DESIGNING AN AUTOMATIC BEVERAGE MIXING SYSTEM BASED ON THE INTERNET OF THINGS

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ARTICLE INFORMATION

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ABSTRACT

This paper focuses on the research and development of an automated beverage mixing system. By applying modern Internet of Things (IoT) technology and information technology, the system incorporates intelligent functions such as touch sensing, internet connectivity, and beverage dispenser control software. It can provide a wide variety of high-quality beverages, including coffee, tea, juices, alcoholic drinks, and drinks made with syrups, sugar and milk. The advantages of this beverage dispenser include cost-effectiveness in installation, reduced labor requirements, compact size for versatile placement, and the ability to meet customer demands conveniently and flexibly. Results from practical testing demonstrate the stable operation of the machine, accurately following the pre-programmed beverage mixing instructions. The product can be used in real-world settings such as cafes, households, or office spaces.

Keywords: Beverage making machine; beverage mixing; sensors; smart robot; Internet of Things.

1. Introduction

A beverage dispenser is a device used for automatically preparing various types of drinks such as coffee, tea, fruit juice, yogurt, and more. Beverage dispensers are commonly used in coffee shops, restaurants, hotels, offices, schools, or industrial areas. They come with various features and different technologies to prepare different types of beverages. Some beverage dispensers can make fruit juice or yogurt, or combine various drinks to create cocktails, mocktails, and more. Different types of beverage dispensers also have their own characteristics and pros and cons. Some automatic machines can quickly prepare drinks, minimizing customer waiting time, but they may not deliver the flavor and aroma of freshly brewed coffee made from fresh coffee grounds. On the other hand, some manual coffee makers allow users to customize the flavor, aroma, and strength of coffee but require time and the user's brewing skills.

Various types of beverage dispensers have been commercialized in the market, or research has been published on modern and efficient beverage dispensers

[1]-[3]. However, the drawback of these publications is that they are expensive, energy-consuming, and employ complex designs that are difficult to maintain at home [4]-[7]. In this study, the authors attempted to construct and design an intelligent beverage dispenser product that inherits the advantages of previously published products. Additionally, the research introduces a novel aspect: affordability, simple installation technology, while still meeting user functions. The functions are optimized for performance through programming and design, making it easy to replace or maintain in case of issues [8]-[11].

The product envisioned in this research is designed to contain up to 5 ingredient tubes. Through a quantitative mechanism regarding ingredient composition, the machine will mix the ingredients and produce a finished beverage, with the time required for the final product depending on the complexity of the beverage's ingredient composition. On the other hand, this is also an intelligent device, with all control operations carried out through a smartphone or tablet application and Internet of Things (IoT) communication. The device directly connects via Bluetooth, allowing users to control the beverage preparation from anywhere and at any time. Through the smartphone or tablet application, users only need to select the ingredients placed in the 5 tubes, choose the type of beverage that can be prepared from those ingredients displayed on the app, press the preparation button, and a delicious drink is ready. The intelligent liquid pumping mechanism allows for the creation of beverages with precise ingredient components and dosages.

2. Electronic design fundamentals and equipments selection

In this research, modern devices and sensors [2] that are currently widely used are employed, such as: *Arduino Uno R3; Servo MG966R; Step Motor; Module Bluetooth HC-05; Stepper Motor Driver A4988; A4988 DRV8825 V2*; and other devices to complete the hardware for this research product, the authors also used additional devices such as a 12V power supply, a 5V-1A adapter, and a set of V-slot wheel PAD.

