Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 1, March : 2024

ADVANCED TRAFFIC MONITORING AND CONGESTION CONTROL

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Abstract
The main issue facing developing cities these days is traffic congestion. In the future, this might get much worse if the traditional approach to traffic management is used. Thus, a smart traffic control system is the main emphasis of our research work. The suggested solution out performs the traditional approach in terms of shorter wait times, fewer accidents caused by speeding, and effective operation in emergency mode. The Arduino UNO microcontroller and sensor network are used in the suggested system. A microcontroller board based on the ATmega328 is called the Arduino Uno. It makes use of portable inductive proximity like a sensor. These sensors don't need to be installed in the road. Alternatively, similar gadgets might be positioned beside the road to gauge traffic in the lane directly next to it. Traffic signals are opened and closed using this sensor system in accordance with the number of vehicles in each lane. This sensor system can be used for counting automobiles, classifying them as heavy or light, and detecting vehicles that are traveling too fast. The number of vehicles is displayed on an LCD panel. Using a GSM SIM900, an alert message can be sent to the local police station following an over speed detection. Every emergency vehicle has an RFID tag installed. The NSK EDK-125-TTL, Arduino Uno, and RFID reader are used to scan the RFID tags affixed to the emergency vehicle. As a result, the emergency vehicle can now arrive at the hospital promptly. The traffic signal includes a voice output feature that continuously announces the remaining seconds before the light turns green. This serves as assistance for visually impaired individuals during road crossings.
Keywords: Traffic Monitoring

I. Introduction

Due to the expansion of urbanization, industrialization, and population growth, managing traffic on the roads has become a significant contemporary societal challenge. The existing traffic system lacks density-based mechanisms, leading to congestion, accidents, and violations at busy intersections. These issues adversely affect both the country's economy and human lives. The existing traffic management methods lack consideration for traffic density, leading to issues such as traffic congestion and delayed identification of over speeding vehicles, which pose a significant risk of accidents. Particularly concerning is the impediment faced by ambulances in heavy traffic, putting patients' lives at risk. Acknowledging these challenges, there is a growing demand for a comprehensive solution to enhance traffic management effectiveness. The conventional traffic system is not density-based, contributing significantly to traffic congestion. Accidents are prone to occur when over speeding vehicles go undetected at the right time. Ambulances encounter substantial challenges in navigating through heavy traffic, jeopardizing timely patient transportation to nearby hospitals. Recognizing the critical role of ambulances as vital medical transport means, the proposed manuscript aims to address these issues comprehensively and meet the increasing demand for effective traffic management solutions.

Figure 1: Progression of sensors

In its initial application, this project employs a microcontroller and an embedded sensing network to regulate traffic density. Unlike the prevalent technology relying on feature extraction from camera systems for vehicle detection and classification, the proposed approach presents a portable sensing system. This system, utilizing Inductive Proximity Sensors, offers advantages over camera-based

methods, which often yield unsatisfactory results in adverse weather conditions like frost and snow, and are typically cost-prohibitive.
Unlike conventional approaches that use strain gauges embedded in roadways for vehicle detection and classification, the proposed sensing system doesn't necessitate any infrastructure modifications. It is characterized by its compactness, portability, wireless functionality, and cost-effectiveness. Importantly, the sensors are positioned on the roadside, eliminating the need for traffic interruptions during installation, as highlighted in [5]. This innovative system aims to provide a reliable and versatile solution for vehicle counting, classification, and speed measurement.
In the work's second application, the identification of speeding vehicles is accomplished through the utilization of an embedded sensing network and a timing circuit. Subsequently, a notification is dispatched to the nearby police station via a GSM module to alert authorities about the presence of over speeding vehicles.
The main goal of this project is to address challenges related to ambulance navigation in traffic. The proposed solution involves activating the green light specifically in the lane where an ambulance is present, while simultaneously turning all other lights to red. This designated pathway ensures a quick and unobstructed route for the ambulance, utilizing RF transmitters and receivers for efficient communication within the traffic system. Additionally, to enhance accessibility, voice output features are incorporated into the traffic signals, assisting visually impaired individuals during road crossings. This holistic approach not only prioritizes emergency services but also emphasizes inclusivity, aiming for a more efficient and user-friendly traffic management system.

