Liquid Detection Cup

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1. INTRODUCTION

1.1 Objective

Nearly every restaurant has cups for the customers to drink from. When the restaurant customers drink from them, there are often two ways to refill them: self-service at some restauraunt's beverage device and waiting for a waiter to refill the water for them; the latter choice is often a hallmark of a higher class restaurant. But the problem is that many times, the waiter is kept busy with multiple different tasks: taking orders, seating customers, communicating to the kitchen staff, etc., and may be too busy to look at every cup that he is serving, forcing the customers to flag him down for a glass of water. As such, our solution is to create a cup that will automatically notify the waiter if a drink is running low with an update directly to a computer screen that notifies the waiter and keeps track of the information, as well as LEDs to pinpoint the precise location of the cup that needs refilling.

1.2 Background

Places such as Red Robin offer free refills on their bottomless items [3], but very often there it is difficult to find which cup needs refills. Very often the customer flags down the waiter to tell them to refill the cup with their specific drink. This cup allows us to track which drinks are most popular by keeping track of the drink statistics, as well as let the waiter know when they need to go refill some cups, and with what drink. When the glass reaches a level that needs to be refilled, an LED lights up to indicate to the waiter of the problem. Because this is automatic, the waiter will be notified that a drink is running low without more burden on his part and the customers will get notified that the waiter will be on his way shortly in a fun visual effect.

The reason why this is unique from the previous project was created because we chose to target a different audience. We decided to target someone with multiple, varying, drinks that might have certain characteristics that change the weight: a lemon on the side of the cup, or a large amount of ice, for example. Because of this, we transferred the sensor directly to the cup, as it would be much easier to track a unique liquid to a cup than a coaster, and by putting a sensor that directly tracks water level instead of weight, we also do not need to worry about any issues weight would provide.

1.3 Physical Design

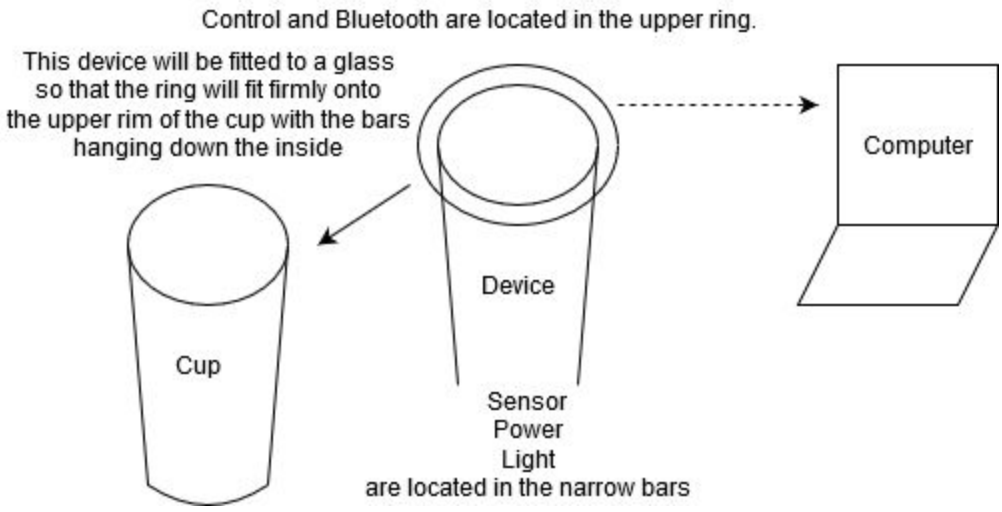

Fig.1 Physical Diagram of Device

1.4 High Level Requirements

1.4.1. Check how empty the glass is.

The sensor needs to detect when the drink has been consumed down to the last 25%, as this should provide ample time for the waiter to finish whatever he is doing before refilling the drink. This needs to also mitigate the number of false positives to below 4%, where a customer might simply be taking a sip from the water, etc.

1.4.2. Communicate with the computer

The device would need to be able to communicate to a computer within 10 meters of the device to create an alert of the drink's situation, as well as update the microcontroller with the type of drink.

1.4.3. LEDs light up

The LEDs need to light up so that the waiter can directly determine which cup is running low with a cursory glance when they are within 5 meters of the cup. These LEDs will light up when the water level falls below 25% and turn off when the water goes above this threshold.