3. System survey, analysis and design

3.1. The block diagram of the system

The block diagram of the system is as follows Figure 1 [3-7]:

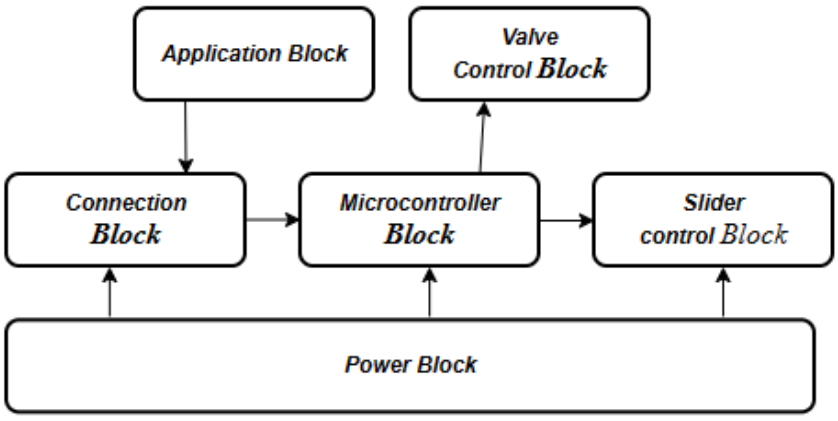

Figure 1: *Diagram of the system*

Detailed functions of each block:

- ***Power Block:*** This block is responsible for supplying power to the entire hardware and mechanical systems. The power block plays a crucial role in enabling the operation of both hardware and mechanical components. It provides the electricity needed to operate and control components like servos, ensuring they can move accurately. If the power block is not functioning or does not supply sufficient power, the systems may not operate correctly or may encounter issues. Therefore, the power block needs to be selected and configured accurately to ensure the proper functioning of the hardware systems.

- ***Application Block:*** This is the block with which users directly interact with the device. It can be understood as a device control block. Control signals are emitted from this block. It provides a user interface for users to perform operations and manage configuration options. It also handles requests from the hardware and provides users with information about the device's status.

- ***Connection Block:*** This block works with Bluetooth connection protocols to establish a connection between the application block and the hardware. It receives control signals from the application block and forwards them to the hardware to execute required tasks. Bluetooth connectivity enables users to directly control the device without the need for physical cables. The device *Bluetooth HC-05* is used in this block.

- ***Microcontroller Block:*** This block is responsible for receiving control signals, reading data from the connection block, and generating output signals to control the valve control block and the slider control block. Input signals from the connection block undergo appropriate calculations and transformations. The control block also autonomously monitors the device's status by reading and processing data from status-indicating devices such as accelerometer sensors or position sensors. If necessary, this block can utilize complex control algorithms to ensure that the output signals meet user requirements. The device *Arduino Uno R3* is used in this block.

- ***Valve control Block***: This block receives control signals from the control block to operate the mechanism for opening and closing the material supply valve. The valve control block consists of a control switch, a servo, and a motor controller to execute the valve's opening and closing synchronously and precisely. Upon receiving control signals, the motor controller activates the servo to adjust the valve's position. Control signals sent to this block must ensure that the valve's opening and closing are carried out safely and without causing any losses or incidents. The device *Servo MG966R* is used in this block.

- ***Slider control Block:*** This block is responsible for controlling the slider to move the water glass to the desired position for collecting materials from the water valves. It receives control signals from the control block and carries out the movement of the slider to the predetermined position. The device *Step Motor, Stepper Motor Driver A4988; A4988 DRV8825 V2*is used in this block.

Operating procedure:

Firstly, after being powered from the corresponding power supply block with varying voltage levels for different components, the entire device ensures that it receives

suitable power to prevent any burning incidents due to exceeding the allowed voltage levels of the hardware components.

Next, it is necessary to establish a connection between the connection block and the application block via Bluetooth so that the device can receive control signals from the application block. Once these control signals are received from the application block, the hardware components begin their operation in response to user requests.

Based on the corresponding signals (the selected beverage types) in the software application, the signals emitted from this block may vary. At this point, the hardware device will receive and process the signals, then operate according to the signal types corresponding to the user's selection of beverage.

The slider will now move to the corresponding ingredient valves based on the selected beverage's ingredient components by the user. The slider's movement to a particular ingredient valve will trigger the respective valve's opening and closing mechanism. The valve opening time aligns with the ingredient quantity as per the drink's recipe.