II. Literature

In 2015 Wenjing Xue, Linbing Wang, and Dong Wang proposed a system called “Portable Roadside Sensors for Vehicle Counting, Classification, and Speed Measurement”[6]. The sensor system consists of wireless anisotropic magnetic devices that do not require to be embedded in the roadway.
Speed measurement in this system relies on calculating the cross-correlation between sensors spaced longitudinally. The classification of vehicles is determined by the magnetic length and an estimate of the average vertical magnetic height. Vehicle length is then approximated by multiplying occupancy and estimated speed [7,8].
In a paper by Rajeshwari S., Santhoshs Hebbar, Varaprasad Golla titled "Implementing Intelligent Traffic Control System for Congestion Control, Ambulance Clearance, and Stolen Vehicle Detection," a unique RFID tag is assigned to each vehicle. A RFID reader is employed to scan these tags, tallying the number of vehicles passing along a specific route within a defined timeframe. If the RFID tag corresponds to a stolen vehicle, a message is dispatched via GSM to the police control room. The paper introduces an intelligent traffic control system designed to facilitate the smooth passage of emergency vehicles. In the case of an approaching ambulance, communication occurs with the traffic controller at the junction through Zig Bee modules.

III. Proposed System

The envisioned system comprises an Arduino Uno microcontroller designed for traffic monitoring and control. Proximity sensors are employed to gather data on vehicle count and classification, with this information transmitted to the microcontroller for the regulation of traffic signals. Integration of a GSM module enables the transmission of messages upon detecting over speed. Additionally, RFID transmitters and receivers play a crucial role in identifying emergency vehicles.. The block diagram of the proposed system consists of three modules:
1. Density based traffic monitoring
2. Over speed detection
3. Emergency vehicle detection

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3.1 Density Based Traffic Monitoring

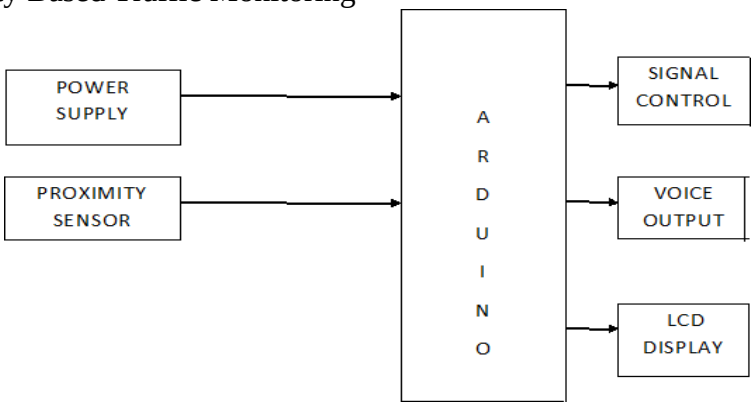

Fig 1. Block diagram for Density based traffic monitoring.

Figure 1 illustrates the block diagram of a density-based traffic monitoring system utilizing the Arduino Uno microcontroller. The module incorporates an Inductive Proximity sensor connected to the controller, arranged horizontally on the roadside. Activation of the sensor system occurs whenever a vehicle passes on the road. The microcontroller manages the sensor system, registering and storing the count of passing vehicles in its memory. Based on the accumulated vehicle count, the microcontroller determines the sequence for activating green signals in different lanes. In this proposed system, a time count is displayed on an LCD screen. Upon reaching the end of the time count, the decision on which lane to open first is made by the microcontroller, considering the vehicle density.

3.2. Over speed detection

Road transportation is integral to the socio-economic development of any nation; however, the escalating toll of life and property losses due to road accidents is a growing concern. The detection of vehicles exceeding speed limits is crucial for accident prevention. Inductive proximity sensors, labeled as (a), (b), and (c) for convenience, are utilized for this purpose.

Upon detection by sensor (a), the timing circuit is triggered, calculating the time taken by the vehicle to reach sensor (b). If this time meets or exceeds the predetermined threshold, the vehicle is considered to be moving at a normal speed. Conversely, if the time falls below the predetermined threshold, the vehicle is identified as over-speeding. This system effectively identifies vehicles violating speed limits. Upon detecting an over-speed vehicle, an instant message is transmitted to the nearby police station through a GSM module, facilitating prompt intervention and enforcement of traffic regulations.

