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Study of artificial intelligence methods for use in traffic accident fatality detection applications

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ABSTRACT:

Because of the human lives lost, property damaged, and money lost, traffic accidents are still a major problem across the world. Important features of contemporary transportation networks include making sure vehicles are safe, avoiding collisions, and providing efficient directions. In order to improve car safety and avoid collisions, this project suggests an AI and IoT-based system that detects and prevents accidents. The system would include ultrasonic sensors, motors, and IoT connection. An essential component of the system, the ultrasonic sensor relays data in real-time to the processor when it detects adjacent obstructions or automobiles. To prevent the car from getting into accidents, the system uses the motor mechanism to automatically change the brakes or steering when it detects a possible collision. In addition, the Internet of Things (IoT) module enables remote data transfer and real-time monitoring, so users or authorities may monitor accident-prone locations and vehicle behavior using cloud platforms. Intelligent transportation networks, smart cars, and autonomous navigation systems are all intended to include this system. By analyzing sensor data, the AI-powered computer can foresee potential collisions and respond swiftly to avoid them. The Internet of Things (IoT) allows for the instantaneous transmission of data in the event of an accident, which improves road safety by decreasing reaction times.
To improve vehicle navigation, obstacle avoidance, and collision detection, the suggested system offers an efficient, scalable, and cost-effective option. To further maximize road safety, future developments might include AI-driven traffic management, predictive analysis based on machine learning, and interaction with smart city infrastructure.

EMBEDDED SYSTEMS

A computer system that is purpose-built to carry out a single or limited set of tasks, often under the restrictions of real-time computing, is known as an embedded system. As with other physical and mechanical components, it is often integrated into a whole device. A personal computer or other general-purpose computer, on the other hand, may be programmed to do a wide variety of functions. These days, many of the everyday items we use rely on embedded systems to function. Design engineers may improve the embedded system to decrease product size and cost while boosting reliability and performance since it is devoted to certain functions. Because of their mass production, certain embedded systems are able to take advantage of cost savings.
From small, handheld gadgets like digital watches and MP3 players to massive, permanently installed systems like those managing nuclear power plants, traffic lights, and industrial controls are all examples of physically embedded systems. From simple systems using a single microcontroller chip to complex systems housing several modules, peripherals, and networks in a massive chassis or enclosure, complexity may range greatly.
The phrase "embedded system" lacks a precise definition because the majority of systems have programmability in some form. While they share some components with embedded systems, such operating systems and microprocessors, handheld computers are not technically embedded systems as they enable the loading of multiple programs and the connection of peripherals.
Computer hardware and software, either fixed in capability or programmable, particularly intended for a certain sort of application device—this is what's called an embedded system. Embedded systems may be found in a wide variety of objects, including but not limited to: vehicles, medical devices, cameras, home appliances, aircraft, vending machines, toys, and, of course, cellular phones and personal digital assistants. A programming interface is given to programmable embedded devices, and programming for embedded systems is a niche field in and of itself. Embedded Java and Windows XP Embedded are two examples of embedded-specific operating systems and language platforms. On the other hand, certain budget consumer goods include integrated application and operating system components, employ very cheap microprocessors, and have limited storage space. Instead of being loaded into RAM (random access memory), as applications on personal computers are, in this situation the program is written permanently into the system's memory.

CHARACTERISTIC OF EMBEDDED SYSTEM

- Speed (bytes/sec): Should be high speed
- Power (watts): Low power dissipation
- Size and weight: As far as possible small in size and low weight
- Accuracy (%error): Must be very accurate
- Adaptability: High adaptability and accessibility
- Reliability: Must be reliable over a long period of time

APPLICATIONS OF EMBEDDED SYSTEMS

Here, in the Embedded World, we are living. The smooth operation of the various embedded goods that surround you is crucial to your day-to-day existence. In your living room, you have a TV, radio, and CD player; in your kitchen, you have a washing machine or microwave oven; and at your office, you have card readers, access controllers, and palm devices that let you do a lot. In addition to all of this, your automobile has a plethora of built-in controls that handle functions between the bumpers, most of which you probably don't give a second thought to.

