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Design and Implementation of an Automatic Tea Vending Machine Using Arduino Uno and Android-Based Customization System

Arpita Phadatare*, Preeti Patil, Priyal Mohole

Abstract

The Android app-based Automatic Tea Vending Machines are a clever and creative way to automate the tea-making process while providing consumers with a customized experience. The Arduino Uno microcontroller, which powers key functions like ingredient delivery, water heating, and customizable settings, is the foundation of this system. To ensure consistent and superior tea preparation, a kettle is used to heat water to the ideal temperature. Users may simply and remotely interact with the machine thanks to the Android app's connection, the system's input selection process, which lets users customize their tea to suit certain tastes, is one of its primary features. The quantity of sugar, milk content, tea strength, tea kind, and preferred serving size are just a few of the variables that users may alter. This degree of personalization guarantees that every tea cup satisfies unique palates. The system offers a high degree of ease and enjoyment in addition to increasing efficiency via the combination of automation and user-friendly technologies. This creative tea vending solution offers a contemporary, effective, and user-centered method of preparing tea, making it especially appropriate for workplaces, cafés, and public areas.

Keywords: Automatic tea vending, Arduino Uno, android app, servo motors, smart beverage system

INTRODUCTION

Tea is one of the most popular drinks in the world, valued for its taste, cultural significance, and several health advantages. However, making tea the old-fashioned way requires human labor, which may be time-consuming, particularly in hectic settings, and can result in variations in flavor, component ratios, and cleanliness. Automation has emerged as a critical component in enhancing food and beverage services' productivity, hygiene, and user comfort in the fast-paced world of today. This project presents an Automatic Tea Vending Machine with an Android-based application to handle these issues. The gadget allows consumers to personalize their tea according to their tastes while automating the whole tea making process, from boiling water to dispensing ingredients. Users may adjust a number of factors, including serving size, tea kind, tea strength, milk volume, and sugar level, using the Android app. All system functions are controlled by an Arduino Uno microcontroller, which guarantees accurate control and reliable quality. By reducing direct touch with components, this contemporary method improves hygiene while also saving time and human labor. The end product is a clever, practical, and easy-to-use system that speeds up, cleans, and customizes tea preparation to personal preferences [1–3].

***Author for Correspondence**
Arpita Phadatare
E-mail: arpitaphadtare9443@gmail.com

Student, Department of Electronics & Telecommunication Engineering, Shri Chhatrapati Shivajiraje College of Engineering, Dhangawadi, Pune, Maharashtra, India

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An Arduino Uno microcontroller was used in the creation of the Automatic Tea Vending Machine. It acts as the main control unit for overseeing the

entire tea-making procedure. This covers tasks including processing user input options, boiling water, and distributing ingredients. The device incorporates a kettle to boil water to the ideal temperature needed for reliable and superior tea production. Servo motors drive the ingredient dispensing system, ensuring precise and regulated dispersion of materials including water, milk, sugar, and tea leaves [4]. This accuracy reduces waste and preserves consistent flavor. The system's user input selection process, which enables users to customize their tea according to personal tastes, is a significant advance. Users may alter a number of factors, such as the amount of sugar, milk content, tea strength, tea kind, and serving size, using an Android app interface. Compared to standard vending machines, which usually only give a small number of preset selections, this great degree of flexibility is a significant gain. The technology improves the entire tea-making experience by fusing automation with clever user control. It offers a contemporary, effective, and user-friendly solution that is especially appropriate for usage in commercial settings, public areas, and workplaces where prompt, sanitary, and individualized service is crucial.

RELATED WORK

Automated vending machines have been widely explored in the food and beverage industry to enhance efficiency, maintain hygiene, and improve customization. Various research studies and commercial implementations have been conducted on automated tea and coffee vending machines, microcontroller-based automation, and mobile-integrated selection mechanisms.

Several existing works have focused on microcontroller-based beverage dispensers. For instance, prior studies have implemented PIC, Raspberry Pi, and Arduino as control units for vending machines, where ingredient dispensing is automated using servo motors and solenoid valves. The accuracy of these systems depends on proper calibration of ingredient flow and integration of sensor-based feedback mechanisms [5–7]. The integration of mobile applications for vending machine control has also been explored in previous research. Many vending systems now incorporate IoT and cloud-based communication to enable remote selection and monitoring. The use of Android applications for beverage selection and customization has gained popularity due to the ease of smartphone accessibility and real-time user interaction.

