IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⁜ Vol. 10, Issue 3, March 2022

DOI: 10.17148/IJIREEICE.2022.10310

Sensor based Intelligent and adaptive traffic management systems

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Abstract: As we are heading towards modernisation and development which is a key feature of many developing and developed countries, the population is also improving its standard and quality of lifestyle accordingly. Owning private vehicles which was once a luxury in India has now become common in majority of the population. This is due to the development in economy due to globalisation, national development and various other factors. With the increase of number of vehicles due to globalisation and economic development major concerns regarding traffic congestion, pollution, traffic inconvenience for emergency vehicles are uprising. This research basically focusses on efficient management of traffic and building a smart traffic system using sensors and networking for eliminating the drawbacks of conventional traffic systems.

Index Terms: Arduino, Traffic, Vehicle density, Congestion

I. INTRODUCTION

The conventional traffic system which is existing today almost all around the world was invented by Garrett Morgan in 1923.In this conventional traffic system the time duration of the signal remains fixed irrespective of the number of vehicles on the road. According to a report by THE ECONOMC TIMES dated 10th February 2022, Mumbai and Bengaluru has become the 5th and 10th most congested cities in the world as per recent 2021 data. Other Indian cities like Delhi and Pune also tops the list of most congested cities in the world. Delhi being 11th most congested city and Pune being the 21st. These cities were mentioned in the TomTom traffic index list of global top 25. [9] As according to a report by THE HINDUSTAN TIMES dated 12th March 2021, Mumbai, Delhi and Bengaluru are among the most highly congested cities of the world and they have been topping the list over the past four years. Mumbai was even ranked number 1 in world's most crowded cities in 2018. As data show India's networks for roads have risen by 30% over the past decade but the number of vehicles registered is grown by about three times. This is one of the major reason of the very high congestion in the cities of India. [8]

	on road population				near road population			
	morning rush hours		afternoon rush hours		morning rush hours		afternoon rush hours	
volume	EDA	Mortality	EDA	Mortality	EDA	Mortality	EDA	Mortality
1000	6–67	0–130	5–50	0–98	10–104	0–203	7–73	0–142
2000	12–123	0–241	9–95	0–184	19–203	0–397	13–143	0–279
3000	16–174	0–339	13–135	0–262	28–299	0–583	20–211	0–412
4000	21–220	0–429	16–172	0–335	37–392	0–764	26–278	0–542
5000	25–264	0–515	20–208	0–405	46–483	0–942	32–344	0–672
6000	29–308	0–602	23–244	0–477	54–575	0–1121	39–411	0–803
7000	34–357	0–696	27–284	0–554	63–670	0–1307	45–482	0–940
8000	41–433	0–844	33–347	0–678	77–820	0–1599	56–592	0–1155
9000	47–501	0–977	38–404	0–788	88–932	0–1818	64–675	0–1318
10,000	57–609	0–1189	47–494	0–965	105–1110	0–2165	76–807	0–1575
			Table 1					

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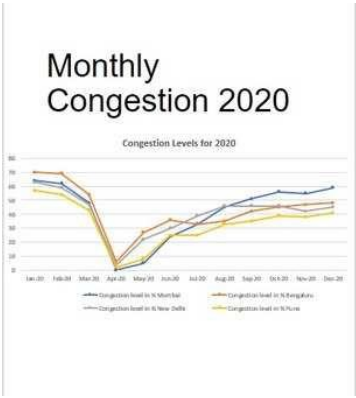

Month	Congestion level in %			
	Mumbai	Bengaluru	New Delhi	Pune
Jan-20	64	70	63	57
Feb-20	62	69	59	54
Mar-20	48	54	47	43
Apr-20	0	6	4	2
May-20	5	27	22	8
Jun-20	24	36	30	25
Jul-20	33	33	39	25
Aug-20	45	35	46	33
Sep-20	51	42	46	35
Oct-20	56	45	46	39
Nov-20	55	47	42	38
Dec-20	59	48	45	41

FIG-A traffic data 2020 India (Source: The Times of India)

The above data shows the congestion level for the year of 2020 in the four cities of India viz. Mumbai, Bengaluru, New Delhi & Pune. It can be figured out well that the congestion levels are quite high during the initial months of January, February in 2020 just before the occurrence of the pandemic. No doubt the pandemic due to lockdown measures has reduced traffic on roads but usually we consider the situation of normal transportation irrespective of the lockdown as they would be the worst case scenarios and the most reliable ones for our analysis purposes.

Excessive traffic congestion not only causes traffic delays but is also responsible for pollution and health risks. Vehicle emissions due to traffic jams add to the overall pollution caused by vehicles on road. According to a research conducted by Kai Zhang and Stuart Batterman increased traffic congestion is responsible for more and more vehicle emissions as a result degrading the air quality. In this research the case of US is considered and proper simulations have been carried out to obtain data about health risks due to vehicle pollution. The data is given in the Table 1. [10]
Therefore, from the above facts and data it is well observed that traffic congestion has become a major problem for growing economies. In order to tackle this menace this research provides a sensor based traffic system along with a user website to efficiently manage traffic and eliminate these problems. The Website provides prior information to user for decision making while travelling. In this research mainly four sections sum up the whole research idea which are sections V, VI, VII, VIII. Section V discusses the components used in the research prototype briefly, section VI discusses the research methodology and main idea, section VII discusses the simulation results and relevant conclusions and section VIII gives an overall conclusion.

II. MOTIVATION

Traffic management is the arrangement, observation and control or impacting of activity. It is expected to boost the adequacy of the utilization of existing foundation and to guarantee dependable and safe operation of transport, it also addresses ecological objectives and guarantee reasonable assignment of framework space among contending clients. Traffic monitoring system developed so far are primarily focused on structured traffic that is not the case in a country like India.