3.3 Emergency Vehicle Detection

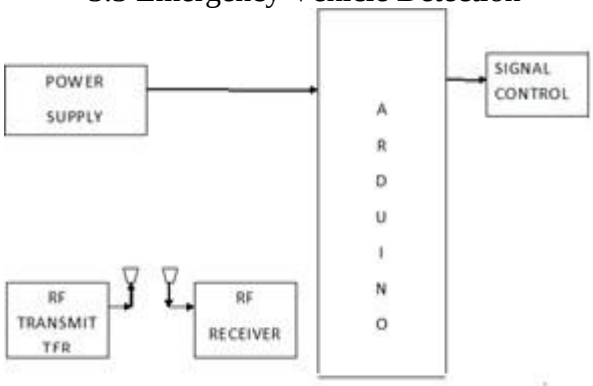

Fig 2. Emergency vehicle detection.

The block diagram for the emergency vehicle detection is displayed in Figure 2. An automatic lane clearance system for ambulances or other emergency vehicles based on RFID technology was proposed by this system. The goal of this effort is to automatically clear the lane the ambulance is traveling in before it reaches the traffic signal, thereby cutting down on the amount of time it takes to

go to the hospital. Every emergency vehicle has a unique RFID tag installed. The RFID tags affixed to the car are scanned by an RFID reader. Data is transmitted to the controller by the RFID reader as soon as it reads the data from RFID tags. Hence, the activation of the traffic signal in the ambulance's path to green when the ambulance reaches a specific distance from the traffic junction is successfully accomplished. The implementation of RFID technology differentiates between emergency and non-emergency situations, effectively avoiding unwarranted traffic congestion. Figure 3 provides an overview of the comprehensive block diagram for the traffic monitoring and congestion system.

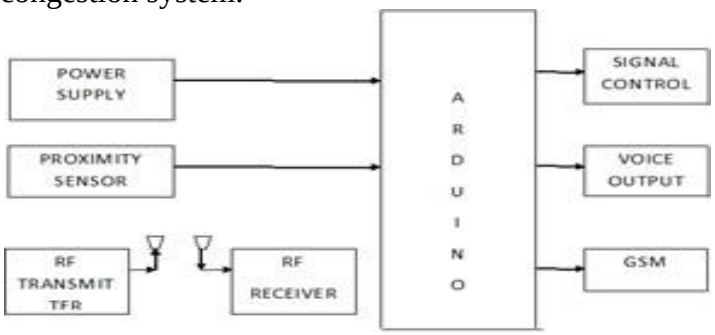

Fig 3. General block diagram

IV. Software Algorithm

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text.

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the Tools > Board menu .The ATmega328 on the Arduino Uno comes pre
burned with a boot loader that allows to upload new code to it without the use of an external hardware programmer.

The software algorithm for detecting presence of vehicle and over speed detection is explained below:

Step1: Include header files for Interfacing LCD with the Microcontroller unit.
Step2: Initialize all the macros and variables.
Step3: Initialize digital ports for interfacing proximity sensors. Step4: Initial sensor state is low. This indicates that no vehicle is detected . After detecting target, sensor state becomes high. Initially the value of variables TO, H, L is zero.
Step5: Configure the sensor output as input to the controller. Step6: Initialize timer.
Step7: Over speed condition is checked initially based on sensor output.
Step8: Vehicle classification takes place depending upon the data from sensors.
Step9: After vehicle classification vehicle count gets incremented.
Step10: All the results are displayed in LCD display.

V. Experimental Results

The Advanced traffic monitoring and congestion control system consist of microcontroller Arduino Uno and Inductive Proximity sensors. These two form the principle components. Apart from these, GSM SIM900, LCD, RFID tag, RFID Reader, Voice Output are also used to perform additional features. The overall system module is shown in Figure 4.

Industrial Engineering Journal
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Volume : 53, Issue 3, No. 1, March : 2024

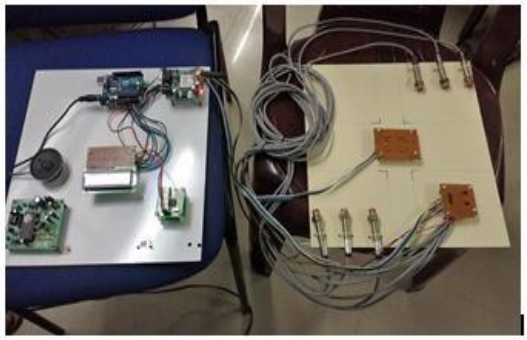

Fig 4. Advanced traffic monitoring and congestion control system.

5.1 Initial Setup Description

A 5V power supply is given to Arduino Uno. It's is the operating voltage for Arduino. GSM SIM900 is interfacedwith the controller. To give audio output, voice board is also interfaced with controller. To display vehicle count, and classified output, LCD display is used. Traffic signal LED is also connected to controller Proximity sensors are placed in horizontal manner on the adjacent side of the road.

