AN-NAJAH NATIONAL UNIVERISTY
FACULTY OF ENGINEERING & INFORMATION TECHNOLOGY
COMPUTER ENGINEERING DEPARTMENT

SWEETCUP ZONE

Students:

Deema Hamoudeh & Razan Khamash

Supervisor:

Dr. Samer Arandi

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Abstract

The SweetCup Maker is an automated production line that has been launched for the sake of simplifying and improving the process of making personalized cheesecake cups as an answer to the rapidly growing market of personalized and efficient dessert production. Cheesecakes, which are famous for their delicate layers and meticulous preparation, usually need precision, particularly when customizing flavors and textures. SweetCup Maker is the one that offers you the possibility to create your own cheesecake cup by choosing from among different base layers (biscuit or cake) and toppings; all of this is accomplished during automation, ensuring both consistency and quality.

A SweetCup Zone offers users a unique way to prepare their personalized cheesecake cups automatically. User start by selecting his preferences for the base and topping layer by using keypad or mobile app, choosing between two choices for the base layer and four different toppings. The process contains several stages to produce a customized cheesecake cup. It starts with dispensing the cup, followed by melting and pouring butter into it. Next, the base layer - either biscuit or cake- is added . Then the whipped Cream, which kept cold by using cooling system, is added to the cup. The final layer will be added which is the chosen topping. After that the cup will enter the cooling system for amount of time. Then the final stage where the cup is sealed. The result in a perfectly customized three-layer cheesecake cup ready to enjoy it.

Acknowledgments

First and foremost,we would like to extend our heartfelt gratitude to our supervisor, Dr.Samer AL-Arandi, for his invaluable guidance, patience, and continuous support throughout this journey. His expertise and insightful feedback have been crucial in shaping this work.

Additionally, our sincere appreciation is extended to our families, who were the pillars of strength and encouragement, their belief in us gave us the power to continue.

We are also would thank our friends, whose support and companionship have made this journey more enjoyable and fulfilling.

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Chapter 1

Introduction

1.1 Statement of the problem

In the food industry, especially in the dessert world, there's a growing demand for fresh and personalized options. This is particularly true for cheesecakes, which offer a wide range of flavors and choices for each layer. Currently, customers who want to buy a cheesecake have only limited pre-made choices that are available at that time. And if they want to have a customization one they need to pre-order it and wait until it prepared. So this is a real problem in both time consuming and limited customization.

1.2 Objectives of the work

The objective of the project: The objective of this project is to design and implement Sweet Cup Zone machine which provide a comprehensive solution for the problem of limited customization and long waiting times needed to make a personalized cheesecake. SweetCup machine aims to enable user to choose his preference for the base and topping layers, using easy-to-use controls, like keypad and mobile app. It automated the entire process passing several stages to prepare his special cup in suitable time.

1.3 Scope of the work

Our project covers a comprehensive scope that contains various stages to deliever an integrated cheesecake maker. Beginning with extensive research to determine the features that met our objectives. Then we studied how each feature can be implemented in both sides : mechanical and electronic components, and we found the best approach for each. After that, we moved to implementation phase, when we build each stage and test it to ensure its correctness and efficiency. After that we start combining all stages together to make a full automated system which prepared the customized cheese cake cup as we aimed. And the final phase is to try to make the control as friendly as we can by using keypad & LCD and then added the mobile app.

1.4 Significance of our work

The Sweet Cup machine offer a valuable service by making a customized cheesecake cup. This machine is worth to invest in business. A store manager who aims to apply personal preference will not be hesitating to have this machine. Additionally, making one personalized cup is helpful to minimize the wasted food which make this machine not only valuable and efficient but also echo-friendly.

1.5 Organization of the report

The report is structured into multiple segments. Chapter 1 introduces the project and outlines its objective. Chapter 2 discuss the limitation and challenges during the implementation of the project. Chapter 3 reviews previous work and how our project differs from existing ones. Next, chapter 4 explains the detailed approaches and steps followed to develop and impelement this project. Chapter 5 shows the final results and discuss the outcomes. And Chapter 6 gives a brief summary to conclude the project and suggestions for future improvements.

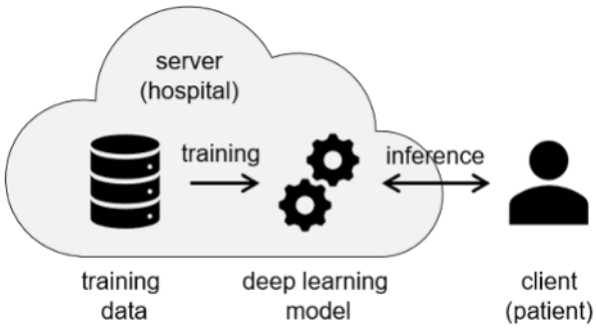

Figure 1.1: Image

Chapter 2

Constraints, Standards/Codes and Earlier course work

2.1 Constraints and limitations

Technical Restrictions:The speed at which the production process can proceed is restricted because it takes the heater nearly five minutes to reach the required temperature. The system's efficiency is impacted by this delay.