Development of overhead structures is not a viable option as it increases the cost substantially and the same goes for under the road construction. It is a necessity to analyse traffic pattern, near real time reporting and simultaneous conduction of smooth traffic flow. India is the second largest population of world, according to that vehicles are increased in day to day life. Here, the questions arise about how to avoid the crowd congestion in the road. The best possible answer to this problem is efficient traffic management.

Traffic management has since quite a while ago existed in some frame, from the beginning of railroad flagging or movement lights on city roads, yet the improvement and execution of modern Intelligent Transport Systems has developed apace lately because of effective ongoing research and technological advances. This has been pushed by acknowledgment of the need to oversee organized transport all the more adequately keeping in mind the end goal to boost the utilization of existing framework, given a solid support of the end client and increment security, while lessening negative natural impacts. To manage the traffic in the road the job is done manually that means one or more traffic police officers are appointed there to serve the people from the congestion in road. But it is difficult to monitor and manage. That's why, the new concept with Real-Time smart traffic Management is implemented to control the traffic.

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III. ABBREVIATIONS USED

ICSP-In Circuit Serial Programming, UART-Universal Asynchronous Receiver Transmitter, IR- Infra-red, LCD-Liquid Crystal Display, LED- Light Emitting Diode, SRAM-Static Random Access Memory, EEPROM- Electrically Erasable Programmable Read Only Memory, CFL-Compact Fluorescent Lamp, IDE-Integrated Development Environment.

IV. LITERATURE REVIEW

Sabeen Javaid et al. described about the drawbacks of present fixed time based traffic systems and they mainly focussed on collection of traffic data through ultrasonic sensors and surveillance cameras. [11] Their main area of concern is the centralized system of traffic networks as due to network errors such servers may crash leading to traffic disorder and nuisance. They created a prototype for demonstrating their research idea and used Blob detection algorithm for noise detection at the video camera nodes. [11]

Charushila Rashkar et al. in their research described about the needs of an intelligent traffic management systems for making up with the increasing vehicle congestion on Indian roads. [12] A system was proposed consisting of a Raspberry Pi controller, a Logitech C920 camera for obtaining traffic data through image processing methods and Blob algorithms were used to process traffic image data. [12]

Rohit Prasad, Himanshu Yadav et al. focussed on the main problem of restricted passage of emergency vehicles due to the current traffic systems in their research. [13] Due to this many cases of deaths are reported which are extremely sorrowful. They have developed a prototype of an intelligent traffic management system in their research consisting of ARDUINO Microcontroller, RFID sensors, ESP2866 Wi-Fi modules. With the help of wireless sensor networks the traffic data acquired through the sensors is sent to the microcontroller for processing and rerouting strategies. [13]

Aniket Singhal, Suman Pant et al. have addressed the problems of false number plate, car robbery, violation of number plate norms and regulations. [14] This problem is solved using NPR (Number Plate Recognition) technique in their research. [14] The NPR technique as described in their research uses Optical Character Reader and Edge detection Technology to detect characters on license number plate. [14]

Jinhua Guo, Ye Kong et al. introduced a new method of area-wide traffic signal optimization which is done under user equilibrium traffic in their research. [5] They developed a genetic algorithm for the derivation of the optimization model. They used PARAMICS simulation software for simulating their optimization model for reduced traffic travelling time. [5]

Gustav Nilsson et al. focussed on a class of dynamic feedback traffic signal control policies in their research work. These polices are based on a generalized proportional allocation rule as according to their research idea. [3] They mainly wanted to improve the stability of dynamic feedback traffic signals for application to the real time traffic systems present all over the world. [3]

Junchen Jin and Xiaoliang Ma proposed a system of signal control which is mainly group based in their research work. It is capable of making intelligent decisions about the traffic pattern at given intersections. [7] This proposed system is designed in such a way so as to be compatible with the existing traffic systems. [7].

Chandrasekhar M. et al. have described and tried to implement about a system that utilizes image processing algorithms in real traffic systems that will help control the traffic light efficiently in their research. [1].

Huajun Chai et al. tried to capture interaction between travellers route choice and traffic signal control in their research. [4] They tested and simulated their smart traffic model in OmNet++ and SUMO (Simulation of Urban Mobility) platforms. Their simulation results were successful in providing reduced overall travel costs. [4] Their Model also helped reduce traffic delay in the simulation results along with reduced travel costs.

Ekinhan Eriskin et al. proposed a new system called the elimination pairing system in their research. [2] This special system as described by them manipulates/controls traffic signal timings at the oversaturated intersections in the route. Results obtained from their research was compared with traditional software simulation results which include Transyt 14 and Webster. [2]

V. COMPONENTS USED

This research prototype comprises of an Arduino microcontroller board (MEGA 2560), a 16X2 LCD display module, 8 IR sensors (HW-201),12 LED_s, Breadboard, Jumper wires as hardware components.

A. ARDUINO BOARD

Arduino board is a microcontroller board which is based on the two main functioning microcontrollers; one is ATMEGA 328P and another microcontroller ATMEL 16U in case of ARDUINO MEGA 2560. There are various types of Arduino boards like Arduino Uno, Arduino Mega 2560, Arduino Due, Arduino Nano, Arduino micro, Arduino Leonardo and so on.

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Arduino MEGA consists of 54 digital input/output pins. Among these 15 pins are used as PWM pins,16 are used as Analog pins and 4 are used as UARTs. Arduino Mega 2560 comprises of a 16 MHz crystal oscillator, a USB connection port, a power jack socket, an ICSP header and a reset button. The Arduino Mega 2560 board can work or is compatible with most of the shields. It can also work properly with the former boards Duemilanove or Diecimila.

