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Smart Coffee Vending Machine

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Abstract: ***Digitizing coffee vending machines is indeed an area where automation and digitization can be profitable. It offers convenience, efficiency, and customization for consumers. The aim is to design a Smart Coffee Vending Machine (SCVM) that serves coffee according to the need of the customer with significant & secure transactions using Radio Frequency Identification (RFID) tags. Smart Coffee Vending Machines are very convenient. These are ideal for places like small, medium, large offices, educational institutes, hospitals and many other places. This machine integrates the latest and user-friendly features to deliver high-quality coffee & hot water on demand.***
Keywords: ESP32 DEV Board, RFID, SCVM, Embedded Systems

I. INTRODUCTION

A Real-time Smart Coffee Vending Machine, SCVM is developed. It is capable of dispensing hot coffee and hot water as output. This occurs upon the provision of required ingredients (milk, water, coffee powder). The machine monitors the parameters like temperature and quantity inside the container. Additionally, it includes an LCD display for presenting interactive messages. These tasks are accomplished using certain methodologies & technologies. They involve the use of Embedded Systems. A Software development tool like Arduino IDE is used for programming and configuring the microcontroller are essential steps. Developing the firmware is also part of the process. Basic soldering required for the circuit assembly. Sawai proposed that a franchise system's effectiveness can be improved. This is done by utilizing the Internet of Things (IoT) for transforming a traditional coffee vending machine to a smart coffee vending machine (SCVM) [1]. At first, the hardware and the software requirements were acquired. The required set up has been made to analyze the connections between the components.

II. HARDWARE AND SOFTWARE REQUIREMENTS

Various components suitable for the proposed system are specified further. Their specifications were taken into considerations. The required hardware components are a Microcontroller that belonged to a family series of ESP32 i.e.; DOIT ESP32 DEV KIT V1. A temperature sensor DS18B20, an immersive water heater, 4-Channel relay, 16X2 LCD Display. Also, 12V Diaphragm DC Motors, Push Buttons, Jumper wires and containers are required. All the hardware components were connected in a circuit form to perform the required action. The components were examined once for their specifications and according to the logic required the program was written in the Arduino IDE platform. A box type structure was made to accommodate the circuit inside it with a cardboard and the wirings were being covered with sheet to make the entire set up look presentable and comfortable to use the machine whenever it is required. There are certain precautionary measurements to be taken during the time of operating the machine, that are the temperature sensor lying inside the container and the immersion water heater lying in the same container are not supposed to get in contact with each other. So, they have been kept at a distance from each other.

The second precautionary measurement that is to be followed is, without any liquid in both the containers the motors should not be run, or the power supply should not be ON. This may damage the motors on both the containers. The vending machine offers customizable quantity options tailored to individual preferences. Users can choose from predefined serving sizes, such as 100 ml or 200 ml for coffee and 200 ml for hot water, accommodating various consumption preferences by selecting their desired quantity through the push buttons, customers can receive the precise amount of beverage they prefer, ensuring satisfaction with each serving. Kim discussed that according to the personal preferences of the user, the network monitors the internal conditions of the machine (ICCE) [2]. Additionally, the user-based quantity options can be adjusted or expanded based on feedback and market demand, allowing for further customization and refinement of the vending experience. In 2019, an identification method using an anomaly for a liquid-coffee machine by using electrical current waveforms are done for which water leakage and lack of coffee beans were major issues (ICICT) [3]. RFID (Radio-Frequency Identification) technology is integrated into the vending machine to enable secure and efficient usage of coffee vending machine, users can utilize RFID tags or cards to use coffee vending machine. The vending machines RFID reader scans the tags, verifies the user's identity and authorizes to dispense the selected beverage.

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III. WORKING PRINCIPLE

The Smart Coffee Vending Machine is a sophisticated system designed to provide users with hot beverages like coffee and water, tailored to their preferences. the system is powered by an ESP32 microcontroller, which serves as the central processing unit orchestrating all functions. The microcontroller is programmed using the Arduino IDE platform. Hardware components such as temperature sensors, two heaters, LCD displays, RFID readers, and push buttons are strategically integrated into the system to enable user interaction, heating and authentication. Upon startup, the system greets users with a welcoming message displayed on the LCD screen that is “Welcome GNITS”.