Environmental Restrictions: The production line operates best at room temperature because the cooling elements are only effective at certain temperatures, causing the food materials to be harmed. We were able to make well-informed decisions early in the design process by having a clear understanding of the constraints, which helped to keep the project within scope while still achieving the necessary performance standards.

physical constraints: The air valves needs air compressor to work and it can't work without it.

2.2 Standards and Codes

The software components of the system are based on the Arduino IDE C++ using many libraries ,including Keypad.h, Stepper.h, OneWire.h,DallasTemperature.h, Wire.h, Liq-

uidCrystal_I2C.h and the mobile application was developed using App Inventor platform.

2.3 Earlier Coursework

Our project wouldn't have been successful without the earlier coursework. The PIC microcontroller lab was important in helping us become familiar with the Arduino Mega2560. Additionally, our participation in the IEEE Arduino course and self-learning through the official Arduino website made using C++ Arduino code much easier. Additionally, the courses we took in the electrical department, such as Electronics 1, Electronics 2, Circuit Analysis, and Signal Analysis, provided us with a solid foundation in electricity. Enabling us to calculate the voltage and the current correctly, so connecting the hardware components correctly. Also, the PIC microcontroller course and the microcontroller course gave us the knowledge to program the microcontrollers in general. Finally, the critical thinking course gave us many important skills, such as planning, evaluating, logical and critical thinking and helped us taking more educated decisions

Chapter 3

Literature Reviews

The authors designed and developed an autonomous cupcake machine, The method employed involved using an Arduino microcontroller board, motors, thermocouple, and inexpensive materials like plastic and wood to automate the cupcake-making process. The key focus was on achieving a cost-effective solution that enhances efficiency and product consistency. The paper emphasizes system development, outlines the methodology, and discusses potential applications and commercial viability. (Polichshuk et al., 2018).

Our machine benefited from previous work, it used some of the above techniques such as the design and implementation of the screw conveyor with additional modifications to suit our purposes.

Chapter 4

Methodology

4.1 Hardware Components

4.1.1 Microcontrollers

Arduino MEGA 2560

Figure 4.1: Arduino Mega 2650

Because of its many features, including its large number of pins—54 digital I/O pins and 16 analog input pins—and its 256 KB of flash memory, which can accommodate large programs, the Arduino Mega 2560 functioned as our project's primary control unit. It was also the perfect choice for handling complicated tasks and integrating with external peripherals. making it the ideal option for our project.

Figure 4.2: ESP8266

NODEMCU ESP8266

The ESP 8266 was used to make the wireless communication between the Arduino and the Application, allowing the user to order wirelessly.

4.1.2 Motors and drivers

Nema23 Stepper Motor and YS-DIV268N Driver The Nema23 stepper motor offers high torque and precise positioning, moving 1.8 degree per step. We used it to control the conveyor belt position and to open and close the butter dispenser, which requires specific steps for accuracy. Additionally, the TB6600 (YS-DIV268N-5A) stepper motor driver was chosen for its ability to supply up to 5A, making it suitable to drive the Nema23 stepper motor efficiently. Nema17 Stepper Motor The Nema17 stepper motor

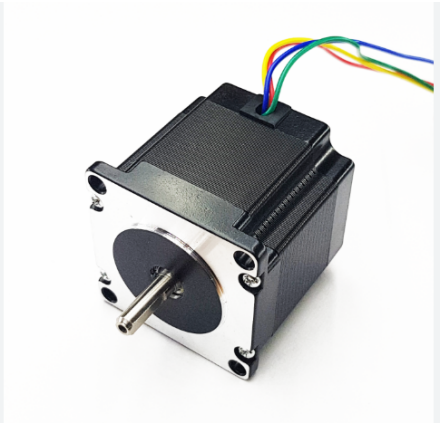

Figure 4.3: Nema23 Stepper Motor

provides precise positioning but has lower torque, making it suitable for applications that don't require high power. We used it to control the topping dispensers, as they

Figure 4.4: (YS-DIV268N-5A Stepper Motor Driver

don't require much torque and benefit from accurate positioning to precisely control the quantity dispensed. Additionally, we utilized the Nema17 for both the cups dispenser and the cream dispenser, where precision is key to ensuring consistent operation.

Figure 4.5: Nema17 Stepper Motor

H Bridge L298N

It was used to control some of the Nema17 Stepper motors.

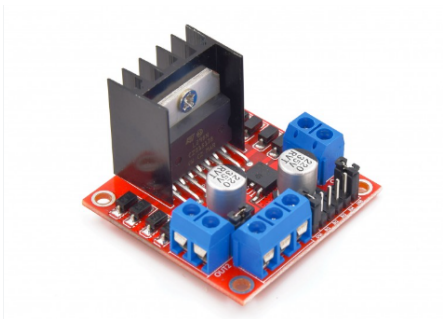

Figure 4.6: H Bridge L298N

A4988 Driver

it's suitable to control Nema17 motors, as it has a comprehensive features and ease of use, It offers precise microstepping capabilities, allowing for smoother and more accurate motor movements.

