An-Najah National University

Faculty of Engineering and Information Technology

جامعة النجاح الوطنية

كلية الهندسة و تكنولوجيا المعلومات

Graduation Project Report II

ML Store Box

BY

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DISCLAIMER

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ABSTRACT

This project aims to design a self-storage system that people use to deliver products safely and easily to the nearest location to the user. Delivering and receiving packages is always a waste of time, effort, and expensive due to the need to deal with delivery companies that need 2 to 3 days to deliver your product even if it is in the same city. With this machine, users can automate this process, saving time and effort, and making sure that their package will not be lost or delivered to another customer by mistake.

The system is designed to include essential features such as monitoring the temperature of each food parcel to ensure proper storage, measuring the weight of each parcel to meet predefined standards, and implementing robust security measures to protect the parcels. Additionally, it streamlines the payment process to ensure smooth financial transactions. These aspects are crucial for maintaining the quality and integrity of food parcels, thereby ensuring customer trust and satisfaction.

The main objectives of this project are to Increase order-picking productivity, Enhance accuracy and reduce errors, Improve employee motivation and satisfaction through performance-based incentives, Ensure the quality and security of food parcels during storage and delivery, and Facilitate the delivery of parcels in our Palestinian community.

The system consists of shelves dedicated to storing packages. The delivery person places the package on one of the designated shelves, and then a notification is sent to the user via their phone or email.

The user goes to the package storage location, The user enters the barcode for their order on a device at the site, The system automatically opens the shelf containing the order, and The user takes their order.

1. INTRODUCTION

1.1. PROBLEM

In this modern era of e-commerce, uncountable amounts of parcels are increasingly seen being delivered each day. It is not uncommon for a delivery driver to handle 200 + today's delivery packages per day and therefore customers want quick and accurate delivery of their orders. Although, in Palestine, this is not always efficient. There is no clear street system and more often than not, parcels get delivered at the wrong address.

Most often than not, the delivery man has to deal with customers being away when he delivers the order, adding on to more time wastage. Not even telephone instructions enhance solvency of this problem, which is annoying to both the delivery man and the customer.

To improve the dynamics of this process, this project addresses a public storage system. These lockers will ensure that parcels have a safe and yet easy to access storage more so to its owners. Since the lockers will be installed on hot spots, collections can be done by the customers at their own convenient times avoiding late deliveries and inaccurate addresses.

1.2. OBJECTIVE

This project introduces the public storage system in Palestine, to address the various challenges of the current delivery process, so There are many objectives to this project, which include:

- **ACCURACY:**

  Using the system of public storage, the deliveryman does not have to call the customers numerous times to find his place. Customers can easily pick up their parcels from the box that has been allocated to their parcel.

- **SECURE STORAGE:**

  The system will ensure the security of the parcel storage in the storage box. Customers use a PIN to access their parcels, and proper closure of the locker is highlighted to ensure the safety of retrieved parcels.

- **AVAILABILITY:**

  The project aims to allow customers to collect their parcel from the public storage

box at their convenience time, which gives the customers flexibility unlike the conventional method, which require the customers to present at home during the specific delivery time.

- **EFFICIENT ROUTE PLANNING:**

By implementing this system, the deliveryman can efficiently plan his route, leading to saving time, money, and environmental emissions.

- **ENVIRONMENTAL IMPACT:**

When the deliveryman optimizes his route and drops the parcel at the public storage box, this will contribute to the reduction in Carbon emissions and save the environment.

- **ENHANCED FEATURE:**

While the idea of this project has been implemented in different countries around the world, it aims to introduce enhanced features and make improvements to the overall functionality of the system.

TIME SAVING:

The deliveryman has to take the parcel from the retailer and place it in the public storage box, which is in an easy and accessible location, and he does not need to spend excessive time searching for the right destination.

1.3. SCOPE OF THE WORK

The “ML Storage Box” project will design the whole system needed to operate the functionality of the project and help the deliveryman to safely deliver and secure the parcel at the public storage box. For the customer, he will have the flexibility in receiving the parcel and getting his order safely as well. This includes the following steps:

1. Design the public storage box.

2. Programming the microcontroller system for managing the system.

3. Integration of hardware and software components to control parcel access, PIN verification, and payment processing.

5. Create a real carousel storage system with three shelves that hold three parcels.

6. Make sure that clients and delivery staff can easily access the system.

7. Provide distinct sections for food and regular packages in the system, along with extra space for things that are sensitive to temperature.

8. Implementation of a PIN verification system to ensure secure parcel retrieval.

1.4. IMPORTANCE

The Carousel Storage System project is significant because it improves the efficiency and security of parcel deliveries, particularly in places where locating addresses can be challenging. Instead of delivery workers spending time looking for houses or worrying about customers not being home, this system lets them store parcels in a secure central location that can be accessed at any time. Customers can retrieve their packages at their convenience by using a secure PIN code, and the use of RFID and other technologies ensures that everything is kept safe and organized. This system also helps minimize unnecessary driving, reducing carbon emissions and making deliveries more environmentally friendly.

1.5. REPORT AND ORGANIZATION

This report highlights the process of the research and the practical side of creating the public system of store box “ML Store Box”. Therefore, the report will consist of the following parts which are:

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Chapter 1: is the introduction chapter It states the importance of the project, the objectives, the Scope of the project, and its importance.

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Chapter 2: is The literature review, projects, and articles from around the world will be further investigated to learn more about how this project was implemented what was their recommendations, and what enhancement features can be added.

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Chapter 3: is the methodology chapter, which outlines what was followed to create the system, and it discuss the constraints and limitation faced by the project.

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Chapter 4: is the result and discussion, it investigates the final result of the project and what was the outcome.

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Chapter 5: is the conclusion and recommendation, it highlight the conclusion of the project and suggest recommendation for any further research and projects.

2. LITERATURE REVIEW

Similar projects around the world have been studied and analyzed; this chapter investigates various literature review to study what mythology was followed, what was the final result, and what are the recommendations?

2.1.Multi-objective Optimization of Carousel Storage Systems (Aminzadeh & Ng, 2020)

This paper looks into developing further optimization techniques that would be applicable to carousel storage systems so as to increase energy efficiency as well as the retrieval times. In this research, energy efficiency and speed of retrieval of items within the carousel system are addressed using multi-objective optimization methods. Carousel systems particularly which are built to turn around in order to bring items to a certain point, have problems of achieving both these aims particularly in space constrained high operational demand environments. The authors propose different optimization solutions and frameworks for carousel system performance enhancement in terms of energy absorption reduction and retrieval time minimization. These findings especially matter for your project, because they give useful methods of improving the performance and the efficiency of extra carousel storage systems.

