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Design and Development of a Graphical User Interface (GUI) in a Medical Dispenser with Smart Card Access

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Abstract: Traditional vending machines serve snacks and drinks, but modern iterations encompass essential supplies. Diverse models emerged to meet various needs. In late 2019, the Covid-19 pandemic prompted global responses. Malaysia enforced movement controls. Strategies, like drive-thru healthcare, aimed to curb gatherings. PKD Pendang, Kedah, adopted this approach but faced queues. The project tackled this with a smart card-accessible medical dispenser linked to patient data. Automation ensured accurate dispensing, secured by authorized smart card access. A user-friendly interface streamlined interactions. Patients could retrieve medication within 10 minutes, enhancing efficiency. Rigorous testing affirmed adherence to this timeline. The prototype effectively addressed dispensing needs, providing timely medication.

Keywords: Medical Dispenser, Covid-19, Queue, Graphical User Interface (GUI)

1. Introduction

HCI (Human Computer Interaction) was first conceptualized in the early 1960s as a result of a new graphical user interface concept. Now that research has advanced to this stage, a Graphical Windows has been created to help us in our daily lives by accelerating and simplifying industrial procedures with a single click. In order to communicate with a computing device, people who are unfamiliar with gadgets, technology, and programming significantly assist from GUI. It can be described as a friendly visual environment. Because there is no need to type text commands into a console, anyone can use it. Today, GUIs are utilized in a wide range of operations, such as industrial manufacturing and home automation. Numerous graphical computer applications integrate GUI (Graphical User Interface) and their programming scripting function in the fields of computer science and electronics to make it simpler for interface designers and software developers to work on software development projects [1].

A plastic card with an embedded microprocessor that can store a lot of data and do basic computations is known as a smart card. Most smart cards have the same dimensions as standard credit cards. Smart cards were affordable, multifunctional, and simple to configure for both logical and

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physical access. They were safe tools that guaranteed user identification. The topics of logical access control include well-known ideas like password verification [2].

Vending machines are known as a machine that provides food instantly such as soft drinks, chocolate, coffee, and snacks. Nowadays, vending machines provide basic needs such as toothbrushes, towels, and tissues. Moreover, there was even a vending machine that sold branded items such as Siti Khadijah. It illustrates how widely this vending machine has been used in the marketplace. Vending machines provide many benefits, including the lack of labor requirements, time flexibility, time savings, lower labor expenses, and more profitability [3]. The main benefit of the vending machine, which serves as the basis for this invention, was that serving times are limitless. It can function around the clock.

In this project, the application of GUI will be implemented into a medical vending machine with smart card access, which is it will help to make the system more systematic and simpler for medical purposes. With the implementation of the GUI, the user can access the system and select the item based on their needs. For this product, the vending machine will be used for medication used. It will provide the medicine needed by patients with the approvable of their doctor. All the data about the patients will be entered into a smart card named a medical smart card.

2. Materials and Methods

The methods, techniques, and processes to design and develop the GUI system in the medical dispenser that will be implemented throughout the project will generally be discussed in this chapter. The methodology is the systematic process used to solve a project's problem and get the desired outcome. This chapter will describe the method for developing a graphical user interface (GUI) for a medical dispenser with smart card access. It contains every important detail to ensure that the project will be useful in resolving the problem. A detailed explanation of the fundamental components and software used in this project is also provided in this chapter.

2.1 Materials

To develop the prototype of the medical dispenser, a lot of components are needed in the system. Each component has a specific rule and working principle. To combine the components into a system, the detail of the components was really important. This chapter will describe the functional description of each component used to develop the prototype of the project.

i. Arduino UNO

Figure 1 shows the visual of an Arduino UNO that was used in this project. A microcontroller board called Arduino Uno is based on the ATmega328P. It had a 16 MHz ceramic resonator (CSTCE16M0V53-R0), 6 analog inputs, 14 digital input/output pins (of which 6 can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button. It comes with everything required to support the microcontroller; to get started, just use a USB cable to connect it to a computer, or an AC-to-DC adapter or battery to power it [4].