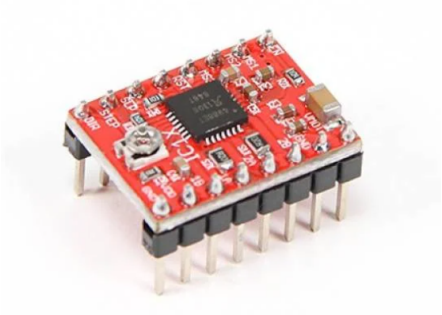

Figure 4.7: A4988 Driver

4.1.3 Sensors

Ultrasonic The ultrasonic sensor measures the distance to an object by emitting ultrasonic pulses and calculating the time it takes for the echo to return. We used it to monitor the quantity levels in the dispensers by attaching the sensor to the lids, ensuring accurate measurement of the remaining contents.

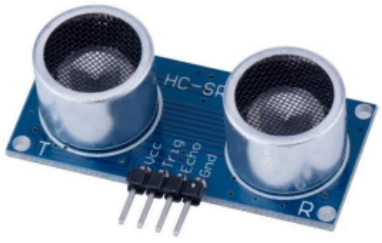

Figure 4.8: UltraSonic

Laser and LDR Module

At each stage, the laser and LDR (Light Dependent Resistor) module were mounted facing each other. When the cup reaches the stage, the laser is interrupted. By continuously reading the LDR value, we can detect if the cup has arrived. IR Sensor

An infrared (IR) sensor is an electronic device that detects objects by emitting infrared

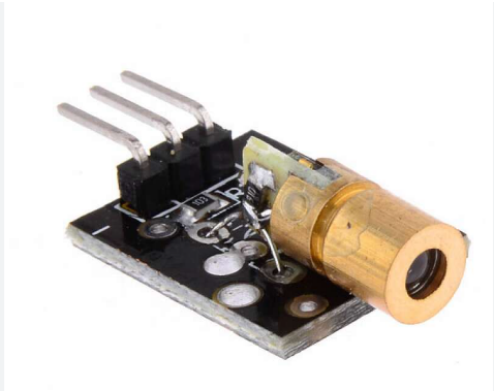

Figure 4.9: Laser

Figure 4.10: LDR Module

radiation and measuring the reflected light. It can distinguish between black surfaces and other surfaces based on their reflectivity. In our project, we used the IR sensor in the toppings' circle by placing black tape near each dispenser. As the circle rotates, the sensor detects the black tape, allowing us to determine which dispenser is currently positioned at the top of the conveyor. This setup ensures accurate tracking of the dispenser's location on the conveyor belt.

Figure 4.11: IR Sensor

4.1.4 Input/Output Devices

LCD and I2C We integrated 20*4 LCD as an output device, to make seamless interaction with the user ensuring enhanced user experience, I2C module was used along with the

LCD to make serial communication with the Arduino by I2C method using only 2 Pins ,SDA(data line) and SCL(clock line).

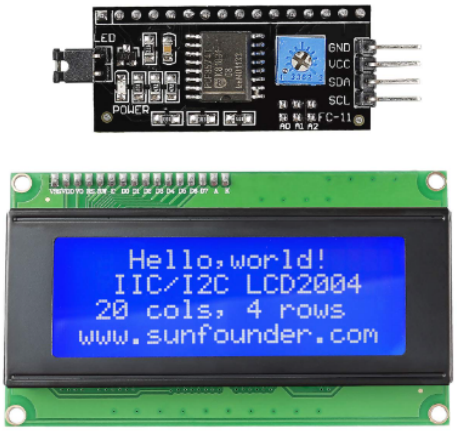

Figure 4.12: LCD and I2c

Keypad The keypad was used as an input device, enabling the user to enter their preferences and choices.

Figure 4.13: Keypad

4.1.5 Power Devices

We used a computer power supply to give consistent and dependable power to different parts and modules. Because of its dependability and capacity to provide adequate

power across several voltage rails,

Figure 4.14: Power Supply

4.1.6 Input/Output Devices

3D printings: Cups Dispenser

The design allows for seamless dispensing of cups, one at a time, ensuring smooth operation in the automated system.

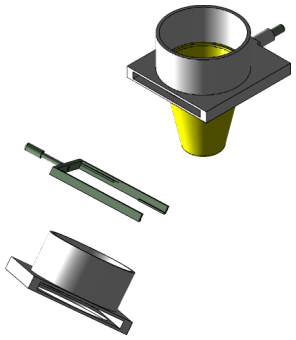

Figure 4.15: 3D design cups dispenser

Cream dispenser control gears:

we design the following gears in order to control the dispensing operation of the cream, ensuring precise and accurate quantites to dispensed.

Figure 4.16: 3D design cream dispenser

4.1.7 Other Devices

Pneumatic Piston

A pneumatic piston uses compressed air to move in a straight line. It has a cylinder with a piston inside, and when air is pumped in, it pushes the piston back and forth, we employed this movement to press the biscuit and to close the lid tightly. Relays Relays are electromechanical switch that can control a high voltage using 5V only, making it compatible with the Arduino microcontroller, in our project we used a 5 channel relay

to control many devices, the butter heater which will be on for a specific time then it should be off, the two switch selectors which used to control the air jacks, to control the cooling tunnel fan, as it required to be on for a specific time only, and finally to control the LED strip Light.