2. DESIGN

2.1 Block Diagram and Module Explanation

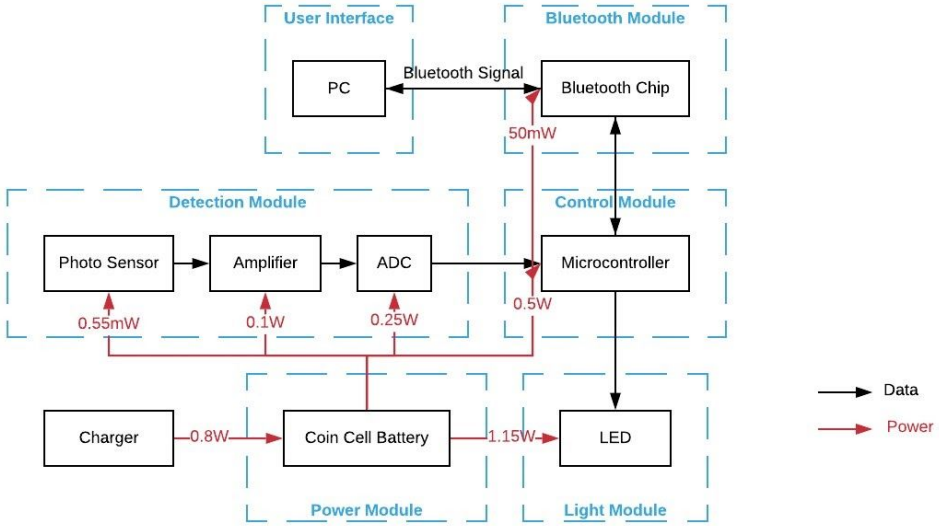

Fig.2 Block Diagram

The detection module contains a photo sensor that detects the surface height of the drink in a cup. After transmitting this data to the control module, the microcontroller performs a simple calculation based on the distance detected to determine the amount of drink left. When a sudden change of surface level is detected, the controller recognizes it as a false positive and mitigates the effect in the calculation. The system communicates with the user interface laptop, through bluetooth protocol, to update the data and send the corresponding control signals to the lights. The LED lights will then turn on to the specified color when the cup is nearly emptied. Since the serving and retrieval of a cup is expected to be completed within a relatively short time period, a rechargeable coin cell battery is sufficient for powering the system when in use. As a conclusion, this design meets all the high level requirements.

2.2 Functional Overview and Interface

The general purpose of this system is to detect the surface level of drink in a specific cup, send the data to the computer to calculate the associated percentage, and to send out an LED alarm to notify the user when it needs to be refilled.

2.2.1 Detection Module

This module is in charge of detecting the surface level of the liquid in the cup using a photo sensor, amplifying it for processing, and sending the digitized data to the control module.

2.2.2 Control Module

This module takes in the data from the detection module, performs a simple calculation based on the height of the liquid surface (adjusting for potential false positives) to determine the amount of liquid left. It also receives user commands from the user interface to determine which color is associated with the cup. When the alarm threshold is reached, the command to turn on the specific color is sent to the light module.

2.2.3 Bluetooth Module

Short-distance wireless signal transmission and reception module embedded within the control module, for communication between the user interface and the control module.

2.2.4 Light Module

Multicolor LED light, activated when the control module sends a signal indicating the drink in the cup has reached the low level. Performs based on both the activation and color signals.

2.2.5 User Interface

Laptop app that provides the user with the ability to specify the color associated with each cup before serving. Communicates with the control module using the bluetooth signal protocol.

2.2.6 Power Module

Coin cell battery embedded with each cup to power the system during the required, relatively short usage time. When the cup is not in use, the battery is recharged through a USB charger.

2.2.7 Interface

The user interface needed for this system is the computer app through which the user can customize the colors associated with the drinks. For example, cup one is filled with pepsi coke. Before serving, the user can customize that this drink’s color is red, and associate this cup’s LED to red. Then when the drink needs to be refilled, the user sees this color and knows pepsi cola is needed. Then, if cup two is filled with another drink and thus another color is needed, the color is set before serving. If a cup is used to hold a different drink, the color needs to be updated manually.

2.3 Block Requirements

2.3.1 Detection Module

The detection module is required to accurately detect the distance between the surface level of the drink and the sensor with a tolerance of +/- 4%, amplify the signal to a 2.0 V level, and convert it to a 5-bit digital signal.

