot, sometimes known as a "robot" is merely some computer code. Nevertheless the bot behaves quite differently when you compile the code.

The natural world serves as a source of inspiration for many robot components. The robot's manipulator arm is modeled after a human arm. The robot is capable of picking and placing objects with its hands as shown in figure 1.3. It can also run independently. Robotic system technology for the electronic industry continues to evolve. The service robot with machine vision capacity has recently been created as one such application.[2]
Automation has become and important thing. Modern industries are increasingly moving towards it, mostly due to the requirement for higher production and to deliver a consistent quality end products. Hard automation systems historically used for automated manufacturing tasks, are inflexible and generally expensive, which has sparked widespread interest in the use of mechanical arms.

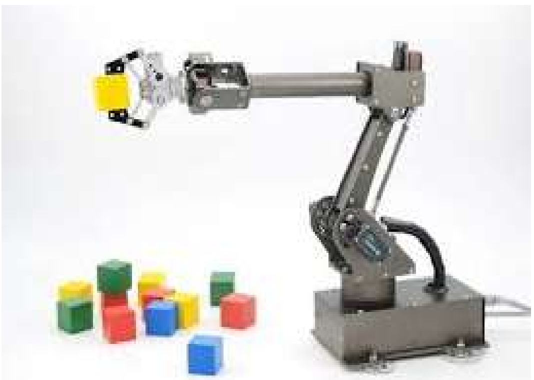

Figure 1.3: Pick and Place Robot in Industry

In this rapidly changing world to complete a large scale task time and manpower are key constraints. In the majority of frequently carried out tasks, automation plays an important role in reducing the need for human labour. The picking and placing of an object from any source location to desired location is one of the most important and frequently performed task. Simply put, robots work faster than most humans. This means that when throughput becomes an issue, automation should be considered first. This is especially true when manual processes create bottlenecks. A bottleneck is created when a single process step potentially slows down the entire process. This can cause the conveyor to slow down on the assembly line to accommodate later assembly speeds. Faster assembly allows for higher conveying speeds. This increases the number of parts per minute, hour, or day. Systems with higher throughput bring more revenue.[3]

Figure 1.4: Robotic Arm

Pick and place applications involve moving parts from one site to another once they have been picked up at one location as shown in figure 1.4. Most frequently connected with palletizing and packaging operations. In processes involving large production, this job could be crucial. The mechanical human controlled robotic arm is a device that locates the object, picks it up from its originating position, and sets it where it is needed. To detect an object, a human must first become aware of its existence before the machine can move it.[4]

1.1.2 Types of Pick and Place Robots

There are many types of Pick and Place Robots including,

- **Robotic Arm**

  The most popular kind of pick and place robot is a robotic arm as shown in figure 1.5. Objects can be picked up in one plane and transported to another using the 5-axis robotic arm robot in normal pick-and-place applications. For more complicated applications, six-axis robotic arms are used. When an object needs to be rotated or re-positioned before being placed somewhere else.

Figure 1.5: Robotic Arm

- **Cartesian**

  The operations of a Cartesian robot are multi-level, similar to a six-axis robotic arm. These robots use Cartesian coordinates to move along three orthogonal axes (X, Y, and Z) as shown in figure 1.6 . Any linear actuator and a variety of drive systems, including belt, ball, and lead screw mechanisms, can be used to create them. In general, positioning precision is better than with a 6-axis robot arm.

Figure 1.6: Cartesian Robotic

- **Delta**

  In applications where the robot gathers objects in groups and sets them into assembly patterns or bins, delta robots are frequently used. Advanced visual technology on the Delta robot allows it to recognize various sizes, shapes, and colours. Although delta robots can be built in many different ways, the majority of them have three arms that are attached to four axes as shown in figure 1.7. Light arms are connected to connecting rods and hefty motors are fixed to the frame. Each arm's ends include joints, which are often ball joints, to facilitate movement.

Figure 1.7: Delta Robotic

- **Fast Pick**

  For use in medium and large volume applications with high speed SKUs, high speed picking robots are perfect. Full automation of the picking process is achieved by high-speed picking robots, which minimizes human effort and frees you up to concentrate on more crucial activities. Ideal for quick-moving replenishment supplies like batteries and promotional items. With a pool of up to 8 SKUs, these robots are capable of picking 300 SKUs every hour.

- **Collaborative**

  Through guidance, site selection, and task guidance, collaborative robots support human work. Cobots increase staff productivity by real-time route optimization while permitting employees to carry on with their tasks as shown in figure 1.8.

Figure 1.8: Collaborative Robot

Pick and place robots primary benefits are consistency and speed. Robots can be easily programmed, adapted for particular industrial requirements, and employed in a variety of ways. Pick and place robots, though they come in a variety of shapes, are frequently lightweight and tiny, making them perfect for applications that require little floor space. In warehouse settings, small pick and place robots enhance performance and facilitate picking and packing procedures. Additionally, it offers manufacturers a fantastic ROI. In both settings, pick-and-place robots free employees and operators from tedious and repetitive activities, boosting productivity while lowering the amount of human labour typically required to do jobs of this nature. lessens the physical strain.[5]

How much does Pick and Place Robots cost?

The proper pick and place robots can help logistics organizations in their warehouse operations. It has never been simpler for companies to automate order fulfillment to meet surging customer demand and a shrinking labour supply as the corona virus pandemic upsets supply chains throughout the globe. has grown in significance. Robots that pick and position items do so without resting, being weary or bored, or becoming distracted by their surroundings. Although estimates set the initial cost of a pick-and-place robot in the tens of thousands of dollars, such automated precision would be quite expensive.Businesses do not need to make significant infrastructure adjustments to their storage space, thus installation time is minimal. With the correct pick-and-place robot, you may start increasing production almost immediately after installation and programming. Our pick-and-place robots are constructed using cutting-edge technology and require no upkeep. Companies can complete all required maintenance work internally if they follow correct cleaning procedures and maintenance rules. Pick-and-place robots, as compared to other warehouse automation systems, have a significantly cheaper total cost of ownership. Businesses can increase facility productivity and gain a competitive edge by investing in pick and place robots.[6]

This IoT based pick and place robot that we aim to built is a robotic system that uses Internet of Things (IoT) technology to pick and place objects as shown in figure 1.9. A system of interconnected computing devices, mechanical and digital machinery that necessitate human-to-human contact is known as the Internet of Things (IoT). It has the capacity to transmit data both with and without using a network. The Internet of Things includes both natural and artificial objects, such as people with implanted heart monitors, animals with transponders on biochips, cars with built-in sensors that alert drivers to low tyre pressure, and more. It is an item, a thing capable of receiving an IP address and sending data via a network.

The Internet of Things (IoT) is made up of web-enabled smart devices that use embedded systems that includes processors, sensors, and communication gear to gather, transmit, and react to environmental data. By connecting to IoT gateways or other edge devices, IoT devices exchange sensor data that has been acquired. There, the data is either examined locally or transferred to the cloud. These gadgets may converse with other similar gadgets and react to information shared between them. Although humans can engage with the device for setup, instructions, and data access, the gadget handles the majority of the job without their help.[7] People can live and work more intelligently and with greater control thanks to the Internet of Things. IoT is crucial for businesses; it goes beyond offering intelligent devices to automate your house. With real-time visibility into how their systems are actually operating thanks to the Internet of Things (IoT), businesses will be able to gain knowledge about anything from machine performance to supply chain and logistics activities. Businesses may automate procedures and save money on labour thanks to IoT. Additionally, it lessens waste, enhances service delivery, increases the cost-effectiveness of the manufacturing and distribution of goods, and offers transparency in consumer transactions. IoT is one of the most crucial technologies in our daily lives as a result, and it will continue to grow as more businesses recognize how critical linked devices are to staying competitive.

These type of robots often use cameras, sensors, and other IoT devices to gathers information about the item that needs to pick up and the locations where they need to be placed as shown in figure 1.9. The user then uses this information to determine how best to complete the job in terms of efficiency and effectiveness. It uses Dc gear motors to drive the robot, which provide fine control and manipulation of the robotic car and the robotic arm. An IoT based pick and place robot can operate more quickly, precisely, and adaptably than standard pick and place robots by merging IoT technologies with traditional robotics.[8]

Figure 1.9: CAD Model Of Pick And Place Robot

1.2 Motivation

The motivation behind the development of IoT based pick-and-place robots is to improve efficiency and productivity in manufacturing and many other purposes. The main advantages of this technology are:

- **Real-time monitoring and control**

  IoT technology enables communication between the robot and its control system as well as real-time monitoring of the robot's functions, enabling quick and efficient problem solving.

- **Increased precision**

  An IoT based pick and place robot may receive information about the product that needs to pick from the source location and then placed at the desired locations using sensors, cameras, and other IoT devices, enhancing accuracy in its motions and lowering errors.

