AUTOMATED ESCALATOR ON ALREADY BUILT STAIRCASE

Final Year Project Report

GSN: Fall 22-15

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16th June, 2023

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CERTIFICATIONS

This document has been prepared by all of us together and we take joint ownership of its contents. We have provided references to the material consulted in preparing this document and, to the best of our knowledge, have not plagiarized anything.

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I am the client of the product proposed in this document and the product specifications and other details are according to my requirements.

Client:

Sir Mohsin Yousuf ______________________________________ Date: 16th June, 2023

The final year project proposal in this document is being submitted to the department of Electrical Engineering with my approval.

Advisor:

Sir Mohsin Yousuf ______________________________________ Date: 16th June, 2023

Head of Department:

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Abstract

The project centers around the development of an Automated Escalator tailored specifically for pre-existing staircases. Its primary objective is to tackle the challenges of locomotion faced by individuals dealing with knee problems, leg injuries, or foot injuries who happen to reside on the second floor of an apartment or building. To achieve this, the project harnesses the principles of engineering, focusing on key aspects such as calculating the optimal mechanical structure, determining the required power for the motor, and assessing the strength of the steel rod.

The proposed solution encompasses an Automated Escalator that seamlessly integrates with a user-friendly mobile application. This application serves as a vital link, establishing a connection between the structure and the users. Its core functionality lies in facilitating the smooth and hassle-free movement of patients between different floors.

The mobility journey begins with the mobile app, providing users with the ability to effortlessly open the designated flap and step onto the Automated Escalator. Once aboard, the automated mechanism takes charge, transporting users to their desired floor with utmost efficiency and without encountering any hindrances along the way. This ingenious solution caters to the specific needs of patients who are prescribed bed rest or face significant challenges in locomotion due to knee problems, leg injuries, or foot injuries.

In summary, the project introduces a groundbreaking solution to address the locomotion difficulties experienced by individuals residing on the second floor of a building. By implementing an Automated Escalator in conjunction with a user-friendly mobile app, patients dealing with knee problems, leg injuries, or foot injuries can effortlessly navigate between floors, ensuring a seamless and secure experience. The project undertakes an extensive engineering exploration, covering crucial aspects such as calculating the ideal mechanical structure, determining the appropriate motor power, and assessing the steel rod's strength. With this all-encompassing strategy, the initiative hopes to provide patients with a trustworthy and effective solution that improves their mobility and general well-being.

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Acknowledgements

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Chapter 1: Introduction

Technology developments in recent years have given people with impairments new opportunities to live independent lives and actively participate in society. However, the existence of stairs in buildings continues to be a substantial environmental barrier for those with mobility limitations, particularly older persons. While various home access solutions exist to facilitate safe entry and exit from homes, they often come with limitations.

The purpose of this project was to develop an innovative and inclusive home access solution that combines a staircase and a lift into a single device. The Automated Escalator system was designed to provide individuals with the independence they need to move around their homes or other places where pre-existing staircases are present. By incorporating an Automated Escalator system, users can easily navigate between different levels, eliminating the need for assistance or strenuous efforts.

A user-friendly mobile application that is seamlessly integrated into the system is essential for creating a relationship between the users and the structure. Its primary function is to facilitate smooth and hassle-free movement of individuals between floors, enhancing their overall mobility and convenience.

In this system, the angle of the seat adjusts based on the user's inclination, regardless of the angle of the wheelchair. This is made possible through the use of an attitude sensor and a relatively small actuator, enabling minimal active control. A similar approach is seen in the concept of using legs in the context of stair climbing. Thanks to advances in robotics, machines can now be built and controlled in various ways. It is conceivable to construct a wheelchair with legs capable of climbing slopes, stepping over obstacles, and even traversing stairs. Notably, in 1987, the University of Illinois at Chicago and the Veterans Administration Hines Rehabilitation Research and Development Centre developed a four-legged chair based on quadruped walking research. This innovative invention was capable of sustaining a weight of approximately 110 kg and had a payload capacity of 113.6 kg.

By combining these technological advancements, the project aims to overcome the challenges posed by stairways and provide individuals with mobility impairments the means to navigate their surroundings with ease. The ultimate goal is to promote independence, enhance accessibility, and improve the overall quality of life for individuals with mobility limitations.

To ensure the success of this project, extensive research was conducted to inform the development of the Automated Escalator system and its integration into a home access solution. Several key research areas were explored to address the unique challenges associated with mobility impairments and the navigation of stairways.

One crucial aspect of the research focused on engineering and mechanical design. In-depth research was done to determine the Automated Escalator's ideal mechanical structure, taking stability, safety, and load-bearing capability into account. Advanced engineering principles were employed to develop a system that can reliably transport individuals with mobility impairments between different floors.

Additionally, research in robotics played a significant role in designing the innovative features of the system. Studies were conducted to explore the possibilities of using robotic technologies to develop a wheelchair with legs capable of climbing stairs and overcoming obstacles. This research helped to inform the integration of robotic elements into the Automated Escalator system, ensuring smooth and efficient movement for users.

The project included human factors research as a crucial component. To better understand the unique needs, preferences, and difficulties faced by people with mobility limitations, extensive user testing and feedback gathering were done. This research helped in refining the design and functionality of the Automated Escalator system, ensuring a user-centric approach and maximizing usability and accessibility.

Furthermore, collaborations were established with healthcare professionals, rehabilitation specialists, and accessibility experts. . To ensure that the Automated Escalator system reached the greatest standards of safety, functionality, and usability, their knowledge and insights were crucial in directing the research and development process.

Chapter 2: Problem Definition
(Client Requirements)

Humans have worked to advance science and technology throughout history in an effort to overcome obstacles and enhance their quality of life. But not everyone has equal access to comfort and convenience, especially people with disabilities who face many challenges and hardships. More than 1 billion individuals worldwide, or around 15% of the world's population, have a disability of some kind. In recent years, society has placed a greater emphasis on addressing the needs and worries of people with disabilities.

Among the various challenges faced by disabled people, mobility remains a primary concern. The introduction of power wheelchairs has significantly alleviated mobility issues for many individuals. However, architectural barriers continue to limit their accessibility and mobility. To address this limitation, several wheelchairs equipped with stair-climbing capabilities have been developed. In the context of Pakistan, there is a lack of facilities specifically designed for disabled individuals to navigate stairs or overcome barriers without assistance.

To address this pressing need, a compact and cost-effective automated escalator with stair-climbing capabilities has been designed. The objective is to provide disabled individuals in Pakistan with a means to achieve independence and autonomy. By equipping the wheelchair with the ability to climb stairs, individuals will be empowered to overcome architectural barriers without relying on external assistance.