Research on tea vending machines has largely centered around preset recipes with limited user customization. Most commercial machines dispense pre-mixed tea using fixed ingredient ratios, offering minimal flexibility. However, recent studies on customizable vending systems highlight that allowing users to select preferences such as sugar level, milk quantity, tea strength, and serving size greatly improves user satisfaction. These personalized options not only enhance the overall user experience but also increase the appeal and demand for the product. Customizable systems represent a shift toward more user-centric solutions in automated beverage dispensing technology, meeting diverse taste preferences effectively.

Automation in beverage preparation has greatly improved with the integration of temperature control systems and precise ingredient dispensing. Maintaining the optimal brewing temperature is crucial for preserving the flavor and quality of different tea types, as highlighted in various studies [8, 9]. The use of a kettle equipped with a temperature control mechanism ensures that water is consistently heated to the required level, enhancing the overall brewing process. Combined with accurate dispensing of ingredients, this approach results in a more consistent, high-quality beverage, making automated systems more reliable and effective than traditional manual methods of tea preparation.

METHODOLOGY

The Automatic Tea Vending Machine is a microcontroller-based system that enables users to prepare personalized tea through an Android interface. It offers customization options such as sugar level, milk content, and tea strength, providing a convenient, efficient, and user-friendly solution for automated tea preparation in various settings [10, 11]. The methodology of this project involves hardware integration,

software development, and automation to ensure precise ingredient dispensing and efficient tea preparation. The key components and steps involved in the system's implementation are outlined below along with Figures 1–3, which represent the block diagram, circuit diagram and flow chart of the automated tea vending machine.

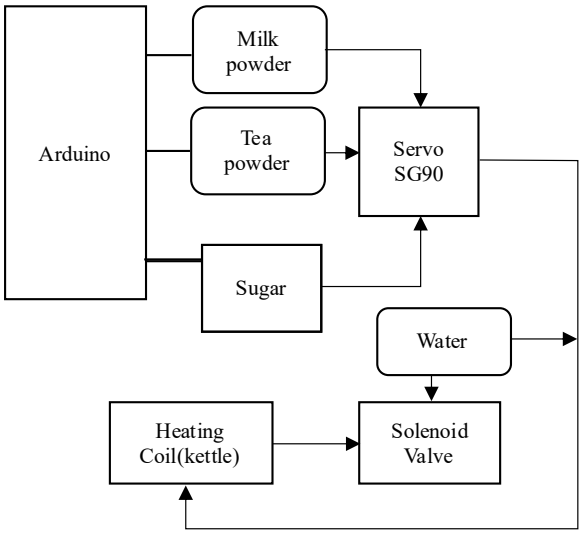

Figure 1. Block diagram of automated tea machine.