- **Robotics:** industrial robots, machine tools, Robocop soccer robots
- **Automotive:** cars, trucks, trains
- **Aviation:** airplanes, helicopters
- Home and Building Automation
- **Aerospace:** rockets, satellites
- **Energy systems:** windmills, nuclear plants
- **Medical systems:** prostheses, revalidation machine.

MICROCONTROLLER VERSUS MICROPROCESSOR

When comparing microprocessors and microcontrollers, what are the key differences? Any general-purpose microprocessor, such an 8086, 80286, 80386, 80486, or a Pentium from Intel, or a 680X0 from Motorola, etc., is considered a microprocessor. In addition to lacking on-chip I/O ports, these microprocessors also lack random-access memory (RAM). Because of this, they are often called general-purpose microprocessors. Designing a working system around a general-purpose CPU like the 68040 or Pentium requires the addition of extra components like as RAM, ROM, I/O ports, and timers. Though these systems are more costly and cumbersome due to the inclusion of external RAM, ROM, and I/O ports, they provide the benefit of being versatile in that the designer may choose the quantity of RAM, ROM, and I/O ports required for the work at hand. Microcontrollers are an exception to this rule. On a single chip, you'll find a microprocessor, random access memory (RAM), read/write (ROM), input/output (I/O) ports, and a timer in a microcontroller. So, since the CPU, random access memory (RAM), read/write memory (ROM), input/output (I/O) ports, and timer are all integrated into a single chip, the designer is unable to include any more memory, I/O ports, or timer into the product. Because of its set quantity of on-chip ROM, RAM, and number of I/O ports, microcontrollers are perfect for many applications where space and cost are important considerations. It is not necessary to have a 486 or even an 8086 CPU for many applications; for instance, a TV remote control. Typically, these programs will need some kind of input/output function in order to read signals and toggle bits.

INTRODUCTION

The current state of road accident rates is a major issue for healthcare and welfare policymakers worldwide. At the present time, one person dies and two more are injured in traffic accidents every 50 seconds [1]. There have been many traffic accidents across the world, resulting in catastrophic injuries for an estimated 20 to 50 million people. The majority of these victims will need expensive and long-term medical care. Despite this misery, road accidents account for 1-3 percent of global GDP in the majority of countries [2-5]. Research into innovative approaches and efforts to promote traffic safety is essential if we are to successfully mitigate the impacts of traffic accidents, which may be achieved via a multitude of methods. If nothing is done, the World Health Organization (WHO) predicts that 1.9 million people would die each year in road accidents by 2020. Although motorized cars have improved many people's lives and whole towns, they have also brought about certain expenses. Despite a declining trend in the percentage of people killed in road traffic accidents in high-income nations over the past decade, the social and economic costs of traffic congestion casualties are increasing dramatically for the majority of people around the world. In underdeveloped countries, where they also inflict a lot of harm and death, road traffic accidents (RTAs) account for almost 90% of lost years to disability-adjusted life expectancy and 85% of all deaths. country after country, India is seeing rapid growth. Every day, a great number of people in India are killed or severely injured in road traffic

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accidents. It is not uncommon for the whole family to perish. Those affected or murdered are disproportionately in their prime earning years. Due to their disproportionate representation as walkers, bikers, and passengers in buses and minibuses, low-income persons have a disproportionately high rate of fatalities and injuries. An important continuing problem is the rapid and precise identification of individuals at risk of collisions caused by drowsy driving. Not everyone is a good fit for or can benefit from using a consciousness scale [7]. Because men are either less perceptive to or less willing to confess to feeling tired, these tests tend to be less accurate and reliable when applied to men than to women. Fatal and injury-causing vehicle traffic accidents are an increasing and serious issue in India's public health system. Every week, road accidents result in 9,000 injuriesand roughly 2,650 deaths. In India, car accidents resultedin 137,423 deaths and 469,900 injuries in 2013, the mostrecent calendar year for which statistics is available [8–10]. With almost 140,000 casualties annually, India now ranks higher than China as the global leader in pedestrian fatalities caused by road accidents. Every hour, 53 people are injured and almost 15 die as a result of traffic accidents, making India the only country in the world to do so [11]. While conditions are generally improving in many developing and industrialized countries, India's situation is deteriorating. China is a part of it [12–14]. According to information issued by the National Crime Records Bureau, Ministry of Home Affairs [8], Fig. 1 displays the states in India where road unintentional fatalities occurred in 2021.

