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Design and Assembly of an Automated Juice Mixing Machine

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Abstract: The refreshments industry is currently at a stalemate where most consumers are oriented towards typical, rigid and low-quality juice products. Most if not all vending machines are of low quality, as most of them offer products that include high amounts of preservative substances due to the machine's inability to maintain fresh products. Moreover, most if not all of the vending machines available in today's market suffer from poorly maintained exterior frames and internal components, in addition to limited funct-ionalities. The design of an automated juice mixing machine that provides the user with a convenient access to healthy alternatives is proposed. The machine can be used at homes and restaurants. A detailed description of the mechanical assembly as well as testing and verification of the correct functionality of the components used are provided. The proposed juice mixing machine has four aluminum containers holding four different types of juices, each having a capacity of 1500 ml. The fifth container holds the water that is used to clean the blender after each cycle. After depositing the payment (in case of using the machine at restaurants), the user can select the desired juice mix using a thin-film transistor (TFT) touchscreen. The TFT screen displays four selections to be chosen by the user. Furthermore, the user can specify the percentage for each type of juice in the mix. After specifying the percentage of each type of juice, the user is then instructed to choose one of the available two cup sizes. The microcontroller completes the required computations of different juice percentages based on the user's choice and cup size. Tubing connections and pumps transfer the require amount of different juices from the containers into the blender, which will perform flavor fusion. All electrical and mechanical components were tested separately to verify correct functionality before final assembly. The microcontroller used is the Arduino Mega which has sufficient number of input and output pins. The controller orchestrates the operation of all components used. Experimental results after final assembly of the machine confirm its correct functionality.

Keywords: Automation, Juice Mixer, Microcontroller, TFT Screen, Valve, Blender, Peltier Thermoelectric Cooler, Pump.

1. Introduction

The 2016 annual meeting of World Economic Forum (WEF), stated that the global economy is on the edge of extreme changes that are comparable in magnitude to the first Industrial Revolution. The WEF has singled out one integral technology that was marked as extreme automati- on [1]. Automation involves the use of various control systems in order to operate equipment with minimal or reduced human intervention [2]. Modern automation systems consist of electrical and mechanical components managed through digital controllers [3]. In the last three years, many Software-Based Intelligent Process Automa- tion products have been introduced in the market. A guide has been developed with the intention to establish a consistent reference for an objective set of criteria to evaluate the capabilities of products in the Intelligent Process Automation family [4].

Today, there is an increasing demand and technology push to reduce human supervision through the use of automated systems [5, 6]. This transition is aimed mainly to improve productivity and increase efficiency [7, 8]. Home automation is now considered as a soaring industry in many of the developing nations. Tremendous drive in business sector has led to hardware partnerships towards home automation. Sony and Apple organizations are attempting to claim a business portion based on home automation [9 - 11].

The current impact of Automation based on sensing technologies, artificial intelligence, and networked infrastructure is greatly uncertain [12, 13]. In [14], the relationship between accuracy and controllability is investigated in 750 participants using a controlled gamif-

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ied task. Self-reported satisfaction remained constant with high controllability, even under very low accuracy conditi- ons. A strong preference was detected for using manual control rather than automated, despite much slower performance and very poor controllability.

Automation systems have been an area for trained experts in highly specialized tasks, until recently where more non-expert users encounter automated systems in their everyday life. The deployment of automated systems has changed practices and experiences in various fields [15]. Human-Automation Interaction (HAI) research, has increased our understanding of how humans are influenced by automation [16 - 19]. Research in Human- Computer Interaction (HCI) that investigates the relation of automation and user experience is rare [20, 21]. However, currently there is a growing body of knowledge on autonomous driving [22]. There is also some user experience-based research in the engineering domain that focuses on issues of automation [23, 24].

