Integrated Smart Student Shuttle System with RFID, Real-Time Updates, Seat Booking, Safety, and GPS

*Efficiency and Safety Enhancement through Technological Integration

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***Abstract*—Addressing the shortcomings of conventional student transportation, our solution, the Digital Shuttle System, employs RFID-based registration, real-time information display, seat booking, safety sensors, and GPS tracking. This multifaceted approach streamlines access, transparency, and safety. Implementation has resulted in notable efficiency gains through swift RFID registration, improved transparency via real-time student updates, optimized seat management, and heightened safety using accurate sensor-based hazard detection. The integrated GPS system enhances operational oversight by enabling real-time shuttle tracking. Overall, the Digital Shuttle System showcases a substantial boost in performance, accuracy, and efficiency for student transportation.**

***Index Terms*—RFID, Transportation, Shuttle, Sensors, GPS, Integration, Hazard, Detection**

I. Introduction

The Digital Shuttle System addresses the challenges prevalent in traditional student transportation systems. The conventional systems suffer from inefficiencies, lack of transparency, and safety concerns, leading to delays, disarray, and potential risks. These shortcomings have prompted the need for an innovative solution that can revolutionize student transportation by integrating advanced technologies. The motivation behind this project stems from the pressing need to enhance the overall student transportation experience. Existing systems often lead to congestion, prolonged boarding times, and a lack of real-time passenger information. Moreover, safety hazards like alcohol presence, smoke, and gas in the shuttle environment pose risks to passengers. Thus, our project aims to create a seamless, efficient, and secure transportation ecosystem for students, improving accessibility, transparency, safety, and operational management.

Through an extensive literature review, we have found related research and projects that have addressed individual aspects of student transportation. Various works have focused on RFID-based access systems, real-time passenger information displays, and safety sensor integration. However, most projects have tackled these elements in isolation, lacking a holistic approach. Furthermore, a comprehensive integration of these features along with GPS tracking is scarce in the existing literature. In [1], The main theme of the paper titled ”Ticket Purchase System using RFID and Bus Location Tracking System with GPS Tracker” is the development and implementation of an integrated system for improving the efficiency and convenience of public transportation services. The paper focuses on utilizing Radio-Frequency Identification (RFID) technology and Global Positioning System (GPS) tracking to create a comprehensive solution that enhances the process of ticket purchasing and bus tracking within the context of public transportation. The integration of these technologies aims to streamline ticketing procedures, enhance passenger experience, and optimize bus operations by providing real-time location tracking. In [2], The main theme of the paper titled ”Smart Vehicle Alcohol Detection System” is the design, development, and implementation of a technological solution aimed at preventing drunk driving by detecting alcohol levels in a vehicle's driver. The paper focuses on creating a system that utilizes advanced technology to enhance road safety and reduce the risk of accidents caused by drivers operating vehicles under the influence of alcohol. The primary goal of the paper is to present a smart and effective approach to alcohol detection within vehicles, highlighting the potential for improved road safety and the reduction of alcohol-related accidents. In [3], The main theme of the paper titled ”Development of IoT-based smart fire detection sensor” is centered around the creation and implementation of a fire detection system that utilizes the Internet of Things (IoT) technology. The paper focuses on the design, development, and deployment of a sensor that can intelligently detect and monitor fire incidents in real time using IoT connectivity. The primary objective of the paper is to showcase the innovation and potential of IoT-enabled fire detection systems, emphasizing their ability to enhance early fire detection, improve response times, and contribute to the overall safety and protection of environments susceptible to fire hazards.

Our Digital Shuttle System stands out through its holistic integration of multiple technologies. Unlike previous projects, our system offers RFID-based registration, real-time student information display during boarding, seat booking capabilities, comprehensive safety sensor systems, and live GPS tracking, all integrated into a single, unified solution. This comprehensive approach addresses the key pain points of existing systems by enhancing efficiency, transparency, safety, and operational control. The unique combination of these features sets our project apart, creating a new benchmark for student transportation systems. By fusing these innovations, we not only optimize the daily transportation experience but also ensure students' safety and provide stakeholders with real-time oversight. Our project represents a significant leap forward in re imagining and redefining student transportation systems to meet the demands of modern educational institutions.

