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AI Assisted IoT Systems for Smart City Public Safety Solutions

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Abstract

As urban areas expand and interconnectivity grows, public safety in smart cities becomes paramount. To address this, integrating AI-assisted IoT systems presents a transformative approach to enhancing public safety. This study proposes a comprehensive safety framework tailored for smart cities that leverages a IoT technology, seamlessly combining various sensors—such as eye blink, ultrasonic, and alcohol sensors—to ensure road and public safety. The eye blink sensor detects driver fatigue, issuing immediate auditory alerts to prevent potential hazards, thus enhancing real-time safety. Ultrasonic sensors deliver continuous data on the speed and proximity of nearby vehicles, optimizing traffic flow and reducing the likelihood of collisions. Addressing the risks associated with alcohol impairment, our framework incorporates an alcohol detection sensor, which, upon identifying high intoxication levels, utilizes GPS and GSM technologies to automatically adjust vehicle speed and inform relevant authorities, enabling prompt intervention. Additionally, the system incorporates Li-Fi technology to improve inter-vehicle communication through Visible Light Communication (VLC), facilitating rapid data exchange across connected vehicles. This Artificial Intelligence of Things (AIoT) enabled framework provides a foundation for safer and more cohesive urban transportation, contributing to a smarter, sustainable, well-integrated public safety network in smart cities. Our model paves the way for significant improvements in urban safety infrastructure through these advancements, setting a standard for evolving smart city safety solutions.

Keywords: Smart cities, AI-assisted IoT, Public safety, Ultrasonic sensor, Alcohol detection, Urban transportation.

1 | Introduction

As urbanization accelerates and city populations grow, enhancing public safety—particularly in transportation—has become an essential focus for sustainable smart city development. High-density urban environments often experience increased traffic incidents resulting from negligent driving, distractions, alcohol-impaired operation, and deteriorating infrastructure, which heighten risks and strain city resources. There is, therefore, an urgent need for innovative, adaptive technologies to foster safer urban environments.

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Integrating Artificial Intelligence (AI) and the Internet of Things (IoT) within smart city frameworks offers the transformative potential to meet these challenges [1], [2]. Artificial Intelligence of Things (AIoT) leverages the power of AI and the IoT to enable real-time monitoring, data-driven insights, predictive analytics, and automated responses. By embedding smart sensors throughout urban transportation systems, this study introduces a comprehensive AIoT-based framework to enhance public safety, especially on city roads. Utilizing technologies like eye blink sensors, ultrasonic detectors, and alcohol monitors, this framework continuously assesses and manages risks within the urban mobility landscape. For instance, eye blink sensors monitor driver alertness, identifying signs of drowsiness that commonly lead to accidents. This detection triggers immediate auditory alerts to encourage driver attentiveness, thus actively reducing the likelihood of fatigue-related incidents. Ultrasonic sensors further support road safety by measuring proximity to surrounding vehicles and adjusting vehicle interactions to promote safer distances. This mechanism assists in collision prevention and traffic flow management, which is particularly valuable in high-density zones where swift and sudden maneuvers are frequent. Addressing the risks of alcohol-impaired driving, the framework integrates alcohol sensors to gauge the driver's blood alcohol levels. If an illegal level is detected, the system enacts safety measures by leveraging GPS and GSM technology to limit vehicle mobility and alert local authorities, promoting timely intervention.

This aspect of the AIoT system plays a vital preventive role, proactively managing one of the primary causes of road incidents. The framework also introduces advanced Vehicle-to-Vehicle (V2V) communication through Light Fidelity (Li-Fi) technology, which employs visible light for high-speed data transfer between vehicles. This connectivity facilitates the rapid exchange of critical information regarding vehicle speed, position, and route, creating a synchronized and responsive urban transportation network. With real-time V2V communication, AIoT contributes to congestion reduction, accident prevention, and traffic flow optimization, making city travel safer and more efficient. Beyond individual vehicle monitoring, the AIoT framework's ability to collect and analyze comprehensive traffic data enables smarter infrastructure decisions. City planners and transportation authorities can assess historical and real-time traffic data to identify bottlenecks, predict traffic patterns, and dynamically manage roadways. AI algorithms and predictive models support these efforts, providing insights that allow for more strategic adjustments to traffic signals, vehicle rerouting, and urban mobility planning, ultimately improving transportation efficiency and reducing emissions [3]. AIoT also enables smart infrastructure that dynamically adapts to changing conditions. For example, AI-driven traffic lights can alter their signal timing based on current traffic density, minimizing delays and congestion at intersections. This adaptability enhances urban infrastructure's efficiency and responsiveness, enabling smart cities to address traffic demands and create a safer environment for pedestrians and drivers alike.