1.1 Motivation and Problem Statement

The automated and mechanized food industry is mostly based on mainstream brand distribution where most vending machines rely on brand market popularity, like sodas, snacks, and coffee vending machines. Moreover, most if not all of the vending machines available in today's market suffer from poorly maintained exterior frames and internal components, in addition to limited functionalities. Unfortunately, automated machines for the distribution of high-quality natural beverages fall short in this industry.

This paper introduces the design of an automated juice mixing machine that provides the user with a convenient access to healthy alternatives. The proposed machine can be equally used at homes and restaurants. The proposed automated juice mixing machine is made out of several components that include a microcontroller, liquid flow meter, Peltier thermoelectric cooler, water pump, temperature sensor, a mixer, and a touch screen. The proposed machine allows the user to pick between two cup sizes, small and large. Furthermore, the user can choose to drink one type of juice or have a mix of two, three, or four different types of natural juices. The mixer is automatical- ly cleaned after every use.

2. LITEARTURE REVIEW

The authors in [25] discuss the design and implementation of a juice mixer machine. The proposed machine contains the following basic components: the Arduino Mega2560, HX711weight sensor module with load cell, five 12V DC water gear pump motor, relay modules, 20x4 LCD and 4x5 matrix keypad. This proposed machine has five channels with five different juice tanks, which are connected to water gear pump motors which are controlled by relays. The user can select the desired juice from a keypad. The desired percentage of each juice is calculated by using the weight sensor module.

Drink-O-Mender is a social robot which serves different fruit juices and iced tea [26]. The proposed robot can monitor the user's selected beverage and its quantity using a smart scale. This information is used with the aim of supporting the user's healthy nutrition. The proposed interactive design includes a Reeti robot augmented with additional sensing and adaptation abilities. The robot which is designed to offer drinks in a social setting, aims to persuade users of consuming healthy drinks.

An interactive system for influencing the level of user satisfaction experienced when drinking a beverage is presented in [27]. The proposed system controls the user's beverage consumption by creating a volume perception illusion using augmented reality that changes the apparent size of the cup. Results show that the consumption of beverages is influenced by the shape of the beverage container. Users consumed greater amounts when drinking from a visually lengthened cup and consumed smaller amounts when drinking from a visually shortened cup. Hence, the proposed technique can be used for daily health-care applications with wearable computers.

WaterCoaster is a mobile application and device used to motivate people to drink beverages more often and more regularly [28]. The WaterCoaster measures the amount drunk by the user and reminds him/her to consume more, if necessary. The app is designed as a game in which the user needs to take care of a virtual character living in a fish tank, where the water level is dropped if the user does not consume beverages in a healthy way.

In [29], Virtual Cocktail (Voctail); an interactive drinking utensil that digitally simulates multisensory flavor experiences is introduced. Three sensory modalities, taste, smell, and color are utilized by Voctail in order to create virtual flavors and augment the existing flavors of a beverage. The system consists of a mobile application that enables users to create customized virtual flavor sensations by configuring each of the stimuli via Blue-tooth. The system includes a cocktail glass that is fused into a 3D printed structure, which holds the electronic control module, three scent cartridges, and three micro air-pumps. When a user drinks from the system, the color is controlled by the RGB light projected on the beverage, the taste is controlled by the electrical stimulation at the tip of the tongue, and the smell is controlled by the micro air-pumps to are combined to create a virtual flavor sensation.

The authors in [30] have conducted a real-world study of a water serving robot at a university cafeteria. The robot was operated in a Wizard-of-Oz manner where it offered water to students having their lunch. The analysis results of the relationship between robot gaze direction and the likelihood that someone takes a drink show that if people do not already have a drink and the interaction is not dominated by an overly enthusiastic user, the robot's gaze behavior is effective in selecting an interaction partner.

The design of a fast food vending machine where the user can choose the type and quantity of hamburgers and drinks on the touchscreen or mobile phone is proposed in [31]. The selected food items are delivered to the dining window via a conveyor. The chef can remotely monitor the stock of hamburgers and drinks through a mobile phone or a computer.

