FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY

Computer Engineering Department

Hardware Graduation Project

MoonBucks

Students

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Contents

1 Disclaimer

This report was written by Mohammad Mubaslat and Hamzeh Saleh from the Department of Computer Engineering at An-Najah National University, as a requirement for Bachelor degree completion. It is worth noting that this report may contain human errors, and is for educational purposes only, so An-Najah National University does not bear any responsibility for this.

2 Acknowledgment

First and foremost, we must thank Allah our creator and our master, who gave us the determination and the strength to complete this work. Such accomplishment would not have come true without his great blessings.

We would like to take this opportunity to deliver our sincere thanks to our doctors especially Dr.Asmaa Afifi for giving us the confidence to work and reach our goal while providing her heartfelt guidance and sparing her valuable time, from the beginning until the completion of this journey. And for everyone who helped us to finish this project.

And finally, the deepest thanks to our families, friends, and to every person who contributed to making this project come into reality with a word or an idea.

3 Abstract

Nowadays Technology and smart devices have become mandatory things that no one can live without, and they have entered all aspects of life. Many people always look for convenience and luxury in any place or time. In their home, work, and car. So they start looking for tools to finish their jobs at the proper time and in a perfect way while they doing something else.

Many people used to drink coffee in the morning or when working, that's because coffee has many advantages such as increasing brain activity, helping us to stay focused and alert, and also it helps on burning fat.

According to that, our project presents a smart coffee machine called **MoonBucks Machine** which will offer modern technology for ordering coffee. Our machine has two ways of ordering, the first one is by using a mobile phone by connecting to the machine's WIFI network, and the second one is by using the attached Keypad and the LCD screen.

Our Machine will detect the size of the mug and fill it according to its size, so all you have to do is just putting your mug and choose your coffee from the menu which contains 4 types of coffee drinks, normal coffee, black coffee -no sugar-, extra sugar coffee, and dark coffee.

Moreover, making coffee requires some ingredients such as coffee, water, sugar, and coffee mate. So if any of these ingredients were missing the machine will notify the owner to fill in the empty ingredients.

4 Introduction

4.1 Problem

Coffee consumption statistics show that around 30-40% of the world's population consumes coffee every day, and it was reported that coffee drinkers enjoyed an average of 2 to 3 cups per day. According to these studies we decided to make a smart coffee machine with a lot of features to serve these people without wasting their time on making coffee.

4.2 Objective

Our main objective is to offer a smart coffee machine that can make coffee in a perfect way and shorter time. The machine will prepare the coffee according to the standard inputs given by the user and it will mix all the required ingredients to come up with a delicious coffee.

4.3 Project Scope

Coffee drinkers who like to save time and effort in making coffee, and those who look for luxury living. These people are our main scope who can get the biggest benefit from this machine

4.4 Report Organization

In general, the report has 9 phases, starting from Disclaimer, then Acknowledgment, Abstract, Introduction, Constraints, Literature review, Methodology, Results and Discussion, finally is the conclusion

5 Constraints, Standards and Earlier course work

5.1 Constraints

5.1.1 Time Limit

In our case, we were racing against time to finish all the requirements. the encountered problem is critical and needs a real, and practical solution. We had many ideas to implement but time didn't help us, so added them on future work.

5.1.2 Machine Architecture

We faced many problems during the design of the machine; because we have powder and liquid ingredients, so we had to take that into consideration.

5.1.3 New Experience

As we are still students, working on this project was a challenge for us. Because it was the first time we deal with all these electronic devices, so we faced many problems while working with it. Some of the problems we faced:

- Dealing with the ESP32 module, there is a lack of resources on the internet about web servers on esp32.
- lack of voltage and current, that because we have many devices connected to the same voltage source so we had to add more than one voltage source.

5.2 Standards

Arduino code is written in C++ with an addition of special methods, functions, and libraries, which are Keypad.h, LiquidCrystalI2C.h, wire.h, OneWire.h, DallasTemperature.h, and Servo.h

5.3 Earlier Coursework

We did our best to apply all that we have learned in university courses, such as Microprocessors and its lab, Microcontroller and its

lab, Digital 1,2, and 3, and Electronics 1 and 2 and its lab. All these courses taught us how to control different electronic parts and how to integrate them together, also we gained knowledge by searching and watching courses on YouTube which was very helpful for us.