LITERATURE SURVEY

A smart fuel theft detection system was created by Kumbhar et al. (2015). It makes use of an ARM7 microprocessor, integrates GSM alert and GPS tracking capabilities, and can monitor the position and gasoline levels of a vehicle in real-time. • An automated system to combat gasoline theft was studied and developed by Ghogardare et al. (2016). With the use of a PIC microcontroller, Shinde and Wahle (2016) developed a digital gasoline meter that is based on GSM technology and a system to detect fuel theft. Digital fuel meters and systems for detecting gas theft were the focus of More et al. (2016). • The detection of fuel theft in big trucks was the primary emphasis of Geetha and Raja (2016). • A system for automatically detecting gasoline theft and monitoring fuel levels was created by Prabhu et al. (2022) using the Internet of Things (IoT). An improved Internet of Things (IoT)-based method to provide a protected system was suggested by Charaan et al. (2022). Intrusion Detection System (IDS) datasets were examined for classification difficulties by Lanfer et al. (2023) using explainable AI algorithms. • A method for automated detection of robberies and thefts in banks was developed by Kakadiya et al. (2019) utilizing artificial intelligence and smart surveillance.

Using the YOLOv5 object detection paradigm, S and Bhuvanesh (2023) created a system that can identify theft in real-time.

EXISTING SYSTEM

Manual driving abilities, simple sensor-based warnings, and human intervention are the mainstays of conventional car safety systems. Delays in responding to potentially dangerous circumstances are common in most traditional automobiles since they do not have automatic collision avoidance systems. Even while some high-tech cars have simple ultrasonic sensors built in, their main use is for parking and not for intelligent navigating or real-time automated braking.

In addition, current accident prevention systems aren't equipped to send data over the internet of things, which means that features like remote tracking, real-time monitoring, and emergency alerts aren't available. Unfortunately, traffic management systems rely on handwritten reporting and CCTV monitoring, neither of which provide immediate means of detecting or preventing accidents. The capacity to anticipate and avoid accidents is further restricted by the lack of predictive analytics powered by AI. Also, many cars still rely on antiquated braking systems that don't have any kind of automation, so drivers still have to respond manually when it really counts. Accidents and deaths are more likely in situations when drivers are required to react quickly, such as while traveling at high speeds. A smart, AI-based solution that can identify, avoid, and react to incidents instantly is necessary since conventional systems do not have integrated Internet of Things (IoT) connection and automation.

PROPOSED MODEL

To improve real-time collision detection and vehicle safety, the proposed AI and IoT accident prevention system includes Ultrasonic Sensors, Motors, and IoT connection. In order to keep an eye out for any hazards, the vehicle's Ultrasonic Sensor scans the area around it in real time. A collision avoidance system that uses data processing to engage the motor-driven braking or steering control mechanism is activated if an impediment is identified within a predetermined range.

Through the Internet of Things (IoT) module's real-time data transmission to a cloud platform, users,

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authorities, or emergency response teams may monitor accident-prone locations, get rapid notifications in the event of a possible collision, and follow the behavior of vehicles. In addition, data from sensors is processed by an AI-based system to foretell potential accident situations and enhance the vehicle's reactions. The suggested system has many important aspects, such as: • Using ultrasonic sensors to identify obstacles in real-time. Using motor control, the vehicle may automatically change the steering and brakes. • Remote monitoring and accident reporting empowered by the Internet of Things. - Predictive analytics powered by artificial intelligence to help avoid accidents. - An emergency alert system to quickly contact the proper authorities. The system's use of these characteristics improves traffic management, decreases accident risks, and makes roads safer. Autonomous cars, smart transit systems, and traffic management solutions powered by artificial intelligence may greatly benefit from it.

