Design of a Real Time Image Processing based Industrial Pick and Place Robot with Path Learning

An Undergraduate CAPSTONE Project
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Faculty of Engineering
American International University - Bangladesh

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A CAPSTONE Project submitted to the Faculty of Engineering, American International University - Bangladesh (AIUB) in partial fulfillment of the requirements for the degree of Bachelor of Science in their mentioned respective programs.

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DECLARATION

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APPROVAL

The CAPSTONE Project titled **"Design of a Real Time Image Processing Based Industrial Pick and Place Robot with Path Learning"** has been submitted to the following respected members of the Board of Examiners of the Faculty of Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in the respective programs mentioned below on **January 2023** by the following students and has been accepted as satisfactory.

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ABSTRACT

Our project goal is to research, analyze, and build a robot that performs real-time image processing based on object selection and placement from one place to another. As we all know, the demand for industrial products is increasing day by day, so we developed this robot in such a way that it can work nonstop and more efficiently. Our robot is based on automation technology that is dynamically picking and putting things in their place automatically. It has advanced sensors that sort products by color and keep them on designated shelves or conveyor belts. This color detection smart camera sensor, called Pixy2 Cam, can work independently. It has a built-in microprocessor, and it works through a hue-based color filtering algorithm. This camera calculates the hue and saturation of each RGB pixel from the image sensor and uses these as a primary filtering parameter. This camera only needs to be trained with color through a software program called Pixymon. The detected object data was sent to the microcontroller (ATmega328p), and the microcontroller commanded the motor to move and followed the line through the IR sensor as programmed. The Arduino IDE software is used to program the microcontroller. The entire programming code is sent to the Arduino UNO microcontroller. Now a day's traditional robotic arm can only pick and place the product only specific location. But our proposed robot can detect the product wherever it is. As a result, this technology has the potential to improve the efficiency and accuracy of the work.

Chapter 1

INTRODUCTION

1.1. Overture

The term robotization was included the vehicle business around 1946 to depict the utilization of programmed and controls in automated creation lines. The term is utilized generally in an assembling setting; however, it is additionally applied external assembling regarding a check of framework where there is a critical replacement of mechanical, electrical, or electronic activity for human exertion and insight. Today, we use robotic arms for everything from building a computer's motherboard to assisting with open heart surgery. We have come a long way from the first incarnation of robotic arms. The first robotic arm, which Devol and Engleberger called the Unimate #001, was made in 1959. In 1961, Devol was awarded a patent for his robot invention and he and Engelberger established the world's first robot company, Unimation—an abbreviation of the term "universal automation." The first robot was installed at a General Motors plant in New Jersey to assist a hot die-casting machine. Traditional robots are heavily utilized in manufacturing environments. Although, collaborative robots (or "cobots") are now the fastest-growing category of programmable robotic arms. This new category, pioneered by Universal Robots in 2008, has forever changed the history of robots. Thanks to innovations in automation safety, robots are no longer isolated behind safety caging. Robots, for the first time, are now working in direct collaboration with human workers. [1]

The main goal of the project is to create a robot that can pick a predefined object and place it into separate divisions by color. Raspberry Pi has discovered many useful and modifiable implementations in robotic systems. The Raspberry Pi does not implement any of the usual motor control peripherals and it is available at a low cost. To control the servos, the Arduino UNO was used. The sketch code is built to create a robotic arm with local web and image processing with a slider to automatically adjust the position of the servomotor. [2]

1.2. Engineering Problem Statement

The main issue driving the start of the project is the fact that the manufacturing industry is growing at a relatively faster rate. Most companies produce high payload robotic arms. Fewer companies are making an affordable, lightweight robotic arm. Therefore, a lightweight and affordable robot is developed to solve this problem. Plastic material is used to make the robot arm's body and a camera (Pixycam) has been set up to provide basic identification of the object being transported. Which is more expensive. Beside this if the package code/label of the product is somehow damaged or erased the robot will not recognize the product. As a result, it will not pick up. The robot arm uses five servo motors for overall operation; four for its joint and one for the clamping mechanism. The clamps are designed and manufactured using Perspex due to the light weight and high strength of the material. The robot arm's behavior is regulated by the Basic Stamp programming sequence, and the device distinguishes between materials and other objects based on the theory of reflections and performs subsequent operations. SolidWorks is used to model the detailed design of the robot arm and simulate the movement of the device. There has been significant progress made when it comes to robots perceiving and navigating their environments. Here our robot uses path learning system. So, if the system did not implement properly, it will faces major problems of movement.

1.3. Related Research Works

The first programmable robotic arm was described in Devol's patent which was called the Unimate, a combination of the words "universal" and "automation." This machine moved with six degrees of freedom and stored step-by-step digital commands making it the first industrial robot ever created. Devol's robotic arm was designed for high-speed handling of parts up to 500 pounds and could perform a variety of tasks. The introduction of robots transformed the automotive industry, allowing production lines to increase both efficiency and quality. The Unimate robot paved the way for today's automatic production lines in many industries. [3]

Robots are considered as an essential piece of businesses. The number of inhabitants in modern robots pursued expanding direction with the last year establishing another deals record (International Federation of Robotics, 2015). In 2015, offer of 240,000 units set apart interestingly, uncovered 8% worldwide year-on-year development. New establishments of modern robots of around 1.3 million are theorized during 2015-2018. [4]

Many industrialists and academic professionals have done research about this topic and it has always been an interesting topic to ponder upon i.e., the material handling system. Therefore, the following review has been written specially to find out about the previous research done on this very particular topic.

1.3.1. Earlier Research

A. Burlacu describes about a real-time architecture for visual servo control of robotic manipulators using nonlinear predictive control. Visual servo has been explored in many different ways. The main goal of the visual servo system is that the image function achieves the desired configuration. Visual servo architectures can be classified as image-based (IBVS) and position. Visual predictive control method applied in 6 d.O.f Eye-to-hand servo system. Using instants as visual features, instantaneous prediction by reference trajectory control achieves a complete performance evaluation of the best instant. [5]

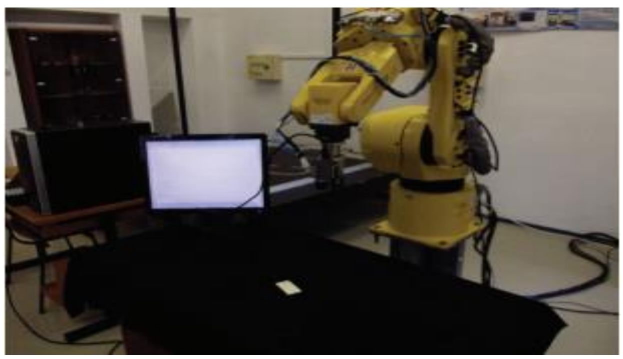

FIGURE 1.1: The visual servoing system

In this paper, Paulo da Cunha Possa design a framework for real-time image and video processing enabling develop a flexible and easily customizable environment for prototyping different processing techniques overview of different requirements and techniques of image and video processing featuring FPGAs. Three real-time video processing algorithms were combined to show the advantages and characteristics of their approach. A framework for real-time image and video processing applications. The objective of this framework is to design, explore, evaluate different images, and video processing modules. They used a low-cost Altera`s FPGA device EP2C35 from the family Cyclone II. Moreover, the performance achieved allows the implementation of applications with hard real-time constraints. [6]

FIGURE 1.2: Color detection with tracking results: a. Image original; b. Image with a red book detected.

In 1994, EDUARDO ZALAMA's study said that a real-time, unsupervised neural network controller that can learn to guide a mobile robot towards a target located at an arbitrary location in a 2-D workspace. The neural network controller must compensate in real-time for unexpected miscalibrations, such as changes in the robot's plant, and changes in the environment, such as moving targets or slippery floors. The NETMORC is always capable of learning, allowing it to adapt to changes in the plant due to wear and tear that may result from normal operation, or from sudden modifications of the plant. This property affords incremental and continuous learning, and adaptation to plant changes such as wear and tear of wheels, and other miscalibrations that may result from normal operation. [7]

M. Weyrich research was about a path planning algorithm which considers location, orientation and arrangement of defects on the conveyed objects. In the industrial quality control, instead of manual inspection, conventional vision based automatic inspection has been applied. Therefore, vision-based path planning which can be applied for guiding the manipulator to process defective objects, is becoming a critical issue in vision based automatic inspection system. It can be divided into some steps. A non-processable object which is applied for the development of a vision-based automatic inspection and path planning system for processing conveyed objects. The prototype system is able to automatically inspect the surface of objects and remove the detected defects. [8]

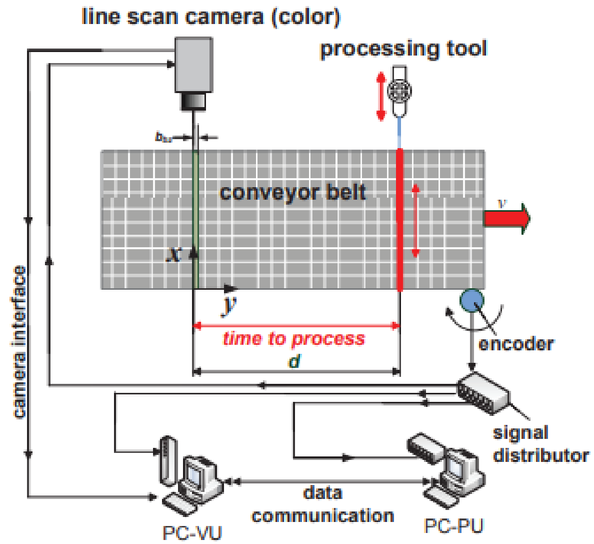

FIGURE 1.3: Configuration of inspection and processing system

G. Michalos proposed a Machine vision that is used in many assembly and welding applications in order to provide image-based solutions for a robot control process. Although 2D systems have proven very reliable, fast and accurate in past applications, the development of innovative flexible assembly technologies and the increasing product variability is continuously posing new challenges, in terms of process adaptation capabilities. The use of highly automated assembly lines that are mostly robot based and the introduction of assembly technologies, which are performed in the three-dimensional space, require monitoring systems capable of fast and accurate, real time process control. The complex geometry of the components to be assembled requires that these tasks are carried out in a 3D space, thus necessitating the use of vision systems with 3D capabilities. Effective calibration application of algorithms involving sub-pixel disparity. [9]

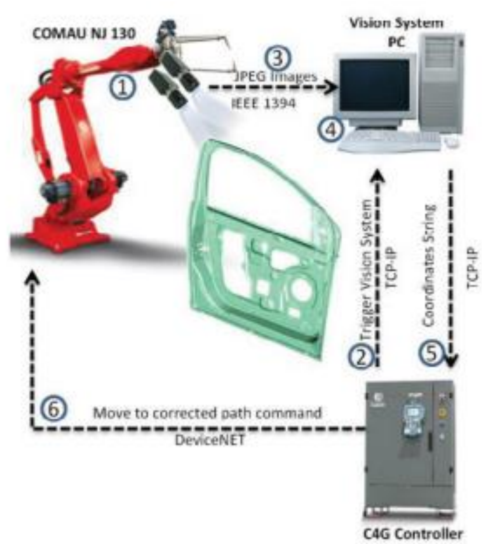

FIGURE 1.4: Vision system integration with the NJ130 robot

1.3.2. Recent Research

According to the findings of this paper, a robot bin-picking platform might use a Convolutional Neural Network (CNN) model that was initially trained using data from humans, and then the robot would continuously train the model to improve its accuracy. When it comes to the human component, a user uses a depth image captured by a lidar sensor to identify parts that can be picked up or left behind. This information is used to create a referenced 3D partial point cloud of a block for the Iterative Closest Point (ICP) algorithm. [10]

In this paper, the idea of robotics for bin picking, which is frequently done manually here, has the potential to increase quality while consuming fewer man hours. The purpose of this paper is to clarify the differences between supervised learning and unsupervised learning. [11]

