Design and Application of Automatic of an Coffee Maker with Coffee Ground and Water Dispenser using Arduino Uno R3

Renz Jericho A. Benitez
Electronics and Computer Engineering Department
De La Salle University
Manila, Philippines
renz_benitez@dlsu.edu.ph

Jason Aaron L. Chua
Electronics and Computer Engineering Department
De La Salle University
Manila, Philippines
jason_aaron_chua@dlsu.edu.ph

Dominic P. Yu
Electronics and Computer Engineering Department
De La Salle University
Manila, Philippines
dominic_yu@dlsu.edu.ph

Miro Manuel L. Hernandez
Electronics and Computer Engineering Department
De La Salle University
Manila, Philippines
miro_hernandez@dlsu.edu.ph

Abstract - Coffee is a widely consumed beverage all over the world. It is also known to have health benefits as long as it is consumed in moderation. However, due to their current conditions and the circumstances they are facing, many people with disabilities find it difficult to do everyday tasks, one of which may be making themselves a cup of coffee. The project addresses this issue by proposing an implementation of an automatic coffee maker using an Arduino Uno R3 microcontroller along with various devices such as a keypad, a load cell or weight sensor, an LCD, and different types of motors. In this manner, individuals will be able to choose the coffee-to-water ratio of their drink more consistently while simultaneously omitting the need to go through procedures that may be rigorous, especially for those with disabilities.

Index Terms - Arduino Uno R3, coffee, automatic coffee machine, coffee dispenser, weight sensor, LCD

I. Introduction

Coffee remains to be one of the most drank beverages in the world along with water and tea. By definition, coffee is a drink derived from the roasted and ground seeds of coffee plants. Coffee's stimulating effect is attributed to caffeine, an alkaloid found in the beans. Two main coffee plant species, Arabica and Robusta, dominate production. Arabica is favored for its milder and aromatic qualities, requiring higher elevations and specific climate conditions. Robusta is hardier, with higher caffeine content, making it common in commercial brands. Common coffee brewing methods include steeping, percolation, filtering, espresso machines, and French presses. Coffee consumption is linked to reduced risks of diseases like cardiovascular issues and type 2 diabetes. Excessive consumption can lead to sleep issues and anxiety. The relationship between coffee and cancer has evolved; recent studies have dispelled the idea of a direct link. The demand for coffee has prompted for a greater production of instant coffee, which is known for its convenience and long shelf life, though it is often considered inferior to freshly brewed coffee in regard to taste [1].

In 2022, people around the world will have consumed around 178 and a half million bags of coffee weighing around sixty kilograms each [2]. The Philippines is also ranked second in Asia in terms of coffee consumption. To provide more context, around 3.05 kilograms of coffee was consumed by each individual in the country in 2021 [3].

Around sixteen percent of the world's population has a disability that negatively affects their capacity to do tasks independently or work without needing much assistance from others [4]. The Philippines is home to about 1.44 million individuals with these ailments, some of which impair their movement or motor skills [5]. People with disabilities often have difficulties doing day-to-day activities, and this includes making themselves a cup of coffee.

This project aims to build an automated coffee-making system using Arduino UNO R3. The system will make use of a keypad so that the user may adjust the coffee-to-water ratio. Relays, PWM, and digital I/O are all to be used in this project. This research also intends to create an embedded technology that reduces the physical effort needed to brew coffee for those with disabilities.

II. Design and Application

To implement such an automatic coffee maker, an input device will be needed to allow communication between the user and system. Sensors will also be needed to ensure that the product is aligned with the input of the user. In addition to this, a microcontroller will be needed to process the information garnered from the aforementioned input devices and direct the output devices. Meanwhile, these output devices will be used to enable procedures involved in creating the drink and display the current status of the processes and other information relevant to the system.

For the design and implementation of this system, the following objectives were drafted:

1. Employ the Arduino UNO R3 microcontroller to design a coffee-making system that automates the entire brewing process.
2. Utilize a keypad interface to enable users to personalize their coffee-to-water ratio according to their preferences.
3. Create an embedded system that streamlines the coffee brewing procedure, particularly benefiting individuals with physical disabilities, by minimizing manual effort.
4. Incorporate key concepts such as Digital Input/Output, Pulse Width Modulation (PWM), and relay control into the embedded system's design and functionality.

A. Materials

Fig. 1. Arduino Uno R3

The Arduino Uno R3 is a versatile microcontroller board based on the ATmega328P microcontroller, featuring 14 digital input/output pins wherein 6 of these can be utilized for PWM applications, 6 analog inputs, a 16 MHz quartz crystal, a USB connection for programming and power supply, an ICSP header for programming with an external programmer, and a reset button. The ATmega328P microcontroller is the brain of the board, responsible for executing code written in the Arduino programming language. Arduino Uno R3 is widely used for its simplicity, ease of programming, and compatibility with a wide range of sensors, actuators, and communication modules. This microcontroller will serve as the main brain of the system and will process the inputs to determine the behavior of the output devices.