2.2 Shuttle-Based Storage and Retrieval Systems (SBS/RS) Performance Analysis (Hu, Zhou, & Zhang, 2017)

The study concentrates on shuttle-based storage and retrieval systems where shuttles act as carriers of items from storage spaces to retrieval points and in the opposite direction as well. The paper also evaluates the extent to which different shuttle configurations affect system performance in terms of travel time and effectiveness among others.

There are many Key Contributions. First, Performance Metrics ,the researchers carry out an analysis on the implications of shuttle variations with regards to performance metrics particularly travel times and throughput.

second,Simulation Models: The paper advocates for the use of simulation based models in performance evaluation of the system, using different design configurations so as to enhance a more realistic approach to performance evaluation.

Travel Time Optimization: Several approaches aimed at reducing travel time in the system are put forth. Since this is one of the crucial points when it comes to increasing the overall retrieval speed, a number of methods on the other hand are proposed to shorten the travel time.

Although our system utilizes a carousel instead of employing shuttles, all of the improvement measures and performance evaluation criteria provided are of relevance. There is no reason why the structure and operation of our carousel should not be worked out, if even shuttle designs and modes of use are understandable.

2.3. LAST MILE DELIVERY SOLUTIONS AND SMART LOCKER TERMINALS (FAUGERE & MONTREUIL, 2016)

The paper shows how increasing growth in e-commerce and demand for timely, efficient, and reliable last-mile delivery solutions have favored Smart Locker Terminals as a promising solution to improve last-mile delivery efficiency.
Smart Lockers are easily accessible and centrally placed in various public places, hence providing customers with an efficient pick-up option for their parcels. According to this literature, Smart Locker Terminals would decrease delivery attempts, congestion, and emission. Consumers can benefit from having their shipments in lockers located near them.
who benefit through increased flexibility in choosing where and when to pick up their packages.
This value comes to the logistics provider through a reduction in unsuccessful delivery attempts and route planning optimization .
The retailers face an opportunity to create further efficiencies in logistics and possibly bring down costs in shipping. Researchers have also investigated using Smart Locker Terminals integrated with the Hyper-connected City Logistics for efficiency and sharing of resources. Use of Hyper-connected Modular Containers-PIContainers introduces
From there, another layer of efficiency follows: real-time communication and tracking of goods.
Literature points to gaps and opportunities that could lead to further investigation in

identifying the perfect location of lockers to ensure access and ease to consumers.
In this regard, future research will explore the possibility of integrating emerging technologies, such as blockchain, to enhance the security and transparency of the Smart Locker Terminal.

3. METHODOLOGY

3.1. HARDWARE COMPONENT

3.1.1. Microcontrollers

ARDUINO MEGA 2560:

Arduino Mega has 54 digital input/output pins, 16 analog inputs, 4 hardware serial ports, a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started (Arduino, Mega 2560 Rev3, 2023).

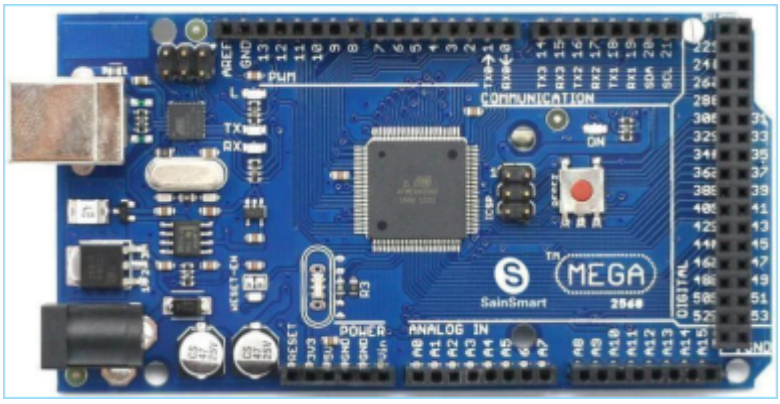


Figure 3.1:1 Arduino Mega 2560

ESP32-WROOM-32:

ESP32 microcontroller was used in the project to store and retrieve data from Firebase since Arduino Mega is not able to connect with the internet so a serial communication was established between ESP32 and Arduino Mega as shown in Figure 3.1:2 below.

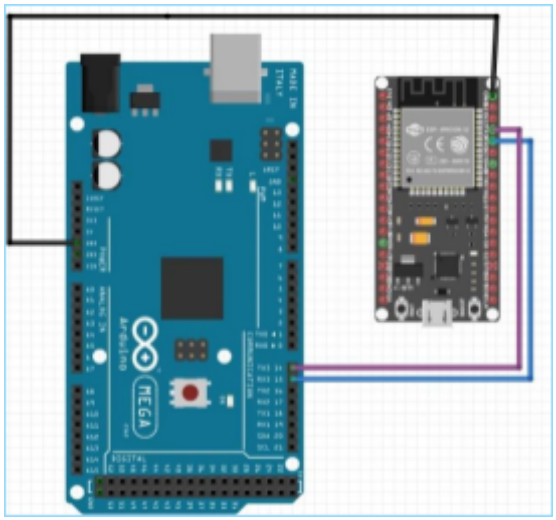


Figure 3.1:2 Serial Communication between ESP32 and Arduino Mega

However, the above connection could destroy ESP32 since Arduino Mega operates on 5 volts and ESP32 operates on 3.3 volts so to make it compatible with Arduino Mega a voltage divider was made to avoid any damage to ESP32 as shown in 3.1:3 below. (Hacker, 2021)

[1] It is an intuitive, visual programming environment that allows everyone to build fully functional apps for Android phones, iPhones, and Android/iOS tablets.