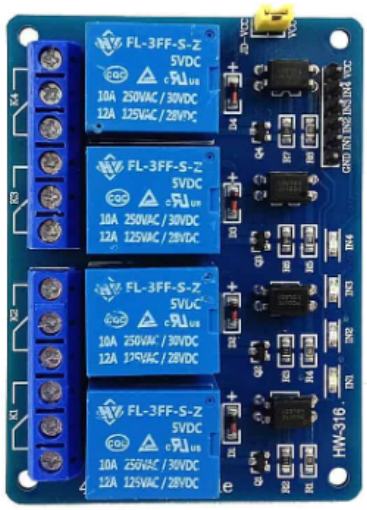

Figure 4.17: Relays

LED strip Lights

It was used as a design element, when the cup enters the Butter and biscuit tunnel the LEDs will be turned on, when the cups leaves it'll be off.

Figure 4.18: LED strip Lights

Air Solenoid Valve

An air solenoid valve is a crucial component in pneumatic systems, designed to control the flow of compressed air so controlling the pneumatic piston.

Figure 4.19: Air Solenoid Valve

Peltier Module

The peltier module is a thermoelectric device which transfers the heat from one side to the other when the current passes through it,We used it to keep the cream cold, and we used it to create the cooling tunnel.

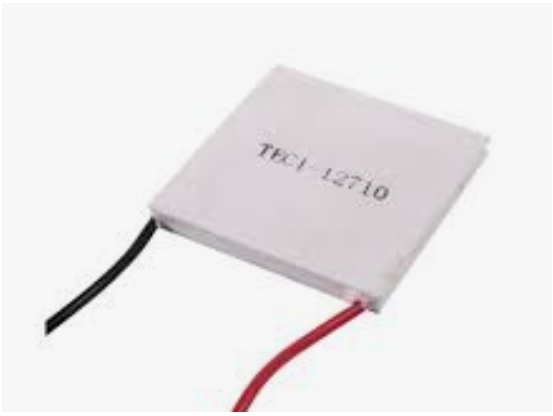

Figure 4.20: Peltier Module

Fan

A fan is a mechanical device designed to create airflow by using rotating blades or vanes to provide cooling, the fan is used with the peltier in order to dissipate the heat effectively.

Figure 4.21: Fan

Valve Speed Regulator

For fluid systems, a valve speed regulator functions similarly to a traffic controller. It aids in controlling a valve's opening or closing speed to guarantee a precise flow of liquids or gases, we used it to control the speed of the air jack which used to press the biscuit, as we need a gentle pressing operation.

Figure 4.22: Air Regulator

cartridge heater 220 volt

A cartridge heater is a type of heating element that is designed to fit snugly into small areas or liquids, it needs 220 to work, we deployed it in our project to heat the water surrounding the butter.

Figure 4.23: cartridge heater 220 volt

4.2 Software Implementation

Firstly, the user place their order, whether using the keypad or through the applications, then the cup will be dispensed, and the cooling tunnel will start cooling, the LDR value value will be checked to ensure the proper dispensing of the cup, the next stage is the butter,when the LDR is interrupted the heater will start heating until the butter is melted, then a specified amount of butter will be dispensed, after that when the next LDR is interrupted, either cake or biscuit will be dispensed based on user selection, after that, if the piston LDR is interrupted the piston will press the base, then when the cream LDR is interrupted a specified amount of cream will be dispensed, if the circle LDR is interrupted, it'll rotates until the specified topping will be placed on top of the conveyor and a specified amount will be dispensed, then the cup will enter the cooling tunnel and staying in it for 1 minute or 5 minutes based on the user' selection, then when the final LDR is interrupted the piston will compress the lid ensuring accurate sealing.

