Survey of Intelligent Traffic Management Systems with Emergency Vehicle Detection: A Review

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Abstract - *In metropolitan cities, traffic congestion has emerged as a major problem. The annual increase in automobile population is 14.19 percent, resulting in increased noise emissions, air pollution, collisions, and travel time delays. Owing to a lack of automated processes, current traffic signals in cities are inefficient and insufficient to solve the problems listed above. The traditional traffic system uses pre-determined times for red and green signals, requiring third parties such as traffic cops to manually manage traffic. On average, Indians spend 7% of their day commuting to work, with a time per kilometer of less than 3 minutes. This paper compares and contrasts various traffic control methods and explores the advantages and drawbacks of each approach.*

Key Words: **Congestion control, emergency vehicle detection, intelligent traffic management system, traffic signal control, traffic analysis, traffic density.**

I. INTRODUCTION

India is the world's second most populated country and has a rapidly growing economy. Its cities are experiencing severe traffic congestion. Owing to space and cost constraints, infrastructure development is slower than the growth in the number of vehicles. In addition, Indian traffic is non-lane dependent and chaotic.

It necessitates traffic management solutions that are distinct from the standard. Intelligent traffic flow management can mitigate the negative effects of congestion [1]. As the number of cars on the road has increased, traffic congestion has increased. This has made it difficult for ambulances to transport patients to suitable destinations on time in the event of an emergency. According to statistics, more than 20% of patients in need of immediate medical treatment die en route to the hospital as a result of delays [2]. Road incidents take the lives of 3,000 people every day, according to the International Road Federation's Geneva Program Center. This equates to 1.3 million deaths per year and a total of 2.4 million deaths from traffic accidents [3].However, the issue of an ambulance failing to arrive at its destination has yet to be resolved. To fix this problem, a system must be put in place that allows ambulances to easily pass through the traffic to get to the nearest hospital.

This paper provides a comparative review of the different techniques that are used by different authors to automate and improvise the traffic management and detect emergency vehicles through Web sockets efficiently. One of the methods uses manual traffic mode to implement an intelligent traffic management system [4] while another author used wireless sensor network [5] which collects data from the sensors installed on the traffic lanes at the junction and interprets the data received. This paper presents a comparative analysis of the various methods used by various authors to automate and improve traffic control and effectively identify emergency vehicles. One approach implements an adaptive traffic management system using manual traffic mode [4], while another author used a wireless sensor network [5] that collects data from sensors mounted on the traffic lanes at the junction and interprets the information collected. A framework in [8] [9] uses Neural Networks to dynamically control traffic and plan future actions. In [11] [12], the author employs an image processing technique to measure and detect the presence of emergency vehicles at a given intersection. Surveillance cameras mounted at traffic signals are used to capture a live feed of traffic and the location of emergency vehicles, which is then processed using image processing techniques in order to automatically change traffic signal timings and thereby manoeuvre emergency vehicles out of traffic as quickly as possible. The remaining part of the paper is laid out as follows. Section II examines the current state of research and development for an intelligent traffic management system. Section III compares and contrasts all of the current processes. Section IV addresses the benefits and drawbacks of all of the approaches discussed in this article. Section V wraps up all of the approaches with a conclusion.

II. LITREATURE SURVEY

2.1. Manual traffic management system

As explained in [4] a typical traffic system is based on timers that are programmed for a particular interval. This is the most widely used traffic control scheme, which is overseen by traffic cops. This device entails a traffic law enforcement officer who stands at each lane intersection and controls traffic flow with the help of a traffic sign. The vehicle operator receives a signal from the traffic enforcer to drive the vehicle or stop if the frequency of vehicles on the lane is higher. The traffic enforcer will offer priority to the lane with a priority vehicle present, allowing that vehicle to pass first. When there are several emergencies, the person becomes perplexed, and it becomes difficult for him or her to handle the traffic. This method is also effective during rush hour and in an emergency, but it has the downside of potential human error, which makes it much less productive. The success of this structure is dependent on the awareness of both the traffic enforcer and the public.

2.2. Traffic Management using Wireless Sensor Networks (WSN)

This application as stated in [4][5] operates on four parameters: (I) data selection; (II) data compilation; (III) data processing to execute the specified movements; and (IV) enactment of the required steps. A Traffic Control Centre (TCC), on-board units on cars, wireless sensors, and Road Side Units are all part of the Traffic Management System (RSU). The sensors collect real-time data, such as the variety of vehicles, vehicle count, and vehicle stay time, and send all of this information to the Roadside unit. As a priority vehicle (emergency/VIP) goes through a cross-section of roads, the vehicle's on-board unit sends information to the Roadside unit. The TCC receives data from every wireless sensor and vehicle On-Board Unit, which is processed by the Roadside unit. The TCC's data collection module collects information, analyses the collected traffic data, and then sends it to the TCC's traffic light control module, as shown in fig 1 below. The information is handled by the control module, which gives priority to priority (emergency/VIP) vehicles. The traffic signals resume regular service once the priority vehicle has passed. This approach regulates traffic density and gives priority to priority vehicles.