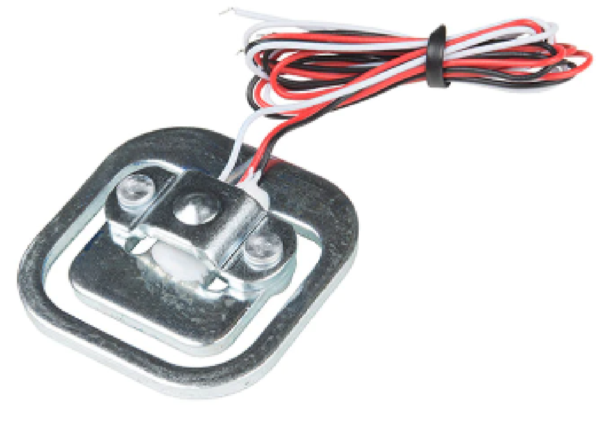

Fig. 2. Weight Sensor

A weight sensor, also known as a load cell, operates on the principle of strain gauges and mainly consists of several strain gauges connected in a Wheatstone bridge configuration. When a force is applied to the sensor, the strain gauges experience deformation, causing a change in their electrical resistance. This change is converted into an electrical signal proportional to the applied force, which is then processed to determine the weight or force being measured. For this project, this sensor will be used to weigh the amount of coffee grounds based on the user's inputs on the keypad component of the system. In this implementation, however, the LM35 temperature sensor was used as a placeholder for demonstration purposes due to the difficulties faced when interfacing it with the chosen microcontroller and writing the corresponding code for its designated function.

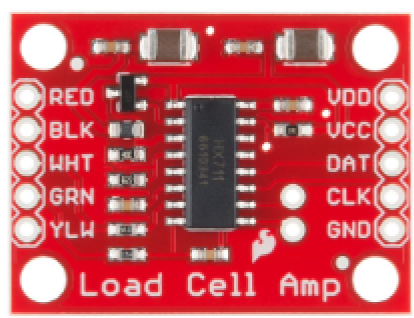

Fig 3. HX711 Amplifier

The HX711 Amplifier is a breakout board containing the necessary components such as an analog-to-digital converter, separate input pins for analog and digital power supply, and a pair of inductor and capacitor for the latter. While it has numerous libraries developed for microprocessor instruction sets, it is still dependent on manual calibration methods to achieve an accurate reading from the load cells. As mentioned in the previous item, an LM35 temperature sensor was used as a stand-in for the HX711 and load cell subcircuit due to interfacing difficulties.

Fig. 4. Servo Motor

A servo motor is a rotary actuator that provides precise control over angular or linear position. It typically includes a small DC motor, a set of gears, and a feedback mechanism (such as a potentiometer). The feedback mechanism allows the servo to know its current position and make adjustments to reach a desired position accurately. This type of motor can be controlled through a control wire interfaced to the motor that enables pulse width modulation (PWM) wherein electrical pulses are sent in varying width in a fixed frequency. It is to be noted that the maximum movement that can be done by these motors is 90° in either clockwise or the counterclockwise direction. Two servo motors will be utilized in this project for the opening and closing aspect of the water and coffee ground dispensers.

Fig. 5. 4x3 Keypad

A keypad is an input device consisting of an array of buttons organized in rows and columns. Each button corresponds to a specific key or character. When a button is pressed, it completes an electrical circuit, allowing the microcontroller to detect the button's position and identify the pressed key. Keypads provide reliable input for various electronic devices, enhancing user interaction and control. For this iteration of the automated coffee brewer, the keypad will allow the user to choose their desired coffee-to-water ratio as mentioned in the introduction section. The specific keypad used in this project was a 4x3 membrane keypad.

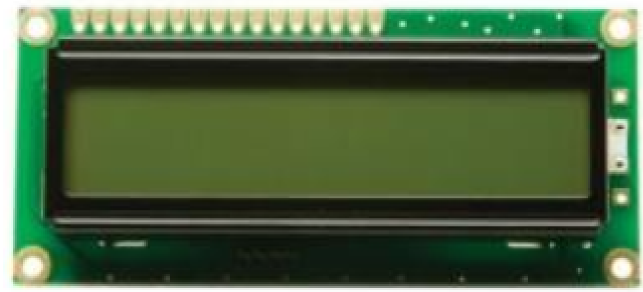

Fig. 6. Liquid Crystal Display (LCD)

A liquid crystal display, or LCD, is a flat-panel display technology that utilizes liquid crystals to modulate light and create visual information. LCDs consist of multiple layers, including a backlight, a layer of liquid crystals that can be manipulated by applying voltage, and a color filter layer. By controlling the voltage applied to different segments of the liquid crystal layer, LCDs can display text, numbers, symbols, and simple graphics. For this project, this device will be used to display relevant information and prompts to the user and is expected to synergize with the keypad.

Fig. 7. Water Pump

Water pump. A water pump is an electromechanical device designed to transport water or other fluids from one location to another. Water pumps come in various types, including centrifugal pumps and diaphragm pumps. They find application in systems such as irrigation, plumbing, cooling systems, and even aquariums. The pump's mechanism varies, but the fundamental principle involves creating pressure differentials to move the fluid through the pump and into the desired area, accomplishing tasks like water circulation, drainage, or distribution. In this implementation, the water pump, which is a form of a DC motor, is driven by a power relay, and will essentially function as a water dispenser.

