Bubble Tea Machine

ECE 445 Project Proposal

Team 30: Emily Hall, Saisita Maddirala, Tracy Tang

Professor: Pengfei Song

TA: Hojoon Ryu

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1. Introduction

1.1 Problem

Bubble tea shops are immensely popular on the UIUC campus. While incredibly tasty to drink, they are not cheap. As the bubble tea fad grows, so does the price of a well-made drink. A person can expect to spend about $6 for their drink. If bought as an infrequent luxury, this price is reasonable. However, many UIUC students purchase bubble tea often. If cheaper high quality bubble tea could be sold, most UIUC students would eagerly buy it all the time.

In order to lower the price, without impacting the drink's quality, we would like to automate bubble tea preparation. The quality of the ingredients could remain the same.

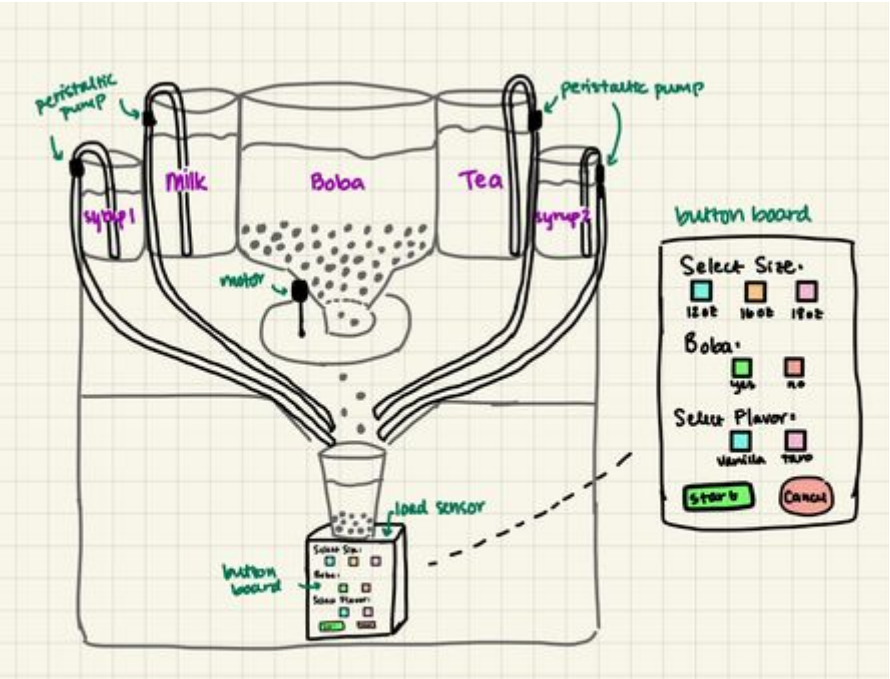
1.2 Solution

Our team proposes a Bubble Tea Vending Machine. To use this machine, a person will place a cup under the drink dispenser. The vending machine will have straws, lids, and cups sitting next to it. The user will interface with the machine via a button board that will be on the outside of the machine. The board will have buttons for selecting the size and flavor of the drink. After making all their selections, the user will press start.

The machine will have large reservoirs for milk, tea, syrup and boba. The boba will be stored in a simple syrup in order to preserve the texture. The machine will only make a drink if there is a cup present. The presence of the cup will be recognized with a load sensor. To dispense the liquids, it will use peristaltic pumps. Based on the size selection, it will dispense differing amounts of tea, milk, and boba. The boba will be dispensed first to prevent splashing then, the liquids will be dispensed. The boba will be controlled by a moving plate. The base of the boba reservoir will have a large opening that is closed by a flat circular plate. The plate will have a hole in it. We will use a motor to spin the plate. When the boba needs to be dispensed the plate will spill so that the hole is aligned with the

bottom of the reservoir. Once the appropriate amount of boba is in the cup, the plate will spin again so that the reservoir is closed.