This initiative acknowledges the importance of enabling disabled individuals to lead independent lives and highlights the significance of designing solutions that are both compact and affordable. By incorporating stair-climbing capabilities into the wheelchair, the aim is to empower disabled individuals to navigate their surroundings with ease and dignity. By addressing the needs and concerns of disabled people, it is hoped that this initiative will contribute to the inclusion of disabled people in Pakistani society and their general well-being.

2.1 Problem Formulization:

Safety Systems:

a. Implementing advanced sensor systems to accurately detect the presence of obstacles and individuals on the escalator, preventing collisions or entrapment.

b. Designing and integrating robust emergency stop mechanisms that can halt the escalator instantaneously in response to any potential hazards or malfunctions.

c . including accessibility features to make the mobile application easier to use for persons with vision impairments, such as audio prompts or text-to-speech capabilities

Accessibility and Compatibility:

a. Designing the escalator to accommodate individuals with diverse disabilities, including those using wheelchairs or mobility aids, while ensuring stability and ease of use.

b. Creating a mobile application with a user-friendly interface that provides comprehensive control over the escalator's functions and settings, supporting different operating systems (iOS, Android).

c. Integrating accessibility features, such as voice prompts or text-to-speech capabilities, to aid visually impaired users in operating the mobile application.

Robustness and Reliability:

a. Developing a structurally sound escalator system capable of supporting various weight capacities and enduring repetitive usage over extended periods.

b. Conducting rigorous testing and simulations to validate the durability and reliability of critical components, including the motor, drive system, and control mechanisms.

c. Implementing predictive maintenance algorithms to detect potential issues before they lead to system failures, ensuring proactive servicing and minimizing downtime.

Power Efficiency:

a. Optimizing the power management system to reduce energy consumption and extend the escalator's operational duration, especially in battery-powered configurations.

b. Incorporating energy recovery systems, such as regenerative braking, to harness and reuse energy during deceleration or descent, maximizing overall efficiency.

c. Integrating smart charging mechanisms that monitor and regulate the battery charging process to prevent overcharging or excessive energy loss.

System Maintenance and Servicing:

a. Designing the escalator with modular components and standardized interfaces to facilitate easier maintenance, repair, and replacement of parts.

b. Implementing comprehensive remote monitoring and diagnostics capabilities, enabling proactive identification of faults and streamlining maintenance activities.

c. Establishing regular maintenance schedules and procedures to ensure optimal performance and minimize disruptions to user accessibility

Regulatory Compliance:

a. Conducting thorough research to understand and comply with relevant accessibility standards, safety regulations, and building codes applicable to escalators for disabled individuals.

b. Collaborating with regulatory authorities to ensure adherence to specific guidelines and certifications relevant to accessibility equipment and user safety.

Cost Optimization:

a. Balancing cost and quality considerations throughout the development process, utilizing cost-effective materials and components without compromising on safety and reliability.

b. Investigating cutting-edge manufacturing methods to lower production costs while preserving the quality of the product, such as automated assembly or additive manufacturing

c. Seeking partnerships with suppliers and manufacturers to source reliable components at competitive prices, optimizing the overall project budget.

By addressing these technical challenges, the development of an automatic escalator controlled via a mobile application provided a safe, efficient, and accessible solution for disabled individuals, enabling them to navigate stairs and steep surfaces with confidence and independence.

2.2 Mapping to Sustainable Development Goals (SDG)

Figure 1: SDG

The project of developing an automatic escalator for disabled individuals, controlled via a mobile application, can be best mapped to the Sustainable Development Goal (SDG) 10: Reduced Inequalities.

This project directly targets SDG 10 by aiming to reduce inequalities faced by disabled individuals in accessing public spaces. The automatic escalator provides a practical solution to help disabled individuals navigate stairs and steep surfaces, enabling them to overcome physical barriers and enhance their mobility and independence. By incorporating safety features and user-friendly controls, the escalator promotes inclusivity and equal access to public spaces for people with disabilities. The goal of SDG 10—to ensure social, economic, and political inclusion for all people, regardless of their disabilities—contributes to the development of a more just and open society.

2.3 Record of Meetings with Client

1st Meeting -January 7th, 2023

2nd^{t} Meeting -March 11th, 2023

3rd Meeting -May 29th, 2023

2.4 Preliminary Product Specification

The automated Escalator is 5 feet long device that weighs 50kg. This is made up of steel and Iron so that it can bear heavy weights efficiently. This device consumes a power of 240 watts. It has flap on which the patient will stand and it opens and closes from the mobile app. The flap has a motor to open and close it.