II. Proposed Method

A. Block diagram of the overall system

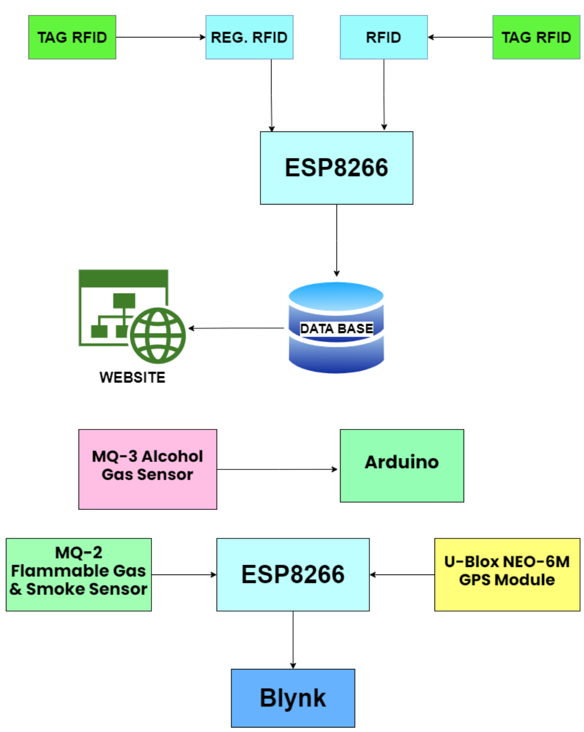

Fig. 1. Block Diagram of the overall system.

The Shuttle System integrates multiple features to enhance safety and passenger experience. RFID card registration enables passengers to securely access the shuttle, with registered card details stored in a MySQL database. An RFID reader validates cards, granting authorized entry. The system employs a GPS module for real-time location tracking, transmitting data to a Blynk app where users can monitor the shuttle's movement. Smoke and gas sensors installed within the shuttle constantly assess air quality. In case of detection, the microcontroller triggers alerts within the Blynk app, informing both passengers and the driver. An alcohol sensor also contributes to passenger safety by identifying alcohol vapors in the shuttle. When alcohol presence is detected, an integrated buzzer activates. The microcontroller acts as the central processing unit, managing data flow and interactions among components. Passengers receive notifications via the Blynk app for RFID access, location updates, smoke or gas detection, and alcohol alerts. This comprehensive solution ensures secure access control, real-time tracking, and proactive safety measures, fostering a seamless and secure travel experience.

III. Implemented Hardware System

A. List of the hardware and software Environment

List of Hardware Components:

- NodeMCU (ESP8266 WiFi Module)
- Arduino Microcontroller
- RFID Readers
- Alcohol, Smoke, and Gas Sensors
- Servo Motors
- Buzzers
- Lights
- GPS Module
- Breadboard
- Jumper Wires

List of Software Environment:

- Arduino IDE for Microcontroller Programming
- Node.js for Web Server Setup
- HTML/CSS/Bootstrap/JavaScript for Web Interface
- RFID Library for RFID Reader Integration
- GPS Libraries for Location Tracking
- Sensor Libraries for Alcohol, Smoke, and Gas Detection
- Blynk IoT Platform for Real-Time Data Exchange
- MYSQL relational database

The implemented hardware system comprises a combination of cutting-edge hardware components and software tools. The NodeMCU and Arduino microcontroller serve as the backbone, connecting and controlling various components. RFID readers enable seamless entry, while sensors ensure safety by detecting hazardous conditions. Servo motors, buzzers, and lights provide functional outputs. The GPS module facilitates live tracking, and the seat booking interface enhances the passenger experience. The software environment involves Arduino IDE for microcontroller programming, cpp programming, Node.js for web server setup, and a mix of libraries for sensor integration, communication protocols, and data visualization. This amalgamation of hardware and software elements forms the foundation of the Digital Shuttle System's functionality.

B. *Figures of the implemented hardware system*

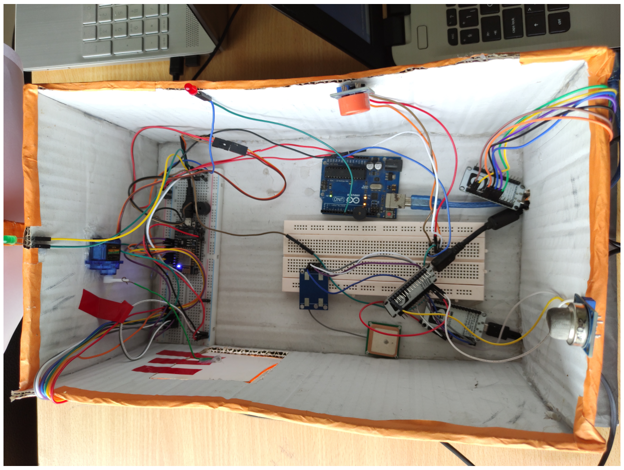

Fig. 2. Complete hardware system overview.

