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Cupcake symphony

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Disclaimer Statement

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Abstract

The Cupcakes Symphony project is an Automated Cupcake Decoration Line intends to transform the confectionery industry by giving customers a streamlined and engaging experience to customize and embellish their cupcakes. Along with giving customers a fun and original method to customize their cupcakes, it also offers a scalable revenue strategy for bakers and confectionery stores.

With automation, the system significantly reduces decorating time, making it suitable for both personal use and commercial applications, it also makes sure that quality control is maintained throughout the decorating process while upholding high standards of hygiene and presentation.

This line consists of several stages which are the decoration items such as frosting, sprinkles, etc., the customers have the freedom to choose whatever they want from these items either by using the keypad or the mobile application. The last stage is the packaging stage.

This idea exists in factories but there are no machines in small stores that do this task, they do that manually and this is time-wasting and there is no guarantee of cleanliness and quality.

Chapter 1

Introduction

1.1 Statement of the problem

The cupcake symphony machine is designed to decorate the cupcakes. Unlike the traditional methods, it guarantees the cleanliness and speed. It also provides a freedom of choice to customize the cupcake with the desired frosting and sprinkles.

1.2 Objectives of the work

The main object behind this project is to Integrate a fully automated cupcake decoration line to reduce decorating time. With materials and features that assures hygiene and food safety. And to allow customers to have an enjoyable customization of their cupcakes. All of these features could help to address the gap in cupcake decoration technology by making the system accessible for small confectionery stores.

1.3 Scope of the work

A carefully planned, multi-phase approach was adhered to throughout the project. Initially, the machine's primary target was identified. to move us on to the following stage, which includes the cautious selection of appropriate parts, including motors, sensors, drivers, and the machine's entire body in addition to the controller. we divided the project into separate units, the frosting, sprinkles and packaging. Before each component was incorporated into the machine's overall design, it underwent independent testing. Ultimately, we created an algorithm to operate the machine efficiently, and we tested the combined system thoroughly to guarantee peak performance in every circumstance.

1.4 Significance of our work

The Cupcakes Symphony project represents a revolutionary change in cupcake customization and decoration, with profound implications for the confectionery sector. The introduction of automation, which not only significantly cuts down on decorating time but also guarantees a consistent and superior final result, is one of the main implications. This invention helps tiny confectionery shops overcome their obstacles by giving them access to modern technology that was previously only available in larger manufacturers. The project's emphasis on personalization encourages a more interesting and tailored experience for clients, in line with changing consumer demands. Furthermore, the emphasis on hygiene and food safety contributes to elevating industry standards, assuring customers of a clean and safe product.

1.5 Organization of the report

There are multiple sections in this report. An outline of the project's goals is given in the introduction. The parameters and extent of the work are outlined in the second part.

The project's methodology and methods are described in the third section.

The results and conclusions, together with any difficulties encountered and how they were resolved, are presented in the fourth section. The project's importance and possible effects are covered in the fifth section. The report's main themes are finally summed up in the conclusion, which also offers suggestions for more research. To offer further details and data pertinent to the project, appendices are also included.

Chapter2

Theoretical Background and Previous Work

To successfully complete this project, we relied on our prior knowledge. The fundamental understanding of C++ Programming and Data Structures and Algorithms courses played a crucial role in enabling us to learn Arduino IDE coding. Additionally, our knowledge gained from Microprocessors and Digital Circuits Design courses was essential in learning how to interface DC and Stepper motors with the Arduino board.

Our ability to approach the project methodically and make wise conclusions was made possible by the Critical Thinking course, which was really helpful for the project. We gained critical thinking abilities from the training that enabled us to recognize possible problems, evaluate them, and suggest workable solutions. This was crucial when we encountered problems with power and design during the project.

The Arduino course was an absolute necessity in the creation of the machine, as it provided us with the indispensable skills and knowledge required to operate the Arduino Mega board. By participating in the course, we were able to acquire practical experience in coding and troubleshooting the Arduino board, which played a critical role in the development of the control system for our machine.