B. Design and Implementation

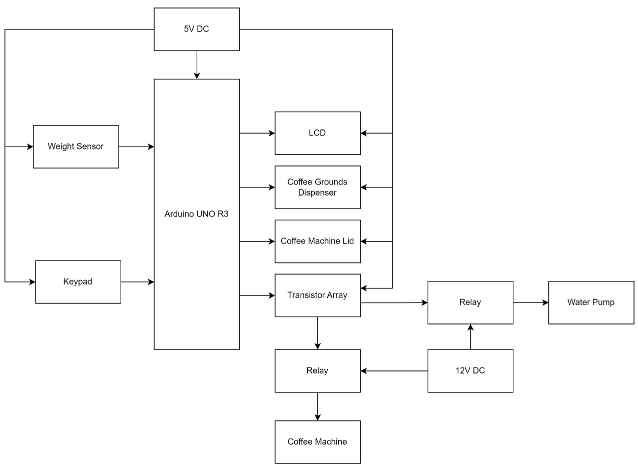

Fig 8. Block Diagram of the System

The figure above shows the manner in which the components in the system are interfaced with each other. A 5V DC power supply is connected to most of the components due to the external power source needed by these devices to function as intended. The weight sensor and the keypad is connected to the microcontroller, which is the Arduino Uno R3, and functions as the inputs of the system. A Darlington transistor array, serving as flyback diodes, is connected as one of the outputs of the microcontroller, and this device is interfaced with two relays, both powered by a 12V DC supply, that power the coffee machine itself as well as the water pump respectively. Other output devices such as the LCD, lid of the coffee machine, and the dispenser containing the coffee grounds will be directly interfaced to the Arduino Uno R3 as their behavior will directly be dictated by the microcontroller.

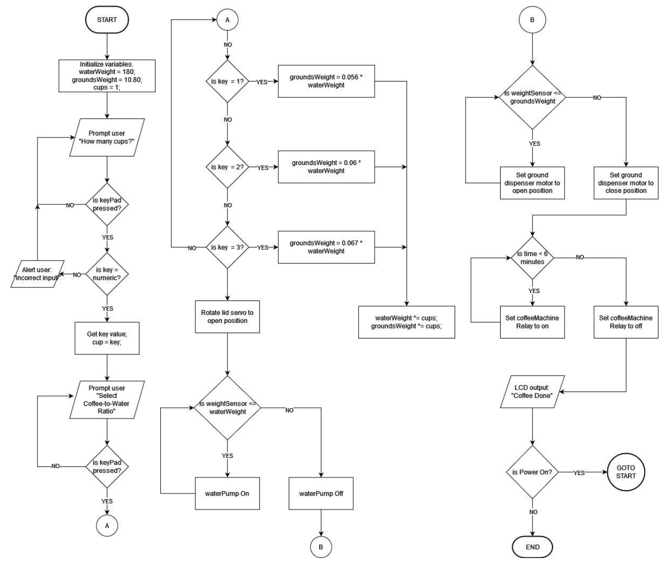

Fig 9. Flowchart of the System

The program flow of the system will run as follows: upon initialization of the program, it will prompt the user to choose the amount of cups that they will brew then their preferred coffee-to-water ratio before the microcontroller with raise the lid to dispense water and the coffee grounds, in that order, according to the amount calculated using the first two user-inputs. Afterwards, the microcontroller will close the lid before switching on the relay for the coffee machine's power; after the expected brew completion time has passed, the power relay will be switched off before the program will restart to its beginning.

III. Review of Related Literature

A. An implementation of an automated coffee brewer system utilized the ATmega16 by Muhammad Reza Hidayat, Try Anugrah, and Achmad Munir

Hidayat et. al. present a novel automatic coffee brewing system based on the ATmega16 microcontroller and the pour-over V60 technique, which was coined after a V-shaped dripper resembling a 60° angle that developed in Tokyo, Japan in 2004. The system receives input parameter values via a keypad, including water volume in milliliters (ml), coffee powder quantity in grams (g), water temperature in degrees Celsius (°C), and extraction time in milliseconds(ms). The coffee powder and water volume parameters determine the coffee solution's ratio to the desired water volume, influencing the coffee taste. The system begins by heating the water in the tank to the desired temperature. Once the water is heated, the coffee powder is dispensed into the filter and the water is poured over the coffee powder. The extraction time begins, releasing CO2 gas from the coffee powder within the specified time. Finally, the water pump activates again for a period matching the inputted water volume value. The system has been experimentally validated, and it was verified that the water temperature sensor was 98% accurate. Furthermore, the system can achieve boiling water within approximately 15 minutes and exhibit temperature stability; thus validating the system's accuracy and potential for automated coffee brewing using the pour-over V60 technique. The authors believe that the system has the potential to be a valuable tool for coffee enthusiasts. They also conclude that their proposed automated coffee brewer system is modular, efficient, and safe as it can be easily customized to meet the needs of different users, uses minimal energy and water, and it is protected from fire hazards and electric shocks [6] .

B. Design and Implementation of the Automatic Coffee Drink Mixing System Based on Total Dissolved Solid (TDS) Level by Aldino Zulmasri, M.T. Adam Faroqi, Lia Kamelia, Aep Kusnawan, Aan Eko Setiawan, Ayi Yunus Rusyan

The paper that was made by Zulmasri et. al states that there is very little research on the extraction and brewing of coffee [7]. In order to combat the miscalculations of coffee concentration and the inefficiency when manually processed by humans, the authors of this paper implemented an IoT system that automatically mixes coffee drinks, with a TDS sensor connected to record the data. The main components of this study are: Arduino Uno microcontroller, the TDS sensor, DS18B20 temperature sensor, pump motor, heater relay, stirrer motor, I^2C LCD, and an adapter. The Arduino Uno microcontroller is the main component in this project, and there are a total of 2 inputs and 4 outputs where the sensors are the inputs and the outputs are the heater relay, the pump motor, the stirrer motor, and the LCD. The output will depend on what the sensors will detect, and the current detected state will also be displayed in the LCD.

