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FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY

Computer Engineering Department

Graduation Project 2

Candy Cotton Machine

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Disclaimer

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Abstract

In the realm of traditional candy machines burdened by manual operation, our project comes as an innovative solution. Focused on enhancing the conventional candy-making experience, we integrate advanced technological features to automate and improve efficiency. This addresses the challenges of manual processes, offering a modernized approach to traditional candy production. Our project unveils an exceptionally candy-making experience. The project will begin with the construction of the basic ingredients of the candy cotton machine, ensuring its basic function of producing cotton candy. Furthermore, our system seamlessly automates sugar addition, dynamically altering its color. Additionally, our project introduces a controlled arm, so it automatically assembles candy cotton without the need for human impact.

The project creates an interactive environment, empowering users to select a the candy cotton. the machine initiates production by guiding the flow of sugar in a specific color into the core mechanism, fashioning the candy cotton. The final touch is bestowed by the arm, meticulously shaping the candy.

This means that the user chooses the shape through a mobile application, and the arm is responsible for making a candy cotton, provided that the appropriate color is chosen and produced using the heater and motors.

1 Introduction

1.1 General background

The rising demand for innovative and high-quality candy experiences has exposed the limitations of traditional, labor-intensive cotton candy production methods. Our project addresses these challenges by introducing an automated cotton candy machine that operates like a vending machine, integrating advanced technology to streamline the process. This machine automates sugar addition, dynamically alters candy color, and utilizes a controlled arm to shape the cotton candy, all managed through a user-friendly mobile application. By eliminating the need for constant human supervision, our solution enhances production efficiency, ensures consistency, reduces costs, interactive experience for consumers, meeting the demands of a modern market.

1.2 Objectives of the work

The objective of our project is to develop an automated cotton candy machine that significantly reduces the need for human resources, ensuring consistent quality and efficient production. Designed for versatile placement in high-traffic locations such as malls, our machine operates autonomously, requiring minimal human intervention.
By integrating advanced technology for automated sugar addition, color customization, and a controlled shaping arm, the machine provides a personalized and interactive candy-making experience, making it an ideal solution for modern consumer demands and enhancing operational efficiency in various environments.

1.3 Significance of the Work

As a novel concept in the market, our automated cotton candy machine taps into the universal love for cotton candy by offering a fresh, engaging experience. Our project leverages automation to revolutionize the cotton candy-making process. By integrating a user-friendly system, our machine allows users to select the color of their cotton candy through a mobile application, personalizing the experience and increasing customer engagement.The ability to place these machines in high-traffic locations such as malls broadens market reach and meets consumer demands effectively. By automating the process of sugar addition and color customization, our system significantly enhances productivity and operational efficiency, making it a innovation in the candy industry.

1.4 Organization of the report

The main body of the report is divided into several chapters, each serving a distinct purpose. The first chapter, known as the Introduction, encapsulates the project's general background, work objectives, significance, and the logical arrangement of the report. The second chapter, called "Theoretical Background and Previous Work," puts the project in context with what is already known. It looks at past research and theories that support the current work. After that, the Methodology chapter describes the system's hardware components, mechanism of action, and how any constraints encountered were dealt with. Then, the Results and Discussion chapter presents the project's findings and engages in a discussion of the results. The Conclusions and Recommendations chapter, the final section, summarizes the project and offers valuable insights for refining and enhancing the approach in future endeavors.

2 Theoretical Background and Previous Work

Cotton candy, a beloved confection also known as candy floss or fairy floss. Initially patented in North America in the late 19th century, cotton candy production involves melting crystalline sucrose at temperatures above 210°C, creating molten liquid sucrose that is ejected into the air where it cools rapidly, forming delicate strands of spun sugar. This process, described by Theodore P. Labuza and Peter S. Labuza [2], is highly sensitive to environmental conditions such as temperature and relative humidity (RH). Furthermore, automation in candy production has advanced significantly, paralleling developments in industrial robotics. Studies such as those by Jeng-Dao Lee et al. [3] have introduced robotic arms into candy production lines to streamline processes and enhance efficiency. These multi-robotic arm systems to ensure precise handling and assembly of cotton candy components.

In the realm of culinary exploration, cotton candy has transcended its traditional role as a childhood treat. Charles Spence et al. [1] delve into its gastronomical potential, highlighting its unique textural qualities that evoke nostalgia and sweetness. Renowned chefs like Ferran Adrià and José Andrés have incorporated cotton candy into innovative culinary creations, underscoring its versatility beyond conventional uses. This culinary evolution underscores cotton candy's appeal as both a sensory delight and a medium for artistic and gastronomic expression.