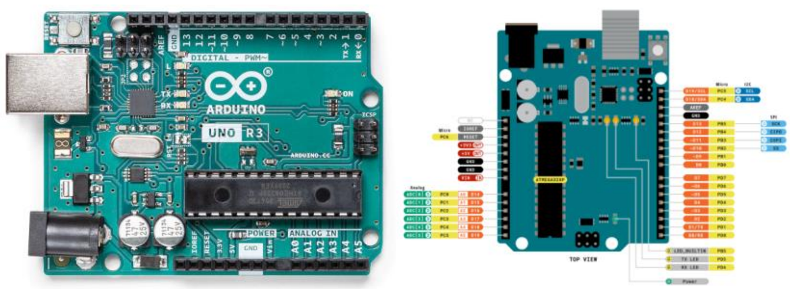


Figure 1: Arduino UNO by [4]

ii. RFID Reader

Figure 2 shows the visual of an RFID Module used in this project. A 13.56MHz electromagnetic field was produced by the RC522 RFID reader module to communicate with RFID tags (ISO 14443A standard tags). With a maximum data rate of 10 Mbps, the reader may interface with a microcontroller using a 4-pin SPI connector. Additionally, it supports the I2C and UART protocols for communication. Instead of constantly checking to see if a card is nearby, the RC522 RFID module can be designed to generate an interrupt, alerting the user when a tag approaches it. Moreover, while though the module's operating voltage ranges from 2.5 to 3.3V, the logic pins are 5-volt tolerant, allowing the user to connect it directly to an Arduino or other 5V logic microcontroller without the need for a logic-level converter [5].

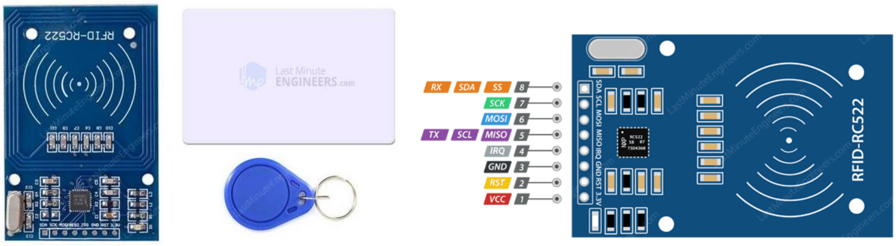


Figure 2: RC 522 RFID Module set by [5]

iii. 2.8" Arduino TFT LCD Touchscreen Module

Figure 3 shows the visual of a 2.8' Arduino TFT LCD Touchscreen Module that was used in this project. The Arduino UNO and Mega 2560 boards are supported by this component. It can be connected immediately by placing the pin into the interface without a wire. Compatible with every type of 5-volt or 3-volt MCU with a 5-volt to 3.3-volt change-over circuit This module can display text, color paintings, graphics, and images with 240 x 320 8-bit color pixels. This module is user-friendly and simple to use because it has a built-in Micro SD Card connection and a wide touchscreen display. As an additional benefit, this display has a resistive or capacitive touchscreen attached to it, allowing it to recognize finger presses anywhere on the screen [6].

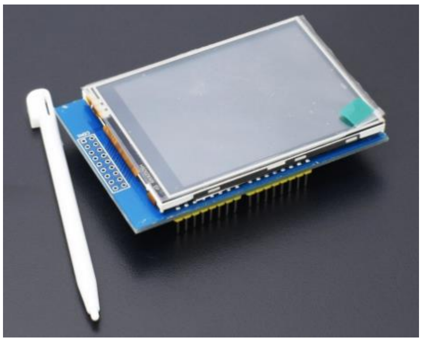


Figure 3: 2.8" Arduino TFT LCD Touchscreen Module by [6]

iv. DC Geared Motor

DC motor has applications in both households and industries and is considered the most basic type of motor. Electromagnetic induction was the basis for the operation of DC motors. It indicates that the force produced by the magnetic fields affects how the motor rotates. Electrical energy was transformed into mechanical energy. Direct currents can be used to power these motors. The stator, rotor, armature, and commutator make a DC motor. Commutator brushes were included. The stator's two stationary magnets were in charge of producing the magnetic field. The alternating current was carried by the armature found in the DC motor. The armature uses torque to transform electrical energy into mechanical energy. This mechanical energy was then transferred further through the shaft. Electrical switches were referred to as commutators. Additionally, it can switch the motor's external circuit's current direction. The brushes act as a connection between the rotating coils and the external power source. Insulated wires were placed around the iron core at the center, focusing on the created magnetic field as the current flowed through the wires. The motor's core was surrounded by insulated wire windings that had been turned numerous times. The ends of the wire were attached to the commutator. The power supply and rotating coils were connected by brushes used by the commutator to further activate the armature coils [7].