C. *Figures Individuals*

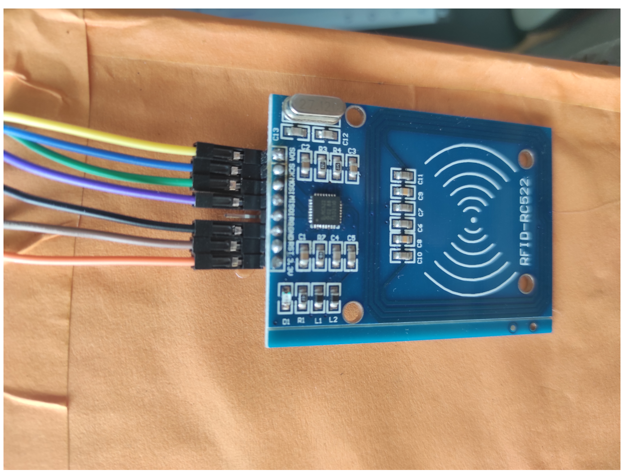

Fig. 3. Radio-Frequency Identification.

RFID, which stands for Radio-Frequency Identification, is a technology that enables the wireless transmission of data between an RFID reader and an RFID tag. An RFID system consists of two main components: the RFID reader and the RFID tag.

RFID Tag: An RFID tag is a small electronic device that contains a microchip and an antenna. The microchip stores data and can be programmed with unique information. The antenna allows the tag to communicate with RFID readers using radio-frequency signals. RFID tags come in various forms, including passive, active, and semi-passive tags. Passive tags don't have their own power source and rely on the energy transmitted by the RFID reader to send data. Active tags have their own power source and can transmit data over longer distances.

RFID Reader: An RFID reader is a device that sends out radio-frequency signals to communicate with RFID tags. When an RFID tag comes into the range of the reader's signals, it responds by sending its stored data back to the reader. The reader captures this data and can process it for various applications. RFID readers can be fixed in place or handheld, depending on the use case.

RFID Applications: RFID technology has a wide range of applications across industries. In the context of the Digital Shuttle System, RFID is used for student identification and access control. Each student is provided with an RFID tag (usually embedded in an ID card) that contains unique identification information. When the student brings the tag close to the RFID reader, the reader detects the tag's data and uses it to allow entry onto the shuttle or perform other specific actions.

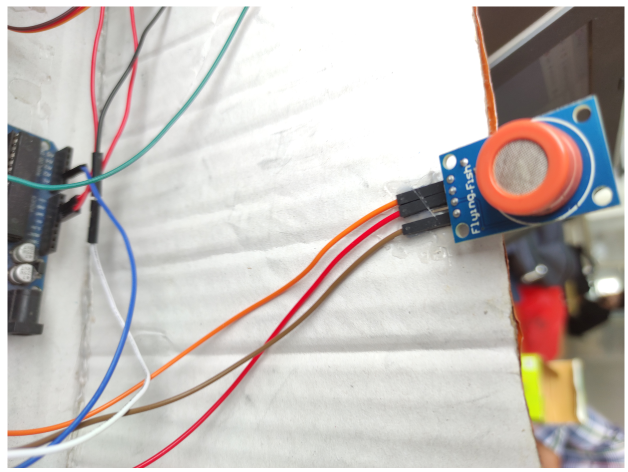

Fig. 4. MQ-3 Alcohol Gas Sensor.

The MQ-3 alcohol gas sensor is a component designed to detect the presence of alcohol vapor in the surrounding environment. It is commonly used in safety and monitoring systems to alert users about the potential presence of alcohol fumes, which can be harmful or indicate unsafe conditions. The MQ-3 sensor utilizes a small heater element along with a sensitive element made of tin dioxide (SnO2). When the sensor is powered on, the heater element heats up, and the tin dioxide material becomes sensitive to changes in the surrounding air composition. Alcohol vapor, such as ethanol, is detected when it comes into contact with the sensor's sensitive element. The presence of alcohol in the air causes a change in the electrical conductivity of the tin dioxide material. This change is measured and translated into an electrical signal that can be read by a microcontroller or other monitoring systems.

