AN-NAJAH NATIONAL UNIVERSITY

FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY

Computer Engineering Department

Hardware Graduation Project

AutoPizza

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Disclaimer

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Abstract

In response to the increasing demand for convenient and personalized food options, particularly in the case of pizza as a popular fast food choice, our idea is to develop a user-friendly and customizable pizza station. By leveraging technology, our pizza station aims to simplify and automate the pizza-making process, making it faster and more accurate. Whether it's for special events or quick hunger cravings since traditional methods often fall short in terms of speed and customization. Our pizza station presents a straightforward solution to the issue of limited options. Its user-friendly interface allows customers to customize their pizzas effortlessly based on their preferences. Moreover, our station boasts a reasonable size that allows for easy placement in various settings, without occupying excessive space like those found in factories

Our pizza station takes a step-by-step approach to pizza-making. The process starts with the use of pre-prepared dough or bread, sourced externally. Once the user specifies their desired pizza options, the pizza goes through different stations tailored to their selections. Finally, it enters the oven and emerges as a delicious, ready-to-eat pie, and notifies the user for it . Our station is carefully designed to minimize waste by efficiently using the necessary ingredients and preserving excess components for future use. This approach not only optimizes the pizza-making process but also aligns with our commitment to environmentally conscious practices. To ensure uninterrupted operations, the machine is equipped with a component tracking system that monitors the availability of ingredients. When a specific component runs out, the system automatically sends a notification to the administrator, prompting them to refill the depleted item. This feature ensures a continuous supply of ingredients for pizza production.

1. Introduction

In the rapid tide of technological advancement, automation has swiftly replaced human labor across diverse sectors, capitalizing on machinery and data-driven knowledge. Among these domains, the landscape of food production and preparation has emerged as a pioneering advocate of automation. This paradigm shift has ushered in a multitude of advantages compared to human involvement, including heightened efficiency, financial savings, reduced time and labor, amplified overall output, and elevated precision. Automation further serves as a bulwark against contamination and human errors, thereby yielding food products of enhanced safety. Additionally, production lines can be meticulously calibrated to fulfill specific tasks, yielding optimized resource utilization and minimized waste.

Our project, distinctively, embodies flexibility and user-friendliness. It empowers users to tailor their pizzas according to their preferences through an intuitive touchscreen interface. With just a few uncomplicated steps, individuals can relish their personalized pizzas in mere minutes, all while benefiting from the compact form factor of our innovation.

The pizza crafting process initiates with the utilization of pre-prepared dough or suitable bread. Once the desired toppings are chosen in precise quantities, the sequence unfurls, activating designated stages in a compartmentalized manner. Crucially, this arrangement permits the conservation of any excess components for future use, thus minimizing food wastage. The apex of this journey unfolds within an oven, where the pizza is expertly baked to perfection, emerging as a fully cooked and ready-to-enjoy creation.

Underpinning the project is an online admin page, which facilitates oversight by an administrator. This monitoring mechanism relies on a network of sensors integrated into the project, ensuring optimal ingredient levels. The admin page provides a comprehensive view of ingredient statuses, issuing alerts when critical thresholds are approached. Additionally, the administrator can access user ratings following each order. Furthermore, the admin holds the ability to remotely activate or deactivate the entire project, with an emergency button situated adjacent to the project for immediate control.

Throughout this report, we will expound upon our project's journey, commencing with the inception phase where inspiration is harnessed to formulate the concept. We imbue this concept with our distinctive insights, building upon past endeavors and incorporating diverse methodologies and tools. This synergy culminates in valuable outcomes delivered through this innovative application. Subsequently, we dissect these outcomes, offering a succinct overview of the experiential tapestry woven during the course of this project.

2. Constraints, Standards and Earlier Coursework

2.1. Constraints Limitations

Time Constraint: Developing this project within the confines of a summer semester posed significant challenges. It was our first endeavor to construct a good apparatus with multiple electronic components demanding various voltage levels (3.3V, 5V, 12V).

Stepper Motor Challenge: Among the obstacles encountered was the high-frequency handling of stepper motors. We used eight stepper motors that require up to three amperes for proper functionality. To accommodate this, we procured a power supply delivering 30 amperes. However, the inexpensive driver modules were unsuitable due to their incapacity to handle high loads. To mitigate this, we devised a method to reduce the number of high-quality driver modules from eight to four. This was achieved by linking each pair of motors to a single driver via a relay for channel.

Mechanical Stages Design: Constructing and designing the mechanical stages presented additional challenges. Consequently, we opted to self-design the stages and have the carpenter execute our designs to ensure precision.

2.2. Standards

Our project adhered to recognized industry standards to ensure compatibility, reliability, and effective implementation.

For coding and hardware control, we employed the Arduino Integrated Development Environment (IDE). This choice allowed us to leverage the features and functionalities of the Arduino platform to seamlessly interface with and control our hardware components.

Remote Control Standard: To facilitate convenient administrative control, we integrated the Blynk platform for both web and mobile applications. By incorporating Blynk, we provided the admin with user-friendly interfaces through which they could remotely monitor and manage the project's operations.