AIoT additionally supports predictive maintenance by identifying infrastructure weaknesses and scheduling repairs before major issues arise, improving reliability and safety across the transportation network [4]. This predictive capability extends to public transportation, where AIoT technology can optimize routes, reduce delays, and improve operational dependability, ensuring smooth travel for city residents. In connecting multiple transportation options—such as buses, trains, ride-sharing services, and bike lanes—AIoT fosters a multimodal urban mobility system. This interconnectedness encourages residents to use public transit options, reducing reliance on private vehicles and promoting sustainable transportation practices. The result is a more cohesive and accessible urban network, improving citywide efficiency and reducing congestion. Safety is further enhanced by AIoT-powered intelligent surveillance, which enables city authorities to monitor traffic patterns, identify accident-prone areas, and proactively respond to hazards.

By implementing Machine Learning (ML) models, authorities can predict and prevent accidents by deploying preventative measures in high-risk locations. This active surveillance and data analysis support urban safety, offering insights that help authorities refine infrastructure and urban planning [5]. In extending the benefits of AIoT beyond individual vehicles, this framework envisions an interconnected, citywide safety system that addresses both immediate and long-term needs in public safety. Through interconnected infrastructure, vehicles, and monitoring systems, AIoT creates a holistic approach to safety that revolutionizes traditional practices. By utilizing AIoT, cities can shift from reactive to proactive safety measures, prioritizing preventive interventions over corrective actions. AIoT's application within smart cities highlights a shift towards sustainable and scalable solutions that meet the growing demands of urban populations. Continuous monitoring, predictive analytics, and real-time interventions provide a solid foundation for creating safer, more resilient cities. The AIoT framework is not merely an enhancement of existing safety measures but a transformative solution that redefines urban safety standards. Through this technological integration, AIoT is a powerful tool for enhancing urban mobility, supporting sustainable practices, and improving the quality of life for all residents. As smart cities embrace AIoT, they establish a foundation for further advancements, creating safe, efficient, and responsive environments that meet the needs of their growing populations.

2 | Conceptual Definition

Smart cities represent a transformative approach to urban development, emerging as a crucial response to the multifaceted challenges of rapid urbanization, population growth, and the demand for sustainable living [6]. Smart cities leverage advanced technologies, particularly the integration of AI and the IoT, to optimize city operations and enhance the quality of life for residents. These cities are characterized by their commitment to incorporating cutting-edge Information and Communication Technologies (ICT) into their infrastructure and governance, facilitating seamless connectivity and efficient resource management.

Historically, the concept of smart cities has evolved significantly since its inception in the 1970s, gaining notable momentum around 2010 when various global initiatives, particularly those supported by the European Union, began prioritizing smart city projects. At its essence, a smart city aims to create an interconnected urban environment where technology catalyzes improved efficiency, resilience, and sustainability. This integration of technology not only enhances urban operations but fosters community engagement and promotes social equity. One of the primary features of smart cities is their reliance on data analytics, which involves the extensive collection and analysis of data generated from IoT devices and sensors embedded throughout the urban landscape. This data-driven approach allows city planners and decision-makers to derive actionable insights, facilitating informed decision-making processes that enhance transportation safety and overall urban functionality. By harnessing AI-driven analytics, smart cities can predict traffic patterns, identify potential hazards, and optimize traffic management systems to prevent accidents and improve the flow of people and goods.

Another key aspect of smart cities is their focus on operational efficiency. By streamlining urban operations, these cities can minimize resource consumption while maximizing service delivery. This is particularly evident in the realm of transportation, where smart cities implement solutions that not only enhance safety but also reduce environmental impacts. For instance, integrating smart transportation systems enables real-time monitoring of traffic conditions, allowing for adaptive signal control and dynamic routing to mitigate congestion and reduce the risk of accidents.