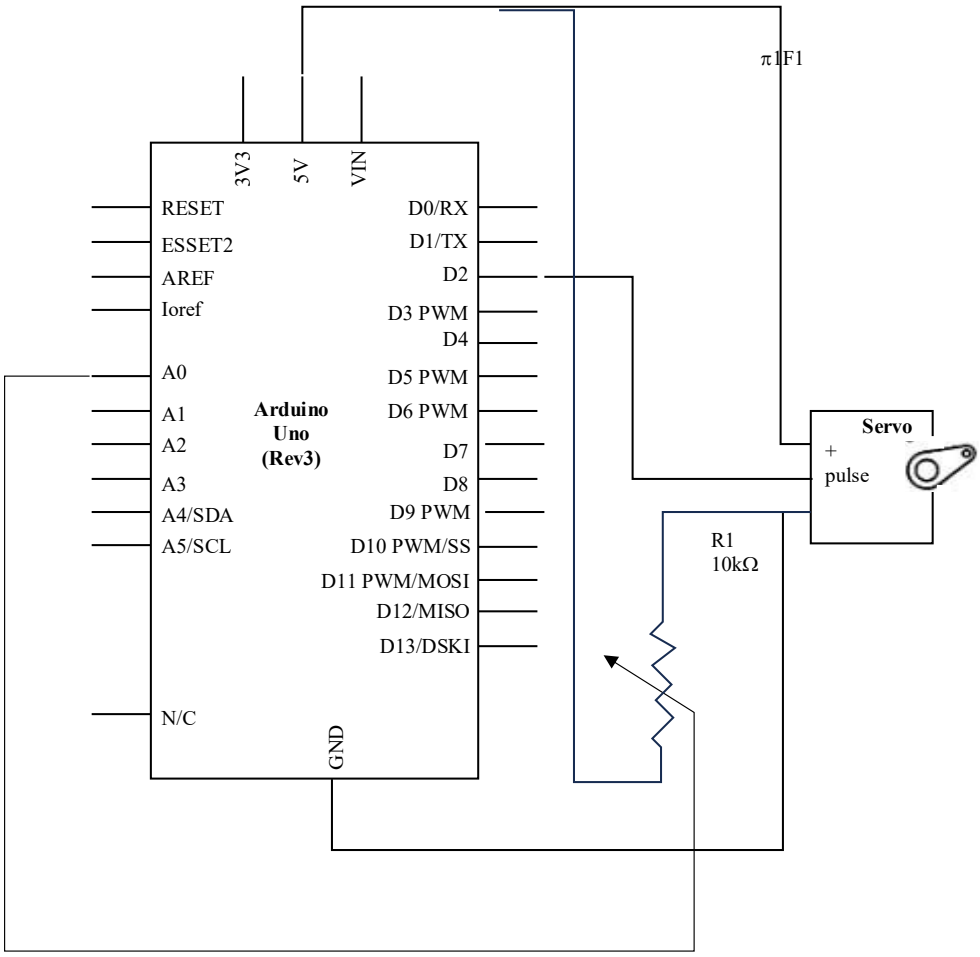

Figure 2. Circuit Diagram of automated tea machine.

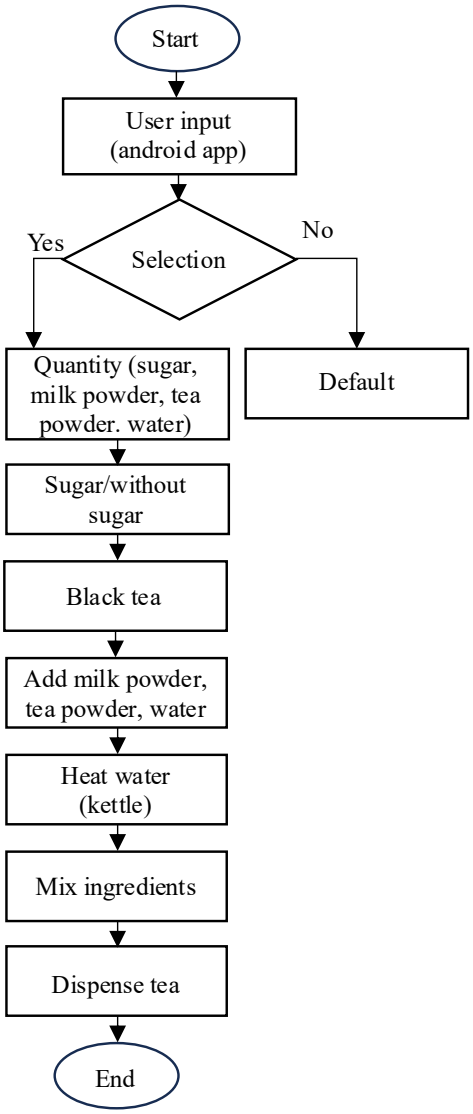

Figure 3. Flow chart of automated tea machine working.

System Design and Architecture

The vending machine consists of three main modules:

1. *User Interface Module:* A mobile application for remote tea customization.
2. *Processing Module:* An Arduino Uno microcontroller that processes user inputs and controls the vending mechanism.
3. *Dispensing Module:* A set of containers for ingredients and SG 90 servo motors for precise ingredient release.

Hardware Components and Their Functions

- *Arduino Uno:* Serves as the central control unit, processing user commands and operating the servo motors.
- *Kettle:* Heats water to the required temperature before dispensing.
- *SG 60 Servo Motors:* Controls the release of ingredients such as tea, sugar, and milk in predefined quantities.
- *Storage Containers:* Holds the tea ingredients (milk, tea leaves, sugar, water, etc.).
- *Pipes and Dispensing Nozzles:* Channels the heated water and mixed ingredients into the cup.

Android-Based User Interface

- A mobile application is developed to allow users to select their preferred tea options.
- The app features a various input selection system.
- The selected options are sent to the Arduino Uno via Bluetooth or Wi-Fi connectivity.

Processing and Control Mechanism

- The Arduino Uno receives input data from the Android app and determines the ingredient proportions.
- The kettle heats the water to the required temperature based on the selected tea type.
- The Arduino triggers the SG 90 servo motors to dispense the correct quantities of tea, milk, and sugar.
- The mixture is stirred and dispensed through a nozzle into the user's cup.

Execution and Workflow

1. The user opens the Android app and selects tea preferences.
2. The app sends the selection parameters to the Arduino Uno.
3. The Arduino processes the request and activates the dispensing components accordingly.
4. The kettle heats water to the appropriate temperature.
5. The servo motors release the tea ingredients based on the user's selection.
6. The tea is automatically mixed and dispensed into a cup.
7. The system resets and prepares for the next order.