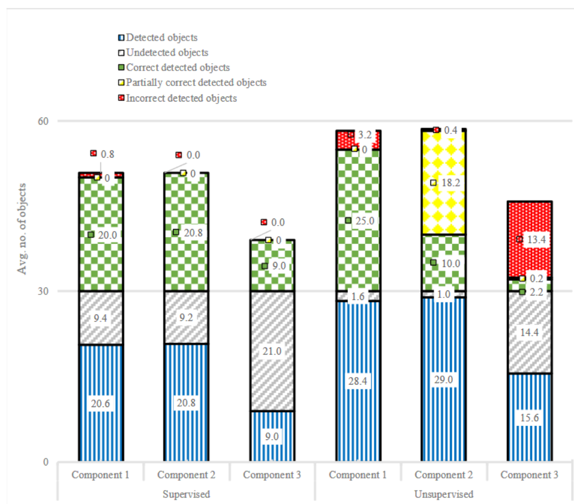

FIGURE 1.5: Recognition results for the two learning approaches

This paper, a machine learning-based image processing technique is suggested for the robotic assembly system. Based on inexpensive visual inputs, it is possible to recognize and locate assembly components and automatically control an industrial robot. Additionally, a geometry library is created as an optional hybrid approach for precise recognition outcomes. [12]

FIGURE 1.6: Output image with the mask

This paper is based on robotic fruit picking and recognizing apples. The use of color and 3D geometric features to characterize apples, branches, and leaves. Also developed an improved genetic algorithm-based automated recognition technique. [13]

Here, a red-green-blue color camera was used to test a method for banana recognition in the natural world based on color and texture attributes. The findings demonstrated that the devised approach may be used to identify bananas in farms under various lighting and occlusion circumstances. [14]

FIGURE 1.7: Detection results of two banana clusters

The pallet is initially recognized in a storage setting using deep learning to address the issue of item location during picking. Then, a technique for determining the posture of the pallet using image processing and the Kinect sensor is suggested in this paper. Deep learning is used to identify the pallet and determine the box it has chosen. Based on this, the image processing technique is used to determine the position and angle of the pallet, after which RGB-D turns the pallet's position and posture into a three-dimensional (3D) coordinate for three-dimensional placement. The experiment's findings indicate that the algorithm can successfully determine the real-time pallet position 81.02% of the time. [15]

FIGURE 1.8: Different inclinations are part of the experimental results

Robots have traditionally been used to replace human work. This article describes the design and construction of a robotic arm with proximity and color detection utilizing an Arduino Mega microcontroller. Six degrees of freedom are present in the robotic arm (6-DOF). This technology not only meets the requirements for replacing hard human work, but it also qualifies as a smart robot since it has the ability to recognize things and gauge its own distance from them. Additionally, it can discriminate between distinct things by recognizing colors. This aids the robot in object recognition and decision-making in accordance with input directives. [16]

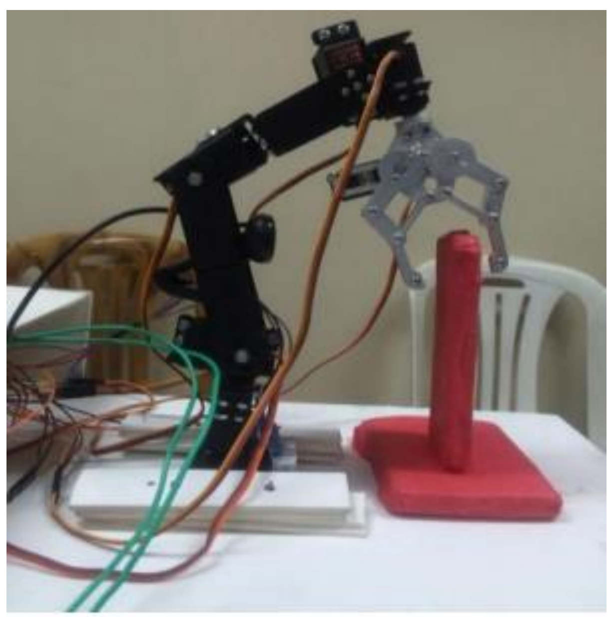

FIGURE 1.9: Assembled 6-DOF robotic arm with six servo motors

In this paper, a real-time SAR method with spotlight mode for tiny satellites is proposed. By utilizing sub-aperture processing, the approach may address the issue of data transmission and get rid of spectrum overlap in the Doppler domain. Range compression and range cell migration compensation (RCMC) are applied to the sub-aperture data using the modified range migration algorithm (MA).

Once the low-resolution complex picture is obtained and is focused on the range time-azimuth frequency domain, dechirp in the azimuth time domain is applied. In order to complete image fusion, all the complicated sub-aperture low-resolution projections are made onto a grid picture with an azimuth interval that matches the full-resolution azimuth interval. [17]

1.4. Critical Engineering Specialist Knowledge

Our project has 2 parts: a Robotic Car and a Robotic Arm. The robotic arm detects any different object through image processing and places it in a separate box and the car will take the robotic arm to that object. Robotic arms are based on several types of engineering discipline related to Electrical Engineering and Mechanical Engineering such as Computer Vision, Embedded Electronics, Robotics, and Power etc. Special software may need to be written for special robotic arms. So, software engineers also need robotic arms. A robot arm has many mechanical parts. What you need to set it up correctly high. The main part of the robot arm is electronics. Various electronic parts such as ICs, motors, Arduino Uno, several types of sensors, goods, connectors, and many other components. It uses 5 servos, 1 Arduino, 1 Dc to dc buck converter, and 1 pixycam. First, we will connect 5 servo and 5 pins with Arduino. Then each servo should be 5v. Because it takes 5v to run a servo. We will take that 5v from direct DC to DC buck converter. Because our power source is 12v. And we can give 12v directly to the servo. So, we will convert the buck to 12v and make 5v to the servo. Then we will give 9v to Arduino because 9v needs to run Arduino. We will give the pixycam to 12v. Then we will connect the Cam with the Arduino with 6 pins. After completing the robotic arm accuracy is an important thing. So that is exactly how a robotic arm works. We made ourselves comfortable Robot arm. The biggest thing an industry owner can buy. If we want to create a perfectly accurate robotic arm, it will be difficult for us. Because it is more expensive to acquire. Our robot arm design is a normal robot arm. A design that works well. We got some ideas from the internet and added ideas to create a typical robotic arm design. Affordable and cost effective. If we want to create a critical design it will be difficult because the cost is high. Creating a robotic arm is expensive, cumbersome processing system. It costs a lot of money to operate the system perfectly and accurately. However, the total cost depends on the number of robots required by the industry and their use. But the main goal is to reduce maintenance costs and improve accuracy.

1.5. Stakeholders

Reading research from prior publications from earlier to recent and examining the contents and limits of each According to case studies of gesture-controlled robotic arms, it is regarded as vital in sectors where it is cutting edge alludes to the most elevated level of general turn of events, starting at a gadget, procedure, or logical field accomplished at a specific time. Our robotic arms can be used to automate the process of placing goods or products on pallets. By automating the process, loading, and unloading becomes more accurate, cost-effective, and predictable. The use of robotic arms also frees workers from performing tasks that pose a risk of bodily injury. Our projects are mostly used on the industrial side and the owners will benefit. The robot is user friendly so workers can use it easily. This robot will protect from accidents so accident rates will decrease. Both time and effort will be reduced. Overall costs will be reduced.

1.6. Objectives

The main objective of this project is to control the robotic arm manually and automatically by using a microcontroller to select moving objects on the treadmill or a designated place. In industries, very advanced robots are used, but the control is still done manually or by processors like Arduino, microprocessor, etc. This project is managed by a microcontroller that will help users to use it as they wish. This project aims to create and fabricate a more compact, useful and cheaper robotic arm to perform various functions where humans prove too dangerous to perform a particular task and also to eliminate human error to achieve more precise work. Our project can work by keeping our distance. It can transport goods from one place to another without being touched by humans. Our projects are often designed to encourage us to think critically, solve difficult problems and develop skills.

1.6.1. Primary Objectives

- To design a real time image processing-based robot.
- Moving robot using path learning.
- Pick and place products to its designated place or conveyer belt.
- Reduce the economic cost of the industry.
- Work more efficiently and non-stop.

1.6.2. Secondary Objectives

- Create a real environment and decorate the system to meet all its criteria in the absence of human control.
- Using pixycam for image processing.
- Arduino UNO has used to control the motors.
- Better designing to pick and place.

1.7. Organization of Book Chapters

Chapter-2: Literature Review with in-depth investigation

This chapter examines the historical background of the project through research and work related to automated real-time imaging robotic arms. This project requires significant engineering expertise already mentioned. I have explained the state of the art (state of the art).

Chapter-3: Project Management

This chapter of the book details project cost analysis, schedule management, S.W.O.T. analysis, P.E.S.T. analysis, individual accountability, management of multidisciplinary components and the project lifecycle.

Chapter-4: Methodology and Modeling

The method for sporting out the assignment has been mentioned on this chapter. Block diagram and different figures were used to explain the layout of the actual time photograph processing robot arm.

Chapter-5: Implementation of Project

This chapter has gone over the simulation process for the automated conveyor belt with integrated robotic arm. The simulation's overview has been depicted. The physical implementation of the project was also demonstrated.

Chapter-6: Results Analysis & Critical Design Review

In this chapter, we used data tables and graphs to analyze the actual results. The required theoretical calculations and equations were presented. This chapter contains an important design review.

Chapter-7: Conclusion

This bankruptcy discusses the findings which have been summarized. The work`s novelty, venture sustainability, destiny scopes, recommendations, and environmental influences have all been examined.

This bankruptcy additionally consists of a dialogue of venture finance. The work's obstacles and related moral worries had been discussed.

Chapter 2

PROJECT MANAGEMENT

2.1. Introduction

Project management is the application of processes, methods, skills, knowledge, and experience to achieve specific project objectives according to project acceptance criteria within agreed parameters. Project management is constrained by tight time frames and budgets. A project is a unique, transient endeavor, undertaken to achieve planned objectives, which could be defined in terms of outputs, outcomes, or benefits. A project is usually deemed to be a success if it achieves the objectives according to their acceptance criteria, within an agreed timescale and budget. Time, cost, and quality are the building blocks of every project. To reach these goals, the priorities should be set early, must be defined, project tasks should be identified, and time estimates should be created. The requirements of resources also must be listed, and budgets must be prepared. Regular monitoring is required for project progress to ensure that the project objectives are met. Project management is aimed at producing a product that will effect some change for the benefit of the organization that instigated the project. It is the initiation, planning and control of a range of tasks required to deliver this product. [18]

Every project requires a suitable management system to be completed successfully. An acceptable time schedule and some specialized planning were needed for a project to be completed effectively. Many aspects needed to be examined to achieve the desired result. Identifying the advantages, disadvantages, and S.W.O.T analysis, a strategic planning method, was employed to identify the project's opportunities and risks. A schedule was created for carrying out and condensing many chores. It was calculated how much it would cost to implement the project. The influence of our initiative on politics, economics, society, and technology was also examined using P.E.S.T. analysis. The accountabilities of the individual ones were selected for completing different tasks.

2.2. S.W.O.T. Analysis

A SWOT analysis is a technique used to determine and define your Strengths, Weaknesses, Opportunities, and Threats – SWOT. SWOT analyses can be applied to an entire company or organization, or individual projects within a single department. Most commonly, SWOT analyses are used at the organizational level to determine how closely a business is aligned with its growth trajectories and success benchmarks, but they can also be used to ascertain how well a particular project. [19]

2.2.1. Strengths

- Production and product handling both employ robotics. These tools operate quickly, consistently, and precisely and is industry-specific, and may be programmed to perform an endless number of jobs.
- In our project, the most significant strength is the use of a robotic arm. It is designed to maintain several manufactured applications.
- This robot reduces manpower in the industrial sector. A worker may need rest but this robot can work without getting tired.
- This robot can increases productivity, efficiency, quality, and consistency of products because it uses image processing technology.
- This robot is cost-efficient compared to other traditional robots because the main components used are cheap. Also, we need low maintenance costs rather than human workers' maintenance costs.

2.2.2. Weakness

- The primary weakness of this system is, by using this robot workers can be lost their job.
- To get the maximum output we need a proper specific and safe place to operate this robot.
- For maximum outcome, it is necessary to check this robot often.
- If any component failed to perform, then the robot will not work properly.

2.2.3. Opportunities

- This robotic system can be used on a large scale.
- Both Government & Private sector can reduce their cost by using this robot in their industry.
- Components that are used are very easy to find in the market. So this robot is upgradeable with a higher efficient component.
- It can be used for multiple tasks in an organization.