C. Design System of Coffee Maker with Manual Brew Method and Coffee Sales Monitoring by Narulita Dwi Nugrahaini, Mila Kusumawardani, Abdul Rasyid

The study by Nugrahaini et. al proposed an automatic coffee brewing system that could cater customers and still output the same taste when compared to a manually brewed coffee by baristas. Aside from the efficiency of having an automatic coffee brewing system, the business can also track or monitor the sales since the system sends data through developed applications on Android [8]. In this study, the ESP32 microcontroller is utilized. The ESP32 microcontroller is a low-cost microcontroller chip that has a built-in Wi-Fi module which is similar to the ESP8266, another Wi-Fi microcontroller that has fewer GPIO pins than ESP32. The study used a heater that is activated by the relay module that is also connected to the power source of the ESP32 microcontroller in order to heat up the water. When the temperature detected reaches the threshold, the water pump will be turned on by the relay module that is connected to it. The ESP32 microcontroller is the main component of the system where a buzzer, an ultrasonic sensor, and Internet is connected. The buzzer is mainly used to imply or to alert the user of the current state of the system. The ultrasonic sensor to detect the amount of water stock in the container. Lastly, the microcontroller is connected to the internet and specifically to the firebase since it is used as their database.

D. The Design of an Intelligent Coffee Machine by Julia Ndjene and Smita Francis

This paper proposes a design for an intelligent coffee machine that uses GSM technology to allow users to remotely control the machine. The coffee machine is equipped with a sensor network that monitors the coffee beans, water level, and temperature. The intelligent coffee machine is a cost-effective way to automate the coffee making process. It is also more convenient than a non-programmable coffee machine, as users can remotely control the machine from anywhere. The intelligent coffee machine is powered by a 230V AC to DC step-down converter that provides a regulated 10V DC output voltage for the Arduino Uno microcontroller. The microcontroller interfaces with the different subsystems of the coffee machine and performs the control and processing functions. The coffee machine has a water sensor to detect the presence of water and a sensor to confirm if coffee is ready. The communication system uses SMS to communicate with the GSM module, which in turn transmits the messages to the microcontroller for commands. The GSM modem transmits messages back to the user as per the instructions sent and the decision made by the microcontroller. The switching system comprises a two-way switch and an Arduino one-channel relay that connects the coffee maker to the entire system [9].

E. Design a Drink Making Tool Automatic Milk Coffee Based Arduino R3 by Nofriadi, Herman Saputra, Juna Eska, Adi Prijuna Lubis and Nuriadi Manurung

Saputra et al. presented an automated drink-making tool for coffee and milk beverages, which is orchestrated by the Arduino R3 microcontroller [10]. The system uses an ATMega8535 microcontroller as its core, which governs the operation of other components such as three buttons, four servos, three DC motors, four relays, and a water pump. When a button is pressed, a signal is sent to the microcontroller, which then activates the required components based on a preloaded program. The system derives its power from a 220 AC voltage source, which is transformed to 12 or 5 volts DC for device operation. Testing of the system focused on both software logic and functional aspects. They ensured that every software statement was tested and that the system produced the expected outcomes for given inputs. Several components were individually tested, including the microcontroller, servos, relays, DC motors, and buttons, to validate their functionality.

F. Automatic Coffee Maker Machine Based on Internet of Things (IoT) by Akbar Sujiwa and Iwan Santoso

In a study by Sujiwa and Santoso, an IoT-based automatic coffee maker machine was built [11]. The device's efficacy was evaluated through several tests, primarily focusing on its DC motor and a 4-channel 5-volt relay system. The DC motor's function was to handle various drink-making tasks, such as running motor 1 for cross-sectionalizing a glass, motor 2 as a booster to remove coffee grounds, and motor 3 and 4 for removing powdered sugar and milk powder, respectively. The relay system was designed to control the stirrer motor, water pump, solenoid valve, and buzzer, with specific input pins assigned for each component. Their findings revealed that the average error in drink-making was below 4%, indicating a high level of precision in the automated process. Specifically, the error percentages for bitter coffee, sweet coffee, warm milk, and coffee milk were 3.03%, 2.70%, 1.10%, and 2.82%, respectively.

G. Automatic Coffee Roaster Design using Arduino by Tigor H. Nasution, Agustinus Putramas, Soeharwinto, Fahmi, and Ikhsan Siregar

Nasution and colleagues devised an automated coffee roaster powered by an Arduino microcontroller that is controlled via an Android app [12]. The Arduino microcontroller facilitates electronic integration across a multitude of uses. Meanwhile, the Android app initiates the roasting process and the recording process of thermocouple temperature data. This app is also responsible for control of roasting time, temperature monitoring, and roasting level selection. These processes are relayed to the Arduino through Bluetooth. The Motor and heating elements are manipulated via a relay. The roaster, made from a 0.3mm zinc plate, has dimensions of 36x16x20cm and contains a drum that accommodates up to 100g of coffee beans. Infrared ceramic elements (150W) offer heating, whilst an AC motor ensures the drum's rotation. Hardware like the Arduino Uno, K Type Thermocouple, MAX6675, and others, are insulated with wood planks and mica plastic boards to prevent heat transfer and are situated on the tool's side.