The MQ-2 sensor is a versatile component designed to detect various types of flammable gases and smoke in the surrounding environment. It serves as an important safety measure in systems that require early detection of potentially

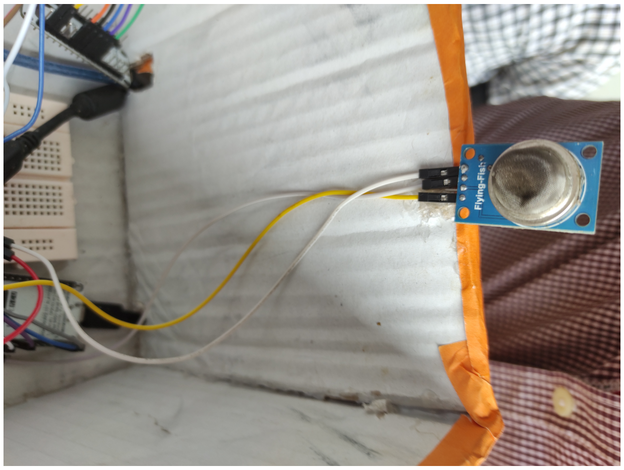

Fig. 5. MQ-2 Flammable Gas & Smoke Sensor.

hazardous situations, such as gas leaks or the presence of smoke. The MQ-2 sensor comprises a heating element and a sensitive element made of tin dioxide (SnO2). The heating element raises the temperature of the sensitive element, and the tin dioxide material becomes sensitive to changes in the composition of the air. When the sensor is exposed to certain gases or smoke, the sensitive element's electrical conductivity changes. The specific type of gas or smoke alters the conductivity in a unique way. This change is measured and converted into an electrical signal that can be interpreted by a microcontroller or other monitoring systems.

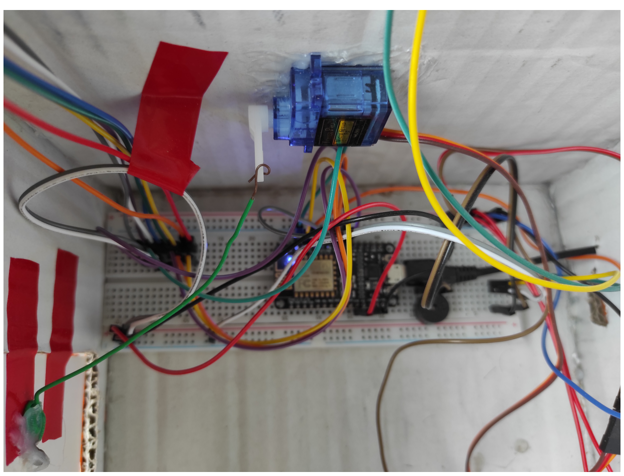

Fig. 6. ESP8266 with Servo Motor.

The ESP8266, a WiFi-enabled microcontroller, can be integrated with a servo motor to create interactive and remotely controlled projects. The combination of these components allows for the creation of dynamic systems that can be controlled over the Internet or a local network.

ESP8266 Microcontroller: The ESP8266 is a powerful microcontroller with built-in WiFi capabilities. It can connect to the internet, send and receive data, and interact with other devices and services online. Its versatility and connectivity make it an excellent choice for IoT (Internet of Things) projects.

Servo Motor: A servo motor is a type of motor that can precisely control its angular position. It consists of a motor, a gear assembly, and a control circuit. Servo motors are commonly used in projects where accurate control of movement is required, such as robotics, automation, and remote control applications.

Integration: The ESP8266 can be programmed to control a servo motor's movement by sending appropriate signals. The servo motor's control circuit interprets these signals and adjusts its position accordingly. By sending varying signals, the ESP8266 can make the servo motor rotate to specific angles, enabling precise control over motion.