6 Literature Review

There has been unbelievable progress in the twenty-first century that has led to the creation of a different life, large gaps between the past and the present, and despite the great development that we live in, in the age of technology, there are many technological solutions appear to help people live an easier and more comfortable life.

IOT -Internet Of Things- which means connecting any device to the internet and to other connected devices, is now used a lot in our lives and in many sectors such as transportation and homes and many people are trying to use it in their own houses; because they can do whatever they want by using a mobile phone.

There are many smart coffee machine projects, but our project is different because we aimed to add more features to our project to come up with a new machine. Some of the new features that we add are:

- Auto-detecting for the cup, so the user can put the cup and the machine will fill it according to its size.
- The user can order the coffee by using his mobile and after a few minutes the coffee will be ready.

So, MoonBucks machine is a new smart machine and it has a lot of features that make it different.

7 Methodology

This part shows some detailed information about the project, the devices we used to build it, and the overall circuit connections.

7.1 Hardware Devices

7.1.1 Overview

Tools and hardware devices we used:

- Arduino Mega 2560 Microcontroller
- ESP32-DevKitC ESP32-WROOM-32U
- 3 Ultrasonic sensors
- 3 Servo Motors
- DS18B20 1-Wire Temperature Sensor
- 2 IR sensors
- Pump
- 16x2 LCD
- I2C Serial Interface Adapter
- 4x3 Keypad
- Buzzer
- Water heater - Kettle
- 2 Relays
- Battery 12 volts
- Power bank 5 volts
- 2 Breadboards
- Connecting wires

7.1.2 Description

- Arduino Mega 2560 Microcontroller

  Is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.[9]

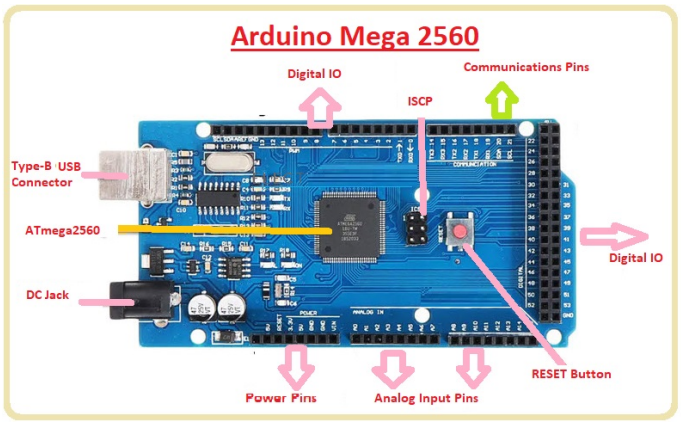

Figure 1: Arduino Mega

- ESP32-DevKitC ESP32-WROOM-32U Core Board

  ESP32 communication via serial communication with Arduino mega, we built a web server-like access point to allow the client to connect via Moonbucks machine network, then he can order a cup with any type of Nescafe that he wants remotely from his mobile phone from any place in his house. Then his order will send via serial to the Arduino and start the preparation automatically.[2] ESP32 and has a lot more features like:

  1. Single or Dual-Core 32-bit LX6 Microprocessor with clock frequency up to 240 MHz.
  2. 520 KB of SRAM, 448 KB of ROM and 16 KB of RTC SRAM.
  3. Supports 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps.

4. Support for both Classic Bluetooth v4.2 and BLE specifications.
5. 34 Programmable GPIOs.
6. Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC
7. Serial Connectivity include 4 x SPI, 2 x I2C, 2 x I2S, 3 x UART.
8. Ethernet MAC for physical LAN Communication (requires external PHY).
9. 1 Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI.
10. Motor PWM and up to 16-channels of LED PWM.
11. Secure Boot and Flash Encryption.
12. Cryptographic Hardware Acceleration for AES, Hash (SHA-2), RSA, ECC and RNG.

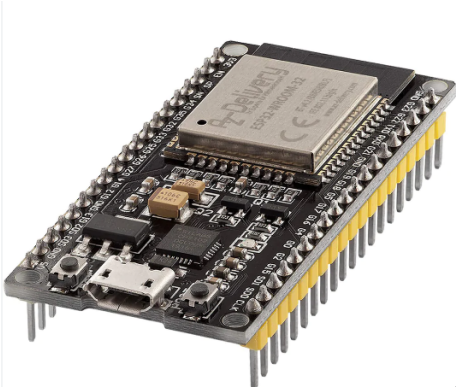

Figure 2: ESP32 Dev Module

- Ultrasonic sensor Is a sensor that can determine and measure distance. It emits ultrasound at 40 000 Hz (40kHz) which travels through the air and if there is an object or obstacle in its path It will bounce back to the module. Considering the travel time and the speed of the sound you can calculate the distance. It is used to check if the components tray is empty or not. If any of them is empty the machine won't start the preparation

until filling it. there is an ultrasonic for Nescafe, an ultrasonic for sugar, and an ultrasonic for a coffee mate.[3]