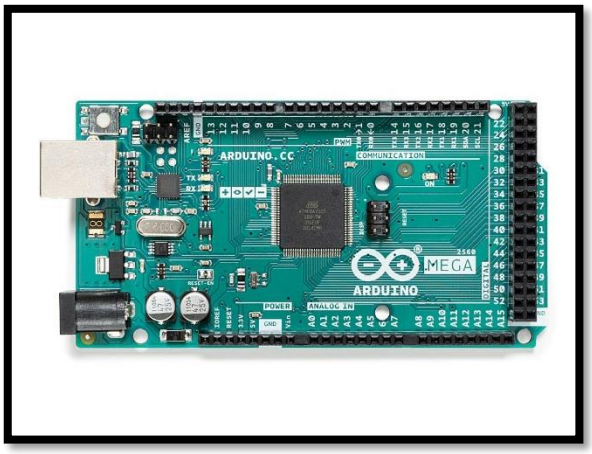

FIG-1: Image of an Arduino Board

Usually the operating voltage of Arduino Mega is 5V. Input voltage can be provided between 7-12V. Maximum permissible range of input voltage for Arduino is 6-20V in case of Arduino Mega 2560. A flash memory of 256KB is allotted to the Arduino Mega 2560 in which 8KB is used by the bootloader. The bootloader is an inbuilt device in Arduino board whose work is to load the program written by the programmer into the Arduino microcontroller without the use of any kind of other external device. Arduino Mega has an SRAM of 8KB. It has an EEPROM of 4KB.The length of the board is 101.52mm and width is 53.3mm. The weight of the Arduino Mega board is 37g.
The Arduino Mega can be programmed with the Arduino IDE.

VI. METHODOLOGY

This research is based on Intelligent Transportation System which take feedback from real time sensor placed on the road and analyse the present traffic trend to predict approximate future traffic trend to avoid any traffic jams and chaotic situations. An image of the research prototype is shown in the FIG-9 given below.

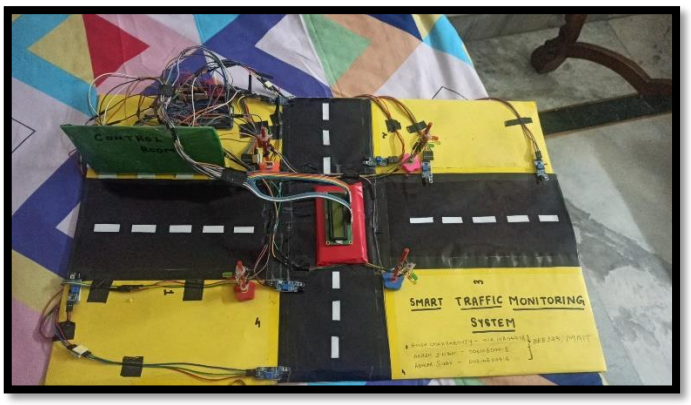

FIG-9: Image of Prototype

A working block diagram of the model is being shown in FIG-10.

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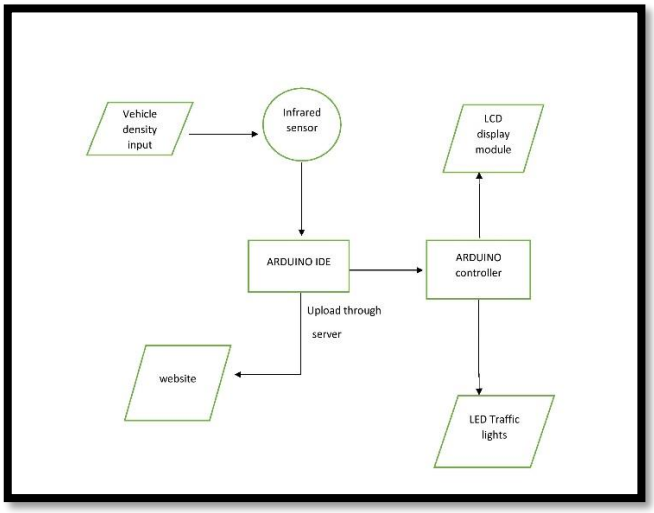

FIG-10: Block Diagram of Research

In this model a crossroad is depicted. In this crossroad 4 roads are joining each other. Now each road is provided with two infra-red sensors. One near the signal and other one at a certain distance to count number of vehicle on the road. Each road is provided with traffic signals. Road is equipped with piezoelectric sensor for the depiction of the idea which is to be conveyed through the research. The LCD Display module is placed at the centre of the model for the display of the time intervals provided for each switching of the signal light.
The working of the model can be explained in two parts; one, explaining the acquiring of all traffic data through real time sensors and second, explaining a mathematical model which help us to analyse future trends and this information can be shown to the user through a publicly accessible website.
To take the reading of vehicles in each road we have used infra-red sensors. The sensor is capable of measuring infra-red radiation which is the heat emitted by an object to detect motion. It is used to detect the vehicles. The data is captured from infra-red reactive objects which then converts the obtained signals into electrical signals. This gives us the number of vehicles which have entered the road. Now it is not necessary that every vehicle in the road will cross during the first opening of the road so to know accurate value of vehicles in the road after each opening of the road due to green signals, we use another infra-red sensor which gives us the number of vehicles leaving the road. Thus, now we the know exact number of vehicles waiting in queue.