Furthermore, the resilience of smart cities is a critical factor in their design and implementation. These cities are built to withstand and adapt to various challenges, such as natural disasters, climate change, and public health crises [7]. Through the development of robust infrastructures and systems, smart cities can ensure the continued functionality of their transportation networks, even in the face of unforeseen events. This resilience is further enhanced by the proactive nature of AIoT applications, which enable predictive maintenance and real-time responses to emerging issues. The livability of smart cities is another cornerstone of their conceptual framework. By creating safe, comfortable, and community-oriented urban environments, smart cities improve their residents' overall quality of life. Advanced transportation systems that prioritize safety and accessibility are integral to this objective, as they facilitate seamless movement within the urban landscape and promote social interaction.

Additionally, smart cities incorporate innovative technologies such as Li-Fi and LED lighting systems to enhance transportation safety and efficiency. Li-Fi technology, which utilizes visible light for high-speed data transmission, enables effective communication between vehicles and infrastructure, improving coordination and reducing the likelihood of accidents. Meanwhile, LED lighting in public spaces enhances visibility and contributes to energy savings and sustainable urban development.

In summary, the conceptual definition of smart cities underscores their multifaceted nature, emphasizing the integration of technology, data analytics, and community engagement to address the challenges of modern urban living. The evolving landscape of smart cities highlights their potential to revolutionize urban mobility and safety through innovative AIoT solutions. As cities continue to grow and evolve, the commitment to creating smart environments that prioritize safety, efficiency, and sustainability will be paramount in shaping the future of urban life.

3 | Artificial Intelligence of Smart City Things in Transportation

Integrating AI with the IoT has given rise to a transformative paradigm known as AIoT. This convergence has profound implications in various domains, particularly smart cities and transportation safety. The conceptual framework presented here elucidates the technical components of integrating AIoT into smart transportation systems, focusing on enhancing safety measures and operational efficiency.

3.1 | Sensing Devices and Data Acquisition

Smart transportation systems begin with a comprehensive network of sensing devices, including cameras, environmental sensors, and GPS units strategically positioned throughout urban environments and transportation infrastructure [8]. These devices continuously gather real-time data on traffic dynamics, vehicle movements, environmental conditions, and safety-related incidents. By utilizing an extensive array of sensors, smart cities can develop a detailed understanding of transportation systems, enabling proactive safety measures and efficient management.

3.2 | Communication Infrastructure

A robust communication framework is essential for the effective functioning of smart transportation systems. Low-latency networks, such as 5G, facilitate rapid data transmission between edge devices and centralized processing systems, enhancing the responsiveness and reliability of safety communications. This infrastructure enables seamless interaction between vehicles and traffic management systems, allowing for timely updates and alerts that are crucial for ensuring road safety.

3.3 | Edge Computing

Edge computing is vital in processing data close to its source, significantly reducing latency and supporting real-time decision-making [9]. Strategically located edge nodes within the transportation network process sensor data, extracting relevant information that can address immediate safety concerns. By enabling data processing at the edge, these nodes ensure that critical information reaches decision-makers swiftly, allowing rapid responses to emerging situations.

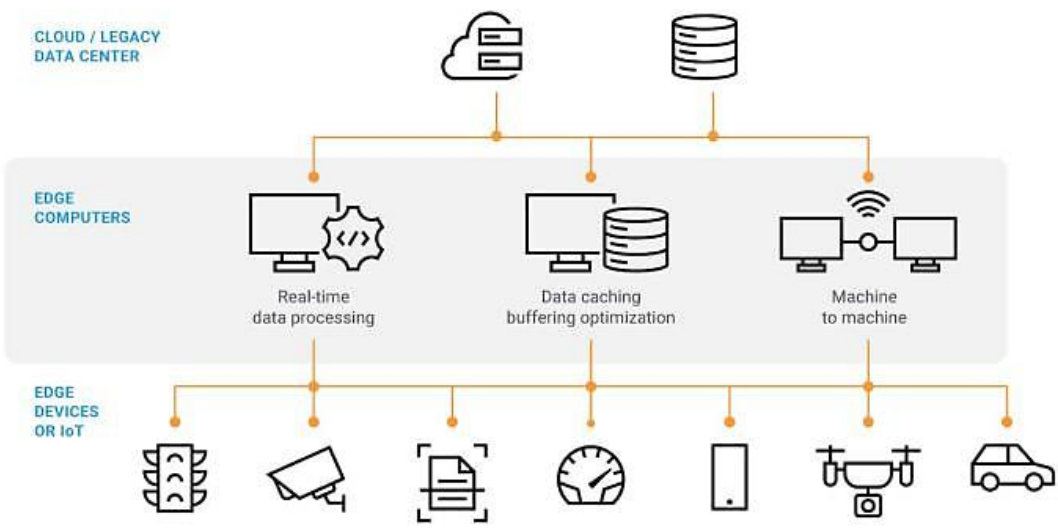

Fig. 1. Edge computing in IoT device processing.