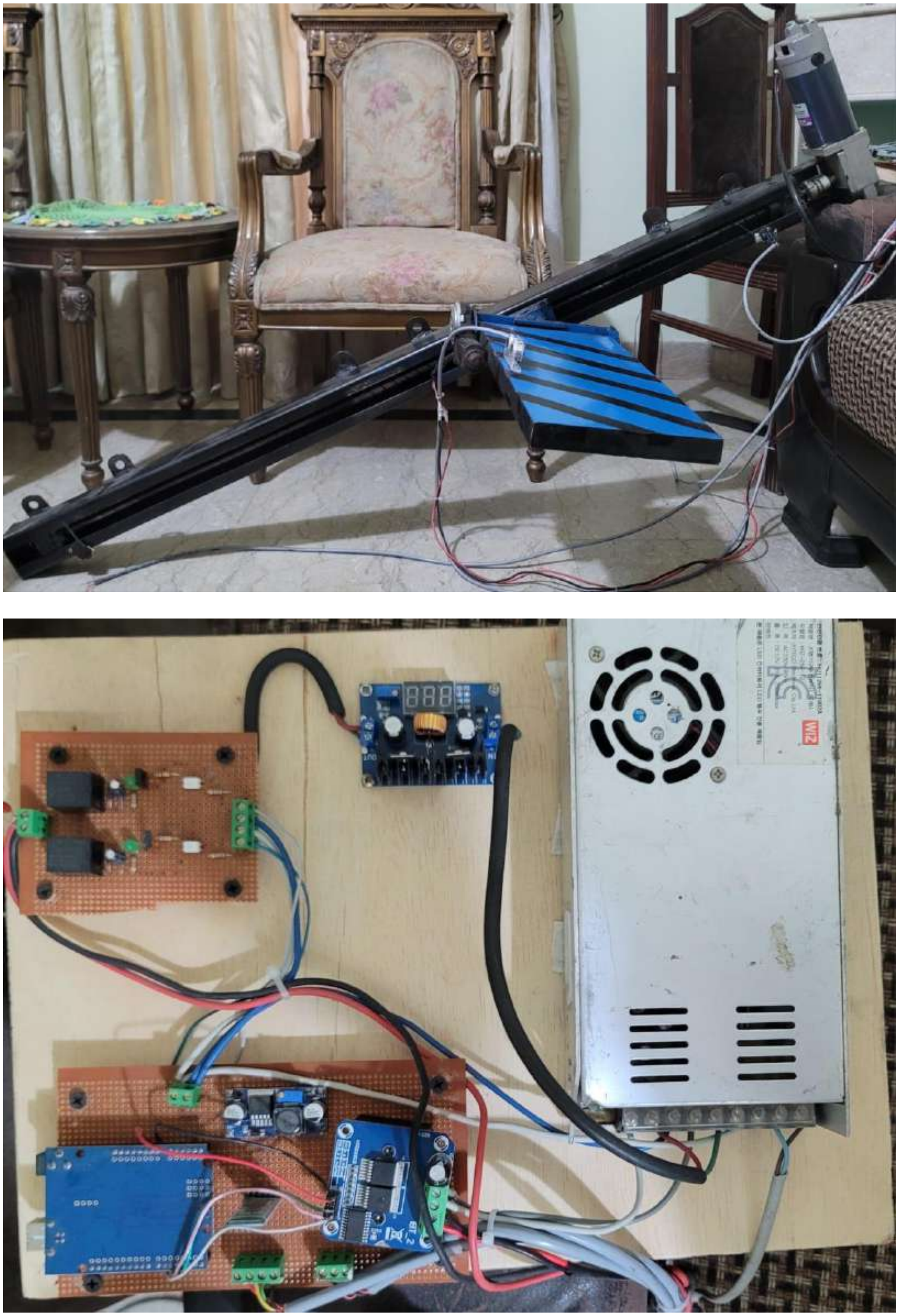

Figure 2: Complete system

2.5 Expected Functionality of Product

In a real-life environment, the automated escalator for disabled individuals will be installed in areas with stairs or steep surfaces where accessibility is a concern. The escalator will consist of a series of steps or platforms that move in a continuous loop, allowing users to step onto them and be transported vertically.

The escalator will be equipped with various safety features such as sensors to detect obstacles or individuals on the escalator path. These sensors will trigger the automatic stop mechanism, ensuring user safety and preventing accidents or collisions. In case of emergencies or malfunctions, an emergency stop button or switch will be available to halt the escalator immediately.

To drive the motion of the escalator, a DC motor may be used. The DC motor will be responsible for driving the load associated with the escalator's movement. The load primarily includes the weight of the steps or platforms, as well as the weight of individuals using the escalator. The motor will need to be adequately sized and have sufficient torque to support the combined load, ensuring smooth and reliable operation.

Additionally, the escalator may incorporate other components such as a control system, power management system, and a mobile application interface for user control. The control system will coordinate the motor's speed and direction, responding to user commands or sensor inputs. The power management system will regulate the power supply to the motor, optimizing efficiency and ensuring the escalator's continuous operation.

In a real-life environment, the automated escalator will provide a convenient and accessible solution for disabled individuals to navigate stairs and steep surfaces. By incorporating safety mechanisms and efficient motor-driven systems, the escalator aims to enhance mobility and inclusivity, enabling disabled individuals to access public spaces with greater ease and independence.

Chapter 3: Problem Analysis

- The scientific analysis aims to evaluate the feasibility and functionality of an automated escalator system designed specifically for retrofitting onto already built staircases. The project's objective is to provide a solution that enables individuals with mobility challenges to navigate existing staircases with ease and independence. This analysis will focus on various scientific aspects, including the structural modifications, motor and power requirements, safety considerations, and user experience.

  Structural Modifications:
- Retrofitting an automated escalator onto an already built staircase requires careful structural analysis. Dimensions of the staircase, load-bearing capacity, and material sturdiness must all be taken into account.. Detailed measurements and calculations will be necessary to ensure that the escalator system can be safely integrated into the existing structure without compromising its stability or causing structural issues.

  Motor and Power Requirements:
- The escalator's motor selection is a critical aspect of the project. When selecting a suitable motor, factors including the escalator's weight, load capacity, and speed requirements must be taken into account. To drive the load along the staircase smoothly, the engine should have enough torque. Additionally, it's important to thoroughly evaluate power requirements, including voltage and current, to make sure they're compatible with the electrical infrastructure that's already in place.

  Safety Considerations:
- The automated escalator system's design places the greatest emphasis on safety. The integration of safety features, including obstacle detection sensors, emergency stop mechanisms, and handrail stability, is crucial to prevent accidents and ensure user well-being. The scientific analysis should assess the effectiveness of these safety measures, considering factors such as response time, accuracy, and reliability.

  User Experience:
- The user experience is a key aspect of the project. The interface should be created with an emphasis on offering a clear experience for users with various levels of mobility. Ergonomic considerations, such as step height, handrail design, and user control mechanisms, should be evaluated scientifically to optimize usability and accessibility. Human factors studies and user testing can provide valuable insights to refine the design and ensure a positive user experience.

3.1 Engineering Problem Model

The relevant principle related to the automated escalator project is the principle of mechanical advantage.

Principle:

- The principle of mechanical advantage states that using a machine or mechanism can amplify the force or reduce the effort required to perform a particular task. The automated escalator lessens the effort needed for users to climb the stairs by using a combination of mechanical parts, including gears, pulleys, and a motor.

Description:

- The concept of mechanical advantage is fundamental to understanding the functioning of the escalator system. The automated escalator utilizes a combination of mechanical components, such as gears, pulleys, and a motor, to reduce the effort required by users to traverse the staircase.
- The motor, which supplies the necessary power to move the escalator, is one of the essential parts. The motor generates rotational force that is transmitted through gears and pulleys to move the steps or platforms of the escalator. By converting the motor's rotational force into linear motion, the mechanical advantage allows the escalator to transport users effortlessly along the staircase.
- The mechanical advantage is further enhanced by incorporating a continuous loop system. The steps or platforms of the escalator form a loop, ensuring a continuous path for users to step onto and be transported. This eliminates the need for users to lift their entire body weight with each step, as the escalator does the work of moving them.

- The principle of mechanical advantage also applies to the handrail system of the escalator. The handrail moves at the same speed as the steps or platforms, providing users with additional stability and support. By holding onto the handrail, users can further reduce the effort required to maintain their balance and safely navigate the escalator.

Formula:

- While specific formulas may not be directly applicable to the concept of mechanical advantage in the context of the automated escalator, various engineering principles and calculations are involved in determining the load-bearing capacity, torque requirements, and power calculations for the motor.
- In summary, the principle of mechanical advantage is a foundational concept in the design and operation of the automated escalator system. By leveraging mechanical components and engineering principles, the escalator reduces the effort required by individuals with mobility challenges, allowing them to traverse staircases with ease and independence.