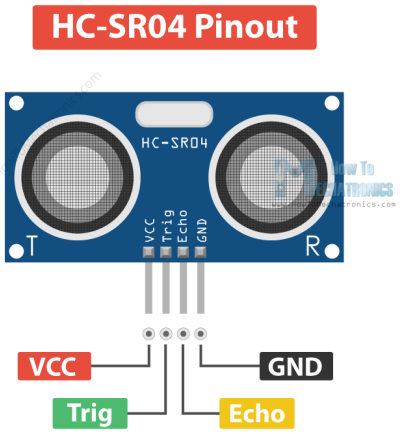

Figure 3: Ultrasonic sensor

- IR sensor module

  IR sensor is an electronic device, that emits light in order to sense some object in the surroundings. An IR sensor can measure the heat of an object as well as detects motion. Usually, in the infrared spectrum, all objects radiate some form of thermal radiation. These types of radiation are invisible to our eyes, but the infrared sensor can detect these radiations. We used it to detect if there is a cup or not, the machine won't work when any order is received without putting a cup.[8]

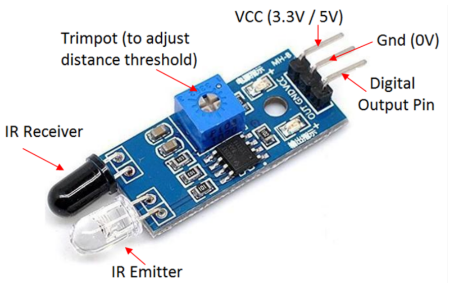

Figure 4: IR sensor module

- Water Heater - Kettle An electronic device used to heat the water, it works on 220 volts. Connected to relay that control when the heater will work depends on the Arduino order. The main idea of using it is to deserve the water hot all the time, so when the temperature sensor reads non-hot water the heater will work automatically.

Figure 5: Water Heater- Kettle

- Keypad The keypad is an input device to read the key pressed by the user and to process it. A 3x4 keypad has four rows and four columns. Switches are arranged between the rows and columns. When a key is pressed, it establishes a connection between the corresponding row and column, between which the switch is placed. We used it to take an order from the user to start the preparation. There are four types of Nescafe, the user can order any type by following the details that appear on the LCD. [5]

Figure 6: Water Heater- Kettle

- LCD is an electronic display module that uses liquid crystal to produce a visible image. The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates o a display of 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5×7 pixel matrix. We used it to display the instructions and the inputs from the user in addition to the preparation progress.[4]

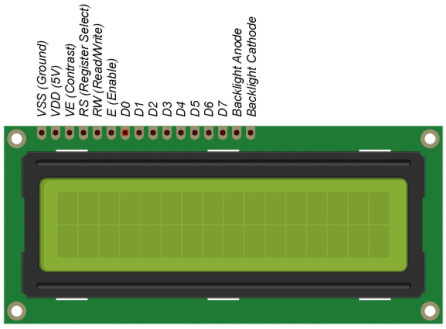

Figure 7: LCD

- I2C Serial Interface Adapter 16*2 LCD Displays use the PCF8574T IC chip to convert I2C serial data to parallel data for LCD display. This interface module also simplifies the connection of an Arduino to a 16*2 Liquid Crystal Display using only 4 wires. [1]

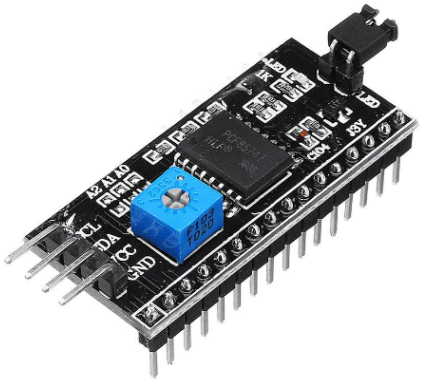

Figure 8: I2C Serial Interface Adapter

- Servo Motor that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

  Servomotors are not a specific class of motor, although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. We used three servo motors to control the quantity of the components depending on the cup size and Nescafe type, there is a motor for Nescafe, a motor for sugar, and a motor for a coffee mate.[6]