Finally, Through the Electronics course, we have gained a robust understanding of the fundamental concepts of electronics. This knowledge has been invaluable in our capacity to design and address any problems related to the machine's hardware components, such as sensors and motors.

Chapter3

Methodology

In this chapter, we will comprehensively cover the hardware components employed in building the system, their interconnections, and the overall system design. Additionally, we will discuss the functioning process of the system, as well as the software implementation, mobile application, and database that were utilized.

3.1 Hardware Components

3.1.1 Microcontrollers

Arduino Mega 2560

With its ATmega2560 microcontroller, the Arduino Mega 2560 is a versatile board. It offers 54 digital input/output pins, 15 of which support PWM outputs. Additionally, it provides 16 analog inputs, 4 UARTs for hardware serial ports, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. This all-inclusive set of features makes it an ideal microcontroller solution for our project requirements.

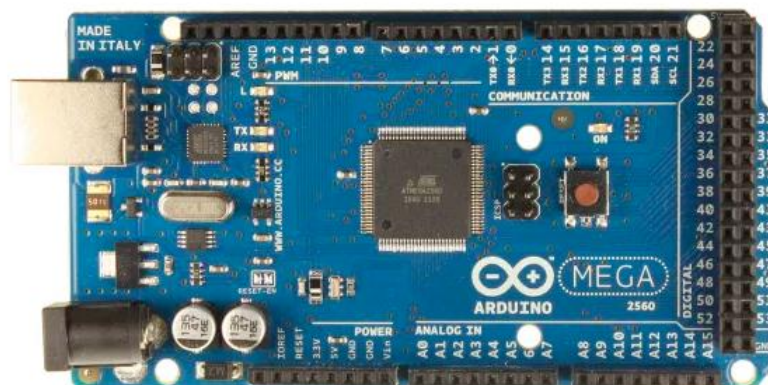


Figure 1: Arduino Mega 2560

ESP32-DevKitC ESP32-WROOM-32U Core Board

The ESP32 is a highly capable System on Chip (SoC) microcontroller that comes with built-in Wi-Fi 802.11 b/g/n, dual mode Bluetooth version 4.2, and a wide range of peripherals. It serves as an upgraded version of the 8266 chips, boasting two cores clocked at different speeds of up to 240 MHz. In addition to these enhancements, it also offers an increased number of GPIO pins, going from 17 to 36, and supports up to 16 PWM channels. Furthermore, it is equipped with 4MB of flash memory.[\[1\]](#)

The ESP32 is equipped with two cores, specifically the Xtensa LX6 processor, which is manufactured using 40 nm technology. Each CPU core can be controlled independently. In terms of memory, there is a total of 520 KB of on-chip SRAM available for storing data and instructions. Additionally, certain SoC modules like the ESP32-Wrover offer 4 MB of external SPI flash and an extra 8 MB of SPI PSRAM (Pseudo static RAM).[\[1\]](#)

A serial communication channel between the Arduino Mega and ESP32 microcontrollers was established as part of our project. To inform the admin (the owner of the cupcake line) of the quantity of the decorative goods, we also created a smartphone application. Following the placing of an order, the Arduino Mega received the amounts via the serial communication channel, and it immediately forwarded them to the application.



Figure 2 :ESP32-DevKitC ESP32-WROOM-32U Core Board

3.1.2 Motors and drivers

J-5718HB2401 Stepper motor and YS-DIV268N driver

A stepper motor is an electromechanical system that operates digitally. It is designed to move the rotor by a specific angle, known as the step angle, with each electrical pulse input. This is why it is called a stepping motor. The motor has input pins or contacts that enable the flow of current from a power source into the coil windings of the motor. By using pulsed waveforms in the correct sequence, the motor can generate the necessary electromagnetic fields to drive its movement.[\[2\]](#)

A stepper motor is well-suited for robotic applications due to its movement consisting of distinct steps. It operates by taking discrete steps at a specific angle known as the step angle. Stepper motors find extensive use in both commercial and industrial settings owing to their exceptional reliability, affordability, ability to generate high torque at low speeds, and their straightforward construction that allows them to function effectively in various environments.[\[2\]](#)

We used bipolar four-wire stepper motors in our project, namely the J-5718HB2401 type, because they are highly accurate and effective for spinning the conveyor belt.