BLOCK DIAGRAM

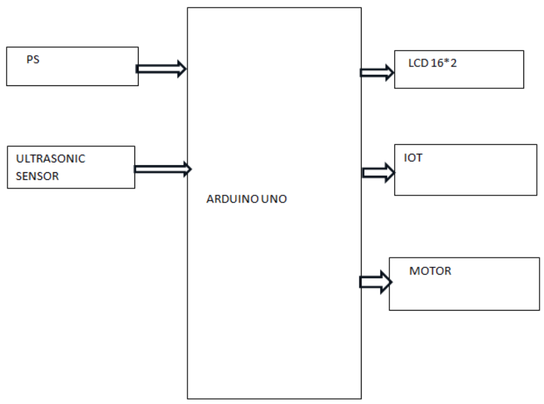

Figure 1: Block Diagram

Microcontroller:

A tiny controller, or microcontroller, as the name implies. Often used as a processing or controlling unit, they are similar to single-chip computers. For instance, microcontrollers that do decoding and other regulating operations are likely integrated into the control you are using. They find further use in vehicles, home appliances, microwaves, toys, and any other area requiring automation.

Arduino Uno Microcontroller:

One such microcontroller board is the Arduino Uno, which uses the Atmega328 (datasheet). It has a 16 MHz crystal oscillator, 6 analogue inputs, 14 digital input/output pins (6 of which may be used as PWM outputs), a power connector, an ICSP header, a reset button, and a USB connection. All you need is a USB cable, an AC-to-DC converter, or a battery to get it going; it comes with everything you need to support the microcontroller.

A key difference between the Uno and all previous boards is the absence of the FTDI USB-to-serial driver chip. Rather of that, it has an Atmega8U2 that has been configured to convert USB to serial. To celebrate the impending release of Arduino 1.0, the name "Uno"—which means "One" in Italian—has been chosen. The Uno and Arduino version 1.0 will serve as the foundational versions for future Arduino releases. For a comparison with prior generations, see the index of Arduino boards. The Uno is the newest in a series of USB Arduino boards and the standard model for the Arduino platform.

ARDUINO UNO BOARD:

One board that uses the Atmega328 microprocessor is the Arduino Uno. A 16 MHz ceramic resonator, 6 analog inputs, 14 digital I/O pins (including 6 PWM outputs), 1 USB port, 1 power connector, 1 ICSP header, and 1 reset button are all part of it. All you need is a USB cable, an AC-to-DC converter, or a battery to get it going; it comes with everything you need to support the microcontroller.

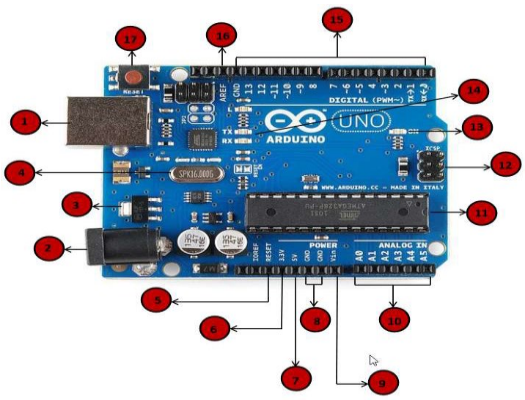

Figure 2: Arduino uno board

In contrast to all of its predecessors, the Uno does not have the FTDI USB-to-serial driver chip. As an alternative, it makes use of USB-to-serial converters coded into the Atmega16U2 (Atmega8U2 up to version R2).

HARDWARE COMPONENTS

POWER SUPPLY UNIT

The power supply for this system is shown below.