A. NUMBER OF VEHICLES IN ROAD

In the research as soon as vehicles start entering the roads the infrared sensors start taking the readings of the number of cars. Now IR_1 counts no of cars entering a road during green signal and let this quantity be mathematically represented as x. IR_2 counts number of cars leaving a road during green signal and let this quantity be mathematically expressed as y.Net cars present on a road at any instant is the difference of x and y. This result is defined as the Vehicle Density. As the road length is considered 1 unit so number of vehicles per unit length of road gives the vehicle density. Now the vehicle density is used as input function for the output switching time of the traffic lights. If we keep on taking the number of vehicles leaving and entering the road the value of x and y will keep on increasing which will unnecessarily create confusion. So, to avoid dealing with such large numbers we keep on resetting the values of x and y after each opening of the respective road.
So now after taking the reading of each road we exactly know the exact number of vehicles in each road at any instant of time.

Vehicle Density= x - y

B. USING THE READING FOR TREND PREDICTION AND ROAD OPENING TIME

In this research we have used ARDUINO IDE with the help of ARDUINO MEGA 2560.We have created a function to take and update the value of number of vehicles through each infra-red sensor these readings are then called to another function which determine the time that should be allotted to each road. The time given prioritise road density and allocate suitable time to each road by a formula which is chosen for its simplicity and convenience for the development of this research.

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Time given = [20 + (5*Z)]

Z=Congestion factor

Z is the Congestion factor i.e. a measure which helps provide vehicle density information. Now the Output time of the switching of traffic lights is the time given to each signal to a specific road at an instant. This output physical quantity is mathematically defined as Timegiven. The Timegiven is a specific function of the Vehicle Density. It can take various mathematical relations. In this research a linear model is considered for the simplicity of the research and keeping in mind an economically optimised research.

By default, each road is given a time of 20s (for prototype). This is the time allotted to each road when the traffic congestion is very low or negligible. In this research traffic congestion factor is taken low at nearly vehicle density equal to 1 or no vehicles. So for no vehicle or 1 vehicle the traffic congestion is considered low and hence the default time of 20s will be allotted for each road.

As the no of vehicles increases with increase of each vehicle, 5s is added to the time allotted successively. 5s is chosen for step increment on random basis for the demonstration of the research but in real life it may vary accordingly as per requirement.

Now readings from infra-red sensors are continuously taken and updated for each road. The order of road opening is pre-determined according to the survey conducted for the roads during operation for fast and time saving clearing of road. The order taken into consideration is road 1 (the road number are taken according to the research) then road opposite to road 1 which is road 3. After road 3, road 2 will open and then road opposite to road 2 which is road 4. There is a simple logic taken into consideration for the opposite opening of roads successively. If adjacent roads are opened, then there are wide chances of collision. This is because if traffic signal of a road switches Red then there would be some leftover cars which may be passing the road or crossing the signal. Usually due to hurry with immediate opening of the adjacent road a collision may occur or if the collision does not occur then definitely a traffic disturbance or chaotic situation would occur.

In order to prevent this from happening opposite roads are opened in turn.

This is the **accident prevention** feature of the research.

As per the formulas it is clear that time given is directly proportional to number of vehicles in each road. So to avoid unreasonable amount of opening time for any particular road thus creating a chaotic situation or traffic jam in other road, no road will get an opening time of duration more than 40 second (for prototype case). The maximum time for opening of a signal is fixed for no of vehicles equal to 5 which is 40s. Also, we can also conclude that irrespective of number of vehicles in the road each road will be given green signal for at least 20 second.

Below graph presents the linear relationship between vehicle density and timegiven as per the mathematical model implemented. The linear model is the simplest yet approximately somewhat closer to the actual traffic modelling. The linear model is assumed for the ease of data interpretation, analysis and convenience of developing and implementing the research idea. Linear increment in time can be well suited for managing traffic in a much better way than the existing ones.

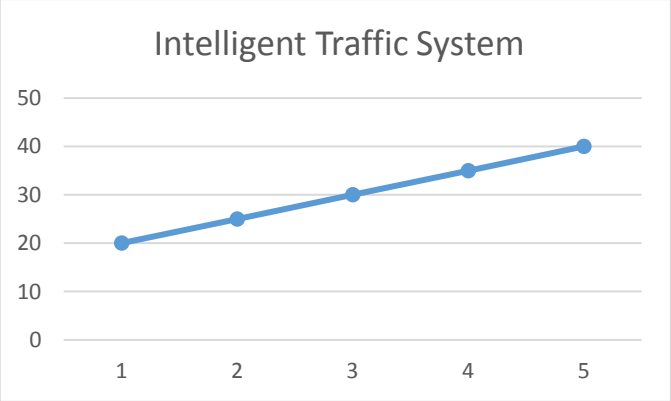

FIG-11: Graphical representation of the mathematical model

On the x axis is the vehicle density and on the y axis is the signal time provided or Timegiven.

Then different constants like average congestion on each road percent congestion of each road are calculated from the value of Z and used to predict future trends and provide information to the general public about the traffic roads. The data is displayed on the website as shown in FIG-13.

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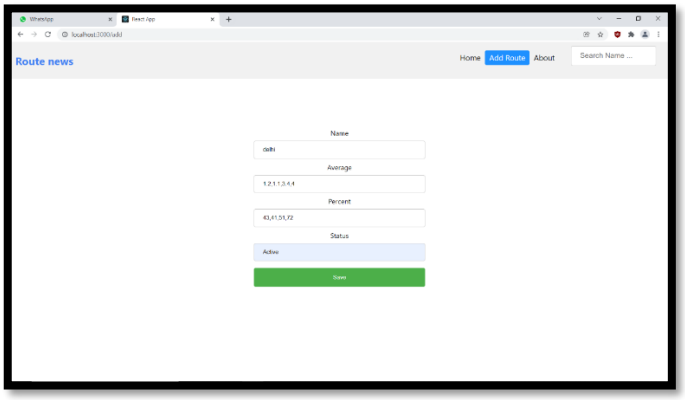

