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**POLITEKNIK SULTAN ABDUL HALIM MUA’DZAM SHAH**

**SMART SHOE RACK**

**CHPNG KHENG CHEN**

**(03DET22F1043)**

**ELECTRICAL ENGINEERING DEPARTMENT**

**SESSION 2: 2023/2024**

****

**POLITEKNIK IBRAHIM SULTAN**

**POLITEKNIK SULTAN ABDUL HALIM MUA’DZAM SHAH**

**SMART SHOE RACK**

**This final report is submitted to the Electrical Engineering Department in fulfilment of the requirements for the award of the Diploma in choose a program**

**CHONG KHENG CHEN**

**(03DET22F1043)**

**ELECTRICAL ENGINEERING DEPARTMENT**

**SESSION 2: 2023/2024**

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| **PUAN HUBSAH BT HUSSAIN** | | ) | ……………………………… |
| (As a project supervisor at (date): …………… | | ) | **PUAN HABSAH BT HUSSAIN** |

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**AUTOMATED SHOE RACK**

ACKNOWLEDGEMENT

In preparing this project I have encountered and learnt so many new experiences. I would like to thank my supervisor, PUAN HABSAH BT HUSSAIN for his excellent advice, guidance, and motivation. I am also very thankful to my classmate, friends and other people that contributed to my project. Without their contribution, I won’t be able to finish my project on time.

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ABSTRAK

Rak Kasut Pintar, direka untuk merevolusikan pengurusan kasut di ruang tamu moden. Mengintegrasikan penderia dan sambungan IoT, penyelesaian inovatif ini mengautomasikan penyimpanan dan pengambilan kasut, menghapuskan pengendalian manual dan mengoptimumkan ruang. Pengguna boleh mengakses dan mengawal rak dari jauh melalui aplikasi telefon pintar, menerima pemberitahuan untuk item yang salah letak dan mendapat manfaat daripada analisis data untuk cerapan penggunaan. Rak Kasut Pintar menjanjikan bukan sahaja kemudahan dan kecekapan tetapi juga persekitaran yang bebas kekacauan, merangkumi pendekatan futuristik kepada penyelesaian penyimpanan yang disesuaikan dengan gaya hidup bandar kontemporari.

ABSTRACT

The Smart Shoe Rack, designed to revolutionize shoe management in modern living spaces. Integrating sensors, and IoT connectivity, this innovative solution automates shoe storage and retrieval, eliminating manual handling and optimizing space. Users can remotely access and control the rack via smartphone applications, receive notifications for misplaced items, and benefit from data analytics for usage insights. The Smart Shoe Rack promises not only convenience and efficiency but also a clutter-free environment, embodying a futuristic approach to storage solutions tailored to contemporary urban lifestyles.

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**LIST OF ABBREVIATIONS**

|  |  |  |
| --- | --- | --- |
| IoT | - | Internet of Things |
| IR | - | Infrared |
| OLED | - | Organic Light-Emitting Diode |
| GSM | - | Global System for Mobile |
| LED | - | Light-Emitting Diode |
| SMS | - | Short Messages Service |
| LCD | - | Liquid-Crystal Display |
| CH4 | - | Methane |
| CO | - | Carbon Monoxide |
| DC | - | Direct Current |
| UV | - | Ultraviolet |
| NO | - | Normally Open |
| NC | - | Normally Close |
| GPIO | - | General-Purpose Input/Output |

# INTRODUCTION

## Introduction

When using shoe cabinets, since traditional shoe cabinets are limited in their type, more and more problems are exposed. Low-type shoe cabinets have limited storage space and the space between the top and ceiling cannot be reasonably used. Suspended ceiling shoe cabinets are not easy to put shoes because of the height. As the number of shoes becomes larger, it will be difficult for the user to sort them out. Since the capacity of the shoe cabinet will not be able to satisfy the demand for storing shoes, the phenomenon of random arrangement will occur, which will seriously affect the cleanliness of the interior and inner beauty, and even lead to safety accidents. In the context of intelligence and home automation, to solve the problems of traditional shoe cabinets and meet people's needs for shoe cabinets, smart shoe cabinets have become the best option. The design and use of smart shoe cabinets has a huge market potential. Currently, most of the smart shoe cabinets on the market are expensive and have many disadvantages. For example, they simply expanded the shoe case room and used an automatic switch to open and close the shoe case door based on a regular shoe cabinet. Also, their functionality is simple and single. They simply designed an ozone disinfection shoe cabinet and deodorization with car shoe polish because they found the closed cabinet would produce a strange smell and meld. However, their products are fundamentally not able to solve people's pressing problems.

In this project, the smartphone uses a button to select a pair of shoes and remove them. It can also monitor how much space is left in the shoe rack to store how many pairs of shoes and will retain the moisture of the space in the shoe rack. The device uses the engine as an elevator using a power of 220 / 240 AC to remove shoes from the shoe cabinet. When the barcode sensor detects the user's shoes, it will push the shoe into the elevator until the elevator lowers the shoe.

The system serves as an excellent product for the convenience of people. This project is one of the solutions to help people use the new high technology using IOT (Internet of Things), which means people can control using smartphones that need to be connected to the internet.

Therefore, people's requirements for smart shoe cabinets are becoming increasingly stringent, and they hope to use simple, smart, and varied smart shoe cabinets.

## Project Background

In the ever-growing shoe industry, studies on the use of smart shoe racks in shoe stores are becoming increasingly important. The use of smart technology in shoe racks not only enhances the customer purchasing experience by providing the convenience of finding the desired shoes, product information, and fast checkout, but also helps shoe stores to attract more customers and improve operational efficiency with automated inventory monitoring. By aligning these initiatives with current technological changes, the shoe industry can continue to compete in a competitive business environment while delivering added value to customers.

## Problem Statement

Traditional shoe cabinets give rise to various limitations such as limited storage space, inefficient use of space, difficulties in sorting and sorting shoes, and potential hygiene and safety problems caused by the random arrangement of shoes.

Existing smart shoe cabinets on the market are expensive and often have limited functionality, such as simply automating the opening and closing of cabinet doors or providing basic shoe maintenance features. This solution fails to comprehensively address the diverse needs of consumers for a simple, smart and customizable shoe storage system.

Many traditional shoe cabinets do not have an effective organizational system, which leads to a cluttered display and the difficulty of finding a specific style, size, or colour of shoes. This inefficiency can prolong the shopping process and reduce the overall customer experience.

Falling Objects: Shoes arranged indiscriminately inside the cabinet may fall off when the seller's girl tries to pick them up, posing a risk of injury from falling objects.

Difficulties in Stock Management: The process of manually restoring and inventory management for traditional shoe cabinets can be time-consuming and error prone. Without an efficient stock monitoring mechanism, stores may experience out-of-stock or overstock situations, leading to loss of sales or excessive inventory costs.

To address this challenge, the project aims to design and develop smart shoe storage cabinets that automatically select, place, and arrange shoes in cabinets. The system uses a unified and the needs and available space. The goal is to provide solutions that maximize the storage capacity of shoes, optimize the use of space, improve user convenience, and maintain internal cleanliness and safety.