2.2.4. Threats

- To regulate these robots, skilled manpower is required.
- Faulty parts can bring disaster to the whole system.
- This robot can caused unemployment problem in the industrial sector where the workers may lose their job and may protest against this robot.

2.3. Schedule Management

Schedule Management is the complete process of systematizing project activities, allocating resources, keeping a timetable, and maintaining equipment. A whole timeline of this project is given here from creating proposal to completing hardware setup. This project schedule includes efficient utilization of project members, equipment and facilities and minimization of time.

The project schedule was prepared and properly followed to ensure that all tasks were finished on time. A time restriction was established for each task, and it was met for all of them.

Project Schedule Gantt chart.

FIGURE 2.0: GANTT CHART OF OUR PROJECT SCHEDULE MANAGEMENT

2.4. Cost Analysis

Our Project required both hardware and software. The hardware components required for our project are listed in the table below. First we have studied the market through online and physically. In online shops, the components are higher in price compared to physical shop. So the components of this project are bought from the physical shop.

TABLE 2.1: Cost Analysis Table

Name of The Components	Quantity (Pcs)	Cost per Unit (BDT)	Total Cost (BDT)	Estimated Cost (BDT)	Standard Deviation
Arduino UNO R3	1	920/-	920/-	1200/-	
Pixy2 Cam	1	9750/-	9750/-	9750/-	
Servo Motor (SG996R)	4	310/-	1240/-	1600/-	
Servo Motor (SG90)	1	180/-	180/-	150/-	
12V Battery	1	2100/-	2100/-	2500/-	
Buck Converter (With Display)	1	100/-	100/-	150/-	
Buck Converter (Without Display)	2	80/-	160/-	250/-	
Jumper Wire (Male to Female)	1 Set	50/-	50/-	70/-	
Jumper Wire (Male to Male)	1 Set	50/-	50/-	70/-	
Line Following IR Sensor	1	320/-	320/-	350/-	
Yellow Wheel (Rubber Tire)	4	60/-	240/-	400/-	
DC Motor	2	650/-	1300/-	1400/-	
Wheel Mounting Bracket	2	100/-	200/-	600/-	
Motor Driver 43A BTS7960	1	400/-	400/-	450/-	
Robotic Arm (3d Printed)	1 Set	5000/-	5000/-	6000/-	
Base Plate	1	300/-	300/-	500/-	
TOTAL			22310/-	25290/-	2760.92

From this table, it can be seen that the overall standard deviation of this project is 2760.92, which is acceptable. Here the table shows that our estimation of the total cost is almost 25000/- taka higher than the final cost of 22310/-. The project has been completed both in simulation process and hardware implementation. We estimated our components total price via the online shop which we considered as our estimated cost. The cost per unit section for each component has been done according to the price in which we bought all the components from physical shop. Maximum of our components are from china and Taiwan. Due to the demand, the prices of some products have been increased during COVID-19.

2.5. P.E.S.T. Analysis

This lesson is a frame that presented the project categorizes macroeconomic factors that may influence the project. For implementing this project, it is imperative to know the political and legal matters related to this project, such as government policies and regulations, and associated laws. PEST Analysis is a measurement tool which is used to assess markets for a particular product or a business at a given time frame. PEST stands for Political, Economic, Social, and Technological factors. Once these factors are analyzed organizations can take better business decisions. PEST Analysis helps organizations take better business decisions and improve efficiency by studying various factors which might influence a business such as political, economic, social, and technology. PEST analysis helps in making strategic business decisions, planning marketing activities, product development and research. It is similar to S.W.O.T. analysis, which stands for Strength, Weakness, Opportunities, and Threats.

In PEST analysis, 'P' stands for Political environment. It includes government regulations or any defined rules for that particular industry or business. It also involves study of tax policy which includes exemptions if any, employment laws, environment laws, etc. The letter 'E' in PEST analysis stands for economic factors. It gauges the economic environment by studying factors in the macro economy such as interest rates, economic growth, exchange rate as well as inflation rate. These factors also help in accessing the demand, costing of the product, expansion, and growth. 'S' stands for social factors that form the macro environment of the organization. It includes the study of demographics, as well as the target customers. These factors help in gauging the potential size of the market. It includes study of population growth, age distribution, career attitude, etc. The letter 'T' in PEST analysis stands for technology. As we all know, technology changes very rapidly, and consumers are hungry to adopt new technology. It involves understanding factors which are related to technological advancements, rate at which technology gets obsolete (Example: the operating system in mobile phones), automation, and innovation. [20]

2.5.1. Political Analysis

Bangladesh government has consistently supported the growth of the industry and encouraged the use of automation technology. Although there are some legal concerns with automation systems, none of them stand in the way of this project. Like the developed world, Bangladesh has legalized automation. In a webinar titled 'Post COVID-19: Challenges & Opportunities for Entrepreneurship and Employment in the context of the current status of Skill Development and readiness for Fourth Industrial Revolution (4IR)', the Planning minister of Bangladesh assured that the government has full support to formulate and implement a national strategy and action plan for making Bangladesh 4IR responsive.[21] An Act to set up the Sustainable and Renewable Energy Development Authority's foundation in order to ensure energy security. The overall structure of this project is sustainable and a reliable robotic arm was employed. Countries that are developing and dependent on large numbers of workers, Automatic robotic arm can provide alternative in an industry for mass production. It is clear from an analysis of the political and legal issues concerning this project that none of them are opposing to its establishment, sustainability, or the promotion of industrial growth.

2.5.2. Economic Analysis

This project is one that will have a stable economy. All of the sensors and other electrical components are available for a reasonable price that is cost-effective, which will have a favorable effect on all economic factors. Additionally, local and online markets carry these components. Technology that wasn't all that expensive was utilized in this project. There will be an enough quantity of consumers once industries undertake this idea on a larger scale. Consumers make purchasing decisions based on their preferences and financial constraints. The project was created while keeping this theory in mind. To save money, functional features were added since unnecessary features were removed. Economics says that the buyer want quality product in lower price while seller wants higher. Keeping this theory in mind, the costing of this project was done in a balanced point price that is suitable for both consumer and manufacturer.

2.5.3. Social Analysis

Modern technology is the automated conveyor belt with an integrated robotic arm system. Typically, modern technologies are desired for commercial and residential uses. People may consider cost, performance, reliability, and other factors when installing an automated conveyor belt with an integrated robotic arm. There is no chance of pollution with this automated system. As factories and industries have grown in recent years, society is acting more productively and at a lower cost. Consequently, it is becoming more and more popular to choose sources of productivity that are both affordable and environmentally friendly. One of the best production methods that will genuinely spark people's interest in society is the automated conveyor belt with an integrated robotic arm system. The project will be highly praised by the general public. Automated conveyor belts with built-in robotic arm systems are preferred everywhere in the current period. We can conclude from this that social trends and behaviors do in fact support this project.

2.5.4. Technological Analysis

On the market, there are several conventional automatic integrated robotic arm systems. This project employs a number of technologies that help to ensure the project's success. The proposed project is real time image processing pick and place robot. So, our robot detects products with real-time image processing. Which is a new concept in this sector. This robot can automatically take the product and place it in its desired place. Along with this, there are various types of servo motors available in the market. These motors can be used according to the size of the robot. This project presents a technology that will undoubtedly be appreciated by governments and universities around the world.

2.6. Professional Responsibilities

Professional responsibilities include the legal and ethical duty to apply knowledge in a way that benefits both the client and society while not harming either. Engineers work in teams and must be able to collaborate with other coworkers to ensure a project's success. Engineers have many responsibilities and have to ensure safety as well as effectiveness of a system. While working on a project, engineers have to maintained the following criteria

- Making plans with detailed drawing.
- Creating accurate project specifications.
- Working to create technical reports for customers.
- Completing regulatory documents pertaining to safety issues.
- Completing projects on time and within budget.
- Informing clients and coworkers about analysis results.

2.6.1. Norms of Engineering Practice

Our project is an eco-friendly safety project. All the necessary guidelines for the project have been maintained. Government has also made policy on automation. For engineering recommendations, a number of study papers and the certain documents were followed where government have taken initiative on ongoing projects and future projects related to pick and place robot. As a result we followed engineering norms related to this project. The guidelines that are followed are given below.

- The product management system has a smart and acceptable design.
- Evaluating and recommending innovative institutional, financial, and technological strategies for Bangladesh's product management planning and implementation.
- Cooperate with project officials and consultants while providing technical support.
- Specified the technical requirements for the equipment and create a structural design for the electrical work.

2.6.2. Individual Responsibilities and Function as Effective Team Member

The members of the group completed the work related to this project, including the necessary documentation, under the supervision of our project supervisor. All the members of the group worked together as a team and were all responsible for the overall project. Tasks were distributed among members, however, for the sake of efficiency and utilizing the members' unique skills. One member was required to perform some additional duties such as combining the work of the individuals, contacting the supervisor and informing progress on a regular basis, and informing others about various deadlines, notices, and other project-related information. The members collaborated properly from the beginning to the end of the project.

TABLE 2.2: Individual Responsibilities

Name	ID	Responsibilities
Umme Habiba Muna	19-39960-1	1. Writing Chapter 1, 3 of the Project Book
		2. Project Modeling
		3. Simulation, Analyzing Real-time image processing results.
Suraya Khondoker	19-40238-1	1. Writing Chapter 1, 2 of the Project Book
		2. Project Modeling
		3. Hardware Implementation, Research for Project Related Works and Gathering Information

Nadif Farhin Sharon	19-41404-3	1. Writing Chapter 1, 2 of the Project Book 2. Cost analysis, Purchasing all components, 3. Hardware Implementation,
Kaniz Mohosina Tabassum	20-42661-1	1. Writing Chapter 1, 3 of the Project Book 2. Simulation, Data Collecting 3. Analyzing Project Feasibility and Electrical Part of the Project

2.7. Management Principles and Economic Models

Management principles are the activities that plan, organize, and control the operations of the basic elements of people, materials, machines, methods, money, and markets, providing direction and coordination, and providing leadership to human efforts, in order to achieve the enterprise's desired objectives.

An economic model is a structure that visually depicts the relationship between variables in an economy. It is a fictional construct that employs a set of variables to represent economic procedures in logical and quantitative relationships. It is also regarded as a simulated or simplified version of reality. Variables in economic models are fundamental concepts that play an important role in the model.

2.7.1. Management Principles

Leadership Skills:

This is the most important thing for an engineer to do before beginning work on any complex project like ours. The leader will distribute all of the work among the team members. A leader also completed the project with all the members. Working on all of the complex issues in this project has helped us improve our leadership skills. Which will come in handy later in our practical and working lives. All of the topics concerning our proposed system was divided by the leader. The group members divided the project work equally. We also collaborate to complete the hardware implementation.

Planning Skills:

We created a Gantt chart at the start to work according to a planned schedule. We kept this Gantt chart up to date and completed all of our tasks. Every week, we contact our supervisor for feedback on our project work. We also informed the external supervisor when we encountered issues while working on the project. However, we were unable to complete some of the work before the deadline.

Technical Skills:

Technical ability is one of the most important skills for any project. Electronic design automation suites such as Proteus, Fusion 360 and the Arduino Integrated Development Environment (IDE) are the technology we used in our project. To obtain robot and sensor output, we had to use Arduino code for both simulation and hardware. Another part is we learned how to find research papers and how to use them as references. We also learned how to use ZOTERO software for adding citations.

Organizing Skills:

Every project's success is dependent on efficient time management and utilization. To successfully complete the project, each project member had specific responsibilities, and there was good collaboration between their works, resulting in perfect teamwork. We agreed on a regular meeting time and followed the schedule properly.

2.7.2. Economic Models

From the beginning of developing this project, we have followed an economic model called 'Agile Model'. Agile is a term that means quick or adaptable. A software development methodology based on iterative development is referred to as an "agile process model." Agile project management techniques divide work into smaller iterations or pieces without directly including long-term planning. The project's requirements and scope are established at the start of the development phase. Plans for the quantity, length, and scope of each iteration are spelled out in detail in advance. In the Agile process model, each iteration is viewed as a brief time "frame" that typically lasts one to four weeks. The project risk is reduced and the overall project delivery time requirements are lowered thanks to the project's breakdown into smaller components. A team goes through the entire software development life cycle at each iteration, including planning, requirements analysis, and design, coding, and testing, before showing the client a functional end result. We followed this model because as a result of retraining we have better understanding and monitoring of the issues within our project. Besides, all the things we have used in this project have been repeatedly tested. Since all the sensors and other electronic parts are reasonably priced, it is cheaper than human labor and other traditional robots. Which will benefit every economic factor. It can be used by people of all backgrounds. Bangladesh's volatile exchange rate can have a long-term impact on Smart Metering investment plans.