3.4 | Fog Computing

Fog computing extends the capabilities of edge computing by enhancing data processing efficiency for time-sensitive applications within smart transportation systems [10]. This approach allows for near real-time processing of sensor data by situating fog nodes closer to data sources, which is particularly important for safety monitoring. Fog computing supports the dynamic analysis of transportation conditions, ensuring that safety measures are responsive to changing environments.

3.5 | Cloud Computing

Cloud computing is pivotal in offering scalable storage and processing power for the extensive datasets generated by smart transportation systems. Centralized cloud servers facilitate intensive data analytics and ML tasks, enabling the development of predictive models that inform safety strategies. By harnessing cloud computing, smart cities can perform comprehensive analyses to identify safety hazards and optimize transportation networks effectively.

3.6 | Data Analytics and Machine Learning

Centralized data analytics platforms leverage ML and Deep Learning algorithms to process large volumes of data collected from smart transportation systems. These predictive analytics models anticipate traffic congestion and identify potential safety threats and patterns. By utilizing data-driven insights, decision-makers can implement strategies that enhance urban transportation's overall safety and efficiency.

3.7 | Data-Driven Decision-Making Systems

AI-driven decision-making systems interpret analyzed data to make informed and intelligent choices. These systems dynamically adjust traffic signal timings, reroute vehicles based on real-time conditions, optimize public transportation schedules, and prioritize safety measures. Smart transportation systems can respond swiftly to changing circumstances by automating decision-making processes, ultimately improving safety outcomes.

3.8 | Safety Monitoring and Response

Dedicated AI algorithms monitor safety-related events, such as accidents or unusual driving behaviors, triggering immediate alerts and responses. Automated safety measures, including real-time notifications to emergency services and adaptive speed controls, significantly enhance transportation safety. By integrating these systems, smart cities can rapidly respond to incidents, thereby reducing the likelihood of secondary accidents and improving overall public safety.

3.9 | User Interfaces and Applications

User interfaces and applications provide a human-centric interaction layer for transportation administrators and the general public [11]. Mobile applications, dashboards, and public displays deliver real-time information about transportation conditions, alternative routes, and safety advisories. By offering accessible information, these interfaces empower users to make informed decisions, enhancing their safety while navigating urban environments.

The technical components outlined in this framework reflect an innovative integration of AI and IoT, creating a powerful system that enhances the operational capacity of smart transportation networks. This framework not only facilitates improved efficiency and safety but also addresses the complex challenges modern urban transportation systems face. By focusing on AIoT solutions, smart cities can pave the way for a future where transportation safety is paramount, ensuring that urban environments remain resilient, efficient, and conducive to quality living. As smart cities evolve, the commitment to leveraging AIoT technologies to enhance transportation safety and operational excellence will be crucial. Integrating these technologies represents a significant advancement in how cities manage their transportation systems, ultimately leading to safer and more efficient urban environments.

4 | System Models and Methodology

This section discusses the autonomous speed detection and accident avoidance frameworks for connected vehicles. The advancement of technology has led to the development of dynamic transport systems that significantly impact society and individuals' daily lives. While these systems offer numerous benefits, they also contribute to adverse situations, primarily vehicular accidents, which pose a severe risk along with urban congestion and pollution. To mitigate these challenges, the proposed framework integrates various sensors for accident prevention and enhances vehicular safety. This section is divided into five subsections.

4.1 | Overview of the Proposed System

The proposed system consists of three distinct modules: A drowsiness detection module, a speed indication module, and an alcohol detection module, as illustrated in *Fig. 2* (diagram of the overall system architecture).

I. Drowsiness detection module: This module employs a wearable device with an eye-blink sensor to assess the driver's fatigue level. If drowsiness is detected, an alert mechanism is activated to wake the driver.

II. Speed indication module: This module utilizes ultrasonic sensors mounted on the vehicle's sides to measure the distance and speed of surrounding vehicles, thereby providing real-time data to help maintain safe driving distances.

III. Alcohol detection module: This module monitors the driver's breath for alcohol presence. If alcohol is detected, the system activates a motor lock to prevent vehicle operation and communicates the driver's location to relevant authorities through GPS and GSM.