- **Increased adaptability**

  With the integration of IoT technology, robots can be programmed and controlled remotely, making it easier to respond to changing demands and conditions in a warehouses and factories.

1.3 Problem Statement

Picking and Placing of a variety of materials is a common requirement in majority industries. Machines have replaced humans in many industrial areas. Basic purpose of all the machines around us is to make our life easy. But manual working has limitations like,

1. Depends on human mind during run time, human feel exhausted, have emotions and natural tendency towards errors.
2. Time consuming.
3. Less Production Rate due to human errors and Manual Working i.e shift change etc.
4. Safety issues due to working in hazardous areas.

Therefore, an Iot Based Pick and Place Robot System is Required to address the limitations and inefficiencies of traditional manual picking and placing process in manufacturing and warehouse environments.

1.3.1 Solution

The solution to this problem is to integrate IoT technology with traditional robotic systems. This integration allows the robot to gather real-time data on the objects it needs to pick up and the locations where they need to be placed, using cameras, and other IoT devices. Through IoT the user will identify the picking and placing points of the object to carry out the task, leading to improved accuracy and efficiency.

Additionally, the integration of IoT technology enables remote control and programming of the robot, providing enhanced flexibility in adapting to changing demands and conditions. The real time monitoring capabilities of IoT technology also improve safety, reducing the risk of accidents and improving overall performance.

Thus this Pick and Place Robot will probably provide:

1. Greater accuracy.
2. Automated control.
3. Improved productivity.
4. Can work 24 hours a day
5. Uniformity in design.
6. Safe to operate.
7. Possibly no human error.
8. Less time required.

1.4 Project Objectives

The objectives that we will achieve in this project are given as,

1. Assembling the robotic arm, thus controlling its displacement so that the arm can be used to pick and place the object from any source to destination.
2. Developing a decision control system based on real time measurement value.
3. Human Machine Interface (HMI) design for the project.

1.5 Project Applications for the Betterment of Society

Pick and place robots are often used in manufacturing but are also used in applications like,

1. Pick and Place, Stacking and Sorting.
2. Its application is to pick object from one location and place to another, stack parts and sort parts on the production line.
3. Assembly: These Robots are used to pick up incoming parts from a single spot, such a conveyor, and attach them to other pieces of the product. The two combined components are then moved to the following assembly location.
4. Inspection: These robots are outfitted with sophisticated vision systems that allow them to pick up objects, spot anomalies, and remove damaged components or products by placing them in a predetermined area.
5. Packaging: These robots are outfitted with sophisticated vision systems that allow them to pick up objects, spot anomalies, and remove damaged components or products by placing them in a predetermined area.
6. And in many other Medical Applications.

1.6 UN's Sustainable Development Goals

There are total 13 UN's Sustainable Development Goals. Out of which our project is achieving Goal 8, Goal 9 and Goal 12.

- **Goal 8:** Decent Work and Economic growth
  By Enhancing productivity and Reducing human labor.
- **Goal 9:** Industry, Innovation and Infrastructure
  By Technological advancement and Efficient supply chain management.
- **Goal 12:** Responsible Consumption and Production
  By Waste reduction and Waste reduction.
  This project can be considered to meet the following aims shown in figure 1.10, which are part of the 17 Sustainable Development Goals.

Figure 1.10: UN's Sustainable Development Goals

Our project is to revolutionize the industrial sector by making it more automated and thus increasing its infrastructure by increasing its economic growth by offering a responsible production.

1.7 Project Timeline

In Table 1.1 we have presented the timeline of our project, we will possibly achieve our objective according to the given timeline. It is divided into 9 sections starting form Literature Review and Proposal Defense to the Thesis Submission and Final Defense.

Sr No.	STARTING DATE	DESCRIPTION OF MILESTONE	DURATION
1	26-09-22	Literature review for FYP proposal plus defence.	3 weeks
2	17-10-22	Finalization of the Block Diagram.	3 weeks
3	07-11-22	Literature review related to project.	5 weeks
4	12-12-22	Components selection, testing and their working.	5 weeks
5	16-01-23	Simulation of the project.	4 weeks
6	13-02-23	Performance analysis of project and its verification.	4 weeks
7	13-03-23	Documentation and presentation work.	4 weeks
8	10-04-23	Hardware project implementation.	5 weeks
9	15-05-23	Thesis Submission and Final Defense.	2 weeks

Table 1.1: Project Timeline

1.8 Thesis Organization

Chapter 1: We expand the notion of Iot based Robotic Arm in Chapter 1 as well as it's background history, objectives and applications.

Chapter 2: In this chapter, we will go into further depth, discussing in terms of literature reviews and comparing all of the possible research methodologies used in the past to achieve our goal.

Chapter 3: Furthermore, we will go to Chapter 3 where we will illustrate the Block Diagram, Mathematical Models, Flowcharts, Code, Component Selection in Projects with Hardware and

Software Setups, and all potential project limits.

Chapter 4: In contrast, Chapter 4 will go into great detail regarding the tests that were conducted throughout the project and will explain all of our simulations and outcomes.

Chapter 5: We will wrap up the project in this chapter and determine the project's future trajectory.

Chapter 2

Literature Review

Artificial Arms are desperately needed in today's society since human interactions are either impossible or extremely difficult owing to the complexity of human situations. This includes distributing explosives and getting readings from active volcanoes. The development of this arm is closely related to the serial communication-based connection of personal computers for signal processing. The Internet of Things has assumed all of the labor-intensive duties formerly performed by humans in numerous daily activities. In essence, the Internet of Things (IOT) is the network of connected gadgets. In a variety of settings, robots assist humans. You can achieve more than you can think by combining robotics and the Internet of Things.A artificial arm that can be programmed to act like a human arm is known as a robotic arm. Recently, robotics has been heavily involved in a number of automation-related fields.

2.1 Pick and Place Robotic Arm

One of the recent developments in automating manufacturing processes is the use of industrial machine arms. However, modern industrial mechanical arms also exhibit closed software architectures and monolithic mechanical designs. They focus on straight forward, repetitive tasks. The necessity to increase productivity and provide uniform quality for the finished product has led to an increase in computerized automation in today's industries. Rigid automation systems that were previously utilized for automated manufacturing jobs were rigid and frequently expensive, which sparked a great deal of interest in mechanical arms that can carry out a variety of manufacturing operations in a flexible setting and at a reasonable price. A mechanical robotic arm is a human controlled device that locates an object, and thus then performs the pick and place operation. The presence of that object must be ensured first A robotic arm used for pick and place operations is mounted on a moving vehicle (chassis). Regardless of how smooth or uneven the surface is, the car may move along it [8].

2.2 Designing of a 5-DOF Pick and Place Robotic Arm

A robotic arm used for picking and placing is a device that can be made in many different ways depending on its intended use. They mostly rely on joints. The joint may be a rotary joint, used to connect two successive bodies of the robot. Arm movements are controlled by joints it determines the degrees of freedom of the component. It is very important to understand the term "degrees of freedom" or "DOF". Each arm joint represents a degree of freedom. Here you can bend, rotate and move your arms. The number of actuators in a robot arm may often be used to determine how many degrees of freedom are there, this is very important. When creating a robot army, you want to have as few degrees of freedom as possible. DOF simply refers to the number of independent relative motions the robot is capable of [2].

2.3 IoT Based Surveillance Robot

The current Internet revolution has shifted all the heavy burden from individuals to themselves, with the increased use of robotics in many everyday IoT operations. At its core, the Internet of Things (IOT) is the connection of many devices. Robots can assist humans in a variety of contexts, and when combined with the Internet of Things, they can do more than you can ever imagine. A robotic arm is a mechanical arm that can be programmed and thus it can act like a human arm. In this work, an anthropomorphic robotic arm is created and used. It can be controlled remotely using Python and the Adafruit programming environment. It has a wide range of uses. When direct human presence is a concern, such as when working in a toxic environment or when disposing of explosives.

- **Current System**

  The real device's high frequency based robotic arm is powered by an Arduino UNO servo microcontroller to which he has three DC motors connected, based on signals. In this device, information is shared via wired communication and is sent to the robotic arm and microcontroller.

- **Proposed System**

  To address the problems of the existing system, the entire system needs to be upgraded by using various modules to transmit information wirelessly. The Raspberry Pi is connected to the robotic arm using an Adafruit front end configuration with a client server Python protocol and a 4-button controller [4].

2.4 IoT Based Pick and Place Multiple Projects

IoT based pick and place projects use Internet of Things (IoT) technology to automate the process of picking and placing objects in a specific location. Some examples of IoT based pick and place projects include,

2.4.1 Object Sorting System

A robot is an electro-mechanical device with joints and connections, driven by actuators or motors, guided by sensors and managed by software. You can manipulate and interact with objects and perform tasks in different working environments.
In many applications, including industry, robotic arms are particularly useful for hazardous tasks like radioactive strikes/impacts. In the configuration of the robot, mainly it has four types. Cartesian, cylindrical, polar or spherical, articulated arms or articulated robots. Metal detectors are used in sorting systems to locate the metal and non-metal items. If the object is metal, a signal is sent to the controller to pick up the robotic arm and if the object is not metal, the robotic arm will not work in the pick and place process [6].