3.1.2. Motors and Drivers

STEPPER MOTORS:

Stepper motor is an electromechanical device that converts electrical power into mechanical power. Stepper motor use a cogged wheel and electromagnets to rotate the wheel one step at a time, each high pulse sent energizes the coil, attracting the teeth closest to the cogged wheel and driving the motor one step forward each time. The sequence of pulses determines the spinning direction of the motor, the frequency of the pulses determines the speed of the motor, and the number of pulses determines how far the motor will turn. Stepper motor was chosen due to its speed control, precise positioning, and repeatability of movement. To implement this project two-stepper motors needed one to control movement in the X-axis and the other to control movement in the Y-axis. (Earl, 2023)

YS-DIV268N DRIVER:

The YS-DIV268N driver is a specialized electronic component used to control and manage the operation of the stepper motor, since Arduino mega could provide up to 5 Volts only and the Stepper motor requires around 12 volts and at least 1.2A two drivers were used to accomplish this job since two stepper motors required in this project. (patrickNX9420)

Figure 3.1:5 YS-DIV268N-5A Driver

3.1.3. Sensors

INFRARED SENSOR (IR):

IR sensor is an electronic device that measures and detects infrared radiation in its surrounding environment with spectral sensitivity in the infrared wavelength range: 780 nm … 50 µm. (Jost, 2019)

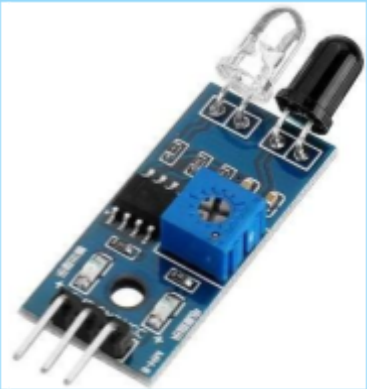


Figure 3.1:12 IR Sensor

Load Cell:

A load cell basically is used as a sensor for forces and weights. The Strain gauges or any other mechanism applied to a mechanical force will be converted to an electric signal, which is further processed for the calculation of the applied force.

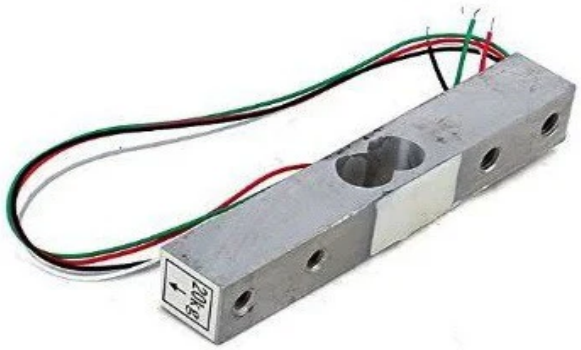


Figure 3.1:13 laod cell

HX711 Amplifier:

The HX711 is an operational amplifier especially designed for load cell applications, with high-resolution and low-noise measurements and with built-in excitation for the load cell. Its I2C interface makes it very straightforward to use in projects.

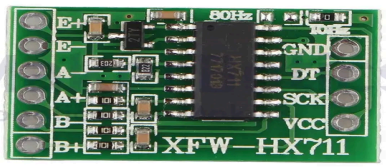


Figure 3.1:14 HX711

2-CHANNEL RELAY:

A compact and efficient device that empowers users to control and switch four separate electrical circuits using a single control signal. This makes it an ideal component for projects requiring versatile and centralized management of various high and low-voltage devices.

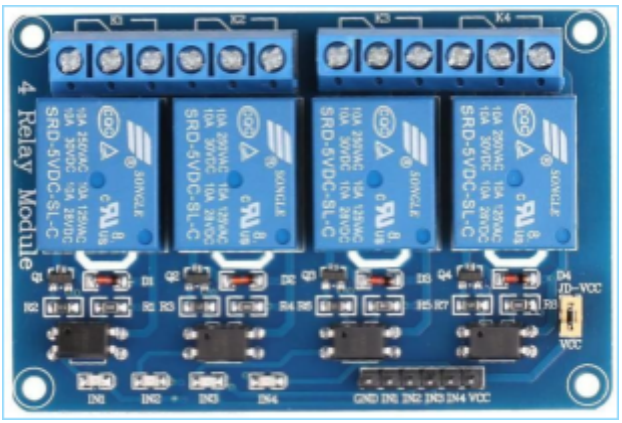


Figure 3.1:15 4-Channel Relay

DHT11 Temperature and Humidity Sensor

The DHT11 is a low-cost, digital sensor that measures both temperature and humidity.

measures both temperature and humidity. It's a simple-to-use device that communicates over a single-wire interface. The DHT11 provides relatively accurate readings, making it suitable for various applications like weather stations.

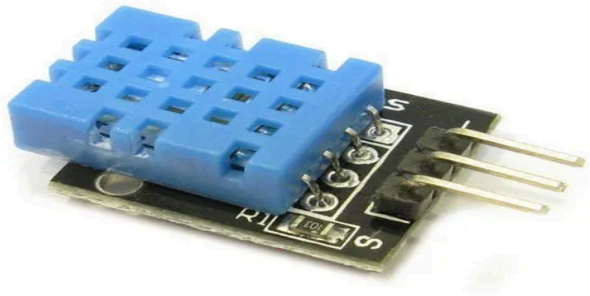


Figure 3.1:16DHT11

LIQUID CRYSTAL DISPLAY (LCD):

LCDs are used to display information from Arduino or keypad or any sensor connected to it. There are two different types of LCDs available: graphical and character LCDs. In this project, a 20×4 character LCD was used (20 columns and 4 rows). A potentiometer is also needed to adjust the contrast of the LCD Figure 3.1:18 shows the complete connection. (Sanjeev, 2018)

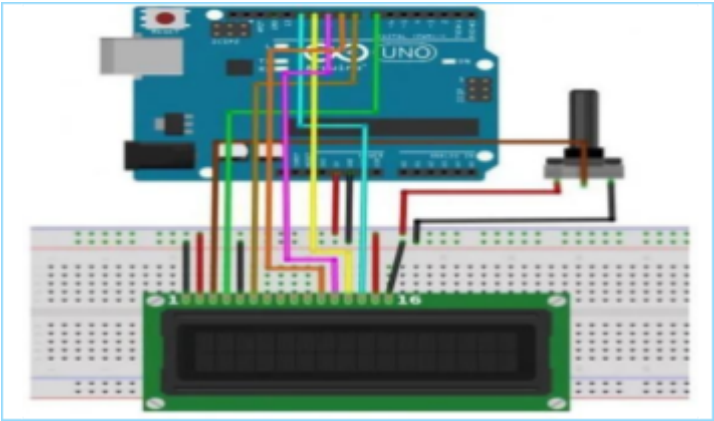


Figure 3.1:18 LCD Connection with Arduino Mega

KEYPAD:

The 4×4 matrix keypad is an input device; it is usually used to provide input value in a project. It has 16 keys in total, which means it can provide 16 input values, and it uses 8 GPIO pins of a microcontroller. In this project, a keypad was used to allow users to enter their information Figure 3.1:19 shows a keypad connection with Arduino Mega.