The visual of a DC Geared motor used in this project is shown in Figure 4. An integrated motor and gearbox were known as a gear motor. A motor's speed decreases but its output of torque increases when a gearbox is added. The most important factors for gear motors are speed (rpm), torque (lb-in), and efficiency (%).

Figure 4: DC Geared motor by [7]

v. L293D Motor Driver Shield

The L293D is a dual-channel H-Bridge motor driver that can operate either one stepper motor or two DC motors as shown in Figure 5. The shield can control up to four DC motors or two stepper motors because it comes with two of these motor drivers. Contrarily, the 74HC595 shift register connects two L293D chips' eight-direction control pins to the Arduino's four digital pins. A motor voltage range of 4.5 to 25 volts is supported by the shield. The Arduino can use this power together or independently. A special jumper with the label PWR is situated close to the two-terminal power connector and was used to select between the two. When the jumper is set, the motors receive power from the Arduino DC power connection. The motors and Arduino in this situation were not physically separated from one another. The shield was easy to use with this method since it only needed one power source. However, it can only be used this way when the motor supply voltage is less than 12V. The motors can be physically isolated from the Arduino when the jumper is removed, which also disconnects the motor power from the Arduino. The two-terminal power connector marked EXT_PWR must, however, be powered separately in this situation.

Two 5-pin screw terminals marked M1, M2, M3, and M4 serve as the output channels of both L293D ICs and were separated to the edge of the shield. These terminals can support a total of four DC motors with a voltage range of 4.5 to 25 volts. The module's channels can each deliver a maximum of 600 mA (1.2A peak) current to the DC motor. However, the capacity of the motor power supply determines how much current is sent to the motor. Two stepper motors can alternatively be connected to the output terminals. M1-M2 and M3-M4 work to connect the two stepper motors, respectively. Connect the center tap wire to the center ground terminal of a 5-wire unipolar stepper motor. Two 3-pin headers, which were used to connect two servo motors, receive the shield's 16-bit PWM output lines. Unfortunately, the 5V supply of the Arduino was used to directly power the servo motors, which is normally not a good choice. By doing this, it can risk damaging the Arduino's internal 5V regulator and adding electrical noise to the 5V supply. It does have a 100uF capacitor on these power pins, which is good and somewhat helpful.

A pulldown resistor array was built into the shield to prevent motors from turning on during power-up. The onboard LED shows the correct operation of the motor power source. If it is not lit, the motors won't operate. The reset button on Arduino was simply referred to as RESET. It has been elevated to the top for convenience. In the bottom right corner were six analog pins (A0 to A5) and connections for ground and 5 volts. These can be filled with headers, which makes them helpful for connecting different sensors [8].

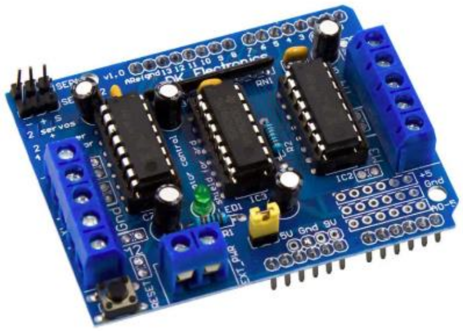


Figure 5: L293D Motor Driver Shield [8]

2.2 The System Working Process

The following flowchart describes how the system works:

