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RESEARCH ARTICLE

Prevention of Traffic Signal Violation and Pedestrian Safety Using Retractable Electric Bollard

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Abstract

Objectives: To propose a novel technique to halt vehicles at the signals before the stop line of a zebra crossing and allow pedestrians to cross the road safely. **Methods**: An advanced automated signal controlling system is developed using a controller, various sensors, and devices. The bollards are one of the important parts of our advanced automated signal controlling system. It is used to halt vehicles before the stop line of zebra crossing. The bollards are raised during the red signal phase and are lowered during the green signal phase. Different sensors such as rain sensor and RFID are used in the proposed model. The rain sensor is used to detect rain and allows the lowering of all the bollards, so that two-wheeler passengers can take shelter nearby. RFID tag and reader is used to detect the emergency vehicle and lower the bollards of the lane such that emergency vehicles can pass through. **Findings**: During the red-light phase, the bollard is raised up in the lane which allows pedestrians to cross the road safely. During the green light phase, the bollard is lowered down in the lane allowing vehicular movement. The use of bollards with the various sensors makes sure the pedestrians cross the road safely. The RFID tag can be used to lower the bollard of the lane for emergency vehicles like Ambulance, Fire brigade etc. **Novelty**: The array of bollards used in the work provide safety to pedestrians while crossing the road. The bollards are controlled by the ESP32 during the red and green phase. The method used is novel and can be used for implementing in smart cities.

Keywords: Metropolitan; Traffic; Vehicles; Transportation; Traffic signal; Pedestrian; Bollard

1 Introduction

The nation's transportation system is its greatest strength, and transportation services are thought of as the economy's main growth driver. Road length is a good indicator of a country's economy. A nation's intelligence, labour force, infrastructure, and lastly the efficiency of its highways all contribute to its success. Pollution and accidents are the by-products of transportation, besides its benefits. According to information maintained by the Transport Research Wing, Ministry of Road Transport & Highways, Government of India,[1] Police Departments of States and Union Territories (UTs) across the nation recorded a total of 4,12,432 road accidents during the calendar year 2021, resulting in 1,53,972 fatalities and 3,84,448 injuries. The majority of those killed in tragic vehicle crashes are young persons in the working age groups. In 2021, victims who were under the age of 45 made up 67.6% of the population. A total of 84.5% of fatalities in road accidents occur among those in the working age range of 18 to 60 years. These figures translate, on an average, into 1130 accidents and 422 deaths every day or 47 accidents and 18 deaths every hour in India.

According to Transport Research Wing, Ministry of Road Transport & Highways, Government of India[1], Of total 4,12,432 accidents that were reported throughout the country in the year 2020-2021, roughly 2% i.e., 8,573 accidents happened at crossings installed with traffic signals and 2,204 out of 8,573 were due to jumping of red signal claiming lives of 679 persons and leaving 1,905 people injured. This is an alarming situation and demands an immediate solution to prevent further loss of lives.

All intersections should be properly signalised, and emergency vehicles such as ambulances and fire trucks should have their own traffic signals because they are delayed at intersections when there is a red light, which is extremely dangerous for our society[2].

To maximize traffic flow, the intersection traffic signal control problem looks for an effective timeline for traffic signal sets at intersections while considering a variety of elements, including real-time techniques, signal timing limitations, quick changes in traffic systems, and practical implementation[3].

Due to the mixed traffic conditions that occur in India, it is challenging to plan the timing of traffic signals. Additionally, changes in volume and saturation flow have an impact on the final signal time settings[4].

In addition to parameters like a signal break, crossing location, type, and time, pedestrian safety is dependent on pedestrian behavior, street infrastructure, and the surrounding environment.[5].

Two weeks were spent conducting a community-based observational study at different Shivamogga city crossroads. At every intersection, information was gathered for five days. Each pedestrian's behavioral and demographic information was collected. SPSS 21 software was used to analyze the data collected. Based on the analysis of data the road traffic injuries were more likely to occur among pedestrians who were distracted by technology and social media[6].

Among all road users, pedestrians are the most at risk and are the ones who suffer the most from traffic accidents in cities. The issue of pedestrian casualties in traffic accidents, particularly at crosswalks, may be resolved by complete segregation from vehicles through distance. This can be achieved by using stairways, pedestrian bridges, and subways[7].

Bollards are used to protect people and regulate vehicle entrance. The line dividing a sidewalk from a road is made up of a row of bollards. According to the author's research, bollard height increases linearly with the width of the space between them. The participants' eye height was linked to their sensation of security[8].

A majority of fatal traffic incidents are reported in the early morning hours on Saturdays and Sundays. The peak during weekends is especially for the people between the ages of 15 and 30, indicating the social preferences of young people, especially young drivers who prefer to ride and cycle. In smart cities, intelligent solutions can be used to provide solution for pedestrian safety[9].