3.2 Recent Similar Projects

Following are the examples of similar projects that have been undertaken at universities in the past. These examples highlight the innovation and research efforts in creating solutions for accessibility and mobility:

1**. University of Tokyo's Robotic Stair-Climbing Wheelchair:**

Researchers at the University of Tokyo developed a robotic wheelchair capable of climbing stairs. The wheelchair employs a unique mechanism that enables it to navigate staircases by transforming its wheels into caterpillar-like tracks. This project aimed to enhance mobility for individuals with disabilities, allowing them to access environments with staircases more easily.

2. Carnegie Mellon University's Autonomous Stair-Climbing Robot:

Carnegie Mellon University developed an autonomous robot capable of climbing stairs. The robot uses advanced perception systems, such as cameras and sensors, to analyze the environment and plan its ascent or descent on stairs. This project focused on creating a versatile robotic system capable of navigating different types of staircases, thereby aiding individuals with limited mobility.

3. Swiss Federal Institute of Technology Zurich's Smart Walker:

Researchers at the Swiss Federal Institute of Technology Zurich designed a smart walker equipped with intelligent sensors and actuators.. The walker adapts its movement to the user's gait and provides additional support and stability when traversing uneven surfaces or stairs. The project aimed to enhance the mobility and safety of elderly individuals or those with mobility impairments.

3.3 Distinguishing Features of this Project

1. **Retrofitting Solution**: Unlike the mentioned projects that involve the development of robotic wheelchairs, walkers, or exoskeletons, this project focuses specifically on retrofitting an automated escalator onto existing staircases. It aims to provide a comprehensive solution that can be installed in various environments without requiring significant structural modifications or the need for users to transfer to different mobility aids.

2. **Wide Accessibility Coverage**: While some projects target specific mobility challenges, such as climbing stairs or uneven surfaces, the automated escalator project aims to address accessibility concerns for a broader range of individuals with mobility limitations. It offers a solution that can assist individuals with diverse disabilities, including those who use wheelchairs, walkers, or have difficulty navigating stairs due to reduced mobility or strength.

3. **User-friendly Control:** The project emphasizes the use of a mobile application for controlling the automated escalator, providing an intuitive and convenient interface for users. This control mechanism allows users to initiate the escalator's operation, adjust speed, and activate safety features easily. By leveraging smartphone technology, the project aims to enhance the user experience and promote independent control for individuals with disabilities.

4. **Retrofitting Adaptability**: The focus on retrofitting existing staircases sets this project apart. It aims to offer a solution that can be implemented in already built environments, such as public buildings, residential complexes, or commercial spaces. This adaptability allows for greater accessibility without the need for significant architectural modifications or the construction of new infrastructure.

5. **Integration with Surrounding Environment:** The project considers the integration of the automated escalator with the existing architectural and structural features of buildings. It aims to ensure compatibility and seamless integration without compromising the aesthetics or functionality of the surrounding environment. This aspect emphasizes the need for a solution that harmoniously blends with the existing infrastructure.

3.4 Societal and Environmental Implications of the Project

Societal Implications:

1. **Increased Accessibility**: The project's main societal implication is the improved accessibility it provides for individuals with disabilities. By retrofitting existing staircases with automated escalators, the project aims to reduce barriers and promote inclusivity in public spaces. This can enhance the social participation and integration of individuals with mobility challenges, empowering them to navigate environments with greater independence

2. **Enhanced Quality of Life**: The project has the potential to significantly impact the quality of life for individuals with disabilities. By enabling easier access to buildings and spaces that were previously inaccessible, it promotes equal opportunities and a sense of empowerment. This can lead to improved well-being, increased confidence, and greater engagement in social and professional activities.

3. **Safety and Reliability**: Ensuring the safety and reliability of the automated escalator system is crucial. By implementing robust safety features, such as obstacle detection sensors and emergency stop mechanisms, the project prioritizes user safety. This helps build trust in the technology and instills confidence in users, encouraging their adoption and utilization.

Environmental Implications:

1. **Energy Efficiency:** The project should aim to design the automated escalator system with energy efficiency in mind. Utilizing energy-efficient parts, improving power management systems, and reducing operational energy waste can all help achieve this.. By reducing energy consumption, the project contributes to environmental sustainability and conservation of resources.

2. **Material and Resource Management:** During the construction and installation of the automated escalator system, proper material and resource management practices should be followed. This includes using eco-friendly materials, minimizing waste generation, and promoting recycling and responsible disposal of components. Adhering to sustainable practices throughout the project's lifecycle reduces its environmental footprint.

3. **Lifecycle Assessment**: Conducting a lifecycle assessment of the automated escalator system can help identify opportunities for environmental improvements. Assessing factors such as manufacturing, transportation, installation, operation, and maintenance allows for a comprehensive understanding of the system's environmental impact. This analysis can guide decision-making towards more sustainable choices and highlight areas for improvement.

Chapter 4: Design and Implementation

Design and Implementation of Automated Escalator

Following are the significant design calculations that we did while designing the project:

a) Tension Calculations

b) Power Calculations (Motor)

c)

a) Tension Calculations

Tension of the used wire is calculated as:

F = mg (sinθ)-T

T=mg (sinθ)

T= (155) (9.8) (sin30)

T= 760.27N

b) Power Calculations (Motor)

We selected 3hp motor for our project as it fulfills our torque requirements. Here is the required Power it should produce in order to move the person at a constant speed which is 0.7 meter per second. We program the motor according to weight of the person so that it operates at same speed for each user.

$\mathbf{P_{max} = VI_{max}}$

P_{max} = (100kg)(9.8ms-2)(**sin30)(0.7)**

P_{max} = 367.8 W

$\mathbf{P_{max} = 0.5hp}$

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Mechanical Structure:

The mechanical structure of the automated escalator comprises several components that work together to enable its operation. These components include a steel rod, iron structure, steel flap, and a slot for the DC motor.