After the ingredients have been pumped into the glass according to the drink's formula, the slider will return the glass to its initial position, and the device will pause, awaiting further signals. The beverage maker can also store hundreds of drink recipes with names, ingredient information, and quantities for each type. This makes it easy for users to find and select their favorite drinks without having to remember how to prepare them or search online. Additionally, the device has an automatic ingredient limit feature.

3.2. Hardware circuit design

The hardware circuit connection diagram is depicted as shown in Figure 2.

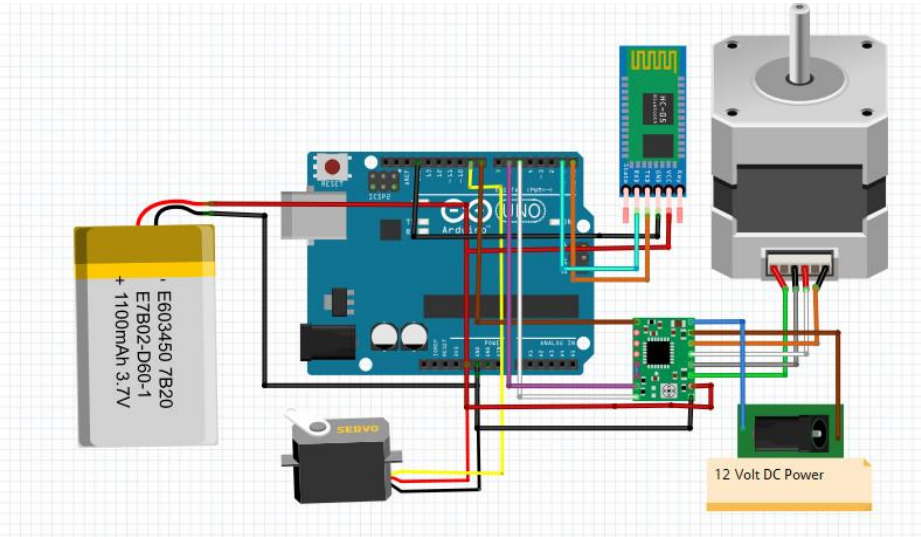

Figure 2: *Circuit connection diagram*

Description: The device uses two separate power sources: a 3.7-5V supply for the microcontroller, servo motor, HC-05 Bluetooth module, and A4988 driver; a 12V supply for the step motor. The three control pins for the step motor, namely ENABLE, Step, and

IR of the A4988 driver, are connected to Arduino's pins 8, 5, and 2, respectively (as shown in Table 1).

Table 1: *Control PINs connections*

Arduino	A4988
2	Step
5	Dir
8	Enable

The control pin of the servo motor is connected to PIN 9 on the Arduino, and the two transmit and receive PINs, TX and RX, on the Bluetooth module HC-05 are connected to the Arduino with TX connected to PIN 0 and RX connected to PIN 1.

3.3. Flowchart Diagram of System Algorithm

The algorithm flowchart of the system, as shown in Figure 3, can be described as follows [9-21]:

- Initialize variables and configure the input/output pins of the Arduino.
- Inside the main loop, check for incoming data. If there is incoming data, read the value and store it in the Switch_state variable.
- Use conditional if statements to process based on the value of Switch_state. Each if statement corresponds to a different type of beverage.
- Inside each if statement, call the Myservo.write() function to control the Servo's movement to a specified angle (GOC_MO or GOC_DONG).
- Inside each if statement, call the MoveX() function to control the stepper motor's steps.
- Inside each if statement, use the Delay() function to pause the program for a certain amount of time.
- Repeat the Loop until there is no more incoming data.