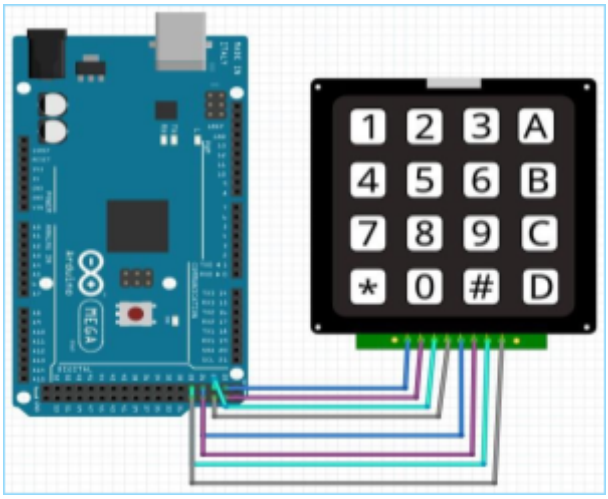


Figure 3.1:19 Keypad Connection with Arduino Mega

RADIO FREQUENCY IDENTIFICATION (RFID):

In simple words, an RFID uses electromagnetic fields to transfer data over short distances. RFID is useful for identifying people and making transactions; the RC522 RFID reader module is designed to create a 13.56MHz electromagnetic field and communicate with RFID tags. (Arduino, What is RFID? How It Works? Interface RC522 RFID Module with Arduino)

Figure 3.1:20 RFID Module

RFID was used in this project to let users pay for their parcels when they receive them, Figure 3.1:21 shows a connection with Arduino Mega.

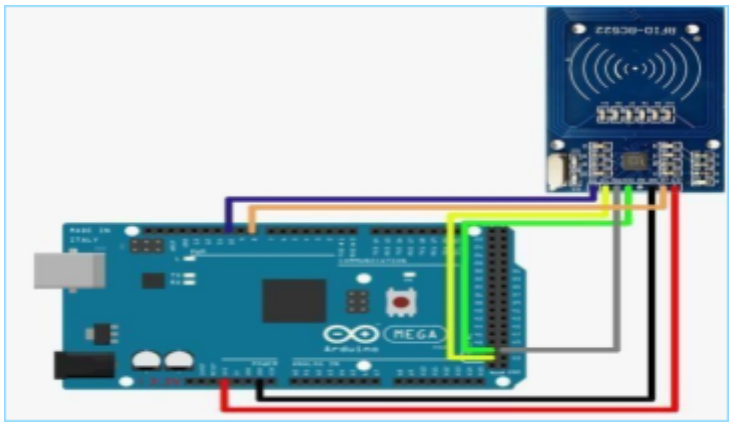


Figure 3.1:21 RFID Connection with Arduino Mega

GSM MODULE SIM800L:

The SIM800L GSM module is a miniature GSM modem that can be used in a variety of IOT projects. This module can be used to make calls to phones or send SMS messages. In this project, this module was used to send SMS messages when a parcel was placed in one of the lockers. The operating voltage of the chip ranges from 3.4V to 4.4V so a DC-DC converter is also needed here you can see Table 2 for the connection map. (Arduino, Send Receive SMS & Call with SIM800L GSM Module & Arduino, 2020)

Figure 3.1:24 SIM800L GSM Module

3.1.4. Different Items

Tec1-12706:

TEC1-12706 is one type of thermoelectric coolers, also known as Peltier coolers. The principle of its work is a transfer of heat from one side to another using electricity: the one side will be hot, and the other one will be cold. On the other hand, it can also generate electricity if there is a supply of heat. In this project, the TEC1-12706 has been used to serve the purpose of heating food parcels in order for them not to lose their temperatures during storage or transportation.

Figure 3.1:23 Tec-12706

BREADBOARD AND PCB BOARD:

To connect various components, such as the GND, 5-volt, and 12-volt power supplies, to devices that need these voltages, we used a breadboard.

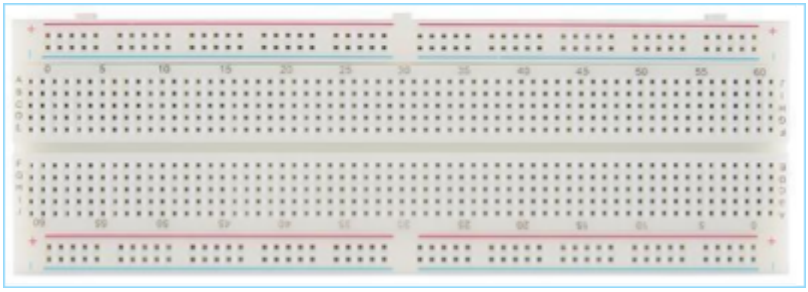


Figure 3.1:24 Breadboard

Relay one chanel:

One-channel relay is a device which operates electrically and allows driving of a high-powered device, like a motor, from a low powered signal of a microcontroller or other device. A one-channel relay in your project drives a wiper motor by allowing its on/off operation via low-powered control signals safely from your system to operate the motor smoothly in moving parcels.

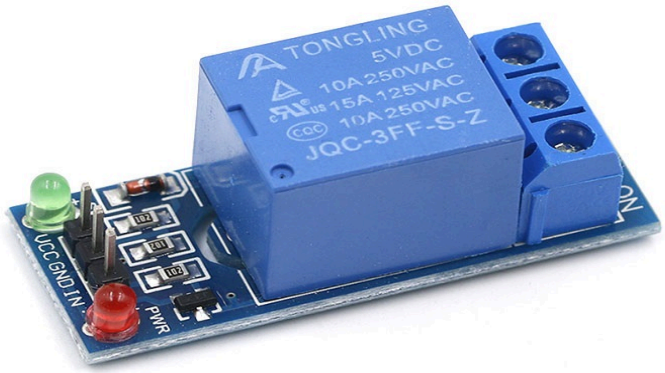


Figure 3.1:25 Relay one channel

Wiper motor:

A wiper motor refers to a small and high torque electric motor, which most automobiles widely apply to actuate windshield wipers. It provides controlled motion in a back-and-forth style. the wiper motor in turn will be used to move the parcels, probably imparting the required force to turn or shift portions of the storage mechanism to correctly place an item.

Figure 3.1:26 wiper motor

WIRES:

A variety of connections was made using four types of wires: Electrical wire, male-to-male, female-to-female, and male-to-female.

