

IoT based Road Traffic Management System for Metropolitan Cities

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Abstract: Many cities in the world face jamming problems in road traffic, particularly in metropolitan cities. At present the traffic controlling systems are semi-automatic in nature. With the introduction of IoT in road traffic management systems, it revolutionizes the field of road traffic management system and improves the road traffic congestion problem. This paper proposes an IoT-based road traffic management system for metropolitan cities. The proposed system provides the hassle free movement of the vehicles to avoid inconvenience and reroute the higher priority vehicles. Experimental results show that the proposed system gives higher success rate for the low traffic density in the lane.

Key Words: Traffic management system, road traffic

I. INTRODUCTION

Road traffic is one of the major problems faced by people in metropolitan cities. As the number of vehicles is increases on the road, the major challenge is to reduce the accidents and no delay in emergency services. Manual road traffic management by traffic controller is measured as a unsafe and tedious task due to high risk of being stuck by passing vehicles and working all day even in critical weathers conditions [1][2].

In the present scenario increasing road traffic is considered as a serious problem to be addressed. It may cost to life in some of the emergency situations like health issues. Therefore the situation of road traffic causes miss happening on the roads due to late medical help for the accidents; this will motivate us to come up with an idea to automate the road traffic management. Research into the use of automated enforcement of road traffic regulations is at an emerging stage.

One of the goals of road traffic control is reducing accident and travel time from one place to another. Reducing the time spent waiting in traffic signals.

The Internet of Things (IoT) concept was introduced in the 1980s. IoT has become a crucial thing in the everyday lives of today's people. Broadly IoT have been applied in the various systems for example wearable's, connected cars, smart cities, smart home, in agriculture field, traffic management and healthcare respectively. Slowly and steadily IoT has becoming a part of almost every technology. To collect real time information IoT uses GPS and other technologies.

To make congestion free roads within metropolitan cities, it is essential to use advanced technology for handling the problems of road traffic through gathering all the data related to the vehicles, process and evaluate the data and find an alternative solution immediately. This paper proposes an alternative solution in real time based on the Internet of Things to solve the road traffic problems of metropolitan cities using different sensors from the junction generating huge amount of data related to road traffic congestion over the given period of time and transfer to base station for further processing which helps in decision making and increasing the road capacity and efficiency.

In general, there is a need for road traffic management System for public safety and the jamming free roads which reduces accidents, and fuel consumption and improving economic profits and could provide business prospects.

With the growing population and vehicles in metropolitan cities, the road traffic pressure on metropolitan roads is increasing. Therefore the gradually crowded road traffic problem cannot be solved by the green transportation advancement [3]. One more problem that arises frequently is the long traffic jamming in the road reconstruction area for the expansion of current roads [4].

There are various vehicles detecting technique are present for road traffic management system such as radar, infrared, ultrasonic and microwave detectors and video traffic surveillance [5]. But these techniques are costly, inaccurate, difficult in installation and have insufficient capacity due to these limitations are not recommended. To make the system cheaper we used the combination of sensors and IOT for automated road traffic management.

The rest of the paper is organized as follows: Section 2 presents the related work in the field of IOT based road traffic management.

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Section 3 describes our proposed architecture of the system. Result and analysis are discussed in Section 4. Finally conclusion is discussed in Section 5.

II. RELATED WORK

Now a day IoT is considered as the most important and challenging platform in every field. In terms of, how physical devices are interconnected in near future. The use of IOT revolutionizes the road traffic management system by redesigning the infrastructure that can solve the enlargement of the road traffic jamming problem.

In the smart cities for managing traffic IoT devices are used widely [6, 7, 8, 9, 10]. Rani et al. [11] proposed that IOT devices need to capture the road traffic conditions like speed, flow, and density for a particular section of road.

K Pangbourne, D Stead, M Mladenović in 2018 [12] analyzing the recent concept of smart mobility referred to as Mobility as a Service (MaaS). MaaS signifies a hybrid innovation technology which combined with a business model for conveying cohesive access to transport services for better road traffic management.

Schimbinschi et al. [13] used the loop detectors for the analysis of traffic data using visual exploratory analysis technique. Though, with the help of loop detectors, it is not fully possible to develop moving vehicles trajectories as such sensors only detect vehicle movement but not summarize the individually recognizing vehicles capabilities.