3. Design and Analysis

In this section, different systems aspects involved in the design of the proposed automated juice mixing machine are explained.

3.1 System Architecture and Flowchart

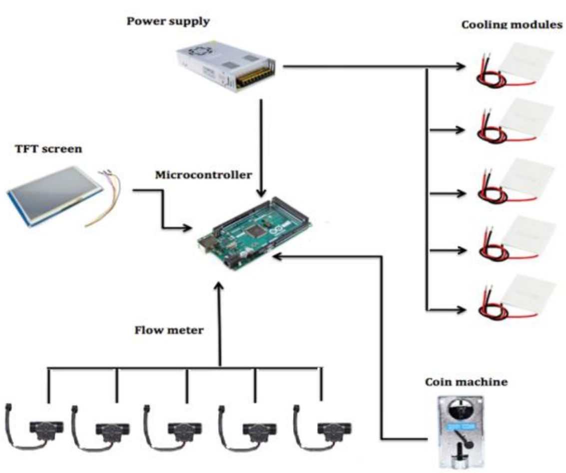

Figure 1. System architecture showing the inputs

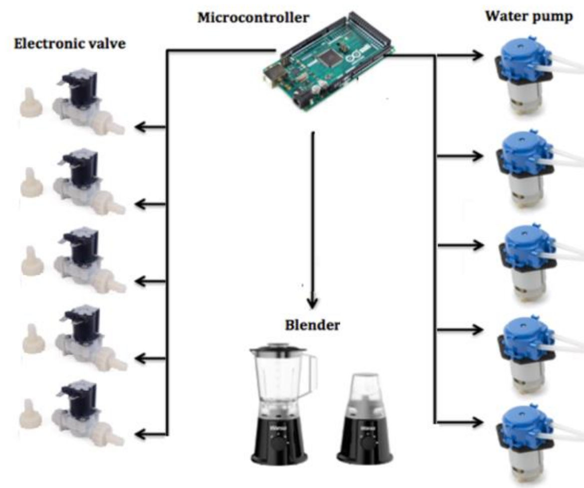

Figure 2. System architecture showing the outputs

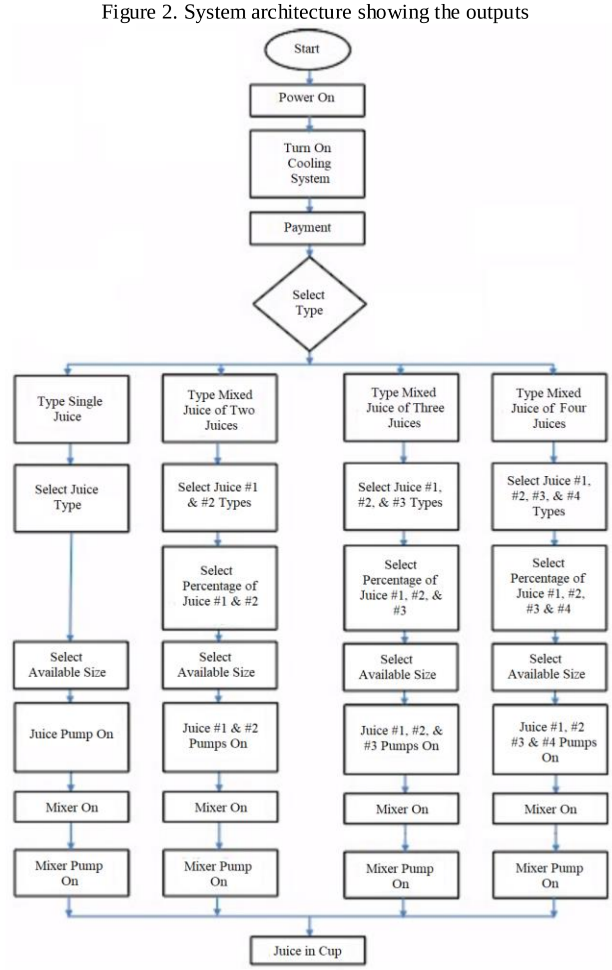

Figure 3. Juice mixing machine flowchart

The system architecture demonstrates all the compone-nts used in building the automated juice mixing machine and the relation between them. For simplicity, the system architecture has been divided to two figures, the first figure is for the inputs and the second one is for the outputs as shown in figures 1 and 2, respectively.