Figure 9: Servo Motor

- Pump We used the pump with the water heater, when the user order a cup the Arduino will give a signal to the pump to start

working, the quantity depends on the cup size. We connected the pump with a battery of 12 volts and a relay to control when the pump will work. The pump will pumping the hot water to the tube including all the required components. Then the batter will go to the cup. [10]

Figure 10: Pump

- Relay We used two relays in Moonbucks Machine, one of them for the water heater to help us control when the heater will work and when will stop. The second relay is for the pump, to detect and control when it's will work. [13]

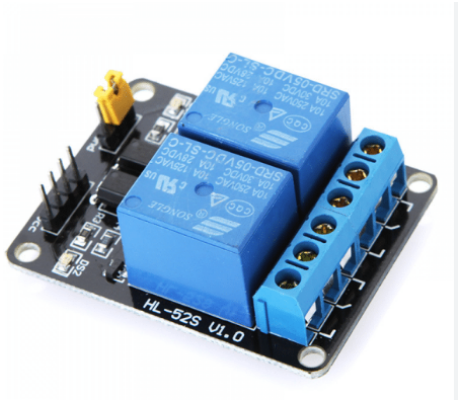

Figure 11: Relay

- DS18B20 Temperature Sensor We used it inside the water heater

to measure the water always, according to its reading the water heater will work or stop. [11]

Figure 12: DS18B20 Temperature Sensor

- Buzzer The buzzer is used to give the alarm to the user when the order is prepared successfully. [7]

Figure 13: Buzzer

- Breadboard Is a rectangular plastic board with a bunch of arrayed tiny holes in it. We can easily insert electronic components into these holes to make up a connective circuit for prototyping or testing. The top and bottom rows are power. Marked with + and -. All dots in each of the rows are connected together. The dots in the middle are divided into columns. All dots in a column are connected together. [12]

Figure 14: Breadboard

- Voltage Sources We used two voltage sources, the battery gives us 12 volts to activate the pump.

Figure 15: Battery 12 volts

The power bank is used to activate the relays, temperature sensor, ultrasonic, and motors.

Figure 16: Power-bank 5 volts

And the other devices were connected to the Arduino voltage like the keypad, LCD, IR sensors, and buzzer.

7.1.3 Hardware Development

- Building the Moonbucks body The Moonbucks body is made from wood to shape a box. To ensure that the user can put it anywhere, the roof of the box can be opened to fill the components, from the front there is a keypad in addition to LCD to help the user enter the input and a place for the cup.

Figure 17: Moonbucks Machine

- Adding the components to the Moonbucks body We started by adding the components containers to the top of the box, and pinning the tube under these containers, to allow the servos open and drop the components into the tube, every container has an Ultrasonic sensor to measure the distance and detect if any container is empty or not, we connected the pump to the kettle with a temperature sensor in the kettle, with relay for each of them, then we connect the Keypad and LCD, in the next level we connect the IR sensors, then we connect the buzzer, in the last step we connect the ESP32 and now Moonbucks is ready.

Figure 18: Moonbucks Machine

7.1.4 Software Implementation

- Arduino Mega

  The first step is to create the file of the project. In the setup function, we determine the names and pins for every device if input or output and connect the serial with baud rate 115200, call LCD init, and declare the flags for IR sensors.

  In the loop function, first, we read the keypad input and Web server connection, then we check if there is a cup or not, but don't do anything until yet. The most two important checks are the IR sensors and the Ultrasonic check, firstly when the user gives any order the IR will check if there is a cup or not, if not, then the machine won't prepare, if there is a cup, then the machine will check the Ultrasonic sensors, to detect if any container is empty or not, if any of it is empty, then the machine will tell the user to fill the container's components, if there is no any container empty, then the machine will start to prepare the wanted type of Nescafe.

  At all times the temperature sensor will keep working, to measure the water and keep it hot always, if the sensor measure that the water is not hot As it should be the relay will give a control signal from Arduino to the kettle to start working, then if the water gets hot, then the kettle will stop automatically.

  The preparation is done in four types for each size of the cup, the most used sizes are two sizes for Nescafe small and medium, we collect many small cups and many medium cups and calculate the average size of the cup, then we used this average for each size to determine the quantity of Nescafe components and the water quantity.

