Automatic Tea Brewing Thermos

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1 Introduction

1.1 Objective

Tea is one of the oldest beverages in the world and has made it into almost all modern societies. However, there has been a severe lack of education in the proper methodology used to brew a proper cup of tea. Tea is not a simple combination of leaves and hot water but a delicate harmony of the two. Tea is best brewed at specific temperatures that are matched to the type of leaf being used. Additionally, the tea leaf should only be steeped for a certain amount of time that ranges from 3-5 min [1]. Unfortunately, most people are either unaware of these facts or don't have enough time to follow the proper brewing procedure. This is a sad tale as tea has been linked to many health benefits and if more people were to drink tea it could lead to a healthier society.

Our goal with this project is to develop an easy to use and mobile automated tea brewing thermos. In the effort of not having to wait for a counter-top machine to boil, brew, and dispense the perfect cup of tea. We plan on designing a thermos that you can put boiling water into and have it do the rest. With the bonus feature of keeping the tea at a comfortable drinking temperature for a short period of time.

1.2 Background

There has been progress in the automated tea industry, however the options tend to limit the mobility. One of the leading options being much like a coffee maker that will brew tea for you on a timer. [2] However this is a limited technology as there is a lack of mobility and has a high cost at roughly $250.

Our thermos must match the autonomous brewing capabilities of its counterpart but have reasonable mobility in addition to a lower cost. Making it much more readily available to the average consumer who is interested in a new tea drinking hobby.

1.3 High Leve Requirements

- Thermos must be able to automatically brew tea with little user input.
- Thermos must keep water at desired comfort level for up to 20 min ideally.
- Thermos must be able to operate when mobile.

2 Design

The thermos requires five sections for successful operation: user interface, control system, core features, sensors, and power. The user interface houses all the mechanical and phone app interactions with the device. The control system contains a micro-controller that will handle all the data form the thermos. The core features house the automation parts of the project with a DC motor, and nichrome heating element. The sensor is the IR temperature sensor that we will be integrating into the micro controller. Lastly the power supply will be a 3.6v lithium ion battery that will supply the system with power to operate.