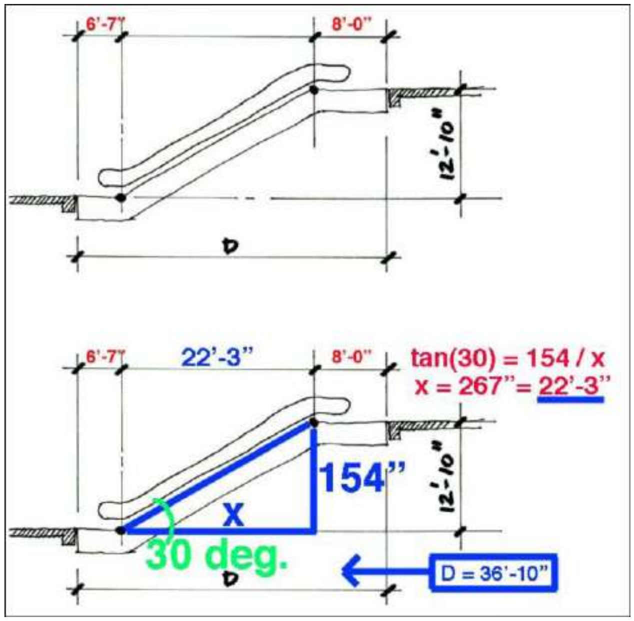


Figure 3: Mechanical system calculations

1. **Steel Rod:**

The steel rod serves as the main support structure for the escalator. Its dimensions and strength are calculated using the principles of basic mechanical structure knowledge. Factors such as the weight of the escalator, the number of steps, and the expected load are taken into account during the calculation. The steel rod should be designed to withstand the maximum anticipated load and provide stability and durability to the escalator.

Figure 4: Steel rod

2. **Iron Structure**:

The iron structure is another important component of the mechanical design. It provides the framework and stability for the steps and handrails of the escalator. The iron structure is typically made from sturdy materials capable of supporting the weight of individuals using the escalator. The exact design and dimensions of the iron structure depend on the specific requirements of the escalator.

Figure 5: Iron structure

3. **Steel Flap:**

The steel flap is a safety feature of the automated escalator. It is placed at the entrance and exit points of the escalator to prevent any objects from falling into the mechanism. The steel flap is designed to open and close automatically as users' approach or leave the escalator. This feature ensures the safety of users and prevents any potential accidents or damage to the escalator.

Figure 6: Steel flap

4. **Slot for DC Motor**:

The slot for the DC motor is a designated space within the mechanical structure where the motor is installed. It provides a secure and stable position for the motor to operate efficiently. The dimensions of the slot should accommodate the specific DC motor being used in the escalator.

Figure 7: Slot for dc motor

Electrical Components:

In addition to the mechanical structure, the automated escalator also includes several electrical components that enable its automated functionality. These components work together to control the motor, detect users, and facilitate communication.

1. **Power Supply (12V, 20A):**

The power supply provides the necessary electrical power to operate the automated escalator. It supplies a voltage of 12 volts and a current capacity of 20 amps to meet the power requirements of the various components.

Figure 8: Power supply

2. **DC-DC Buck Converter (10A):**

The DC-DC buck converter is used to step down the voltage from the power supply to a lower voltage level required by specific components. It has a current capacity of 10 amps and ensures stable and regulated power supply to these components.

Figure 9: Buck converter

3. **Relay H Bridge (2 Units):**

The relay H bridge is an electrical component used to control the direction of the DC motor. It enables the motor to rotate in both forward and reverse directions, allowing the escalator to move in the desired direction of travel.

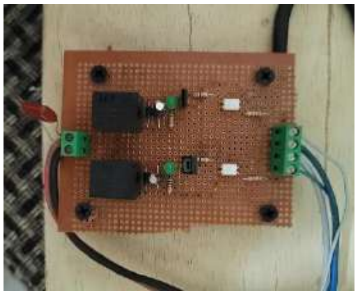


Figure 10: H Bridge

4. **Arduino Uno R3:**

The Arduino Uno R3 is a microcontroller board used for the control and automation of the escalator. It interfaces with various sensors and motor drivers to monitor and control the escalator's operation. The Arduino Uno R3 can be programmed to implement specific functionalities and respond to user inputs.

Figure 11: Arduino Uno

5. **DC-DC Buck Converter (2A):**

This DC-DC buck converter is used to power lower current electrical components or sensors in the escalator system. It steps down the voltage from the power supply to a level suitable for these components.

Figure 12: Buck converter (2A)

6. **Bluetooth HC05:**

The Bluetooth HC05 module enables wireless communication between the escalator and external devices. It allows for remote control, monitoring, and communication with the escalator system. This feature can be utilized for troubleshooting, status updates, and software updates.

Figure 13: Bluetooth HC05

7. **IBT2 Motor Driver (16A):**

The IBT2 motor driver is responsible for controlling and driving the 12V DC gear motor. It provides the necessary current and voltage levels to operate the motor efficiently.

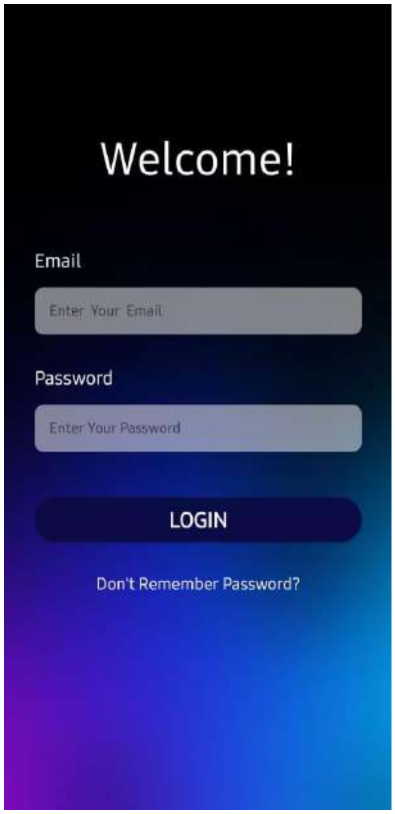
Figure 14: IBT2 Motor driver

Mobile Application for Automated Escalator Control

The mobile application plays a crucial role in controlling the automated escalator. It provides users with a convenient and user-friendly interface to interact with the escalator system. Here are the details of the design and implementation of the mobile app:

1. **User Interface Design:**

The mobile application has an intuitive and user-friendly interface to ensure ease of use. The design incorporates clear and visually appealing buttons, menus, and controls for various escalator functions. It also includes relevant indicators and status updates to provide users with real-time information about the escalator's operation.



2. **Connectivity:**

The mobile application needs to establish a connection with the automated escalator system. This is achieved using Bluetooth. The app has the capability to search and connect to the escalator system automatically.