Figure 5. Initial Setup

5.2 Vehicle Count In Lane 1

In this condition, proximity sensor detects a vehicle in Lane1. In the proposed system, only two lanes of road are considered. Three sensors are arranged horizontally in lane 1. As soon as the first sensor detects metal target, vehicle count starts. Classification of vehicles is performed by second and third sensor. If the sensor 2 and 3 detects vehicle individually, then the vehicle is considered to be light vehicle. And if both the sensors detect the vehicle simultaneously then we call it as heavy vehicle. In this condition, lane 1 detects light vehicleand whereas lane 2 does not detect any vehicle. As soon as vehicle is detected in lane 1, green led in lane 1 glows andlane 2 shows red light indication.

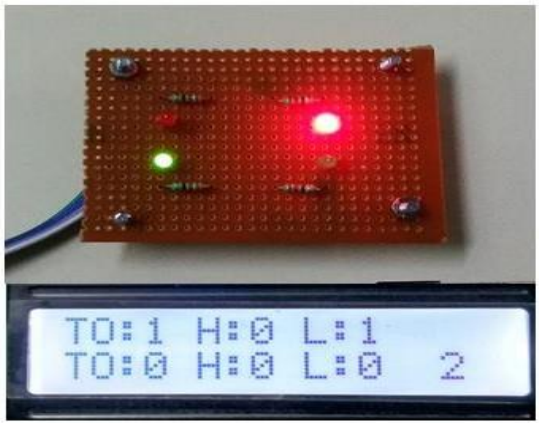

Fig 6. Vehicle count in LANE1.

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Volume : 53, Issue 3, No. 1, March : 2024

5.3 Vehicle Count In Lane 2

In the proposed system 3 proximity sensors are arranged horizontally in lane 2.Whenever the density of vehicles ismore in lane 2, green signal is shown in lane 2. In this condition, there is no vehicle in lane 1 and light vehicle is detected in lane 2. So lane 2 shows green light whereas lane 1 indicates red light in the figure7.

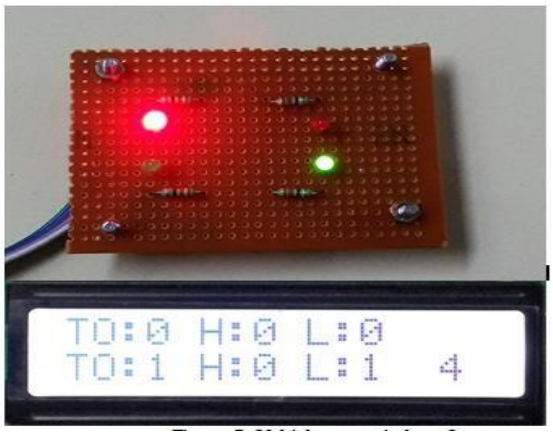

Fig 7. Vehicle count in lane 2.

5.4 Over Speed Detection

In this condition, sensor 1 and sensor 2 are used to detect over speed. A predetermined time delay between the sensors 1and 2 is set initially in the timer of controller. When any vehicle takes less time than the predetermined time delay, overspeed condition is detected.

Fig 8. Over speed detection.

5.4.1 Message Sent To Phone

As soon as over speed condition is detected, alert message is sent to the nearby police station using GSM SIM900 module. The message received in the mobile phone during over speed detection in lane1 and lane 2 is shown in theFigure 9.

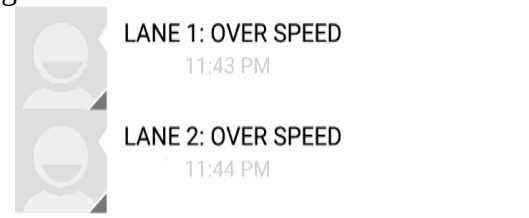

Fig 9. Message sent to phone.

Emergency Vehicle Detection

In this condition, all the emergency vehicles are given unique RFID tag. Here emergency vehicle passes through lane 1. As soon as the RFID reader detects the tag, it transmits tag information to the controller. As soon as the reader reads tag data, signal of that particular lane turns green irrespective of the density of that lane. Signal is turned green in lane 1 till the emergency vehicle crosses the traffic signal. Emergency vehicle detection is shown in shown in the Figure 10.