1.3 Visual Aid

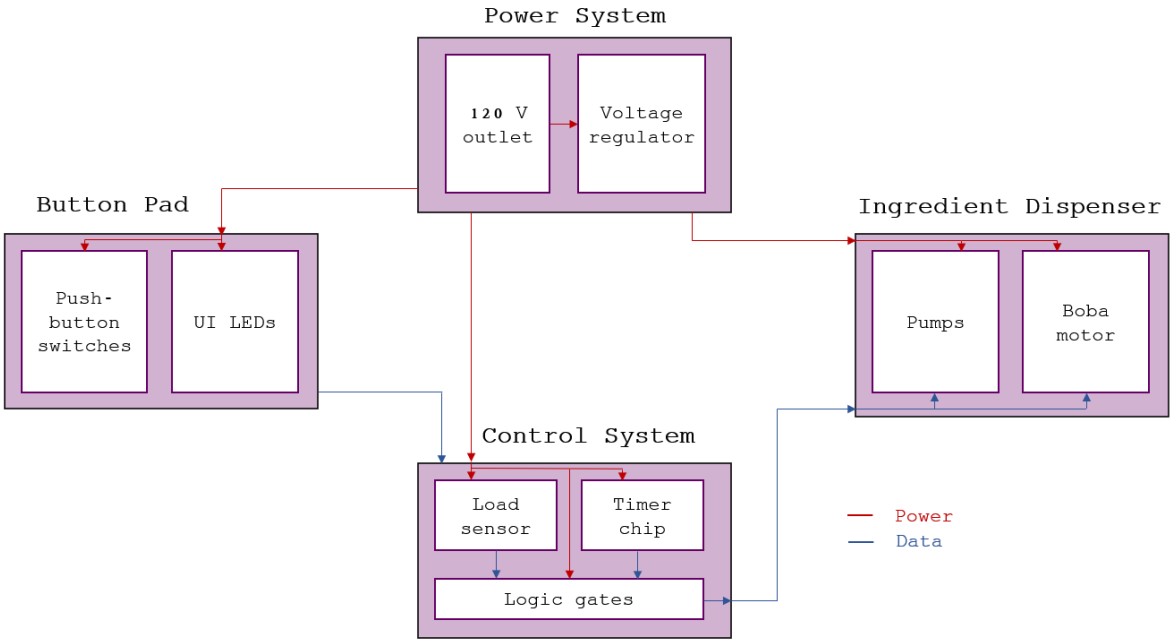


1.4 High-Level Requirements List

- The device must provide the user with many combinations of size and ingredients. We will have two flavor options, three size options (12 oz, 16 oz, and 18 oz), and an option for no boba. Each combination will be allowed, giving the user 16 possible drink options.
- The device must be able to dispense pre-calculated amounts of liquid and boba into the cup. Each size will consist of 15% boba, 40% milk, 40% tea, and 5% syrup.
- The device must start/cancel under the appropriate conditions. It should start only when a cup is present and if the “start” button is pressed. The machine should stop the order if the “cancel” button is pressed.

2. Design

2.1 Block Diagram



2.2 Subsystem Overview

2.2.1 Power System

The power supply will provide power to the whole system. This includes the PCB, the pumps/valves, and the load sensor for the cup. The voltage will need to be initially stepped down from 120 V to a more manageable voltage of 12 V. We know that the motor, the most powerful component, will need 12 V to function with reliable strength. We will then step this down for the other components.

2.2.2 Button Pad

The button pad will serve as the user interface for our device. The user will make their selections and these will be communicated to the PCB.

2.2.3 Control System

The PCB control system will receive input from the button pad about drink selections. It contains the control logic to decide the appropriate pumps to pump or valve to open (logic gate) and when to stop/close them (timer chip).

The PCB will also receive input from the load sensor that will indicate whether or not a cup is present along with its weight. If the user presses start without a cup placed, the drink request will be rejected, and the PCB will communicate with the button board to display an error code (a red LED) indicating that the cup is missing. If the PCB receives input that validates the presence of a cup, it will proceed to make the drink.

2.2.4 Boba/Liquid Dispenser

There are four liquids (milk, tea, and two syrups) that will each need a pump, which makes a total of four pumps. We have one boba reservoir, which will utilize a valve for release. Each valve will receive input from the PCB to decide when they should open and close.

2.3 Subsystem Requirements:

2.3.1 Power Supply:

The power supply provides power to each of the subsystems. It will be plugged into the wall outlet and will convert voltage to the required amount for each subsystem. The power supply should be able to safely provide upto 12V and upto 500 mA to the entire system. A voltage regulator will provide the 5 volts that is required for most chips.

Requirement: Must be able to supply upto 12 V and 500 mA to the machine.