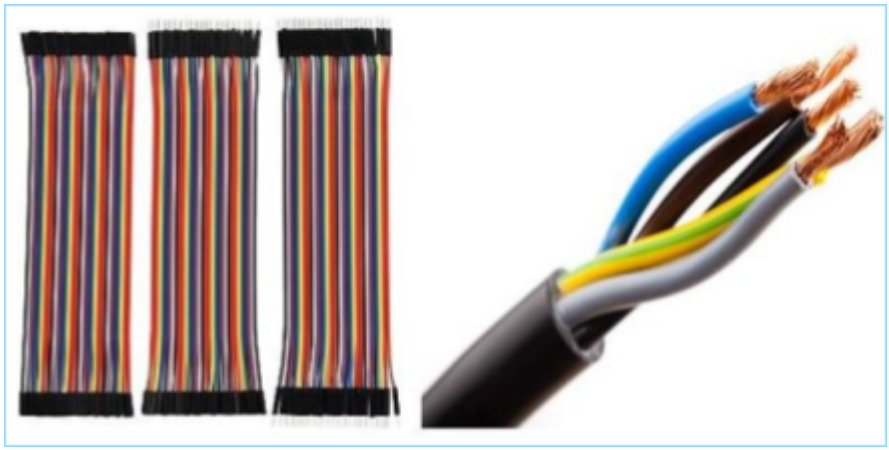


Figure 3.1:27 Different Types of Wires

POWER SUPPLY:

Since multiple devices operate at 5 and 12 volts, a computer power supply was chosen to meet voltage requirements. The power supply also provides enough current to meet the needs of this project.

Figure 3.1:28 Power Supply

3.2. SOFTWARE IMPLEMENTATION

3.2.1. Libraries:

· Liquid Crystal Library: Used to allow Arduino Mega to control what to display on LCD.

· Keypad Library: Used to allow Arduino Mega to use matrix style using keypad.

· Serial Peripheral Interface (SPI) Library: used by Arduino Mega to communicate with Radio Frequency Identification (RFID).

· MFRC522 Library: used by Arduino Mega to read data from RFID devices.

· Software Serial Library: used by Barcode Scanner to make serial communication with Arduino Mega using digital pins, since Barcode Scanner requires a speed of 115200 bps.

· Firebase ESP32 Library: used by ESP32 to read, store, and update data on Firebase.

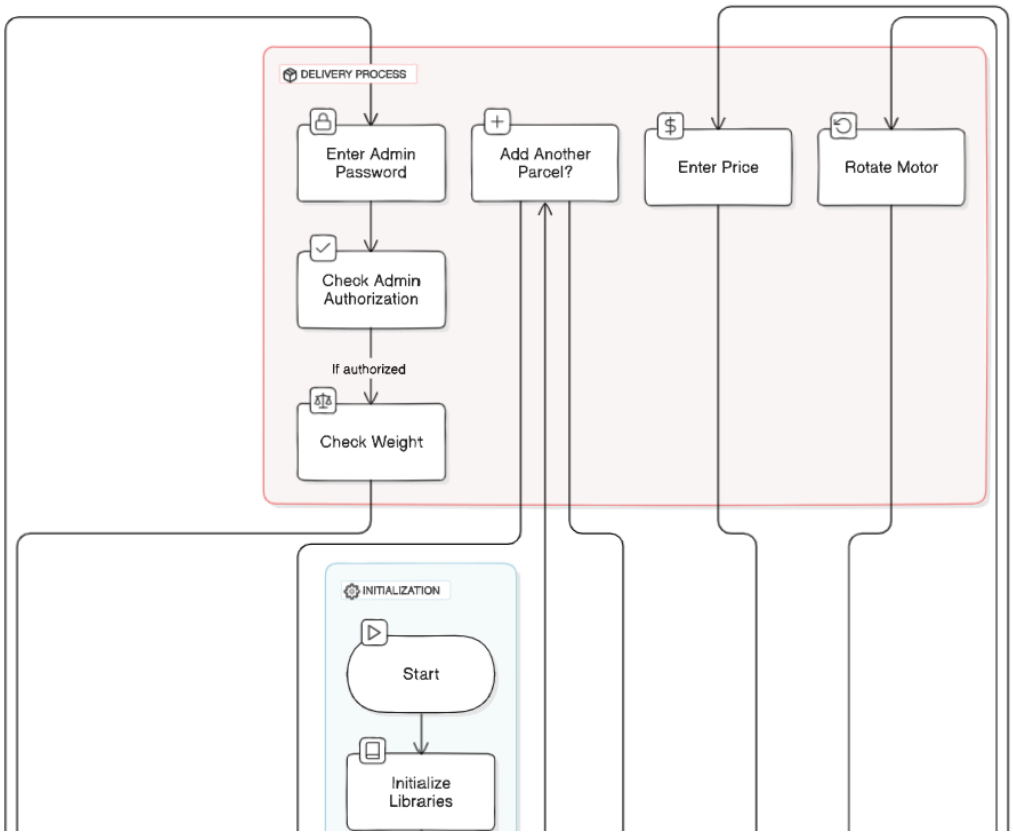
· Wi-Fi Library: used by ESP32 to connect it to the internet.

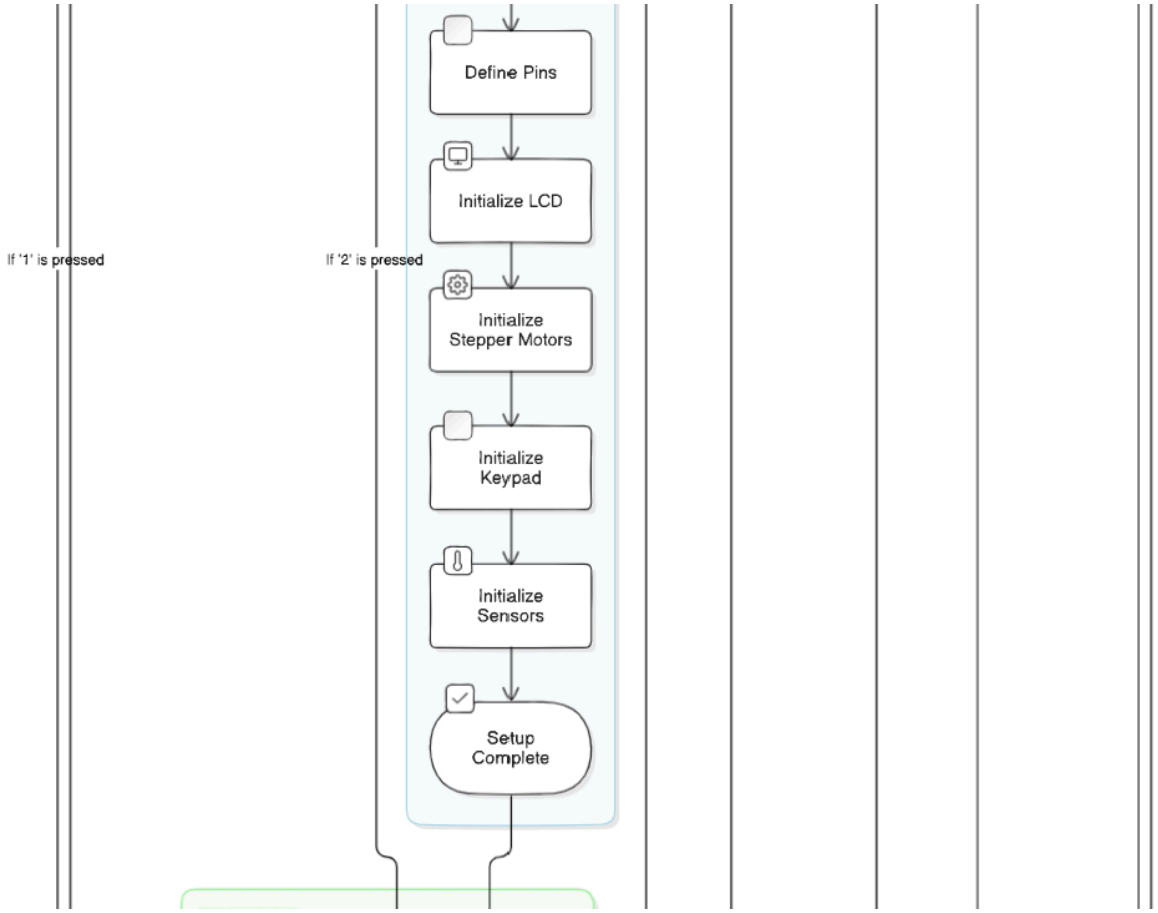
· HX711.h Library: used for load cell driver.