We used the YS-DIV268N driver with a 12V power source to operate the motors. The driver's A and B pins were linked to the motor coils, and the control pins were linked to the equivalent Arduino pins, with the negative pins being united with the Arduino ground. Three stepper motors could be driven with the power and stability of the 12V power supply, which supplied the DC+ and DC- pins.



Figure 3: J-5718HB2401 Stepper motor



Figure 4: YS-DIV268N driver

Dc motor and H-Bridge

A DC motor is an electrical apparatus that transforms electrical energy into mechanical energy. Within this type of motor, the input electrical energy is in the form of direct current, which is subsequently converted into mechanical rotation.

In our project, we used a coupler and two 200rpm DC motors to build a unique whipped cream dispenser. Whipping cream is dispensed more enjoyable with this arrangement. The coupler turns smoothly once the motor is turned on. Not only was it important to pour whipped cream properly, but it was also important to make the process enjoyable. To control the motor's performance, we installed an H-Bridge.



Figure 5: DC motor

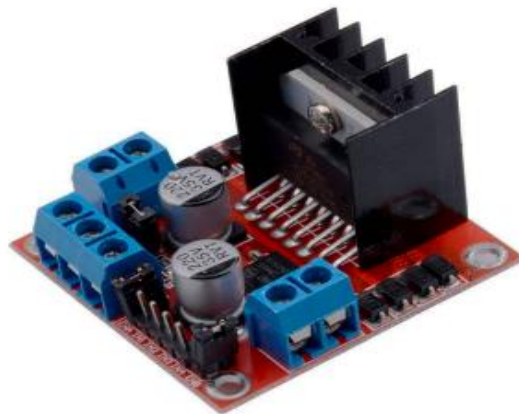


Figure 6: H-bridge

Servo motor

Servomotors are extensively utilized in various industries to regulate both static and dynamic loads. The primary concerns associated with AC Servomotors are the accurate management of position, speed, and torque. Industries highly value AC Servomotors for their ability to deliver precise responses even under dynamic load conditions.[\[3\]](#)

Servomotors are motors used to control the position or speed in closed-loop control systems. They have the capability to operate at a wide range of speeds and can execute instructions for controlling both position and speed. In general, DC and AC servomotors are commonly employed in various applications due to their robust machine structure.[\[3\]](#)

Within our project, we have used 2 types of servo motors which are the micro servo and the high torque servo in three stages to optimize the process of decorating and packaging. The first stage entails the precise control of a servo motor for sprinkling, facilitating accurate and controlled distribution of sprinkles onto the desired surface. In the second stage, another servo motor is employed to handle the chocolate decoration process, ensuring a methodical and artistic application of chocolate. Finally, the third stage utilizes a servo motor for packaging, guaranteeing a controlled and efficient packaging process. The incorporation of servo motors in these stages significantly enhances the precision and automation of each step, ultimately contributing to a more streamlined and visually pleasing final product.



Figure 7: SG9 micro servo



Figure 8: MG996R High torque servo

3.1.3 Sensors

IR sensor

An IR sensor is an electronic device that is capable of measuring and detecting infrared radiation in its surrounding environment. It finds extensive applications in both industrial and medical fields. IR sensors are crucial in obtaining precise data and minimizing noise levels and errors during tests and processes.[\[4\]](#)

To optimize the cupcake decoration and packaging process, we incorporated infrared (IR) technology into our project through six stages. The first stage involves the use

of an IR sensor to detect the presence of a cake, ensuring that the system operates only when necessary. In the following four stages, IR sensors are employed to precisely locate the cupcake under the frosting and sprinkles, enhancing the accuracy of the decoration process. Each IR sensor contributes to the systematic application of toppings, resulting in a cupcake that is beautifully decorated. Finally, in the last stage, an IR sensor is utilized to streamline the packaging process, ensuring that cupcakes are efficiently and accurately placed in their packaging. This integration of IR technology greatly improves the overall efficiency and precision of the cupcake decoration and packaging system.