H. Design Automatic Dispenser for Blind People based on Arduino Mega using DS18B20 Temperature Sensor by Ali Nur Fathoni, Noor Hudallah, Riana Defi Mahadji Putri, Khusnul Khotimah, Tri Rijanto and Miftahul Ma'arif

People with disabilities such as visual impairment and blindness experience several challenges and obstacles in their daily life, may it be from social interactions, and dealing with the loss of sight is a challenge enough itself [13]. In this study, Fathoni et. al designed an automatic dispenser for blind people based on Arduino Mega microcontroller using DS18B20 Temperature Sensor in order to make things easier for the people with disabilities. The automatic dispenser for blind people is powered by a 220 volt AC voltage. It has a mat at the front to make it easy for blind people to place their glass. There are two sides to put the glass, one for cold water and one for hot water. A proximity sensor detects the presence of the glass and the height of the glass. An ultrasonic sensor determines the height of the water when it almost touches the surface of the glass. The water heater system has a choice of three temperatures: 50°C, 70°C, and 80°C. A 16x2 LCD monitors the temperature and status of the glass. The main part of the dispenser is an Arduino microcontroller that controls the dispenser's operation. The Arduino microcontroller receives data from the ultrasonic sensor, DS18B20 sensor, and keypad/push button switch. The Arduino microcontroller controls the relay module and MP3 Shield Module based on the data it receives. The relay module controls the AC voltage to turn on and off the heating element.

IV. Significance of the Project

An automatic coffee maker with coffee ground and water dispenser using relays would be a significant innovation in the coffee maker market. This type of coffee maker would be able to brew coffee with minimal human intervention, which would be especially beneficial for people inflicted with disabilities. This demographic often has difficulty using traditional coffee makers, which can be difficult to operate and require a lot of dexterity. An automatic coffee maker with coffee ground and water dispenser using relays would be less challenging for disabled people to use while simultaneously alleviating them from the issues typically brought upon by using traditional coffee makers.

Besides catering to people with disabilities, the system promotes precision and guarantees consistency in every cup. It is both time and energy-efficient and liberates users from manually monitoring the brewing process. One of its predominant strengths lies in the personalized user experience—allowing different predetermined levels of coffee-to-water ratio to suit individual preferences. Due to the high precision, human error is eliminated in the process of coffee making, yielding potential financial savings in the long run through preventing unnecessary coffee grain wastage per cup.

V. Recommendation

To group recommends that a physical implementation of this circuit be performed using a basic coffee drip machine to determine the best method of connecting the machine’s lid to the servo, method of connecting a water pump to the reservoir without seriously damaging the lid’s sealing, and to accurately measure and calibrate the results of the coffee ground dispensers and water dispenser.

Additional improvements that could be considered involve quality-of-life improvements for the end-user which includes modifying the program to allow the user to input a custom coffee-to-water ratio, as well as water and ground input instead of the current hardcoded values.

VI. Conclusion

To conclude, the group was able to design and implement, at least on a digital circuit simulation application, an automated addition to the drip coffee machine with the use of the Arduino UNO which is expected to assist people with disabilities by minimizing the physical effort needed to brew coffee.

The project was able to incorporate a 4-by-3 keypad that has been programmed to provide user-input with regards to the amount of cups they wish to brew, and the coffee-to-water ratio.

A buzzer implementation was removed due to the inclusion of an LCD screen which allows for a better user-experience with regards to the aforementioned in the previous paragraph as well as being unnecessary after the program incorporated a method to automatically cut power to the coffee machine after a certain amount of time as well as concerns that the target user base may have reservations with such a loud emission of sound.

PWM manipulation was implemented with the use of hobby servo motors, however, while the simulations suggested issues with the code with regards to the movement of the servo but physical observation using an Arduino and a hobby servo shows that it is simply a limitation of the Proteus software. Digital I/O was implemented with the use of the digital input and output pins of the microcontroller where the voltage levels of each pin display a more or less uniform value. Relays were implemented for the use with the water pump motor, and the coffee machine.

Acknowledgment

The group would like to thank Dr. Jay Robert Del Rosario for his excellent teaching and guidance in the Embedded Systems course. His patience and enthusiasm helped us to understand the material, and his variety of study materials were invaluable. The students are grateful for his dedication to our learning and for his commitment to making the course a success.

Bibliography

[1] N. Myhrvold. "Processing the bean", Britannica (n.d.). https://www.britannica.com/topic/coffee/Processing-the-bean (accessed Aug. 11, 2023)

[2] The International Coffee Organization. "Coffee Report and Outlook (CRO)", International Coffee Organization (2023). https://icocoffee.org/documents/cy2022-23/Coffee_Report_and_Outlook_April_2023_-_ICO.pdf (accessed Aug. 11, 2023)

[3] K. MacDonnell, "15 coffee consumption statistics in the Philippines 2023: Interesting facts!," Coffee Affection, https://coffeeaffection.com/coffee-consumption-statistics-in-the-philippines/ (accessed Aug. 11, 2023).