2.3. Earlier coursework

The knowledge and skills gained from our preceding coursework greatly contributed to the triumphant realization of our project. A spectrum of concepts acquired from disciplines like digital design, microprocessors, CPU lab, electronic circuits, wireless, and microcontrollers significantly guided our project's trajectory and influenced our strategic decisions.

In addition to our coursework, we must acknowledge the impact of the "Arduino Essentials" course organized by the IEEE Najah Branch. The insights and practical exposure we gained from this course notably contributed to our adept use of the Arduino platform, facilitating the seamless integration of hardware and software elements within our project.

Moreover, Through self-learning, we harnessed freely accessible online resources to further augment our capabilities and understanding. This proactive approach enabled us to overcome obstacles and enhance our proficiency.

3. Literature Review

In the landscape of technological advancement, the realm of food production and preparation, especially concerning universally popular choices like pizza, has emerged as a pioneering advocate of automation. Given its global popularity, it is reasonable to expect that this field has been extensively explored, leading to numerous studies and initiatives aimed at enhancing its processes.

Following the principle that knowledge builds upon itself, our project drew inspiration from a plethora of in-depth research studies and models commonly employed in industrial settings. These established the bedrock for our initial concept, design formulation, and element selection, all of which underwent refinements based on our observations to attain optimal outcomes.

Significant examples that have significantly influenced our project include:

1. AMF Tromp Lines[1]: AMF Tromp specializes in advanced pizza production lines tailored for bakeries and pizza manufacturers. These lines offer a blend of flexibility, precision, reliability, and hygienic design. With the capacity to produce a range from a few to an impressive 80,000 pizzas per hour in large-scale facilities, AMF's Stress-Free Tromp Sheeting Lines combine rapid and accurate dough sheeting with enhanced water absorption capabilities.
2. Quantum Terminator Production System[2]: The Quantum Terminator Production System presents a remarkable output potential of up to 12^11 pizzas per minute. Composing various components, including the QTMC4000 for precise sauce distribution, TC-3 for cascading cheese application, TP-2 for accurate pepperoni and cheese slicing, and TC-3 for seamless sausage distribution, this innovative system achieves unparalleled levels of automation.
3. Grote Pizza Topping Production Line[3]: Grote's pizza topping equipment transforms the pizza processing journey, encompassing tasks from precise sauce deposition to topping slicing and application, all facilitated on single or multiple lanes. Customized to align with individual pizza manufacturers' needs and production capacities, this equipment underscores the industry's dedication to optimizing processes.

What sets our project apart is its compact size and adaptability, rendering it suitable for home and small-scale applications. Its user-friendliness is another standout aspect, offering everyday users the capability to effortlessly control, order, receive, and provide feedback through intuitive methods like touchscreen interactions. This alignment with the user's daily experience ensures a seamless and accessible engagement.

In the forthcoming sections, we will delve into the meticulous implementation of our project, traversing its inception, development, testing, and outcomes, all of which culminate in a comprehensive understanding of its contribution to the domain of automated pizza production.

4. Methodology

4.1. External design

Figure 1: Overview of Completed AutoPizza Station Project.

- **Part A**: In this project, the conveyor system is configured in a unique manner. Each stage of the conveyor is isolated from the others, allowing any additional ingredients to be directed onto trays below. This ingenious design prevents wastage by ensuring that any extra toppings or ingredients that might otherwise go to waste are collected.

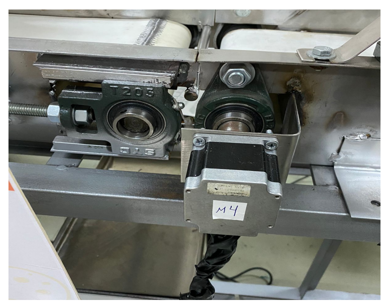
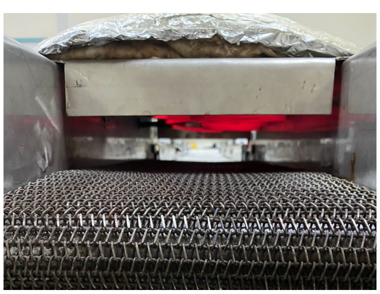


Figure 2: Isolated Conveyor System.



Notably, the conveyor within the oven segment of the system is constructed using metal that exhibits exceptional heat tolerance. This specialized choice of material enables the conveyor to withstand high temperatures generated within the oven, significantly contributing to the efficient cooking of pizzas.

Figure 3: Heat-Tolerant Metal Conveyor in Oven Segment

- Part B: The Ketchup Application Stage: This particular stage is meticulously crafted to introduce ketchup onto the pizza. The design of this stage involves a unique "shower" mechanism, allowing controlled droplets of sauce to descend through a designated slot. This innovative setup utilizes the force of air pressure to ensure that these sauce droplets are evenly distributed across the entire bread surface.
This precision in applying ketchup guarantees a consistent and delightful flavor experience for each slice of pizza.

Figure 4: Innovative "Shower" Mechanism for Controlled Ketchup

- Part C: The Ingredients Dispenser Unit: This integral component takes the form of a plastic container specifically designed for holding various ingredients. This container is ingeniously fashioned to house the ingredients and dispense them in appropriately sized portions. This dispensing process is meticulously synchronized with the rotation of the roller, ensuring that the ingredients are released onto the bread precisely when needed. Through this innovative mechanism, the ingredients are seamlessly incorporated onto the pizza, contributing to a delectable and uniform final product.

