Smart Traffic Signal with Motorbike Safety

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***Abstract*—Reasons like inadequate infrastructure, traditional traffic signals, narrow roads and family to vehicle ratio are the causes of traffic congestion. Due to traffic congestion emergency vehicles find it difficult to reach their destination on time. Another concern of today is that motorbike riders neglect the usage of helmets. To improve traffic management with current infrastructure, we have developed a system called Smart Traffic Signal with Motorbike Safety. Our system uses ultrasonic sensors to measure real-time traffic and controller dynamically allocates time to manage traffic as well as prioritize passing of emergency vehicles by using Radio Frequency Identification technology. Through temperature sensor and buckle status our system cross-checks whether motorbike riders have worn their helmets or not. We observed that our system's performance is better than traditional signal, by comparing our system's result with simulated traditional signal.**

Keywords—Traffic congestion, Internet of Things (IoT), Ultrasonic sensor, Radio Frequency Identification (RFID), Arduino, Controller.

I. INTRODUCTION

Traffic congestion is a condition where the number of vehicles on road networks increases more than its capacity resulting in an increase in energy loss, slow moving traffic and longer waiting time. Current scenario of traffic management in India is poor as time allocation in conventional traffic signals is static due to which vehicular traffic is slowed down at peak working hours of day. In traffic congestion drivers tend to jump red light signals in order to save time. Safety of other road users is compromised at such times. This act by one driver incites another driver to attempt the same. Main cause of traffic jams in highly populated cities are such traffic signal offenders [1].

Time is a critical factor in emergency operation. In several countries there is no separate and reserved lane on the road for emergency vehicles. At present in India, lane on the extreme right on any road is considered as disaster management lane and according to Motor Vehicle Act 2019 a driver will face a penalty of ₹10,000 if they do not give way to an ambulance on the road [2]. So as per Motor Vehicle Act 2019, drivers are required to make way for an emergency vehicle. However, this is difficult to achieve because of high traffic congestion.

As per 2018 survey of International Journal of Health Sciences and Research [3], out of 52,500 two-wheeler riders killed in road accidents 10,135 riders were reported to be not wearing helmets. According to their research, the average age of helmet law offenders lied between 25 to 45. In a road accident the resulting damage can vary from minor head injury to instantaneous death depending on the severity of the crash and whether the driver has worn a helmet.

"Smart Traffic Signal and Motorbike Safety" is a system based on the advanced technology of Internet of Things (IoT) to dynamically manage vehicular traffic, prioritize passing of emergency vehicles and enforce usage of helmets.

This paper consists of three sections that is Literature Review, Proposed System and Result Analysis.

II. LITERATURE REVIEW

As per researchers of [4] traffic congestion has an adverse effect on the environment and finance of a country. It decreases the quality of life. According to them, Internet of Things can improve the traffic management system. They have discussed Video Data Analysis and Sensor Network which can be used to manage traffic. In Video data analysis traffic is captured using a camera and the video is then transmitted to central monitoring station. The video is then analyzed to compute traffic statistics like frequency of vehicles and whether the traffic is moving slow or fast. Basic element of the sensor network is a sensor like Infrared sensor and Radio Frequency Identification sensor. A sensor can record changes in the environment and then transmit the data across the gateways. The researchers have concluded that successful implementation of any IoT technology differs from region to region. As per us, implementation of video data analysis will be expensive because we will require high quality video cameras and time consuming because first captured data will be sent to central server, analyzed and then according to complex algorithm traffic will be managed. We learnt about RFID sensor from their paper and used it in our system to detect emergency vehicles.
Mirza Sarwar Kamal and her team of [5] have proposed a system design by using Radio Frequency Identification