Figure 9: IR Sensor

Ultrasonic sensor

An ultrasonic sensor is a device that utilizes sound waves with frequencies higher than what humans can hear to determine the distance to an object. These sensors are commonly employed in automation tasks for measuring distance, detecting position changes, and performing level measurements. They operate by measuring the time it takes for ultrasonic waves to propagate, ensuring accurate detection regardless of the object's color or surface design.[\[5\]](#)

The ultrasonic sensor was employed in our project to measure the distance and calculate the amount of ingredients left in the funnel. The administrator is provided with this information to ensure timely refilling of the ingredients.



Figure 10: Ultrasonic Sensor

3.1.4 Input/Output Devices

Lcd with I2C

The Liquid-Crystal Display (LCD), depicted in Figure 2, is an electronically modulated optical device or flat-panel display. It utilizes the light-modulating properties of liquid crystals in conjunction with polarizers. Instead of emitting light directly, liquid crystals rely on a backlight or reflector to generate color or monochrome images. The 16x2 LCD is a specific type of LCD display capable of presenting up to 16 characters in each of its 2 rows. This particular display finds extensive usage in various applications that necessitate the presentation of substantial data quantities, such as industrial automation systems, medical devices, and consumer electronics.[\[6\]](#)

In our project, we made use of the LCD 16x2 as an output device to present important information and instructions to the customer. This approach offers a user-friendly interface, enabling the customer to interact with the system effortlessly. The LCD

screen displays prompts and questions, guiding the customer to input their response using the keypad. The system then processes the input and provides the appropriate response on the LCD.

Furthermore, we incorporated the I2C Serial Interface Adapter into our setup. This module acts as an intermediary between a microcontroller and an LCD display, facilitating communication through the I2C protocol. By converting parallel signals from the display into serial signals, it enables seamless transmission over the I2C bus.



Figure 11: LCD with I2C

Keypad

A keypad is a collection of buttons organized in a matrix layout, wherein each button can be distinguished by its corresponding row and column coordinates. Such keypads are frequently utilized as input devices in microcontroller-centric systems, including those constructed using the Arduino platform.

As part of our project, we have incorporated the keypad as an input device to enable customers to select their desired drink. This is accomplished by presenting clear and succinct instructions on the LCD display that accompanies it. Customers can then input the instructions into the keypad to confirm their choice.



Figure 12: Keypad

3.1.5 Power Devices

Power supply

To meet the voltage specifications of our project, we decided to make use of a power supply. This choice was made because it can provide the required 5 volts for multiple devices and 12 volts for pumps and stepper motors. Additionally, the power supply offers an adequate current output that meets the demands of our project.



Figure 13: Powe Supply

3.1.6 Other Devices

Conveyer belt components

We used a wooden framework with two rods, a chain, and a circular base in our machine to hold the cupcake.



Figure 14: Linear rod



Figure 15: Chain

Wires

For various connections, we made use of three types of wires: male-to-male, female-to-female, and male-to-female wires.