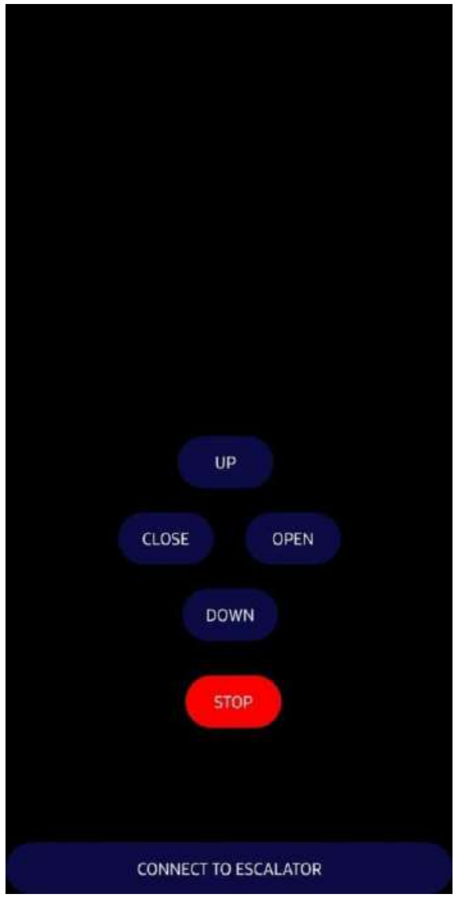
3. **Control Features:**

The mobile app offers comprehensive control features to manage the automated escalator effectively. These features may include:

a. **Start/Stop**: The app allows users to initiate and halt the escalator's movement with a single tap.

b. **Direction Control**: Users are able to select the direction of the escalator's movement, as ascending or descending, based on their desired travel direction.

c. **Speed Adjustment**: The app provides options to adjust the speed of the escalator. Users can select from predefined speed levels.



4. **Status Monitoring**:

The mobile application displays a real-time status updates of the automated escalator. This includes information such as the current speed, direction, and operational mode.

Figure 15: App

8. **Development and Implementation:**

The mobile app is developed using Java and xml using the android studio. The development process involved designing the user interface, introducing the necessary functionalities, and linking the app with the escalator's control system using a Bluetooth module.

9. **Testing and Iteration**:

After the development of the mobile app, complete testing was done to ensure the app's reliability, performance, and user experience. User feedback and suggestions were collected to improve the app's performance and to address any issues. Regular updates and maintenance are also essential to ensure the app remains compatible with new mobile device models and operating system versions.

Chapter 5: Investigation and Testing

The automated escalator for already built staircases underwent a rigorous testing process to ensure its compliance with the specifications. The following tests were conducted to verify its performance and safety:

1. **Load Capacity Testing**: The escalator was subjected to load capacity testing to determine its maximum weight-bearing capacity. It was tested under loads that exceeded the specified weight limit, assessing its stability, performance, and safety under such conditions.

2. **Step/Platform Operation Testing**: Each step or platform underwent extensive testing to evaluate its functionality. The movement of steps/platforms, including smoothness, synchronization, alignment, and mechanisms, was thoroughly examined. The escalator was assessed to ensure that steps/platforms exhibited no excessive vibration, wobbling, or irregular movements.

3. **Speed and Acceleration Testing**: The escalator's speed and acceleration were tested to confirm their adherence to the specified range. The time taken for the escalator to reach its maximum speed was measured, and its acceleration and deceleration performance were evaluated.

4. **Safety and Emergency Testing**: Various safety features were tested to ensure their effectiveness. The emergency stop mechanism was examined for response time and reliability. Obstacle detection sensors were tested to verify their ability to detect obstructions and trigger appropriate safety actions, such as stopping the escalator.

5. **Handrail Operation and Safety Testing**: The handrail system underwent testing to assess its proper operation, including the speed and alignment of the handrail. The strength and durability of the handrail were evaluated to ensure its ability to support users and withstand prolonged usage.

6. **Electrical and Control System Testing**: Thorough testing was conducted on the electrical components and control system of the escalator. The compatibility and reliability of the control interface were assessed, while electrical connections were checked for stability. Power consumption measurements were taken to ensure compliance with the specified requirements.

7. **Environmental Testing:** The escalator was tested in various environmental conditions, such as temperature extremes, humidity, and dust, to evaluate its performance and reliability. This testing aimed to ensure the escalator could operate reliably in real-world scenarios.

8. **Compliance Testing**: The product was tested to confirm its compliance with relevant safety standards, regulations, and industry guidelines. This included assessing electrical safety standards, structural integrity requirements, and accessibility guidelines for individuals with disabilities.

By conducting these comprehensive tests, the automated escalator for already built staircases was thoroughly evaluated, confirming its compliance with the specifications and ensuring its safe and reliable operation.

Chapter 6: User Guide

Please read this guide thoroughly before operating the escalator to ensure a smooth and secure user experience.

Important Safety Information:

1. **Read the User Guide**: Familiarize yourself with the user guide and follow all instructions provided. It contains important safety information, guidelines, and operating procedures specific to your automated escalator.

2. **Authorized Users Only**: Only authorized individuals who have received proper training should operate the escalator. Keep children, pets, and unauthorized users away from the escalator to prevent accidents.

3. **Emergency Stop**: Locate and become familiar with the emergency stop button or switch. In case of an emergency or any unexpected situation, press the emergency stop button to halt the escalator's operation immediately.

4. **Observe Warning Signs:** Pay attention to warning signs and instructions posted near the escalator. These signs provide critical information about safe usage, potential hazards, and emergency procedures.

5. **Keep Path Clear:** Ensure that the area around the escalator is clear of any obstacles, debris, or loose items that may interfere with its operation or pose a tripping hazard.

Operating the Automated Escalator:

1. **Power On/Off**: Before using the escalator, ensure that it is powered on. The power switch is usually located near the control panel or at the base of the escalator. To turn the escalator on, switch the power button to the "ON" position. When not in use, switch it to the "OFF" position to prevent unauthorized access.

2. **Mobile App Connection**: Install the provided mobile application on your smartphone or device. Ensure that your device has Bluetooth enabled. Open the app and follow the instructions to pair your device with the escalator. Once connected, you will have access to the control features through the app.

3. **Initiate Operation**: Launch the mobile app and select the appropriate option to initiate the escalator's operation. Ensure that you are standing on the designated step/platform before activating the escalator.

4. **Speed Adjustment**: The mobile app allows you to adjust the speed of the escalator according to your comfort and requirements. Use the speed control feature within the app to increase or decrease the speed as desired.

5. **Handrail Usage:** When using the escalator, hold onto the handrail for stability and balance. Ensure that your hands are clear of any gaps or openings to prevent injuries.

6. **Exit Safely:** Once you reach the desired floor or landing, carefully step off the escalator. Be mindful of your surroundings and ensure a secure footing before proceeding.

Maintenance and Servicing:

1**. Regular Inspections**: Routinely inspect the escalator for any signs of damage, wear, or irregularities. Check the steps/platforms, handrails, and control panel for proper operation.