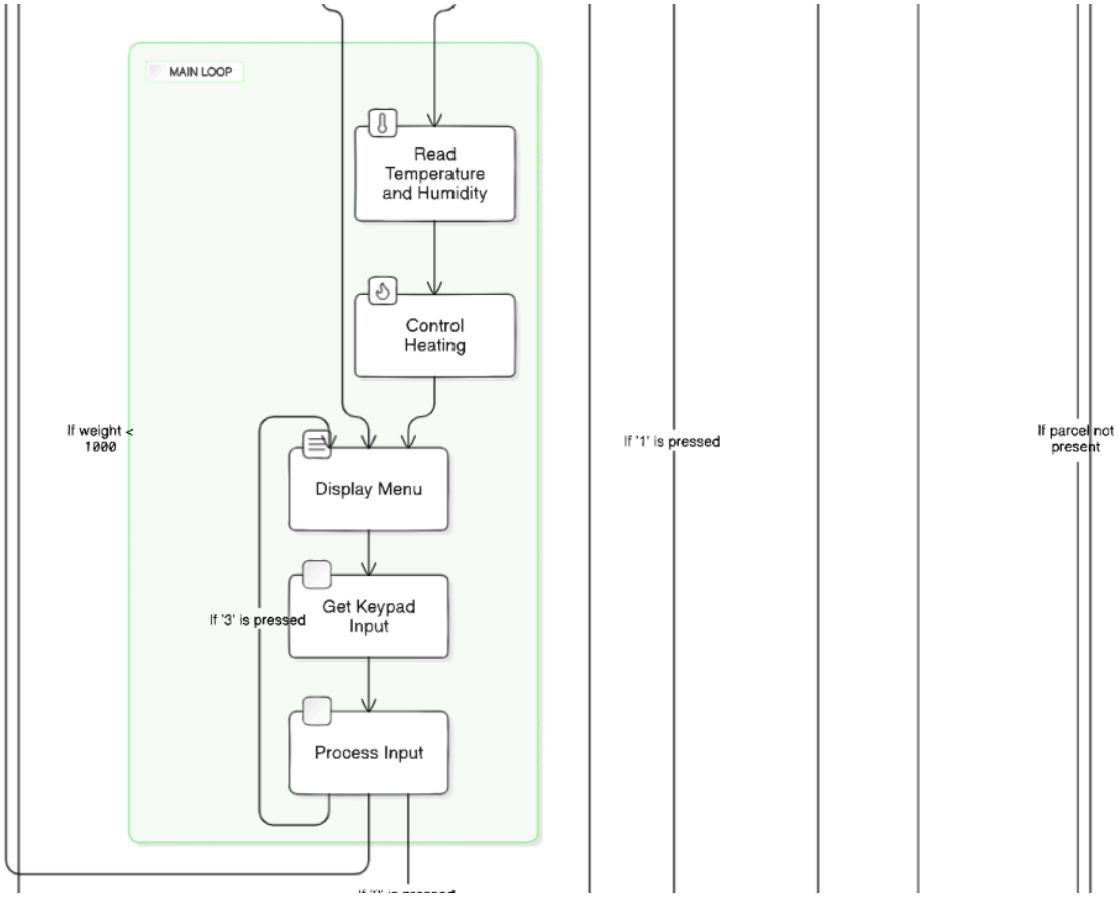
3.2.2. Flow Chart:

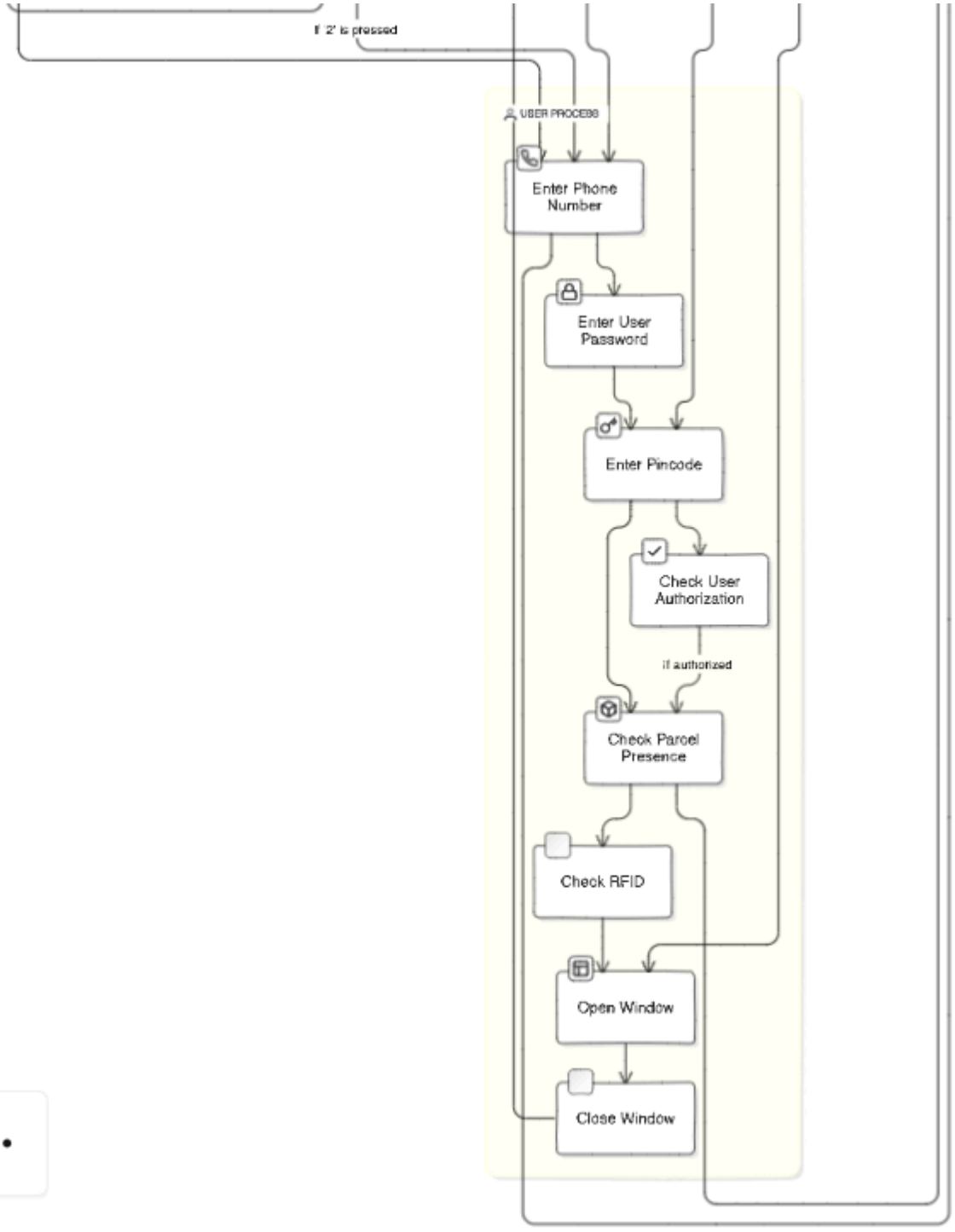
First, the user asked if he wanted to deposit a parcel or pick out a parcel. If he wants to put a parcel, he should select "1". After that, parcels are checked to make sure that at least one parcel is empty, and then the admin is asked to enter his password, if it correct he should put the package at the weight module to check out the package weight,if it suitable, he is able to add details , then the machine rotate for the desired shelf and then opens specific window where the package is , after some time , ir sensor check if the parcel is added or not ,if it is , it add it to the database and send sms to the user with the pin code of his package, and finally the window close if it is sensor sure that there is no hands there.

if he wants to pick up the package,he should select “2”.after that, he is able to enter his details, if it authorized, he is asked to check his card for payment, if it has enough money , he could take his package easily , safely and quickly.


DELIVERY PROCESS
Enter Admin Password
Check Admin Authorization
If authorized
Check Weight
Add Another Parcel?
Enter Price
Rotate Motor
INITIALIZATION
Start
Initialize Libraries

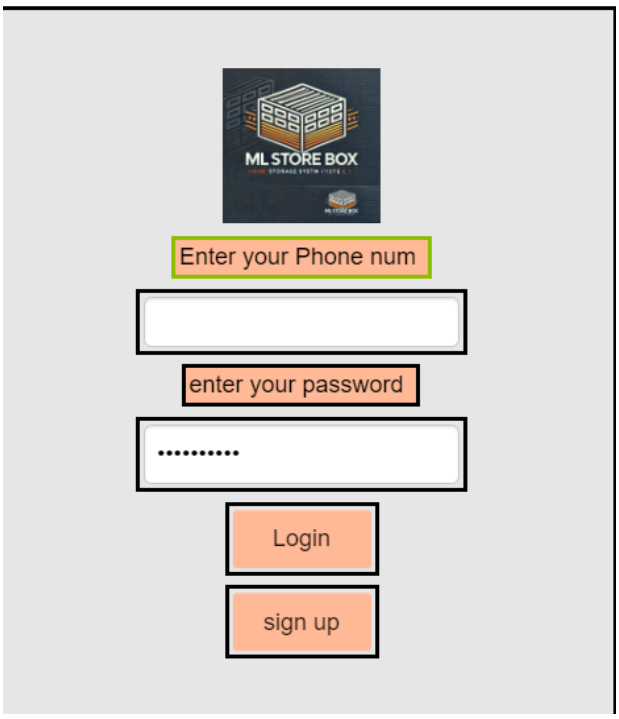

If '1' is pressed
If '2' is pressed
Define Pins
Initialize LCD
Initialize Stepper Motors
Initialize Keypad
Initialize Sensors
Setup Complete

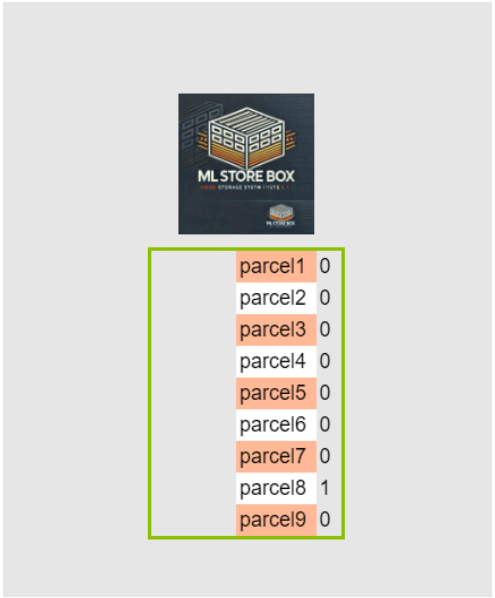

MAIN LOOP
Read Temperature and Humidity
Control Heating
Display Menu
Get Keypad Input
Process Input
If weight < 1000
If '3' is pressed
If '1' is pressed
If parcel not present