4.2.1 Flow Chart

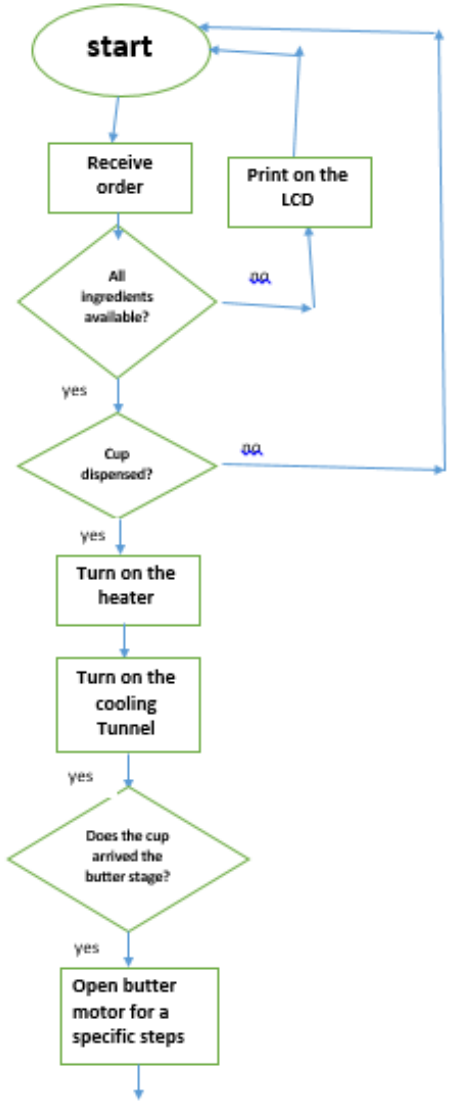

Figure 4.24: Flow Chart

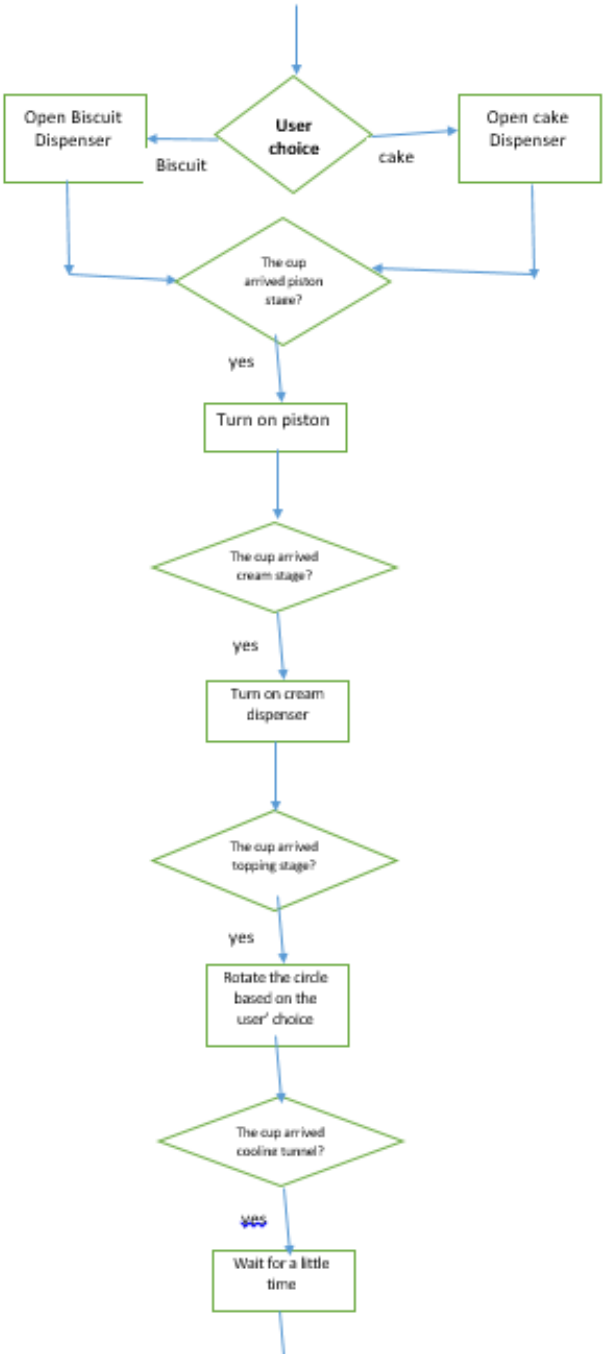

Figure 4.25: Flow Chart

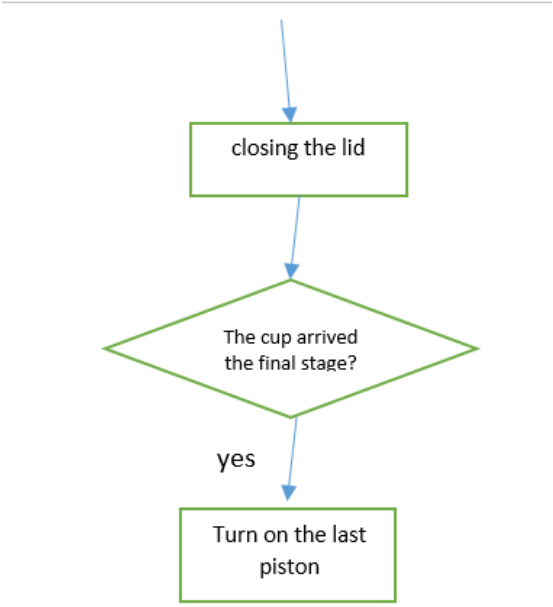

Figure 4.26: Flow Chart

4.3 Hardware Implementation

4.3.1 Input/Output unit

Our system is controlled by easy-to-use component which is Keypad and LCD screen. When the system starts, a welcoming message will appear in the LCD followed by a prompt to choose your base layer (biscuit or cake). After selecting, other message will appear to choose between four types for toppings.