sensor to detect emergency vehicles and Programmable Logic Controller to smartly manage traffic. Every new cycle starts from the first lane and ends on the last lane. Every lane is allocated green signal for pre-defined time. There can be two scenarios as per them. Emergency vehicles can appear on lane X when the signal is green or when the signal is red. If the signal is green when the emergency vehicle is detected, the controller will continue to keep the signal green till the emergency vehicles pass the intersection. If the signal is red when the emergency vehicle is detected, then the control will switch the signal to green and activate other signals to red till the emergency vehicle passes the intersection. Once the emergency vehicle passes the intersection, then the controller will retain the normal sequence state of the traffic signal. 4:1 high priority encoder is used to handle multiple emergency vehicles. Priority is assigned according to the road number. As per statistical data, roads that are frequented by emergency vehicles get more priority. However, this proposal fails to manage real-time traffic because of static traffic signals. Also, abrupt change of signal in case of emergency vehicles is poor management. We liked their idea of using a RFID sensor to detect emergency vehicles and used the same device in our developed system.

Researchers of [6] have developed a system called Golden Aid for betterment of service given by emergency vehicles. By using this system an emergency van can avoid time delay in traffic jams and reach its destination in time. The system consists of 4 modules, that are Ambulance registration and authentication module, Location tracking module, Real time monitoring module and Traffic signal triggering module. An emergency vehicle needs to be registered at the traffic management department. Registered emergency vehicles will obtain unique identity and password. The drivers of emergency vehicles are supposed to use these credentials to login on an android application. The android application will be used to send GPS coordinates to the central server. In case of an emergency, the driver will use the android application to receive the shortest route to the nearest hospital. When the ambulance approaches a signal, the central server will switch the signal in order to allow the ambulance to pass the signal. This management isn't secure because unauthorized ambulances can misuse the system. Their traffic signal management is not capable of handling real-time traffic and regular traffic will be disturbed in case of high frequency of emergency vehicles.

In order to protect two-wheeler riders, researchers of [7] have proposed a system that firstly identifies a moving object in a real-time traffic image captured by using video camera. Then a feature vector is created to classify whether the moving object is a motorcycle or not. Finally, the region of interest is determined in order to reduce computational cost and to improve helmet search. KNN, Random Forest, Naive Bayes, MLP, RBFN and SVM classifiers are used with WT, HOG and LBP descriptors. Multiple classification and descriptor combinations are performed to obtain the best result. Implementation of the Image classification method may not be efficient in highly dense traffic. Though their proposed helmet detection algorithm achieved an accuracy rate of 91.37%, it is not a solution to enforce usage of helmet. Researchers of all the above proposed and developed systems have realized that current traffic congestion is a major issue that needs to be solved by using advanced technology. Each paper has some drawbacks and some good ideas. To develop a solution for traffic congestion and helmet law offenders we developed a system based on sensor network.

After reviewing above research papers, we identified few drawbacks such as absence of dynamic traffic management, low cost investment and complex mechanism. We have managed to overcomes these issues by developing our proposed system.

III. PROPOSED SYSTEM

Smart Traffic Signal with Motorbike Safety is a system developed to achieve three distinct objectives:

- Traffic management
- Prioritize emergency vehicles
- Enforce helmet usage.

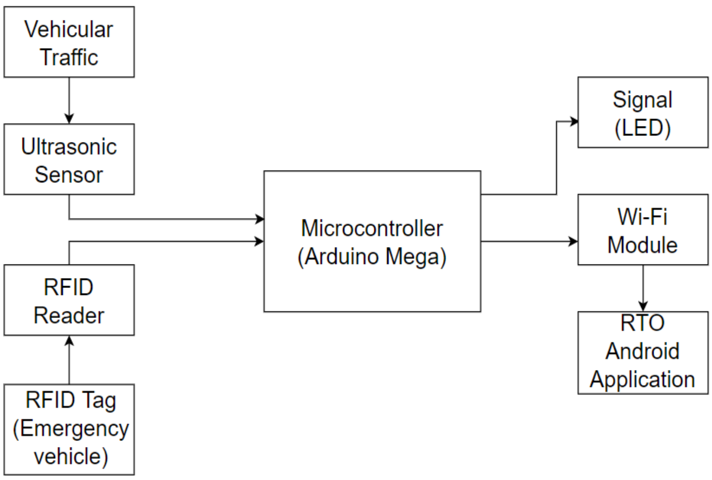

Fig. 1. Smart Traffic Signal Block Diagram

The Smart Traffic Signal system in the above Fig. 1. is built using:

- To measure traffic density Ultrasonic sensor (HC-SR04) is used.
- Emergency vehicles are assigned RFID tags.
- To detect emergency vehicle RFID reader is used.
- To compute calculation, manage traffic and emergency vehicle Microcontroller (Arduino Mega) is used.
- To display traffic light signals, red and green LEDs are used.
- To provide wireless network Wi-Fi connectivity is used.
- To develop system code Arduino IDE is used.

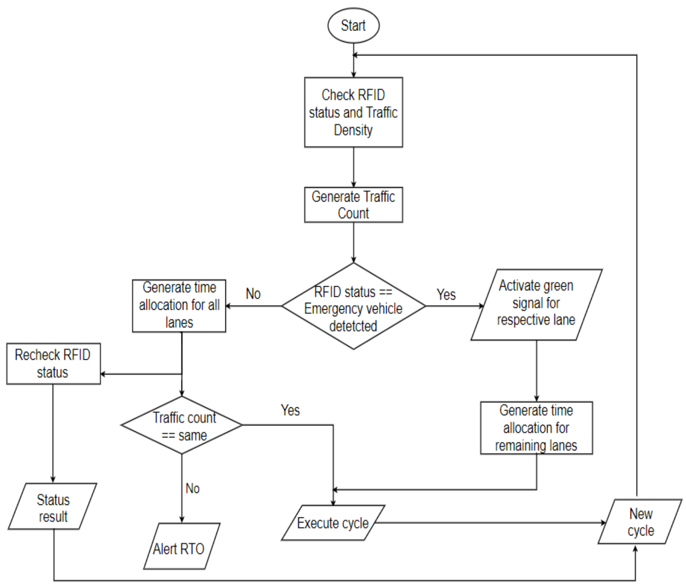

Fig. 2. Smart Traffic Signal Flow Chart

In the above Fig. 2. controller collects information about the presence of emergency vehicle and traffic density of each lane. For experimental purpose RFID reader is placed 45 centimeters away from the traffic signal. In the absence of an emergency vehicle controller generates traffic count and determines the time slot for all lanes. Traffic signals are activated based on the current density of the lane. However, if an emergency vehicle is detected at the start of a new cycle, then the RFID reader will alert the controller about the emergency vehicle and the controller will activate respective green signal for 18 seconds for emergency vehicle to pass the signal and then compute time allocation for remaining lanes. If RFID reader detects an emergency vehicle in the middle of a cycle, then it will alert the controller and the controller will use this input in the next cycle.
Ultrasonic sensor is placed on each outgoing lane so that it covers half the length of the lane. Certain distance, for experimental purpose about 9.5 centimeter, is maintained between them. If it detects an object on the lane, then the traffic count is increased for the respective lane. At the start of a new cycle a network of ultrasonic sensors measures traffic density and give the input to the controller.
Time allocation is computed based on traffic density and predefined formula. If the traffic count is 0 then for experimental purpose the time allocation is fixed for 3 seconds. If traffic count is more than 0 then formula is,

$$time\ allocation = traffic\ count * 5 + 3 \quad (1)$$

In case of heavy traffic, that is if the traffic count is same for all lanes, then every signal is switched green one after the other for 18 seconds and nearby RTO agent is alerted through android application.

The Helmet Safety system in the following Fig. 3. is built using:

- To measure body temperature of the rider Temperature sensor (DHT11) is used.
- To show the rider's initiation to start the motorcycle Push Button is used.
- To check rider’s buckle status Push Button is used.
- To check whether to allow rider to start the motorcycle or not, the Controller (Arduino Uno) is used.