2.8. Summary

In the project management chapter, we discussed the entire project execution strategy. Our project budget, project constraints, economics, and societal analysis are all discussed here. Our project was completed with full project management from the beginning, which included many features such as planning, scheduling, cost analysis, organizing individual accountabilities, multidisciplinary components, and learning the life-cycle of our project. We are Scheduling project tasks with work distribution and adhering to a timetable ensures that resources are used effectively and that all tasks are completed on time. The strategic analysis evaluated various details that are reviewed in the project details. Furthermore, macroeconomic factor analysis enabled the examination of critical external factors and decision-making in response to them. While tasks, efficient use of multidisciplinary components provides benefits. With proper project management, the project ended with the goals being met successfully.

Chapter 3

METHODOLOGY AND MODELING

3.1. Introduction

This chapter describes project methodology and modeling. Description of the block diagram is given and planning is done for implementation. Various types of sensors for different purposes were used to design the entire system here. Designing an efficient automation system necessarily requires a thorough understanding of automation's fundamentals and theoretical underpinnings. Before launching the project, the system should be modeled. This chapter went over some fundamental automation theory, system modeling, and additional pick-and-place robot analysis. This robot's use will be discussed at the end of this chapter. Our project's theory and analysis are completed.

3.2. Block Diagram and Working Principle

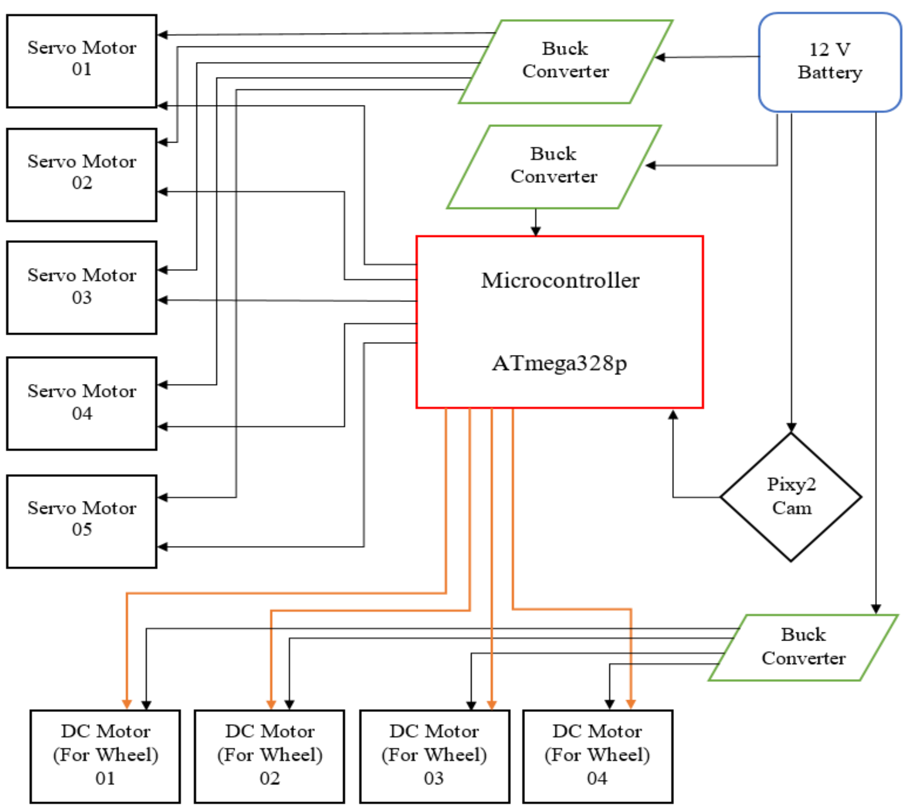

FIGURE 3.1: BLOCK DIAGRAM OF PROPOSED PROJECT

3.2.1. Working Principle

Our project has 2 parts. A Robotic Car and a Robotic Arm. The robotic arm detects any different object through image processing and places it in a separate box and the car will take the robotic arm to that object. It uses 5 servos, 1 Arduino, 1 DC to DC buck converter, and 1 Pixy 2 Cam. First, we will connect 5 servos and 5 pins with Arduino. Then each servo should be 5v. Because it takes 5v to run a servo.

We will take that 5v from the direct DC to DC buck converter. Because our power source is 12v. And we can give 12v directly to the servo. So, we will convert the buck to 12v and make 5v to the servo. Then we will give 9v to Arduino because 9v needs to run Arduino. We will give the Pixy 2 Cam to 12v. Pixy 2 Cam runs through 3.3 v and it will not work in a 12v battery directly. So, Buck converter is connected to decrease the voltage to 3.3v.

Then we will connect the Cam with the Arduino with 6 pins. Controlling a robotic arm for applications such as object placement using image sensors requires extensive image manipulation computations to recognize and find objects of interest. First, the elements are recognized. This is achieved by extraction calculations. The removed image (boundaries based on the classifier) is then sent from the classifier to figure out what the object is. This sensor's operation is really straightforward: it merely recognizes the images that are required and transmits the necessary data to the processor via any one of six channels, including UART, SPI, I2C, USB, digital, and analog.

To find objects, Pixy employs a hue-based color filtering technique. Most of us are familiar with the RGB system of color representation (red, green, and blue). The key filtering parameters used by Pixy are the hue and saturation of each RGB pixel from the image sensor. Changes in exposure and lighting have little effect on an object's color. Color filtering algorithms may frustratingly malfunction as a result of changes in exposure and lighting. In comparison to earlier iterations of the CMU cam, Pixy's filtering algorithm is substantially more resistant to changes in lighting and exposure.

Once this is done, the result will be an item type holding instructions to complete the robotic arm. Pick and spot tasks. Therefore, a focused imaging approach was chosen. Working of image processing: To apply image processing techniques, we first digitize a photograph or other image into an image file. Digital techniques can then be applied to identify perfect objects based on color separations. These techniques are widely used in commercial areas that involve retouching or rearranging products. The robotic arm finds objects through image processing. A camera (e.g. Pixy 2 Cam) attached to the robot arm trains on a specific object during training. The Arduino code is sent by the Arduino UNO. It has been trained to extract specific objects from a set of objects. The robot places the object in the desired location after successfully training its Pixy 2 Cam with image processing.

3.2.2. Flowchart

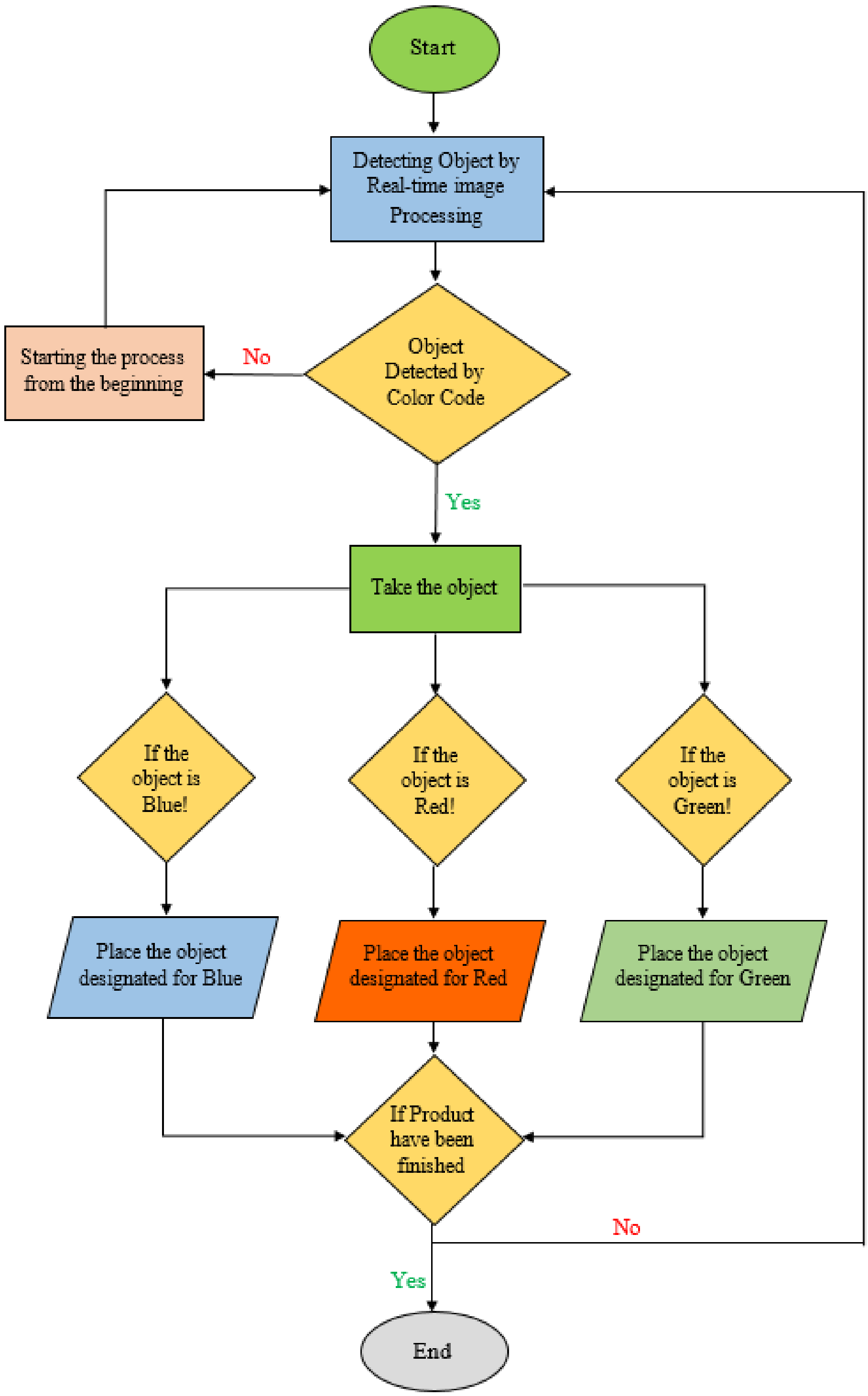

FIGURE 3.2: FLOWCHART OF THE PROPOSED PROJECT

3.3. Modeling

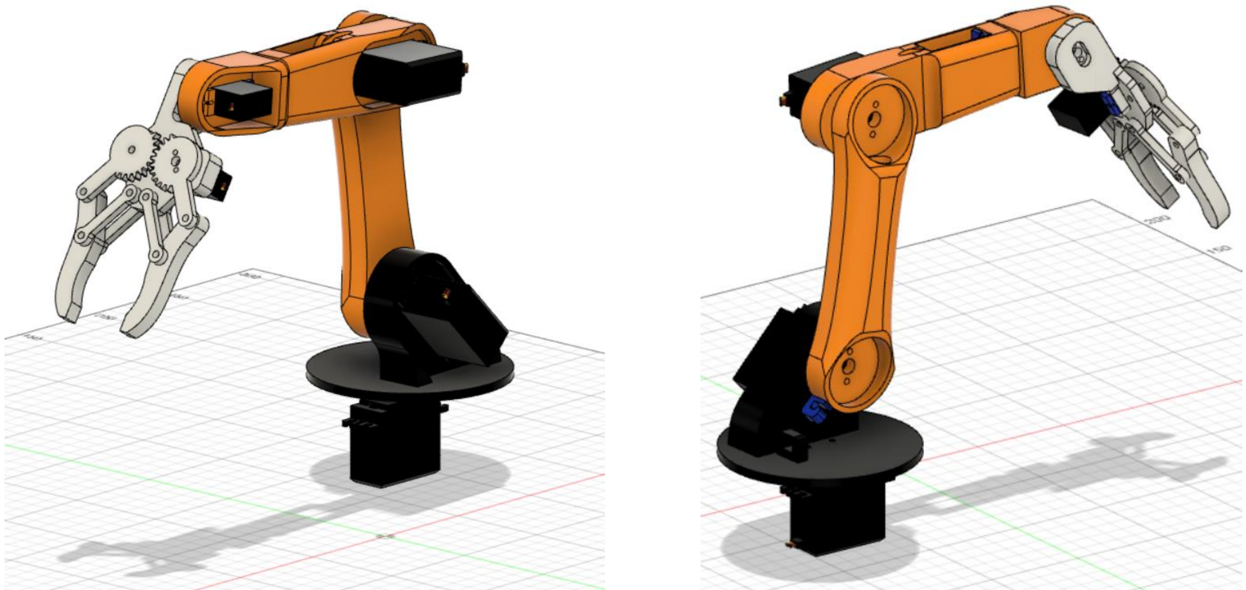

FIGURE 3.3: 3D MODEL OF OUR DESIGN OF ROBOTIC ARM.