Figure 4.27: greeting message

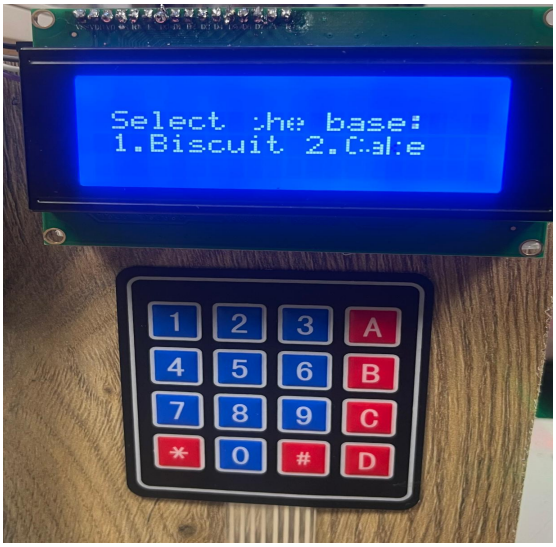

Figure 4.28: First choices

Figure 4.29: Seconf choices

After selecting the ingredients, the process will start. And in each stage an explained message will appear to show the customer where his customized Cheese Cake cup are.

4.3.2 Cup Dispensing

This cup dispenser was custom-designed using 3D printing to fit our specific cup sizes. Once the user enters his preferences for base and topping layers, the system will start with this stage, dispensing the cup to the conveyor belt. Laser and LDR modules are

positioned to detect the cup's arrival to the belt. Once the cup detected, a subsequent stages will be triggered automatically.

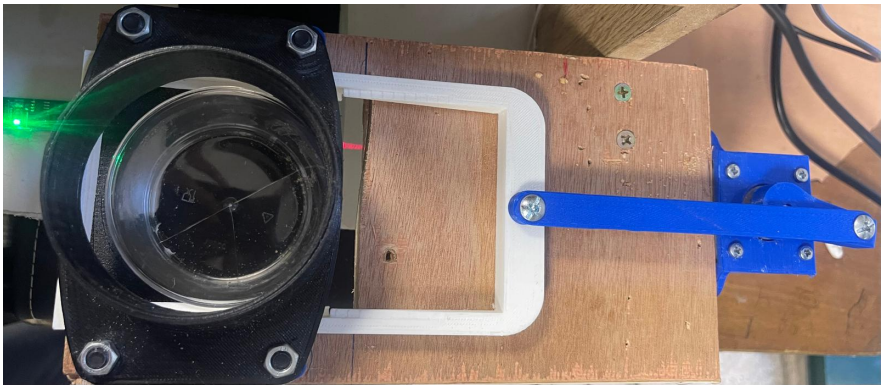

Figure 4.30: Cup dispenser

4.3.3 Butter Stage

In the butter stage, we use a stainless steel dispenser to pour the melted butter into the cup. To make sure the butter melts correctly, we designed a double-layered stainless steel bowl that acts like a water bath, keeping the dispenser surrounded by gentle heat. Inside this setup, we placed a 200-watt heater and a temperature sensor to carefully manage the melting process. A NEMA 23 stepper motor controls when the butter dispenser opens and closes. Once the cup is detected by the Laser and LDR sensors, the heater kicks in for just the right amount of time to melt the butter perfectly. When it's ready, the dispenser opens up to pour the exact amount of butter into the cup, then closes, wrapping up this stage.

Figure 4.31: Butter dispenser

4.3.4 Base layer Stage

In the base stage layer we have two containers positioned at the top, one with powder biscuit and the other with cake. Each container is equipped with a stepper motor to control its opening and a specific steps. And to make sure that the ingredients fall in the correct position of the cup we've connected the openings of both containers to transparent guiding tubes. When cup reaches the correct spot, one container will open - based on the user's choice at the beginning - and a specific amount will be dispensed into the cup.

Figure 4.32: Base Stage containers

4.3.5 Piston Stage

In the Piston stage, we use a pneumatic piston with two air controls to press down on the cup, which contains the ingredients of the first layer(butter with cake or biscuit), this process is very important to make the layer cohesive and even layer. So the cup will be ready to move to the next stage.

Figure 4.33: Pneumatic Piston

4.3.6 Whipped Cream Stage

In the Whipped Cream stage, we used a cream decorator tool and designed a custom 3D-printed extension to control its movement. This extension is connected with stepper motor that manages the decorator's operations. And to ensure that Cream is stored in cold environment as it should be, we designed a simple cooling system box around it. This system contains a Peltier with heat sink and fan to manage its temperature.

When laser and LDR modules detect the cup positioned under the decorator, the stepper motor works ,moving precise steps and speed to dispense a specific amount of cream into the cup.

Figure 4.34: Cream Decorator

4.3.7 Topping Stage

For the Topping Stage we designed a rotating square platform which hold four containers of different toppings (chocolate chips, M&M's Sprinkle top-n-fill, mini marshmallows and pistachios). Each container is connected with a stepper motor which will make it open with a specific steps, and in the middle the platform itself is powered by a nema 23 stepper motor which make it rotate to arrive the selected topping.

When the Laser and LDR sensors detect the cup beneath the platform, and based on the user's selection, the platform smoothly rotates to position the correct container over the cup. Once the container is in place, its motor carefully releases the right amount of topping, adding the final touch to the customized cheesecake cup.