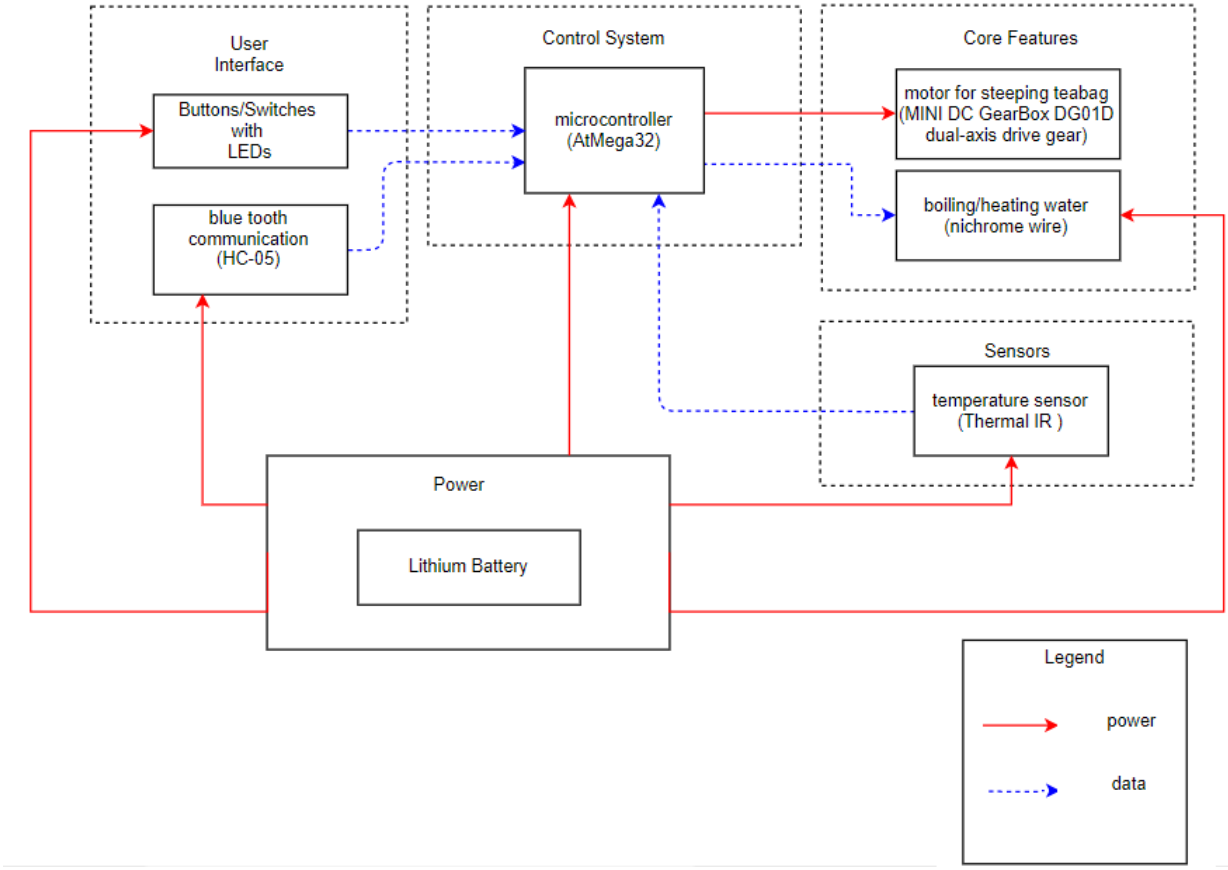

Figure 1 Block Diagram

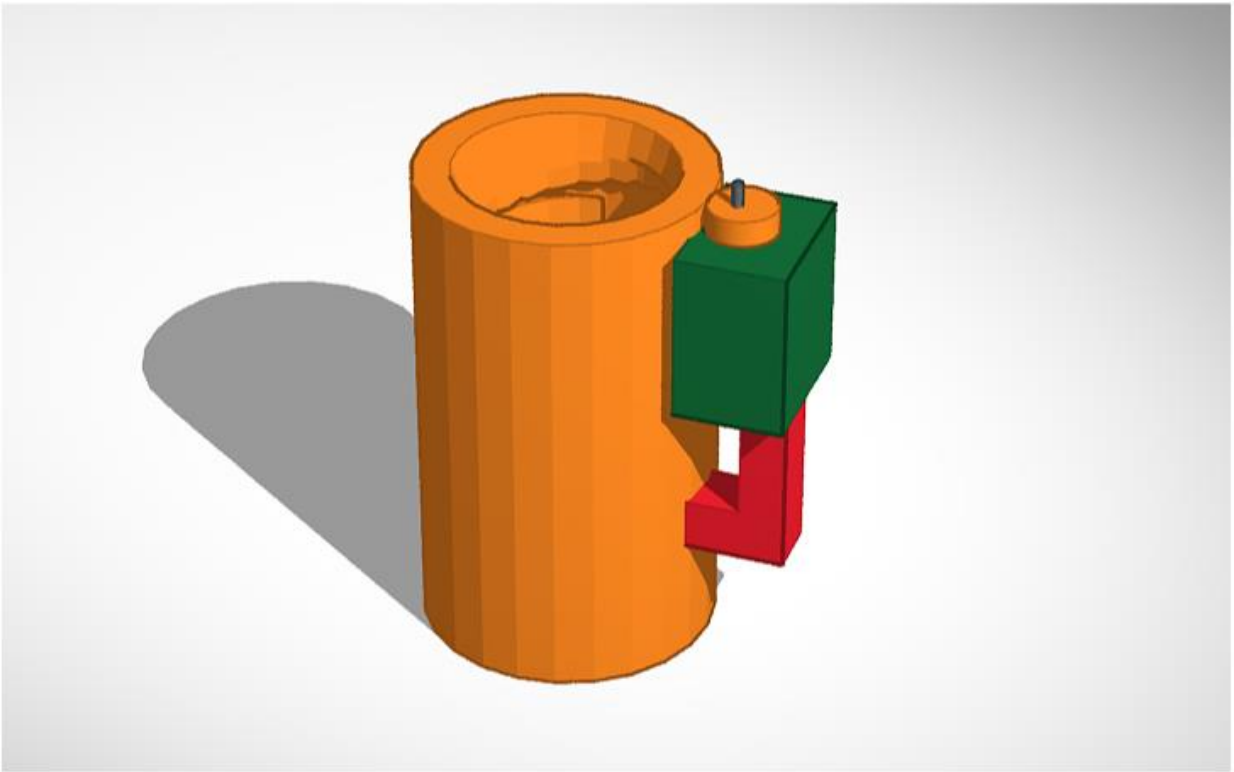

Figure 2 Mock-Up Physical Design.

2.1 User interface unit

The User interface will allow the user to manually set the drinking temperature and steeping temperature onto the buttons/switches of the thermos itself or through a phone app connected to the thermos via blue tooth. This data will be fed into the microcontroller to decide which core function to initiate.

- 2.1.1 Buttons/switches with LEDs
  There will be a switch that allows the user to choose between a comfort drinking temperature, brewing temperature, and steeping time. In addition, there will be two buttons to increase or decrease these values. It will be defaulted to the suggested temperature of 90 degrees F for drinking, and 185 degrees F for brewing, and 4 min for steeping. We need another button to verify. There will be LED (Red Yellow and Green) that will notify the progress in when it is ready to drink.
  Requirement: Switches and buttons must be easy to press and have clear functionality for the user.

- 2.1.2 Blue tooth communication
  A phone app will be created that will communicate with the Bluetooth module that will consist of an HC-05 and the microcontroller ATmega32. The HC-05 will transfer data between the phone and the microcontroller through UART (Universal Asynchronous Receiver/Transmitter).

Requirement1: Control and change values with connected app on phone
Requirement2: Maintain thermal stability below 125 ˚C

2.2 Control Unit

The Control Unit will receive the temperature of the water through the temperature sensor and will compare it to the user's desired value. It will obtain this information through the user interface module. If the temperature falls below, it will send a signal to the heating unit to heat up the water back within range of the user's desired value.