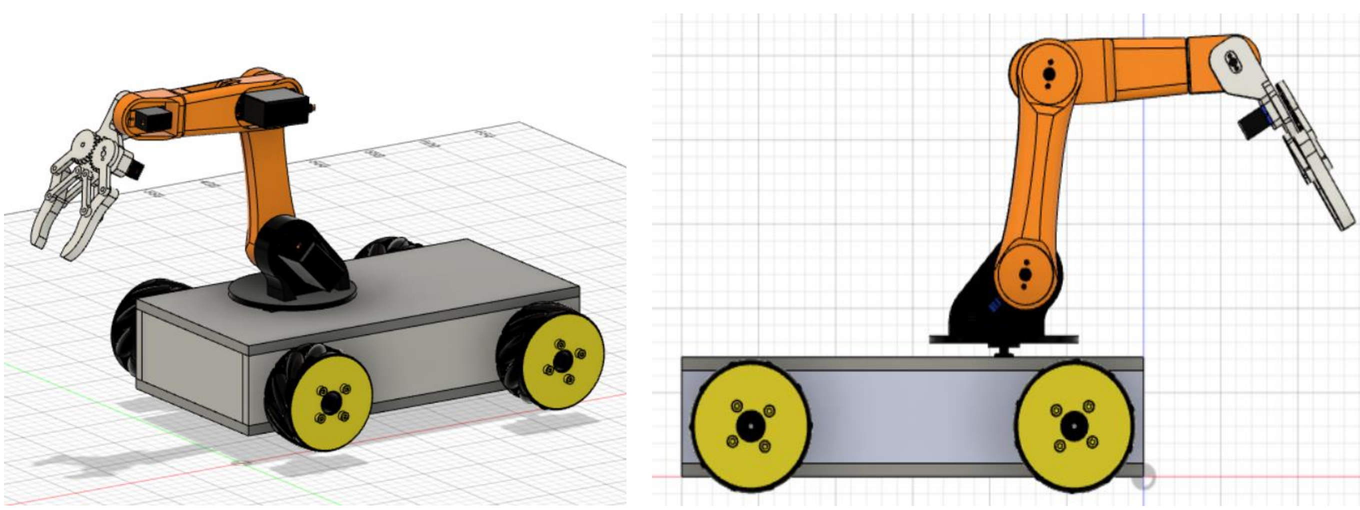

FIGURE 3.4: 3D MODEL OF OUR DESIGN OF FULL ROBOT.

The usage of robotics in the industry has substantially increased in order to increase productivity and lower labor expenses. Labor costs are crucial for every sector. These robots are built with a variety of structures to do certain jobs, and their movements or trajectories are produced by computer programming as they manipulate the products on the assembly line. The wheel helps the robot to move easily and everywhere. Using Auto Desk Fusion 360, the 3D modeling of the robotic arm was completed. To produce the 3D modeling, all of the parts collaborated. The waist, base, gripper, and gripper base all served the robotic arm. The object was moved and grasped by the robotic arm's five servo motors. The robotic arm used all of its motors to move in an efficient manner. For a 5-DOF robotic system to accomplish accurate movement, five servo motors are mostly used.

3.4. Summary

In this chapter, we described the working principle as well as 3D modeling, which aids in visualizing the prototype. In terms of operation, the Pixy 2 Cam vision sensor was used to accurately detect the object and reduce working time. This chapter includes a block diagram and a flow chart of the proposed device. As a result, the precise mechanism associated with the project concept has been eventually realized.

Chapter 4

PROJECT IMPLEMENTATION

4.1. Introduction

This chapter explains the effort of execution by implementing all the necessary components regarding our proposed automated pick and place robotic arm. Every aspect of the project has been built around by the hardware as well as simulation of the components have been also added. All the components that are used for hardware implementation will also be discussed and the hardware implementation will be explained briefly in this chapter. The software-based simulation component of our project will also be discussed briefly in this chapter. Proteus 8 Professional, AutoCAD, and Tinker Cad software were used to complete the entire project.

4.2. Required Tools and Components

1. Arduino UNO R3
2. Pixy2 CMU Cam Smart Vision Sensor
3. Power Supply
4. Servo Motor MG995
5. Buck Converter
6. DC Gear Motor
7. Motor Driver (BTS7960)
8. Line Following IR Sensor
9. Wheel
10. Wheel Bracket
11. Jumper Wire
12. Robotic Arm

4.2.1. Arduino UNO R3

The Arduino UNO is an ATmega328P-based microcontroller board. It is the newest third version of AN Arduino family which was arrived in the year 2011. It has 14 digital I/O pins including 6 PWM output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It includes everything required to support the microcontroller; simply connect it to a computer via USB or power it via an AC-to-DC adapter or battery to get started. [22]

TABLE 4.1: Technical Specifications of Arduino UNO R3

MICROCONTROLLER	ATmega328p
OPERATING VOLTAGE	5V
INPUT VOLTAGE (NOMINAL)	7-12 V
INPUT VOLTAGE (LIMIT)	6-20 V
DIGITAL I/O PINS	14 (of which 6 provide PWM output)
ANALOG INPUT PINS	6
DC CURRENT PER I/O PIN	20 mA
MEMORY	2KB SRAM, 32KB FLASH, 1KB EEPROM
CLOCK SPEED	16 MHz
LED BUILD IN	13
WEIGHT	25 g
WIDTH	53.4 mm
LENGTH	68.6 mm

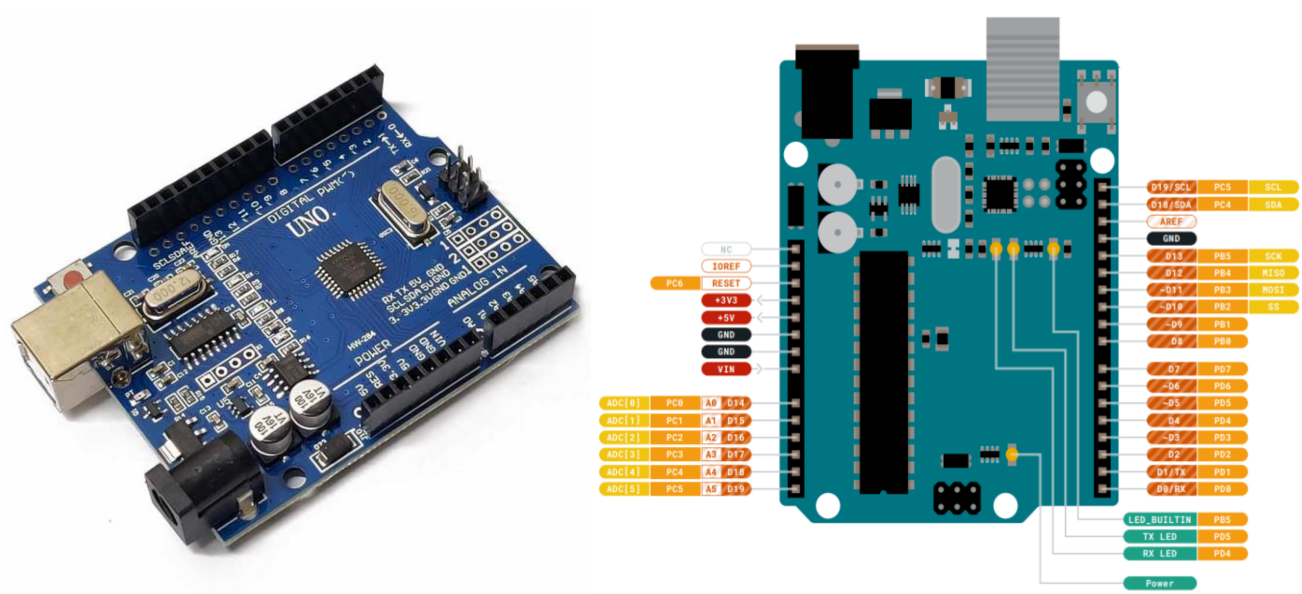

FIGURE 4.1: Pin Diagram of Arduino UNO R3

4.2.2. Pixy2 CMU Cam Smart Vision Sensor

A computer-aided visual recognition system is used in the Pixy2 camera. It enables ones microcontroller to detect colors or lines, for example, to build a line-following robot or to catch colored objects. It is the second version of Pixy. It's faster, smaller, and more capable than the original Pixy, adding line tracking/following algorithms as well as other features. The Pixy2 camera is a full vision system that includes an image sensor and a microprocessor. It includes color, line, intersection, and small barcode detection algorithms as well as learning algorithms. It contains all of the technology required for visual recognition. [23]

TABLE 4.2: Technical Specifications of Pixy2 Cam [24]

PROCESSOR	NXP LPC4330, 204 MHz, dual core
IMAGE SENSOR	Aptina MT9M114, 1296×976 resolution with integrated image stream processor
POWER CONSUMPTION (CURRENT)	140 mA typical
POWER CONSUMPTION (VOLTAGE)	USB input (5V) or unregulated input (6V to 10V)
AVAILABLE	UART serial, SPI, I2C, USB, Digital, Analog
DIMENSIONS	38.1 x 41.91 x 15.24mm
WEIGHT	10g

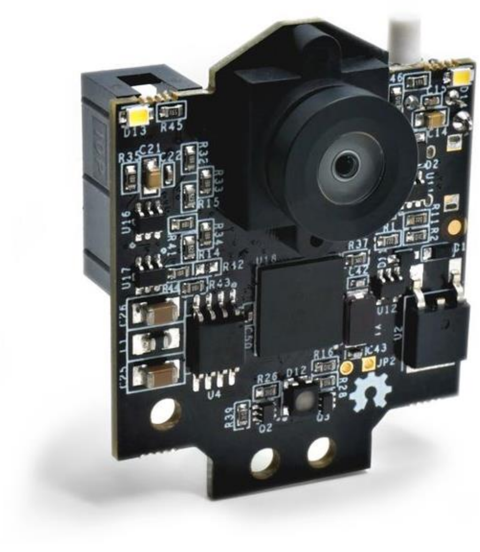

FIGURE 4.2: Pixy2 CMU Cam

4.2.3. Power Supply

A lithium-polymer (LiPo, LIP, or Li-Poly) battery is a type of rechargeable battery that has a soft polymer casing and a soft external "pouch" for the lithium-ion battery inside. It may also refer to a lithium-ion battery with an electrolyte made of gelled polymer. However, the term most commonly refers to a pouch-style lithium-ion battery. Lithium-polymer batteries are lighter and more flexible than other kinds of lithium-ion batteries because of their soft shells, allowing them to be used in mobile and other electronic devices. In this project LiPo Battery have been used. [25]

FIGURE 4.3: 12V LiPo Battery

4.2.4. Servo Motor (MG 995)

Servo motors are components of a closed-loop system that include a control circuit, servo motor, shaft, potentiometer, drive gears, amplifier, and either an encoder or resolver. A servo motor is a self-contained electrical device that rotates machine parts with high efficiency and precision. This motor's output shaft can be moved to a specific angle, position, and velocity that a standard motor cannot. The Servo Motor combines a standard motor with a sensor to provide positional feedback. [26] The MG995 servo is a simple, widely used standard servo for mechanical applications such as robotic heads and arms. It includes a standard 3-pin power and control cable and metal gears for high torque. Servo can turn around 180+/-5 degrees (90 toward every path), and works very much like the standard sorts yet more modest.