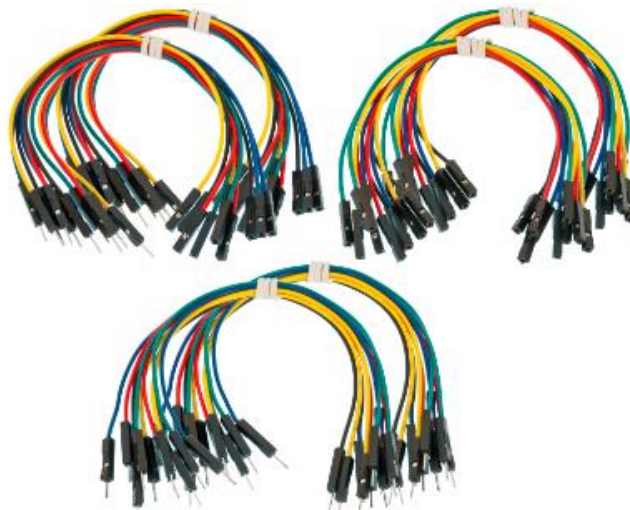


Figure 16: Wires

Switches

limit switches

To ensure precise control over the start and stop of the conveyor belt's movement, we have strategically incorporated a limit switch into our conveyor system. This limit switch is strategically positioned along the conveyor path and serves as a pivotal component in our automation process. When an object, such as a package or product, reaches the designated position, the limit switch detects its presence and transmits a signal to the control system. This signal acts as a command, directing the initiation or termination of the conveyor motor. By implementing this design, we guarantee an efficient and controlled flow of items along the conveyor belt, thereby enhancing automation accuracy, preventing collisions, and optimizing the overall operational workflow of the system



Figure 17: Limit switch

On/Off switch

We used an on/off switch to control the power supply.



Figure 18: On/Off switch

RGB LED strip

An RGB LED is a type of light emitting diode that can display red, green, and blue colors. It may produce a vast spectrum of colors by altering the intensity of these main colors. Pulse Width Modulation is used to control its color (PWM).



Figure 19: RGB LED strip

PCB board

We utilized a PCB to connect the limit switches with the resistors and GND.

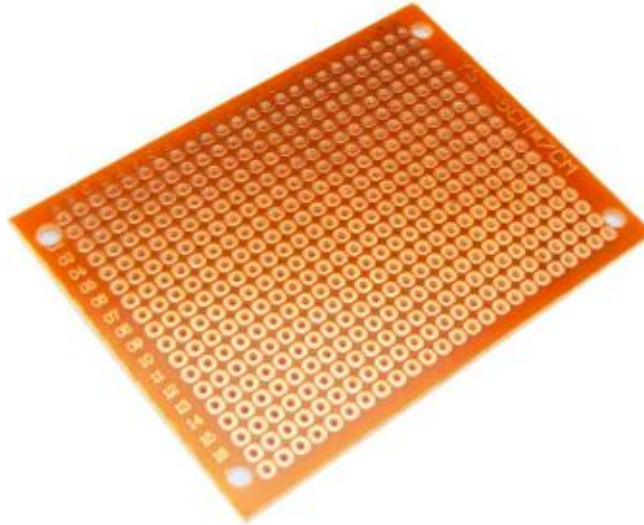


Figure 20: PCB board

Jumpers

We utilized a jumper to connect the components, such as the 5 volts and 12 volts power supply, to the devices that require these voltages.



Figure 21: Jumper

The outer design



Figure 22: Outer design

Whipped cream station, either white or pink



Figure 23: Whipped cream station

Sprinkles station



Figure 24: Sprinkles station

Chocolate station



Figure 25: Chocolate station

Closing the lid station



Figure 26: Packaging

3.2 Software implementation

In order to make it easier to manipulate different components, we used multiple libraries:

- The Servo Library <Servo.h>: responsible for precisely controlling the servo motors.
- Keypad Library <Keypad.h>: Controls keypad input, enabling the system to react to particular key combinations.
- LiquidCrystal_I2C Library <LiquidCrystal_I2C.h>: Facilitates I2C protocol-based communication with the LCD display.

First, we examine the reading from the IR sensor to make sure the cupcake package is positioned correctly.

And there is an IR sensor in every stage to detect the cupcake and start working if it was the chosen stage.