4.2 | Drowsiness Detection Module

The drowsiness detection module is implemented using an Arduino mini controller. It consists of a lightweight temporary eyeglass that the driver wears, equipped with an IR sensor, a buzzer, and a power source—the IR sensor functions by emitting infrared light toward the driver's eyes. When the eyes are closed, the reflected light intensity is detected by a photodiode, triggering the buzzer if the driver does not blink within a specific timeframe. This mechanism ensures unobstructed vision for the driver, maintaining safety on the road while effectively detecting signs of fatigue.

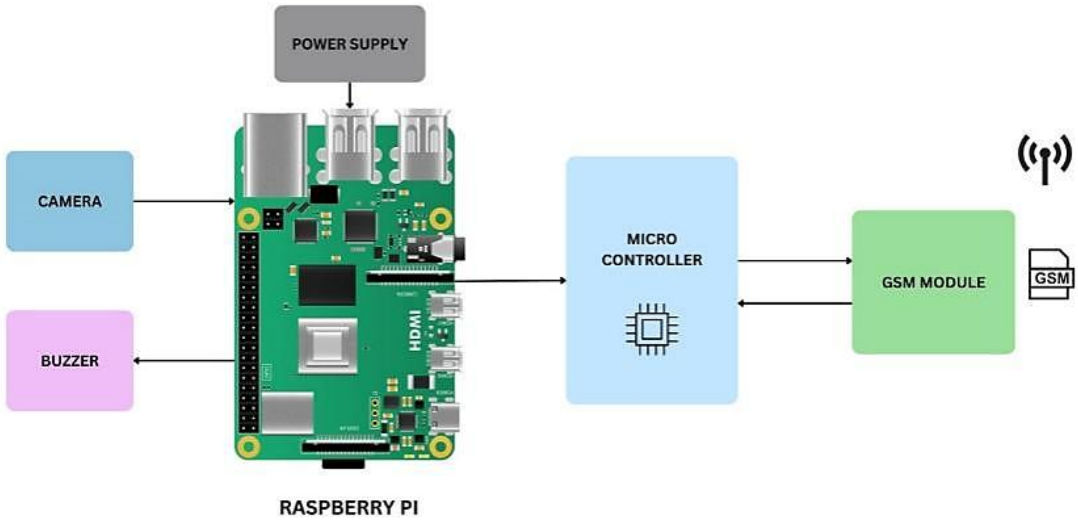

Fig. 2. Drowsiness detection module.

4.3 | Speed Indication Module

Accurate speed monitoring is crucial for safe driving. The speed indication module employs ultrasonic sensors positioned on the vehicle's sides to measure the distance and speed of nearby vehicles. The sensors emit high-frequency sound waves that bounce off surrounding objects, calculating the distance based on the time the waves return. This real-time data is displayed to the driver, enabling timely adjustments to maintain safe distances. The system includes an LCD and an Arduino Mega for processing, ensuring that the driver receives continuous feedback about surrounding traffic conditions.

4.4 | Alcohol Detection Module

To combat drunk driving, a robust alcohol detection module is integrated into the system, utilizing an MQ3 alcohol sensor interfaced with an Arduino Mega. This sensor can detect alcohol levels starting from 0.4 mg/L. Upon detecting alcohol, the system immediately locks the vehicle's motor, preventing operation. Simultaneously, the system alerts authorized personnel, providing real-time location data via a GPS receiver and GSM modem. This proactive approach enhances driver safety and protects other road users.