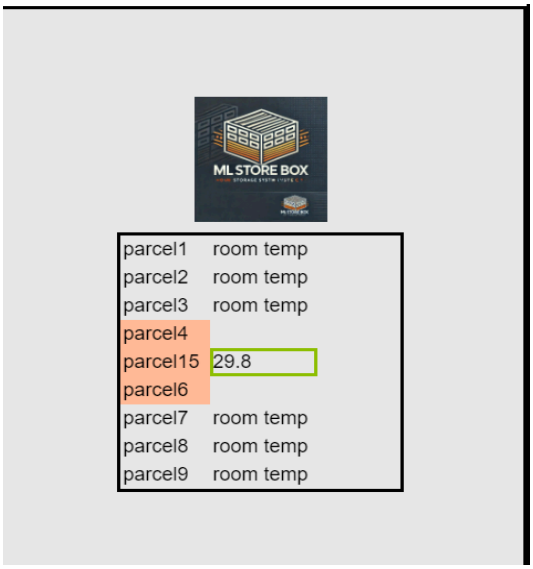

if '2' is pressed
USER PROCESS
Enter Phone Number
Enter User Password
Enter Pincode
Check User Authorization
if authorized
Check Parcel Presence
Check RFID
Open Window
Close Window

3.3. MOBILE APPLICATION

ADMIN PAGE:

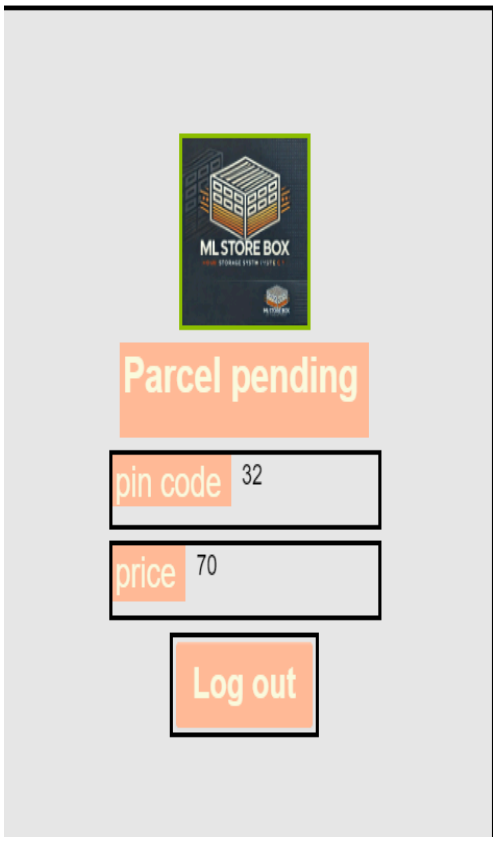


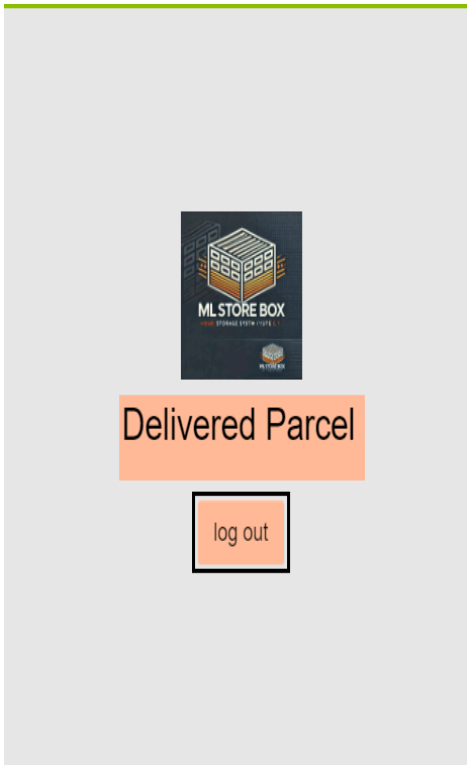




User PAGE:


ML STORE BOX
Enter your Phone num
enter your password
Login
sign up


ML STORE BOX
Parcel pending
pin code
32
price
70
Log out


ML STORE BOX
Delivered Parcel
log out

4. RESULTS AND DISCUSSION:

By the end of this project, we had successfully built an intelligent, automatic "ML storage box" with outstanding features-easy and secure payment and saving the time of recipients and deliverymen both. With the mobile application, the admin could show: send the parcels remotely, and if the package has been in the parcel for more than 10 days, the admin will call the owner of the parcel, and in case of no response, admin may take the package off the parcel.

some problems and how been solved:

1. At the first, the design and the calculations needed for the maximum weight possible for each basket, to keep the balance between shelves and baskets.Also,at first we used 3d printed gears ,which got broken just 2 weeks before, and we was forced, to replace all the design with more solid and durable one.

2. Providing power to the various components of the machine. Some required 5 volts, others needed 12 volts. We solved this by using a power supply from an old computer that provided both 5 volts and 12 volts and using the normal Electric converter and regulator.

3. Low signal problem with the GSM module SIM800L so we tried to change our location but that did not work.

4. Some of the components were working correctly but after adding another component they stopped working or worked in the wrong way, After careful consideration, we united the ground.

5. Using app inventor and making a connection with firebase , because it needs esp32 which has many problems and got damaged very fast.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. SUMMARY

This research will focus on the design of an automated self-storage system to ease delivery processes for parcels within Palestine. The delivery process within Palestine is usually plagued with non-clear addresses and customers not present at home. The system has been designed in a way that it makes the process easier and more reliable by automating both the storage and retrieval of parcels. Equipped with weight verification, temperature control for food packages, and secure pin code access, it will ensure that the packages will be kept safe but still be readily accessible. Notifications will reach the users, and an inbuilt payment system will smooth out the entire process. Such a system removes exactly this frustration of delayed or wrong deliveries and hence alleviates life and makes it more efficient both for the customer and the delivery driver.

5.2. RECOMMENDATIONS

1. Before connecting, read about each device to know more about it and to know how many volts each device needs.
2. Be careful when distributing currents and voltages.
3. Test each device separately and write its connection and its pins on the Arduino board to make sure that all of them working correctly.
4. Never just, connect wires, as they can easily break. Solder them instead.

5.3. WHAT WE HAVE LEARNED

1. How to work with sensors like IR, and motors like servomotors, and stepper motors.
2. How to connect and use various types of high-voltage devices and how to distribute currents and voltages.
3. How to connect Arduino to ESP32 and use its Wi-Fi features.
4. How to use ESP32 as a server for mobile applications and use MIT App Inventor to build quick mobile applications.

c5. How to work with GSM module SIM800L.

5.4. FUTURE WORK

1. Use material stronger than wood for more security.In addition to the tracking system with cameras, to make sure the machine is secure and safe.

2. add space for pet cages, in addition to being careful for the ventilation.

3. Adding frozen parcels could help on many sides such as:food and some medicines.

4.credit card payment and cash payment system.

5. barcode scanner for packages, and could add a small machine that generates barcode and sticks it at the package before storing it.

6. System to retrieve the current status of the machine in case of any power outage, after closing all windows.

7. fingerprint security system.

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