FIG-12: Adding data for roads

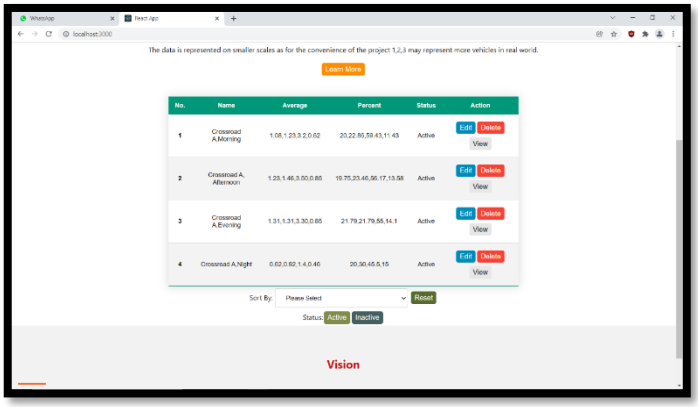

FIG-13: The result display to the user

C. CALCULATION OF AVERAGE CONGESTION

For calculating the average of each road, the sum of value of Z gets keep adding after each green signal and after the given time slot (different time slot is allocated according to different time zone which will be explained later in this paper) it will be divided by total number of opening until that time. Now this will give us an average amount of vehicle passed through each road in each green signal of the road. This value is taken for 7 or more days for the same time zone which gives us the average congestion of the road per time zone which is then added to website as shown in FIG-12. And user is given the data in the format shown in FIG-13.

D. CALCULATION OF PERCENT CONGESTION

For calculating the percent congestion of any road, we simply take the ratio of average congestion of that road to the sum of average congestion of all the four road in the same time zone. This value is taken for 7 or more days for the same time zone which gives us percent congestion of the road per time zone which is then added to website as shown in FIG-12. And user is given the data in the format shown in FIG-13.

E. STATUS OF THE CROSSROAD

Status of the crossroad is one of the important features of our research. This entry tells the status of the road i.e. road is functioning or not-functioning. Sometimes the data takes a little time to get updated and people may need to get there to find out the working condition of the road. But, through our website it can be instantly updated if any event or any construction is to be performed. The crossroad status for a particular road can immediately turn into inactive and people can avoid taking that road which in turn result in better traffic flow in that area through our website. Also, users can plan their multiple trips by sorting crossroad from status and know all the inactive road in the city directly as shown in the FIG-14 given below.

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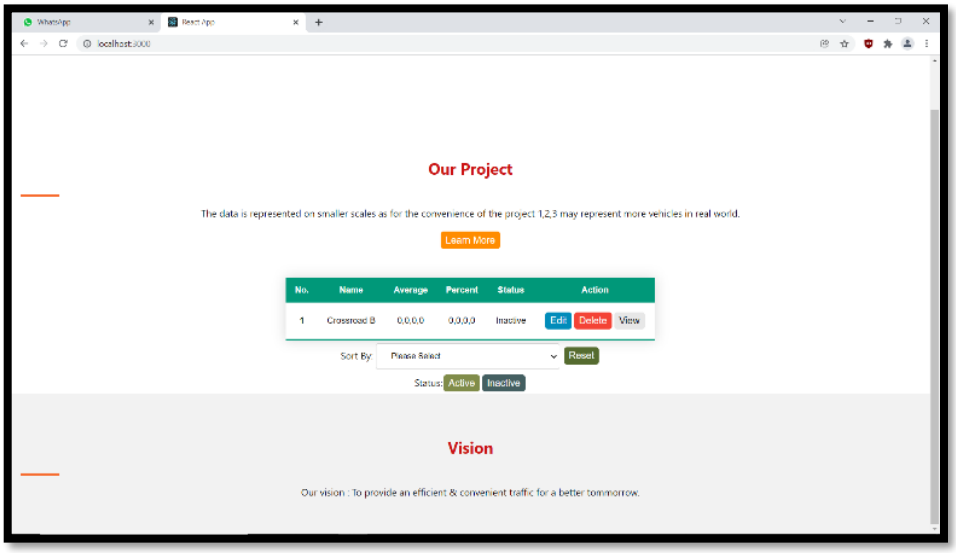

FIG-14: Status of crossroad feature

F. EDIT FEATURE

As we know new value of average congestion of each road and percent congestion of each road will be updated every 24 hours and also the status of each crossroad in a variable which can change any time so it can be difficult to delete and add the crossroad again and again every day. So to avoid these our website has feature like edit which can be used to update data where one can choose the data one wants to change and all data entries will remain the same.

G. VIEW FEATURE

For the security purpose of the website the user is not allowed to delete or edit the information given to him/her. So, we have created view option where user will be provided with the data important to him/her. The text will be in read only mode so he/she can only see and cannot change any data as shown in the FIG-15 given below.