3 Methodology

3.1 Hardware Components

To ensure accurate and smooth operation, a variety of hardware components were necessary for constructing this system. The components employed in building this system include:

- **Arduino Mega 2560**

  Arduino Mega 2560 precision controller served as a central controller for Candy Cotton Machine, managing a variety of components. Controls ultrasonic sensor for distance measurement, H-Bridge L298N for DC drive direction and speed, 4 and 2 relay units to switch high power devices. It also handled 12V NEMA17 engines with TB6600 driver for precise rotation, high MG996R torque of robotic arm, various power supply (5V, 12V, 24V) to ensure stable operation. In addition, it managed the contact device for high-current circuit, AC motor 220V heater for basic functions, 18 volt drilling motor for additional power, and 12V RGB LED for user feedback. Arduino processed input and implemented control procedures, ensuring the machine operated efficiently and safely.

Figure 1: Arduino Mega 2560.

- **220V Heater**

  The heater is responsible for melting sugar, which is critical to the process of producing cotton candy. Works based on the temperature and volume of sugar distributed in the machine. The heater is activated for a fixed period to achieve the optimal melting texture required to form a cotton candy.

Figure 2: Arduino Mega 2560.

- **5V temperature sensor**

  The temperature sensor monitors the temperature of the heater, ensuring that it operates within the optimal range of soluble sugar.

Figure 3: Heater.

- **220V Ac motor**

  The AC motor in the candy machine serves an essential role in the cotton candy production process. Controlled by Arduino Mega 2560 microcontroller, it rotates clockwise to turn melted sugar into the thickest cotton candy yarn. Motor movement is pivotal in rotating hot sugar yarns in the final form of thin cotton candy.

- **Contactor**

  Contacter in candy cotton machine is used to effectively manage 220V heater due to large electric load. By using the contact device, the operation of the heater can be controlled safely and reliably, ensuring effective heating operations while mitigating potential electrical hazards.

Figure 4: Contactor.

- **18V Drill motor**

  The 18V drilling motor is mechanically associated with a larger Outdoor Bowl, high-voltage external receptacle. Rotates in the opposite direction of AC motor, facilitating the process of assembling cotton candy on the path of return of the automated arm.

Figure 5: Drill.

- **2-Relay module**

  The 2-Relay unit in candy cotton machine is necessary to control contacter and 220V AC motor at specific intervals. Interacts with Arduino Mega 2560 to regulate contact, which manages the heater for sugar soluble, and controls the AC motor for rotating machine components such as cotton candy rotor, a second relay within the unit is employed to control the drill motor.

Figure 6: 2-Relay module.

- **Ultrasonic sensor**

  The ultrasonic sensor is used to monitor sugar levels in two colored sugar boxes, and plays a crucial role in ensuring the effective operation of the candy cotton machine. Find out if the sugar boxes are full or almost empty. When the sugar level is low, the sensor triggers the Arduino Mega 2560 precision controller to deactivate the device, preventing problems such as the formation of incomplete cotton candy. In addition, it interacts with the precision controller to light a red indicator on the RGB LED, to alert users to the need to refill the sugar box.

Figure 7: Ultrasonic sensor.

- **12V NEMA17 stepper motor**

  The 12V NEMA17 stepper motors are paired to each box of colored sugar. They operate in tandem, opening at a specified angle and duration to release sugar when needed. This synchronized movement ensures controlled dispensing of colored sugar into the candy cotton machine.

Figure 8: 12V NEMA17 stepper motor.

- **12V NEMA17 stepper motor "CREALITY" with gearbox**

  This motor with gearbox is used at the head of the arm to support and withstand the weight of the arm, ensuring smooth movement and precise positioning during operation.

Figure 9: 12V NEMA17 stepper motor with gearbox.

- **MG996R high torque servo tower pro**

  Two of these servos are integrated into the arm mechanism to controlled movement, ensuring precise shaping of cotton candy shape.

Figure 10: MG996R high torque servo tower pro.

- **5V DC motor**

  This motor is connected to a spindle mechanism, enabling continuous movement to assemble cotton candy on the rotating kit.

Figure 11: Dc motor.

- **H-Bridge L298N**

  This component is used in candy cotton machine: two to control the NEMA17 motor and one to regulate the DC motor. Manages the direction and speed of these motors, which is critical for accurate movement and rotation within the machine.