Figure 3 presents the flowchart of the proposed machine. This flowchart explains the nature of operation for a single cycle of interaction between the user and the machine. At the start, the machine needs to be connected to a power supply and turned on. When it is activated, the cooling system is switched on and the machine will be on hold and waiting for a payment from the user. When the payment is deposited, the user can use the thin-film transistor (TFT) touchscreen to select the type of desired juice based on his/her preference. The TFT screen displays four selections, one of which to be chosen by the user. The four selections are the following: one type of juice, a mix of two types, three types, and four types of juice. Furthermore, for the second to the fourth selection, the user can specify the percentage for each type of juice in the mix. After specifying the percentage of each type of juice, the user is then instructed to choose one of the available two cup sizes. The microcontroller completes the required computations of different juice percentages based on the user's choice and cup size.

The pump associated with each type of juice will then be activated. The different types of juices will flow to the mixer which is activated to mix all juices together. After that, the mixer pump will turn on and the mixed juice is poured into the cup.

The flow meter measures the liquid rate of motion through a pipe using a magnetic field to compute the volumetric flow. Magnetic flow meters are based on the principle of Faraday's law of electromagnetic induction, according to which liquid generates voltage when it flows through a magnetic field. The liquid flow sensor is required to record and report the compressed and pumped amount of juice into the cup. In order to reach required amounts, several tests were performed.

The microcontroller used is the Arduino Mega. It has 54 digital I/O pins and 16 analog I/O pins. It is equipped with a 256kB of flash memory, 8kB SRAM, and 4kB of EEPROM. The clock frequency of the chip is 16 MHz. The working voltage on the chip is recommended to be in the range of 7 to 12 V.

3.2. Components Used and Approximate Cost

Table I provides a brief description of the components used, the number of units needed for implementing the solar-powered electric vehicle, and the associated cost.

TABLE I. DETAILED COST OF THE JUICE MIXING MACHINE

Component	Quality	Cost ($)	Total ($)
Coin acceptor	1	45.32	45.32
Velleman water valve	5	10.34	51.7
Electric water pump	6	12.52	75.12
Wansa blender w/ grinder 300W 1.5L	1	16.14	16.14
Thermo electric cooler	5	34.95	174.75
Arduino Mega 2560 Microcontroller Rev3	1	37.34	37.34
DC universal regulated switching power supply 360W	1	49.44	49.44
TFT display with touchscreen	1	47.5	47.5
Metal pushbutton with green LED ring	1	4.95	4.95
Seedstudio water flow sensor	5	9.5	47.5
Wood	7	35	245
Plastic tubes	5	3.29	16.46
Relays	1	11.99	11.99
Driver board	1	34.95	34.95
Total ($)			**858.16**

4. IMPLEMENTATION AND ASSEMBLY

The rectangular wooden frame of the proposed juice mixing machine has a thickness of 5 mm. Four containers are used for the four different types of juices, each having a capacity of 1500 ml and is made of aluminum. The fifth container holds the water that is used to clean the blender after each cycle. The blender used also has the same capacity of 1500 ml. The inner section of the frame showing the coolers and bender is shown in Figure 4.

Figure 5 demonstrates how the blender cup was drilled to make a hole as an exit for the mixed juice. A plastic valve with a pump is used to connect the blender cup with a tube. Five round holes were drilled in the lid of the blender cup and are connected to the tubes (Figures 6 and 7). Four of the holes are for the four types of juice and one hole is for the water used to clean up the blender after each cycle.