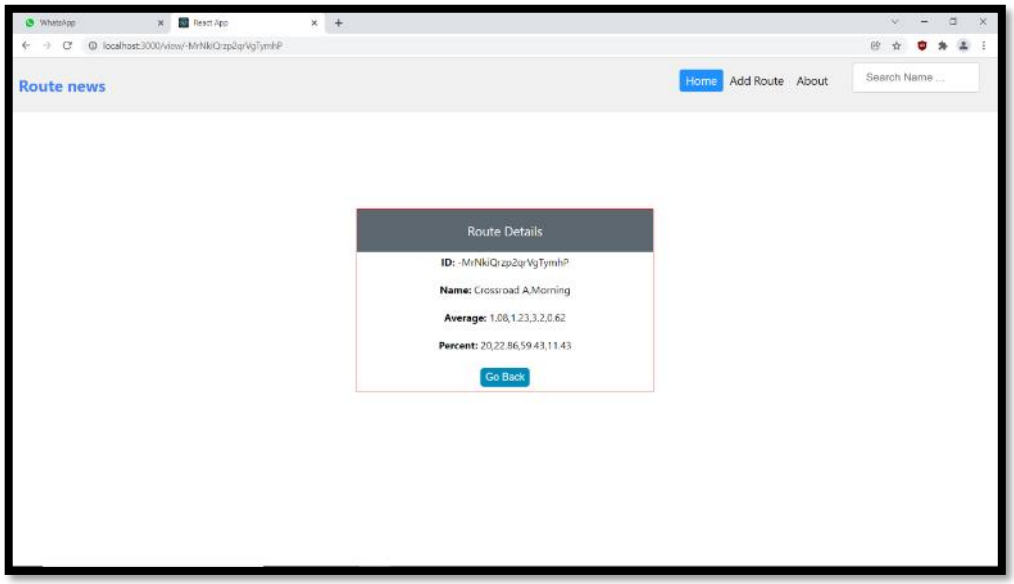

FIG-15: View feature of website

H. DELETE FEATURE

In the time of entering detail of the crossroad there can be error so to rectify all such error delete option is also provided in our website. Also, if a crossroad turns permanently closed due to some technical issue and we cannot find average congestion or percent congestion then in such cases the details of crossroad must be deleted from the list of route news. Also, to avoid deleting any data entry by mistake a confirmation message is generated as shown in the FIG-16 given below.

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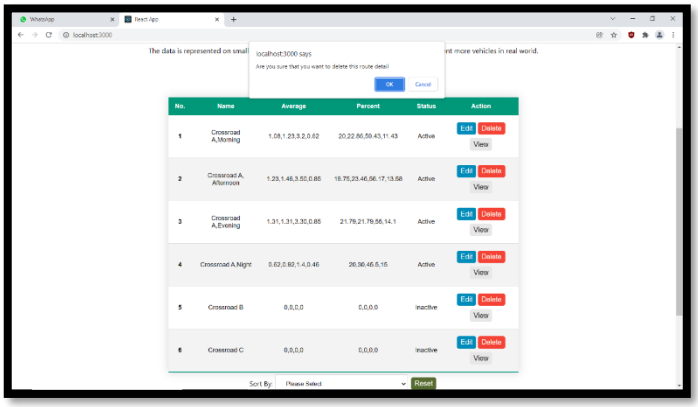

FIG-16: Delete feature of Website

I. SEARCH AND SORTING FEATURE: -

A city in country like India has many crossroads so in times it can be difficult to find details for any particular crossroad from the list of crossroad detail in route news. So, to avoid such difficulties to the user and make our website more customer friendly we have given the feature like search where one can search the crossroad by its name as shown in the FIG-17 given below. Also sorting feature is provided where an individual can sort crossroad in alphabetical order. Also crossroad can be sorted according to their values of averages congestion per road, percent congestion etc.

The search and sorting feature can be a great help for users to quickly search for their desired routes which will consist of all the crossroads occurring in their routes. Sorting feature can help find route information in easy and organized manner.

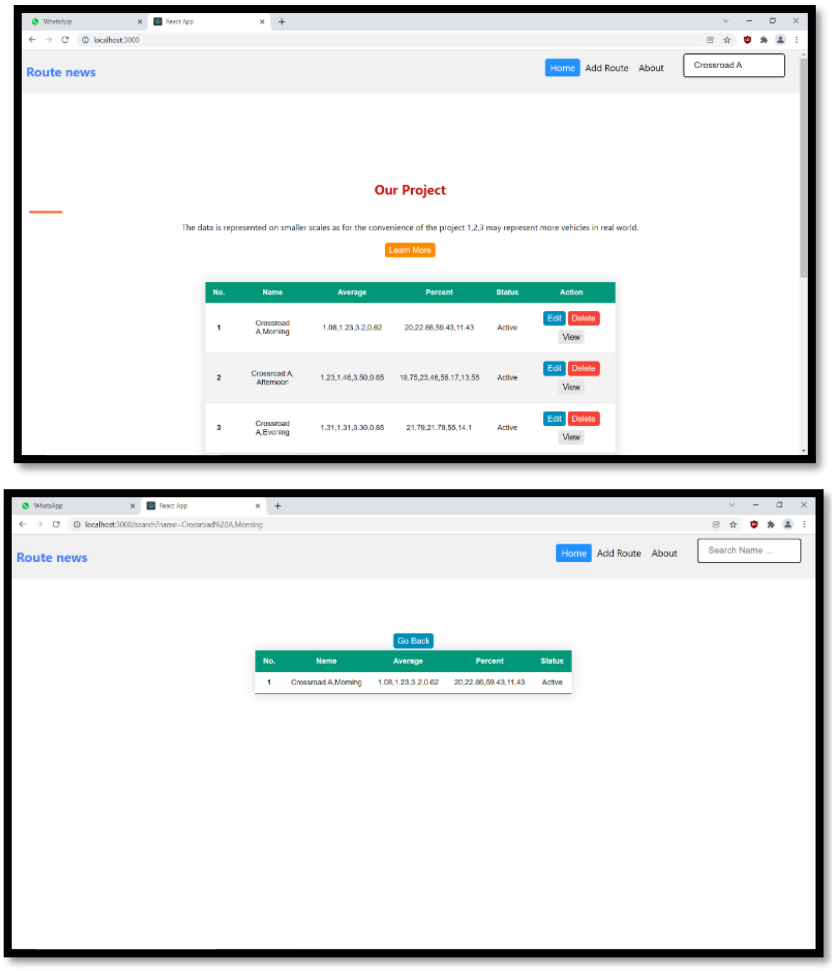

FIG-17: Search ad Sort Feature

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J. ADDITIONAL FEATURES OF THE WEBSITE

- Random error like missing of data can happen at any time. So to avoid such error, a message is automatically generated at the time of entering the detail of crossroad which is filling of all the details is necessary and data cannot be saved if all the required data is not given by an individual.
- To make trip planning more efficient sorting with average congestion and percent congestion can play a major role. It can tell people which route they should choose among all the options to reach their destinations as fast as possible and avoid traffic jams in their journey.
- Easy maintainable website with low maintaining cost and also more features can be added like showing visibility of the road, dust, chances of rain, humidity and lot more by taking important data directly from internet and show it in the website so user can have complete guidance from this one website for their trips.