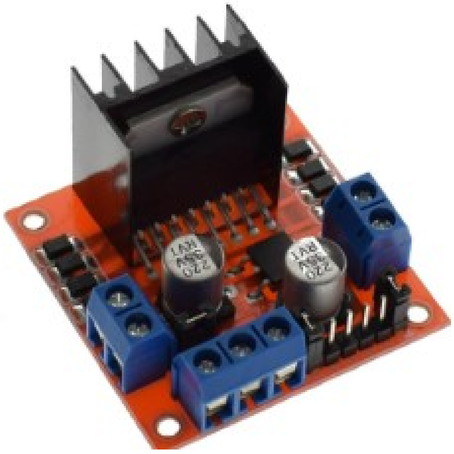

Figure 12: H-Bridge L298N.

- **YS-DIV268N-5A driver**

  It is coupled with a NEMA17 stepper motor "CREALITY" with gearbox and is used to precisely control and automate motion. The driver translates input signals into specific step movements, allowing the NEMA17 steppermmotor to achieve accurate positioning and rotation. This driver enabled us to control both the motor's current and its stepping mode.

Figure 13: YS-DIV268N-5A driver.

- **12V RGB LED**

  The project aesthetically promotes and tracks its processes by changing colors during each phase. Red color indicates error or malfunction.

Figure 14: 12V RGB LED.

- **4-Relay module**

  Three channels are used with the RGB LED, each channel controlling one color.

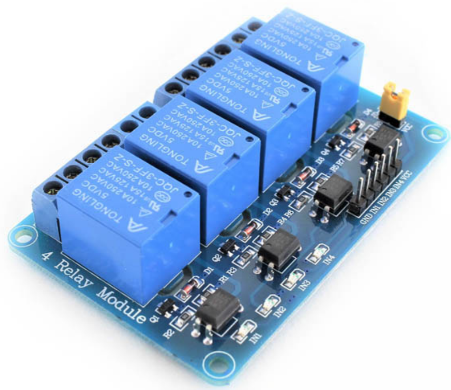

Figure 15: 4-Relay module.

- **MFRC522 IC**

  The RFID system employs two cards, one accepted and one rejected. The user must use the accepted card to operate the machine. This system uses an RFID reader module (typically based on the MFRC522 IC) that communicates with the Arduino Mega 2560 via SPI interface. When the accepted card is scanned, the system allows operation. If the wrong card is used, the RGB LED turns red, indicating an error. The RFID reader sends the card data to the Arduino, which processes it to determine if access should be granted or denied.

Figure 16: MFRC522 IC.

- **power supplies**

  - **PC power supply**

    PC power supply is used to provide stable and reliable power for various candy cotton machine components. It converts AC power to the required DC voltage (usually 12V, 5V and 3.3V) required by different parts of the system. This power source is used to power Arduino Mega 2560, stepper motors, RGB LEDs and other electronic components. Using PC power supply, we ensure that all devices have consistent and sufficient power.

Figure 17: PC power supply.

  - **5V power supply-3A**

    Due to the high demand and pressure on the PC power supply, we needed a separate adapter to supply the 5V-arm servos with sufficient current for them to function properly. This ensures that all components receive consistent and adequate power.

Figure 18: 5V power supply-3A.

– **24V power supply-15A**

The 24V power supply, capable of delivering up to 15A, is used primarily to power the 18V drill motor. Since the market availability is limited to 24V power supplies, a potentiometer is used to adjust the voltage down to approximately 18V. This adjustment is necessary to ensure the drill motor operates correctly under high load conditions, allowing it to effectively move the large outdoor bowl used in the cotton candy making process.

Figure 19: 24V power supply-15A.

3.2 Mechanism of Action

The implementation of this project was divided into three key stages. Firstly, the base of the Candy Cotton Machine was constructed to serve as the foundation for the entire system, ensuring it could effectively produce cotton candy. Secondly, the method for dispensing sugar from the boxes to the head of the machine was designed and built, ensuring a smooth and consistent flow of sugar for the candy-making process.Thirdly, this phase also involved the development of a mechanism to rotate the large outer receptacle to facilitate the gathering of the arm for candy. Finally, the arm mechanism was developed and implemented to collect and shape the cotton candy.

1. **User Interaction**: The user begins by selecting the desired color of the cotton candy through the machine's interface and scanning their RFID card.

    - If the card is rejected, a red light from the RGB LED illuminates, indicating rejection.
    - If the card is accepted, the process proceeds to the next step.

Figure 20: Mobile application screen.

2. **Sugar Dispensing**: The NEMA 17 stepper motors control the dispensing of sugar from the storage boxes.

    - Each motor is tied to a specific sugar box. When activated, the motors open at a certain angle and for a specific duration, allowing the sugar to flow.
    - The ultrasonic sensors monitor the sugar level to ensure the boxes are adequately filled. If the sugar level is low, the machine stops, and the RGB LED turns red.