[4] World Health Organization. "Disability", World Health Organizatio (2023). https://www.who.int/news-room/fact-sheets/detail/disability-and-health#:~:text=Key%20facts,1%20in%206%20of%20us. (accessed Aug. 11, 2023).

[5] J. Velasco,. V. Obnial,, J. C. Pastrana, A. Ang, H. K. Viacrusis, P. M. & Lucero-Prisno III, D. E. (2021). COVID-19 and persons with disabilities in the Philippines: A policy analysis. Health promotion perspectives, 11(3), 299.

[6] M. R. Hidayat, T. Anugrah, & A. Munir. (2019). ATmega16 Microcontroller-based Automatic Coffee Brewing System using Pour Over V60 Technique. In 2019 16th International Conference on Quality in Research (QIR): International Symposium on Electrical and Computer Engineering (pp. 1-4). IEEE.

[7] A. Zulmasri., M. Faroqi, A. Kamelia, L. Kusnawan, A. Setiawan, A. E. & A. Y. Rusyan. (2022). Design and Implementation of the Automatic Coffee Drink Mixing System Based on Total Dissolved Solid (TDS) Level. In 2022 8th International Conference on Wireless and Telematics (ICWT) (pp. 1-4). IEEE.

[8] N. D. Nugrahaini, M. Kusumawardani, & A. Rasyid. (2023). Design System of Coffee Maker with Manual Brew Method and Coffee Sales Monitoring. Journal of Telecommunication Network (Jurnal Jaringan Telekomunikasi), 13(1), 43-50.

[9] J. Ndjene., & S. Francis. (2022). The design of an intelligent coffee machine. Global Journal of Engineering and Technology Advances, 11(01), 052-057.

[10] H. Saputra, J. Eska, A. P. Lubis, and N. Manurung, "Design a Drink Making Tool Automatic Milk Coffee Based Arduino R3," in Journal of Physics: Conference Series, vol. 1339, no. 1, IOP Publishing, Dec. 2019.

[11] A. Sujiwa, & I. Santoso. (2022). Automatic Coffee Maker Machine Based on Internet of Things (IoT). BEST: Journal of Applied Electrical, Science, & Technology, 4(1), 1-6.

[12] T. H. Nasution, A. Putramas, S. Soeharwinto, F. Fahmi, and I. Siregar, "Automatic coffee roaster design using Arduino," in AIP Conference Proceedings, vol. 2044, no. 1, AIP Publishing, Nov. 2018.

[13] A. N. Fathoni, N. Hudallah, R.D. Putri, M. Khotimah, K. Rijanto, T. & M. Ma'arif (2020). Design automatic dispenser for blind people based on arduino mega using DS18B20 temperature sensor. In 2020 Third International Conference on Vocational Education and Electrical Engineering (ICVEE) (pp. 1-5). IEEE.