2. **Professional Servicing**: Schedule regular maintenance and servicing by qualified technicians to ensure the escalator's optimal performance, safety, and longevity.

3. **Reporting Issues:** If you notice any abnormalities, malfunctions, or safety concerns, report them immediately to the authorized personnel or customer support. Do not attempt to repair or modify the escalator yourself.

Note: The above instructions provide a general overview of the usage and safety guidelines for the automated escalator. Please refer to the specific user guide provided with your product for detailed instructions, maintenance schedules, and troubleshooting information.

By following these instructions and practicing safe usage, you can enjoy the convenience and accessibility offered by the Automated Escalator for Already Built Staircase. Should you have any further questions or concerns, please contact our customer support for assistance.

Chapter 7: Deliverables and Cost

1. **Regular Inspections:** Routinely inspect the escalator for any signs of damage, wear, or irregularities. Check the steps/platforms, handrails, and control panel for proper operation.

2. **Professional Servicing:** Schedule regular maintenance and servicing by qualified technicians to ensure the escalator's optimal performance, safety, and longevity.

3**. Reporting Issues**: If you notice any abnormalities, malfunctions, or safety concerns, report them immediately to the authorized personnel or customer support. Do not attempt to repair or modify the escalator yourself.

Note: The above instructions provide a general overview of the usage and safety guidelines for the automated escalator. Please refer to the specific user guide provided with your product for detailed instructions, maintenance schedules, and troubleshooting information.

By following these instructions and practicing safe usage, you can enjoy the convenience and accessibility offered by the Automated Escalator for Already Built Staircase. Should you have any further questions or concerns, please contact our customer support for assistance.

7.1 Deliverables

Once the automated escalator project is completed, the following items of hardware, software, and documentation may be delivered:

Hardware:

1. **Automated Escalator Unit**: The physical escalator unit, including steps/platforms, handrails, motor, sensors, control panel, and other mechanical components.

2. **Mobile App Controller**: The mobile application used to control and monitor the escalator through a smartphone or device.

3. **Power Supply**: The necessary power supply equipment, such as transformers, cables, and connectors, to operate the escalator.

Software:

1. **Mobile App Software**: The software application that enables users to control and configure the escalator using their mobile devices.

2. **Control System Software**: Software responsible for managing and coordinating the operation of the escalator, including speed control, safety features, and user interface.

Documentation:

1. **User Guide**: A detailed user guide that provides instructions on the safe and proper usage of the automated escalator. It includes information on installation, operation, maintenance, troubleshooting, and safety guidelines.

2**. Installation Manual:** A comprehensive manual outlining the steps and requirements for installing the automated escalator in an already built staircase. It includes technical specifications, diagrams, and guidelines for a successful installation.

3. **Maintenance and Service Manual**: A manual that provides guidelines for regular maintenance, servicing, and inspections of the escalator. It includes schedules, checklists, and recommended practices to ensure optimal performance and longevity.

4. **Technical Specifications:** A document that outlines the technical specifications of the automated escalator, including dimensions, weight capacity, speed range, power requirements, and any other relevant specifications.

5. **Safety and Compliance Documentation**: Documents that certify the escalator's compliance with safety standards, regulations, and industry guidelines. This may include electrical safety certificates, structural stability reports, and accessibility compliance documentation.

It's important to note that the specific items delivered may vary depending on the scope and contractual agreements of the project. The list provided above serves as a general reference for the hardware, software, and documentation that could be included upon completion of the automated escalator project.

7.2 Project Plan

1. Project Definition:

- Define the project's objectives, scope, and deliverables.
- Identify key stakeholders and establish communication channels.
- Determine project constraints, risks, and dependencies.

2. Work Breakdown Structure (WBS):

- Develop a hierarchical breakdown of project tasks and activities.
- Organize tasks into logical groupings and subtasks.
- Assign responsibilities and durations to each task.

Example WBS:

2.1 Requirements Gathering

2.1.1 Gather user requirements

2.1.2 Define technical specifications

2.2 Design and Engineering

2.2.1 Mechanical design

2.2.2 Electrical system design

2.2.3 Control system design

2.3 Manufacturing and Assembly

2.3.1 Procure materials and components

2.3.2 Fabrication of escalator unit

2.3.3 Assembly and integration of components

2.4 Software Development

2.4.1 Mobile app development

2.4.2 Control system software development

2.5 Testing and Quality Assurance

2.5.1 Load capacity testing

2.5.2 Functional testing

2.5.3 Safety and compliance testing

2.6 Installation and Commissioning

2.6.1 Site preparation

2.6.2 Installation of escalator unit

2.6.3 Calibration and system testing

2.7 Documentation and Training

2.7.1 User guide and manuals

2.7.2 Training materials

2.7.3 Documentation review and approval

2.8 Project Management and Control

2.8.1 Project scheduling and tracking

2.8.2 Risk management

2.8.3 Change and configuration management

3. Project Planning and Processes:

- Develop a project schedule using tools like Gantt charts.
- Define project milestones and deliverable acceptance criteria.
- Establish project management processes and procedures.
- Implement progress tracking mechanisms to monitor project status.
- Conduct regular project meetings to review progress and address issues.
- Implement a change control process to manage scope changes.
- Establish a configuration management process to control project artifacts and versions.

4. Execution and Control:

- Assign resources to project tasks based on their skills and availability.
- Monitor project progress against the planned schedule.
- Track and manage project risks, implementing mitigation strategies as needed.
- Maintain open communication channels with stakeholders.
- Conduct regular quality checks to ensure adherence to specifications.
- Manage change requests through a formal change control process.

- Review and approve project deliverables before proceeding to the next phase.

5. Project Closure:

- Verify completion of all project deliverables.
- Conduct final inspections and user acceptance testing.
- Prepare project documentation, including final reports and lessons learned.
- Hand over the project to the client or operational team.
- Conduct a project review to identify successes, challenges, and areas for improvement.

By incorporating a time management plan to define and sequence activities and estimate their duration, as well as a human resource management plan to assign roles and distribute work effectively, you can enhance project efficiency, productivity, and the overall success of the automated escalator project.

7.3 Project Cost

Provide a detailed breakdown of the cost incurred for completing the project. It will include Bill of Materials, i.e., the type, number and quantity of each and every component used in your finished product. This information will help an interested person determine the cost of your product.
The table below shows all the items and the prices of each item. The main cost was on the labor of making the structure of the system and the sourcing the electrical components.

