CUED - Engineering Tripos Part IIB 2021-2022 **Module Coursework**

Module	4B25	Title of report	4B25 CW5: Smart Mug
Date submitted:	27/01/2022	Assessment for this module is ☑ 100% / ☐ 25% coursework of which this assignment forms 35 %	

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Feedback to the student ☐ **See also comments in the text**		Very good	**Good**	Needs improvmt
CONTENT	**Completeness, quantity of content:** Has the report covered all aspects of the lab? Has the analysis been carried out thoroughly?			
	Correctness, quality of content Is the data correct? Is the analysis of the data correct? Are the conclusions correct?			
	Depth of understanding, quality of discussion Does the report show a good technical understanding? Have all the relevant conclusions been drawn?			
	Comments:			
PRESENTATION	**Attention to detail, typesetting and typographical errors** Is the report free of typographical errors? Are the figures/tables/references presented professionally?			
	Comments:			

Indicative grades are not provided for the FINAL piece of coursework in a module

Assessment (circle one or two grades)		A*	A	B	C	D
Indicative grade guideline		>75%	65-75%	55-65%	40-55%	<40%
Penalty for lateness:		*20% of maximum achievable marks per week or part week that the work is late.*				

Marker: Date:

4B25 CW5: Smart Mug

Yuyi Zhang

1 Introduction

While leaving your coffee mug beside the laptop, the last thing you want to see will be the spilling mug ruining your work electronic device when accidentally tipped over by some innocent passer without noticing anything wrong. Using a water bottle will prevent spilling efficiently with a lid, but you might not want to have a lid when waiting for your boiling tea to cool down. A smart mug will warn you by flashing LED and buzzing when it is tilted.

Many people have the habit of drinking tea or coffee made from boiling water, but it is often difficult to estimate the temperature of the liquid and could sometime end up scalding themselves. Had that ever happened to you? If yes, then our smart mug with temperature detecting and showing on LED light and OLED screen is all you need. The mug is even able to help you cooling down the liquid to an ideal temperature you set.

Scientists suggest people to drink 3000 mL water daily to keep hydrated. However, without proper tracking of the water amount we have consumed daily, it is easy to over or under drink the suggested amount, which could potentially do harm to our health. With a water level sensor, the smart mug will be able to tell the amount of water you have consumed today, and how far away you are from the suggested water amount. Let it be your health coach in water drinking from today!

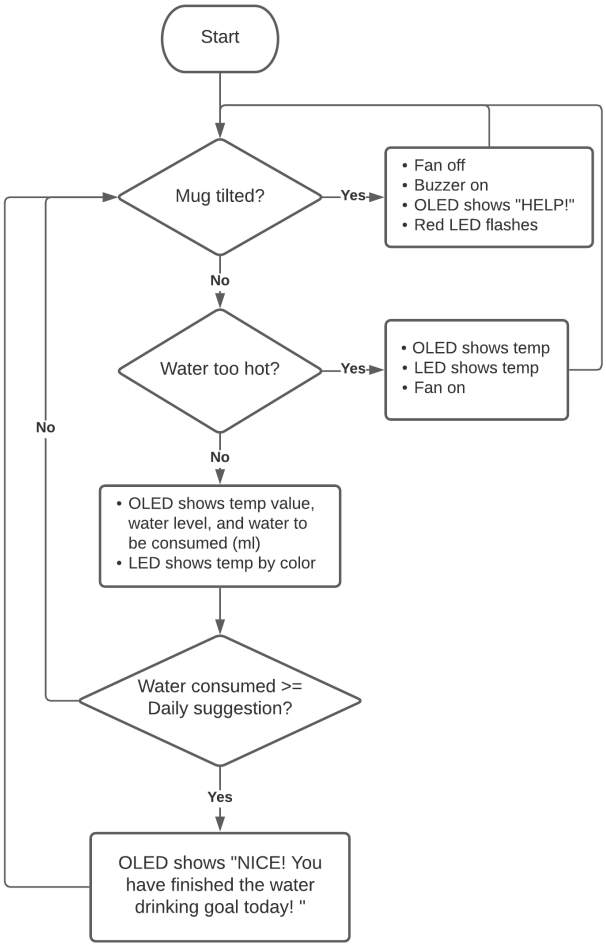

Figure 1: Flow chart of the smart mug system

2 System design

The tilting detection has the highest priority in the smart mug. When the mug is not placed vertically, the system will first turn the fan off, then turn on the buzzer, show "HEEEELP!" on OLED and flash red LED.