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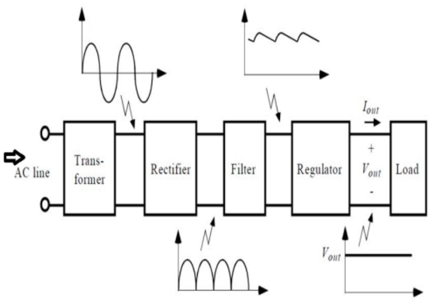

Figure 3: power supply

Diodes:

Only one path of electrical current may pass through a diode. Current may flow in either direction, as shown by the arrow in the circuit symbol. Originally termed valves, diodes are essentially an electrically enhanced version of the mechanical component.

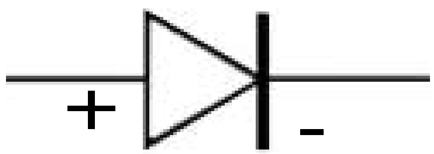

Figure 4: Diode Symbol

One kind of electrical component that restricts current flow is the diode. A voltage loss of around 0.7V will be the sole influence on the signal when the diode is "forward-biased" in this way. No current will flow through a diode that is "reverse-biased" when the current is applied in the other direction.

Rectifier

A rectifier's job is to change the phase of an alternating current (AC) waveform so that it appears as a direct current (DC) waveform. Both "half-wave" and "full-wave" rectifiers are used for rectification. Diodes are used in both devices to convert AC current into DC current.
The Half-Wave Resettable
The graphic shows that the half-wave rectifier is the simplest rectifier type since it only employs one diode.

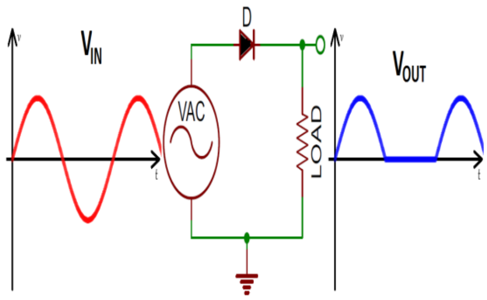

Figure 5: Half Wave Rectifier

LIQUID CRYSTAL DISPLAY

An array of color or monochrome pixels arranged in front of a light source or reflector makes up a liquid crystal display (LCD), a thin, flat display device. Two polarizing filters, with their polarity axes perpendicular to one other, and a column of liquid crystal molecules hanging between two transparent electrodes make up each pixel. Light would not be able to travel through them if the liquid crystals weren't interposed. To make light flow through two filters, the liquid crystal changes the polarization of the light entering the first filter.
A program's ability to communicate with the outside world depends on its input and output devices, which in turn rely on human communication. An LCD display is a typical accessory for controllers. 16X1, 16x2, and 20x2 LCDs are among the most popular types of displays that are often linked to the controllers. Which works out to sixteen characters on a single line. The first set has 16 characters on each line while the second set has 20 characters on each line. The use of "smart LCD" displays allows for the visual output of information by many microcontroller devices. Affordable, user-friendly, and capable of producing a readout utilizing the display's 5X7 dots plus cursor, LCD displays built on the LCD NT-C1611 module are a great choice. They use mathematical symbols and the usual ASCII set of characters. The display needs a +5V power and 10 I/O lines (RS, RW, D7, D6, D5, D4, D3, D2, D1, D0) for an 8-bit data bus. The only additional lines needed for a 4-bit data bus are the supply lines and six more (RS, RW, D7, D6, D5, D4). The data lines are tri-state and do not affect the microcontroller's function when the LCD display is disabled.

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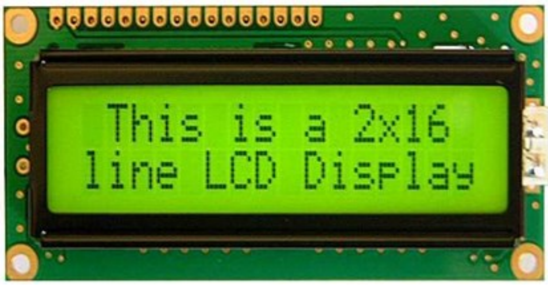
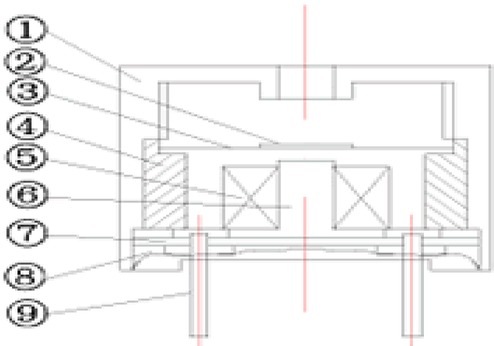