2.4.2 Trainable Robotic Arm

Robotic manipulators play an crucial role in robotic systems in order to maintain the accuracy and effectiveness of robotic arms.The three main components of this system are the servo motor controller, the serial interface between MATLAB and the microcontroller unit, and the MATLAB program implementation. When the user inputs an angle into the computer, the robot arm's microcontroller receives the angle value and thus sends it to each servo motor and gripper. The MATLAB GUI makes it simple to predefine not only the arm motion component, but also the arm position. Then, an analytical solution for the forward kinematics of a 5-DOF robotic arm is presented to examine how it moves from one position to another [1].

2.4.3 Manually Controlled Swab Collecting Robot

The novel corona virus pneumonia (NCP) pandemic has spread quickly. Swab sampling is a reliable method for detecting corona virus disease in 2019. (COVID-19). Healthcare personnel who collect NP samples are at significant risk of cross infection because they work in close proximity to suspected patients. Because of this many healthcare workers become infected when swabbing patients.

This problem can be solved using a swab collection robot that can be manually operated via Bluetooth and a mobile application can solve this problem by eliminating the need for anyone to be present during the test. This can be done with small, low cost robots that are easily assembled and can be controlled remotely. This system includes a passive positioning robotic arm and a swab gripper [3].

2.4.4 Pick and Place Robot Using PLC

An automated material handling system synchronizes the movements of the robotic arms to pick up items as they move on the conveyor. The pick and place operating requirements of the industry are automated by the help of with this technology. Robotic pick and place automation speeds up the movement of parts to new locations and thus increasing the production rates.

PLC programmable logic controller is used to control the entire process. Primary objects are automatically removed from the conveyor and placed in the desired location [5].

- **Programmable Logic Controllers (PLC):**
  Electronic devices called Programmable Logic Controllers (PLCs) are used in many industries to control and monitor the building systems and manufacturing processes. A PLC collects and processes data from connected sensors or input devices and initiates outputs according to pre-programmed parameters. As a flexible and reliable control solution, programmable logic controllers can be used in a variety of application.

2.4.5 Pick and Place Robot Using a Microcontroller

Automation, according to definition, is the use of mechanical, electronic, and digital systems to run and manage production. A robotic device used in this research can pick up items from predetermined locations and place them in specific locations. The PIC16F877A microcontroller's

C program is embedded utilising mikroC PRO for PIC to power this system. The printed circuit board (PCB) for the robot controller was created in Autodesk Eagle, and the robot arm was modelled in Autodesk Inventor.Wrist motions and arm and body movements are the two broad categories into which robot movements can be separated. Degrees of freedom, which relate to the individual joint movements associated with these two categories, are commonly used to describe industrial robots that typically have 4 to 6 degrees of freedom. Drive joints allow for the movement of robots. Links, which are stiff components, connect the numerous manipulator joints. Industrial robot joints frequently feature the rotational or linear relative motion of adjacent connections. Links move along linear joints by sliding or translating. This movement can be carried out in a number of different ways (for example, by pistons, telescopic mechanisms, and relative movement along linear tracks or rails) [7].
In Table 2.1 we have discussed about the related works done in the field of Robotics mainly related to Pick and Place Robots. A pick and place robot can be used to perform various tasks either in industrial or medical field to assist humans by giving more precise and accurate results. A Robotic arm can be implemented by various methods or techniques. In past many works were done although some designs were simple and inexpensive, others were elaborate and expensive attempts to emulate human hand movements.

Sr No.	RESEARCH PAPER	SOFTWARE	FINDING
1	Manjula VS and KaramagiRI,“Automatic Pick and Place Robot Manipulation Using a Micro-controller” Journal of Applied and Computational MathematicsISSN: 2168-9679	PIC16F877A micro-controller, Kinematic Modeling	The manipulative workspace was surrounded by a wooden stage on which the robotic arm was installed. It utilised mains voltage and had stage-mounted circuitry. There are now pick and place targets available for linear motions.
2	M.T. Islam, M.A. Wazed and T.Mohammad, “Design and Fabrication of a 5 DOF Dexterous Robotic Arm for Industrial Tasks”, International Conference on Mechanical Engineering 2007, ICME07-AM-58, 29-31 December 2007.	Arduino IDE, Solid Works 18, Bluetooth Module.	The robotic hand is able to hold a wide range of things that are vary in size, form, and weight.
3	Khin Moe Myint, Zaw Min Min-Htu, HlaMyoTun, “Position Control Method for Pick and Place Robot Arm for Object Sorting System”, International Journal of Scientific and Technology Research, ISSN: 2277-8616,Volume 5,Issue 06, June 2016.	Arduino IDE, OpenCV library	Kinematic control methods are useful for robotic system.Based on Forward and Reverse Kinematic methods the robot moves accordingly.
4	Dr.P.Gomathi, S.Baskar, “Design and Implementation of Pick and Place Robot Using Arduino for Smart Grid Monitoring”. International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682 Vol.6, No.9, September 2017 DOI:10.15693/ijaist/2017.v6i9.18-24	Arduino IDE, OpenCV Library, Software Serial Bluetooth Communication	The robot that collects swabs can be used successfully and adequately to obtain a throat sample from a covid-19 patient. The operator who will control the robot via a mobile application will determine its efficiency.
5	Jambotkar, Chaitanya. (2017). Pick and Place Robotic Arm Using Arduino. 2278-7798.	Arduino IDE, RF Transmitter and Receiver.	The robot so implemented is used to locate the position of object that is to be picked and thus then perform its opeartion by using Dc gear Motors.
6	H. R. and M. H. Safwat Hussain, ”Surveillance Robot Using Raspberry Pi and IoT,” 2018 International Conference on Design Innovations for 3Cs Compute Communicate Control (ICDI3C), Bangalore, 2018, pp. 46-55.	Raspbian buster, VNC Viewer, IOS, Python IDLE, SD Card Formatter, Adafruit IO	The robot is Controller by the aid of the Internet of Things, which is the growing technology instead of using the wired controls.
7	Mo Mo Aung, Saw Aung NyeinOo, “Design and Implementation of Trainable Robotic Arm”, International Journal of Science, Engineering and Technology Research (IJSETR), ISSN: 2278-7798, Volume 7, Issue 2, February 2018.	Matlab, Arduino IDE, Kinematic Modeling	The robot manipulator is a key component of the robotic system that maintains the accuracy and repeatability of the robotic arm. Additionally, the position and orientation of the end effector with respect to the base are calculated using the kinematics modeling method.
8	Kunal Chopade , Abhiraj Bhalerao , Prasad Doifode , Jitendra Gaikwad, 2019, Pick and Place Robotic ARM using PLC, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH AND TECHNOLOGY (IJERT) Volume 08, Issue 08 (August 2019),	WinProLadder PLC software, I-TriLoGi, WPLSoft, Micro Ladder ,Open PLC editor	A robotic arm using a PLC is a completely autonomous system, it may also be operated manually. It aids in the solution of problems arising from industrial automation.

Table 2.1: Literature Review And Related Works

Chapter 3

Methodology

The IoT-based Pick and Place Robotseeks to design and build a robotic system that uses IoT technology to automate the operation of choosing and positioning goods. The robot is intended to boost productivity, minimise human labour, and drive economic progress. Furthermore, through promoting technical improvements and effective supply chain management, the initiative coincides with the aims of Industry, Innovation, and Infrastructure. Furthermore, by minimising waste, optimising energy and resource utilisation, and supporting sustainable manufacturing practises, it contributes to responsible consumption and production. Thethe step-by-step process used to design, build, and deploy the IoT-based pick and place robot.

3.1 Methodology

The technology of "IoT-based pick-and-place robots" involves a systematic approach to developing and deploying intelligent robotic systems capable of picking and placing objects using Internet of Things (IoT) technology to increase efficiency. The next phase will focus on the key components of the methodology

- **Isolate the problem**

  Determine your requirements for pick-and-place robots that can automate certain operations in an industrial or residential environment, increasing efficiency and reducing human intervention.

- **Literature review**

  An in-depth look at his existing IoT-based pick-and-place robot, including its design, architecture, and control methods. Browse relevant research papers, journals, and web resources to gain insight into the state of the art in this field.

- **Collecting Requirements**

  Define the project's unique needs, taking into account aspects like the sort of things to be handled, the environment in which the robot will work, communication protocols, sensor capabilities, and user interface requirements.