The next step was the placement of the top side of the frame. The cup is placed on the blender base and is covered by the blender lid with the five tubes connected as shown in Figure 8. Each pump is then placed inside one of the five containers which are rested on top of the frame as presented in figures 9 and 10, respectively.

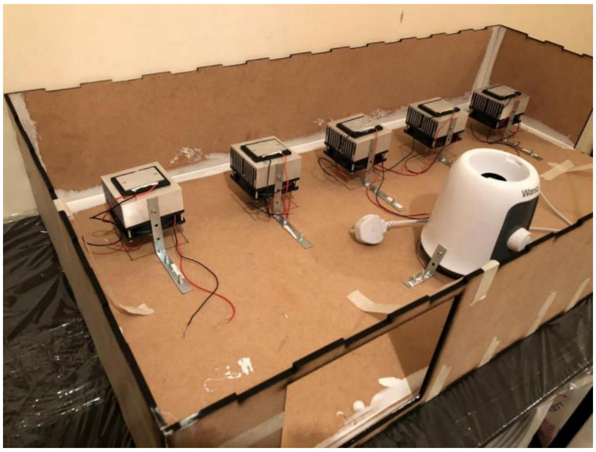

Figure 4. Top view of the inner frame showing the five coolers and the base of the blender

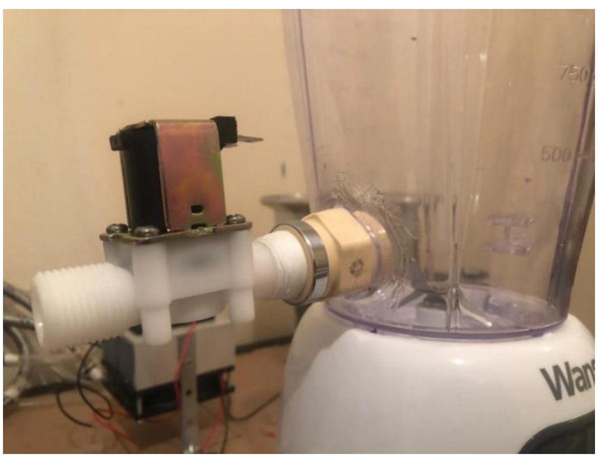

Figure 5. The hole drilled in the blender cup and the connecting valve

Figure 6. Five holes drilled in the blender lid

Figure 7. Inner view of the blender lid

Figure 8. Placement of the blender and containers

Electrical connections between different components in the machine need to be precise and well-planned due to the presence of liquids in the five containers. The five Peltier coolers previously shown in Figure 4 are placed under the containers as illustrated in Figure 11. The coolers were placed at a small distance above the ground to avoid overheating.

In order for the mixed juice inside the blender to flow directly and smoothly to the cup, an additional water pump
was added as seen in Figure 12. Three wires connect the coin acceptor to the Arduino microcontroller. The wires are for the 12V power supply, the ground, and the pulse. The acceptor is where the user can adjust the desired amount needed. The connections are shown in Figure 13.