Access to the vending machine is regulated through RFID tags/cards, which users present for authentication. Once authenticated, users can select their desired beverage quantity using push buttons. The microcontroller processes these inputs, triggering the dispensing mechanism to release the appropriate amount of coffee or water. Meanwhile, temperature sensors monitor the temperature inside the containers to ensure optimal brewing conditions. In the Box type arrangement, the power supply is directly given to the heaters immersed in both the containers, that is the heaters will receive directly 230V AC Supply. The DC Motors operating voltage is 12V that is coming through the relay which is directly going to get power from the 230V AC supply. The DC Motors have two pipes attached to it, one of the two is suction pipe and the other is outlet pipe through which the liquid is expected to be dispensed. These two DC Motors are being soldered on the two containers and the required connections of the motors are given to the relay circuit to control the operation of the motors based on the program. The block diagram of SCVM is depicted in the Fig. 1.

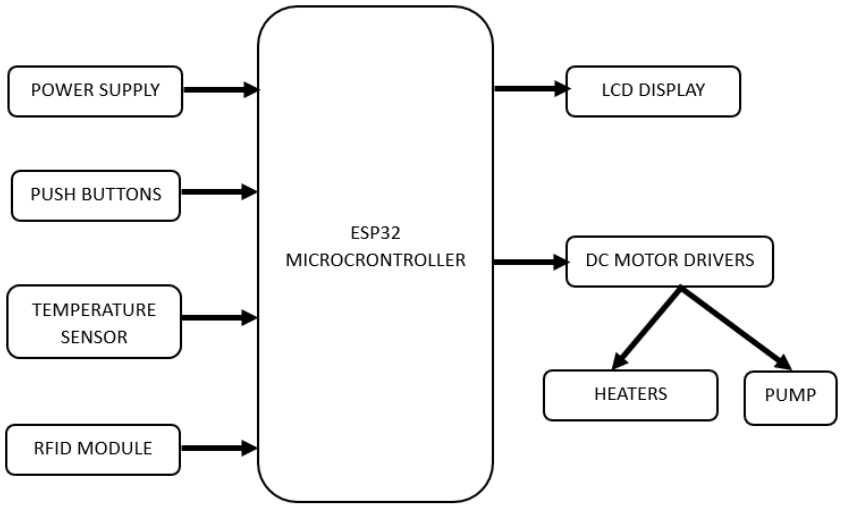


Fig. 1. Block Diagram of SCVM

This can be indicated by the indicator light that get turns off when this action is performed. Whenever they are off, even if we have the permission, we will not be able to pour the liquid into the containers. This action of turning OFF and ON is done by using the 4-Channel Relay. The 4- Channel Relay has 4 channels in which two channels are responsible to control the two motors on top of the containers, and the other two channels are responsible for two heaters. Channel 1 & Channel 4 are responsible for operating motors. Channel 2 & Channel 3 are responsible for heaters. Two of the four relays are off and two of them are on. These are connected according to the concept of normally open and normally close type connections. All these may be operated in continuous manner or in triggered manner.

The switches or push buttons are directly connected to the ESP32 by using the jumper wires. LCD wires are responsible for LCD Connections connected to ESP32. The lines such as lcd.print written in the program will print the statements on the LCD Display. Also, there are two resistors being used in the circuit that act as pull up resistors for the temperature sensor DS18B20. This is because the ESP32 30 Pin IC, some of the GPIO pins must be operated only with pull up/pull down resistors or with some high impedance connected to those pins. The interfacing of the relay, motors, push buttons, LCD Display, temperature sensor, is done across the pins of 30 pin ESP32 DEV KIT IC. The pins VCC, GND, D13, D12, D14 and D27 are used to connect the push buttons, relay and further from relay to motors. The D2 and D4 pins are connected to the pull up resistors that are connected in series, for the sensors.

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The motor connections are given directly to the relay and further to the ESP32. The push button connections are directly given to ESP32 and is the same with the LCD Display. As soon as the relay power supply is ON, the motors receive a voltage of 12V on which they start operating, meanwhile the heaters are given 230V AC Supply on which they start reaching the temperature till the coffee is reached to desired hotness. During this ESP32 is ON and the program configured and dumped into the controller begins to execute and thus with some time delay the hot water and the concentrated extract or liquid obtained from ground coffee beans is being dispensed together.