2 Methodology

The focus of this paper is to provide safety to the pedestrian while crossing road at traffic signal. A modified automatic traffic signal is designed and developed. The details of each block are presented below Figure 1.

2.1 ESP 32

The ESP32 is a popular low-cost, low-power system-on-chip (SoC) microcontroller module that is designed for internet of things (IoT) applications. The ESP32 is based on a dual-core Tensilica Xtensa LX6 processor, which is capable of running at up to 240 MHz.

Various components are connected to the ESP32. Following are the list of sensors used for the automation of signal controller: Rain sensor, manual override key and RFID sensor are the input devices. Traffic lights, and array of bollards are the output devices.

2.2 Long Range RFID Sensor

Radio frequency identification (RFID) technology offers a unique identification system. RFID devices must all be scanned or swiped against the appropriate readers for retrieving data.

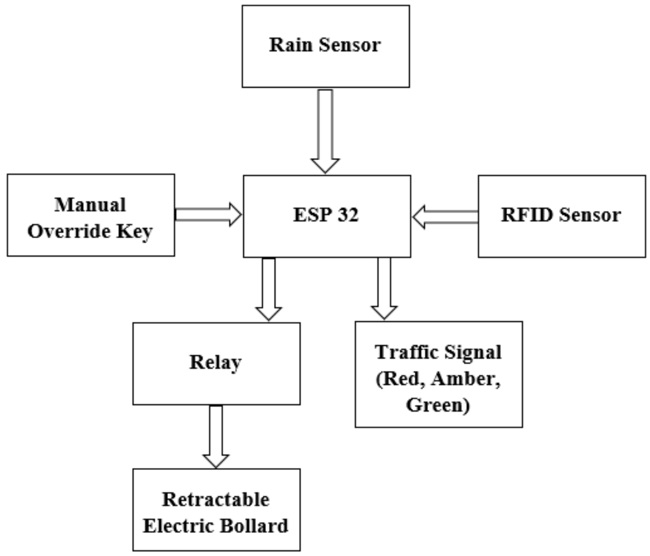

Fig 1. Block diagram

RFID is used to identify emergency vehicles at the signal crossing. Emergency vehicles such as ambulance, fire brigade etc. are provided with a unique RFID Id tag. Ultra-high frequency (UHF) band identification devices are used for identification for long range called Long Range RFID (LR-RFID). The RFID tagging system consists of various data of vehicle such as vehicle number, type of vehicle.

In case of emergency ambulance, fire brigade RFID tag can be scanned from long distance by a card reader. The controller ESP32 identifies from which lane the tag has been detected. The lane bollard will be lowered down for easy moment of emergency vehicle.

2.3 Rain Sensor

A rain sensor is a device used to detect the presence of rain and trigger an automated response. When rain drop comes into contact with the conductors, it completes the circuit and sends a signal to the control circuit.

The rain sensor is a part of automated traffic signal and is placed in open space. This sensor is basically useful for two-wheeler passengers. During the raining session, whenever the rain is detected by the sensor, the controller will lower all the bollards, such traffic can move, and two-wheeler passengers can take shelter nearby.

When the rain has stopped, all the signals will switch to red and later after a few seconds bollards will be raised.

2.4 Retractable Electric Bollard

A retractable electric bollard is a type of traffic barrier that is used to control vehicle access to certain areas. The bollard is designed to rise up from the ground when activated, preventing vehicles from passing through. When the bollard is no longer needed, it can be lowered back into the ground, allowing vehicles to pass through again.

The retractable electric bollard is powered by an electric motor, which raises and lowers the bollard. The motor is controlled by a controller thought relay.

During the red phase of signal, the bollard is raised up from the ground. This will make vehicles halt before the stop line so that pedestrians can cross the road safely. During the green phase of signal, the bollard is lowered down, and vehicles can move in that direction.

2.5 Relay

An electric relay is an electromagnetic switch that is used to control electrical circuits. It consists of a coil of wire that, when energized, generates a magnetic field. This magnetic field then pulls a movable contact or armature towards a fixed contact, closing an electrical circuit and allowing current to flow.

ESP32 controls raising and lowering of the bollards using relays. Two Single Pole Single Throw (SPST) momentary contact relays are used, one each for raising and lowering of bollard respectively.

Initially, both SPSTs are in open circuit mode and bollards are lowered below the ground. System comes alive once the traffic signals are activated. On detecting red signal, ESP32 raises the bollards by activating the first SPST momentary contact relay during which time the second SPST relay stays in open circuit condition. Whereas the vice-versa happens with the relays upon detection of green signal.

2.6 Software Description

Several firmware and programming languages can be used to programme the ESP32. Our preferred method to program the ESP32 is with Arduino programming language.