K. CONCEPT OF TIME ZONE

As per the normal day and traffic scenarios we have divided 24 hours into 4 important time zone which provides traffic data for different intervals of the day. The different time zones have different traffic patterns depending upon the public preferences, office times, night times etc. These time zones are namely morning time (7am – 11am), afternoon time (11am – 3 pm), evening time (4pm – 7 pm) and night time (8pm – 11 pm). The traffic trends at this time greatly affect all traffic situation in any crossroad. Traffic detail of any other time can be taken as traffic details of time zone closest to that time. The information of traffic during different time zones is helpful in determining the traffic usage during different intervals of the day and this information can be used to provide beneficial routes for people to travel quickly saving their precious time.

L. ABOUT US

This is an introductory page in our website to give a basic idea about the website, what it is meant to do, some basic information regarding roads, basic traffic safety rules to spread awareness among people to follow traffic rules. This is shown in FIG-18.

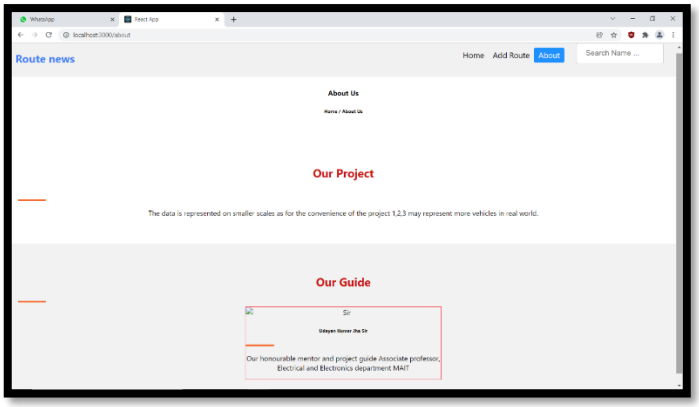

FIG-18: About us page

M. ANTI RED LIGHT VIOLATON SYSTEM

Now we will be discussing about an important feature of our research i.e. **Anti-red light violation system**. The reason for this feature can be well understood from a report given in the following paragraph which highlights the need of this feature.

According to a news report of THE TIMES OF INDIA dated July 26,2021, Nagpur city traffic police had recorded a 73% increase in the number of cases of wrong side driving and jumping red lights, riding without helmets or using mobile phones while driving [6]. The data was taken from 10 zones of the traffic police and on an approximate basis 4.42 lakh motorists were caught and a total of ₹7.35 crore fined from them [6]. This was the data acquired during the first six months of 2021 [6]. The traffic police department also recorded a threefold increase in red light jumping, nine-fold rise in use of fancy number plates and more than two-fold increase in use of cell phones while driving, which rose from 15,563 cases in 2020 to 35,173 cases in 2021 [6]. From this report it can be concluded that cases of red light jumping are often observed in many places in India and many of them go unnoticed. This can create traffic disorder which result in traffic jams and further problems. In order to avoid this traffic light violation, the **Anti red light violation system** is being provided in our research for the idea of an intelligent traffic monitoring system.

A piezoelectric sensor is placed in one of the roads. The sensor is connected to a passive buzzer. Now whenever a vehicle steps on the piezoelectric sensor while crossing the road during red light, the sensor gets activated and generates a voltage signal. The voltage signal generated helps the Arduino board to generate a triggering signal for the passive buzzer. When

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 7.047 ⁜ Vol. 10, Issue 3, March 2022

DOI: 10.17148/IJIREEICE.2022.10310

a vehicle steps on the sensor the voltage generated triggers an Arduino pin into HIGH state and that condition is utilized to trigger the buzzer through the Arduino code. The buzzer after getting triggered generates an alarm. The triggering of an alarm due to red light violation has three advantages. First, alarm will notify the authorities by attracting attention and help them get hold of the violators for fine. Second, alarm sound due to its irritating nature may also prevent an individual from violating the red light signal. Third, public on the road can actively cooperate to get hold of the violator. Infact the **Anti red light violation** system has a wide future scope. It can be attached with additional devices like optical counters for getting the number of exact number of red light violation cases. It can also be attached with cameras for capturing images of the violators for ease in locating their identities for further processes.

VII. RESULTS AND DISCUSSION

road 1		road 2		road 3		road 4			
no of vehicles	opening time	no of vehicles	opening time	no of vehicles	opening time	no of vehicles	opening time		
70	150s	20	125s	5	120s	5	120s	round 1	
40	135s	0	120s	0	120s	0	120s	round 2	
5	120s	0	0s	0	0s	0	0s	round 3	traffic cleared
						total traffic clearance time		18.833min	
Table 2(b)									

road 1		road 2		road 3		road 4			
no of vehicles	opening time	no of vehicles	opening time	no of vehicles	opening time	no of vehicles	opening time		
70	120s	20	120s	5	120s	5	120s	round 1	
55	120s	5	120s	0	120s	0	120s	round 2	
30	120s	0	120s	0	120s	0	120s	round 3	
5	120s	0	0s	0	0s	0	0s	round 4	traffic cleared
						total traffic clearance time		26min	
Table 2(a)									

In Table 2, two data sets of traffic clearance times for given number of vehicles are demonstrated. Table 2(a) shows the traffic model of the present traffic system which has a fixed opening time for green signal of 120s irrespective of the number of vehicles present on the road. In the conventional traffic system, the traffic is cleared in four rounds with a total clearance time of 26 minutes for 100 vehicle entering the crossroad. Due to lack of survey data 100 vehicles (at a given interval of time) are taken for analysis purposes and reduction of vehicles per road are accordingly considered. With the same set of data, results obtained in Table 2(b) represent the traffic model of this research applied to the practical crossroad. With increase of number of vehicles, the value of Z increases accordingly as shown in Table 3.