- **System Design**

  Create a thorough system design that encompasses the physical construction of the robot, sensor and actuator selection and integration, Internet of Things connection protocols, and the software architecture needed for control and coordination.

- **Hardware Installation**

  Assemble the physical robot by connecting the needed mechanical components, sensors, and actuators to a microprocessor or embedded system. For dependable functioning, ensure appropriate power supply and circuitry.

- **Software Design**

  Create the software modules required to manage the robot's mobility, process sensor data, interface with the IoT platform, and implement pick and place capability. This might entail writing code in languages like C/C++, Python, or Arduino.

- **Integration of IoT**

  Connect the robot to an IoT platform or a cloud service. Implement the appropriate protocols for data interchange, remote monitoring, and control (for example, MQTT or HTTP). Use the capabilities of the IoT platform to analyse data, develop insights, and provide remote access.

- **Validation and Testing**

  Perform extensive testing to confirm that the robot's performance satisfies the set parameters. To test the system's dependability, accuracy, and responsiveness, run numerous scenarios and edge cases. Based on test findings, iteratively improve the design and software.

- **Delivery/Display Deploy**
  IoT-based pick-and-place robots in suitable environments, such as production lines or simulated homes. Introduce its features to stakeholders and highlight its efficiency, security features, and user-friendly interface.

- **Evaluation and documentation** Evaluate project success against pre-determined criteria such as compliance, performance, usability, and innovation. Complete documentation such as project reports, user manuals, technical specifications, etc. should be prepared for easy future reference and reproduction.

This project will use this technology to develop a functional and intelligent robotic system capable of automating object-handling tasks while leveraging IoT technology for enhanced connectivity, control and monitoring.

3.2 Block Diagram

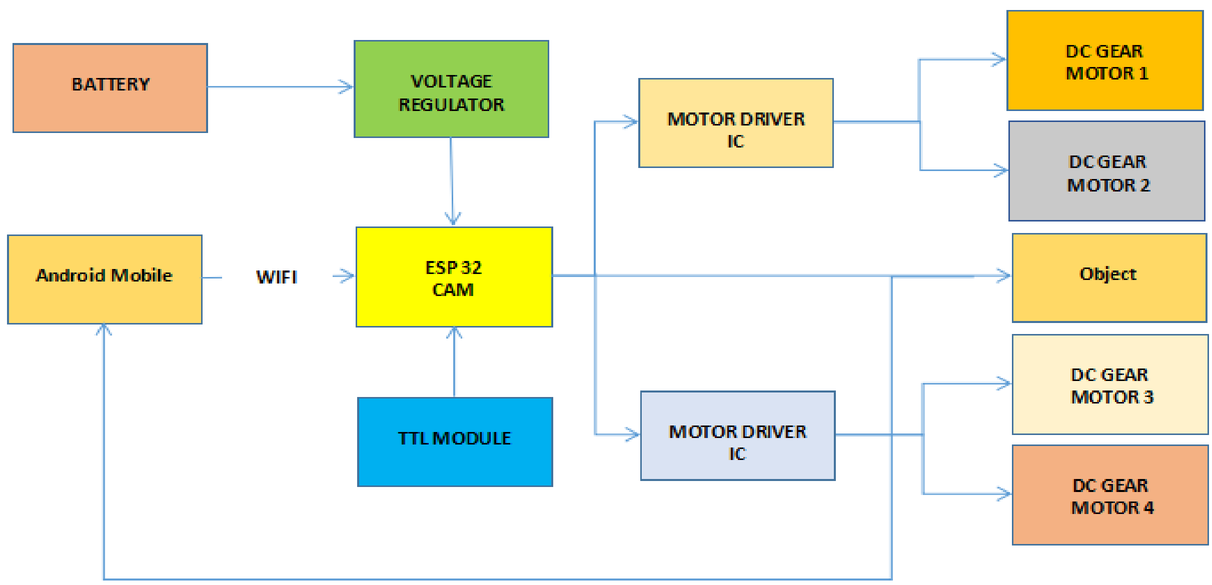

Figure 3.1: Block Diagram of Robotic Car

The block diagram of our proposed model, as depicted in figure 3.1 and figure 3.2, illustrates the systematic arrangement of components involved in our design. This design comprises two distinct sections, each playing a crucial role in the overall functionality of the system. In the first section, the ESP Cam Module serves as the primary source of signals, transmitting them to the Motor Driver IC. The purpose of this interaction is to actuate the DC Gear Motors, which are responsible for implementing the movements of the Robotic Car. By receiving signals from the ESP Cam Module, the Motor Driver IC precisely controls the motion and positioning of the Robotic Car, enabling it to carry out specific tasks with accuracy and precision. Meanwhile,

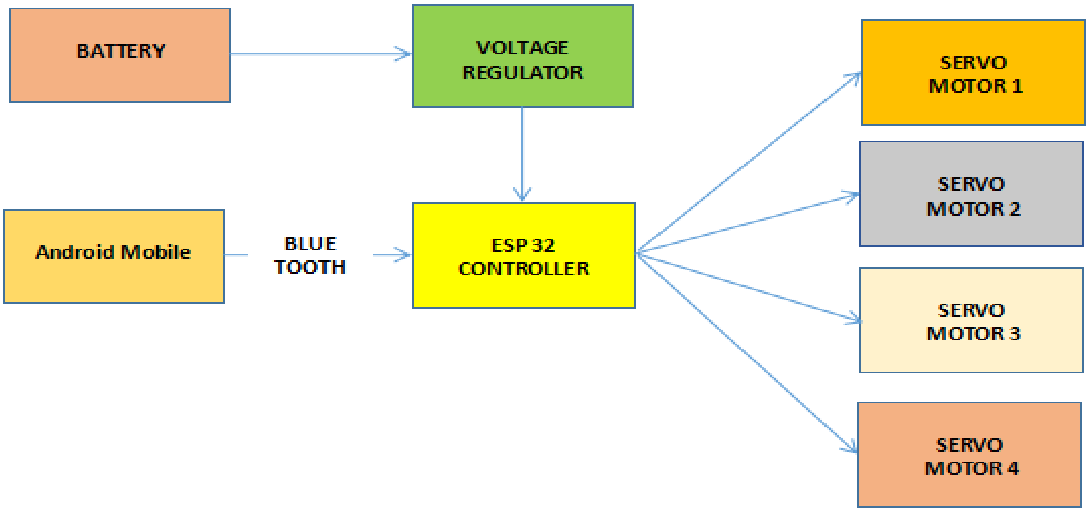

Figure 3.2: Block Diagram of Robotic Arm

in the second section, the ESP32 Controller takes center stage by directly sending signals to the servo motors responsible for implementing the movements of the Robotic Arm. This direct communication channel allows for efficient and rapid response, as the ESP32 Controller controls the servo motors position and rotation angles, resulting in smooth and coordinated movements of the Robotic Arm.

It is important to note that our system incorporates a feedback path, which serves as a vital component in ensuring the continuous monitoring of the Robotic Arm's actions. This feedback path provides real time information about the arm's position, status, and performance. This valuable data is then displayed on a Mobile Screen, allowing operators and users to have a comprehensive overview of the Robotic Arm's operations and make any necessary adjustments or interventions. By combining these sections and integrating a feedback mechanism, our proposed model offers a comprehensive and dynamic solution for controlling and monitoring the Pick and Place Robot. It facilitates precise and coordinated movements, allowing for enhanced efficiency, accuracy, and adaptability in various applications, ranging from industrial automation to scientific research and beyond.

3.3 Mathematical Modeling

Below here is the mathematical model of a 4 DOF Robotic Arm,

1. **Forward Kinematics**

   First Joint (Link 1)

   The X-coordinate of the first joint is given by:

   $$X1 = L1 * \cos(theta1) .... (1)$$

   where L1 is the length of the first link and theta1 is the angle of the first joint.

   The Y-coordinate of the first joint is given by:

   $$Y1 = L1 * \sin(theta1) .... (2)$$

   where L1 is the length of the first link and theta1 is the angle of the first joint.

   Second Joint (Link 2)

   The X-coordinate of the second joint is given by:

   $$X2 = X1 + L2 * \cos(theta1 + theta2) .... (3)$$

   where X1 is the X-coordinate of the first joint, L2 is the length of the second link, and (theta1 + theta2) is the sum of the angles of the first and second joints.

   The Y-coordinate of the second joint is given by:

   $$Y2 = Y1 + L2 * \sin(theta1 + theta2) .... (4)$$

   where Y1 is the Y-coordinate of the first joint, L2 is the length of the second link, and (theta1 + theta2) is the sum of the angles of the first and second joints.

   Third Joint (Link 3)

   X-coordinate of the third joint is given by:

   $$X3 = X2 + L3 * \cos(theta1 + theta2 + theta3) .... (5)$$

   where X2 is the X-coordinate of the second joint, L3 is the length of the third link, and (theta1 + theta2 + theta3) is the sum of the angles of the first, second, and third joints.