Figure 4.35: Topping platform

4.3.8 Cooling system

In the cooling system, we designed a simple system to chill the cup for amount of time. It consists of a foam-insulated box with an entry and exit point for the cup. And the cooling system is a Peltier cooler with heat sink and fans to control its temperature. Once the cup detected by Laser and LDR modules it will stop in the middle of this system for amount of time to achieve the desired chill before moving to the next stage.

Figure 4.36: Cooling System

4.3.9 Cup Sealing

The cup sealing stage is the final touch of our process. It has two main parts: First, a clever system gently lowers the lid onto the cup as it moves beneath it. Once the lid is in place, a pneumatic piston applies just the right amount of pressure to seal it tightly. This ensures that each cup is perfectly closed and ready to go, making sure everything stays fresh and secure.

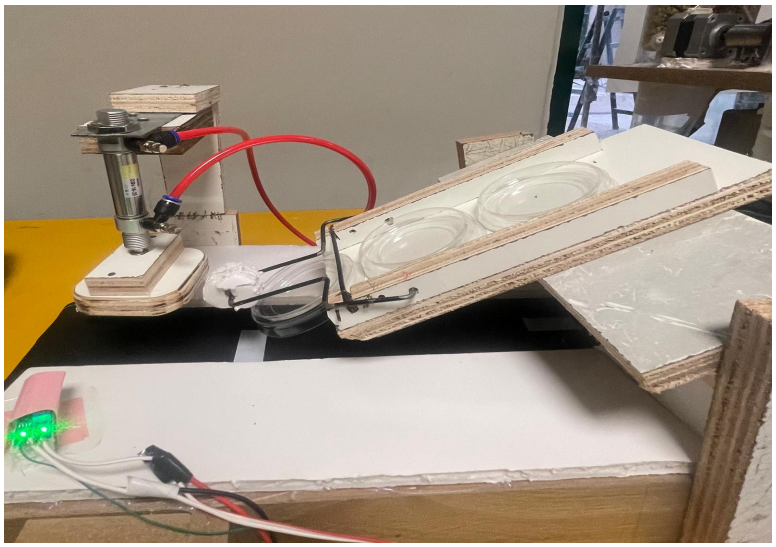

Figure 4.37: Cup Sealing

4.4 Mobile App

Beside the keypad and the LCD we offered another ordering way enhancing the user's experience, which consists mainly of an opening page and ordering page The opening page:

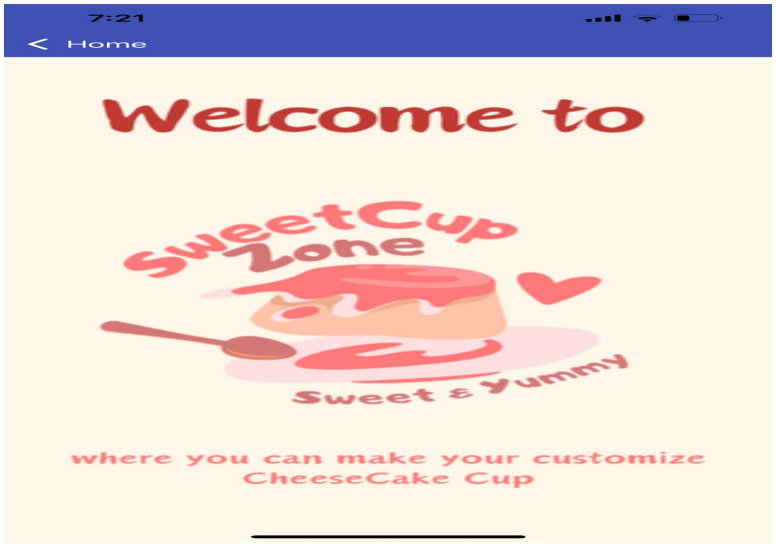

Figure 4.38: App Opening Page

The primary page enables the user's offering from the app, by selecting their preferred cup base whether cake or biscuit, then selecting the preferred topping, and finally selecting whether he wants a short cooling time or longer one.

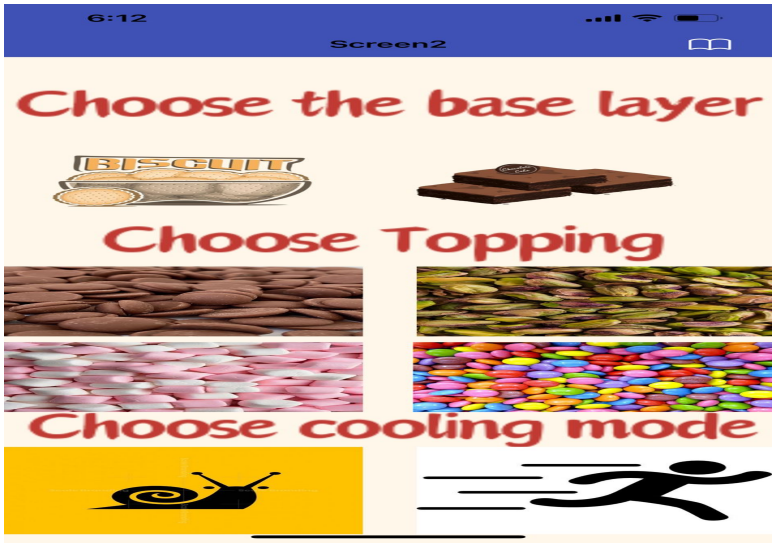

Figure 4.39: Ordering Page

Chapter 5

Result and Discussion

Our project aims to automated and customized the process of making a personalized cheese cake cup according to the customer's preferences. We aimed to provide users with simple way to select his preferences and ensuring a personalized cheesecake experience with minimal wait times. We achieved that by designing and implementing multi-stages system which contains cup dispensing, butter stage, base stage, piston , whipped cream decoration, topping , cooling system and closing cup.