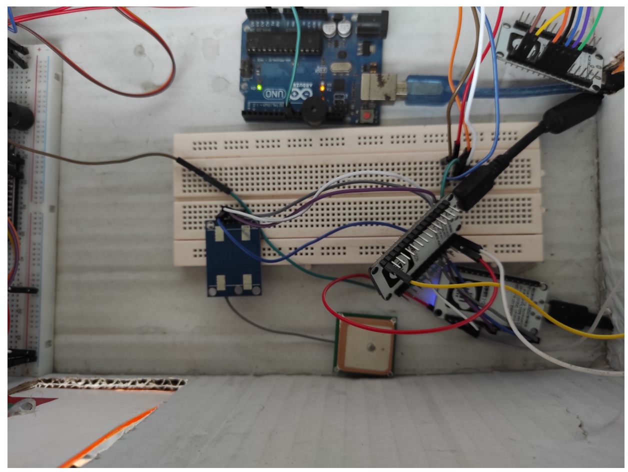

Fig. 7. u-blox NEO-6M GPS module and Arduino UNO Board

Gps module and application: The u-blox NEO-6M GPS module is a compact device equipped with a GPS receiver and u-blox chipset, enabling it to communicate with satellites for accurate positioning, velocity, and time information. It interfaces with devices through serial communication (e.g., UART) and requires an external GPS antenna. Operating at low power, it outputs standardized NMEA sentences and can be configured for different settings. With applications in vehicle tracking, navigation, drones, outdoor sports, and more, its accurate positioning capabilities have broad uses across industries.

Arduino: An Arduino-based alcohol sensor project functions by utilizing a dedicated alcohol sensor module (e.g., MQ-3) that measures the presence of alcohol vapor in the air. The sensor outputs an analog voltage proportional to the detected alcohol concentration. This analog signal is read by the Arduino using an analog input pin. The Arduino's programmed code interprets the analog reading, compares it to a predefined threshold representing a certain alcohol level, and triggers an action accordingly, such as illuminating an LED, displaying a warning, or activating an alarm. This setup enables the Arduino to provide a responsive indication of alcohol presence, making it useful for applications like breathalyzer devices or safety systems.

IV. Results

Our Digital Shuttle System has exhibited promising results across various dimensions, highlighting the successful integration of its multifaceted components.

- The RFID-based registration system has significantly streamlined student entry processes. Data transmission to the server is efficient, ensuring accurate attendance records and minimizing entry delays.
- During door opening, the web interface promptly displays real-time student information. This feature enhances transparency and accountability during boarding operations.
- The seat booking mechanism provides an intuitive platform for students to visualize available seats and make reservations in real time. This feature optimizes seat allocation and enhances shuttle occupancy management.
- Rapid responsiveness of the alcohol, smoke, and gas sensors is evident, promptly detecting hazardous conditions. Immediate alerts and safety measures are triggered, contributing to passenger safety and well-being.
- The GPS module reliably tracks the shuttle's live location, empowering stakeholders with accurate real-time tracking for operational oversight and informed decision-making.
- Evident efficiencies include reduced boarding time due to RFID registration, improved passenger communication through real-time updates, and streamlined seat booking procedures.
- The safety sensors demonstrate swift detection of hazards, reflecting their effectiveness in ensuring a secure environment for passengers.

The project's success paves the way for future enhancements, such as predictive analytics for route optimization, integration with smart campus infrastructure, and potential machine learning applications to bolster safety and predictive maintenance capabilities.

V. Figures of Our Websites

Here, live location is determined using GPS technology.

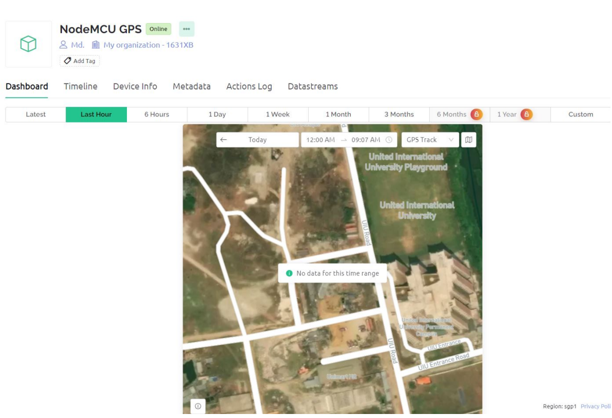

Fig. 8. Live location using GPS.

Here, we will find displayed all the data belonging to the user.