- 2.2.1 Microcontroller
  The ATmega32 is in mind as it has an UART digital communication capabilities, as well as flash memory with read-and-write capabilities.
  Requirement: The microcontroller must be able to take in sensor data and run autonomously.

2.3 Core functions unit

This unit houses the core features for the automation in the tea brewing process. It contains the motor that lowers the tea bag into the water and the heating unit.

- 2.3.1 Motor
  The motor will be controlled by the micro controller. This will physically lower and raise the tea bag in and out of the water when the conditions have been met. It will lower when brewing temperature has been achieved and raise when the seeping time has ended.
  Requirement1: Have bi-directionality that can be controller via micro controller
  Requirement2: Maintain sufficient and constant speed ranging from 1 to 3 inch/s for the motor to have constant tension in the wire.
  Requirement3: Maintain thermal stability below 100˚C

- 2.3.2 Heating unit
  The heating unit is comprised of a nichrome wire. This unit operates by sending current through the wire, which results in an excess of heat generation.
  Requirement1: Maintain custom drinking temperature for 10min ranging from 80-100˚F ±2˚F

2.4 Sensor

This unit houses our sensing capabilities. For this project a temperature sensor was all that was deemed necessary.

- 2.4.1 IR temperature sensor
  This sensor is a non-contact temperature sensor. It will be used to measure the water temperature in the inner most cylinder of our design. The data it collects will be sent to our micro-controller.