   The Y-coordinate of the third joint is given by:

$$Y3 = Y2 + L3 * \sin(theta1 + theta2 + theta3) \text{.................. (6)}$$

where Y2 is the Y-coordinate of the second joint, L3 is the length of the third link, and (theta1 + theta2 + theta3) is the sum of the angles of the first, second, and third joints.

End Effector

The X-coordinate of the end effector is given by:

$$X = X3 + L4 * \cos(theta1 + theta2 + theta3 + theta4) \text{.................. (7)}$$

where X3 is the X-coordinate of the third joint, L4 is the length of the fourth link, and (theta1 + theta2 + theta3 + theta4) is the sum of the angles of all four joints.

The Y-coordinate of the end effector is given by:

$$Y = Y3 + L4 * \sin(theta1 + theta2 + theta3 + theta4) \text{.................. (8)}$$

where Y3 is the Y-coordinate of the third joint, L4 is the length of the fourth link, and (theta1 + theta2 + theta3 + theta4) is the sum of the angles of all four joints.

These equations describe the forward kinematics of a 4-degree-of-freedom robotic arm, where you can calculate the X and Y coordinates of each joint and the end effector based on the given joint angles (theta) and link lengths (L).

Explanation

First Joint (Link 1)

The first joint connects to the base of the manipulator. Its position is determined by the angle theta1 and the length of the first link, L1. The X-coordinate of the first joint is found by multiplying the length of the first link (L1) by the cosine of the angle theta1. The Y-coordinate of the first joint is found by multiplying the length of the first link (L1) by the sine of the angle theta1.

Second Joint (Link 2)

The second joint connects to the first joint. Its position is determined by the angles theta1 and theta2, as well as the lengths of the first (L1) and second (L2) links. The X-coordinate of the second joint is found by adding the X-coordinate of the first joint (X1) to the product of the length of the second link (L2) and the cosine of the sum of angles theta1 and theta2. The Y-coordinate of the second joint is found by adding the Y-coordinate of the first joint (Y1) to the product of the length of the second link (L2) and the sine of the sum of angles theta1 and theta2.

Third Joint (Link 3)

The third joint connects to the second joint. It's position is determined by the angles theta1, theta2, and theta3, as well as the lengths of the first (L1), second (L2), and third (L3) links. The X-coordinate of the third joint is found by adding the X-coordinate of the second joint (X2) to the product of the length of the third link (L3) and the cosine of the sum of angles theta1, theta2, and theta3. The Y-coordinate of the third joint is found by adding the Y-coordinate of the second joint (Y2) to the product of the length of the third link (L3) and the sine of the sum of angles theta1, theta2, and theta3.

End Effector

The end effector represents the tool or object held by the manipulator. Its position is determined by the angles theta1, theta2, theta3, and theta4, as well as the lengths of the first (L1), second (L2), third (L3), and fourth (L4) links. The X-coordinate of the end effector is found by adding the X-coordinate of the third joint (X3) to the product of the length of the fourth link (L4) and the cosine of the sum of angles theta1, theta2, theta3, and theta4. The Y-coordinate of the end effector is found by adding the Y-coordinate of the third joint (Y3) to the product of the length of the fourth link (L4) and the sine of the sum of angles theta1, theta2, theta3, and theta4. These equations allow you to calculate the X and Y coordinates of the end effector based on the angles of the four joints (theta1, theta2, theta3, theta4) and the lengths of the four links (L1, L2, L3, L4) in a simple and sequential manner.

2. **Inverse Kinematics**

First Joint (Link 1)

Given the desired end effector coordinates (X, Y):

$$\text{theta1} = \text{atan2}(Y1, X1) \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

Second Joint (Link 2)

$$\text{theta2} = \text{atan2}((Y2 - Y1), (X2 - X1)) - \text{theta1} \ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

Third Joint (Link 3)

$$\text{theta3} = \text{atan2}((Y3 - Y2), (X3 - X2)) - (\text{theta1} + \text{theta2}) \ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

End Effector

theta4 = desired orientation angle - (theta1 + theta2 + theta3).................. (12)

These equations allow you to determine the joint angles (theta1, theta2, theta3, theta4) of a robotic arm with 4 degrees of freedom based on the desired end effector coordinates (X, Y). The atan2 function calculates the arctangent of the given ratios, taking into account the signs of the input values to determine the correct quadrant of the resulting angle.

Explanation

First Joint (Link 1)

The angle theta1 is calculated using the atan2 function, which returns the angle whose tangent is the ratio of Y1 and X1. This calculates the angle between the positive X-axis and the vector from the origin to the desired end effector position.

Second Joint (Link 2)

The angle theta2 is calculated using the atan2 function again, but this time the inputs are the differences in Y and X coordinates between the second and first joints (Y2 - Y1) and (X2 - X1), respectively. By subtracting theta1 from the result, we obtain the angle between the first and second links of the robotic arm.

Third Joint (Link 3)

The angle theta3 is calculated in a similar manner as theta2. It uses the differences in Y and X coordinates between the third and second joints (Y3 - Y2) and (X3 - X2), respectively. However, in this case, we subtract the sum of theta1 and theta2 from the result. This yields the angle between the second and third links of the robotic arm

End Effector

The angle theta4 represents the desired orientation angle of the end effector. To obtain this angle, we subtract the sum of theta1, theta2, and theta3 from the desired orientation angle. This ensures that the total joint angles of the robotic arm, including the orientation angle, add up to the desired orientation.

By calculating the joint angles using these equations, you can determine the configuration of the robotic arm needed to reach a desired end effector position and orientation

3.4 Component Selection

This section contains two things Software Tools and Hardwarde Components.

3.4.1 Software Tools

1. **Arduino IDE**

    - The Arduino IDE is an open-source programme created by Arduino.cc that is primarily used for authoring, compiling, and uploading code to nearly all Arduino Modules.
    - It is an official Arduino programme that makes code compilation so simple that even a layperson with no prior technical expertise may start learning.
    - It is accessible for all operating systems, including MAC, Windows, and Linux, and runs on the Java Platform, which has built-in functions and commands for debugging, editing, and compiling code
    - Arduino modules include the Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro, and many others.
    - On the board of each of them is a microcontroller that has been programmed and takes input in the form of code.The core code, also known as a sketch, written on the IDE platform will eventually generate a Hex File, which is then transmitted and posted in the board's controller.
    - The IDE environment consists primarily of two fundamental components: the Editor and the Compiler, the former of which is used for creating the needed code and the latter for compiling and uploading the code into the supplied Arduino Module.
    - This environment supports both the C and C++ programming languages.

2. **Proteus 8 Professsional**

    - Proteus Design Suite (created by Labcenter Electronics Ltd.) is a software tool set used mostly for drawing schematics, modelling Electronics and Embedded Circuits, and designing PCB Layouts.
    - Engineering students and experts use Proteus ISIS to generate schematics and simulations of various electrical circuits.

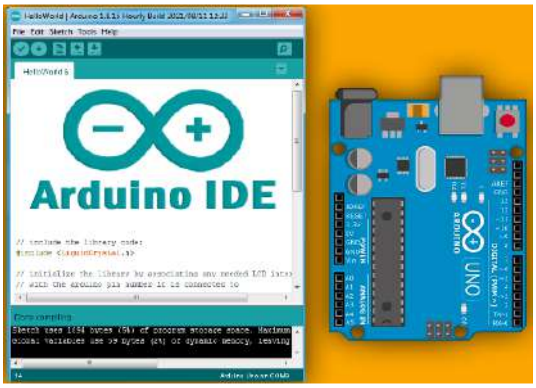

Figure 3.3: Arduino IDE

- Proteus ARES is used to develop electronic circuit PCB Layouts.
- It is accessible in English, Chinese, Spanish, and French.
- Proteus is highly forgiving in circuit design and operates under perfect conditions, i.e. if no pull up resistors are used in Proteus simulation, it will not return a trash value.
- We utilise Proteus ARES for PCB design as well.
- Proteus is also used to build and test programming codes for various microcontrollers such as Arduino, PIC Microcontrollers, 8051s, and so on.

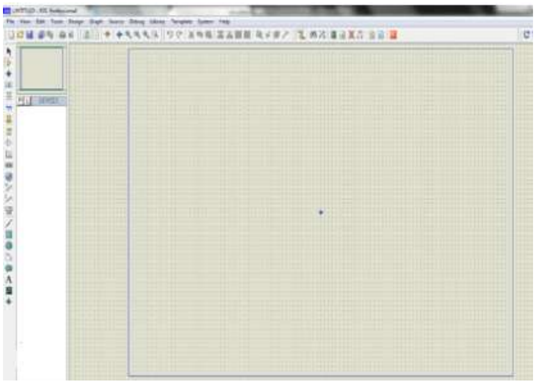

Figure 3.4: Proteus 8 Professional

3. **MATLAB**

MATLAB is a software package for high-performance mathematical computing, visualisation, and programming. It provides an interactive environment with hundreds of built-in tools for technical computing, graphics, and animations.MATLAB is an abbreviation for Matrix Laboratory. MATLAB was created to apply a basic approach to matrix software produced by the LINPACK (Linear system package) and EISPACK (Eigen system package) programmes.MATLAB is a sophisticated programming language environment with improved data structures, built-in editing and debugging tools, and support for object-oriented programming.MATLAB is multi-paradigm. As a result, it may be used with a variety of programming methods, including functional, object-oriented, and visual.

