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Shuttling Train Between Stations

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ABSTRACT: Shuttling trains, operating between fixed stations, play a crucial role in efficient and sustainable transportation systems. This paper explores the design, optimization, and operational efficiency of shuttle train systems, focusing on scheduling algorithms, and energy consumption. Key considerations include minimizing dwell times, optimizing acceleration and braking profiles, and integrating automation for improved reliability. The study also examines the impact of real-time data analytics in enhancing performance and reducing delays. By leveraging modern engineering solutions, shuttling train systems can enhance urban mobility, reduce congestion, and contribute to more sustainable public transport networks.

KEYWORDS: Automation, Sensor-based Control, Microcontroller, Collision Avoidance, Railway Safety System

I. INTRODUCTION

Rail transportation remains one of the most efficient and sustainable modes of mass transit, particularly in urban and suburban environments. Among various rail systems, shuttling trains, which repetitively operate between fixed stations, play a vital role in ensuring seamless connectivity. These systems are widely used in metro networks, airport link services, and high-frequency commuter routes, where punctuality and efficiency are paramount.

The design and operation of shuttling train systems involve several engineering challenges, including optimal scheduling, energy-efficient acceleration and braking, passenger flow management, and real-time monitoring. Arduino UNO microcontroller is being used as the CPU. Whenever the train will arrive at the station the train will be stopped automatically, as the IR sensor will sense. Then the door will open automatically, allowing the passengers to get inside the train. The door will get closed after a prescribed time.



Fig. 1. Implementation of train doors

Traditional metro systems that covers extensive routes with multiple destinations, shuttling focuses on connecting the key points within a metropolitan area, which operates on short and direct routes. This specialization addresses the needs of Tourists providing a safe mode of transport.





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Many of the modern shuttling train use this control systems which ensures safety, consistency and efficiency. Some of them are fully automated and it reduces the need of human operators and minimizeas operational costs.

Passenger Experience:-

A. <u>Comfort and Accessibility</u>: Shuttling trains are designed for passenger comfort travel, which includes spacious seating and amenities such as Wi-Fi, air conditioning and accessibility options for the individuals having disabilities.

B. <u>Safety Protocols</u>: Enhancement in safety measures, which includes emergency communication systems, surveillance cameras, and visible security personnel, this are important for ensuring secure travelling environment. A shuttling metro train between stations is a train system which travels between two desitinated stations without any human interference. The goal of these proposed systems is to reduce the need of human interference, which will eliminate errors and maintain high security. Whenever the train will arrive at the platform, the train shall stop automatically when the train will sense the IR sensor. And the door will get open automatically so that the passengers will enter in the train. The door will close after a given time set which will be set in the controller using the program.

II. LITERATURE SURVEY

Initially, when train starts, the train will move automatically using motors which consist of the motor drivers will control and run the train in the forward direction. With the limit switches, one can identify either the door is open or close and the messages can also be observed on the LCD screen. We can also count the passengers entering and leaving using IR sensors. If the person is entering in the train then the first IR sensor will get high. If the person is leaving from the train then second IR sensor will get high,. If the train is full and there are no more seats then will also reduces the overcrowding of the passengers inside the train.

Limitation: Shuttle trains can face some limitations like technical challenges, and also safety concerns. [1][9] In this project, the control of trains using Arm 7 reduces the risk of safety and availability. IR sensors are implemented to inform the train that the station has arrived. Also, the doors are equipped with IR sensors. Hence, the door opens automatically so that the passengers can go inside the train. It is equipped with a passenger counting section, which will count the number of passengers entering and leaving the train. There should be a passenger limit. The passenger counts and the stations will be displayed on an LCD interfaced with the ARM 7. The train also has a buzzer which will alert the passengers before closing and opening of the door [2][6]

In this project, programming will control by using Aurdino, which reduces of accidents and enhances availability. The project will display necessary parameters on an LCD otherwise on the seven Segment Display. IR sensors are implemented to make the train aware that the station has arrived, doors are also equipped with sensors to make a count of passengers and after it reaches the limit it will close automatically.

Limitation: Shuttle trains face limitations like technical challenges and safety concerns. [3][8][2] This paper presents about the development of an automatic shuttle train system which eliminates the need for a driver when there is a need to stop the train by sensing the RFID tags and after stopping it is programmed to open and close the door automatically with the help of motor drivers L293D and L298H, after a prescribed time. The system uses IR sensors to detect station arrivals, automatically opens.