Figure 6: 2x16 LCD Display

BUZZER

In a magnetic transducer, the circuitry includes an iron core, a yoke plate, a wound coil, a permanent magnet, and a vibrating diaphragm that can be moved. The magnet's field gently draws the diaphragm up nearer the core's surface. A positive alternating current (AC) signal causes the diaphragm to move up and down, which in turn vibrates the air. This is achieved by the current passing through the excitation coil, which forms a fluctuating magnetic field. A resonator, which is composed of a cavity and one or more sound holes, may amplify vibrations in order to generate a loud sound.



ESP8266 Wi-Fi Module

This project revolves on this. Because the project relies on WIFI control of appliances, the module is a crucial part of it.
One remarkable feature of this tiny board is the integrated MCU (Micro Controller Unit), which allows for the control of I/O digital pins via a simple programming language that is almost pseudo-code like. Another benefit is that the ESP8266 Arduino compatible module is a low-cost Wi-Fi chip with full TCP/IP capability. The Chinese company Es press if Systems is situated in Shanghai and makes this gadget.
In August 2014, this chip made its debut in the ESP-01 version module manufactured by the third-party company AIThinker. The MCU can establish basic TCP/IP connections and connect to WiFi networks with the help of this little module. He was His tiny size and cheap pricing (1.7–3.5$) enticed a lot of hackers and geeks to look into it and utilize it for all sorts of projects. Because of its enormous success, Espressif now offers a wide variety of models with varying size and technological specs. Its replacement includes ESP32.

RELAYS:

Industrial controls, automotive systems, and home appliances all make extensive use of electrically controlled switches called relays.
By using a relay, two independent voltage sources may be isolated from one another; in other words, a little quantity of voltage or current on one side can manage a big amount of current or voltage on the other side, and vice versa.

Inductor

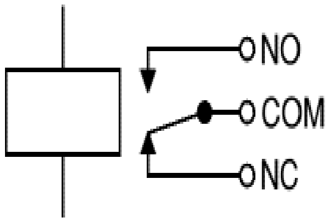


Fig7 : Circuit symbol of a relay

DRIVING A RELAY:

Two of the SPDT relay's five pins are used by the magnetic coil, one serves as the common terminal, and the other two are typically closed and normally connected. The coil is activated when a current passes across it. At the beginning, when the coil is deenergized, the usually closed pin and common terminal will be connected. A new connection will be formed between the common terminal and usually open pin when the coil is activated, breaking this connection. Therefore, the relay will be activated whenever the microcontroller sends an input signal to it. You may drive the loads connected between the common terminal and typically open pin while the relay is on. Consequently, the high-current loads are driven by the relay, which receives 5V from the microcontroller. This means the relay may be used as a means of isolation.
The microcontroller and digital systems do not have enough current to operate the relay. In contrast to the 10 milliamps required to activate the relay's coil, the microcontroller's pin can only provide 1 or 2 milliamps. This is why the

microcontroller and the relay are separated by a driver, like ULN2003, or a power transistor. By connecting ULN2003 to the relay and microcontroller, it is possible to activate many relays simultaneously.