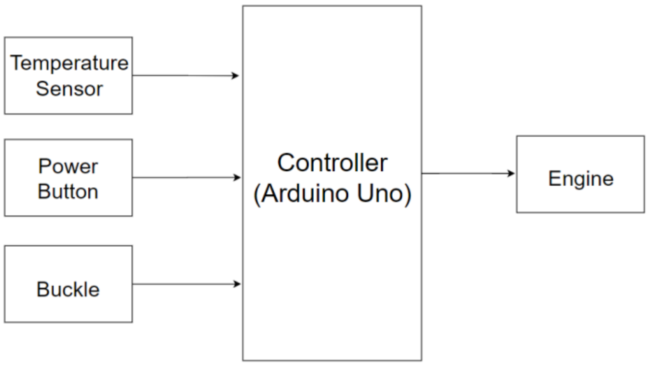

Fig. 3. Helmet Safety Block Diagram

In the following Fig. 4. when a user tries to start a motorcycle the Helmet Safety system crosschecks two conditions before allowing the user to start the motorcycle. The controller reads value from the temperature sensor and buckle. If the temperature sensor value lies in a predefined body range, then the first condition is evaluated to be valid. Then the controller checks whether the worn helmet is buckled or not. If the buckle is fastened, then the second condition is evaluated to be valid. When both the conditions are evaluated to be valid the controller allows the motorcycle’s engine to be ignited. If any one condition is not valid, then the engine will not be allowed to start.
Once the engine is ignited, earlier conditions will be cross checked, for experimental purpose after every 5 seconds. As soon as any one condition happens to be invalid, the engine will slow down gradually and finally stop.

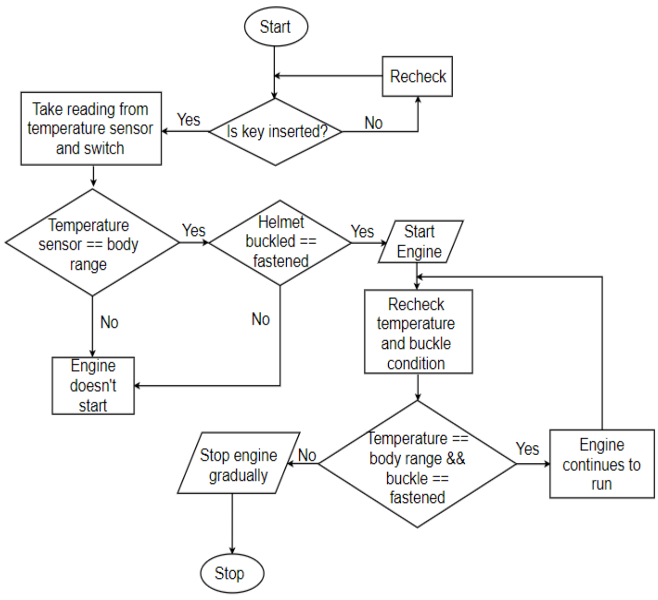

Fig. 4. Helmet Safety Flowchart

IV. RESULT ANALYSIS

For experimental purposes, predefined time of green signal in the traditional system is 18 seconds for each lane. When vehicles are waiting near the intersection, 2 seconds are taken to pass the traffic signal. 'L' stands for lane.

For comparing results of traditional and developed system we have consider following scenarios:

TABLE I. Low Traffic Scenario in Traditional System

Traditional Traffic Signal						
Inputs	L1	L2	L3	L4	Maximum waiting time	Total life cycle
Traffic	0	0	1	1		
Waiting time in each lane	NA	NA	36	54	54	
Total cycle time	18	18	18	18		72

TABLE II. Low Traffic Scenario in Proposed System

Proposed Traffic Signal						
Inputs	L1	L2	L3	L4	Maximum waiting time	Total life cycle
Traffic	0	0	1	1		
Waiting time in each lane	0	3	6	14	14	
Total cycle time	3	3	8	8		22