Here are some of Matlab's important features and capabilities:

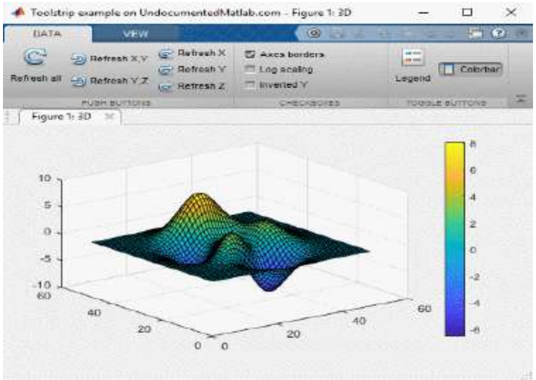

Figure 3.5: MATLAB

- Matlab provides an interactive and user-friendly environment in which you may create and execute code, visualise data, and conduct debugging activities. It includes both a command-line interface and a graphical user interface (GUI) called the Matlab Desktop.
- Data Analysis and Visualisation: Matlab is particularly adept at handling and analysing huge datasets. It has several built-in functions for data processing, statistical analysis, curve fitting, and visualisation. To successfully show your data, you may make 2D and 3D charts, create animations, and customise visualisations.
- Matlab offers a large library of mathematical functions and libraries for conducting sophisticated computations and simulations. Matrix and vector operations, linear algebra, numerical integration, differential equations, optimisation, and other functions are all supported. Matlab's tremendous calculation capabilities allow it to be used to solve a wide range of scientific and engineering challenges.
- Matlab is commonly used for building and prototyping algorithms. It provides a comfortable environment for creating and testing code, allowing you to iterate and refine your algorithms rapidly. Simulation tools for modelling and simulating dynamic systems, control systems, and communication systems are also available in Matlab.
- Matlab has a vast ecosystem of toolboxes and add-ons that enhance its capability for

certain subjects and applications. Image processing, signal processing, control systems, machine learning, optimisation, and other topics are covered in these toolboxes. They offer specialised features, algorithms, and processes that are suited to the unique demands of certain fields.

- Matlab's integration and deployment capabilities make it simple to integrate with other programming languages, software, and hardware. You may communicate with external devices, databases, and files, as well as exchange data with programmes written in C/C++, Python, or Java. Matlab also allows you to run your code as standalone executables, web apps, or integrated modules within bigger systems.

  Overall, Matlab is a strong and adaptable tool for data analysis, algorithm development, and solving complicated mathematical problems. It is a popular choice for scientific computing and research because to its wide function library, interactive interface, and visualisation features.

4. **MS Visio**

   Microsoft Visio is a diagramming application for creating basic and complicated diagrams as well as vector graphics. It allows you to design elaborate organisation charts, floor layouts, and pivot diagrams based on your business requirements. It has built-in templates that allow you to virtually build diagrams of any complexity, such as shape-based artwork or intricate drawing.

   Types of Visio File

   The Visio programme supports the following file types:

   - **VSD (Visio Drawing)**

     The Visio binary file format is connected with this file extension. It is used to keep flowchart and diagram document files.

   - **VSS (Visio Stencil)**

     This file type is related to Microsoft Visio. The document includes smart shapes (stencils). The file is a binary Visio document.

   - **VST (Visio Template)**

     Microsoft Visio templates are connected with the VST file suffix.

   - **VDW (Visio Web Drawing)**

Microsoft Office Visio is coupled with the VDW extension. It includes a web drawing developed in Microsoft Office Visio.

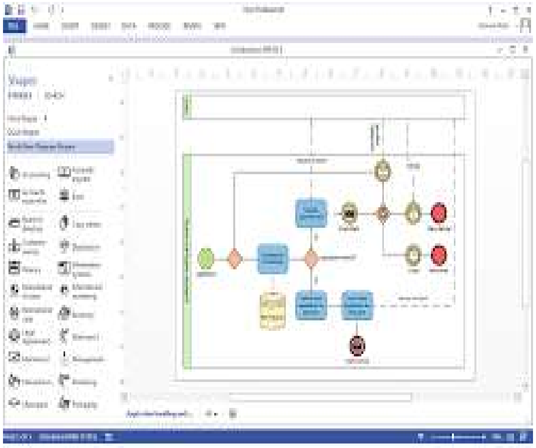

Figure 3.6: MS Visio

5. **Fritzing**

   Fritzing is an open source software tool for designing and prototyping electrical circuits and projects. A user-friendly interface allows users to create and share schematics, schematics and PCB layouts. Designed for beginners, Fritzing features a drag-and-drop interface that makes it easy to create and modify circuit designs. It also contains various components and modules that can be used in electrical applications.

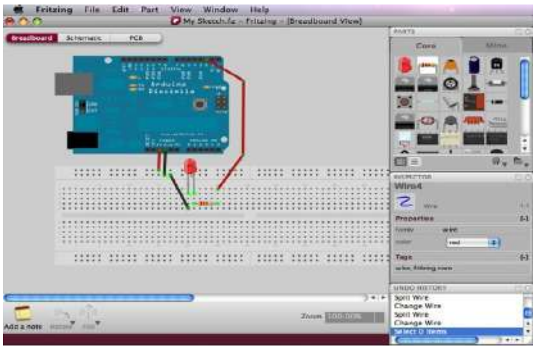

Figure 3.7: Fritzing

3.4.2 Hardware Components

1. **Esp 32 controller**

   The ESP32 is a high-performance microcontroller module commonly utilised in Internet of Things (IoT) applications. Espressif Systems created it, and it has gained popularity because to its adaptability, low power consumption, and various networking choices as shown in figure 3.7.

Figure 3.8: ESP 32 Controller

Here are some of the ESP32 controller's important features and capabilities:

- **Dual-Core CPU**

  The ESP32 is equipped with a dual-core Tensilica Xtensa LX6 CPU, which enables multitasking and the efficient execution of complicated tasks. The dual-core design allows both user application code and system activities to execute concurrently.

- **Wi-Fi and Bluetooth Connectivity**

  The ESP32 includes Wi-Fi and Bluetooth capabilities, making it suited for a variety of IoT applications. It supports 2.4 GHz Wi-Fi 802.11 b/g/n, allowing it to communicate wirelessly with routers and other devices. It also supports the Bluetooth Classic and Bluetooth Low Energy (BLE) protocols, allowing it to connect to smartphones, wearables, and other Bluetooth devices with ease.

- **High-Speed Interfaces**

  The ESP32 includes a variety of high-speed interfaces such as SPI, I2C, UART, I2S, and SD/SDIO/MMC. These interfaces allow sensors, monitors, memory cards, and other auxiliary devices to communicate with one another.

- **GPIO Pins**

  The ESP32 has a large number of GPIO pins for interacting with external components like as sensors, actuators, and displays. These GPIO pins provide a variety of functions like as digital input/output, analogue input, PWM, and interrupt management.

- **Memory and Storage**

  The ESP32 has enough of memory, with up to 520 KB of SRAM for programme execution and data storage. It also has external flash memory choices for storing bigger quantities of data, firmware, and other resources.

- **Low Power Consumption**

  The ESP32 is power-efficient, making it ideal for battery-powered and energy-conscious applications. It has a number of power-saving modes, including deep sleep, which uses the least amount of power while the device is not actively processing tasks.

- **Development Environment**

  The ESP32 may be programmed using a variety of programming environments, including the Arduino IDE, the ESP-IDF (Espressif IoT programming Framework), and

MicroPython. These environments provide libraries, examples, and tools that make it simple to create and distribute programmes on the ESP32.Other components of the ESP32 controller include a real-time clock (RTC), analog-to-digital converters (ADCs), digital-to-analog converters (DACs), touch sensors, and cryptographic hardware acceleration. These characteristics improve its capabilities and allow for the creation of more complicated functions.

The ESP32 is extensively used in IoT projects, home automation, industrial automation, wearable devices, and other applications that demand wireless communication, low power consumption, and efficient processing because to its broad feature set and sturdy performance. Its versatility, rich documentation, and significant community support make it a popular option among both developers and enthusiasts.