If the mug is not tilted, the mug will check the water temperature. If it is above the drinkable threshold, the mug will turn its fan on to cool the water down until the water temperature is below the threshold. The RGB LED changes its color gradually from blue to red as the water temperature increases from 0 to 100. While the LED light gives user an intuitive idea of the temperature, the exact temperature value is shown on the OLED screen.

By adding the value that the water level sensor reading has decreased, the mug calculates the amount of water you have consumed. A threshold is set to avoid the effect of fluctuating water surface. The OLED screen shows current water level and the remaining water amount needing to drink today. If the water consumed is less than the daily water suggestion 3000mL, the mug will show a reminder for you. Every mid-night, the mug will reset the water consumed amount to be 0mL for a new day.

3 System realisation

Board	ELEGCO UNO R3 Controller Board
Sensor	- Thermistor - WAVESHARE Liquid level sensor - Tilt ball switch - 3-6V DC motor and Fan blade
Signal	- Adafruit OLED SSD1331 - RGB LED - Active buzzer
Power	- 9V Battery - Adruino power supply module
Others	- L293D Motor driver - 4×220k resistors, 1×1k resistor - PN2222 NPN Transistor - Jumper wires

Table 1: Devices and sensors used in the smart mug

The smart mug system is built on ELEGCO UNO R3 Board using Arduino. The first part of circuit is directly powered by the UNO board and includes the OLED screen, water level sensor, RGB LED light, tilt ball switch and thermistor. The second part of circuit is powered by a 9V battery connected to the Adruino power supply module. It includes the DC motor, the fan blade and the buzzer. The board only send signal to the second part of circuit. The DC motor is controlled using a L239D motor driver and the active buzzer is controlled by a NPN transistor switch.

3.1 Wiring

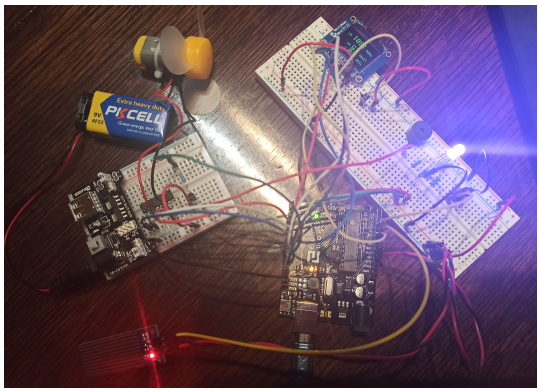

Figure 2: Wiring of the smart mug circuit.

3.2 The mug

The outer mug body is designed using Solidworks with a cable whole for board charging, a window for OLED screen and a handle to place the DC motor and the fan. It is 3D printed and assembled with the circuit.

Figure 3: Assembling the mug and OLED screen under normal and tilting conditions.

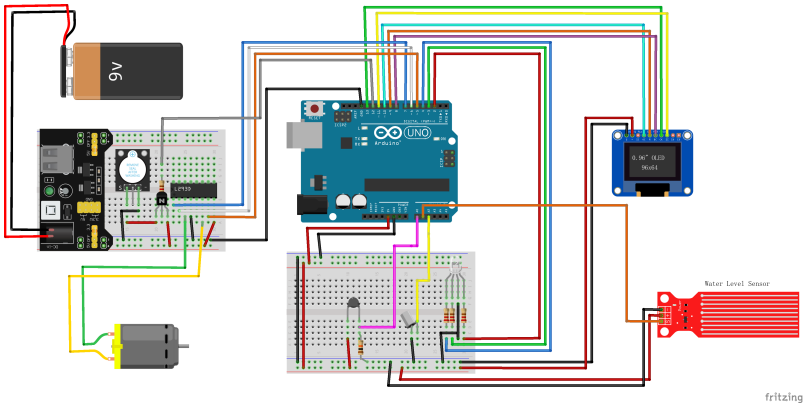

Figure 4: Circuit diagram of the smart mug circuit.

4 Future work

4.1 Water consumption monitoring

The readout becomes erroneous when the water level sensor is wet. In the future, we may be able to compute water volume using a submerged water pressure sensor. It is common for the water surface to vibrate when the cup is moved. The question of how to avoid water consumed measurement error from fluctuating water surface remains unsolved.

4.2 Circuit size and waterproof

The ELEGCO UNO R3 board and the half-sized breadboard are too big to fit inside a regular mug. To improve the system and fit it to a cylinder-shaped mug, we may utilise smaller boards like Arduino Nano and a flexible OLED screen. Using waterproof material to cover the circuit will assist to prevent the electrical components from short circuiting.

Acknowledgements

I want to thank Ben Petty, my housemate and friend, for kindly helping me with the mug's CAD modelling and 3D printing.