* Limited storage capacity and inefficient space usage.
* Difficulty in sorting and retrieving shoes, especially by style, size, or color.
* Hygiene and safety concerns due to disorganized shoe placement, leading to potential falling hazards.
* Manual stock management in stores is time-consuming and error-prone, often resulting in inventory issues (overstock or out-of-stock).

Existing smart shoe cabinets are expensive with limited functionality, focusing mainly on basic automation like opening doors. They fail to address the need for a smart, customizable, and efficient shoe storage system.

This project aims to create a smart shoe rack that automatically selects, organizes, and tracks shoes, providing a space-optimized, user-friendly, and iot-integrated solution.

## Project Objective

* **Modular Design**: Develop a customizable shoe storage system with a unified and expandable structure, allowing users to adjust modules based on space and needs.
* **User-Friendly Interface**: Provide a mobile app (via Blynk) that allows users to **remotely control** and retrieve shoes from the storage system.
* **Automation**: Automate the process of shoe storage and retrieval using a 3x3 grid system with 2 active compartments.
* **Barcode Integration**: Implement a barcode scanner for efficient shoe identification and placement.
* **IoT Control**: Utilize IoT technology via Blynk for remote operation, enhancing user convenience.

## Project Scope

* Focus on a 5-compartment system using a 3x3 grid.
* Utilization of stepper motors (X, Y, Z axes) for compartment navigation.
* Use of ESP32 and A4988 drivers to control motor movement.
* Integration of trigger switches for homing (0,0,0) axis detection.
* Blynk integration for remote control via mobile devices.

## Chapter Summary

Customer Experience Improvements: Smart shoe racks allow customers to find and access shoes more easily and quickly. This can improve the customer experience in the shoe store, allowing them to feel more comfortable and satisfied with the services provided. Increased Sales: With a more organized and easy-to-see arrangement, customers are more likely to find and buy the shoes they want. This can increase sales in shoe stores, providing economic benefits to businesses. Optimize Space: Smart shoe racks can better optimize the space in a shoe store. This can help store owners to use their space more efficiently, increasing capacity for storage and product exhibition. Innovation and Competitive Advantage: Through the implementation of smart shoe racks, shoe stores can demonstrate commitment to innovation and technology in their industry. This can help attract the attention of customers who appreciate such things and give them a competitive edge in the market. Marketing Analytics: Some smart shoe racks may be equipped with analytical technology that can collect data on customer favorites and behavior. This information can be used to streamline inventory, organize promotions, and improve marketing strategies. Time and Energy Reduction: With a smart shoe rack system, shoe store employees may have to spend less time managing shoe reorganization and repositioning. This can free up time and energy for other uses in the store or provide a more personalized service to customers. Inventory Accuracy: Using smart shoe rack technology, shoe store owners can manage inventory more efficiently and accurately. This helps to avoid the problem of overstocking or too little, saving costs and increasing customer satisfaction.

## Definition of Term or Operation

Sensors: A device used to track the position and availability of shoes in a rack. Sensors can be vibration sensors, light sensors, or distance sensors. Processing Device: A computer or microcontroller responsible for processing data from sensors and controlling storage rack functions, such as opening and closing shelves. Stock Management Software: An application or software system that manages in-store shoe inventory. It can include functions such as stock calculation, production tracking, and automatic inventory syncing. User Interface: An interface that allows users, whether customers or store staff, to interact with storage shelves. The user interface can be a touchscreen display, a mobile app, or a voice interface. Shoe Detection System: A system that allows customers to use smartphones to find in-store shoes. It can involve a mobile app that displays the location of shoes in a shelf using tracking or tagging technology.

## Expected Result

Improved Customer Experience: Smart shoe racks reduce shoe search time, increase customer comfort, and increase the likelihood of purchase. Increased safety: The use of smart shoe rack reduces the risk of falls or injury with an orderly and regular display of the shoes on the shelves. Inventory Management Optimal: Automatic identifiers enable more efficient inventory management with trend data and product popularity. Energy and Cost Savings: Smart shoe rack uses energy efficiently and reduces inventory waste costs. Installation and Usage Executability: Easy installation without interruption of daily operation, with an intuitive user interface for store staff.

## Summary

Traditional shoe cabinets often have various disadvantages such as limited storage space, inefficient use of space, difficulties in the arrangement of shoes, and the hygienic and safety risks that may arise because of random arrangement of shoes. Existing smart shoe cabinets on the market are often expensive and poorly meet the needs of consumers.

The project aims to create smart shoe cabinets that have more spacious and comprehensive functionality. Using the latest technology, the system allows users to easily find, sort, and retrieve their shoes with the help of mobile applications. The cabinet consists of modular units that can be customized according to the needs and available space.

The advantages of using this smart shoe cabinet include improved customer experience in shoe stores, increased sales through more organized arrangement, space optimization, innovation in the industry, marketing analytics, reduced time and energy, and reduced inventory errors. Through this project, it is expected to increase customer satisfaction while increasing the efficiency of shoe store operations.

# LITERATURE REVIEW

## Introduction

The smart shoe rack project aims to simplify the shoe storage experience in a shoe store by utilizing smart technology. It aims to overcome traditional problems such as inefficient organization, difficulty finding shoes, and manual inventory management.

By utilizing sensors to detect shoe position and availability, as well as using mobile apps for user interaction, the project enables customers to find and acquire shoes more quickly and easily. This not only improves customer satisfaction but also improves the efficiency of store operations.

Through automated inventory management and constant monitoring, store owners can optimize their shoe stock without having to spend excessive time on manual stock management. This helps reduce inventory wastage and increase the overall profitability of the store.

By simplifying the process of finding and acquiring shoes, as well as improving inventory management, the smart shoe rack project provides tangible benefits to shoe stores and their customers. It represents a step towards a more efficient, smart, and connected direction in the shoe industry.

## Literature Review Topic 1

## Design of Smart Shoe Box Based on IOT

Feet are very important parts which support weight and hold the center of gravity, so that they make us be able to walk and move in a balanced way. The importance of managing feet has been emphasized enough to call feet the second heart. However, it is difficult to manage them because the secretion of sweat is three times more than other parts of a body and there are few sebaceous glands, which makes it easily dry and rough. It is very important to manage footwear for foot care in respect of foot care. Nevertheless, it is neglected by many. Footwear should be worn to be out and is the optimum space for microorganisms due to sweat, dead skin cells, dust secreted from feet. Therefore, it is essential to wear footwear for foot care. Yet, it is not easy for people who live busy daily lives to invest their time in shoe care.

In this paper, we design the IOT (Internet of Things) shoe box which can be managed without investing time and effort. It is made to be able to keep footwear clean by judging temperature, humidity and the status of opening/closing of the door and operating UV lamp, halogen lamp and a cooling fan depending on the conditions through temperature/humidity sensor and ultrasonic sensor. Moreover, using the Bluetooth sensor, the conditions inside the shoe box can be checked and the devices can be controlled.