2. **Esp 32 Cam Module**

The ESP32-CAM module is a compact camera module that combines the ESP32 microcontroller with a camera sensor as shown in figure 3.8. It is intended for applications that require camera capability in addition to the capabilities of the ESP32 microcontroller.

Figure 3.9: ESP 32 Cam Module

The following are the ESP32-CAM module's primary characteristics and functionalities:

- **Sensor in the camera**

  The ESP32-CAM module has a camera sensor for image and video capture. The resolution of the camera sensor varies depending on the module, however popular values include 2MP and 5MP. A serial link connects the camera sensor to the ESP32 microcontroller. The module incorporates an ESP32 microcontroller, which offers the processing power and capabilities needed to control the camera, capture photographs, and do other activities. The ESP32 microcontroller has dual-core processing, Wi-Fi connectivity, Bluetooth capability, GPIO ports, and the other features mentioned previously.

- **Wi-Fi and Bluetooth integration**

  The ESP32-CAM module has Wi-Fi and Bluetooth connectivity, enabling for wireless communication and remote control of the camera module. This function allows the module to connect to networks, stream video through Wi-Fi, and communicate with other Bluetooth devices.

- **Memory and storage**

  Typically, the module comprises flash memory for storing firmware, camera setups, and recorded material. It may also support microSD cards, allowing for the storing of photographs and videos on external memory cards.

- **GPIO Pins**

  The ESP32-CAM module includes a number of GPIO pins for interacting with external components and sensors. These pins enable the module's capabilities to be expanded and connected to other devices or peripherals.

- **Programming and Development**

  The ESP32-CAM module may be programmed using the Arduino IDE or the ESP-IDF (Espressif IoT Development Framework), together with the appropriate libraries and examples. This makes it simple for developers to manage the camera, take photos or video, and incorporate it into IoT projects or apps.

- **Power Consumption**

  Because the module is designed to be power-efficient, it is appropriate for battery-powered applications. It offers a variety of power-saving modes and choices for optimising power usage based on the project's individual needs. The ESP32-CAM module has a tiny form factor, making it easy to integrate into small devices or projects. Its tiny size offers for greater positioning and installation flexibility.

  The ESP32-CAM module is used in a variety of fields, including surveillance systems, home automation, robotics, monitoring systems, and IoT projects requiring camera capabilities. It combines the capabilities of the ESP32 microcontroller with a camera sensor to provide a simple and adaptable solution for image and video capture in embedded systems

3. **4 DOF Un-Assemble Robotic Car Kit**

   An unassembled robotic vehicle kit is a package that contains all of the components and pieces needed to make a robotic automobile but is not preassembled as shown in figure 3.9. Mechanical components, electronic components, sensors, a microcontroller or development board, and other accessories are commonly included in a kit to build a working robotic automobile.

Figure 3.10: Robotic Car Kit

4. **4 DOF Un-Assemble Robotic Arm Kit**

   A 4 DOF (Degrees of Freedom) unassembled robotic arm kit is a kit that contains all of the components and pieces needed to construct a robotic arm with four degrees of freedom as shown in figure 3.10. Mechanical components, electrical components, servos or motors, a control board, and other accessories are included in the kit to build a working robotic arm.

Figure 3.11: Robotic Arm Kit

The following are the main features of a 4 DOF unassembled robotic arm kit:

- **Mechanical Components**

  The kit contains the mechanical components needed to build the robotic arm. Aluminium or acrylic brackets, linkages, joints, and screws are common components. They enable the robotic arm's construction and mobility.

- **Servos or Motors**

  The kit contains servos or motors that serve as actuators to move the robotic arm. A servo or motor controls each degree of freedom, letting the arm to move in different directions and accomplish numerous tasks.

- **Degrees of Freedom**

  A four-degree-of-freedom (DOF) robotic arm features four moveable joints that allow for four separate degrees of freedom. Each joint provides a unique range of motion, such as rotation or bending, allowing the arm to achieve various postures and orientations.Unassembled robotic arm kits often include thorough assembly instructions in the form of a handbook or guide. Users are guided through the process of constructing the mechanical components, connecting the servos or motors, and wiring the electrical components by the instructions. Users may create a working robotic arm with four degrees of freedom by following the assembly instructions, connecting the electronic components, and programming the control board. Unassembled robotic arm kits provide an engaging and informative approach to learn about robotics ideas, mechanical systems, and control mechanisms. They are appropriate for amateurs, students, and anybody who wants to obtain hands-on experience with robotic arm technology.

5. **Motor Driver IC's**

   In robotics, motor driver ICs are often used to operate DC motors from microcontrollers. They are commonly utilised in automation since they are a vital component in regulating mobility in autonomous robots. They can also be found in more common places like office appliances and car electronics.

   L298N Motor Driver IC

   The L298N is a dual H-Bridge motor driver that can regulate the speed and direction of two DC motors at the same time. The module can power DC motors with voltages ranging from 5 to 35V and peak currents of up to 2A.

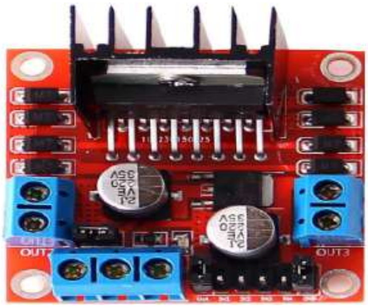

Figure 3.12: L298N Motor Drive IC

6. **Dc Gear Motors**

   A gear motor is a combination of an electric motor and a power reduction that decreases the number of revolutions while increasing the torque of the working shaft.

Figure 3.13: DC Gear Motor

Such electric motor gears are commonly employed in contemporary machines and systems, and it is applicable to a wide range of equipment. Some hybrid versions combine convenience and durability. The gears are constructed of metal while the housing is made of plastic. This design provides a low noise level during device operation, and the voltage can range from 12 to 24 V.

Chapter 4

Result and Discussions

4.1 Software Results

Figure 4.1 aims to emulate the behaviour and functionality of a 4-DOF robotic automobile using Arduino. The car's motions are controlled by an L298N motor driver IC and four DC gear motors. The project provides a virtual environment for testing and validating the design and performance of the robotic car by modelling the system in Proteus. The simulation evaluates the motor driver's ability to manage the four motors, allowing the car to go forward, backward, and turn. Furthermore, the simulation enables for the assessment of the car's general stability, manoeuvrability, and response to various commands.The simulation allows for the identification and correction of any design defects or programming errors, assuring the smooth and efficient functioning of the robotic car.

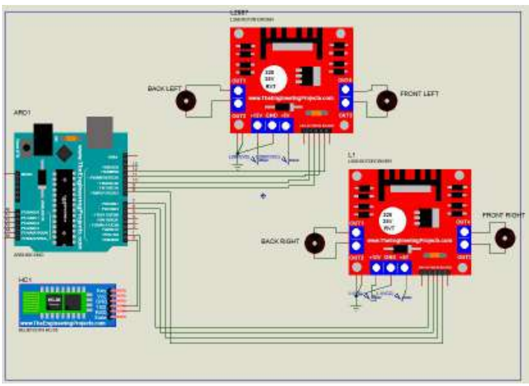

Figure 4.1: Simulation of Robotic Car

4.1.1 Matlab Implementation

- **2 DOF Robtic Arm**

  Figure 4.2 depicts the development and visualisation of a control system for a two-jointed robotic arm. It uses MATLAB to create and build the control algorithms needed to manipulate the arm's movement. Forward and inverse kinematics computations, joint angle control, and trajectory planning are all part of the implementation. The project enables for the examination and assessment of the robotic arm's motion and performance in a virtual environment by modelling it in MATLAB. The resulting image depicts the arm's configuration, joint angles, and probable trajectories. This visualisation gives information on the reachability, workspace, and path planning capabilities of the arm. The next parts describe the MATLAB implementation process and show the resulting figure, which highlights the control system and the movement of the 2-DOF robotic arm.