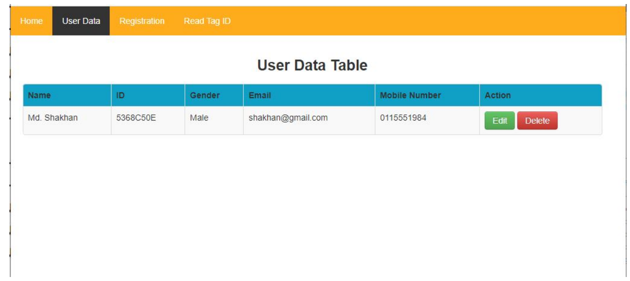

Fig. 9. User Data table.

The registration form is shown here.

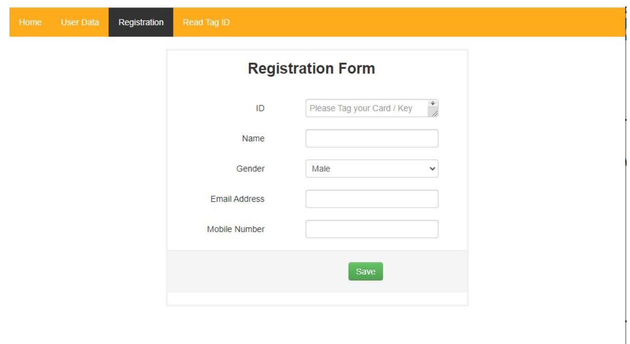

Fig. 10. Registration Form.

The information of the user is shown here after RFID verification.

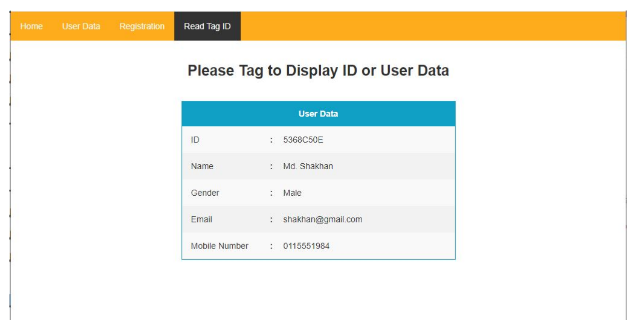

Fig. 11. Display user's data.

This is the seat booking for our system.

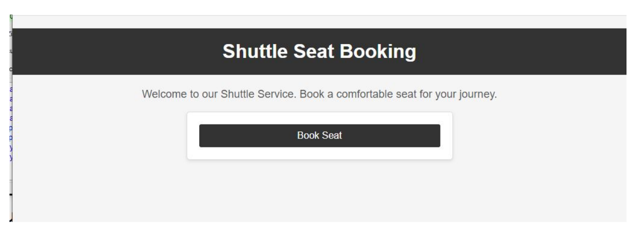

Fig. 12. Seat Booking system.

After the successful verification of RFID, anyone can book the seat from here.

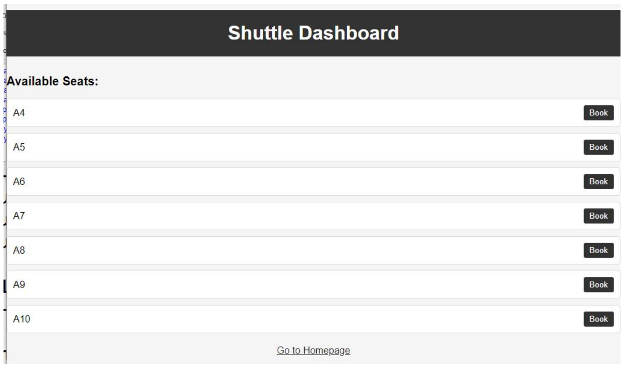

Fig. 13. Available seats in the shuttle,

VI. Conclusion

To sum it up, the Digital Shuttle System represents a big change in how students travel, bringing together things like RFID registration, showing updates in real-time, reserving seats, checking for safety, and finding the shuttle's location with GPS. Our work has already made things better by making processes smoother and sharing information more openly, and we see the potential for even more improvements, like predicting things ahead of time and connecting with the smart campus. This shows how student travel and safety can keep getting better over time.

Acknowledgment

We extend our heartfelt appreciation to our mentor, Md. Jahidul Hoq Emon, for his unwavering guidance, expertise, and encouragement throughout the course of this research. His valuable insights and constructive feedback played a pivotal role in shaping the direction of our project. We are truly grateful for his mentorship, which greatly enriched our understanding and contributed to the success of this work. Additionally, we would like to thank all individuals and institutions that supported us.

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The source code for our model can be found here: click

The YouTube link for our model can be found here: click