Pinheiro [14] conducted a study on mobile phone data of metropolitan area of Rio de Janeiro, Brazil to analyze the behavior of human mobility to build human trajectories. Similar research have been conducted on the analysis of vehicle trajectory using GPS data [15, 16] and based on human mobility data [17].

To analyze the urban traffic, a visual analysis system known as BVIS proposed by the Pei et al. in 2018. For experiment they used the comprehensive real sparse public transportation datasets [18]. Similarly Armas et al. (2018) combined the multi-objective evolutionary algorithm with the multi-agent traffic simulator MATSim to study the level of service of urban traffic [19]. For urban road networks Wang et al. (2018) proposed a prediction framework for the instant traffic flow [20].

Djahel et al. [21] proposed adaptive TMS emergency scenarios of three levels. They used a set of controllers, sensors and connected vehicle system for the changes in traffic policy system.

On the basis of related work, the study is summarized as traffic flow control using IoT is the most prominent field for research now a days, the road traffic conditions, smart mobility service for better traffic management, loop detectors for vehicles trajectories, analysis of vehicle trajectory using GPS data, visual analysis system approaches are used to analyze the urban traffic, and adaptive TMS to analyze emergencies in road traffic etc.

III. PROPOSED ARCHITECTURE OF THE SYSTEM

In our proposed system we have webcam, LED light, buzzer and RFID sensor which give the traffic jamming information. RFID sensor positioned in the four lanes near the traffic signals to collect the data from the four lanes. For the real time decision making towards road traffic management raw data comes from the sensor send to the traffic controller. Webcam, LED light, buzzer are connected to the Raspberry Pi 3B+ central processing unit. Sensors collected the data and then evaluated by the CPU and give the priority from the high congestion lane to the low congestion lane and take decisions. If the sensors of all the lanes give the same output status, then the same time duration will be assigned by the CPU for the corresponding lane. In our proposed algorithm we set the value of high congestion lane to 30 vehicles.

For the vehicle priority (Emergency vehicles like ambulance) XBee transmitter and receiver module operating at 2.4 GHz frequency band are used which is connected with Raspberry Pi through Wi-Fi. XBEE will be placed on moving the higher priority vehicle and approximately 100 m apart from the sensor receiver antenna will be placed. When the receiving antenna receives the signals of higher priority vehicle, it will send the signals to Raspberry Pi and Raspberry Pi will turn LED light to red for the remaining three lanes [22]. The process of the proposed approach is shown in Figure 1.

The components of the system are described as:

Raspberry Pi 3 B+

Our proposed approach of road traffic management requires an intelligent hardware platform for better performance in the critical traffic environment. Therefore we select Raspberry Pi B+ for this purpose. It is like a credit card size motherboard of a mini computer some versions are even smaller than it. It consists of SD card instead of hard disk to install an operating system which allows convenient software updates and installation. The advantage of Raspberry Pi B+ is that after set up it can run without external peripherals. It includes GPIO pins to attach sensors, LED and other electronic hardware.

Webcam

Installed the webcam in all the traffic junctions in order to classify the higher priority vehicles and then reroute them to avoid delays.

RFID Sensors

Radio frequency identification (RFID) technology is observed as an important prerequisite of the IoT.

RFID Sensors are arranged on each side of the road to measure the traffic flow. It refers to a technology where reader captured the digital data via radio waves and encoded in tags which have a unique digital identity. Therefore RFID is important to connect the physical world with the digital one.

Light Emitting Diode (LED) and Buzzer

We combine buzzer with the LED for traffic light operation. Whenever a higher priority vehicle like ambulance and police vehicle stuck in the traffic jam LED turns red and buzzer sets an alarm for route diversion.

The algorithm of the proposed system is given below.