Appendix

Table 1. Program Code

```
#include <LiquidCrystal.h>
#include <Keypad.h>
#include <HX711.h>

#define opDelay 200 // LOWER VALUES TO COMPENSATE FOR SIMULATION SLOWDOWNS

// KEYPAD SETUP
const int rowNum = 4;
const int colNum = 3;
char keys[rowNum][colNum] = {
  {'1','2','3'},
  {'4','5','6'},
  {'7','8','9'},
  {'*','0','#'}
};
byte pin_rows[rowNum] = {A0,A1,A2,A3};
byte pin_cols[colNum] = {8,9,A5};
Keypad keypad = Keypad(makeKeymap(keys), pin_rows, pin_cols, rowNum, colNum);

// LCD SETUP
int rs = 6;
int en = 7;
int d4 = 2;
int d5 = 3;
int d6 = 4;
int d7 = 5;
LiquidCrystal lcd(rs,en,d4,d5,d6,d7);

// PIN NAMES
int h2oPump = 11;
int coffeeGrounds = 12;
int basketLid = 13;
int powerRelay = 10;
```

```
// STATUS FLAGS
int waterPumping = 0;
int groundDispensing = 0;
int lidOpen = 0;

// WEIGHTS
int maxWaterWeight = 180;     // FOR 1 CUP AT 1:16.67
int maxGroundsWeight = 10.80; // FOR 1 CUP AT 1:16.67
int cups = 1;

// HX711 -- UNUSED
int loadCell_SCK = 0;
int loadCell_DOUT = 1;
HX711 scale;

// FOR DEMONSTRATION MODULE
int demoPin = A4;

int waterPumpOn(int on)
{
 if (on)
 {
  digitalWrite(h2oPump, HIGH);
  return 1;
 }
 else
 {
  digitalWrite(h2oPump, LOW);
  return 0;
 }
}

int lidState(int state)
{
 int i;
 switch(state)
 {
```

```
  case 0:             // CLOSE AND ROTATE TO 0 DEG
    for(i=0;i<50;i++)
    {

      digitalWrite(basketLid, HIGH);
      delay(1.0);
      digitalWrite(basketLid, LOW);
      delay(19.0);
    }
    return 0;
  case 1:            // OPEN AND ROTATE TO 90 DEG
    for(i=0;i<50;i++)
    {
      digitalWrite(basketLid, HIGH);
      delay(1.5);
      digitalWrite(basketLid, LOW);
      delay(18.5);
    }
    return 1;
 }
}

int groundState(int state)
{
 int i;
 switch(state)
 {
  case 0:             // CLOSE
    for(i=0;i<50;i++)  // ROTATE TO 0 DEG
    {
      digitalWrite(coffeeGrounds, HIGH);
      delay(1);
      digitalWrite(coffeeGrounds, LOW);
      delay(19);
    }
    return 0;
  case 1:            // OPEN
```

```
    for(i=0;i<50;i++) // ROTATE TO 90 DEG
    {
      digitalWrite(coffeeGrounds, HIGH);
      delayMicroseconds(1500);
      digitalWrite(coffeeGrounds, LOW);
      delayMicroseconds(18500);
    }
    return 1;
  }
}

unsigned long readScale()
{
  unsigned long count;
  unsigned char i;
  pinMode(loadCell_DOUT, OUTPUT);
  digitalWrite(loadCell_DOUT, HIGH);
  digitalWrite(loadCell_SCK, LOW);
  count = 0;
  pinMode(loadCell_DOUT, INPUT);
  while(digitalRead(loadCell_DOUT));
  for (i = 0; i < 24; i++)
  {
    digitalWrite(loadCell_SCK, HIGH);
    count = count << 1;
    digitalWrite(loadCell_SCK, LOW);
    if (digitalRead(loadCell_DOUT))
    {
      count++;
    }
  }
  digitalWrite(loadCell_SCK, HIGH);
  count = count ^ 0x800000;
  digitalWrite(loadCell_SCK, LOW);
  return count;
}
```

```
int setCoffeeWeight(int ratio, int waterWeight)
{
  return ratio * waterWeight;
}

float roundToTwoDec(float x)
{
  float value = (int) (x * 100 + .5);
  return (value/100);
}

void setup()
{
  pinMode(loadCell_DOUT, INPUT);
  pinMode(powerRelay, OUTPUT);
  pinMode(h2oPump, OUTPUT);
  pinMode(coffeeGrounds, OUTPUT);
  pinMode(basketLid, OUTPUT);

  lcd.begin(16, 2);
  lcd.setCursor(0,0);
  lcd.println("SELECT CUPS NO.: ");
  lcd.setCursor(0,1);
  lcd.println("Press NumKey.");
}

void loop()
{
  int sensorADC;
  float sensorFinal;
  sensorADC = analogRead(demoPin);
  sensorFinal = (sensorADC * 5.00) / 10;

  int waterWeight = maxWaterWeight;
  int groundsWeight = maxGroundsWeight;
  int tempCups = cups;
  // GET CUPS
```

```
char key = keypad.waitForKey();
if (key != '*' || key != '#' || key != '0')
{
  tempCups = key - '0';
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Cups: ");
  lcd.println(key);
  delay(opDelay);
}
else
{
  lcd.setCursor(0,1);
  lcd.println("Consult Manual.");
}
// GET COFFEE TO H2O RATIO
lcd.clear();
lcd.setCursor(0,0);
lcd.println("COFY/H2O RATIO?");
lcd.setCursor(0,1);
lcd.println("1=M; 2=N; 3=L");
key = keypad.waitForKey();
if (key != '*' || key != '#' || key != '0')
{
  int ratio;
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.println("COFY/H2O RATIO:");
  switch(key)
  {
    case 1:
      ratio = 0.056;
      groundsWeight = setCoffeeWeight(ratio, waterWeight);
      lcd.setCursor(0,1);
      lcd.println("NORMAL");
      break;
    case 2:
```

```
      ratio = 0.06;
      groundsWeight = setCoffeeWeight(ratio, waterWeight);
      lcd.setCursor(0,1);
      lcd.println("NORMAL");
      break;
    case 3:
      ratio = 0.067;
      groundsWeight = setCoffeeWeight(ratio, waterWeight);
      lcd.setCursor(0,1);
      lcd.println("STRONG");
      break;
    default:
      break;
  }
}
else
{
  lcd.setCursor(0,1);
  lcd.println("Consult Manual.");
}
// Modify according to cup
waterWeight *= tempCups;
groundsWeight *= tempCups;
// DO THE THING
// OPEN THE LID
if (!lidOpen){
  lidOpen = lidState(1);
}
delay(opDelay);
sensorFinal = 0;
// POUR THE WATER
lcd.clear();
lcd.setCursor(0,0);
lcd.println("POUR H2O: ");
while(sensorFinal <= 50) // sensorFinal <= waterWeight IF suitable sensor used
{
  sensorADC = analogRead(demoPin);
```

```
  sensorFinal = (sensorADC * 5.00) / 10;
  waterPumping = waterPumpOn(1);
  if (waterPumping)
  {
    lcd.setCursor(0,1);
    lcd.print(sensorFinal);
    lcd.println(" ml");
  }
  else
  {
    lcd.setCursor(0,1);
    lcd.println("PROG FAIL!");
  }
}
waterPumping = waterPumpOn(0);
delay(opDelay);
// UNLEASH THE GROUNDS
lcd.clear();
lcd.setCursor(0,0);
lcd.println("DISP. COFY: ");
while (sensorFinal <= 100) // sensorFinal <= (waterWeight + groundsWeight) if suitable sensor used
{
  sensorADC = analogRead(demoPin);
  sensorFinal = (sensorADC * 5.00) / 10;
  groundDispensing = groundState(1);
  if (groundDispensing)
  {
    lcd.setCursor(0,1);
    lcd.print(sensorFinal);
    lcd.println(" g");
  }
  else
  {
    lcd.setCursor(0,1);
    lcd.println("PROG FAIL!");
  }
}
```

```
 lidOpen = lidState(0);
 delay(opDelay);
 if (!lidOpen)
 {
  digitalWrite(powerRelay, HIGH); //  TURN ON DRIP MACHINE
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.println("BREWING.");
  lcd.setCursor(0,1);
  lcd.println("ALERT: HOT!");
 }
 else
 {
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.println("ERROR!");
  lcd.setCursor(0,1);
  lcd.println("PROG FAIL!");
 }
 delay(opDelay); // REPLACE WITH EXPECTED TIME TO FINISH
 lcd.clear();
 lcd.setCursor(0,0);
 lcd.println("COFY DONE!");
 lcd.setCursor(0,1);
 lcd.println("ANYKEY=OFF");
 key = keypad.waitForKey();
 if (key)
 {
  powerRelay = 0;
 }
}
```