Figure 9. Pump inside the container

Figure 10. Position of containers on top of the frame

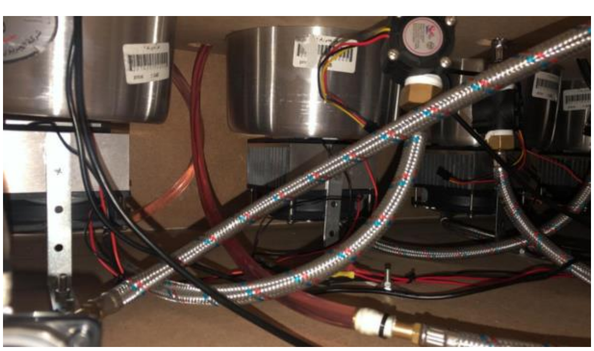

Figure 11. Internal connections of the coolers and tubes

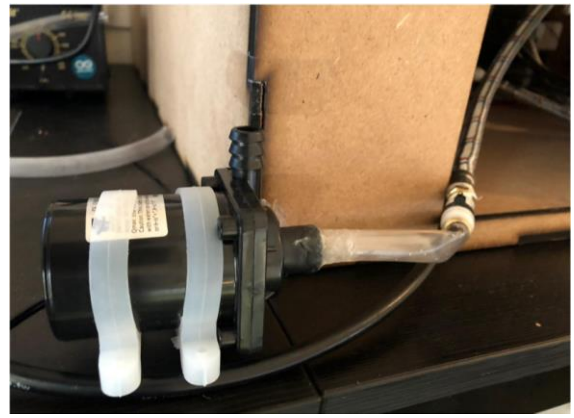

Figure 12. 6^{th} water pump added between blender and cup

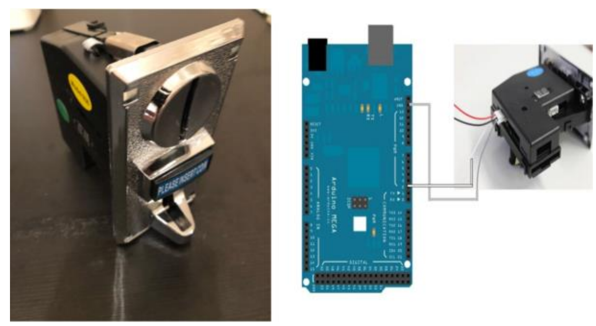

Figure 13. Connecting the coin acceptor to the Arduino microcontroller

The coin acceptor accepts multiples of 50 fils, a known coin in Kuwait that has a value of .05 K.D. When a 50 fils coin is added, the coin accepter will return a pulse (interrupt) to the microcontroller. If a 100 fils is added, i.e., two 50 fils coins, the acceptor will generate two pulses. To calculate the total amount, each pulse is multiplied by 50. For example, if three pulses were detected, it means that the user has inserted a total of 150 fils.

The 40-pin TFT touchscreen is connected to the RA8875 driver board. The driver clocks the screen contin- uously having every pixel drawn at an estimated rate of 60 frames per second. Such a medium proved favorable to support our Arduino high-speed controller connection. The 800 by 480-pixel TFT display touchscreen features a 24-bit color capability. Successful testing of the TFT touchscreen is shown in Figure 14.

The Peltier thermo electrical cooler module is operated using a 12V DC power supply and consumes 3A current. The Peltier system creates difference in temperature, with a maximum operating temperature of 200 °C and a minimum operating temperature of -50 °C. The system heats on one side and cools on the other. The cooler implementation was rather simple to implement as it does not need input or output connections to the microcontrol- ler. Its functionality is constant and starts when the machine is turned on (Figure 15).