Figure 5: Ingredients Dispenser

Part B & C Revision: The Ketchup Application Stage and Ingredients Dispenser Unit: These pivotal components are both expertly crafted from stainless steel, a material known for its food-safe properties and durability.

- Part D: The Oven Chamber: The oven segment is derived from an electric baking apparatus, operating at a voltage of 220V to activate its heating element. It features a strategic design that maximizes heat retention and distribution. The oven is enveloped in a layer of foil, effectively conserving the generated heat within the chamber.

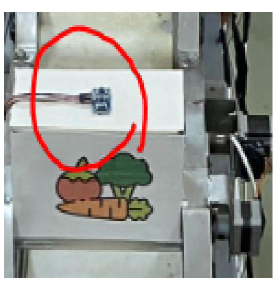
Figure6: Oven Chamber

Notably, the conveyor mechanism within the oven is constructed from a durable metal material, rendering it capable of withstanding the high temperatures essential for effective pizza baking. This combination of features ensures efficient cooking and optimal temperature control for consistently delicious results.

- Part E: Collection Trays Beneath Conveyors: Positioned strategically underneath each conveyor stage are specialized collection trays designed to capture any excess ingredients that may fall during the pizza assembly process. These trays serve a dual purpose: they prevent wastage by capturing unused toppings, and they facilitate resourcefulness by storing these ingredients for potential future use. By implementing this innovative feature, the project not only minimizes food wastage but also promotes sustainability by enabling the reutilization of these collected ingredients in subsequent culinary endeavors.

- Part F: Sensing and Monitoring System: This intricate system incorporates a diverse range of sensors to ensure precise ingredient management and optimal baking conditions. The system is equipped with various sensors that collectively contribute to the project's success.
For ketchup application, a soil moisture sensor is ingeniously employed to gauge the ketchup level. This sensor provides real-time feedback on the ketchup's quantity, ensuring accurate and consistent application throughout the pizza-making process.

Figure 7: Innovative Ketchup with Soil Moisture Sensor



In managing other ingredients, an ultrasonic sensor is harnessed. This sensor gauges the distance between the ingredients and itself, thereby determining ingredient levels based on proximity. This intelligent approach guarantees the precise dispensing of ingredients and minimizes the risk of shortages or excesses.

Figure 8: Ingredient Management Using Ultrasonic Sensor

In the realm of temperature control, a temperature sensor is seamlessly integrated into the oven. This sensor continuously measures the oven's internal temperature, thereby allowing the system to regulate and maintain the temperature within the optimal baking range. This meticulous control ensures that the pizza is cooked to perfection each time.

Figure 9: Oven Temperature Sensor

- Part G: User Interface and Emergency Control: The system incorporates a user-friendly touch screen interface, thoughtfully designed to empower users to customize their own pizzas based on available ingredients. This intuitive interface facilitates easy selection and arrangement of toppings, creating a personalized culinary experience. Further details about this customization process will be elaborated on shortly.

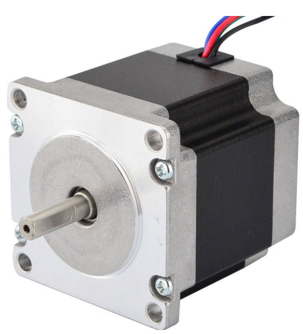
Moreover, in terms of safety and control, an emergency shutdown button is seamlessly integrated into the system. This button serves as a fail-safe mechanism, allowing users to instantly deactivate all attached electrical components without causing any harm or loss. This feature reinforces the system's commitment to user safety and operational control, enhancing the overall reliability of the pizza-making process.

Figure 10: Seamless User Interaction with Intuitive Touch Screen Interface

4.2. Hardware components

Arduino MEGA 2560
Selecting the microcontroller was a key decision for our project. After comparing options in our microcontroller lab, we found Arduino to be the optimal choice due to its user-friendly interface and programming simplicity. Arduino Mega was our microcontroller of choice because of its ample pins, accommodating our need for multiple connections. It was also chosen for its dual serial communication capacity, essential for both the touch screen and ESP module interaction.

Our familiarity with Arduino Uno from the IEEE Najah Branch's Arduino course further influenced our decision. This familiarity facilitated our implementation process, making the learning curve smoother. Arduino Mega's computational power and compatibility met our project's needs, contributing to the project's functionality and ease of use.

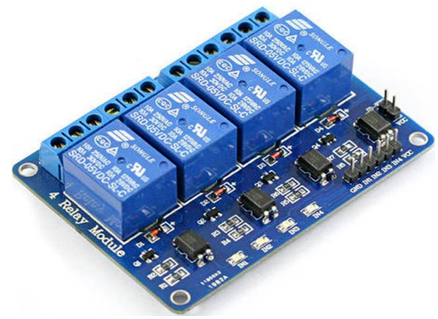


Stepper motors played a pivotal role in our project's execution. We employed five NEMA 23 stepper motors for each stage of the process, while three NEMA 17 stepper motors were dedicated to ingredient handling.
Stepper motors were an ideal choice for stage movement due to their precision. Their ability to move in discrete steps allowed us to accurately control the pizza-making process.