After placing a cupcake packet in the allotted space, the user must choose the required decorating supplies (chocolate, sprinkles, pink and white whipped cream). The user has the option to choose this option using our mobile application or the keypad.

the whipped cream station with a DC motor, screw, and nut is a simple but efficient device. Using a nut positioned along the threads of the screw, the hypothetical design attaches a screw to the DC motor shaft, thereby utilizing its rotational force. To stir the cream in a special container, the nut is moved along the axis of the screw.

The chocolate and sprinkles stations use servo motors to carefully and accurately sprinkle toppings on cupcakes. Each of the two distinct, servo-equipped sections in the design is meant for sprinkles and chocolate.

The cupcake packet moves on to the packaging station after decorating. A servo motor pushes the lid after the IR sensor detects it, and a second servo pushes it down to close it.

The LCD shows the current status of the system. Quantity-related notifications are also sent to the mobile application.

3.3 Hardware implementation

3.3.1 Input-Output Unit

this unit has an LCD screen for user interface and an infrared sensor for cupcake detection. A mobile application is used to select decorative elements. This unit's main functions are to make sure the cupcake package is positioned correctly and to expedite the user's choosing procedure.

3.3.2 Decorating Unit

This stage has four stages which are the white whipped cream, pink whipped cream, sprinkles and chocolate each stage has an IR sensor for accurate position of the cupcake.

The whipped cream stages with a with a DC motor, screw, and nut if the cupcake is detected by the IR sensor the DC motor will start rotating and the whipped cream will stir down.

The sprinkles and chocolate stages are attached with servo motors, whenever the IR sensor detected the cupcake, the servo will be open for a specific amount of time and a specific angle, each of these stages also have an ultrasonic sensor to get the amount of the items and send it to the mobile app.

3.3.3 packaging Unit

It's the final stage which has two servos to control the closing of the lid one of them if for pushing the lid towards the box and the other one to close it and there is an IR sensor for an accurate positioning.

3.3.4 Control unit

The Arduino in the control Section is in charge of the machine's whole operation. It communicates with the ESP32, which connects to the mobile application after that. With this configuration, consumers can use the internet platform to create custom scent mixtures.

3.4 Mobile application

We developed a mobile application with Bluetooth and an ESP32 microcontroller using App Inventor. An easy-to-use interface was developed by utilizing App Inventor's visual programming feature. Robust connection between the ESP32 and Bluetooth enabled the mobile app to effectively control and interact with the associated hardware.



Figure 27: Mobile application

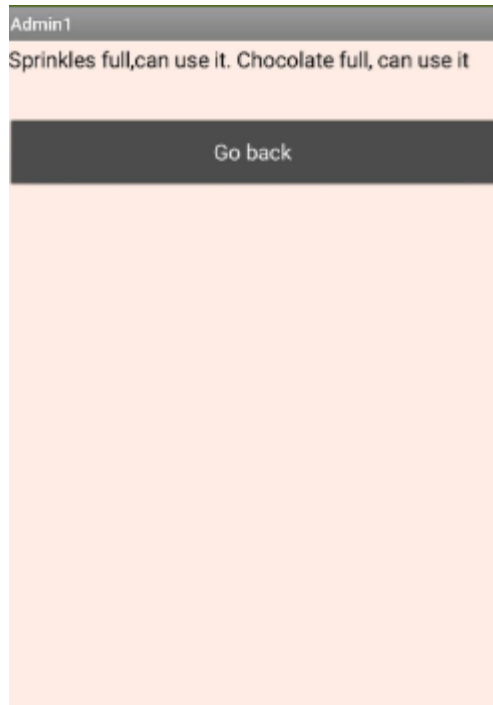


Figure 28: Admin

This screen shows the admin the quantities of the items and if he should refill them or not.