  When the order arrives and all sensors give the correct read, the machine will check if this order is from the keypad or ESP32, then will check the type wanted. There are four types Normal, No sugar, Sugar plus, Dark. depending on the IR sensors reading the machine will detect the cup size, the will start preparing

and write on the screen the preparation progress, We control the quantity of the components from the speed of the servo motors and the delay for each step according to the cup size and Nescafe type. The flags of IR will go to false to prevent the machine prepare in an infinite loop, in the last step the machine will give an alarm for the user about the cup is ready.

- ESP32

  We used the WiFi and Web-Server libraries to allow an open ESP32 connection as an access point, we declared the SSID and password for the AP, the server was started at port 80, it have four buttons as the number of Nescafe types, it was built using HTML and CSS. Firstly the buttons will start at low. In the setup function, we open the serial on baud rate 115200, starting the Access point with the selected SSID and password, for gateway we used the IP 192.168.1.1, for local IP we used 192.168.1.1, for subnet we used 255.255.255.0 and in the last step in setup, we determine each case of each button if on or off, by observing the URL of the page.

  In the Loop, we put the buttons low every time to prevent multi-order, and call the web page. We edit the web page and the URL in href, any editing is connected with two functions for each button, one for on and one for off. When any button is high then the other buttons are low, it will be high for one second and then will be low, no more than one button can be high at the same time.

  Each button has a number, the first one is one, the second button has the number 2m third button has the number 3, and the fourth button has the number four, when all buttons are low the ESP32 will send a zero to the Arduino.

  On the Arduino side, the Arduino will control according to the receiving number, every type of Nescafe has a number. When the zero is received, then the Arduino will not prepare anything. By the way, all checking steps for the keypad work in

the ESP32 orders also.

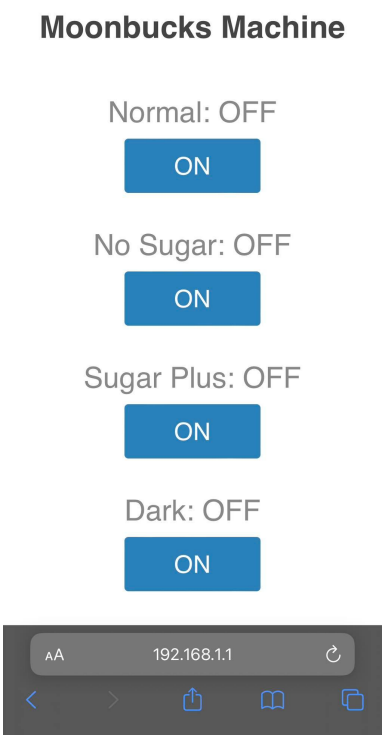

Figure 19: Web Server

8 Results and Discussion

During the work on the project, we encountered many problems with the sensitivity of the motors, dealing with ESP32, and IR sensors conflict. We learned and solved these problems.

Firstly, we solved the servo motors issue, it was because of the voltage of the servos, when connecting the servos to the same voltage source with other devices, it will cause disconnect the other devices, so we connected the motors individually on a voltage source.

Additionally, we solved the ESP32 problem, it was caused errors when trying to download the code and serial problem with Arduino, we solved the first one by reading the documentation and updating the library to the latest version and we solved the second one by using the Serial2 to write from ESP32 on the same baud rate 115200.

Finally, we are happy that we solved all the problems that we encountered and were able to operate the machine completely as planned, and we were able to achieve the main objective of the project, which is to solve the problem of the fixed cup in the regular Nescafe machines, as we provided more than one size of the cup, provided that the size of the cup is determined by the machine and disposal Based on the readable volume, in addition to providing the remote request feature through the phone, which requires that the user always put a cup in the dish in preparation for the remote request.

9 Conclusion

9.0.1 Summary

Moonbucks machine was made to make life easier for the machine users, solve the fixed cup size problem, and provide remote orders by connecting to the Moonbucks APP.

In this project we do several things:

- How to use the ESP32 module
- How to use the Servo motor
- How to use the Pump
- How to use the Temperature sensor
- How to use the Ultrasonic sensor and find the distance
- How to use the Keypad
- How to use the LCD with I2C
- How to use the Relay
- How to use the IR sensor
- How to use the Buzzer

9.0.2 Future Work

In order to improve the efficiency of the Moonbucks machine, we plan to provide the machine with a GSM device to send an SMS to the Admin mobile, in addition, to add a response from the machine to the smartphone after ordering, making the machine support multi hot drinks.

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