2.3.2 Control Module

The control module is required to perform the necessary calculations, and send out turn-off and color commands to the light module with a latency of less than 100ms; it also needs to communicate with the user interface with a latency of less than 700ms.

2.3.3 Bluetooth Module

The bluetooth chip is required to send and receive the wireless signals from the control and user interface modules.

2.3.4 Light Module

The LED is required to be able to display at least 4 distinct colors, and have a noticeable brightness level of 100 lumens +/- 5%.

2.3.5 User Interface

The laptop app is required to provide the user with the ability to modify the color associated with each cup, and wirelessly communicate with the control module.

2.3.6 Power Module

The coin cell battery is required to provide a 3V, 340mA output for at least 45 minutes (assuming a long time for the drink to be emptied).

2.4 Risk Analysis

The detection module and the control module are key components of this project. The functionality of the system largely depends on it. Without a good detection module, no matter how good are the rest of the modules, it will be useless. Also, the control module needs to be accurate and precise, because if we are using a good detection module, it will be for nothing if the control module is not as good as the detection one.

It will be fundamental to make the detection module work within the parameters we have stated in the high level requirements, as we need the system to detect the amount of water the cup

has on it, as we are using a sensor, we need the sensor to be quite accurate, we will need to test it before using it.

The control module calculation must also be precise, because we will not want to lose the precision we gain with the detection module, by having a bad control module. After testing the sensor of the detection module, we will need to introduce the error allowed into the control module, so we can take it also into account. We will need to take into account that the device is User-friendly, so it will be easily used by waiters and so that it can manage as many glasses as possible without generating errors or reducing the utilities .

In addition, the Bluetooth receiver and the Bluetooth sender are also crucial for the project performance. Remote control is one of the essential functions of the empty-cup detector. We need bluetooth to be fast, stable and safe. The noise around the receiver and the sender, will need to be taken into account and tried to be mitigated. Bluetooth communication is known to be stable once the devices have established the connection, the connection must be stable also for 10 metres.

Another problem that we need to face is dealing with liquids, so the device must be water resistant, because as being close to water or any kind of drink, it has a lot of risk of getting wet.

Lastly, for the power module, the only potential risk could be battery size. The battery, as we are dealing with “small” and “manageable” objects (glasses) must be also small and a battery-size that can fit with a glass and does not make the person that will drink uncomfortable.

3. ETHICS AND SAFETY

The general goal of both the IEEE Code of Ethics [1] and the ACM Code of Ethics [2] is to ensure quality without either intentionally or unintentionally causing harm. Our design does not appear to break any laws; the device’s only detection module is a capacitive sensor, which will not invade anyone’s privacy since it is only detecting capacitance to determine the water level. Furthermore, the sensor requires very little power and would not be harmful to a person. The only wireless connections are made via bluetooth, so there is little to no possibility of invading personal privacy or interfering with other signals.

Every subsystem aside is contained within one compartment, which only comes in contact with the cup, a human intending to drink with it, and a liquid. We will take our due diligence to ensure that the device will be able to withstand hot conditions such as hot coffee. We also need to ensure that every module that requires power is encased in plastic to ensure that it will not harm any human contacting it. This will double as protection from water during either a wash or usage. Overall, the power required of the system is minimal, so risk is also at a minimum, and coin cell batteries are generally safe to use aside from swallowing concerns.

Final safety concerns occur in the creation of our device in the Senior Design Lab. We have already performed standard safety training, and understand how to use the equipment while

avoiding electrical shorts, shocks, and burns. The most dangerous would probably be soldering, as forgetting something as simple as forgetting to turn it off will create safety hazards to us and everyone in the lab. As such, safety is our priority when it comes to physical work in the design lab and we will work with at least one other person in case either find the situation dangerous, in order to adhere to rule 9 of the IEEE code of ethics [1].

Overall, we believe that we are following both Codes of Ethics [1], as we are not breaching any regulations or standards. We will keep careful note to prevent our primary controller from overheating, but otherwise no safety concerns or breaches of privacy arise.

REFERENCES

[1] "IEEE Code of Ethics," *IEEE*, Jun-2019. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 2-April-2020].

[2] "Code of Ethics," *Code of Ethics*, 22-Jun-2018. [Online]. Available: https://www.acm.org/code-of-ethics. [Accessed: 2-April-2020]

[3] "Bottomless," *Red Robin*, 2020. [Online]. Available: https://www.redrobin.com/pages/everyday-value/bottomless/. [Accessed: 3-April-2020].