Figure 21: Sugar Dispensing structure.

3. **Heating**: The first crucial step in converting sugar to cotton candy involves melting the sugar into a liquid state using a 220V heater.

    - The heater is responsible for elevating the sugar's temperature to its melting point, turning it from solid granules into a thick, liquid form.

- The heater's operation is controlled by a contactor, which handles the high current required, ensuring safe and efficient operation.
- A temperature sensor, strategically placed near the head nozzle, continuously monitors the heat levels to maintain the optimal temperature for melting the sugar. This precise temperature control is essential to achieve the perfect consistency needed for forming cotton candy threads.

-Red arrow indicates heat sensor

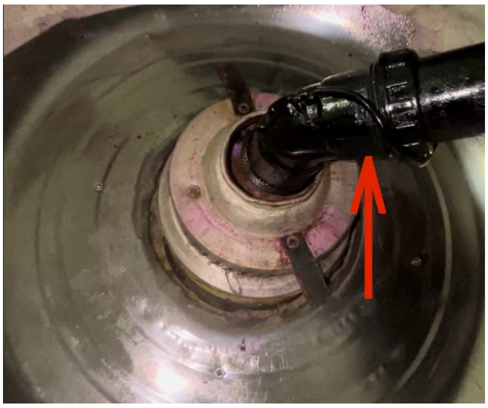

Figure 22: Heating.

4. **Cotton Candy Formation**: The process of forming cotton candy involves the coordinated operation of both a 220V AC motor and an 18V drill motor.

- **220V AC Motor**:
  - This motor is responsible for spinning the head of the machine, which is essential for converting the melted sugar into thin threads.
  - The motor rotates clockwise, creating centrifugal force that draws the liquid sugar through tiny holes in the head, forming it into fine threads of cotton candy.
- **18V Drill Motor**:
  - Mechanically connected to the large outer bowl, this motor rotates counterclockwise.

– The counter-rotation helps to efficiently collect the cotton candy as it forms, preventing it from sticking to the machine and aiding in the smooth accumulation of the fluffy candy on the stick.

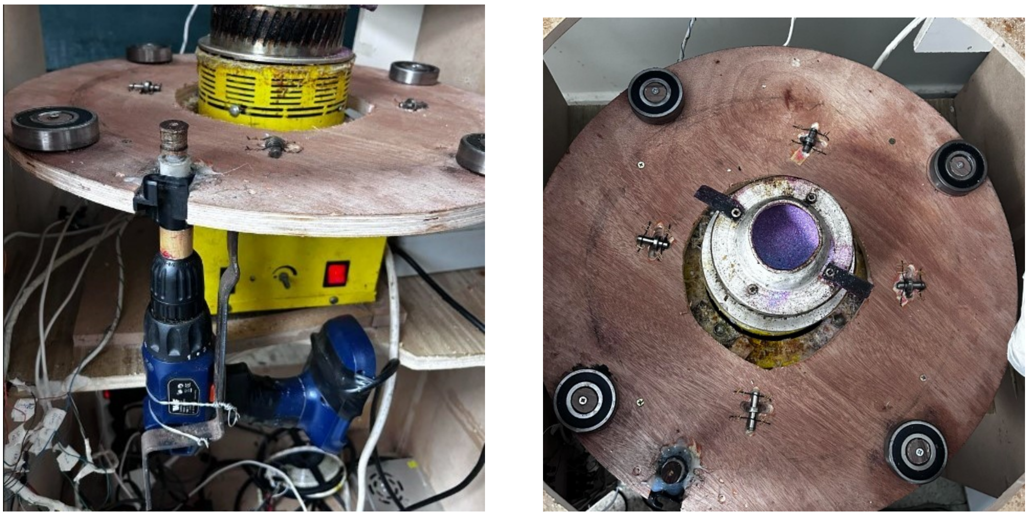

Figure 23: Structure of the outer bowl rotation movement.

5. **Arm Mechanism**: The arm mechanism plays a crucial role in collecting and shaping the cotton candy. This complex system involves multiple components working together to ensure precise movement and control.

- **12V NEMA17 Stepper Motors with Gearbox**:
  – These motors are used to provide precise control of the arm's movement, allowing it to position accurately while bearing the weight of the arm.
  – The gearbox enhances the torque, ensuring stable and reliable operation when moving the arm.
- **MG996R High Torque Servo Motors**:
  – Two servo motors are integrated into the arm to provide precise angular movement, enabling the arm to adjust its position and angle accurately.
  – These servos allow the arm to move in multiple axes, enhancing its flexibility and control in shaping the cotton candy.
- **5V DC Motor**:

  - This motor is connected to a spindle through which the wooden stick is placed. It provides continuous movement necessary for assembling the cotton candy onto the stick.