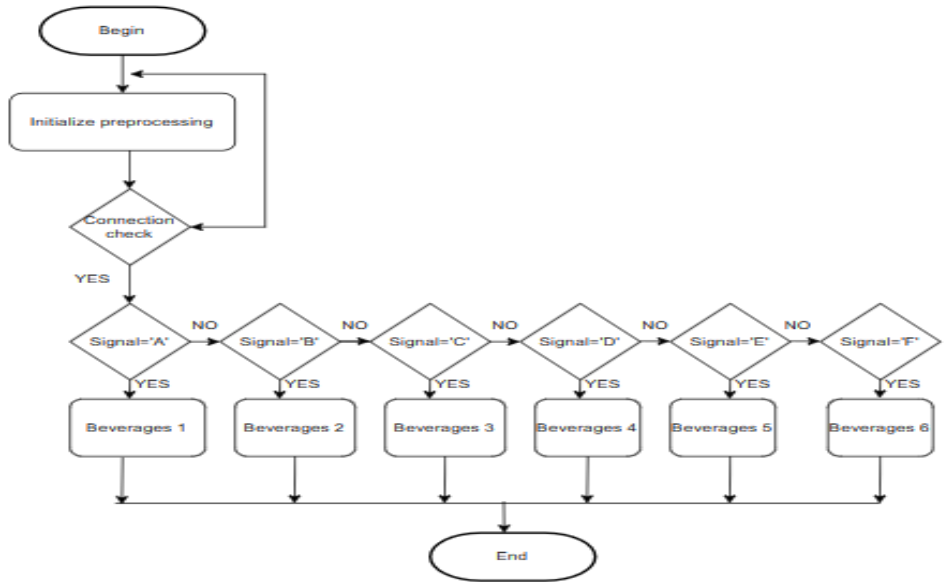

Figure 3: *Algorithm flowchart*

4. Software development

- In this research, Arduino IDE is used to program the system and load the code programs into the components. Additionally, the research utilizes the App Inventor tool, which operates on the Android mobile platform. If users want to use the application on the iOS operating system, they can utilize conversion tools like Mechdome Android to iOS Converter.

- Software interface design (Figure 4): The software can connect to the hardware via Bluetooth connectivity and offers 6 types of beverages, along with information on the components and quantities for each type chosen by the user.

Figure 4: *Software frontend*

The software features an intuitive and user-friendly interface with 3 main components:

- Bluetooth connection button: This button is used to establish a connection between the device and the hardware via Bluetooth. When the user taps this button, the software will automatically search for and connect to the hardware. If the connection is successful, the button will turn green and allow the user to access the software's functions.

- Beverage selection button: This button displays a list of stored beverage types within the software. Users simply need to tap the name of the beverage they want to select, and the software will automatically carry out the process of dispensing water from the valves and creating the requested beverage.

- Detailed information about each beverage, including its name, ingredient information, and quantity, is available for users to view. Additionally, users can read detailed instructions on how each selected beverage is made. This information helps users

gain a better understanding of the preparation process and the suitability of each ingredient for the chosen beverage.

The software displays 6 types of beverages that users can choose from (Table 2):

Table 2: *Selecting beverages for the user*

Beverage name	Ingredient measurement
Rum With Sprite	- 150 ml Sprite - 50 ml Rum
Pear Martini	- 40 ml Martini - 60 ml Sprite - 10 ml Lemon
Rum Martini	- 70 ml Rum - 70 ml Martini
Orange Juice	- 150 ml Orange Juice
Classic Mojito	- 70 ml Rum - 30 ml Lemon
Orange Crush	- 30 ml Sprite - 60 ml Orange Juice - 10ml Lemon

5. Testing and result

The hardware product, after research and design, is as follows:

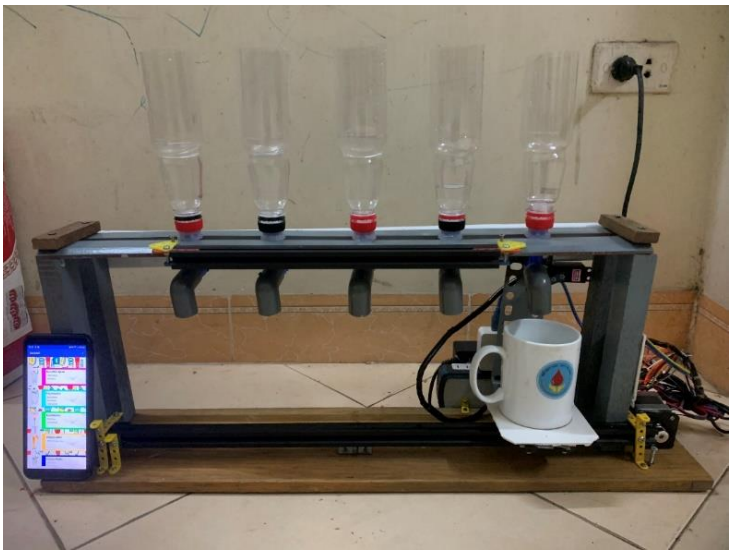

Figure 5: *Automatic beverage dispenser product*

Figure 5 is the result of the beverage dispenser construction process. The test results have shown that the machine performs its programmed and designed functions well. During operation, the ingredients are dispensed in the correct quantities, ensuring the quality and consistency of the final product. The mobile phone control software has been

seamlessly and effectively integrated, allowing users to easily customize parameters and manage the product.

6. Conclusion

The paper has presented the process of developing an automatic beverage dispenser product, building upon the advantages of previously published products. The article has provided detailed information, from its construction to operation, from features to advantages of the device. The results indicate that the automatic beverage dispenser has the capability to prepare various types of beverages depending on customer requirements automatically, conveniently, and quickly. This helps reduce customer waiting times and lighten the load for sales staff, allowing them to focus on serving customers better. However, the product still has some drawbacks, such as the slow delivery of water to the ingredient valves and relatively small ingredient storage compartments. The automatic beverage dispenser can be widely used in various locations, whether it's in beverage stores, entertainment centers, or places with a demand for automatic beverage vending. To be more practical and provide better service, the machine needs software upgrades to expand the range of beverages it can offer, including fruit juices, fruit drinks, coffee, tea, and more. Additionally, the device should be customized to achieve more precise ingredient measurements, ensuring consistency in quality and taste among different servings of beverages. The quality and accuracy of ingredients are crucial to ensure customer satisfaction and economic growth for the business.

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TÓM TẮT

NGHIÊN CỨU XÂY DỰNG HỆ THỐNG PHA CHẾ ĐỒ UỐNG TỰ ĐỘNG ỨNG DỤNG CÔNG NGHỆ IOT

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Ngày nhận bài 13/9/2023, ngày nhận đăng 10/10/2023

Bài báo này tập trung nghiên cứu, xây dựng một hệ thống (máy) có chức năng pha chế đồ uống một cách tự động. Bằng cách ứng dụng các công nghệ hiện đại của mạng kết nối vạn vật, công nghệ thông tin để thực hiện các chức năng thông minh như cảm ứng chạm, kết nối Internet, và phần mềm điều khiển máy pha chế đồ uống có thể cung cấp một loạt các loại đồ uống phong phú, đa dạng và chất lượng cao, từ cà phê, trà, nước ép, đồ uống có cồn cho đến các thức uống sử dụng siro, đường và sữa. Ưu điểm của máy pha chế ở đây đó là tiết kiệm chi phí lắp đặt, giảm nhân lực phục vụ, kích thước nhỏ gọn có thể đặt ở nhiều vị trí khác nhau, đáp ứng nhu cầu của khách hàng một cách tiện nghi, linh hoạt. Kết quả sau khi thiết kế được thực nghiệm trên thực tế cho thấy máy hoạt động ổn định, thực hiện đúng các yêu cầu chức năng pha chế theo thiết kế lập trình trước đó. Sản phẩm có thể đem sử dụng trên thực tế tại quán Cafe, hộ gia đình hoặc nơi công sở.

Từ khóa: Máy pha chế; pha chế đồ uống; cảm biến; robot thông minh; mạng kết nối vạn vật.