2.3.2 Button Pad:

The button pad will be made up of 9 push-button switches for the 9 drink options (3 size options, 2 syrup options, Y/N option for Boba, Start, Cancel) available to the user. The data from these buttons will be sent to the control system (PCB) so that the appropriate drink choices can be carried out. Each button requires 12 VDC and up to 50 mA.

2.3.3 Control System:

The PCB will contain all of the control logic for the bubble tea machine. Data from the button pad is received and the appropriate control signals to the motor/pumps are computed via CMOS logic gates. These logic gates require 5V and 16 mA. The control system will also contain a CMOS 555 timer chip that controls the amount of time each pump/motor runs. The amount of time will be preset (with more logic gates) for each size option for the drink. The larger the drink, the longer the pumps/motor are run, resulting in the correct amount of ingredients. The timer chip requires 5V and 10 mA. Additionally, the control logic cannot be carried out until the “start” button is pressed by the user. There is a “cancel” button which the user can press if they want to cancel their order before they press start. This will allow for users to begin again if they make an undesired selection. Once the start button is pressed the cancel button will not impact the production of the current drink. In order for the bubble tea machine to begin making the drink, the cup must be present and the “start” button must be pressed. We will also use a load sensor underneath the cup to detect the amount of boba that falls into the it.

Requirement: Logic gates must start the motor to dispense the boba, wait, and then start the pumps.
Requirement: Logic gates must keep the pumps on for different lengths of time depending on the size of the drink, using the timer chip.

Requirement: Bubble tea machine should only start making the drink when a cup is detected and “start” is pressed.
Requirement: Bubble Tea Machine should ignore the “cancel” button once “start” has been pressed.

2.3.4 Boba/Liquid Dispenser:

Each reservoir of ingredients (boba, milk, tea, syrup1, syrup2) will be a plastic container. The liquid ingredients require Peristaltic pumps with silicon tubing. A peristaltic pump has 2 tubes, one placed in the reservoir and one placed in the cup. Each pump requires 5V and 500 mA. The boba dispenser will have a funnel like device at the opening. This funnel will be connected to a plate that has a hole cut into it, allowing the boba to escape into the cup. The plate will be attached to a motor that rotates it so that the opening of the plate will be aligned with the funnel area at the appropriate time that the boba must be dispensed into the cup. The motor requires 3V and 160mA. We will also need an extra motor inside the boba container that will aid the boba in falling out and making sure they do not get clogged. This motor will be connected to a flat, butter knife-like device that spins whenever the plate is set to open.

Requirement: Motor for the boba must spin fast enough (precise enough) so that the boba can escape easily without any blockage.
Requirement: Motor must stop at the appropriate time so that the opening in the plate and the funnel opening perfectly align.
Requirement: Ingredients from the liquid dispenser must be pumped into the cup.

2.4 Tolerance Analysis

One potential problem we will run into is keeping the texture of the boba consistent (covered with enough syrup) while making sure no excess syrup falls into the cup along with the boba. Our current solution is to have a motor that allows the attached plate to start

and stop fast enough so that excess syrup does not fall out. We ran a manual simulation with a plastic bottle container for the boba dispenser and some cardboard that models the plate with an opening. In this simulation, we tested whether opening and closing the plate against the boba bottle will help the boba fall out and keep the syrup in. This solution works well, however, we found that the plate must be more rigid and pressed tightly against the boba dispenser so that the syrup does not fall out.

3. Ethics and Safety

3.1 Food safety

We recognize that any product that touches food will have some safety concerns. IEEE Code of Ethics agrees to "uphold the highest standards of integrity, responsible behavior, and ethical conduct in professional activities." Further, "to hold paramount the safety, health, and welfare of the public". We have taken into consideration the necessity to inform the user of both proper cleaning practices and to ensure that we use food safe components in our design.

3.1.1 Cleaning

This device needs to be properly cleaned between uses. Hot water and soap are effective to clean out all the reservoirs. There will be a “cleaning” mode for the device that will run all pumps to be cleared of any residue. For this to work, reservoirs should be filled slightly with hot water and a large cup placed in the cup holder.

3.1.2 Food safe components

All components and reservoirs will be entirely food safe. The main concern is the tubing, so we will avoid PVC tubing. There are many alternatives, including silicon tubing.

References

[1] “IEEE code of ethics,” IEEE, Jun-2020. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 02-Feb-2022].