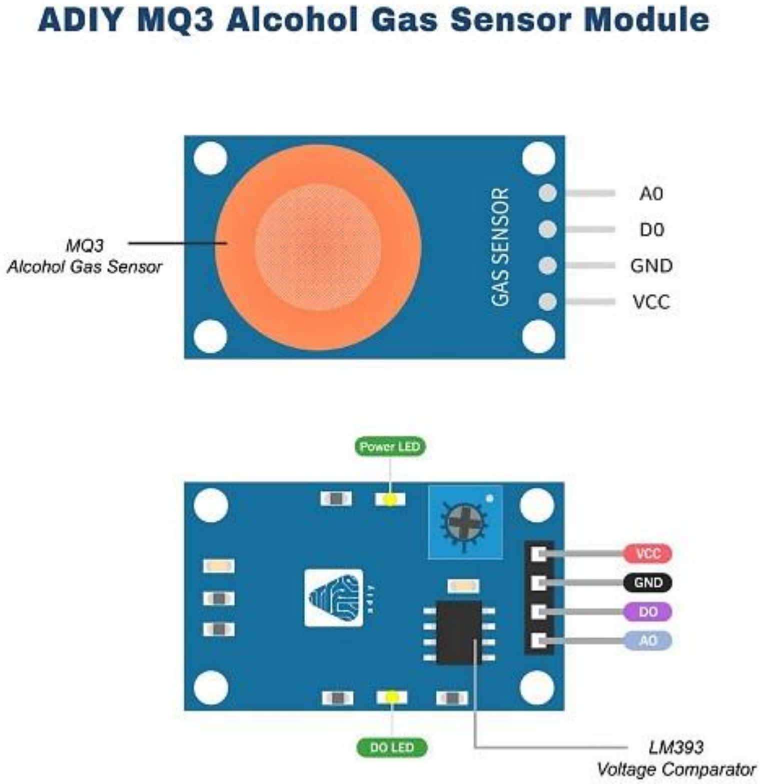

Fig. 3. Alcohol detection module.

4.5 | Vehicle-to-Vehicle Communication Using Li-Fi Technology

The integration of Li-Fi technology facilitates efficient V2V communication, significantly enhancing the safety and responsiveness of the transportation system. This communication framework enables vehicles to share real-time information regarding speed, location, and traffic conditions, creating a collaborative driving environment. By leveraging light signals for data transmission, Li-Fi can overcome the limitations of traditional communication methods, ensuring faster and more secure data exchange. This interconnectedness among vehicles allows for synchronized actions, such as coordinated braking or acceleration, which can substantially reduce the likelihood of accidents.

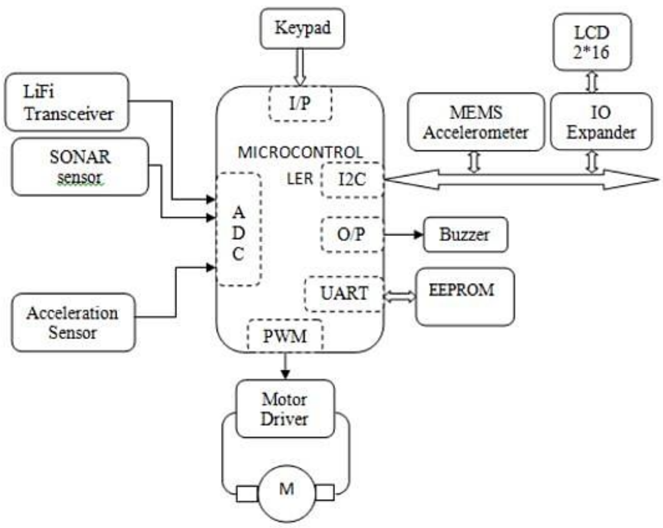

Fig. 4. Vehicle-to-vehicle communication flowchart.

4.6 | AIoT Integration

The proposed system leverages AIoT to enhance predictive maintenance and traffic management. IoT sensors continuously monitor vehicle health, enabling proactive maintenance strategies that reduce downtime and improve fleet reliability. Furthermore, AIoT algorithms analyze real-time data from integrated devices to predict traffic patterns, dynamically adjusting traffic signals to optimize flow and minimize congestion. This holistic approach improves public transportation systems by providing real-time passenger data, optimizing routes, and enhancing user experiences through tailored services such as smart parking and customized navigation.

5 | Results and Discussion

A prototype instrument to detect sleepiness consists of temporary glasses with an installed IR sensor powered by a 3.7V battery that supports an Arduino Pro Mini processor. Standard safety spectacles are equipped with an Infrared emitter and detector pair positioned laterally across the palpebral fissure to generate a monitored IR stream interrupted when the eyes close. This interruption is detected by the IR sensor, signaling the processor to activate an alarm or alert system to notify the driver of their drowsiness. If the outcome from the eye flicker monitor is minimal, the indication will be adjusted to high. If the driver begins to nod off, the buzzer will sound as a warning, and the indication can be turned off if necessary.

To improve blink recognition and minimize the likelihood of false-positive blink events resulting from non-blink lid movement, it is possible to include one or more extra emitters and/or detectors. This additional equipment would augment the capabilities of a single IR LED (emitter) and phototransistor (detector), enhancing the system's accuracy. An array of two or three emitter/detector pairs positioned parallel to the eye surface may provide an alternative path for IR rays to travel when the lids move up and down simultaneously while remaining apart (for example, during a downward gaze). Furthermore, by incorporating a collection of emitters and detectors, the sensing system's resistance to changes in eyeglass position caused by head or facial movements that cause the skin on the nose's bridge to move or by head movements may be improved.