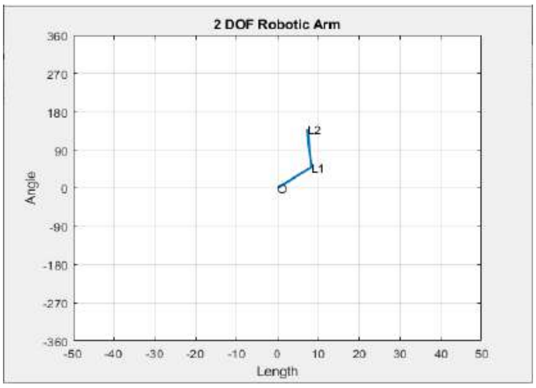

Figure 4.2: 2 DOF Robotic Arm

- **4 DOF Robtic Arm**

  The 4-DOF Robotic Arm project's MATLAB implementation entails building and visualising the control system for a multifunctional robotic arm with four joints. The research uses MATLAB to build and implement control algorithms that allow for exact modulation of the arm's motions. Forward and inverse kinematics computations, joint angle control, and trajectory planning are all part of the implementation. The project allows for in-depth examination and assessment of the robotic arm's movements and performance by simulating it within the MATLAB environment. The generated figure 4.3 depicts the 4-DOF robotic arm's configuration, joint angles, and probable trajectories in detail. This visualisation provides useful information about the arm's reachability, workspace, and path planning skills. It allows users to study the arm's dexterity, flexibility, and capacity to complete difficult tasks in various angles. The control system's MATLAB implementation

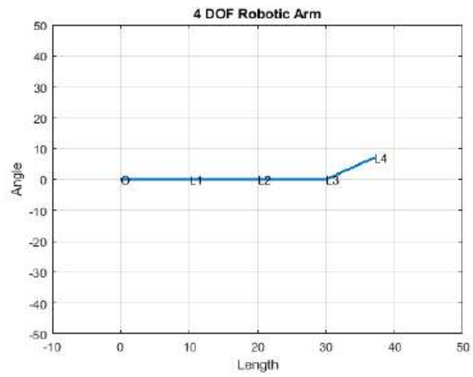

Figure 4.3: 4 DOF Robotic Arm

allows users to experiment with different input parameters, such as desired end-effector locations and orientations as shown in figure 4.4. This flexibility enables the arm to correctly perform certain activities or follow predetermined trajectories. The system also includes collision avoidance methods to assure the robotic arm's safety during operation. The 4-DOF robotic arm MATLAB solution and accompanying image provide a thorough and unique technique to modelling and visualising the arm's capabilities. The project is a great resource for researching the arm's performance, optimising its control system, and investigating its possible applications in fields such as manufacturing, automation, and research.

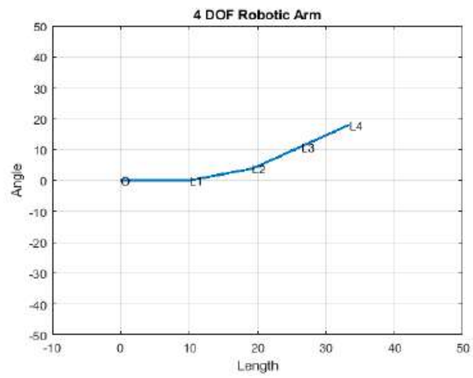

Figure 4.4: 4 DOF Robotic Arm

4.2 Hardware Results

The hardware results of the IoT-based pick and place robot as shown in figure 4.5 and 4.5, which incorporates a 4-DOF robotic arm and a robotic vehicle powered by an ESP32-CAM module and controller, provide vital insights into the system's performance and potential. This thorough review covers the hardware implementation's important discoveries and accomplishments. Picking and positioning things with the 4-DOF robotic arm requires precise and controlled motions as shown in figure 4.5. Four servo motors and proper linkages are used in the hardware configuration to accomplish the requisite range of motion. The arm performs functions such as item handling, achieving certain locations, and maintaining stability while operating successfully. Control algorithms and sensory feedback systems guarantee that commands are executed accurately and efficiently. The hardware findings show that the robotic arm, robotic vehicle, and

Figure 4.5: Robotic ARM

IoT infrastructure were successfully integrated. Through IoT connection, devices may interact, exchange data, and receive orders from a central control system. This connection provides real-time monitoring, remote control, and effective coordination of pick and place activities, as well as autonomous navigation of the automobile. The hardware findings obtained open up possibilities for a variety of applications, including warehouse automation, industrial processes, and surveillance systems. The capacity of the 4-DOF robotic arm to conduct accurate pick and place jobs increases productivity and efficiency in production situations. The robotic car's autonomous navigation skills employing computer vision allow it to travel complicated terrains, check surroundings, and collect data in a variety of settings. The IoT-based pick and place robot project's complete and distinctive hardware findings emphasise the successful development of the 4-DOF robotic arm and the robotic vehicle utilising the ESP32-CAM module and controller as shown in figure 4.6. The integration of these components demonstrates their capacity to execute complicated tasks, navigate surroundings autonomously, and contribute to IoT-enabled automation systems.

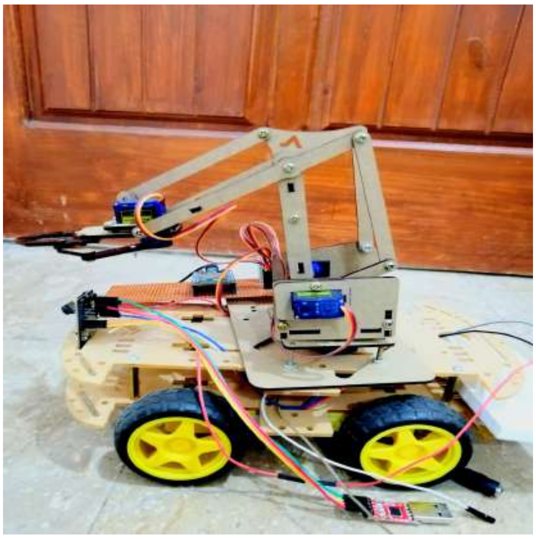

Figure 4.6: Pick and Place Robot

Chapter 5

Conclusion and Future Work

5.1 Conclusion

The IoT-based pick and place robot project demonstrated the effective installation of an intelligent robotic system that uses IoT technologies. The robot was able to choose and position goods autonomously, demonstrating its capability in industrial automation and logistical applications.The incorporation of IoT capabilities enables the robot to be controlled and monitored remotely. The robot may be controlled and monitored from a centralised location using IoT protocols and connectivity choices, increasing its usefulness and versatility.This shows the robot's capacity to recognise and handle things properly, demonstrating its potential for efficient and precise work in a variety of sectors.The pick and place robot exhibited enhanced efficiency and productivity by using IoT technology. The seamless integration of IoT-enabled functions improved the object manipulation process and minimised human interaction, resulting in higher productivity and decreased mistakes.

The initiative highlighted the ability of IoT in bridging the physical-digital divide. The experiment demonstrated how IoT may enable smooth communication and data sharing, opening up options for further developments in robotic systems by connecting the robot to the internet and utilising cloud-based services.Overall, the findings of the "IoT-based Pick and Place Robot" project will highlight the effective deployment of an intelligent robotic system that integrates IoT technology with object manipulation skills. The project's outputs emphasise the possible uses, advantages, and future prospects for IoT-driven robots in industrial automation and other important disciplines.

5.2 Limitations

IoT-based pick-and-place robot limits may vary depending on the specific implementation and context. However, IoT-based pick-and-place robots have some common limitations.

- To perform effectively, IoT devices require network access. If there are problems with the network or internet connection, the robot's capacity to communicate, receive orders, or transfer data may suffer. This might cause delays or disturbances in the robot's operation.
- IoT devices, such as pick and place robots, are susceptible to cybersecurity risks. If the communication or control systems of the robot are not effectively protected, they may be vulnerable to hacking, unauthorised access, or data breaches. This might jeopardise the robot's operation, integrity, or possibly constitute a safety issue.
- IoT devices typically operate within a specific area of a network or connectivity infrastructure. If the robot moves out of range or out of coverage, it may lose connectivity and affect its ability to receive instructions or transmit data. This limitation can limit the robot's mobility and flexibility within its operating environment.
- Implementing an IoT-based pick and place robot system might be costly. Hardware components, network infrastructure, software development, maintenance, and continuous connectivity fees are examples of costs. In certain cases, pricing may hinder the adoption or scalability of IoT-based solutions.

5.3 Recommendations for Future Work

- **Improve Object Recognition**

  By combining modern machine learning algorithms, the object recognition system may be improved further. Training the system with a larger dataset and employing methods such as deep learning can improve object identification accuracy and broaden the robot's capabilities.
- **Autonomous Path Planning**

  Using autonomous path planning techniques, the robot can optimise its movement and identify the most effective pathways for picking and placing goods. This can increase overall efficiency and decrease the time required for item handling.

- **Expand Communication Protocols**

  Consider adding more communication protocols to the IoT-based pick and place robot's connectivity possibilities. This may entail incorporating protocols such as MQTT or CoAP to allow for smooth communication with a broader range of IoT devices and platforms.

- **AI and Machine Learning Integration**

  Investigate the integration of artificial intelligence (AI) and machine learning algorithms to enable the robot to learn and adapt to various object forms, sizes, and circumstances. This increases the robot's adaptability and capacity to handle a wider range of things.

- **Robustness and Reliability**

  Focus on enhancing the robot's robustness and reliability through thorough testing and the implementation of fault tolerance systems. In real-world circumstances, this will ensure constant performance and minimise downtime.

  These suggestions attempt to improve the capabilities, performance, and usability of the IoT-based pick and place robot. Future work can help to the development of more advanced and efficient robotic systems for industrial automation and other relevant domains by investigating these topics.

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