A diagram of a system

Description automatically generatedThe products based on IOT technology enable more convenient lives with intelligent systems and their configurations come to be diverse depending on different situations and user’s environment. In this study, the IOT shoe box has been implemented, which automatically judges and controls the conditions inside the shoe box based on an embedded system, including smartphone control. Using ultrasonic sensor and temperature-humidity sensor, the conditions inside the shoe box are judged and each device is automatically controlled. Furthermore, it can be controlled through a smartphone based on the Bluetooth sensor. By developing this study, furniture, such as wardrobes and drawers, is to be designed and studied as the next smart products with IOT technology.

## Figure 2.2 :block diagram (Design of Smart Shoe Box Based on IOT)

## Smart Shoe Storage Controlled by One-Chip Computer

Traditional shoe cabinets often fall short in addressing modern storage needs, leading to issues like limited space, difficulty in organization, and compromised hygiene. Low-type cabinets offer limited storage, while suspended ceiling cabinets pose usability challenges. As shoe collections grow, disorganization becomes a common problem, resulting in clutter and potential safety hazards. Recognizing these shortcomings, the emergence of intelligent shoe cabinets presents a promising solution, leveraging automation and smart technology to optimize storage and enhance convenience. However, existing smart cabinets often come with high price tags and limited functionalities, failing to meet the diverse and evolving demands of users. Consequently, there is a growing demand for affordable, versatile, and truly intelligent shoe storage solutions that effectively address these pressing challenges.

Current smart shoe cabinets fall short of meeting ideal expectations, lacking automation in shoe storage and retrieval. This design addresses these shortcomings by automating the entire process from organizing to retrieving shoes, effectively utilizing vertical space and simplifying shoe storage. Its user-friendly operation enhances home comfort and tackles shoe clutter efficiently, aligning with contemporary social needs. Featuring a unique mechanical design requiring minimal energy consumption and a precise control system, it offers heightened intelligence and improved user experience. Compared to existing models, it boasts advantages such as compact size, affordability, ease of use, and seamless integration, making it suitable for widespread adoption in various households, thereby enhancing quality of life and fostering smart home environments. Its versatility positions it with significant potential for broad application.

A diagram of a computer chip

Description automatically generated

Figure 2.3 Smart Shoe Storage Controlled by One-Chip Computer

## Study on the Perceived Marketability of ShoeVid-19 as an Effective Disinfecting

Amidst the COVID-19 pandemic, heightened concerns regarding virus transmission via surfaces, including shoes, have necessitated innovative solutions. Introducing Shoevid-19, a shoe rack designed to address these concerns by incorporating UV disinfection technology. In response to the surge in demand for disinfection equipment worldwide, especially in medical facilities, Shoevid-19 aims to provide a convenient and effective way to disinfect shoes, thereby enhancing safety and peace of mind for users. This product aligns with the growing emphasis on health and hygiene, offering a practical solution to mitigate the risk of virus transmission within households.

In response to the ongoing COVID-19 pandemic, the development of ShoeVid-19, a shoe rack equipped with UV light and deodorizer, emerges as a timely global innovation. Given the heightened awareness of virus transmission via surfaces like shoes, this product offers an effective solution to disinfect viruses and bacteria, including the potentially deadly COVID-19 virus. The study, validated by 251 Filipino respondents and analyzed using the SEM model, demonstrates high acceptance and marketability among consumers. The SEM model indicates strong positive correlations between various factors, such as perceived usefulness and ease of use, affirming the product's effectiveness and appeal to end-users. With its innovative features and positive reception, ShoeVid-19 has the potential to make a significant impact in the global market, contributing to efforts to combat the COVID-19 crisis and enhance public health and safety.

## Related Project

During the research phase, similar projects were identified, though they employed different methodologies and approaches. For instance, one comparable project utilized high-cost materials and complex electronic circuits, which significantly increased both the production cost and assembly time. In contrast, this project emphasizes affordability and simplicity, using low-cost materials and streamlined, easy-to-assemble circuits without sacrificing functionality.

Below is a comparison of advantages and disadvantages between the identified related project and this current project:

1. Related Project Example:

- Methodology: The related project integrated advanced sensors and a high-power processor to achieve fast processing speed and enhanced functionality. However, this led to a complex setup that required specialized knowledge to assemble and troubleshoot.

- Advantages:

- Higher processing speed.

- Extensive functionality due to a high-tech component selection.

- Disadvantages:

- High production costs.

- Requires advanced assembly skills and longer setup time.

2. Current Project:

- Methodology: By using simpler circuits and budget-friendly materials, the current project minimizes costs while maintaining essential features and performance. This approach also simplifies troubleshooting and makes the project more accessible to end users without specialized technical skills.

- Advantages

- Cost-effective and accessible for a wider range of users.

- Easier assembly and maintenance, with no need for specialized tools.

- Disadvantages:

- Limited processing power, which could restrict the project’s ability to handle complex tasks.

- Potentially fewer features compared to higher-cost alternatives.

This project is distinct from previous projects by prioritizing affordability and accessibility, making it a viable solution for commercial use without a steep learning curve for end users. The selection of cost-effective materials and simplified circuitry demonstrates a unique approach that contrasts with the high-cost, high-complexity focus of similar projects. This difference aligns with the goal of creating a practical, market-ready product that can be produced and maintained efficiently.

**2.5.1 Project 1**

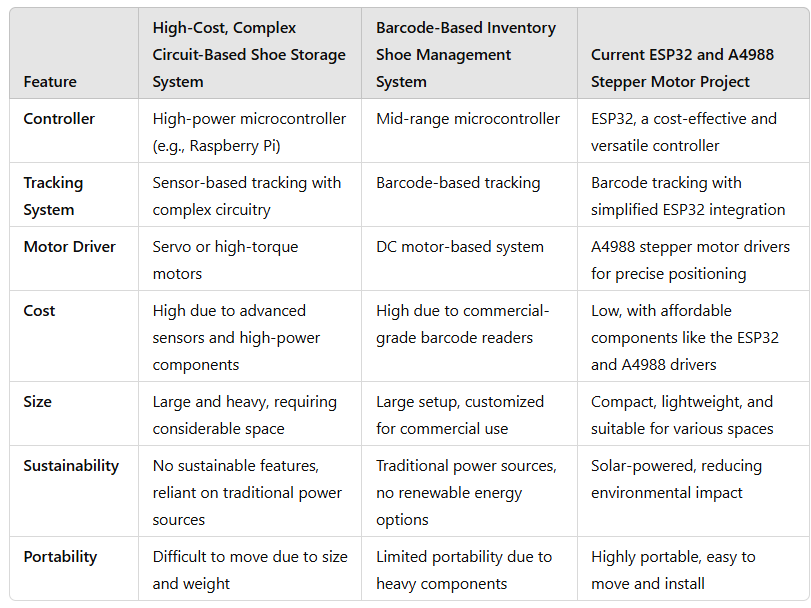
One related project uses a sophisticated, high-cost approach to automated shoe storage, involving advanced sensors, a high-power microcontroller, and complex circuitry. This design relies on high-grade materials and intricate components to maximize storage efficiency and precision. However, the high material costs and assembly requirements make it impractical for budget-conscious or commercial applications. Additionally, the system’s large and heavy design limits its portability and adaptability to different spaces. In contrast, our project uses low-cost materials, a simplified circuit, and a compact, lightweight structure, making it affordable, easy to maintain, and versatile for various environments.