Z = congestion factor

Opening time = 120 +5*Z

As per the above formula the opening times are calculated in Table 2(b). The traffic is cleared in three rounds within a total clearance time of 18.33 minutes.

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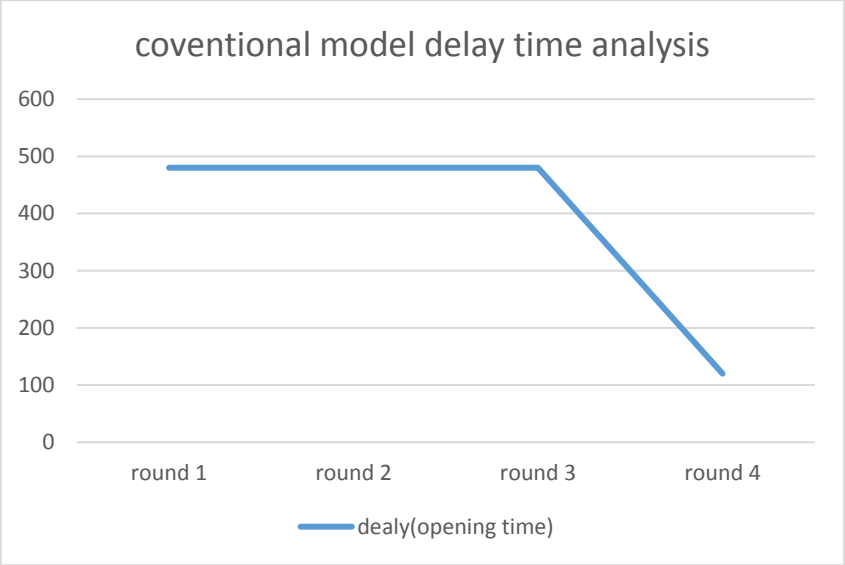
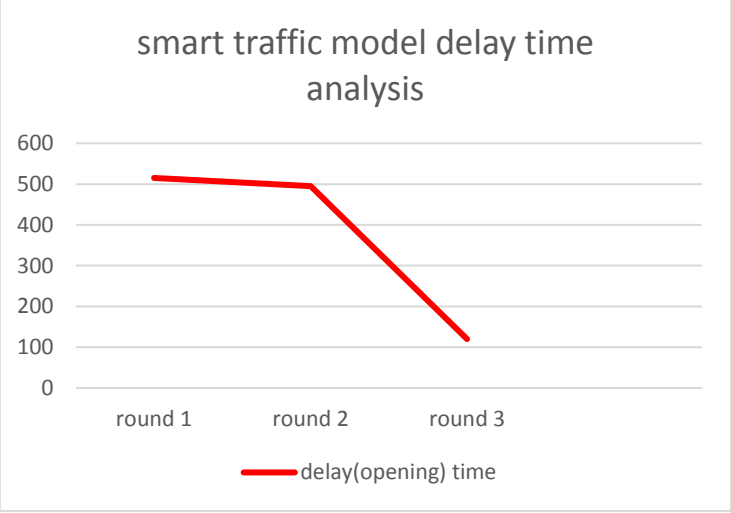
vehicle density	congestion factor (Z)
0-10 low	0
>10	1
>20	2
>30	3
>40	4
>50	5
>60	6
>70	7

Table 3



Analysis-1



Analysis-2

Thus with the help of this new traffic model in the data set of 100 vehicles 1.67 minutes are saved and these saved minutes with each no of vehicles entering the crossroad can add up to save considerable time making traffic faster and quicker. In Analysis-1 the delay time trend shows a slow decline whereas in Analysis-2 the delay time trend shows a sharper decline representing a quick and efficient traffic.

As we have less factual stats for Indian traffic due to lack of proper sensor on road. We can assume and Indian traffic situation will go hand in hand or even bad as India is a developing country which have almost triple the total number of

DOI: 10.17148/IJIREEICE.2022.10310

vehicle on road with only 30% increase in road networks. India has to adapt to smart traffic management solution before the situation become dire or out of hands.

VIII. CONCLUSION

This research idea is implemented in its initial stages in various cities globally. These are Singapore, New York city, London, Paris, Beijing, Berlin, Seoul, Barcelona. This research idea has not gained much momentum in India and is still under development and enhancement. Early testings have shown considerable improvement in traffic flow in above cities. Thus this can be a great step towards achieving the goal of sustainable development.

This research based on smart traffic technology has a wide future scope. It is a futuristic traffic system which will save time, manage traffic efficiently and provide traffic information to the people. With the advancement of technology enhanced versions of intelligent traffic systems can be planned. These enhanced versions can provide more advanced features like priority clearance. **Priority clearance** is a feature of smart traffic systems which can clear way for emergency vehicles i.e. fire brigade, ambulance etc. Some advanced features like **over speeding detection** can be achieved using cameras. Facial recognition systems can be used to get information about the passengers. These were some of the futuristic aspects of intelligent traffic management systems and will make traffic more efficient and more public friendly.

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