The primary input source is the interconnection between the wearable component, which tracks driver intoxication and sleepiness, and the vehicle's onboard systems. It is used to continually track important physiological indicators, including heart rate, eye movements, and alcohol content of the breath. The vehicle's central processing unit receives these real-time data streams wirelessly and using cutting-edge ML techniques; it evaluates them to determine the driver's level of drunkenness and cognitive state. To reduce possible safety concerns, relevant measures, such as automated speed decrease or audio alarms, are initiated based on the results of the analysis.

Subsequently, the vehicle's collision avoidance system is integrated with the ultrasonic speed detector, which keeps track of another vehicle's speed. Real-time situational awareness through ultrasonic sensors can detect the relative velocities and distances from other surrounding vehicles. Moreover, the collision avoidance system uses V2V Li-Fi technology to connect with other cars, enabling cooperative maneuvers and improving traffic safety in smart city settings. These integrations can be realized by configuring the decision-making phase in the distributed AIoT integrated platforms. The role of AIoT in the scenarios above facilitates smooth communication and coordination between various system components. AIoT ensures prompt reactions to changing driving circumstances and new safety concerns by enabling dynamic data exchange and decision-making across heterogeneous devices and platforms through a distributed network architecture.

Additionally, the system can continually adjust and enhance its performance based on contextual information and real-world input thanks to AIoT-driven analytics and predictive modeling, which maximizes driving efficiency and safety. The proposed approach can be applied in various situations, including personal vehicles, public transit, and commercial fleets. For example, the technology might be implemented in commercial fleets under forced adoption situations to enforce safety standards and reduce the hazards related to driver fatigue and alcohol impairment. Conversely, when adoption is voluntary, the system may be sold as an optional accessory for private automobiles, attracting customers who value safety and want to improve their driving experience.

To determine the speed of a nearby vehicle, we utilize an ultrasonic sensor, which consists of a transmitter and a receiver that emits and receives sound waves, respectively. By transmitting high-frequency sound waves and monitoring the time it takes to return after hitting an object, the ultrasonic sensor can measure the distance between the object and the sensor. This concept enables the measurement of an object's motion as it passes the ultrasonic sensor. When the item moves in front of the sensor, the sound waves bounce back to the sensor. The speed of the passing vehicles can be calculated using the equation, which represents the object's velocity, the distance between the object and the sensor, and the time it takes for the sound waves to reach the object and return. We can determine and display the speed of passing vehicles using this technique.

To detect overtaking vehicles, we can interface three ultrasonic sensors on the rear of our car. When the rightmost sensor detects a vehicle overtaking on the right, the display will show the message "Alert, Vehicle overtakes at Right." The message "Alert, Vehicle Overtakes at Left" will be displayed when the leftmost sensor is in use. If the moving vehicle approaches our car too closely, a "Danger" warning will appear, while the message "No vehicle" will be displayed if there are no nearby vehicles.

To improve the accuracy of alcohol detection, we have integrated an MQ3 sensor into the microcontroller. This sensor is known to be reliable and widely used for alcohol monitoring. Its detection range extends up to 2 m, making it an efficient tool for detecting the presence of alcohol. Furthermore, the sensor's sensitivity can be adjusted to meet specific requirements, making it adaptable to different scenarios. The MQ3 sensor's conductivity increases as the alcohol concentration rises, providing the Arduino with the corresponding reading.

The results of using the alcohol sensor to detect the presence of alcohol in *Fig. 5* indicate that there is no alcohol detected in the driver's exhaled air as the level is below 150. However, it should be noted that there may still be an undetected alcohol level present. When the driver exhales, the sensor can detect a small amount of alcohol, and if the level is above the legal limit, a "DRUNK" notification will appear on the screen. Conversely, a message stating "Within legal limits" will be displayed if the level is within legal limits. The system aims to reduce the number of accidents caused by impaired driving by implementing an engine locking system.