**2.5.2 Project 2**

Another related project developed a barcode-based system to manage shoe inventory in commercial spaces, using high-cost barcode readers, a heavy-duty microcontroller, and custom-built storage racks. The system was designed to track each shoe’s location and automatically retrieve it based on a barcode scan. However, this project’s high-cost materials and large structure increase both setup costs and space requirements, making it challenging to implement in smaller retail spaces or homes. Additionally, the reliance on heavy-duty components makes it less portable and difficult to customize. In contrast, our project minimizes costs with affordable barcode readers and lightweight materials, creating a compact and easy-to-install system that fits a wider range of environments.

## comparison of Project

While similar projects address automated shoe storage and inventory tracking, the current design differentiates itself in terms of cost, size, and environmental sustainability. Table 2.2 provides a comparison of each related project with the current ESP32 and A4988 stepper motor-driven design.

Table 2.2 Comparison of Related Projects and the Current Project

Summary of Table 2.2

The High-Cost, Complex Circuit-Based Shoe Storage System uses a high-power microcontroller, such as a Raspberry Pi, along with complex sensors, making the system large, heavy, and costly. Its reliance on conventional power sources also increases energy costs.

The Barcode-Based Inventory Shoe Management System uses barcode tracking but relies on commercial-grade components and a large setup, primarily suitable for commercial applications. Without renewable power options, its environmental impact is also higher.

In contrast, the current project uses an ESP32 microcontroller with A4988 stepper motor drivers, which reduces cost, improves precision, and offers a compact, lightweight design. Powered by a solar panel, this system minimizes environmental impact, making it a sustainable choice. Its portability and adaptability make it ideal for home or small-scale commercial use, offering a practical and affordable alternative to previous designs.

## Summary

This formula focuses on the integration and synthesis of information from reference materials covering the field of development of smart shoe racks in shoe stores. With reference to a thorough review of literature, this formulation provides an overall view of existing knowledge in this domain.

The articles examined highlight developments in technology identification, inventory management, user-computer interaction, and the design of smart shoe rack systems. With this survey in mind, this formulation reflects an in-depth understanding of the key issues, challenges, and potentials associated with smart shoe rack projects.

This formulation not only lays out the need for a more efficient and effective shoe racking system, but also emphasizes the importance of using smart technologies such as RFID, IoT, and human-computer interaction in the context of shoe storage. It also outlines a comparison and analysis of the different approaches that have been taken in the development of automated shoe racking systems.

By embracing views from multiple reference sources, this formulation provides a solid foundation for the development of smart shoe rack projects aimed at enhancing customer experience, optimizing store operations, and providing added value to the shoe industry.

# METHODOLOGY

## Introduction

In this chapter of the methodology, we will discuss the approaches used in the

realization of the smart shoe rack project. It will include steps taken from initial.

planning to project implementation. This study will focus on the aspects of design,

software development, technology integration, testing, and overall evaluation of the

suitability of the project with the objectives set. Covering key aspects of each phase

of development, this chapter will provide clear guidance on the development.

process of smart shoe storage systems.

## Project Design and Overview

Initial Design:

Identification of user needs and project objectives.

Preparation of technical and functional specifications.

Discussion sessions with designers, developers, and users to understand the needs and

expectations.

System Design:

Intuitive and functional user interface design.

Construction of storyboards, wireframes, and prototypes.

Compilation of software specifications and hard devices.

Software Development:

Arduino esp32

Development of system prototypes and integration of software components.

Integration and Testing:

Integration of software components and hard devices.

Implement system-wide testing to ensure reliability and performance.

Implementation and Assessment:

Implementation of the system in the real environment of the shoe store. Data collection and assessment of system performance based on user experience.

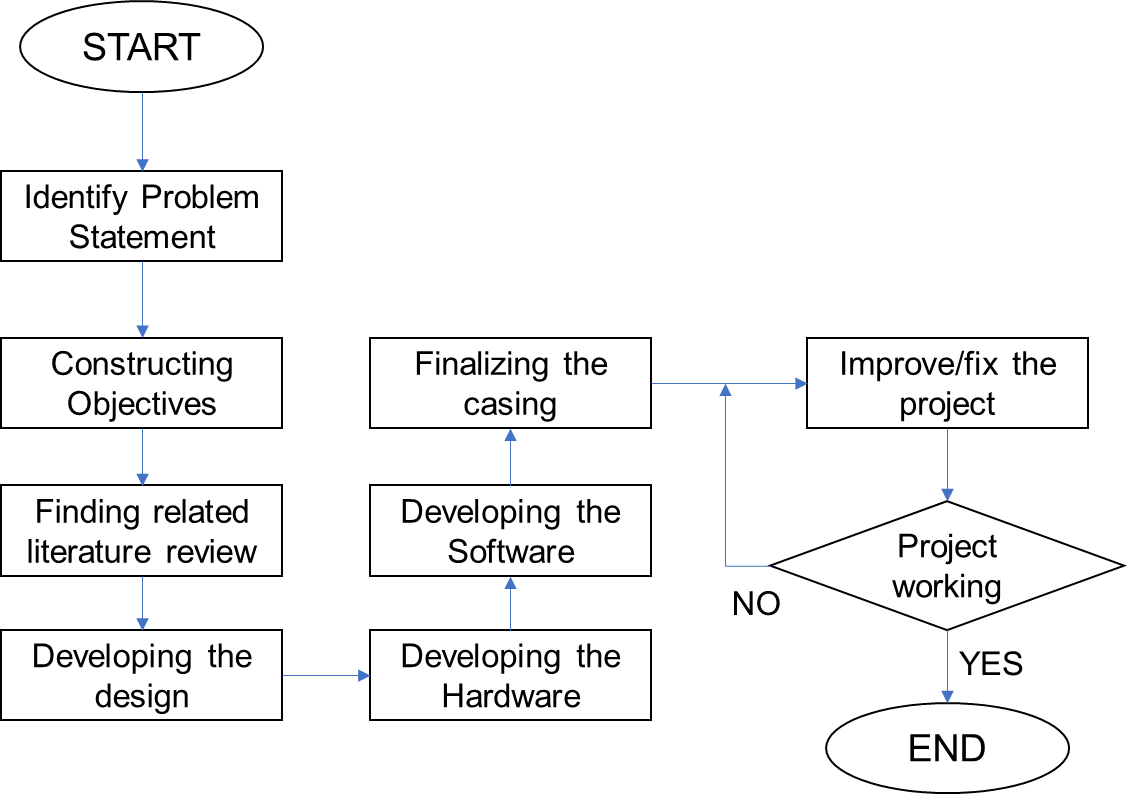


Figure 3.1: Process flowchart of system.