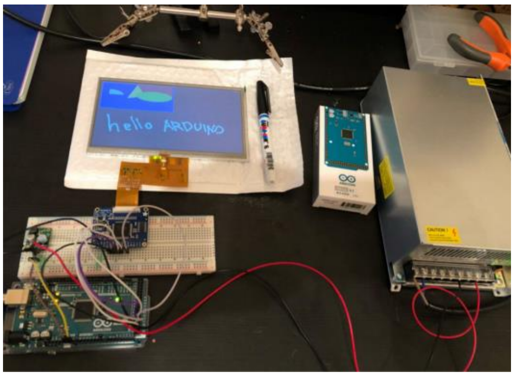

Figure 14. Testing of the TFT screen

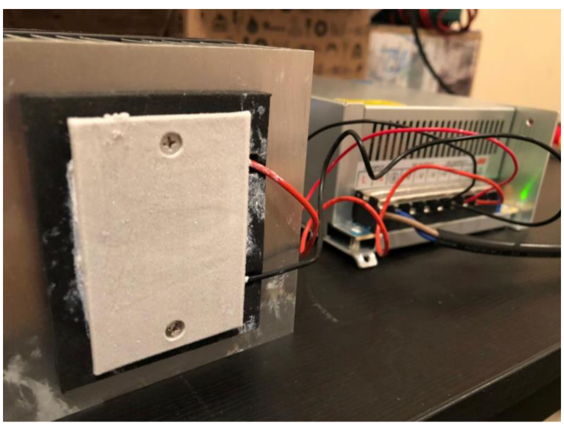
Figure 15. Testing the cooler

A total of eight relays were used. Four are used for the pumps in the juice containers, one is used for the cleaning water pump, one for the blender valve, one to rotate the blender blades and the last one is used for the sixth pump between the juice mixer and the cup. The relays conne-ctions are shown in Figure 16.

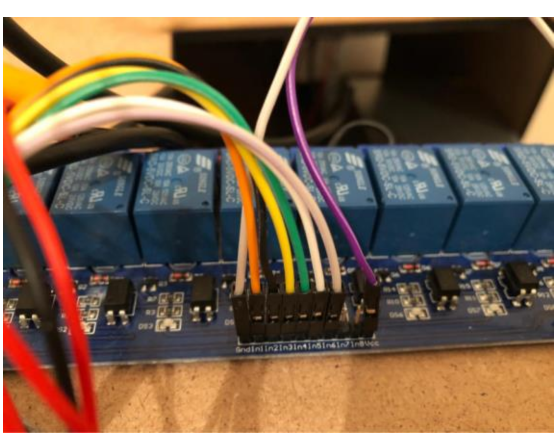
Figure 16. Connecting eight relays

All components of the proposed juice mixing machine have been successfully tested, programmed, and their correct functionality verified. The operation of the machine follows the basic steps listed below:

1. The cooling system tuns on when the machine turns on.
2. The machine will stay idle waiting for the user to complete the payment.
3. The user has the following options to choose from (refer to Figure 17):
   - one juice only,
   - a mix of two types of juices,
   - a mix of three,
   - a mix of four.
4. If a mix of juices is selected, the user has to specify the percentage of each juice in the mix as seen in Figure 18.
5. Then, the user has to specify the desired cup size. The user has to select one of two available choices as shown in Figure 19.
6. The microcontroller calculates the percentage of each juice in accordance to the selected cup size.
7. The pumps for the chosen juices and the blender are turned on as seen in Figure 20.
8. The sixth pump is activated, the mixed juice is poured into the cup (Figure 21).
9. The pump for the cleaning water container is turned on along with the blender and the sixth pump to clean the mixer and dispose of the water.

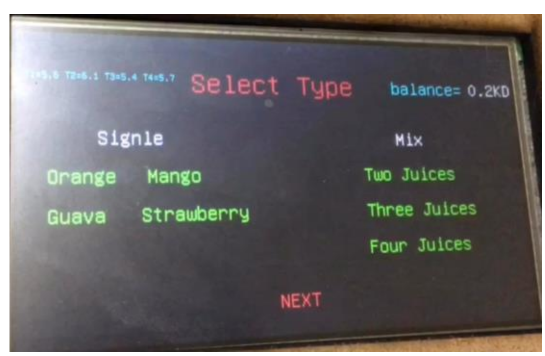

Figure 17. TFT screen displaying four options to the user

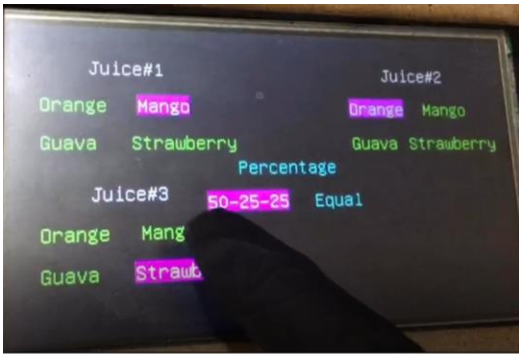

Figure 18. Choosing a mic of three juices and the percentage for each one of them