Each stage in the machine was carefully designed and tested to achieve its purpose. Our approach consist intensive research and iterative testing to ensure the reliability and efficiency of each element in the project.

The result is a user-friendly machine which give the user a great personalized cheesecake experience and addressing the demand of automated, customized food production. This machine doesn't only match user satisfaction but also make a greet job in automated food production industry.

However, this journey wasn't without its challenges. This aspect is very huge and we can extend a lot in it, but the main constrains was the limited time we have and the highly cost for each electronic or mechanical components. We faced many challenges and we successfully passed it, one of them was melting the butter. Melting butter is not an easy process because it need a specific condition to success, if you put the heater immediately to it it will burn not melt. So our solution was a water bath. However, the

initial heater we used wasn't efficient, so when we realized the problem we replace it with 200 watt heater which was very efficient.

Another challenge was closing the cup, our cups are lightweight, and our first attempt used a wooden pulley to hold the lid. But it was very heavy for the cup to handle,. We redesigned it using a foam which is lighter for the cup and hold the lid at the same time.

Also there is a challenge we have that we made a cup so the amount we want it very accurate and precise. So we tried to achieve that by handling the stepper motor as most efficient as we can. By controlling its steps, speed and direction accurately.

Chapter 6

Conclusion and Recommendation

6.1 Summary

Our project introduced an automated system to make a customized cheesecake cup which matches the customer preferences. By combining advanced hardware and a user-friendly interface, we successfully implemented each stage in an efficient and automated way. We've achieved a lot with this system, including the ability to deliver personalized desserts quickly and efficiently, making it a standout solution for anyone who loves fresh, custom treats. With smart design and innovative features, our project not only simplifies the process of making personalized cheesecakes but also sets a new benchmark in automated food preparation.

6.2 Recommendations

Arduino Board Selection: Choose the suitable Arduino board meets the project's needs. analyze your project reqierement first in order to determine.

Wiring Practices : solder the wires correctly,and don't forget to cover them with insulating material to avoid short circuit. Power Supply Management: Since Arduino is mainly for control, don't use it as power supply.

Wire Organization: use power collecter for multiple connections,as it reduces wiring

complexities, and ensure labelling each wire for better organization. Real-Ingredient Testing: make sure to make tests with real ingredients, as ingredients behaves differently, not always as expected.

6.3 What we have learned

The project provided us with a wealth of knowledge and valuable insights on both the personality level and the technical level, for example: -Dealing with various types of electronics and mechanical tools like motors, conveyors, air jacks, drivers and a variety types of sensors like IR, Ultraonic, LDR module,,,etc. -Engineering Design:we gained an experience in designing and integrating the component. -Troubleshooting and Maintenance: we learned to diagnose the problem and solving it as required. -User Experience: as the production line needs the user's interaction, we developed a user friendly interfaces using two methods the keypad and the the app. -Creativity:designing a production line enhances creativity and problem solving skills. -Patience and Persistence: as the project includes numerous obstacles. -Adaptability: the unexpected problems made us more flexible to change. -Importance of Testing: as things does not always goes as expected.

6.4 Future work

For future work, there is so much ways for growth and improvements. This aspect of the project is wide, and there are many ways we can extend it.

One of the key enhancements we plan is to upgrade the butter storage. Currently, we use a water bath to melt the butter. In the future, we want to add a cooling system using a Peltier module to keep the butter cold until it's needed. When an order is placed, the system would then heat the butter just in time.

additionally, we currently offer only one type of whipped cream, but we can add more flavors in the future, also we can add more choices for topping and base layer to provide more customization. Another important thing we have to add is powerful and efficient cooling system instead of simple one we use right now.

In terms of more advanced features, we could add a grinding mechanism to prepare fresh biscuits instead of relying on pre-powdered ones as now.

In conclusion, our project represents a solid start in the vast world of automated food preparation, but it needs continuous work and effort to evolve further. It was a good and innovative first step that can lead to even greater achievements.

Chapter 7

References

Arduino - Home. (n.d.). Retrieved January 27, 2024, from https://www.arduino.cc/

Polichshuk et al. (2018) designed and developed an autonomous cupcake-making machine. The project employed an Arduino microcontroller board, motors, and a thermocouple, along with inexpensive materials like plastic and wood to automate the cupcake-making process. The primary focus was to achieve a cost-effective solution that improves both efficiency and product consistency. The paper outlines the system's development and methodology while discussing its potential applications and commercial viability.

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