## 3.2.1Block Diagram of The Project

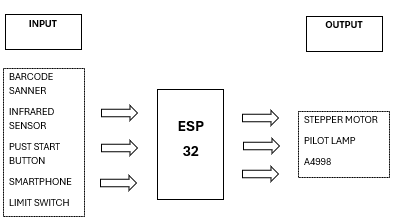
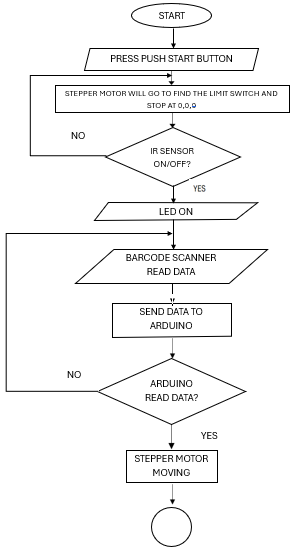


Figure 3.2Block Diagram

## 3.2.2Project flow chart



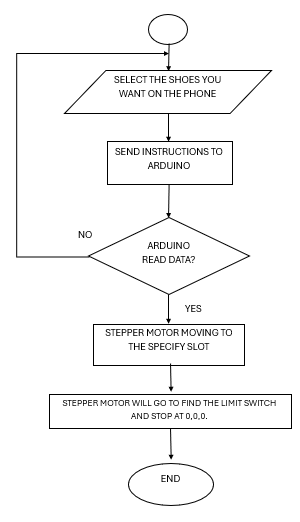


Figure 3.4: Flow chart of the model

### 3.2.3Project Description

3.2.3 : Data Analysis Methods

**Data Collection:**

System performance data such as response time, shoe storage capacity, and power

consumption are measured during laboratory experiments and tests.Application usage data

or user interface to determine usage patterns by customers.

**Data Organization:**

The data obtained are compiled in a format suitable for advanced analysis. This may involve

arranging data in the form of tables or graphs for easy understanding.

**Data Analysis:**

Using statistical techniques such as averages, ranges, and distributions to analyse system

performance data and application usage.

Create graphs to visualize data, such as line graphs to show system performance over time

or bar graphs to compare performance between system variations.

Perform comparative analysis between system variations or performance measurements

before and after implementation to assess improvements or changes that occur.

Interpretation and Conclusion:Based on the results of the analysis, assess the

effectiveness of the system and performance of use.Provide conclusions about the

results of the analysis and suggest improvements or further steps to be taken.

## List of components

### ESP 32

Nedelcu is a Microcontroller board that comes together with Wi-Fi Module which is suitable.

for IOT (Internet of Things) project. It includes firmware which runs on the ESP8226 Wi-Fi

and the hardware which based on the ESP-12 Module. The ESP8226 is a low-cost Wi-Fi.

chip, and it contains integrated Transmission Control Protocol/Internet Protocol (TCP/IP)

that allowed any Microcontroller to access a Wi-Fi network. The Nedelcu shown in

Figure 3.4.

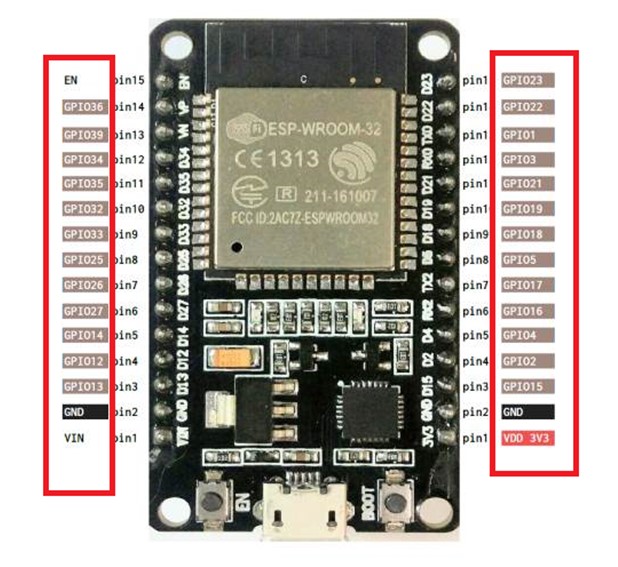


Figure 3.4: ESP 32

Figure 3.5 below shows the pin mapping of Nedelcu. There are a few precautions need.

to be sensitive to during the pin installation. NODE MCU ESP-12E dev board should be.

connected to 5V (Vin) using micro-USB connector directly to the computer or using a

power bank. The I/O pins of ESP8226 using input/output max 3.3V only.

### IR PROXIMITY SENSOR

This Infrared Proximity detector could be a utile infrared detector which might use for

obstacle sensing, colour detection, fire detection, line sensing and encode detector.

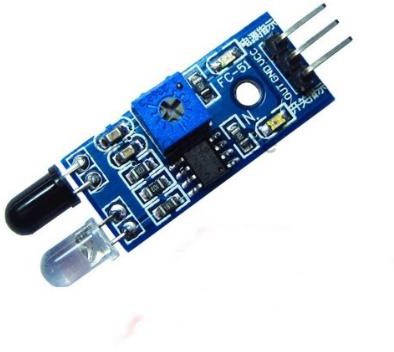
 The detector provides a digital as an output. The IR Proximity sensor was shown in Figure 3.6.

Figure 3.6: IR Proximity Sensor

The detector outputs (+5V) at the digital output once some object is placed ahead of

the detector and a logic zero(0V), once there is no object ahead of the detector. This sensor

is directly connected to Nedelcu to give information. Infrared detectors unit extremely

vulnerable to close lightweight and therefore, the IR detector on this detector is fitly lined to.

scale back result of close lightweight on the sensor. The detector incorporates a most.

vary of around 40- 50 cm inside and around 15-20 cm outdoors.

**Features of the IR Proximity sensor is:**

1. Operating Voltage: DC 5V
2. Proximity Sensing
3. Gesture Detection
4. Operating Range: 4-8in
5. I2C Interface

**The IR Proximity sensor pin details:**

1. VCC: Power
2. GND: Ground
3. OUT: Digital

### A4988 Stepper Motor Driver ModuleThe A4988 stepper motor driver carrier is a breakout board for Allegro’s A4988 micro stepping bipolar stepper motor driver. The driver features adjustable current limiting, overcurrent, and over-temperature protection, and five different micro-step resolutions (down to 1/16-step). It operates from 8~35V and can deliver up to approximately 1A per phase without a heat sink or forced air flow (it is rated for 2A per coil with sufficient additional cooling).

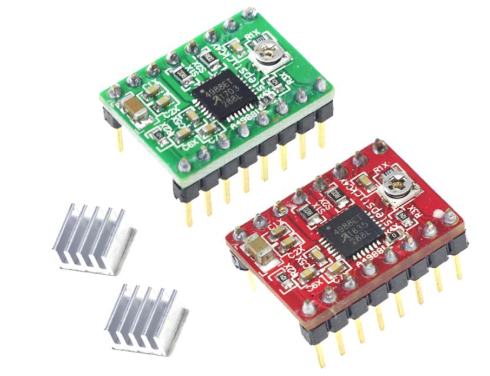


Figure 3.7: A4988

Brief Data:

 Minimum operating voltage: 8V.

 Maximum operating voltage: 35V.

 Continuous current per phase: 1A.

 Maximum current per phase: 2A (with heatsink).

 Minimum logic voltage: 3V.

 Maximum logic voltage: 5.5V

 Micro-step Resolutions: 1, 1/2, 1/4, 1/8, 1/16.

 Size: 0.6″ × 0.8″.