- **Design and Construction**:
  - The arm is designed using 3D-printed gears and other components to ensure durability and precision.
  - The structure is robust enough to handle the movements and weight, with motors positioned strategically for optimal performance.

- **Operation and Coordination**:
  - The arm is controlled by the Arduino Mega 2560, which processes inputs and coordinates the movements of all motors and servos.
  - During the cotton candy formation process, each motor and servo moves at precise intervals and angles to collect the candy efficiently.

Figure 24: Arm structure.

Throughout the process, each motor and sensor works in synchronization, controlled by the Arduino Mega 2560, to ensure smooth and efficient operation. The RGB LED provides visual feedback at each stage, helping users track the machine's status. This detailed coordination ensures the final product is a well-formed cotton candy meeting the desired specifications.

3.3 Constraints

In the development and deployment of the Candy Cotton Machine, several constraints were encountered that influenced the design, functionality, and implementation of the system. These constraints include:

- **Technical Constraints:** Integrating the heating element, color dispenser, rotating mechanism, and robotic arm required extensive testing to ensure compatibility and seamless operation.

- **Safety Constraints:** Ensuring user safety involved implementing robust safety mechanisms for heating elements and moving parts, adhering to safety standards and regulations.

- **Time Constraints:** The restricted project timeline required efficient management and prioritization of tasks, with potential delays in procurement, testing, or assembly impacting the schedule.

- **Experience Constraints:** Optimizing heating time and temperature was crucial for efficient sugar melting and cotton candy formation, necessitating extensive experimentation and fine-tuning.

4 Results and Discussion

In this section, we present the results obtained from our Candy Cotton Machine project and provide a detailed discussion on their implications and significance.

- Hardware Components: The Candy Cotton Machine incorporates essential hardware components crucial for automated cotton candy production. Each component underwent rigorous testing to ensure functionality and reliability under various operational conditions.

- Mechanism of Action: The operational mechanism of the Candy Cotton Machine was tested extensively to validate its functionality. User interaction through a mobile application, automated sugar processing, cotton candy formation via a rotating mechanism, and final shaping using a robotic arm were all tested to ensure seamless integration and efficient operation.

- Performance Evaluation: To assess the Candy Cotton Machine's performance, we conducted several experiments measuring:

  - **Production Rate**: Average time taken to produce one unit of cotton candy.
  - **Quality Control**: Consistency in cotton candy texture and color across multiple batches.
  - **User Experience**: Feedback from users on the ease of operation and satisfaction with the final product.

  Results indicate that the machine operates within acceptable parameters, meeting or exceeding industry standards for cotton candy production.

- Discussion: The integration of advanced robotics and automation in traditional cotton candy production represents a significant advancement in confectionery technology. By automating the production process, our machine offers consistent quality, reduces labor costs, and enhances user engagement through customization options. Moreover, placing these machines in high-traffic locations like malls and amusement parks can potentially increase revenue streams for vendors while providing a novel interactive experience for consumers.

However, challenges such as maintenance of delicate machinery and initial setup costs need to be carefully managed to ensure long-term viability in commercial settings. Future iterations could focus on optimizing energy efficiency, expanding flavor customization, and integrating real-time data analytics for production monitoring and quality assurance.

5 Conclusions and Recommendations

- Conclusions:

  The Candy Cotton Machine represents a significant advancement in confectionery technology, successfully integrating heating elements, color dispensers, rotating mechanisms, and robotic arms to automate cotton candy production. Through rigorous testing, the machine has demonstrated reliable performance in terms of production rate, quality control, and user satisfaction. Its ability to engage users through customizable cotton candy shapes and colors makes it ideal for deployment in diverse high-traffic settings. By reducing labor costs and improving production efficiency, the Candy Cotton Machine presents a competitive solution in the confectionery market.

- Recommendations:

  Building on the success of the Candy Cotton Machine, several recommendations for future enhancements and iterations include:

  - Optimize energy efficiency to minimize operational costs without compromising production quality.
  - Expand flavor customization options to cater to a wider range of consumer preferences.
  - Develop robust maintenance protocols to ensure the longevity and reliability of machine components.
  - Implement real-time data analytics for monitoring production metrics and quality assurance.
  - Explore strategic partnerships and marketing initiatives to broaden market reach and adoption.

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