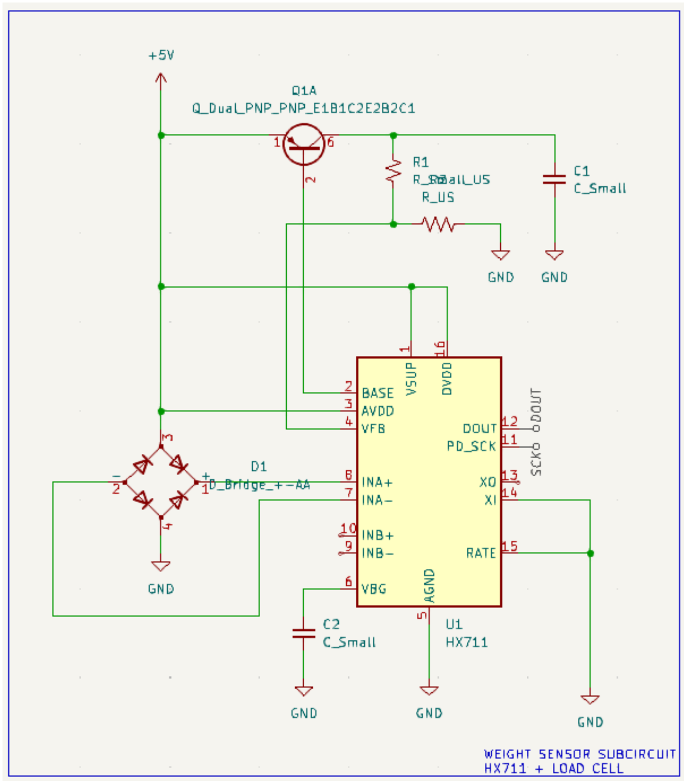

Fig 10. Schematic Diagram of Planned Weight Sensor

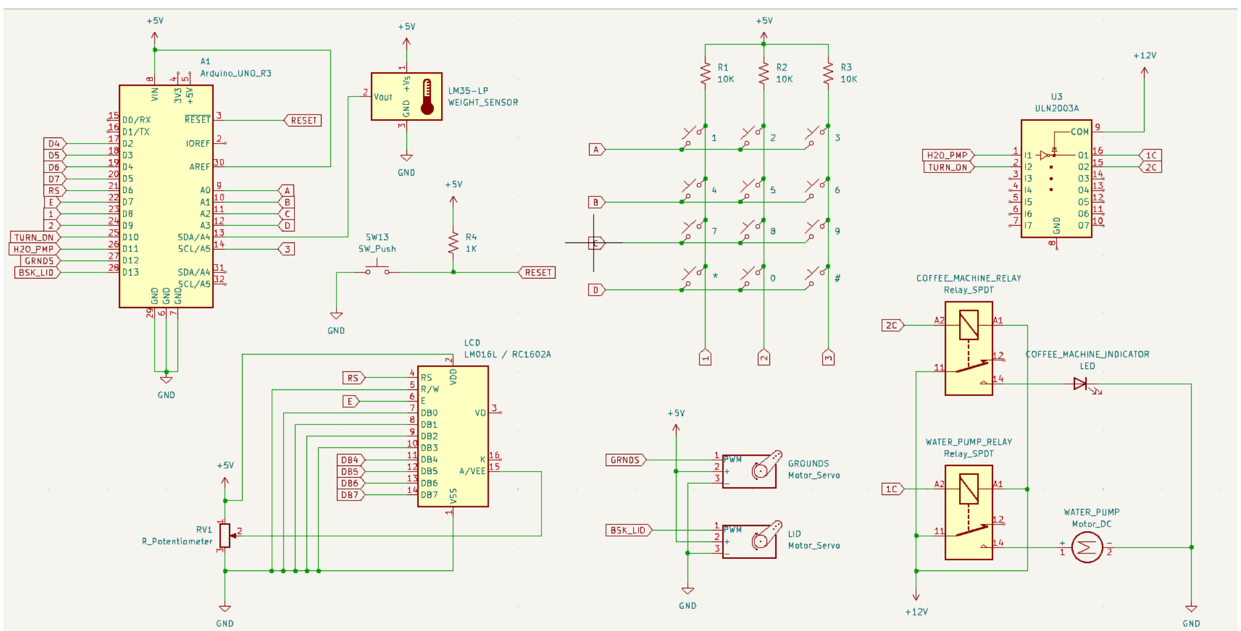

Fig 11. Schematic Diagram of the System