 Weight: 1.3g

A close-up of a red circuit board

Description automatically generated

### Stepper motor

**NEMA 17** is a **hybrid stepping motor** with a 1.8° step angle (200 steps/revolution). Each phase draws 1.2 A at 4 V, allowing for a holding torque of 3.2 kg-cm. NEMA 17 Stepper motor is generally used in Printers, CNC machines and Laser Cutters.

A black and grey mechanical device

Description automatically generated with medium confidence

Figure 3.8: stepper motor

### ****NEMA 17 Stepper Motor Technical Specifications****

* Rated Voltage: 12V DC.
* Current: 1.2A at 4V
* Step Angle: 1.8 deg.
* No. of Phases: 4
* Motor Length: 1.54 inches
* 4-wire, 8-inch lead
* 200 steps per revolution, 1.8 degrees
* Operating Temperature: -10 to 40 °C
* Unipolar Holding Torque: 22.2 oz-in

### ****Stepper Motor Applications****

* CNC machines
* Precise control machines
* 3D printer/prototyping machines (e.g. RepRap)
* Laser cutters
* Pick and place machines.

## Circuit Operation

In the modified smart shoe rack design, the circuit's primary function shifts to controlling the stepper motor responsible for moving shoes into the rack. The microcontroller, like Arduino or ESP8266/ESP32, governs the stepper motor's operation based on input signals. When activated by the user or triggered by a sensor (such as a button press or motion sensor indicating the presence of shoes), the microcontroller commands the stepper motor to rotate, guiding the shoe holder mechanism to receive the shoes. Once the shoes are in place, the microcontroller halts the stepper motor's motion. Integration with the Blynk application allows users to initiate the shoe placement process remotely and receive notifications once the task is completed. This revised design streamlines shoe organization and retrieval while maintaining user control and convenience through smart automation and connectivity.

### 

**3.4.1 Schematic circuit**

Figure 3.10: Circuit Diagram

### Blynk Application

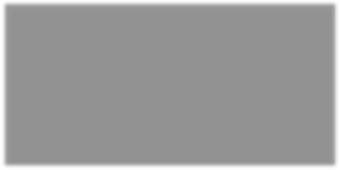


Figure 3.11: Blynk Application

Figure 33.15 shows that Blynk is a smartphone application that allows creating an interface for controlling and monitoring a project. Blynk app is free to download for Android and iOS. Blynk uses an interface of drag and drop widgets. Blynk also can work over the internet, Bluetooth, and USB.

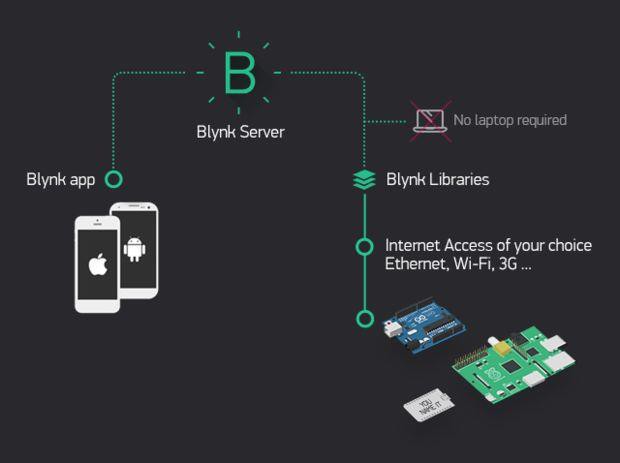
To run the Blynk application, they will use an Internet platform. To connect a Blynk server and pair it with the smartphone, Blynk libraries should write in the sketch (coding section). It is simple easy because we can get it from the internet. The architecture, as shown in figure 3.16 below:

Figure 3.12: Blynk Architecture

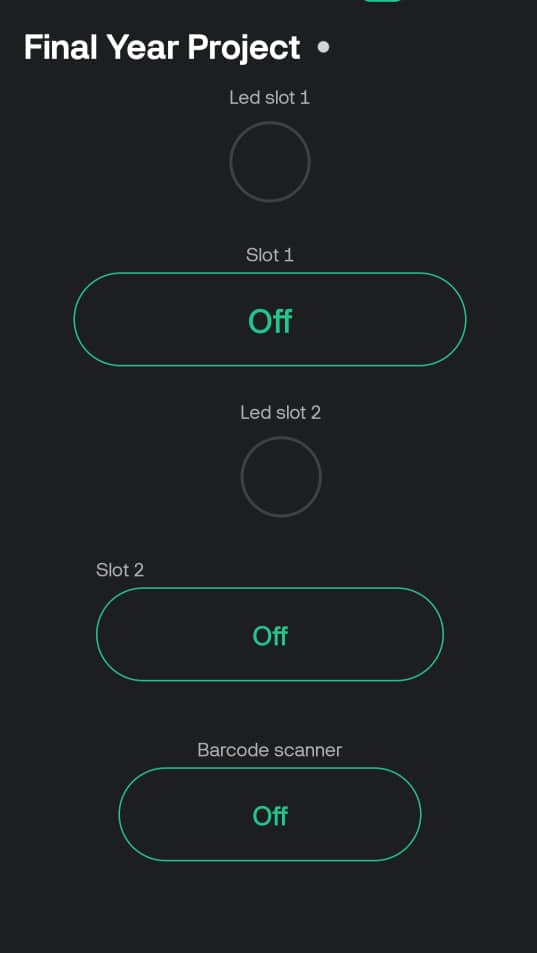


Figure 3.13: Blynk Architecture

## Project Duration (project 1)

A screenshot of a computer screen

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## A screenshot of a computer Description automatically generatedProject Duration (project 2)

A black line on a white background

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Figure 3.2.1 project gantt chat (project 2)

## Project Costing List

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No.** | **Component and materials** | **The unit price** | **Quantity** | **Total** |
| 1 | ESP32 | RM 20.14 | 1 | RM 20.14 |
| 2 | 3D printer guide rail sets | RM 105 | 3 | RM 315 |
| 3 | Infrared Module - IR Obstacle Avoidance Sensor | RM 1.48 | 1 | RM 13.32 |
| 4 | Barcode scanner | RM 66.60 | 1 | RM 66.60 |
| 5 | Stepper motor | RM 37 | 3 | RM 111 |
| 6 | A4988 | RM 4 | 3 | RM 12 |
| 7 | Board | RM 20 | 1 | RM 20 |
| 8 | Push start button | Rm 5 | 1 | Rm 5 |
| 9 | Other materials | RM200 | - | RM200 |
|  | **Total:** | | | **RM 763.06** |
|  | **List of other costing** |  |  |  |
| 1 | Transportation |  |  |  |
| 2 | Postage |  |  |  |
| 3 | Craft Work |  |  |  |
| 4 | Internet |  |  |  |
| 5 | Application |  |  |  |
|  | **Total:** | | | **RM50.00** |
|  |  |  | **Overall total** | **RM 813.06** |

Figure 3.3 cost list

## Chapter Summary

Chapter 3 covers the analysis of this project which is the production and evaluation of the performance of the smart shoe rack system. Project implementation involves several steps such as initial planning, system design, software and hard device development, integration, and testing, as well as implementation and evaluation. System performance data and user feedback are carefully collected, compiled, and analysed using statistical methods and data visualization. The choice of study/project method is selected with strong justification, emphasizing its suitability and effectiveness in achieving project objectives as well as meeting the needs of consumers. By providing this comprehensive analysis, chapter 3 presents a solid foundation for understanding and evaluating the entire project without introducing new elements that will be detailed in the next section.