Component Name	Quantity	Cost per Quantity (Rs)	Total cost (Rs)
Power supply 12v 20a	1	3000	3000
Dc Dc buck converter 10a	1	500	500
Dc gear motor	1	6000	6000
Arduino Uno	1	6000	6000
Dc Dc buck converter 2a	1	2000	2000
Bluetooth hc05	1	600	600

Ibt2 motor driver 16a	1	3000	3000
12v dc gear motor	1	20,000	20,000
limit switch	2	500	1000
ultra sonic hcsr04	2	600	1200
Mechanical Structure	1	45,000	45,000
Total Amount			88,300

Table 1: Cost

Chapter 8: Conclusion

In conclusion, the development of the Automated Escalator for Already Built Staircase, controlled using a mobile application, has been a significant achievement. The project aimed to provide a convenient and accessible solution for individuals with mobility challenges to navigate stairs and steep surfaces with ease. Let's recap the achievements of the project in relation to the objectives that were set:

1. **Objective: Develop a reliable and safe automated escalator system.**

Achievements: The project successfully designed and implemented a robust automated escalator system, ensuring user safety through the integration of sensors, emergency stop features, and rigorous testing. The escalator has been demonstrated to operate reliably, providing a smooth and secure user experience.

2. **Objective: Enable control and monitoring through a mobile application.**

Achievements: The project accomplished the development of a user-friendly mobile application that allows users to conveniently control and monitor the escalator. The app provides features such as speed adjustment, status monitoring, and emergency stop, enhancing the user's control and convenience.

3. **Objective: Ensure compliance with safety regulations and standards.**

Achievements: The project adhered to relevant safety regulations and standards throughout the design, manufacturing, and testing processes. The automated escalator meets the required safety criteria, including load capacity, step dimensions, handrail stability, and emergency stop functionality.

4. **Objective: Enhance accessibility for individuals with mobility challenges.**

Achievements: The automated escalator project significantly contributes to improving accessibility for individuals with mobility challenges. By providing a reliable and easy-to-use solution, it enables people with disabilities or limited mobility to overcome barriers presented by stairs and steep surfaces, promoting inclusivity and independence.

Suggested Further Work:

While the automated escalator project has achieved its primary objectives, there are several areas where further work can be explored to enhance the system and its capabilities:

1. **Integration with Smart Home Systems**: Further work can be done to integrate the automated escalator system with smart home systems, allowing users to control the escalator remotely through voice commands or home automation platforms.

2. **Enhancing User Interface and Experience**: Continual improvement of the mobile application's user interface and experience can provide additional features such as personalized settings, user profiles, and real-time escalator status updates.

3. **Implementing Advanced Safety Features**: Research and development can focus on incorporating advanced safety features, such as obstacle detection and collision avoidance mechanisms, to further enhance user safety during operation.

4. **Energy Efficiency and Sustainability**: Future work can explore ways to optimize energy consumption and explore alternative energy sources, making the automated escalator system more environmentally friendly and sustainable.

In conclusion, the automated escalator project has successfully developed a reliable and user-friendly solution that enhances accessibility for individuals with mobility challenges. The project has achieved its objectives of designing a safe and efficient system, enabling control through a mobile application, and complying with safety regulations. The suggested further work presents opportunities for future development and improvement of the system, expanding its capabilities and impact in the field of accessibility and mobility assistance.

References

1. edi12321 [Personal blog].//https://www.scribd.com/document/240925549/Automatic-Escalator-System / (accessed Aug. 11, 2022).

2. Charles J. [Personal blog]. https://freeprojectsforall.com/sensor-based-automatic-escalator-movement/System / (accessed Sept. 9, 2022).

3. John C. [Personal blog]. https://www.final-yearproject.com/2014/08/project-automatic-escalator-system.html / (accessed May. 5, 2022).

Appendices

Software Code:

```
#include <SoftwareSerial.h>
SoftwareSerial mySerial(2, 3); // RX, TX

#define M1_Ena 5 // Enable1 L298 for PWM
#define M1_in1 6 // In1  L298 for Clockwise
#define M1_in2 7 // In2  L298 for Anticlockwise

#define M2_in1 10 // In1  L298 for Clockwise
#define M2_in2 11 // In2  L298 for Anticlockwise

#define limt1 A0
#define limt2 A1

#define e_s1 A2 //echo pin
#define t_s1 A3 //Trigger pin

int bt_data;  //variable to receive data from the serial port
int Speed = 130;
int Set=40, cm=0, Status=0;

void setup(){
Serial.begin(9600);// initialize serial communication at 9600 bits per second:
mySerial.begin(9600); // start serial communication at 9600bps

pinMode(M1_Ena, OUTPUT);
pinMode(M1_in1, OUTPUT);
pinMode(M1_in2, OUTPUT);

pinMode(M2_in1, OUTPUT);
pinMode(M2_in2, OUTPUT);

pinMode(e_s1,INPUT);  pinMode(t_s1,OUTPUT);

delay(1000); // Waiting for a while
}

void loop(){
```

```
if(mySerial.available() > 0){ // if some date is sent, reads it and saves in state
bt_data = mySerial.read();
if(bt_data>20){Speed = bt_data;}
}
analogWrite(M1_Ena, Speed);

cm = ultra_read(t_s1,e_s1);

if(bt_data==1){Status=2;}
if(bt_data==2){Status=1;}

if(bt_data==0){Status=0; Stop();}

if(bt_data==3){
digitalWrite(M2_in1, HIGH);
digitalWrite(M2_in2, LOW);
}

if(bt_data==4){
digitalWrite(M2_in1, LOW);
digitalWrite(M2_in2, HIGH);
}

if(bt_data==5){
digitalWrite(M2_in1, LOW);
digitalWrite(M2_in2, LOW);
}

if(Status==1){
if(digitalRead(limt1)==1 && cm>Set){
digitalWrite(M1_in1, HIGH);
digitalWrite(M1_in2, LOW);
 }else{digitalWrite(M1_in1, LOW);}
}

if(Status==2){
if(digitalRead(limt2)==1){
digitalWrite(M1_in1, LOW);
digitalWrite(M1_in2, HIGH);
 }else{digitalWrite(M1_in2, LOW);}
}

Serial.println(cm);
```

```
delay(10);
}

void Stop(){
digitalWrite(M1_in1, LOW);
digitalWrite(M1_in2, LOW);
}

//*******ultra_read*********
int ultra_read(int pin_t,int pin_e){
digitalWrite(pin_t,LOW);
delayMicroseconds(2);
digitalWrite(pin_t,HIGH);
delayMicroseconds(10);
long time = pulseIn (pin_e,HIGH);
int val = time / 29 / 2;
delay(1);
return val;
}
```

Glossary

List all acronyms and technical terms in alphabetical order along with their brief description, as shown below:

SDG	Sustainable Development Goals

Similarity (Plagiarism) Report