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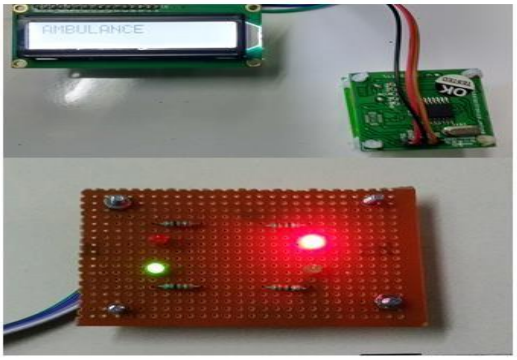

Fig 10. Emergency vehicle detection.

5.6. Voice Output

The voice board called audio play back board using APR33A3IC is placed at the traffic junction. This will first say the name of the lane, whether lane1 or lane 2. Then it will announce the time left for the corresponding signal to turn green. This helps the people in being aware of the signal status and also helps impaired people in road crossing.

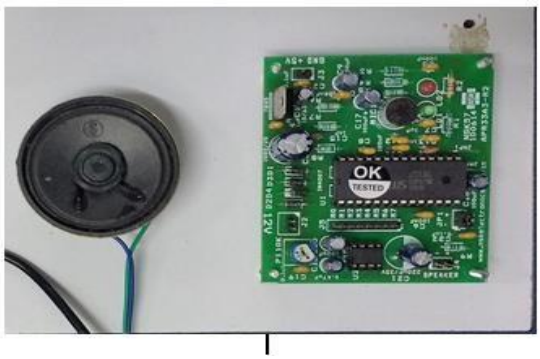

Fig 11. The Voice board

VI. Conclusion

This innovative approach to advanced traffic monitoring and congestion control employs portable inductive proximity sensors to count and classify vehicles, dynamically adjusting traffic signals based on the density of vehicles. The use of these sensors also enables the detection of over-speeding vehicles, prompting an alert message sent to the nearby police station via a GSM module. Special provisions are implemented to prioritize emergency vehicles, such as ambulances, by turning their corresponding lane traffic light green while all others turn red, ensuring a swift and unimpeded route to the hospital.

The placement of sensors on the roadside eliminates the need to halt traffic for installation, enabling seamless implementation. This system enhances over-speed detection without requiring human intervention, contributing to efficient traffic management. Prioritizing emergency vehicles facilitates prompt hospital arrival, potentially saving lives. Additionally, voice output in the traffic signal aids impaired and elderly individuals in crossing roads. Overall, the proposed system is characterized by its compactness, portability, wireless functionality, and cost-effectiveness.

References

[1] Sarika B. Kale, Gajanan P. Dhok," Design of Intelligent Ambulance and Traffic Control, "International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-2, Issue-5, April 2013.

[2] Y. George and C. Antoniou, "Integration of weigh-in- motion technologies in road infrastructure management," ITE J., Vol. 75, No. 1, pp. 39–43, 2005.

[3] J. Lan. Y. Xiang, L.Wang, and Y. Shi, “Vehicle detection and classification by measuring and processing magnetic signal,” Measurement, Vol. 44, No. 1, pp. 174–180, Jan. 2011.
[4] B. Coifman and S. Kim, “Speed estimation and length based vehicle classification from freeway single-loop detectors,” Transp. Res. C, Emerging Technol., Vol. 17, No. 4, pp. 349–364, Aug. 2009..
[5] Saber Taghvaeeyan and Rajesh Rajamani,” Portable Roadside sensors for vehicle counting, classification and speed measurement”, IEEE Transactions On Intelligent Transportation Systems, Vol. 15, No. 1, February 2014
[6] Rajeshwari S., Santhoshs Hebbar, Varaprasad Golla,” Implementing Intelligent Traffic Control System for Congestion Control, Ambulance Clearance and Stolen Vehicle Detection” DOI 10.1109 /JSEN.2014.2360288, IEEE Sensors Journal
[7] Legon-Okponglo, “Design and development of microcontroller based traffic system using image processing techniques”. University of Ghana, published in ICAST, 2012 IEEE 4th International Conference.
[8] Xu Li, Wei Shu, Minglu Li, Hong-Yu Huang, Pei-En Luo, Min-You Wu, “Performance Evaluation of Vehicle-Based Mobile Sensor Networks for Traffic Monitoring” IEEE transactions on vehicular technology, May 2009, Vol. 58, No. 4, pp. 1647-1653.
[9] Harpal Singh, Krishan Kumar, Harbans Kaur, "Intelligent Traffic Lights Based on RFID", International Journal of Computing & Business Research, ISSN 2229-6166.