Limitation: Shuttle trains face limitations like technical challenges, and safety concerns because of drivers. [4][7] The Prototype of the shuttle train is a 8051 microcontroller-based Device. This proposed system will reduce the need of any driver for the function of the doors .As the train senses the IR Sensor which are placed at the station the train will stop automatically and the door will also open automatically which will allow the passengers to come inside the train and the train is also equipped with a passenger counting section, which counts the number of passengers entering and leaving. The train will show the number on the LCD. The working or the motion of the shuttle train is done by the Motor driver IC. Before starting and after stopping the train at the station the controller blows the Buzzer.

Limitation: Track Availability and scheduling issues, Shuttle trains face limitations like technical challenges and safety concerns. These factors can complicate their implementation and operation. [5][10]





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III. METHODOLOGY

We are implementing this project using Arduino, so Arduino is used as a CPU as controlling trains using Arduino reduces the risk of safety and availability. IR sensors are implemented to inform that the platform has arrived. Also, The doors are equipped with IR sensors. Hence, the door opens automatically so that train drivers' efforts to open and close doors are minimized. The train will also have a buzzer which is to alert the passengers before the door closes which will reduce the risk of accidents. As the train will reach the destination the process will again repeat and it will achieve the desired operation. This model is designed to provide safety, consistency, efficiency, and high-quality services to the passengers travelling. This type of automated train can be inserted in traffic without the help of human operations, which can be performed so that traffic levels will be reduced. We also provide longer waiting times at crowded stations and regular service to other stations. L293D motor driver IC is used for the Functioning of the SD (sliding door). The DVD loader trolley is connected with the BO motor. The motor connected To L293D motor driver IC. For avoidance of obstacle, Arduino is interfaced with an Infrared sensor (IR), that will detect any obstacle on the track within its proximity. i.e., it gets a notification at the time when the metro train will reach to the station, forwarding as well as reverse in movements, and monitoring the train. Buzzer can produce sound alerts to notify passengers of important information, such as upcoming stops or safety warnings. Using a piezo buzzer enhances communication and safety and better passenger experience for passengers.

As shown in Fig.2, we can implement



Fig. 2. Block Diagram

An IR transmitter, or infrared transmitter, is a light-emitting diode (LED) that sends infrared (IR) radiation to other devices. IR transmitters are often used in remote controls and other IR signaling devices. IR technology is easy to implement and integrate with microcontrollers like Arduino, making it accessible for project development. IR components are relatively inexpensive, helping keep project costs low. Ideal for applications within a limited range, such as between stations or along a track, providing reliable data transfer without interference. Using an IR transmitter enhances the train's automation and safety features, making it a valuable component in the project. It receives signals from the IR transmitter, allowing the train to communicate with the control system or sensors. The IR receiver can detect reflected signals from obstacles, helping the train avoid collisions. IR receivers are simple to connect to microcontrollers like Arduino, making them easy to incorporate into the project. It converts the IR signals into electrical signals that can be used by the device to perform an action. They are inexpensive components, helping keep the overall project budget manageable. BO motor is also used for controlling train doors. A piezo buzzer are easy to connect to microcontrollers like Arduino, allowing for straightforward programming and control. Using a piezo buzzer enhances communication and safety in the shuttling train system, contributing to a better passenger experience. We are using an LCD Display 16x2 for showing that the train door is closed and open and also for which station is arriving. Like "Doors: [Status], Arriving: [Station]". DC motor wheels are the driving force behind train projects, enabling locomotion and providing precise control over speed and direction. DC motor wheels provide the rotational force necessary for train movement, enabling controlled locomotion in model railways and automated systems.





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Software Requirement : Arduino IDE (Compiler): The Arduino IDE (Integrated Development Environment) is a software application used for writing, editing, and uploading code to Arduino boards. You can write code (often called sketches) in a simple programming language based on C/C++. It includes libraries that make it easier to control various hardware components like sensors and motors. Once your code is written, you can upload it directly to your Arduino board with a click. The IDE allows you to see output and errors, making it easier to fix problems in your code. Using the Arduino IDE allows for efficient coding and testing, making it a suitable choice for controlling the components in a train system.

• Components and their Uses.