Our choice of the **TB6600 Driver** was the result of careful evaluation. After testing various driver options, we settled on the TB6600 due to its ability to handle our project's substantial load requirements. Unlike smaller drivers like H-bridge, the TB6600 proved efficient in managing the load effectively.

The TB6600 Driver's precision in controlling both current and steps was crucial for our project's precision. We incorporated four TB6600 Drivers, with each pair dedicated to specific stepper motors. This selection facilitated smooth coordination between paired motors, enhancing overall accuracy.

To efficiently manage the coordination of eight motors with four drivers, we incorporated the **5V Four-Channel Relay Module**. We utilized four units of this component, assigning one to each driver. The relays served as a bridge, enabling seamless communication between two stepper motors driven by a single driver.



The 5V Four-Channel Relay simplified the complex motor coordination process by efficiently managing the interactions between the paired motors.

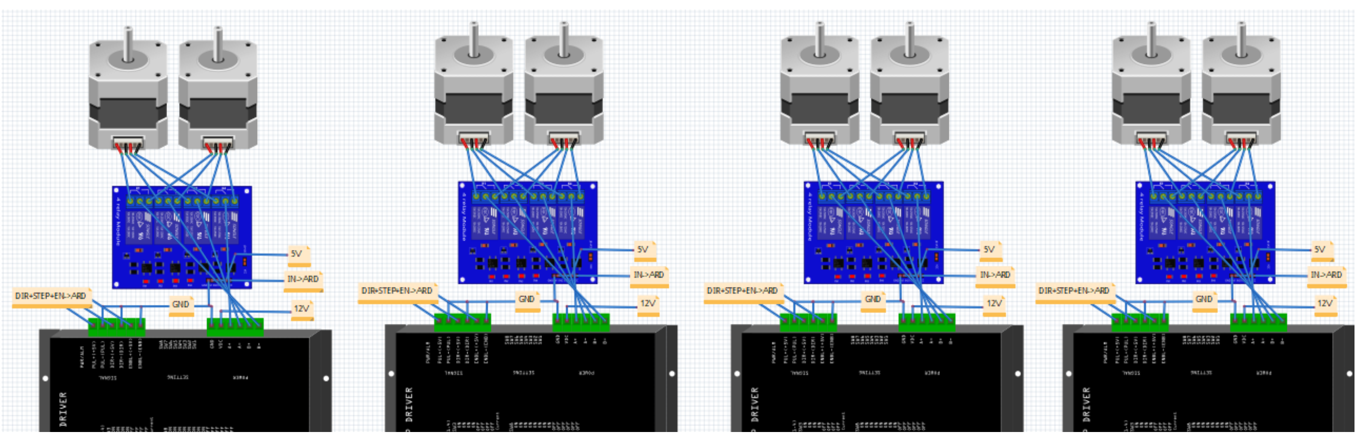
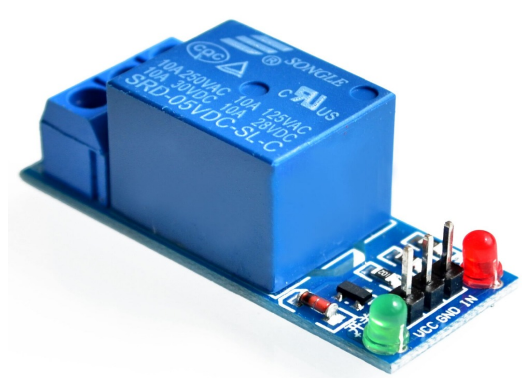


Figure 11: Motors Coordination using Four-Channel Relay Module and drivers

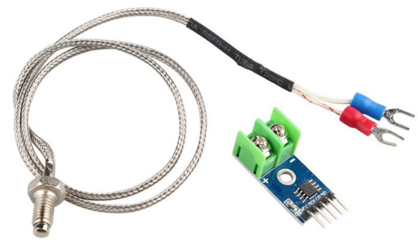
We employed three units of the **5V 1-Channel Relay Module Active Low** for multiple functions, including voltage conversion and control. Utilizing these relays, we converted the standard 220V power supply to a stable 5V, adapting it for compatibility with our electronic components.

Furthermore, one relay controlled the operation of an air pump for precise ingredient dispensing, enhancing the pizza-making process. Another relay managed the oven's temperature and operations with precision. Lastly, a relay played a pivotal role in regulating the entire project's power supply, enabling convenient on-off control.

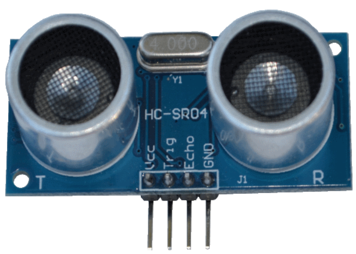


The integration of the **Thermocouple Temperature Sensor Module MAX6675** played a pivotal role in our project's precision temperature monitoring, particularly for the oven's operations.

Due to the high temperature values generated within the oven, accurate temperature measurement was essential for both safety and optimal cooking results. The MAX6675 thermocouple module efficiently converted thermal signals into readable temperature data, allowing us to closely monitor the oven's temperature fluctuations.



Ultrasonic Sensor Module HC-SR04 providing accurate distance measurement for monitoring ingredient levels within containers.