Algorithm of Road Traffic Management System

Input: RFID SENSOR (input), webcam (input)

Procedure:

variables initialization

1. Current Lane = Lane I
2. Divert_Lane (I) = Lane II
3. Signal_Light = Light(Current Lane)
4. Divert_Lane (II) = Lane (III)
5. Divert_Lane (III) = Lane (IV)
6. Divert_Lane (IV) = Lane (I)

On the basis of traffic congestion selection of the traffic light status

7. Start
8. While(waiting Time \geq 5min)
9. if (no priority is set)
10. status of traffic light set to red
11. if(traffic congestion of Current Lane \geq 30 vehicle)
12. buzzer set an alarm
13. turn Light(CurrentLane) to green
14. Current Lane = Divert_Lane (n) where n=I to IV
15. If (traffic congestion of Lane 1= traffic congestion of Lane 2= traffic congestion of Lane 3= traffic congestion of Lane 4)
16. If (lane 1 sensor is active)
17. Wait for time t
18. Turn light (Lane 1) to green
19. End if
20. If (lane 2 sensor is active)
21. Wait for time t
22. Turn light (Lane 2) to green
23. End if
24. If (lane 3 sensor is active)
25. Wait for time t
26. Turn light (Lane 3) to green
27. End if
28. If (lane 4 sensor is active)
29. Wait for time t

30. Turn light (Lane 4) to green
31. End if
32. End

On the basis of vehicle priority selection of the traffic light status

33. Start
34. While (waiting time \geq 5 min)
35. If(XB sensor of current lane is high)
36. Priority of the current vehicle lane is set high
37. Turn the remaining lanes LED lights to red
38. buzzer set an alarm
39. Status of the current lane light set to green
40. Read the XB sensor of the remaining other lane until the sensor of other lane goes high and turn red.
41. No priority set for the current lane
42. END if
43. END while
44. End

IV. RESULT AND ANALYSIS

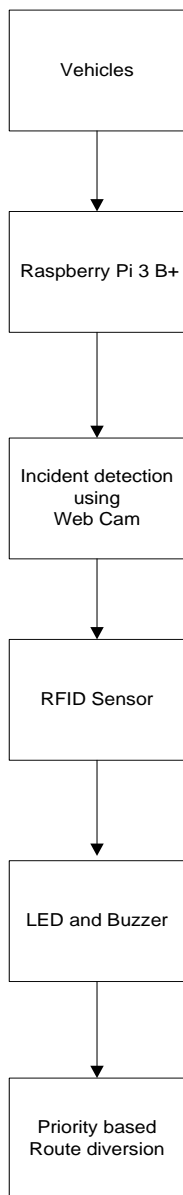
The implementation of IoT in road traffic management system would be helpful in smooth running of traffic. The proposed system simulated with Raspberry Pi 3 B+ and RFID sensor. We classify vehicles as higher priority vehicles (ambulance, police vehicle, fire vehicle etc.) and no priority vehicles. In our proposed system, we used the four lanes architecture for congestion free movement of vehicles at the traffic junctions.

The overall performance of the system is defined as the hassle free journey for the people and allows priority to the emergency vehicles. The system performance is evaluated by the Repeater Operating Curve (ROC). The observational and predictive rates of success of congestion free movements of vehicles are shown as the ascending true positive rates by the ROC curve. Table 1 show the number of vehicles passes at traffic junction without congestion at an instance of four hour period. The successful movement of vehicles from the traffic junction is considered as the priority and the movement times at the traffic junction.

Table 1: Analysis of the observational and predictive probability at traffic junctions

Lanes	Vehicles at the traffic junction	RFID sensor	Congestion-free passes in traffic junction	Observational probability	Predictive probability	Success	Failure
Lane 1	21	Sensor 1	14	0.92245	0.93572	15	24
Lane 2	35	Sensor 2	9	0.88656	0.79213	8	23
Lane 3	40	Sensor 3	7	0.83452	0.86789	6	29
Lane 4	25	Sensor 4	15	0.91743	0.90832	19	26

From the above table 1, the frequency of the congestion free movement of vehicles at the traffic junction shows the success of the experiment.



V. CONCLUSION

Road traffic jamming causes a significant loss in productivity and economy, as well as it is highly impacted on the environment. There are numerous parameters present that mark the road traffic management and efficiency of metropolitan roads. Based on the IoT, the lane speed limit is optimized and avoids the traffic. In our proposed approach, traffic is managed by collecting information from multiple RFID sensors to get the correct information about traffic jamming; and taking decisions accordingly, hence saving time and fuel and reducing inconvenience. It also provides an alternate route to the highest priority vehicles. In the future, we will address the disabled and pedestrian-related challenges in road traffic congestion due to fluctuations in metropolitan traffic.

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Figure 1: Process of the Road traffic Management system

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