TABLE III. Medium Traffic Scenario in Proposed System

Traditional Traffic Signal						
Inputs	L1	L2	L3	L4	Maximum waiting time	Total life cycle
Traffic	1	2	0	2		
Waiting time in each lane	0	20	NA	56	56	
Total cycle time	18	18	18	18		72

TABLE IV. Medium Traffic Scenario in Proposed System

Proposed Traffic Signal						
Inputs	L1	L2	L3	L4	Maximum waiting time	Total life cycle
Traffic	1	2	0	2		
Waiting time in each lane	0	10	NA	26	26	
Total cycle time	8	13	3	13	37	

TABLE V. High Traffic Scenario in Proposed System

Traditional Traffic Signal						
Inputs	L1	L2	L3	L4	Maximum waiting time	Total life cycle
Traffic	3	3	1	2		
Waiting time in each lane	4	22	36	56	56	
Total cycle time	18	18	18	18		72

TABLE VII. High Traffic Scenario in Proposed System

Proposed Traffic Signal						
Inputs	L1	L2	L3	L4	Maximum waiting time	Total life cycle
Traffic	3	3	1	2		
Waiting time in each lane	4	22	36	46	46	
Total cycle time	18	18	8	13		57

Fig. 5. represents the result analysis of Maximum Waiting Time in Traditional system and Proposed system. Density value lies on x-axis and time value lies on y-axis. Simulation is performed using PTV Vissim software and result analysis is performed using VisMe tool.

Fig. 5. Maximum waiting time graph

In our research we have considered four lanes where each lane is provided with three ultrasonic sensors. To represent traffic density we used numbers 0, 1, 2 and 3. Here 0 means least density and 3 means maximum density. Twenty-six scenarios have been considered to conduct result analysis. In the above figure analysis begins with low traffic density, followed by medium traffic density and ends with high traffic density. In every scenario, waiting time in the traditional system is more than that in proposed system.

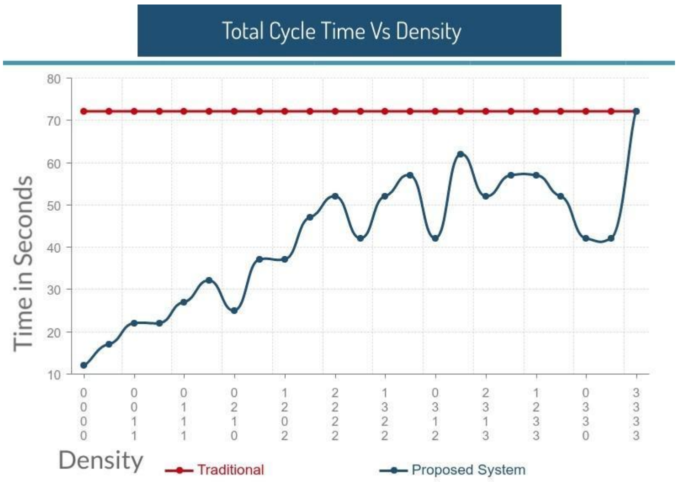

Fig. 6. Total life cycle versus density graph

Figure 6 represents the result analysis of Total Cycle Time Versus Density in traditional system and proposed system. Density value lies on x-axis and time value lies on y-axis. Twenty-three scenarios have been considered in the above conducted result analysis. In the above figure, the traditional system is flat because the time allocation in the traditional system is fixed therefore its total cycle is constant. Whereas the total life cycle in our developed system varies depending on real-time requirement of time allocation.

CONCLUSION

This system has aimed to identify effective traffic management and emergency vehicle management strategies for existing inadequate infrastructure and increased family to vehicle ratio. Based on a quantitative and qualitative analysis of traditional traffic signal system versus smart traffic signal system, it can be concluded that traffic congestion can be improved by using dynamic time allocation formula and emergency vehicles can pass traffic signal in shorter time periods by using RFID technology. Great number of lives can be saved by allowing emergency vehicles to pass in the shortest possible time and through the compulsory use of helmets. This system can further be improved with the consideration of the presence of multiple emergency vehicles on the same lane and different distances or present on different lanes altogether.

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