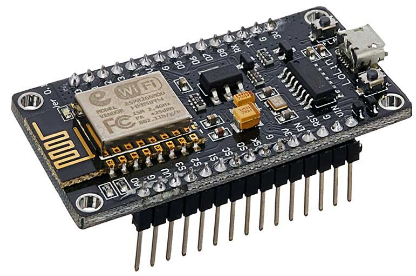
Utilizing ultrasonic technology, this module effectively measured the distance between the sensor and the contents of the container. By doing so, it allowed us to determine the precise levels of ingredients, enabling timely replenishment and minimizing the risk of shortages.

The incorporation of the **Soil Moisture Sensor Module**, originally designed for soil humidity testing, was strategically repurposed as a ketchup sensor within our project.

By utilizing the sensor's corrosion-resistant probe, we were able to detect the presence and level of ketchup. The sensor's ability to assess moisture content made it a suitable choice for detecting the viscosity and volume of ketchup within the container.

Through this innovative adaptation, we enhanced the project's capability to accurately monitor the ketchup's status and utilize this information for efficient pizza customization.

The NodeMCU ESP8266 Module played a pivotal role in establishing wireless connectivity for our project. Utilizing its Wi-Fi capabilities, we enabled administrative access through a dedicated application. This connectivity empowered administrators to monitor ingredient levels, control the project's on-off state, and view user ratings and feedback.



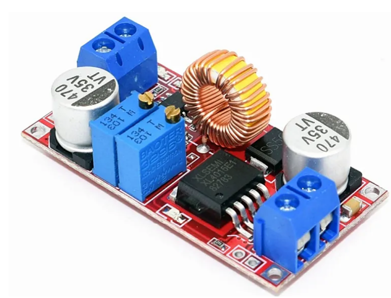
By integrating the NodeMCU ESP8266 Module, we enhanced the project's accessibility and control, allowing administrators to manage and oversee various aspects of the automated pizza station remotely.

A **rocker switch** was integrated into the project to serve as an emergency button, allowing the administrator to swiftly turn the entire system on or off. This functionality proves crucial, particularly when dealing with components like the oven that operate at high voltages of 220V, enhancing safety and control measures.

The inclusion of a **12V 30A switching power supply** significantly contributed to the successful operation of our project. This type of power supply, also known as a switched-mode power supply (SMPS), proved indispensable due to its ability to provide various voltage levels and substantial power output.

Switching power supplies offer a remarkable advantage in terms of efficiency when compared to linear power supplies. Their operation involves rapidly switching the input voltage on and off at a high frequency, with output voltage regulation achieved through control circuitry. This design approach results in higher efficiency and allows for more compact and lightweight power supply designs, which were essential for driving the eight stepper motors and other project components.

The incorporation of a **Buck Converter** played a pivotal role in maintaining efficient voltage regulation within our project. This component served the critical purpose of converting the 12V power supply to a stable 5V, ensuring that components requiring this voltage level, such as sensors and screens, received the appropriate power supply.



TouchScreen and FTDI : We integrated a TouchScreen component along with the FTDI (USB-to-Serial) module to enhance user interaction and enable seamless communication with our automated pizza station.

The home screen features a simple and intuitive layout, presenting users with two prominent buttons for distinct actions:

1. ** Order Now:** This button is designed to initiate the pizza customization and ordering process. Upon selection, users will be guided through a series of steps to personalize their pizza by choosing from available ingredients and configurations. Once the customization is complete, the system will prompt users to confirm their order and proceed with the baking process.

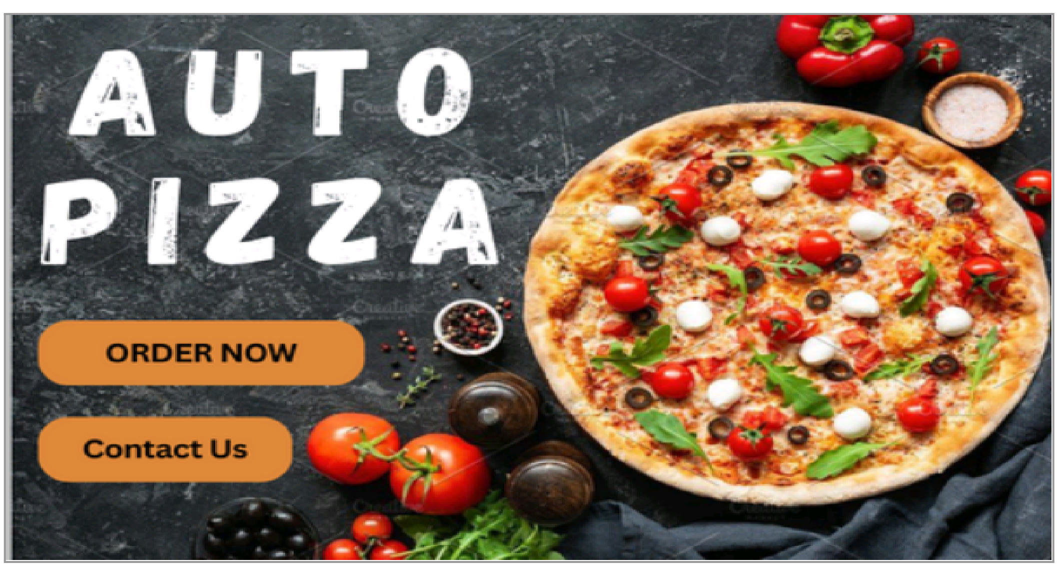


Figure 12: "Order Now" Button and Pizza Customization Process

2. **Contact Us:** The second button provides users with access to contact information. By selecting this button, users can retrieve essential contact details for inquiries, support, or any additional information they may require.