**CHAPTER 4**

**STUDY FOUND AND DISCUSSION**

**4.1 INTRODUCTION**

The primary objective of this project is to streamline and optimize the storage, retrieval, and management of shoes in commercial spaces through an automated, smart shoe rack. The proposed solution addresses the common challenges of space limitations, manual effort, and inefficient storage in retail outlets, showrooms, or warehouses that manage large inventories of shoes. The smart shoe rack will not only automate the shoe storage and retrieval process but also provide enhanced inventory tracking capabilities, reducing operational time, and improving overall user experience.

How the Proposal Solves the Problem

1. Efficient Space Utilization: The automated rack system with a 3x3 grid configuration (utilizing 5 compartments) allows businesses to store more shoes vertically, maximizing floor space.

2. Automated Retrieval System: The integration of an X, Y, and Z axis controlled by stepper motors and barcode identification ensures that each shoe pair is quickly and accurately retrieved. This minimizes the time employees spend searching for specific pairs, leading to greater efficiency.

3. Remote Control and Monitoring: The integration of Blynk provides remote access, allowing employees or managers to retrieve shoes with just a few clicks from any connected device. This feature will enhance workflow and give businesses more flexibility in managing their inventory.

Benefits of the Smart Shoe Rack

1. Increased Operational Efficiency:

- With automated storage and retrieval, employees save time and effort, allowing them to focus on more customer-centric tasks.

- Managers can also benefit from streamlined inventory tracking, leading to quicker decision-making and improved stock management.

2. Enhanced Customer Experience:

- Fast retrieval and accurate storage mean that customers face minimal waiting times, creating a smoother and more satisfying shopping experience.

- For customers in a retail environment, easy access to a specific pair of shoes becomes possible in seconds, potentially boosting sales and satisfaction.

3. Cost-Effectiveness and Space-Saving:

- The compact and organized structure of the shoe rack helps reduce the storage footprint in busy commercial areas.

- The cost of labour and space rental may decrease as the automated system reduces the need for a larger workforce and makes better use of available space.

4. Reduced Errors and Loss Prevention:

- Barcode scanning minimizes human error in tracking inventory, reducing the chances of misplaced or unaccounted-for items.

- The Google Sheets integration provides a transparent record of inventory, making audits more straightforward and helping to prevent stock discrepancies.

Beneficiaries and Their Gains

1. Retail Store Owners and Managers:

- They benefit from better inventory management, reduced operational costs, and a more efficient workforce.

- They can easily track sales trends, manage stock levels, and streamline restocking processes using accurate, real-time data.

2. Employees:

- Reduced manual workload and enhanced productivity allow them to serve more customers or attend to other essential tasks.

3. Customers:

- Quick and seamless service provides a better shopping experience, potentially increasing customer retention and loyalty.

Consequences if the Proposal is Not Accepted

If this project is not implemented, businesses may continue to struggle with inefficient shoe storage, resulting in wasted space, higher lab or costs, and customer dissatisfaction. Without automation, employees will spend more time retrieving items, increasing lab or costs and reducing overall efficiency. Poor inventory tracking may lead to stock-outs or overstock situations, impacting sales and customer satisfaction. Additionally, the opportunity to leverage technology for operational excellence will be missed, putting such businesses at a disadvantage in an increasingly digital retail environment.

In conclusion, the Smart Shoe Rack Project represents a scalable solution to the common logistical challenges faced by commercial entities. Its implementation promises significant benefits in terms of efficiency, space management, and customer experience, making it a valuable investment for the future of retail inventory management.

**4.2 EXPECTED RESULTS**

The Smart Shoe Rack Project aims to develop an automated, efficient system for managing shoe storage and retrieval in commercial environments, such as retail stores or warehouses. Upon completion, the project is expected to achieve the following specific, measurable outcomes that demonstrate its success:

1. Automation of Shoe Storage and Retrieval

- Outcome: The automated shoe rack will successfully store and retrieve shoes based on a user's selection, with accuracy in 5 predefined compartments within a 3x3 grid setup.

A machine on a table

Description automatically generated - Measurement: The system will be able to retrieve a selected shoe pair within 10 seconds, using a barcode scanning method for identification. The motorized movements (X, Y, Z axes) will be fully functional and synchronized to provide a smooth operation without any malfunctions during retrieval or storage.

Figure 4.1: motor x,y,z position

2. Space and Efficiency Optimization

- Outcome: The design of the shoe rack will maximize space usage in commercial environments, ensuring a compact and organized solution for shoe storage.

- Measurement: The rack will store shoes in a space-efficient manner, optimizing vertical storage while maintaining easy access to all compartments.

- Target: The system will improve space efficiency by at least 30% compared to traditional shoe storage methods, leading to better use of available floor space.

3. Improved Workflow and Reduced Labor Costs

- Outcome: The automated system will significantly reduce the time employees spend on retrieving shoes, thereby improving operational efficiency.

- Measurement: It is expected that shoe retrieval time will be reduced by at least 50%, compared to the time spent manually searching for shoes in a traditional storage system.

- Target: A reduction in employee time spent on shoe retrieval by at least 5 hours per day per employee, based on typical commercial operation hours.

4. Remote Control and Monitoring

- Outcome: The system will allow employees or managers to control the shoe rack remotely via a smartphone or tablet using the Blynk application.

- Measurement: The remote-control feature will be tested for ease of use and reliability, ensuring that the system can be controlled and monitored from a mobile device with minimal delay.

- Target: Achieve successful remote operation 95% of the time during testing scenarios, with no significant lag in operation or connectivity.

A screenshot of a phone

Description automatically generated Figure 4.1.2: Blynk

5. User Satisfaction and Business Benefits

- Outcome: The project will improve the customer experience by enabling faster shoe retrieval and providing a streamlined shopping or business environment.

- Measurement: Customer satisfaction will be assessed via surveys or feedback from employees and store managers, aiming for at least an 85% satisfaction rate with the system’s performance.

- Target: Increase customer or employee satisfaction with the shoe retrieval process, reducing waiting times and increasing overall efficiency.

Realistic and Achievable Expectations

- Feasibility: Based on the current scope and resources, the project is realistic and achievable. The integration of existing technologies, such as stepper motors for movement control, barcode scanners for inventory management, and Blynk for remote access, ensures that the required components are readily available, and the system can be effectively developed within the project timeline.

- Evidence: Previous similar automation projects, such as automated shelving systems and robotic storage units, have demonstrated the viability of this type of system in commercial environments. The use of barcode scanners and spreadsheet integrations for inventory tracking has been successfully implemented in other industries, providing a solid foundation for this project.

# 4.3 ENVIRONMENT AND SUSTAINABITY

1. Material Selection and Waste Reduction

- Eco-Friendly Materials: Using sustainable or recycled materials for the shoe rack structure and compartments, such as recycled plastic or metal, can reduce environmental impact. This can help lower the carbon footprint and improve the product’s appeal to eco-conscious users.