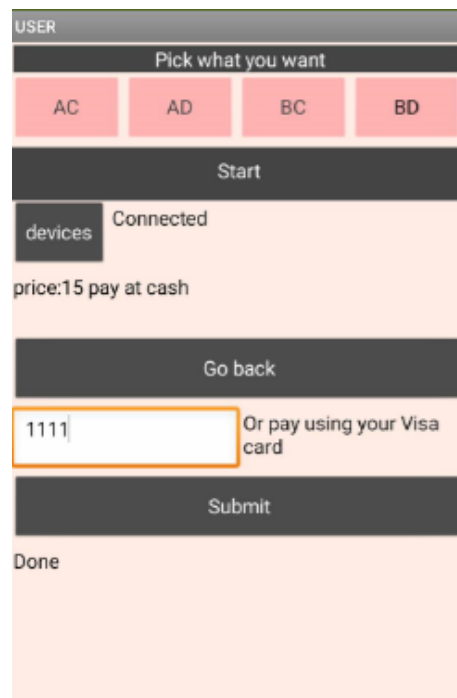


Figure 29: User

This screen allows the users to select the decorating items, show them the price and two ways of payment

Chapter4

Results, analysis and discussion

At the end the results were satisfying according to the intended object of the project. A smart and fully-automated cupcake decoration assembly-line was made with outstanding features like closing the box that contains the cupcake and sending an alert message to the person responsible for refilling via a mobile app, when the storage is nearly empty.

The results obtained from the Cupcakes Symphony project were good. However, it is important to objectively evaluate both the features and limitations of the work in order to draw meaningful conclusions.

One of the problems that were faced was trying to fix the cans containing the whipped cream in their place and prevent them from moving along with the movement of the 200 rpm DC-motor. But the problem was resolved by using multiple adhesive tools.

Unfortunately, it was difficult to control the appearance of the frosting. It is not as easy to do machine-made ornaments as hand-made ones. But by using special nozzles, it helped to make the final appearance very well and accepted

Another problem was finding an appropriate box for the cupcake. Regarding the size and the way that the lid closes. We were finally able to find boxes from a local coffeehouse that best suited our system.

An issue we faced was the IR-sensors that were extremely sensitive to different lighting and whenever the project was moved, they needed a re-check. And the system depends on them to stop at each stage in the right spot. This issue is out of our hands, so we kept adjusting them whenever they needed to be adjusted.

Chapter5

Conclusions and Recommendation

5.1 Summary

Our team created the automated Cupcake Decoration Line, which allows consumers to easily and hassle-free customize their cupcake orders. To order drinks, users can utilize a keypad and a smartphone application on the machine from a distance.

The proposed cupcake decoration machine is a forefront apparatus made to precisely and precisely dispense chocolate, sprinkles, and whipped cream onto cupcakes. A user interface, servo motors, DC motors, IR sensors, and other parts are integrated into this automated station to produce a smooth and engaging dessert-topping experience.

The entire system is turned on when an infrared sensor in the system detects an existence of a cupcake. The cupcake is moved through several steps using stepper motor, and precise placement and advancement are ensured by additional IR sensors positioned at each level.

5.2 Recommendations

1. Take care while utilizing the Chinese version of the Arduino board, as its output voltage is only 3.1 volts instead of 5 volts. We suggest using the Italian version instead.
2. Caution of directly powering sensors and other devices from the Arduino board. Employ a different power source.
3. Because wires are readily broken, you should always solder them rather than just connecting them.

5.3 What we have learned

1. How to use Arduino to connect and operate several kinds of high-voltage sensors and devices
2. adaptation: We learned the value of adaptation in engineering projects by encountering problems. A focus on finding solutions is essential.
3. How to connect Arduino to ESP32 and use its Wi-Fi features.
4. How to deal with different types of sensors like IR and Ultrasonic and also with motors like DC, Servo and stepper motors

5.4 Future Work

1. Auto Refilling for the whipped cream containers when they are nearly empty.
2. Provide payment methods via the system, so that it could be placed anywhere, not only in confectionery stores.
3. Adding GSM to allow the machine to give notifications to the admin.

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