Figure 13: "Contact Us" Button and Information Access

This streamlined home screen design ensures user convenience and access to both the core functionality of the system and essential support resources.

After selecting the "Order Now" button, the system seamlessly transitions to a screen displaying a comprehensive list of possible ingredients that can be added to the pizza. Users are presented with the following options:

1. **Ingredient Selection:** For each ingredient on the list, users can choose whether to add it to their pizza. This is done by tapping on the respective ingredient. A visual indicator, such as a checkmark or highlight, confirms the selection. Users have the freedom to mix and match ingredients according to their preferences.

2. **Add Extra:** Alongside the ingredient list, there is a designated "Add Extra" button. This functionality allows users to increase the quantity of a specific ingredient if desired. Tapping this button provides a simple interface to adjust the quantity of the chosen ingredient.

This interactive ingredient selection process provides users with complete control over the pizza's composition, catering to individual tastes and preferences. The user-friendly interface ensures an enjoyable and personalized pizza customization experience.

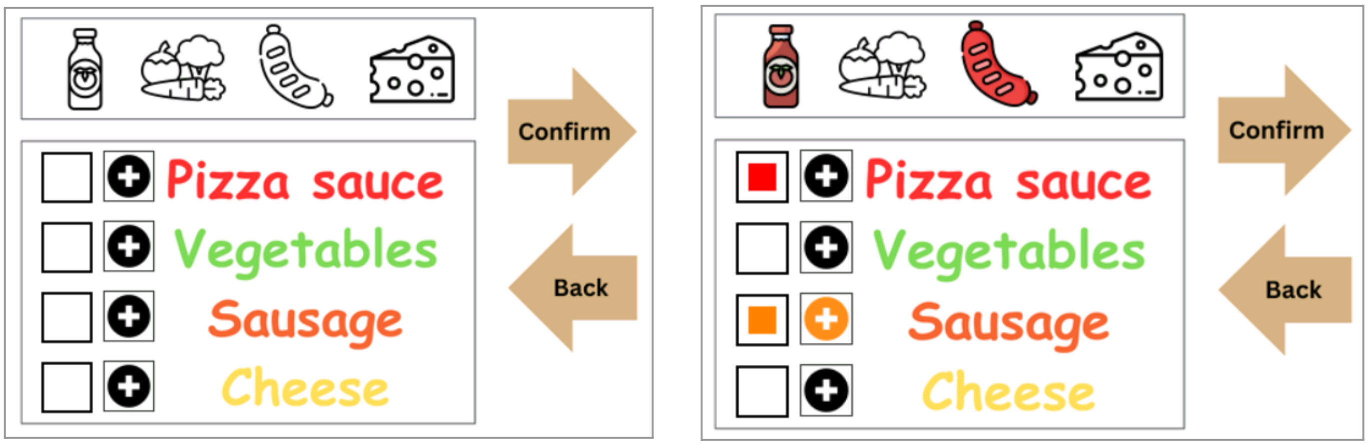


Figure 14: Personalized Ingredient Selection Interface

Upon selecting and confirming the chosen ingredients, the system promptly generates a clear and detailed bill for the user's order. The bill is thoughtfully designed to include the following information:

1. **Order Details:** The bill presents an overview of the user's order, listing the selected ingredients and any customized options. This section provides a comprehensive view of the chosen pizza configuration.

2. **Ingredient Breakdown:** A breakdown of the selected ingredients is provided, along with their respective prices. Each ingredient is accompanied by its individual cost, allowing users to understand the cost distribution of their customized pizza.

3. **Total Amount:** The bill culminates with a total amount, summarizing the entire order cost. This provides users with a clear understanding of the final price they will be charged for their customized pizza.

By presenting this detailed and transparent bill, users can review their choices and associated costs before finalizing their order. This level of transparency ensures that users have full control over their spending and are fully informed about the components of their custom-made pizza.

Figure 15: Order Bill

After reviewing the bill, users are presented with two options:

1. **Rate the Order:** Users have the opportunity to provide feedback by rating their order. Tapping on the "Rate" button will lead to a simple rating interface where users can express their satisfaction level with the order. This feedback mechanism allows the system to continually improve and tailor its offerings to user preferences.

2. **Skip to Next Order:** Alternatively, users can opt to proceed directly to the next order without providing a rating..
By offering these choices, the system maintains a user-centric approach, ensuring that users have the flexibility to engage with the ordering process according to their preferences.