Table.1 Components and their uses

COMPONENTS	USE IN THE PROJECT
Arduino UNO	The microcontroller acts as the brain, controlling the train's movement, door operation, and passenger counting, based on inputs from IR and LDR sensors ,and communicating with other components like motor drivers and displays
L293D Driver	The L293D motor driver IC is used to control the DC motors responsible for train movement and door operation, allowing for precise control of the train's direction and stopping at stations.
Infrared (IR) sensors	Infrared sensors (IR), detect objects or the change in the environment by sensing the infrared radiation, with common applications which includes motion detection, remote controling, and security systems.
Piezo Buzzer	A piezo buzzer is an electronic device that produces a sound, tone, or alarm using a piezo buzzer enhances communication and safety in shuttling train systems
POWER SUPPLY	It supplies power to additional components. The adapter provides a stable power supply to drive the train forward and backward between station





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Fig.3. Functional Flow diagram of shuttling train between stations.

- When a train leaves, someone presses "Start," A display says "Train is departing," a buzzer sounds, then "Doors are closing" shows with another buzzer, the doors close ("Motors: ON"), and the train goes.
- When a train arrives, it shows "Train is Arriving" with a buzzer, the doors stop ("Motors: OFF"), then "Doors are Opening" shows with another buzzer, and someone presses "Stop." This shows the simple steps for train doors opening and closing when arriving and leaving.
- The process concludes with a "Stop" signal, presumably after passenger exchange, preparing the train for its next departure cycle.
- This flow diagram effectively illustrates the automated steps involving visual and auditory cues, as well as the activation and deactivation of door mechanisms for the safe and orderly movement of passengers during train arrivals and departures

Experimental results



Fig.4. Connection





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This project is based on Arduino UNO, which will work as the brain of the entire system for controlling trains. We implemented an IR sensor to inform that the platform has arrived. IR(TX) transmits that the station arrives and IR(RX) receives it and opens the door, the doors are also equipped by an IR sensor. The train also has a buzzer which alerts the passengers before closing the train door. By using a piezo buzzer it will enhance the communication and safety in the shuttle train system, contributing to a better passenger experience. As the train reaches the destination, the process repeats again thus it achieves the desired operation. We also provide longer waiting times at crowded stations and regular service to other stations. L293D motor driver is used it is the IC and it is used for the operation of the doors ,SD (sliding door). The DVD loader which acts as a trolley, and it is connected to the BO motor and this BO motor is also used to control the train doors. These are the major three steps in which explains the whole project and the system we will get the notification when the train will reach at the platform of the desired station, forward and backward movements of the train, and monitoring the entire process.



Fig.5. L.C.D. Display of the doors.

We are using an LCD Display 16x2 for showing that the train door is closed and open and also for which station is arriving. Like "Doors: [Status], Arriving: [Station]".



Fig.6. Setup

DC motor wheel are used as the driving motion behind train projects, enabling locomotion and it provides precise control of speed and direction. DC motor wheels provide the rotational force necessary for train movement, enabling controlled locomotion in model railways and automated systems.

IV. CONCLUSION

In conclusion, the implementation of shuttling train systems between stations offers numerous advantages that enhance urban mobility, improve passenger safety, and foster inclusivity, reducing waiting times and getting a smoother transit experience. The design of shuttling train doors, specifically tailored for accessibility, ensures that individuals with





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disabilities can navigate the transit system with ease. The main reason of this paper is to maintain the efficiency of public transport in order to contribute in the improvement of the quality of the people in the respective cities. This paper implemented the development of new technology for the train.

Despite some challenges, such as higher initial costs and potential mechanical complexity, the benefits of increased efficiency, safety, and passenger comfort make shuttlr trains a valuable addition in the transportation networks. As cities continue to grow allowing higher demand of efficient transit solutions rises, shuttling train systems stands out as a practical and forward-thinking option for meeting the needs of diverse populations.

V. ADVANTAGES

1. Efforts required to open and close the door manually are minimized.

2. These doors can open and close quickly, reducing the time the train spends at stations and improving the overall schedule

3. Shuttling doors help ensure passenger safety by preventing accidental openings while the train is in motion. They often have sensors that detect obstructions

4. Modern shuttling door designs can enhance the visual appeal of the train, contributing to a more contemporary and attractive look.

VI. DISADVANTAGES

1. The initial cost of installation and maintenance can be higher compared to standard doors, impacting budget considerations for transit systems.

2.In some designs, the space required for the door's operation may be limited, which could complicate boarding in crowded conditions.

VII. FUTURE SCOPE

Future considerations should focus on addressing maintenance needs, ensuring proper training for staff, and continually enhancing user experience, To maximize the advantages of shuttling train systems.

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