- Minimizing E-Waste: Designing the system with easily replaceable or upgradeable components (e.g., modular motors or drivers) can help extend the product's life and reduce electronic waste.

2. Energy Efficiency

- Low-Power Components: Selecting energy-efficient components, such as energy-optimized motors or low-power sensors, can significantly reduce the overall power consumption. This is particularly important in a commercial environment where the system might be in continuous use.

- Sleep Mode for ESP32: Implementing a low-power mode for the ESP32 during idle times could further conserve energy, especially if the system doesn’t require constant operation.

3. End-of-Life Recycling and Disposal

- Component Recycling: Designing with recyclable components in mind can make it easier to repurpose parts at the end of the product’s lifecycle, reducing e-waste. This includes using standardized components and materials that can be easily separated and recycled.

- Encouraging Proper Disposal: Providing guidelines for proper disposal or recycling of components, such as the motors and electronics, can help users minimize environmental impact.

4. Transportation and Supply Chain Considerations

- Local Sourcing: Using locally sourced components and materials can reduce the carbon footprint associated with transportation and logistics.

- Compact Design for Shipping: A compact, modular design can help reduce packaging and transport needs, which translates to lower emissions from shipping.

5. Product Longevity and Maintenance

- Durability: Designing the product for durability can extend its lifespan, reducing the need for frequent replacements. Robust construction with easily maintained parts can help avoid early wear and tear, especially in commercial environments.

- User-Friendly Maintenance: Allowing users to easily access and replace worn parts, such as motors or switches, promotes a longer product lifecycle and reduces waste from full replacements.

6. Reduced Carbon Footprint with Automation

- Efficient Inventory Management: By automating shoe storage and retrieval, the smart shoe rack can potentially reduce energy consumption compared to manual systems, especially in large commercial setups. Efficient storage can also lead to space savings, potentially lowering the need for larger facilities and their associated environmental footprint.

- Encouraging Sustainable Practices: Integrating real-time monitoring via Blynk could allow users to track and optimize usage patterns, encouraging more efficient power usage and reducing the system's environmental impact.

7. User Education on Sustainability

- User Awareness: Educating users on best practices, such as shutting down the system when not in use, or cleaning and maintaining the rack to prevent mechanical strain, can enhance sustainability.

A chart of goals for a sustainable development

Description automatically generated

Figure 4.3: **Sustainable Development Goals**

**4.4 SUMMARY**

In conclusion, your smart shoe rack project is an innovative solution designed for efficient commercial use, with key considerations for durability, energy efficiency, and environmental impact. Addressing component limitations and designing for recyclability, energy conservation, and user-friendly maintenance can enhance sustainability and longevity. This project balances technological functionality with eco-conscious design, positioning it as both a practical and sustainable automated storage solution.

CHAPTER 5

CONCLUSION

**5.0 CONCLUSION**

The completion of the Smart Shoe Rack Project represents a successful application of automation and efficient design tailored for commercial footwear management. This project has achieved its goals of enhancing storage efficiency, reducing operational workload, and improving the customer experience within retail and warehouse environments.

With a fully functional, automated retrieval system utilizing a 3-axis motorized mechanism, the shoe rack maximizes vertical storage while allowing for quick, precise retrieval of shoes based on barcode identification. By streamlining the retrieval process through automated compartment selection and reducing the manual effort required for inventory handling, this system has brought a new level of efficiency to shoe storage.

The smart rack’s ability to be remotely controlled via a mobile app further empowers businesses, allowing employees or managers to retrieve items quickly from any device. This feature reduces retrieval times, lowers lab or costs, and ensures a seamless user experience for both staff and customers.

Overall, the Smart Shoe Rack Project demonstrates the value of combining automation and practical design to solve common challenges in retail and storage. It offers measurable benefits, including faster retrieval times, better space usage, and improved operational efficiency, positioning it as a forward-thinking solution that meets the demands of a modern commercial setting. Through careful planning and innovative engineering, the project has proven that technology can significantly enhance the way businesses manage and interact with their inventory, paving the way for greater customer satisfaction and operational improvements.

**5.1 RECOMMENDATION**

* Advanced drivers: use improved motor drivers for better performance.
* Camera integration: add a camera for automatic compartment location.
* Upgraded motors: implement high-quality stepper motors for reliability.
* Better rails: utilize superior rails for smoother and quieter operation.
* Expanded capacity: design for a larger grid to hold more shoes.
* Enhanced barcode scanner: improve scanner accuracy for quicker identification.
* Voice control: integrate voice control for hands-free operation.
* Commercial applications: explore uses in smart homes and retail environments.

**5.2 POJECT LIMITATIONS**

1. Mechanical Complexity and Durability

- Stepper Motor Alignment: Keeping the X, Y, and Z axes consistently aligned, especially in commercial environments with frequent use, could be challenging. Over time, vibrations or minor misalignments might impact precision.

- Rack Weight Limit: Depending on the shoe rack’s material and motor capacity, there may be a weight limit for each compartment. Heavier shoes could strain the motors or cause mechanical wear.

- Compartment Flexibility: The system currently supports only 5 compartments. Expanding beyond this configuration may require significant modifications to the motor arrangement or rack design.

2. Sensor and Component Limitations

- Barcode Scanner Accuracy: Depending on the quality of the barcode scanner, there could be limitations in reading dirty, faded, or damaged barcodes.

- Trigger Switch Reliability: The mechanical switches used for homing may wear out over time, requiring regular calibration or replacement.

3. Power and Energy Efficiency

-Power Consumption: Running three stepper motors and a barcode scanner with an ESP32 can consume significant power, which may be a limitation in environments with limited power sources or where energy efficiency is a priority.

4. Control and Software Constraints

Response Time: The current setup with stepper motors may have slower response times compared to high-speed conveyor systems in commercial environments.

ESP32 Processing Limitations: Complex tasks, like multi-axis coordination or integrating additional features, might push the processing limits of the ESP32.

Network Reliability for Blynk Control: Relying on Blynk for remote control requires a stable internet connection; poor connectivity could limit functionality.

5. User Interaction and Adaptability

Barcode-Only Identification: If a shoe lacks a readable barcode, the system will not recognize it. Implementing alternatives (e.g., RFID) might improve flexibility but would add to project complexity.

Learning Curve for Users: Users might need time to get accustomed to placing shoes in specific orientations or maintaining clear barcodes, especially in a commercial setting.

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# APPENDICES

**APPENDICES 1: A4988 Stepper Motor Driver**

**A4988 Stepper Motor Driver**

A close-up of a circuit board

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A circuit board with red squares and black text

Description automatically generated

A white paper with black text

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# REFERENCES

# APPENDICES

A diagram of a circuit board

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**APPENDICES 2: BARCODE SCANNER**

**A diagram of a circuit board

Description automatically generated**

A diagram of light sources

Description automatically generated with medium confidence

**APPENDICES 3: INSTRUCTION MANUAL**

**A screenshot of a computer

Description automatically generated**

A screenshot of a phone

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**APPENDICES 4: POSTER**

**A screenshot of a smart shoe rack

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**APPENDICES 5: DIAGRAM**

A machine on a table

Description automatically generated

**APPENDICES 6: BUSINESS PLAN**