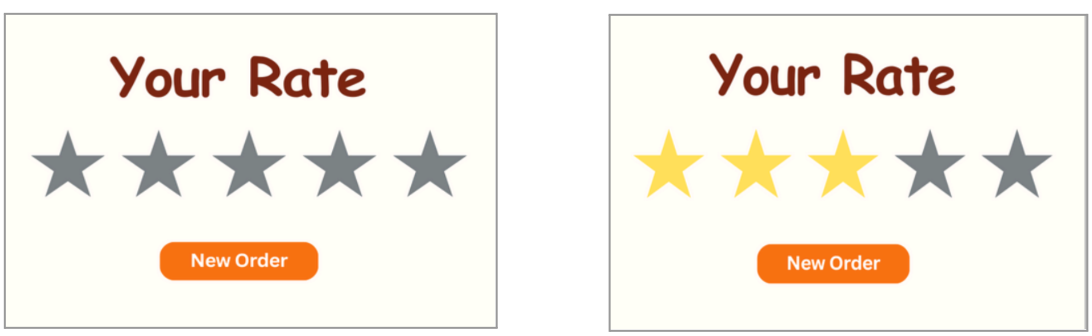


Figure 16: User Rating and Feedback

Finally, after completing the current order and any associated actions (such as rating or skipping to the next order), the user will transition to a modified version of the home screen. This modified screen serves as a waiting area until the ongoing order is fulfilled. Once the ongoing order has been processed and completed, the user will be automatically redirected back to the original home screen to initiate new orders.

Figure 17: Transition and Order Completion

4.3. Dashboard for Admin

The development of an efficient and comprehensive control center for project administration was achieved through the integration of Blynk, a versatile platform for creating customized web and mobile dashboards. This dashboard empowered administrators with real-time insights and control over various aspects of the automated pizza station.

Blynk Integration

We harnessed the capabilities of the Blynk platform to craft an intuitive and user-friendly dashboard accessible via both web and mobile devices. This dashboard provided administrators with a centralized hub to manage and monitor critical functions of the automated pizza station.

Key Features of the Admin Dashboard:

- On/Off Control: The dashboard facilitated remote project activation and deactivation, offering administrators the convenience of remotely turning the project on or off based on operational requirements.

- Ingredient Level Monitoring: Through the integration of sensors, administrators could efficiently gauge the levels of ingredients within the containers. This real-time data allowed for timely ingredient replenishment, minimizing disruptions.

- Alert Mechanisms: The dashboard was programmed to generate alerts when ingredient containers reached empty levels. These alerts ensured administrators were promptly notified of potential shortages, facilitating proactive action.

- Rate : Administrators could access the last rate after each user order. This feature enabled administrators to track user's satisfaction

- ESP8266 Integration: The NodeMCU ESP8266 module acted as the bridge between the Blynk platform and the project's hardware components. This module established a seamless connection, ensuring the synchronization of real-time data and commands between the dashboard and the automated pizza station.

Mobile Application:

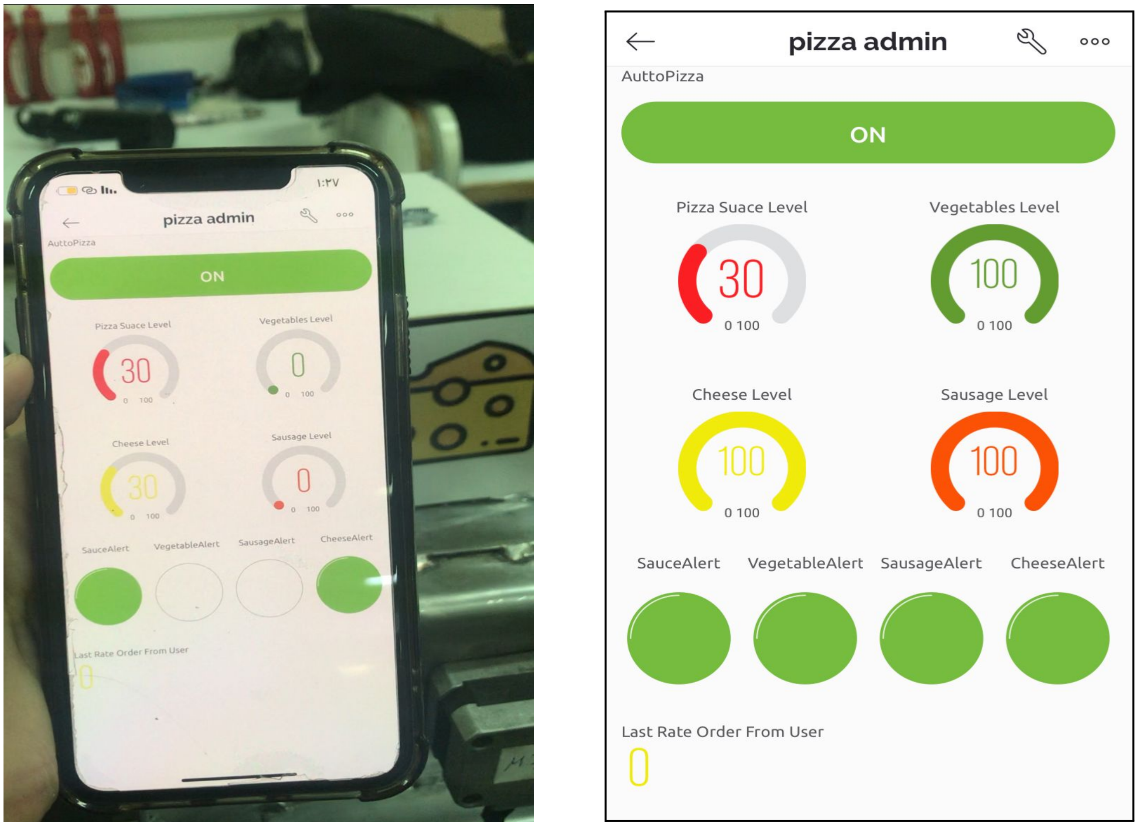


Figure 18: Mobile Application Dashboard for Admin

Web Page:

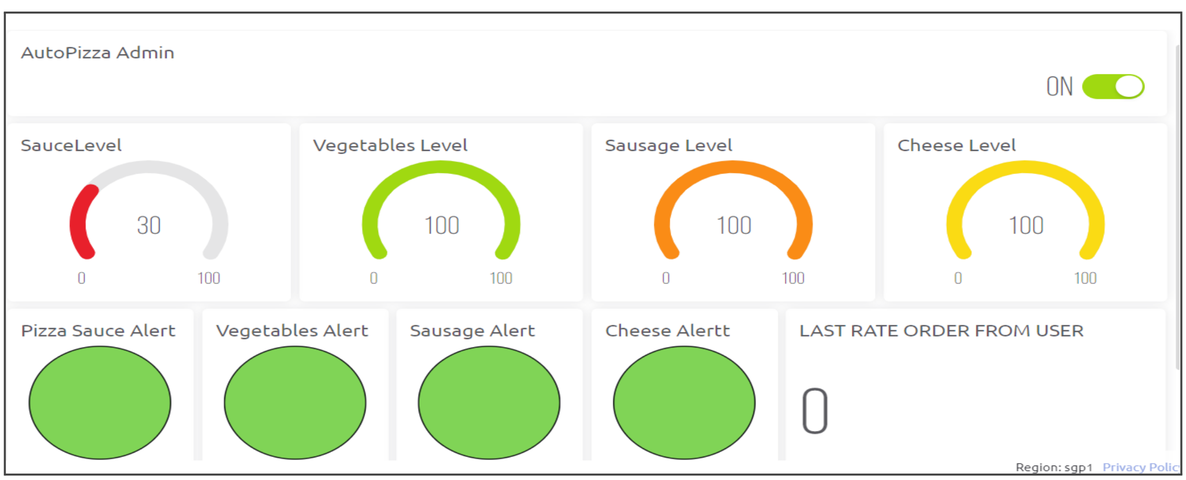


Figure 19: Web Page Dashboard for Admin

5. Results and Discussion

In the culmination of the project, we successfully achieved the creation of a delectable and flavorful product that precisely aligns with customer preferences. Executed within a concise timeline, the project maintained an exceptional level of precision in terms of ingredient measurements, leading to minimize wastage.

The precision of the operation is rooted in the utilization of a stepper motor, which is meticulously controlled through precise management of its steps, directions, activations, and intervals. This meticulous approach ensures optimal outcomes at every stage of the process, including smooth transitions between stages. The orchestration of the entire process, involving driver and relay control, ensures the accurate delivery of the desired current.

Interactions with users have been elegantly addressed through two distinct approaches. From the customer perspective, intuitive and user-friendly touch screens facilitate food orders, adapting options and responses based on sensor inputs. Additionally, this interactive interface offers users the opportunity to provide feedback through a rating system, enhancing overall user engagement.

From the administrative standpoint, remote project management is facilitated through an online dashboard. This comprehensive dashboard provides real-time insights into sensor statuses and alarms, as well as displaying user ratings. Moreover, it empowers administrators with the capability to remotely activate or deactivate the system as needed.

To further enhance safety, the project incorporates a hardware emergency button. This button is designed to swiftly deactivate all connected electrical components, including the power supply and the 220v circuit, both under the governance of relays.

The meticulous arrangement of these components ensures a seamless and user-friendly experience, catering to users of all levels of expertise. The successful integration of precision, interactivity, and safety highlights the project's alignment with its objectives and showcases its potential to meet user demands effectively.

Figure 20: Final Output of Pizza

6. Conclusions and Recommendations

6.1. Summary

In conclusion, our project has successfully realized the development of an automated and user-friendly pizza station. Through the integration of technology and precision control, we have effectively streamlined the pizza-making process, delivering personalized and delicious outcomes that align with customer preferences.

6.2. Future work

While our project marks a significant achievement, there are several avenues for further enhancement and expansion:

* Parallel Processing: Exploring the possibility of processing multiple requests simultaneously could significantly enhance the device's efficiency. Implementing parallel processing mechanisms would cater to high-demand scenarios, such as during peak times or events.

* Automated Ingredient Return: An automatic ingredient return system could be integrated to further reduce wastage. This system would ensure that any excess ingredients not utilized in a pizza are automatically returned to their respective containers.

* Dough Kneading Mechanism: Inclusion of a dough kneading component would present an opportunity to provide freshly kneaded dough, enhancing the station's offerings and allowing customers to enjoy the taste of freshly prepared dough instead of using Ready dough.

* Expanded Ingredient Choices: Expanding the range of available food ingredients would enhance the station's versatility and appeal.

As we consider these potential advancements, we recommend conducting thorough research and development in each area. Prototyping, testing, and iterative refinement would be crucial to ensure the effectiveness, safety, and user-friendliness of these enhancements.

7. References

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