Arduino programming language is a simplified version of C/C++ programming language, designed to make it easier for non-programmers to use microcontrollers such as the Arduino board. It is a high-level language that supports a wide variety of functions and libraries, making it accessible for beginners and experienced developers alike.

The syntax of Arduino programming language is similar to C/C++, with a few simplifications and additional libraries to make it easier to use with the Arduino board.

3 Results and Discussion

A traffic signal, also known as a traffic light or stoplight, is a device used to control the flow of traffic at road crossings. Traffic signals typically consist of three lights: red, amber, and green. The operation of a traffic signal can be broken down into three phases:

- **Red Phase:** During the red phase, the red light is illuminated and traffic in the lane must come to a complete stop. The Bollard is raised up from the ground.This allows pedestrians to cross the road safely without the risk of being hit by a vehicle.
- **Amber Phase:** The amber phase is the transition period between the red and green phases. The amber light is illuminated to warn drivers that the light is about to turn red and bollard will rise up and they should slow down and prepare to stop.
- **Green Phase:** During the green phase, the green light is illuminated, the bollard is lowered back into ground indicating that it is safe for traffic to proceed through the intersection.

Traffic signals also include additional features such as detecting rain and emergency vehicle preemption systems, which allow emergency vehicles to override the traffic signal and proceed through the intersection safely and quickly. For emergency vehicles, we can use passive UHF RFID tags that have a long-range and can be read from a distance.

Each emergency vehicle can be assigned and install with a unique ID tag. The Vehicle registration number can be used to assign IDs to the tags. An RFID reader is placed in each lane at certain distance from the stop line of zebra crossing to detect the emergency vehicle. upon reading and verifying the tag ID the lane is cleared by lowing the bollard and allowing to pass the emergency vehicle. A manual override key can be used to lower the bollard if the rfid tag is not detected. This feature is provided as a redundancy.

To prevent the passengers of two-wheeler vehicles from getting wet due to rain, a rain sensor is utilized to detect rainfall and automatically lower the bollards of all lanes.

Figure 2 provides the sketch representing the placement of the array bollard at the signal crossing.

In the existing work[2], at intersections, emergency vehicles should have their own traffic signals, which will incur an extra cost for the transport department in terms of crores. The issue is solved in the proposed work by using RFID tags and readers with the traffic signal controller. The RFID tags will be issued to emergency vehicles, and an RFID reader will be placed at the intersection. The RFID reader will read the tag of the emergency vehicle and lower the bollards in the lane for easy movement of emergency vehicles.

In the existing work[5] [6], pedestrian injuries are due to pedestrian behavior, distraction by technology, and social media. Road traffic injuries of pedestrians will be reduced in the proposed work by using an array of bollards at the stop line of the zebra crossing. The bollards are used to protect pedestrians at the intersections and regulate vehicle movement.

The methodology used in the work is unique in the area. It's an advanced traffic signal model that can be utilized in the development of smart cities. The advantage of this model is to provide better safety to pedestrians while crossing the street and reduce the fatal accidents near the signal crossing. The estimated cost of the conventional traffic lighting system is between Rs 25 to 30 lakhs. It will cost about Rs 2.5 to 2.7 lakhs/piece to install a bollard. The sensors would run about Rs 3 to 5 lakh.

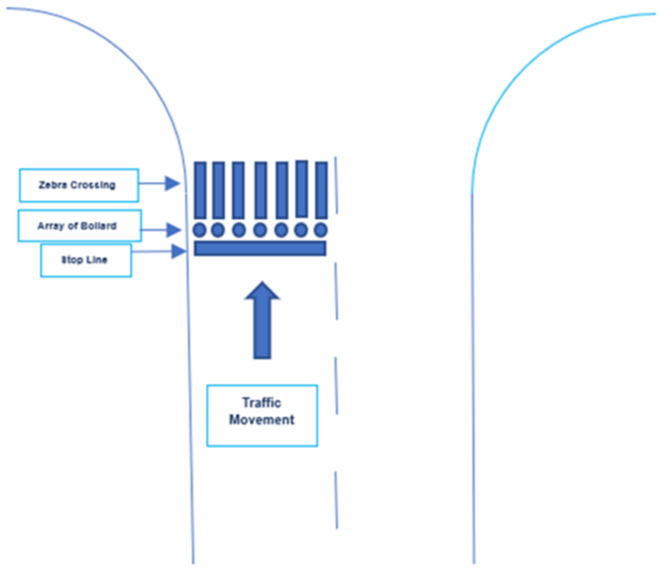

Fig 2. Layout of array of bollard

4 Conclusion

This system is designed to ensure smooth and hassle free traffic flow while allowing pedestrians to cross safely. Adequate signs and posts must be put up near the crossing alerting people about the new system in place to avoid chaos and fatalities.

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