Safety and Efficiency Considerations

- *Temperature control sensors* ensure water is heated precisely to avoid overheating.
- *Quantity calibration* ensures accurate dispensing of ingredients to maintain quality and consistency.
- *Minimal waste strategy* is employed to optimize ingredient use.
- *User authentication* via the mobile app prevents unauthorized access.

Testing and Validation

- The system is tested for accuracy of dispensing, temperature control, and Android-Arduino communication.
- User trials are conducted to evaluate the ease of use and customization efficiency.
- Performance is analyzed based on speed, precision, and consistency of tea preparation.

EXPERIMENTAL RESULT

The Automatic Tea Vending Machine is an Arduino Uno-based system that allows users to customize their tea preferences using an android application [12]. The experimental research focuses on evaluating the efficiency, accuracy, and reliability of the system through systematic testing. The research investigates various parameters such as ingredient dispensing accuracy, temperature regulation, response time, and user satisfaction to determine the system's effectiveness.

Hardware Components Used

- *Arduino Uno:* Acts as the central processing unit.
- *Kettle:* Heats water to the required temperature.
- *SG 60 Servo Motors:* Controls ingredient dispensing (milk, sugar, tea leaves, water).
- *Ingredient Containers:* Store and release tea ingredients.
- *Android Device:* Runs the app for user input.
- *Bluetooth/Wi-Fi Module:* Connects the mobile app to the Arduino.

Software Components

- *Arduino IDE:* Programming and testing of microcontroller functions.
- *Android Application:* Provides the 5-input selection interface for users.
- *Embedded C/C++ Programming:* Used for writing control logic in Arduino.

Accuracy of Ingredient Dispensing

- The system is tested by selecting different ingredient quantities.
- The actual dispensed amount is measured and compared to the expected values.
- Multiple trials (N=30) are conducted for each selection to analyze consistency (Table 1).

Water Heating Efficiency

- The kettle heats water based on the selected tea type (black tea, green tea, masala tea, etc.).
- The target temperature (°C) is compared with the actual achieved temperature using a thermometer.
- The time taken (seconds) to reach the required temperature is recorded (Table 2).

Response Time and User Interaction

- The time taken (ms) from user input (via the Android app) to the Arduino response is measured.
- The overall tea preparation time (s) is tested under different conditions.

User Experience and Satisfaction

- A group of 20 participants tested the machine and rated the system on accuracy, taste, and ease of use on a scale of 1 to 5.

Table 1. Accuracy of ingredient dispensing.

Ingredient	Expected Quantity (ml/g)	Measured Quantity (ml/g)	Accuracy (%)
Sugar (1 tsp)	5 g	4.8 g	96%
Milk (50 ml)	50 ml	49.5 ml	99%
Water (150 ml)	150 ml	149.2 ml	99.5%
Tea Leaves (2 g)	2 g	1.95 g	97.5%

Mean accuracy =98.2%, showing precise ingredient dispensing.

Table 2. Water Heating Efficiency.

Tea Type	Target Temp (°C)	Achieved Temp (°C)	Heating Time (s)
Black Tea	90°C	89.5°C	40 s
Green Tea	80°C	79.8°C	35 s
Masala Tea	95°C	94.7°C	45 s

Mean heating efficiency =99.3%, indicating consistent temperature regulation.

CONCLUSION

The Android app-based Automatic Tea Vending Machine presents a significant advancement in beverage automation, offering both efficiency and customization. By utilizing an Arduino Uno microcontroller, the system successfully automates the tea preparation process, providing users with the ability to personalize tea based on factors such as strength, sugar level, milk content, and tea type. The system ensures consistent and high-quality tea by accurately controlling water temperature and ingredient dispensing. This innovation not only improves convenience and hygiene but also enhances user experience, making it ideal for workplaces, cafés, and public spaces where quick, personalized service is essential. Moreover, the future of the Automatic Tea Vending Machine lies in further integration with IoT technologies, enabling remote monitoring and additional smart features. Incorporating machine learning algorithms could allow the system to adapt to user preferences over time, offering even more refined customization. Additionally, expanding the ingredient options, such

as offering herbal teas or various milk alternatives, could broaden the system's appeal. The integration of cloud-based systems for data analysis and inventory management would also improve operational efficiency. Ultimately, these advancements could lead to more intelligent and autonomous beverage-making solutions, revolutionizing how tea and other beverages are prepared and served in commercial and public environments.

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