TABLE 4.3: Specifications of Servo Motor (MG 995) [27

MODEL:	Servos MG995
DEAD BAND:	0.100 ms
CONTROL SYSTEM:	+Pulse Width Control
WORKING FREQUENCY:	20ms period / 50hz (Analog Control)
REQUIRED PULSE:	3.0 ~ 5 Volt Peak to Peak Square Wave
OPERATING VOLTAGE:	4.8 ~ 6 V DC Volts
OPERATING TEMPERATURE RANGE:	-0 to + 55 Degree C
OPERATING SPEED (4.8V):	0.200 sec/60° degrees at no load
OPERATING SPEED (6V)	0.160 sec/60° degrees at no load
STALL TORQUE (4.8V):	9.4kg/cm

STALL TORQUE (6V):	11kg/cm
MOTOR TYPE:	Brushed Motor
POTENTIOMETER DRIVE:	Direct Drive
BEARING TYPE:	Output Bearing
GEAR TYPE:	Brass & Aluminum Gears
CASE MATERIAL:	Plastic
PROGRAMMABLE:	NO
CONNECTOR WIRE LENGTH:	32.0cm (12.6 inch)
DIMENSIONS:	40.7×19.7×42.9mm
WEIGHT:	55 grams

FIGURE 4.4: Servo Motor (MG 995)

4.2.5. DC Gear Motor

A gear motor is a combination of an electric motor and a power reducer that reduces the number of revolutions while increasing the torque of the operating shaft. Such electric motor gears are commonly used in modern machines and mechanisms, and it is applicable to a wide range of equipment. Some hybrid models combine convenience and durability. The gears are made of metal and 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. [28]

TABLE 4.4: Specifications of DC Gear Motor [29]

GEAR MATERIAL	Metal
RATED SPEED (RPM)	500
OPERATING VOLTAGE (VDC)	12
RATED TORQUE(kg-cm)	0.5
STALL TORQUE(kg-cm)	2
LOAD CURRENT MAX (mA)	300
NO-LOAD CURRENT (mA)	85
MOTOR DIAMETER(mm)	28
MOTOR LENGTH (mm)	58

SHAFT DIAMETER (mm)	4
SHAFT LENGTH (mm)	12
WEIGHT (gm)	89
DIMENSIONS	7 × 3 × 3 cm

FIGURE 4.5: DC Gear Motor

4.2.6. Buck Converter

A buck converter is a DC-to-DC converter that is used to perform step-down conversion of applied dc input. The applied fixed dc input voltage is reduced to a specific dc output voltage in a buck converter, so the output voltage is always less than the input voltage. As a result, the Buck converter is also known as a step-down converter or a step-up chopper. [30] In this project two types of buck converter is used to convert the voltage. One is with display (LM2596) and another one is without display (HW-411A LM2596).

TABLE 4.5: Specifications of Buck Converter [31]

INPUT VOLTAGE (V)	4 ~ 40 VDC
OUTPUT VOLTAGE (VDC)	1.3 ~ 37
MAX. OUTPUT CURRENT (A)	2
SWITCHING FREQUENCY(KHz)	150
OPERATING TEMPERATURE (°C)	-40 to 90
LENGTH (mm)	62
WIDTH (mm)	34
HEIGHT (mm)	12
WEIGHT (gm)	22
DIMENSIONS	7 × 4.5 × 2 cm

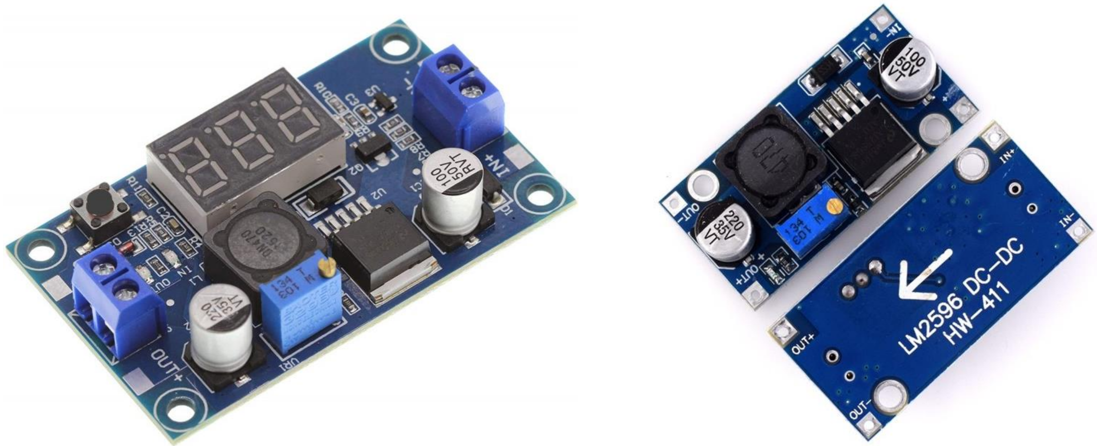

FIGURE 4.5: Buck Converter with Display & without display

4.2.7. Motor Driver

A motor driver causes the motor to move in response to instructions or inputs (high and low). It receives low voltage from the controller/processor and controls an actual motor that requires high input voltage. A motor driver IC, in simple terms, controls the direction of the motor based on the commands or instructions received from the controller. [32] In this project BTS 7960 model is used.

TABLE 4.6: Specifications of Buck Converter [33]

INPUT VOLTAGE(V)	6 – 27
MAXIMUM CURRENT(A)	43
INPUT LEVEL(V)	3.3 – 5
DUTY CYCLE	0 – 100%
PATH RESISTANCE	16 mΩ at 25°C.
LOW QUIESCENT CURRENT	7 µA at 25°C
OPERATING FREQUENCY(KHz)	25
DIMENSIONS (mm)	50 x 50 x 43
WEIGHT(gm)	67
DIMENSIONS	6 × 6 × 4 cm

FIGURE 4.6: Motor Driver (BTS7960)

4.3. Implemented Models

In contrast of running the project, hardware implementation means that the job is done using a physical device or electronic circuit. It shall be defined to include placement, wire routing, terminal assignment, and hardware interface. Typically hardware implementation is costly and takes times but gives practical output. But for a proper output of hardware implementation, a simulation is necessary. Because only simulations model can helps us to find the error which may not be seen in hardware. So, here for the proposed project, both hardware and software implementation is done to get the expected result.

4.3.1. Simulation Model

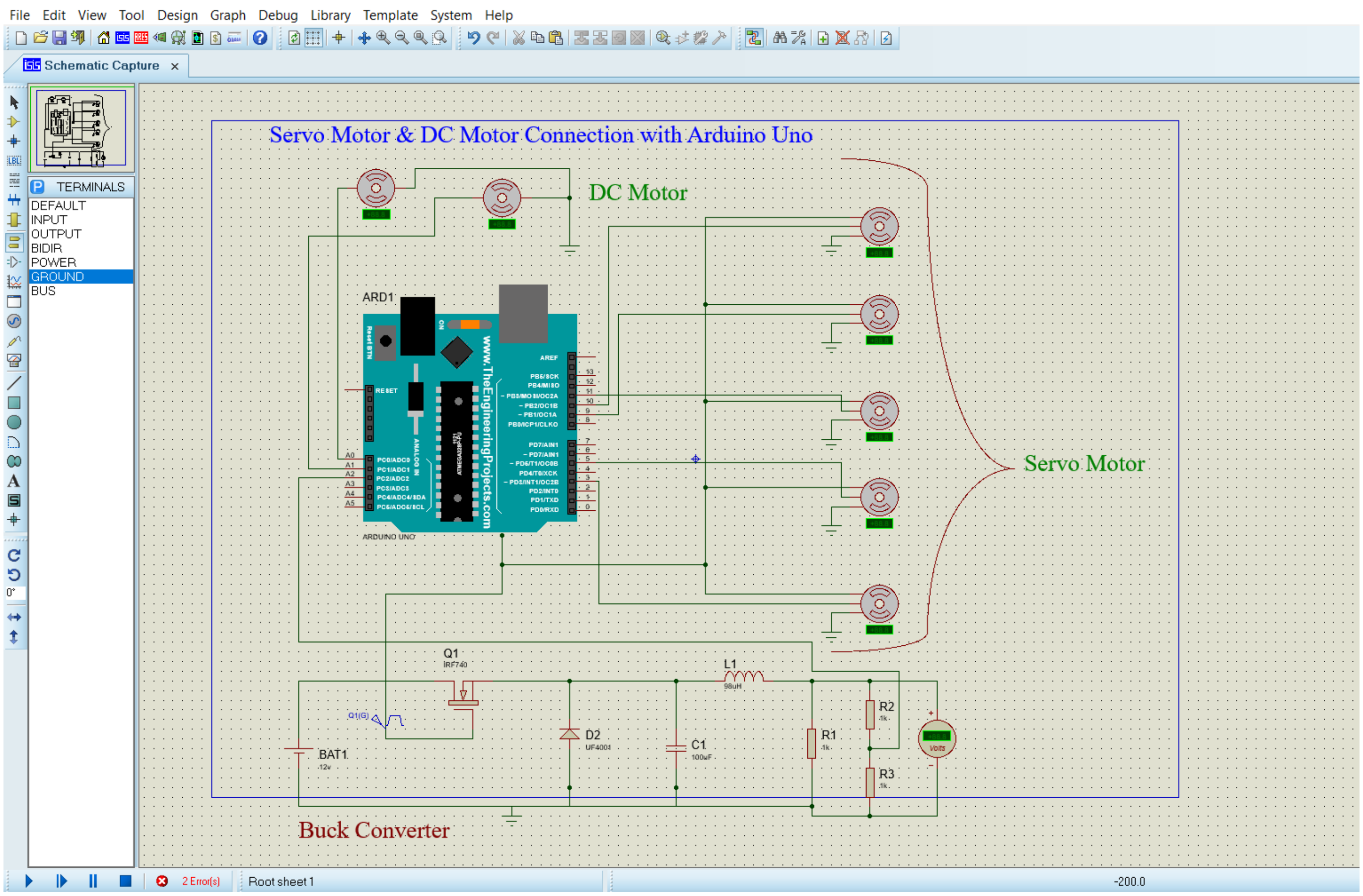

FIGURE 4.6: Simulation Model

First, a buck converter converts the 12v input to a 5v output. The Arduino Uno is given a 5v connection for connecting to the Vcc pins of four servo motors. The Arduino UNO's 5v and ground pins are linked to a relay. The relay's primary function is switching. The relay is connected to an analog pin on the Arduino UNO. The servo motor's PWM signals are connected to Arduino UNO pins 5, 3, 9, 10, and 11. The servo motor's other two pins are connected to Vcc and ground. The code is then uploaded from the Arduino UNO IDE software to the Arduino UNO. The simulation is complete once the connection is completed.

4.3.2. Hardware Model

FIGURE 4.7: Hardware Model of our Robot

4.4. Engineering Solution in accordance with professional practices

Developing an automation system necessitated a higher level of education in engineering, public health, or environmental and social safety engineering. For proper management and maintenance, increasing responsibility in project management and construction project monitoring is required. Experience includes directing and supervising advisory teams, integrating national and international support, and designing and organizing national and international training programs. In terms of mechanical technology, modern robotization is now an integral part of both modern and human improvements. One of the most buzzwords in modern mechanization is robot arm. It is a subset of robotization in which the mechanized machine has human-like characteristics. The powered mechanical arm is the most recognizable humanlike feature of a modern industrial robot. The robot's arm can be programmed to perform a series of useful tasks, such as stacking and dumping parts at a manufacturing machine. Higher results and increased usefulness have been two of the primary reasons for advocating the use of computerization. Regardless of cases of excellent workmanship by people, robotized frameworks frequently play out the assembling system with less variation than human specialists, resulting in more noteworthy control and consistency of item quality. Professional well-being is a compelling reason to automate a modern activity. Computerized frameworks frequently remove workers from the workplace, protecting them from the hazards of the industrial facility climate. The Occupational Safety and Health Act of 1970 (OSHA) was enacted in the United States with the public goal of making work more secure and safeguarding the actual prosperity of the laborer. In the manufacturing plant, OSHA has advanced the use of mechanization and mechanical technology. Another advantage of mechanization is that it reduces the number of hours that assembly line workers must work each week. Engineers with project management responsibilities are also required. By following the guidelines, this project meets the requirements to be a Professional Engineering Solution to society and culture. The project also helped the culture as well as the society. The project is very environmentally friendly.

4.5. Summary

We have provided detailed hardware implementation and circuit simulation for our project in this chapter. The circuit diagram was simulated for the overall simulation of our project and the main microcontroller of our project is Arduino UNO R3. Following Proteus simulations and outputs are also shown to demonstrate the automation process. Fusion 360 software was also used to design the full robot especially robotic arm. Finally, all hardware implementations were shown and described. All Arduino UNO circuit simulations and pin configurations were precisely guided.