Figure 19. Choosing the desired cup size

Figure 20. Mixing juices in the blender

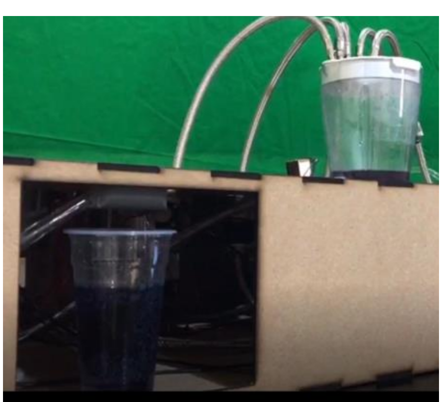

Figure 21. Mixed juice is poured into the cup

Part of the code to present different functions and user choices appearing on the screen is shown in Figure 22. The code presents the main choices that appear on the screen in Figure 19 where the user can select a small or large size for the cup.

```
void screen5txt() {
 tft.fillScreen(RA8875_BLACK);
 tft.textMode();
 tft.textSetCursor(260, 150);
 tft.textEnlarge(2);
 tft.textTransparent(RA8875_BLUE);
 tft.textWrite("Select Size");
 tft.textSetCursor(450, 250);
 tft.textEnlarge(2);
 tft.textColor(RA8875_WHITE, RA8875_BLACK);
 tft.textWrite("Large");
 tft.textSetCursor(190, 250);
 tft.textEnlarge(2);
 tft.textColor(RA8875_WHITE, RA8875_BLACK);
 tft.textWrite("Small");
 tft.textSetCursor(370, 430);
 tft.textEnlarge(1);
 tft.textColor(RA8875_GREEN, RA8875_BLACK);
 tft.textColor(RA8875_RED, RA8875_BLACK);
 tft.textWrite("NEXT");
}
```

Figure 22. Portion of the code used to present the user choices in Figure 19

Relays 6 and 8 are used for activate the valve and pimp for pumping the juice from the blender into the cup. As shown in Figure 23, LOW signal means that the valve and pump are activated. The HIGH signals turn them off. The activation period depends on the size of the cup, if the size is 1 which is used for the large cup size, the “bigdelay” is used. If the size chosen is 2 which is used the small cup, the “Smalldelay” parameter is used.

```
void coctailout(){
 digitalWrite(Relay_6, LOW);
 digitalWrite(Relay_8, LOW);
 if (Size==1){
  delay(Bigdelay*2);
 }
 else if (Size==2){
  delay(Smalldelay*2);
 }
 digitalWrite(Relay_6, HIGH);
 digitalWrite(Relay_8, HIGH);
}
```

Figure 23. Code used to specify the activation time window depending on the chosen cup size

The code for cleaning the blender (Figure 24) allows water to enter the blender by turning relay 5 on. The blender is filled with water about 2.5× the size of the large cup.

```
void cleanblinder() {
 Serial.println("Cleaning");
 digitalWrite(Relay_5, LOW); // water on
 delay(Bigdelay*2.5);
 digitalWrite(Relay_5, HIGH); // water off
}
```

Figure 24. Code used clean the blender after each use

5. Conclusion

In this paper, the design, programming, and assembly of an automated juice mixing machine has been introduced. The main goal of the proposed machine is to provide a fast and convenient access to healthy juices at homes and restaurants. Different components of the machine have been testing individually to ensure correct functionality before final assembly and implementation.

Future plan includes but is not limited to the following: adding a level sensor to alarm the user when one of the juice containers is running low and needs to be refilled, developing an app to connect the machine to the local network so that the user can order and prepare the desired mix remotely, adding a temperature sensor to keep track of the functionality of the coolers, and a mechanism to get rid of the juice if the cooler malfunctions for some reason.

Acknowledgment

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