The relay used here is programmed to control the operation whenever the liquid in both the containers in below the threshold level. Relay also controls the motors in a such a way that dispenses only certain amount of liquid to be pour into the coffee cup. This delay can be increased or decreased in the program itself depending upon the dimensions of our desired coffee cup that we place under the dispenser.

IV. RESULTS

The Fig 4.1 shows the overall structure of the coffee vending machine in which the entire circuit and the components are assembled neatly.



Fig. 4.1 SCVM

The Fig 4.2 depicts the internal circuit. In the internal circuit, connections are arranged in order to obtain the desired output. Fig 4.3 show a valid RFID tag used by the user to get the access. Fig 4.4 LCD Displaying ‘Welcome GNITS’.



Fig. 4.2 Internal Circuit of SCVM

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Fig. 4.3 RFID Tag

The illustration of 'Welcome GNITS' is shown in Fig. 4.4. The message is displayed on LCD as an interactive message.



Fig. 4.4 LCD Displaying 'Welcome GNITS'

The Fig 4.5 illustrates that the authentication process is successfully completed. Thus, displaying a message on the LCD as 'access approved Select Quantity'. As soon as the user observes the message on the display, he selects his choices & gets a cup of his choice.



Fig. 4.5 Authentication for Access Approval

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The Fig. 4.6 shows the values of the temperature on the serial monitor. The temperature sensor is placed within the machine to capture the temperature variations. The variations are seen through serial monitor of IDE console. Operators can observe these temperature fluctuations when necessary.

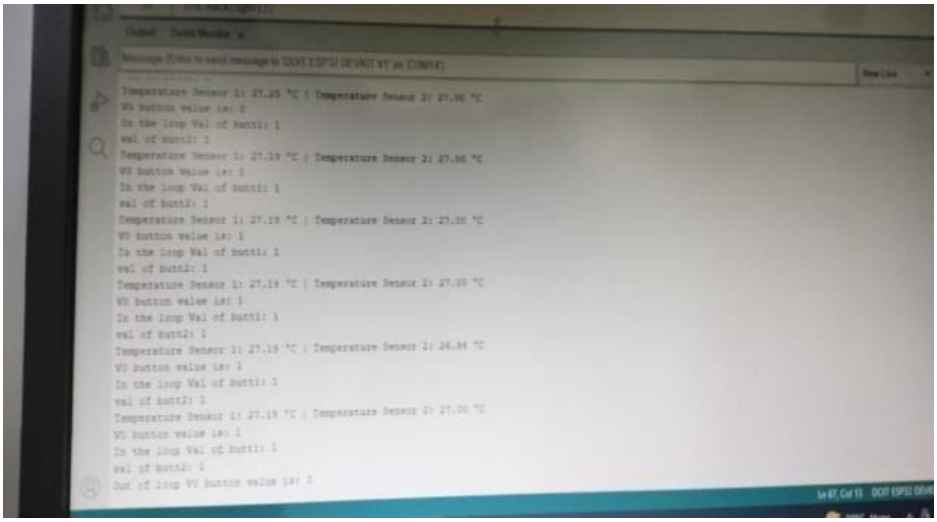


Fig. 4.6 Temperature Values on Serial Monitor

V. CONCLUSIONS

A Smart Coffee Vending Machine (SCVM) with a comprehensive set of features has been successfully developed. This machine caters to user preferences by dispensing beverages based on their selections. Users can choose from three options: hot water, hot coffee in 35ml quantity, or hot coffee in 40ml quantity. Authentication is efficiently managed through RFID tags, ensuring safe and secure usage for customers. The machine enhances user experience through interactive messages displayed on an LCD screen, including welcoming messages, access approval notifications, quantity selection prompts, and gratitude messages.

VI. FUTURE SCOPE

Implementing a GSM module in the machine's interface enables seamless communication with the owner by sending messages directly to their email or mobile phone, ensuring prompt notifications and updates regarding the machine's status. Additionally, integrating a touch screen interface enhances user interaction, allowing intuitive navigation through the machine's functionalities via touch gestures on displayed images or text. To diversify payment options and potentially boost revenue, the inclusion of coin-based transactions alongside RFID technology offers users greater flexibility in choosing their preferred payment method.