Chapter 5

RESULTS ANALYSIS & CRITICAL DESIGN REVIEW

5.1. Introduction

We have developed a 4 axis robotic arm which is attached to a 4 wheel bot. It will follow a path to the destination and pick the specified object automatically. It will pick the selected object by color code. It will select the color that is trained. We have taken outputs from the automatic robotic arm in our project for several days. In this chapter, we will discuss and analyze all the results and findings. Output comparison between our project and other related researches will also be shown in this chapter.

5.2. Results Analysis

A 12v battery will power up the system. Then we plugged the camera cable into the PC and the Pixymon software will display the feed. Color trains will be done in advance. There will be a connection from better to buck. Then there will be connection from buck to motor, camera. Another line from battery will be in 2nd buck. From this there will be connections to the motor driver, Arduino and sensor. We have tried it a few times. Initially the bot followed the path properly but returned without picking the object. After that we did the servo calibration again and gave a trial. Then it worked fine. One motor Driver burnt to provide 24v instead of 9v in Arduino.

5.2.1. Simulated Results

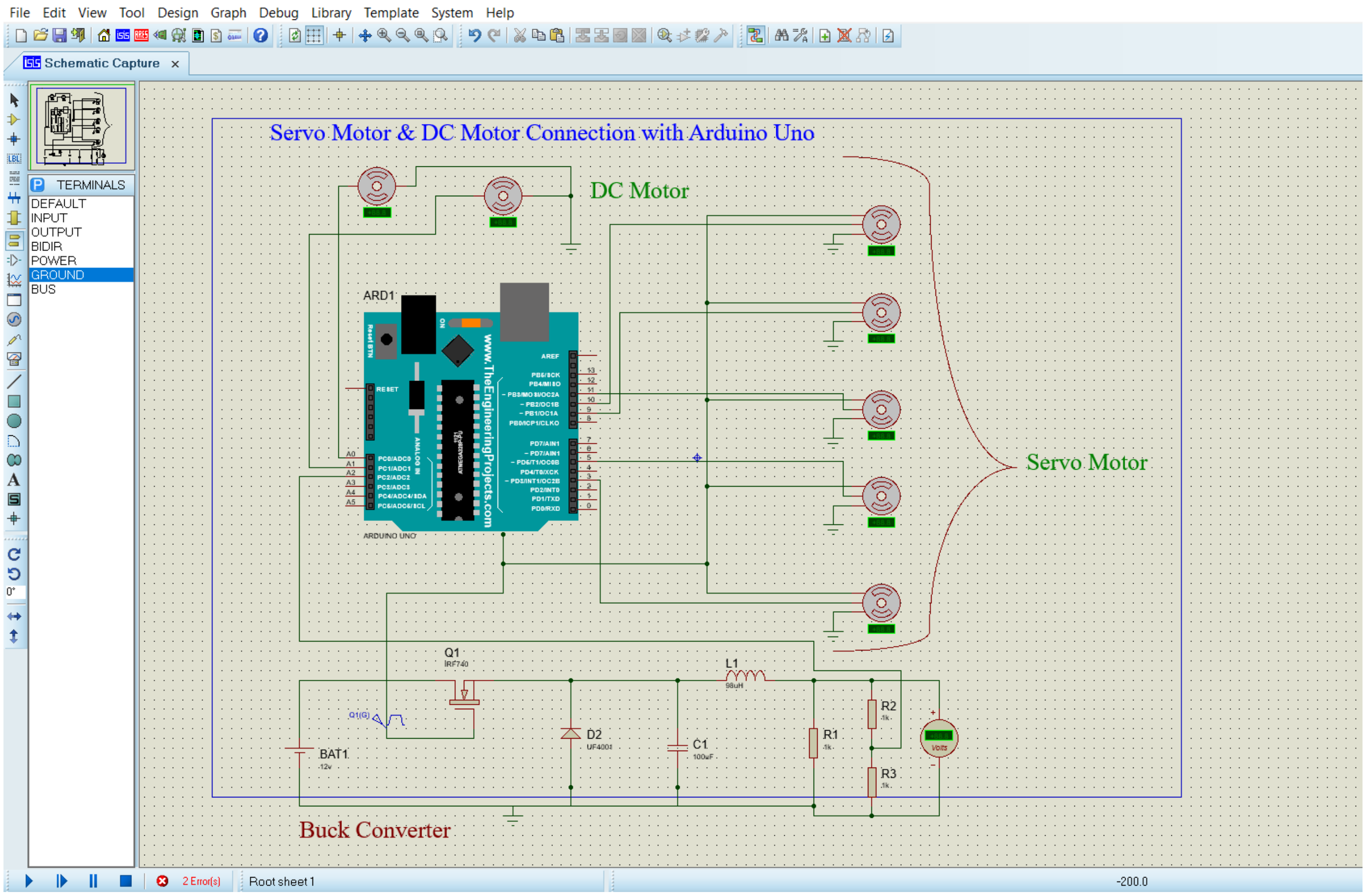

FIGURE 5.1: Simulated Model

5.2.2. Hardware Results

The hardware results are given below:

1. Mechanical arm length: 400 mm
2. Axis cover: 4
3. Car length: 300mm
4. Object weight: 50gm
5. Distance cover when car stopped 152.4 mm

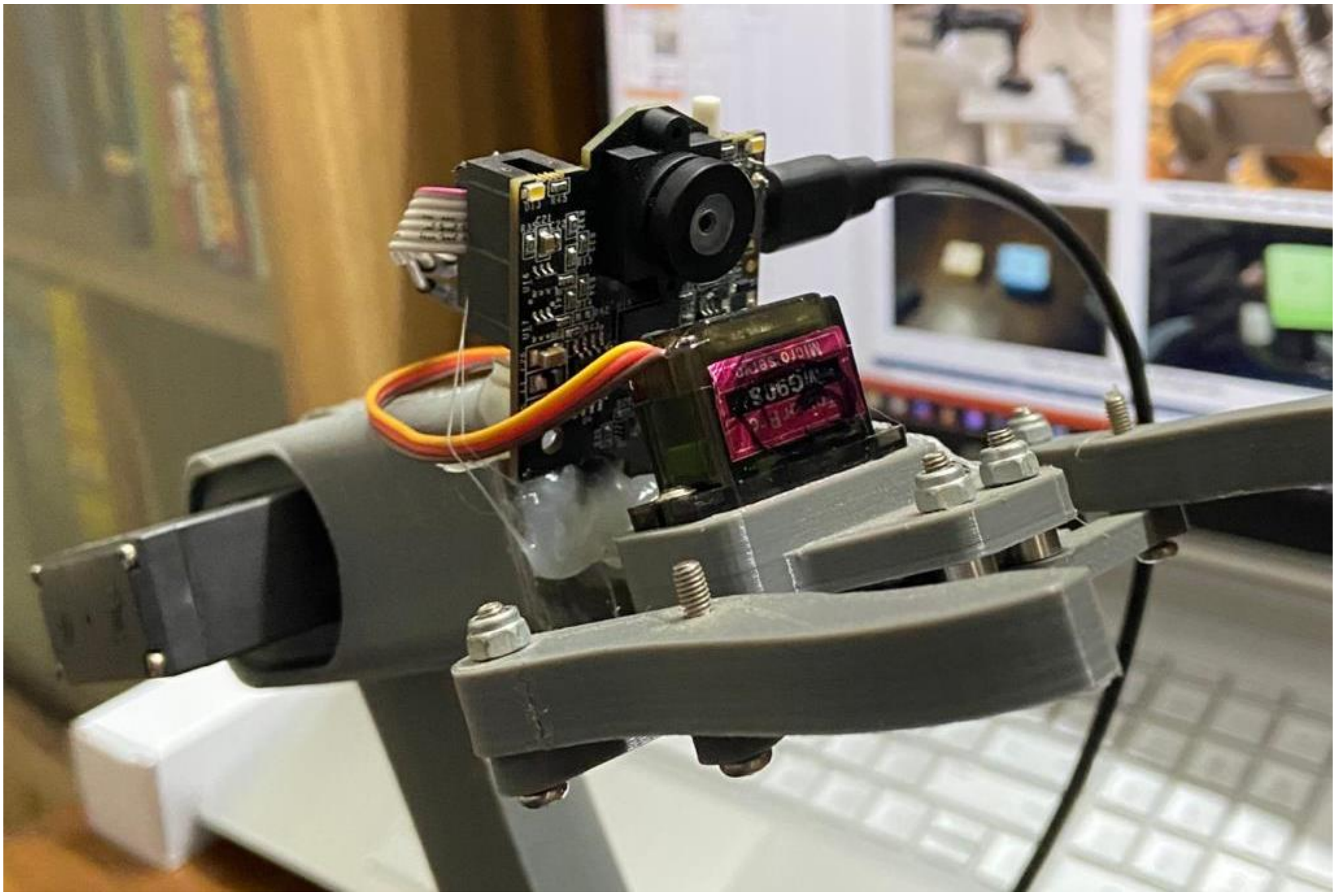

FIGURE 5.2: Robotic Arm with Pixy2 Cam

FIGURE 5.3: Output Result of our Project

Here Pixy2 Cam need to be trained by color. To see the output of the camera, a software (e.g.: Pixymon) need to be installed on Windows. Here it shows the camera detected the color perfectly and it said this is green color. So multiple attempts have been taken after training. The result have been shown in the TABLE 5.1.

TABLE 5.1: Hardware Result

Number	Time (In Second)	Pick and Place Accuracy
1	10.20	1
2	12.13	1
3	13.47	1
4	14.11	0
5	10.45	1
6	16.39	0
7	15.00	1
8	19.39	1
9	10.30	0
10	17.26	1
11	16.23	1
12	34.15	1
13	23.08	1
14	15.44	0
15	16.55	1
16	17.85	0
17	14.53	0
18	14.93	1
19	11.64	1
20	13.32	1
	Average time = 15.82 second	Total Pick = 20, Missing = 6

In our project, the original results were determined using twenty sample results. Sixteen of the twenty sample tests worked properly, while three failed. A robotic arm object is detected and placed on a belt in 15.82 seconds on average in sample tests. It takes two seconds for the object to turn after it is placed. We indicate pick and place accuracy in the hardware result table by 1 and 0. In this case, 1 represents the picking indicator and 0 represents the missing indicator.

5.3. Comparison of Results

Ten experiments were conducted during the simulation, and each one was completed successfully. For simulation, we use the Proteus software. The simulation result is satisfactory. However, we conducted ten hardware experiments, seven of which were successful. There was a minor hardware error that we can overlook. Accurate object detection is possible with Pixy2cam vision camera sensors, which can then use Arduino Uno to control a robotic arm to pick up and place the object. Last but not least, both the hardware results and the simulation were completed successfully.

5.4. Summary

Our project's primary goal is to select and position the object. The work has been successfully finished, and all goals have been achieved. We successfully created a simulation model in order to conduct a better experiment. This chapter displays a hardware model and a simulation model. The pick-and-place process can be automated to shorten cycle times, boost productivity, and lower material handling expenses. Simple, safe, and space-efficient operations characterize the design.

Chapter 6

CONCLUSION

6.1. Summary of Findings

With the aid of contemporary science, our project can succeed. It can operate in factories and other crucial locations. In this project, automated systems adapt to the environment and people's values. By using an automatic system for image training, good results can be attained for a reasonable price. The robotic arm can process precise images to locate the correct object, lift heavy objects, and place **them in predetermined locations** and can be moved automatical**ly from one location to another** which can complete the tasks of a team of workers in a short period of time.

6.2. Novelty of the work

The automation industry has made enormous strides in recent years. In our nation, the majority of people work, which takes time and money because people should be paid for their labor. A worker might become ill and be unable to function properly. For this reason, the here suggested prototype is utilized to handle the work simply. The cost of our suggested automation system is extremely low, and it can function properly quickly. The cost of maintenance is much lower than the wages of the employees. Work can stop when employees aren't present, but in an automated system, this is impossible. It can operate without stopping continuously. Additionally, it has been observed that our suggested automation system can complete tasks that take workers a day to complete in a matter of hours. Therefore, it can be said that the suggested one requires less time and can be used to enrich it. The government can implement a number of strategies to promote it broadly and increase public awareness.