MODULE	FEATURE DETECTED	ACCURACY (%)	REAL-TIME RESPONSE	IMPACT ON SAFETY
DROWSINESS DETECTION	EYE BLINK DETECTION	94	YES	HIGH
SPEED INDICATION	VEHICLE PROXIMITY	93	YES	MODERATE
ALCOHOL DETECTION	BREATH ALCOHOL LEVEL	96	YES	HIGH
V2V COMMUNICATION (LI-FI)	DATA EXCHANGE BETWEEN VEHICLES	90	YES	HIGH

Fig. 5. The results of detection of the presence of alcohol.

The Arduino will turn the DC motor off when the reading goes beyond the threshold level. The L293D is connected to the Arduino and supplied with 5V, which is then linked to the DC motor. This model uses the SIM800A and NEO6M GPS modules to message the vehicle's location to the registered cellphone number after the engine is locked. GPS receivers can determine their distance from several satellites, with the locations of the 32 GPS satellites pre-programmed into them. The GPS module is responsible for determining the vehicle's speed and location. Radio signals from the satellites are sent to Earth, carrying details about their positions and the time at that moment. These signals identify the satellites and provide location information to the receiver.

The SIM800L module can send text SMS data to a host server after receiving serial data from radiation monitoring equipment like survey meters or area monitors. When the alcohol level crosses the threshold, the GSM module sends an SMS to the appropriate authorities at the provided number. The GPS module records and securely stores location data. The location is stored on the Arduino Mega board as soon as it is known because the initial fix takes longer to establish.

The complete system module developed in this work consists of a transmitter unit and a receiver unit. The two units act as transceivers, each equipped with an LCD screen displaying its state and any data from the sensing modules mounted in the vehicles. The transmitter transforms digital data into visible light using an LED. LEDs are suitable because of their linear relationship with current and light output. The receiver uses a photodiode to convert the incoming light into an electrical charge. The photodiode is a semiconductor device that converts light into an electric current.

The first transmitter is connected to the Arduino device. Once the transmitter receives data from the Arduino board, it converts it to binary and transmits it using the LED. If the binary value is 0, the LED does not blink, but if the binary value is 1, the LED blinks. The blinking happens so fast that it is invisible to the human eye. The photovoltaic cell on the receiver side absorbs the light from the LED and converts it into electrical energy. The receiver then decodes the binary data received, allowing for effective communication between the transmitter and receiver.

6 | Conclusion

This study presented an innovative solution to enhance transportation safety in next-generation smart cities. The Li-Fi-enabled vehicle safety framework integrates eye blink, ultrasonic, and alcohol sensors to address critical issues like driver drowsiness, speeding, and alcohol consumption, major contributors to fatal road accidents. The system effectively detects driver drowsiness and alerts the driver through a buzzer, thus preventing fatigue-related accidents. Ultrasonic sensors provide real-time information on surrounding vehicle speeds, enhancing traffic flow and reducing collision risks. Additionally, the alcohol sensor detects alcohol consumption, restricting the vehicle's operation and alerting authorities via GPS and GSM to prevent drunk driving incidents. Using Li-Fi technology for V2V communication via Visible Light Communication (VLC) further improves data exchange, enhancing road safety.

Looking ahead, this adaptable system prototype can be customized and expanded to meet the diverse demands of various markets. It stands as a testament to technology-driven solutions to make urban transportation systems safer, more efficient, and conducive to the overall well-being of smart city residents. The implications of this study are significant, as the proposed system has the potential to substantially reduce fatal road accidents by addressing key factors such as drowsy driving, speeding, and alcohol consumption. Integrating ultrasonic sensors enhances traffic flow, reducing congestion and accident risks. By automatically restricting vehicle speed when alcohol is detected, the system serves as a deterrent against drunk driving. Furthermore, adopting Li-Fi for vehicle communication emphasizes the role of VLC technology in enhancing transportation safety and efficiency.

Our forthcoming research will focus on improving the practicality of the drowsiness detection module, particularly when drivers are wearing prescribed driving lenses. We will thoroughly investigate and test the system's ability to consistently and accurately detect signs of fatigue and drowsiness in such scenarios. This research aims to make the system more user-friendly and adaptable to real-world driving conditions. Additionally, significant attention has been given to justifying the choice of Arduino and GSM technology in our proposed framework for smart city transportation safety. We recognize the importance of ensuring these choices align with the specific applications of our framework.

Integrating AIoT innovations for transportation safety signifies a revolutionary step toward creating safer and smarter mobility systems. Our vision is to shape a future in which transportation is not only more efficient but also fundamentally safe for all road users.

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