Requirement: The sensor must be accurate to within 2˚F.

2.5 Power

A power supply will be required to keep the thermos mobile. This will be comprised of a 3.7v battery.

- 2.5.1 Lithium Ion battery
  The battery must be able to keep the circuit powered long enough for a user to enjoy a thermos full of tea.
  Requirement1: Maintain output voltage of 3.8V to 3.4V
  Requirement2: Maintain thermal stability below 40 ˚C.

2.5 Risk Analysis

With the nature of our project we will inherently have several risks which pose rather large obstacles in the completion of our design. These primary risks include the size and weight of the design. Mobility is key in this project and will strain the safe implementation of our heating elements and battery. We will need to insulate the battery, microcontroller, Bluetooth communication system, and DC motor in manner which is both ergonomic and safe. Our heating element if not regulated properly, can reach temperatures upwards of 300-400 F. In order to counteract this we will have a voltage regulator that once a certain voltage is passed, both ends of the nickel chromium wire will be set to ground. As for the size of the design, we will building the majority elements into the handle area of the mug. This allows us to build off the side of the mug and allows us a bit more space to help keep the electronics isolated from the liquid and heating elements.

3 Safety & Ethics

As for the safety of our design we will be greatly concerned with our Li-Ion battery. We will have to make sure to keep it within the correct operating temperatures, 0 ~ 45℃ for charging and -20 ~ 60℃ for discharging. We will attempt to avoid these risks by mounting the battery in the handle the area furthest from the bottom where the heating elements are mounted in order to give us a lot of separation in case of any failure in the insulation around the heating elements.

Along with this we know as state in the article “Safety of Lithium-ion batteries” [5] that as well as operating temperature, we must also ensure we regulate the current flow to and from the battery. The specific values are 6A maximum continuous discharge/charge. We are going to ensure that these values are not reached in our circuit by testing the circuit rigorously.

Some important ethical issues intertwined with safety also are included. We have to make sure our heating element is properly insulated. We want to ensure that is does not cause any harm to others as state in the ACM Code of Ethics “loss of property, property damage, or unwanted environmental impacts.” [4] In our case if we do not properly make the heating element safe for the user to not burn or start a fire. We can do this by properly regulating the voltage across our heating element. We will

include a safety that will shut off power to the heating element if a certain voltage is reached. This will ensure the heating element, regardless of sensor failure, will not reach certain temperatures.

We will also to make sure our hot tea is safely insulated and safe to drink. Mention in the IEEE code of conduct it is stated we are "to hold paramount the safety, health, and welfare of the public" [3] . We must do this by ensuring that our temperature sensors are functioning at all times to alert the user if the drink is too hot to drink. If our microcontroller receives data from our sensors which is not within its set range the user will be notified, also the sensor we are using sends a fault signal and this will also notify the user notified in this case that the sensor isn't working and all heating elements will be shut off.

[1] Art of Tea, 'Recommended Steep times', 2017 [Online]. Available: http://www.artoftea.com/what-is-tea/recommended-steep-times [Accessed: 30/1/2018]

[2] Maloney, Lisa, 'Best Automatic Tea Makers', December 04, 2017. [Online] Available: https://www.consumersearch.com/tea-kettles/best-automatic-tea-makers [Accessed: 2/5/2018]

[3]'IEEE Code of Ethics' [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html [Accessed: 2/5/2018]

[4]'ACM Code of Ethics and Professional Conduct' 10/16/92. [Online]. Available:

https://www.acm.org/about-acm/acm-code-of-ethics-and-professional-conduct [Accessed: 2/2/2018]

[5] 'Safety of lithium-ion batteries' June 2013 [Online]. Available: http://www.rechargebatteries.org/wp-content/uploads/2013/07/Li-ion-safety-July-9-2013-Recharge-.pdf [Accessed: 2/4/2018]