6.3. Cultural and Societal Factors and Impacts

6.3.1. Cultural and Societal Factors Considered in Design

Advanced mechanics is essentially defined as the evaluation, organization, and use of robot frameworks for assembly. Generally speaking, dangerous, unsafe, dreadfully boring, and terrible tasks are carried out by robots. They have a variety of capacities, including material management, gathering, curve and obstruction welding, machine device load and dump capacities, painting, splashing, and more. The two main categories of robots are modern mechanical and assistance robots. An "administration robot" is a robot that, with the exception of manufacturing tasks, operates partially or entirely independently to provide services beneficial to the welfare of people and equipment.

However, the ISO describes a modern robot as a multipurpose controller that can be programmed in at least three hubs and is consequently controlled. Industrial robots are designed to move various types of objects, including supplies, parts, tools, and specialized equipment, using a variety of preprogrammed motions to carry out a variety of tasks. The robots themselves, any equipment and sensors required for the robot to complete its tasks, and any interfaces for sequencing or observing correspondence make up the framework for a modern robot.

The strategy was created in accordance with government standards, and the design concepts were created utilizing some automation design concepts. Future plans will include the preservation of a few extra resources to allow for future design modifications. A major issue for the industry was that the pick-and-place robotic arm's previous method was not accurately detecting the object. However, our intended course of action is to modernize the production system, which is predicted to reduce the cost of money and workers' labor while also providing a good idea component for societal and cultural advantages.

6.3.2. Cultural and Societal Impacts of the Proposed Design

The pick and place robotic arm is primarily intended for use in industrial manufacturing systems. One of the Ministry of Industry's top priorities is the automatic management of production. Product management has become an extremely important issue, particularly in many industries and factories in Bangladesh. It might result in significant loss problems. So, the expected project outcome was that it would automatically pick the product and place it in the fixed area, and that it could be installed in both large and small industries and factories. Because small factories primarily employ workers, worker absences can sometimes impede production. It would be extremely beneficial if our proposed system could be installed in a small factory.

The device works exactly as expected after implementation. The plan was carried out in accordance with legal requirements, and the design principles were developed with inspiration from autoclave architecture. Future-proofing includes keeping a few extra sources on hand in case the design specifications change. Professional solutions to society, culture, and the environment are proposed in the proposed projects. The prototype will be very helpful in the future, as mentioned in earlier management analyses. The engineers adhered to some rules and planned the project with a positive impact on society, culture, and the environment in mind.

6.4. Limitations of the Work

The general concept of automatic pick and place robot is detecting the object by image processing for pick the selected object and put it on a desire place. In this proposed system there need to write a Code for Arduino, which run the robotic arm. There has some limitation:

- Our proposed system can‘t take over weight product.
- Sometimes it missed to detect the selected object, for this problem there need to stop the program and Start again.
- By working continuously it‘s some electrical parts may be overheated, so there have a little chance to Hamper the production.
- In our proposed system there need to be select the working area of robotic arm. For this reason, if it needs to move in another place there also need to select the working area.

6.5. Future Scopes

The modern world automation industry is distinguished by a number of key characteristics, each of which has a significant impact on the industry's growth. Robotics system plays a vital role in the automation industry. These robots bring into an industrialized manufacturing atmosphere. At present all the manufacturing industries are going towards innovative ideas, methods, and techniques for better results and for the growth of the industry. That's the main concept of the future of the robotic industry. Because in the old day production was a small scale it was possible to perform these tasks manually by labor but a present due to an increase in production it is not possible to do it manually and it also increases the labor expenditure. More advanced technology can be used to increase the efficiency of the robotic arm which will reduce the cost of making the robotic arm and increase the massive demand of industrial factories. The use of robotic arms and conveyor belts is increasing rapidly, modern technologies can be used to enrich it. Various measures can be taken by the government to spread it everywhere and raise awareness among the people.

6.6. Social, Economic, Cultural and Environmental Aspects

6.6.1. Sustainability

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. All 193 member states of the United Nation have adopted 17 global goals to be achieved by 2030, known as the Sustainable Development Goals or SDGs. The SDGs offer a framework and blueprint for achieving sustainable global prosperity and commit participating countries to individual and joint action for the good of all on the planet.

This projects meets the goal of SDG. Specifically it met with goal number 8 and 9. They are Industry, Innovation & Infrastructure and Decent Work & Economic Growth. There is no doubt that this project is straight to the industrial sector. There is no doubt that this project is associated with the industry along the way. Our robot is innovative because it works through automation. Along with that, the latest camera sensor has been used. The use of these robots can make the working environment of an industrial plant orderly and noiseless. Its performance is several times higher than that of a human. As a result, more work can be done with less errors. As a result, this robot will directly and indirectly participate in economic growth.

6.6.2. Economic and Cultural Factors

Engineers work to ensure public safety and national development. Furthermore, in order to maintain their professionalism, they must always adhere to certain rules and regulations. During the construction of the project, no code of ethics was broken. We have strictly followed the safety while developing this robot. Special attention has been paid to its battery system so that it does not cause any kind of fire. Besides that, every component is perfectly placed so that even if there is a knocking problem, it can be easily fixed. No substandard or inappropriate materials were used in the construction of this project. While verifying each component, more consideration has been given to making the robot cost-effective and durable.

6.7. Conclusion

We have discussed various aspects of our project in this section. In our project, we discussed innovation. We also talked about the project's culture and social aspects. We've discussed ethical concerns and the code of ethics. Finally, we've discussed the effects of our technology on the environment and economic growth.

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Appendix A

CODE

CODE 01

```
#include <Pixy2.h>
#include <Servo.h>
#define CLAW_MIN 50
#define CLAW_MAX 140
#define YAW_MIN 50
#define YAW_MAX 180
#define S2_MIN 45
#define S2_MAX 120
#define S1_MIN 10
#define S1_MAX 150

Servo YAW, S1, S2, CLAW;
Pixy2 pixy;

int YAW_POS=90, S1_POS=40, S2_POS=70, CLAW_POS=CLAW_MAX;

void setup(){

 Serial.begin(9600);
 pixy.init();
 pixy.changeProg("color_connected_components");

 YAW.attach(6); S1.attach(5); S2.attach(3); CLAW.attach(9);
 delay(500);

// S2.write(70); S1.write(50); YAW.write(180);    while(1);
```

```
 BASE_POSITION();
}

int16_t GET_BLOCK(){
 if (pixy.ccc.numBlocks && pixy.ccc.blocks[0].m_age>30)
   return pixy.ccc.blocks[0].m_index;

 return -1;
}

Block *TRACE_BLOCK(uint8_t index){
 for (uint8_t i=0; i<pixy.ccc.numBlocks; i++)
   if (index == pixy.ccc.blocks[i].m_index)
     return &pixy.ccc.blocks[i];

 return NULL;
}



void loop(){
 static int16_t index;
 Block *BLOCK = NULL;

 pixy.ccc.getBlocks();
 index = GET_BLOCK();

 if (index>=0)
    BLOCK = TRACE_BLOCK(index);

 if (BLOCK){

   int W = BLOCK->m_width;
   int H = BLOCK->m_height;
```

```
  int X = BLOCK->m_x + (W/2);
  int Y = BLOCK->m_y + (H/2);
  //Serial.print("X:   ");   Serial.print(X);   Serial.print("\tY:   ");   Serial.print(Y);   Serial.print("\tSize:   ");
Serial.print(W); Serial.println(' ');
  delay(100);
  MOVE(X, Y, W);
  }

else BASE_POSITION();
}

void BASE_POSITION(){
 S2_POS = 70;
 S1_POS = 40;
 YAW_POS = 90;
S2.write(S2_POS); delay(100);
S1.write(S1_POS); delay(100);
YAW.write(YAW_POS); delay(100);
CLAW.write(CLAW_MAX);

}

void DROP_OPERATION(){
 delay(200);
 S1.write(50); delay(100);
 S2.write(70); delay(100);



 while(!(YAW_POS==YAW_MAX)){
 if(YAW_POS>YAW_MAX)
    YAW_POS--;
 if(YAW_POS<YAW_MAX)
    YAW_POS++;
```

```
 YAW.write(YAW_POS);
 delay(10);
 }

 for(int i=CLAW_MIN; i<CLAW_MAX; i++)
    CLAW.write(i), delay(10);

 delay(300);
 BASE_POSITION();
}

void MOVE (int X, int Y, int W){
 int X_ERROR = X-170;
 int Y_ERROR = Y-150;

 if(abs(X_ERROR)>10)
   if     (X_ERROR>0 && YAW_POS>YAW_MIN)
        YAW_POS-=(X_ERROR/10);

   else if(X_ERROR<0 && YAW_POS<YAW_MAX)
        YAW_POS-=(X_ERROR/10);

 if(abs(Y_ERROR)>20)
   if     (Y_ERROR<0 && S1_POS>S1_MIN)
        S1_POS-=5;
   else if(Y_ERROR>0 && S1_POS<S1_MAX)
        S1_POS+=5;

 if (abs(X_ERROR)<10 && abs(Y_ERROR)<20){
    S1_POS++;
    S2_POS++;
```

```
    if (W>90)
      GRAB();
 }

  S2.write(S2_POS);
  S1.write(S1_POS);
  YAW.write(YAW_POS);
  //Serial.print("YE:    ");    Serial.print(Y_ERROR);    Serial.print("\tS1:    ");    Serial.print(S1_POS);
Serial.print("\tS2: "); Serial.print(S2_POS); Serial.println(' ');

}
void GRAB(){
 delay(1000);
 for(int i=CLAW_POS; i>CLAW_MIN; i--)
     CLAW.write(i), delay(10);

 DROP_OPERATION();
}
```

CODE 02

```
#define LMB 11
#define LMF 10
#define RMB 6
#define RMF 9

inline void Set_Speed(int L, int R);

void setup() {
  Serial.begin(9600);
  pinMode(LMF, OUTPUT);   pinMode(LMB, OUTPUT);
  pinMode(RMF, OUTPUT);   pinMode(RMB, OUTPUT);
  pinMode(8, 1); digitalWrite(8, 1);
```

```
  pinMode(A0, 0);  pinMode(A1, 0); pinMode(A2, 0); pinMode(A3, 0); pinMode(A4, 0);

// Set_Speed(-100, 200); while(1);

}

void loop() {
  int s5 = digitalRead(A0);
  int s4 = digitalRead(A1);
  int s3 = digitalRead(A2);
  int s2 = digitalRead(A3);
  int s1 = digitalRead(A4);

Serial.println(s5);

if( s1 &&  s2 &&  !s3 &&  s4 &&  s5)   Set_Speed(100, 100);         //11011

else if( s1 &&  !s2 &&  !s3 &&  s4 &&  s5)   Set_Speed(80, 100);     //10011
else if( s1 &&  !s2 &&  s3 &&  s4 &&  s5)   Set_Speed(0, 80);     //10111
else if( !s1 &&  !s2 &&  s3 &&  s4 &&  s5)   Set_Speed(-50, 80);     //00111
else if( !s1 &&  s2 &&  s3 &&  s4 &&  s5)   Set_Speed(-100, 100);     //01111

else if( s1 &&  s2 &&  !s3 &&  !s4 &&  s5)   Set_Speed(100, 80);     //11001
else if( s1 &&  s2 &&  s3 &&  !s4 &&  s5)   Set_Speed(80, 0);     //11101
else if( s1 &&  s2 &&  s3 &&  !s4 &&  !s5)   Set_Speed(80, -50);     //11100
else if( s1 &&  s2 &&  s3 &&  s4 &&  !s5)   Set_Speed(100, -100);     //11110

else if( !s1 &&  !s2 &&  !s3 &&  !s4 &&  !s5)  { Set_Speed(0, 0); while(1); }    //00000
}


inline void Set_Speed(int L, int R) {
```

```
  if (L >= 0)
  {
    analogWrite(LMF, L);
    digitalWrite(LMB, 0);
  }
  else
  {
    digitalWrite(LMF, 0);
    analogWrite(LMB, abs(L));
  }

  if (R >= 0)
  {
    analogWrite(RMF, R);
    digitalWrite(RMB, 0);
  }
  else
  {
    digitalWrite(RMF, 0);
    analogWrite(RMB, abs(R));
  }

}
```

Appendix B

iThenticate Plagiarism Report