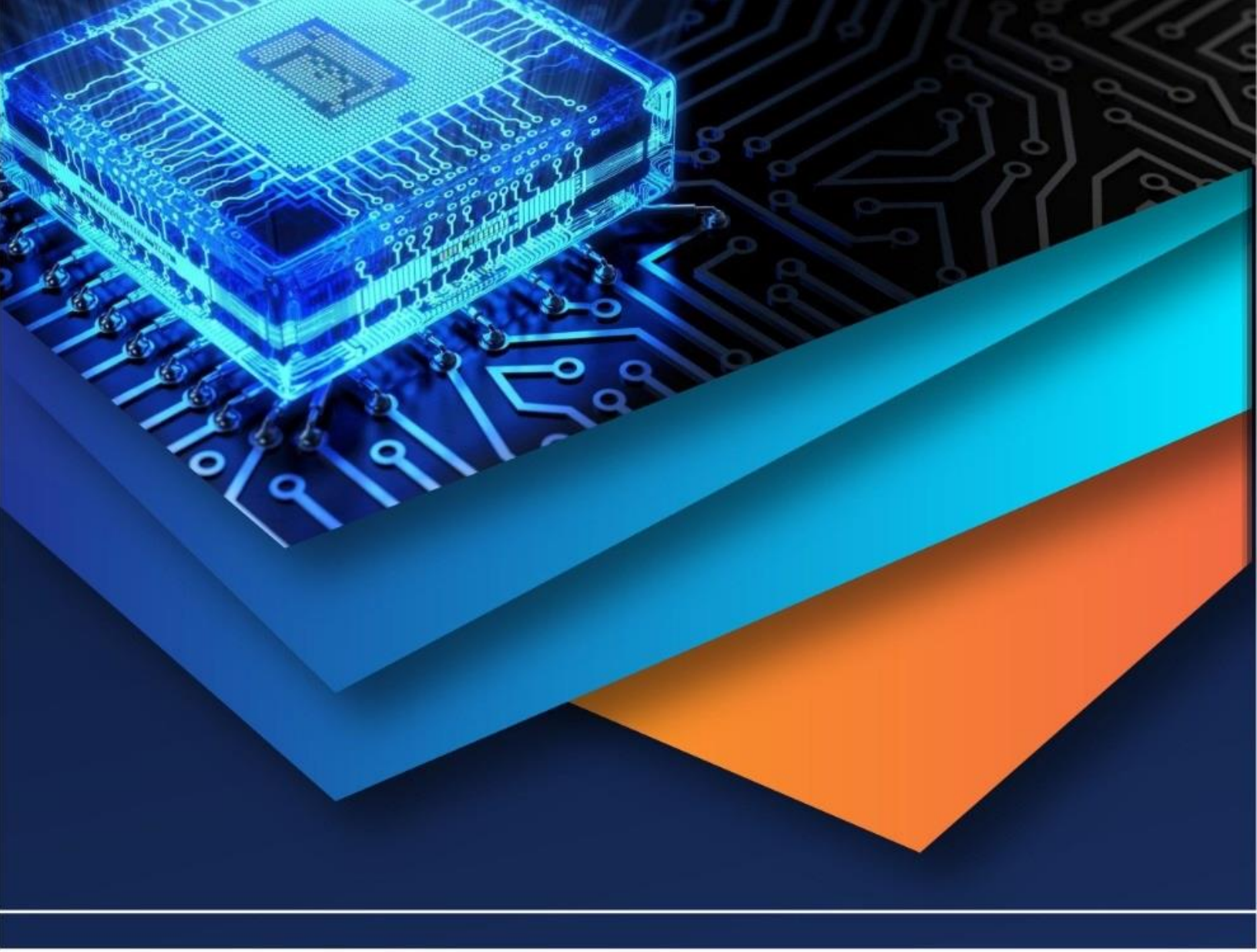
Moreover, enabling further customization by allowing users to select specific ingredients caters to individual preferences and dietary requirements. For instance, diabetic patients can exclude sugar from their chosen ingredients, ensuring a tailored experience that promotes inclusivity and customer satisfaction. By incorporating these features, the machine not only improves user experience but also maximizes economic benefits through enhanced functionality and adaptability.

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