SOFTWARES

The Arduino platform is an open-source, user-friendly hardware and software environment for prototyping. It is comprised of a programmable circuit board (also called a microcontroller) and an Integrated Development Environment (IDE) called Arduino that is pre-made for writing and uploading code to the physical board. The main characteristics are: • Many sensors can send signals in digital or analog formats to Arduino boards, which may then be used to activate motors, control LEDs, establish connections to the cloud, and much more. • The Arduino IDE (also called "uploading software") allows you to command your board's operations by communicating with the microcontroller on the board. • A separate device, known as a programmer, is not required to load fresh code into an Arduino board, in contrast to most prior programmable circuit boards. The usage of a USB connection is all that is required. • The Arduino IDE employs a streamlined version of C++, which facilitates programming learning. Last but not least, Arduino offers a standardized form factor that simplifies the microcontroller's tasks. Now that we know what the Arduino UNO board is and how it works, we can go on to setting up the Arduino IDE. As soon as we figure this out, we can upload our software to the Arduino board.

CONCLUSION

One promising strategy for improving road safety and decreasing the frequency of car accidents is an accident detection and prevention system that makes use of artificial intelligence and the internet of things. Remote monitoring, automated collision prevention, and real-time obstacle detection are all made possible by the system's integration of Ultrasonic Sensors, Motors, and Internet of Things connectivity.

Automating the vehicle's braking and steering reactions, this system actively avoids accidents, unlike conventional vehicle safety systems. The monitoring system, which is based on the Internet of Things, allows authorities and emergency responders to act immediately in the event of an accident by providing real-time notifications. Integration with smart city infrastructure for improved traffic management, cloud-based accident data, and risk assessment driven by machine learning are all potential future upgrades. Contributing to safer roads, lower deaths, and enhanced transportation efficiency, this cost-effective, scalable, and AI-driven system is a major leap forward in current car safety technology.

REFERENCES

[1] K. Goniewicz, M. Goniewicz, W. Pawłowski, and P. Fiedor, "Roadaccident rates: strategies and programmes for improving road traffic safety," Eur. J. Trauma Emerg. Surg., vol. 42, no. 4, pp. 433–438, 2016,doi: 10.1007/s00068-015-0544-6.

[2] S. Gopalakrishnan, "A Public Health Perspective of Road TrafficAccidents,"J.Fam. Med. Prim. Care, vol. 1, no. 2, p. 144, 2012, doi:10.4103/2249-4863.104987.

[3] M. H. Smolensky, L. Di Milia, M. M. Ohayon, and P. Philip, "Sleepdisorders, medical conditions, and road accident risk,"Accid. Anal.Prev., vol. 43, no. 2, pp. 533–548, 2011, doi:10.1016/j.aap.2009.12.004.

[4] S. K. Singh, "Road Traffic Accidents in India: Issues and Challenges,"Transp. Res. Procedia, vol. 25, pp. 4708–4719, 2017, doi:10.1016/j.trpro.2017.05.484.

[5] NCRB, "Accidental Deaths & Suicides in India 2021," Natl. CrimeRec. Bur. Minist. Home Aff., p. 298, 2022, [Online]. Available:https://ncrb.gov.in/en/ADSI-2021.

[6] R. Li, F. C. Pereira, and M. E. Ben-Akiva, "Overview of traffic incidentduration analysis and prediction," Eur. Transp. Res. Rev., vol. 10, no.2, pp. 1–13, 2018, doi: 10.1186/s12544-018-0300-1.

[7] B. Ostendorf and A. E. Retallack, "Current Understanding of the Effects of Congestion on Tra ffi c Accidents," 2019.

[8] H. M. Hammad et al., "Environmental factors affecting the frequencyof road traffic accidents: a case study of sub-urban area of Pakistan,"Environ. Sci. Pollut. Res., 2019, doi: 10.1007/s11356-019-04752-8.

[9] A. Moradi, S. S. H. Nazari, and K. Rahmani, "Sleepiness and the riskof road traffic accidents: A systematic review and meta-analysis ofprevious studies," Transp. Res. Part F Traffic Psychol. Behav., vol. 65,pp. 620–629, 2019, doi: 10.1016/j.trf.2018.09.013.

[10] M. Imprialou and M. Quddus, "Crash data quality for road safetyresearch: Current state and future directions,"Accid. Anal. Prev., vol.130, pp. 84–90, 2019, doi: 10.1016/j.aap.2017.02.022.