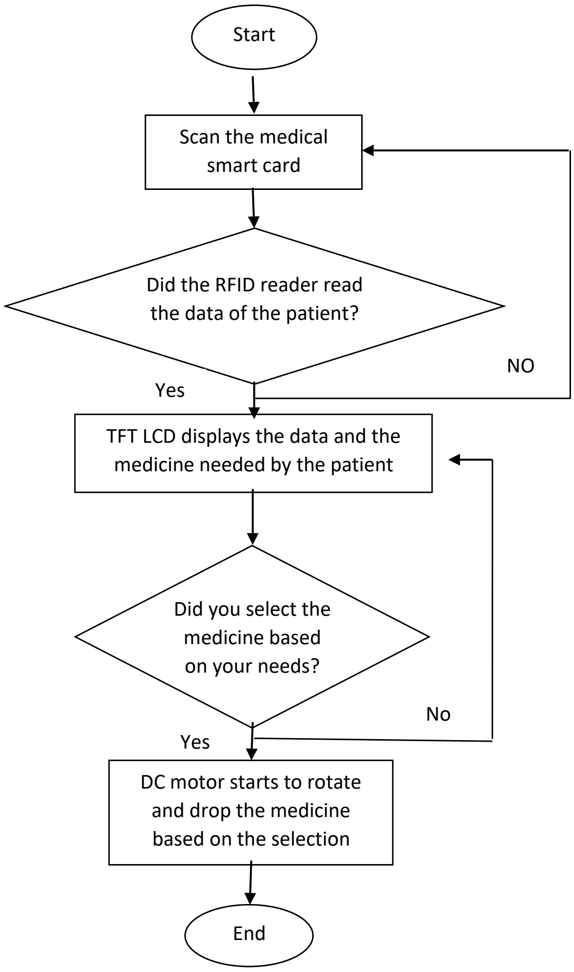


Figure 6: Flowchart of the working flow of the product

The product's working flow is represented in Figure 6. When the RFID reader reads the smart medical card, the product begins to work. The TFT LCD will then show patients' details and a list of the medications they require when the RFID reader has read the data. The process will repeat with the card reader portion if the data cannot be read. The patients need to select the appropriate medication based on their needs after the TFT LCD has displayed the list of medications. The DC motor will then begin to rotate in the direction of the selected medication. The patients can take the medication once it falls into the drop box area. The operation comes to an end at that point, afterwards, it will begin once more at the beginning.

3. Results and Discussion

In 14 weeks, this semester, the outcome that could be reached was the finding of the fundamentals and developing the prototype based on the objective and scope of the project. Based on past research, the components needed for this product had been decided which are Arduino UNO and Arduino mega 2560 as the microcontroller, and the RFID module as the smart access of the vending machine to control the medicine taken by the patients. Additionally, the DC geared motor also will be used in this project as a tool to drop the medicine from the medical shelf provided in the machine. Last but not least, the medium of the GUI application that allows the machine to interface with humans is a TFT LCD.

3.1 Results

The combination coding below used the “Uart” method which is used to combine two or more controllers in one system. Using this method, the coding will be divided into three part which is for RFID, MOTOR, and TFT LCD Display. This coding will be called master code and slave code where the master code is the main controller and the other two controllers will receive the input from the master controller and work on the command provided.

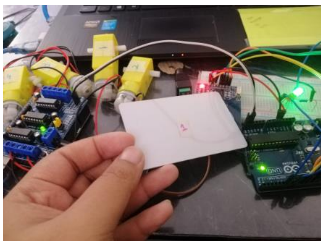
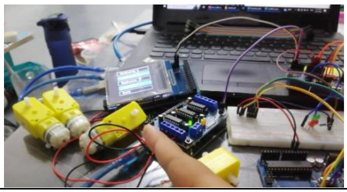
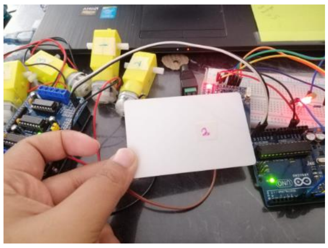
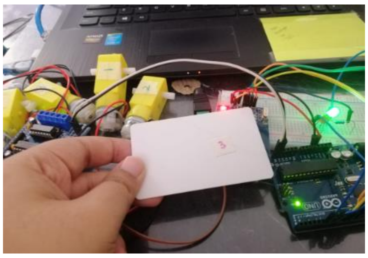
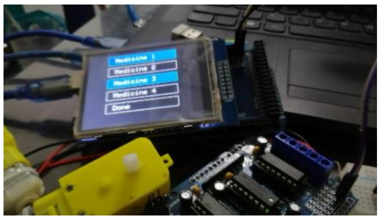
3.2 Discussions

Based on the prototype that had been developed, there is a lot of improvement that can be added to increase its functionality and competence. The medical dispenser can be made more user-friendly, and flexible, effectively serving a larger range of users, and secure by making the recommended improvements. Following are some suggestions for future improvement:

i. The card system may be replaced by the thumbprint identification system. In modern technology, the RFID and TFT system may cause some difficulty for the elderly to use it. The thumbprint system also has some pros and cons for certain people but it will make the system easier for the elderly.
ii. The motor system in the medical dispenser system can be improved from the spring system to the rail system where it can serve the medicine in more secure ways than just drop the medicine. Using this method, the medical dispenser can provide more types of medicine such as the liquid, and bottled type of medicine instead of just in a stripe form.

Table 1 shows that the combination of the microcontroller works successfully. The motor moves based on the data given by the RFID reader. As shown in the picture above, when the RFID reader reads card no 1, the LED green will turn on for 3 seconds, motor numbers 1 and 4 will move for a second and the TFT LCD will display Buttons 1 and 4 ON. If card no 2 is detected, the red LED will be on, motor numbers 2 and 3 will move for 2 seconds and TFT LCD will display Buttons 2 and 3 ON. Lastly, if card number 3 was reared, the green LED will be ON, motor numbers 3 and 4 bill move and TFT LCD will display Buttons 3 and 4 ON.

Table 1: System combination test's result

No of card	RFID	DC MOTOR	TFT LCD Display	Outcome	Overview
1	LED Green ON for 3 seconds and OFF	Motor 1 and 4 move for 2 second	Buttons 1 and 4 ON	TRUE	 
2	LED Red ON for 3 seconds and OFF	Motor 2 and 3 move for 2 second	Buttons 2 and 3 ON	TRUE	 
3	LED Green ON for 3 seconds and OFF	Motor 3 and 4 move for 2 second	Buttons 3 and 4 ON	TRUE	 

3.3 Complexity of Project

To overcome the complexity of constructing the prototype, the development and implementation of this project need to handle numerous challenges and complicated components. A lot of research and testing sessions are needed to get an understanding and archive the system demand.

One of the most challenging aspects of this project was to develop the coding for each system, especially for the TFT LCD. This component required a lot of commands to make is display based on the demand. Besides, it also used a lot of unfamiliar coding that was not used in other components. To develop the coding based on the project demand, a lot of research from previous projects had been done. Moreover, many types of libraries were needed to make it function.

After the development of coding for each component used in this project was complete, all the coding needed to be compiled into one main coding which is used for the overall system. However, in this project, the motor's system used an L293D DC motor drive as the controller and it used the whole Arduino UNO to make the system work. Because of that, UART serial communication had been developed in each coding to make all of the component systems work in one main system. UART stands for Universal Asynchronous Receiver-Transmitter and is frequently used for serial data transmission. In this case, the microcontroller attached to pin A5 would take on the role of the transmitter (TX), transmitting data to the receiver (RX), the microcontroller connected to pin A4. The UART protocol is used by the two microcontrollers to exchange data through a serial connection. Using this communication, some of the coding needs to be changed to make it suitable for the communication system.

4. Conclusion

The design and development of a graphical user interface (GUI) in a medical dispenser with smart card access were completed by using Arduino UNO as the microcontroller, RFID reader and TFT LCD as the input data, DC geared motor as the output of the project and L293D as the DC motor drive.

The prototype has been tested by the capability to provide medicine in a short time which is expected 10 minutes per person. Besides, the accuracy of the prototype to work based on the data entered also had been tested. From the data discussed in the previous chapter, the results show that the prototype can work smoothly and can provide the medicine in a short time which is less than 10 minutes. This shows that the prototype already archives the objective of the studies.

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