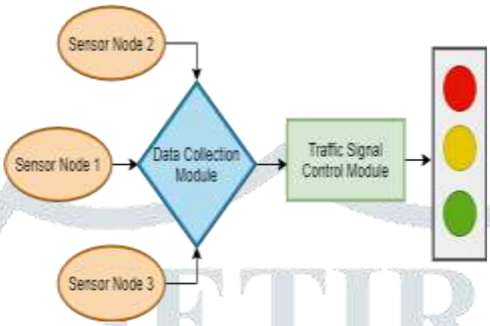

Figure 1. 1 Master 3 Slaves

2.3. Rfid Based Intelligent Traffic Management system

As previously mentioned in [6]. The RFID transmitter and receiver module in the Smart traffic signal system transmits and processes the data obtained in real time. Rfid technology is easy and effective; it collects information from the transmitter (Rfid tag) and receiver modules such as traffic density, vehicle number, vehicle priority (for emergency vehicles), and vehicle type (2 or 4 wheeler), all of which can be handled by a processor such as the Raspberry Pi. When traffic density exceeds the regular cap, the system chooses to provide overtime to the lane with the most traffic; the system has four sets of signals in operation. Each lane follows the same signal pattern, which begins with a green signal, then a yellow signal, and finally a red signal to stop, before repeating the process. The traffic scheme starts with a green signal in lane 1 and finishes with a red signal in the remaining lanes. The green signal moves from each lane until it reaches the last lane, following the sequential pattern. If the lane moves, the timer resets. The RFID-based traffic model is depicted in fig 2 as a flowchart. If there is a lot of traffic, the green signal stays on for an additional 10 seconds to clear the road. Every lane has an RFID reader that monitors the lane and scans priority vehicles RFID tags to identify them [7].

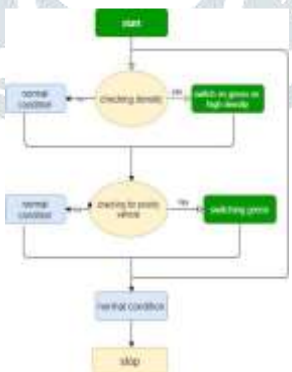

Figure 2 Flowchart of a RFID based traffic management system

2.4. Neural Network based Traffic Management System

This model proposes an adaptive traffic light based on a neural network trained using reinforcement learning [8].The neural network is the agent in reinforcement learning, which uses environmental feedback as a reward or punishment [10]. The agent in this algorithm makes recommendations after completing a task [8]. This feedback tells the operator how well its action was implemented.

Ultrasonic sensors are installed on the roadside in this model to detect passing vehicles. The data from the sensor is used by the controller to analyze queue lengths and time delays on certain routes. As ultrasonic waves interfere with a vehicle, the waves are transmitted back to the sensor's receiver [8]. The time speed formula is used to determine the distance between the transmitter and the vehicle. As soon as the vehicle crosses the distance threshold, it detects traffic on that lane. The Micro-controller is in charge of processing sensor data and calculates, queue length, and queue time measurements. The length of the queue can be calculated by placing sensors at the beginning and end of the lane [9].The flowchart of this system is depicted in fig (3). To estimate the queue lengths and time for each lane, a queue data structure algorithm is used in combination with the sensors. Using the queue time and queue length data the neural network algorithm determines the traffic signal light timing. If a lane has queue length and queue time greater than the threshold then the lane is given highest priority and traffic signal is tuned green to that lane. It is removed from the queue as it passes the exit stage. The time vehicle spend between the two points can be divided into two components: the time it take to get to the queue and the time it spend standing in the queue. To determine the queuing time we need to eliminate travel time from the total time spent between the points. Thus after estimating the queuing time the neural network which acts as an agent will offer priority to lane where vehicles have been waiting for a long time using Reinforcement learning algorithm [9].

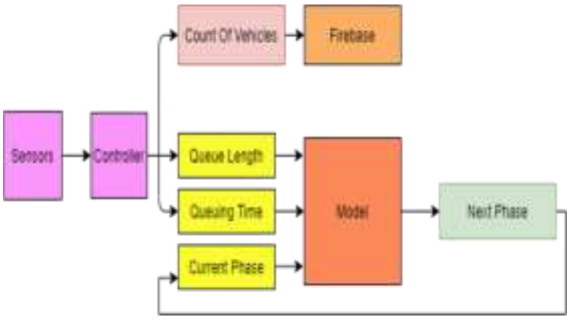

Figure 3 Neural Network flowchart

In this review, the environment state is a traffic intersection with which the agent interacts. The action taken by the agent is to adjust the current stage of the traffic signal. The neural network's performance is the feedback as reward or punishment it receive for each loop, which it incorporate on the traffic signals at the same time. Following that, the agent receives feedback that adjusts the action's outcome based on the number of traffic jams in each lane. The neural network's feedback illustrates how it improved the transit system [10]. The sum of all the feedbacks calculated for each lane is the feedback that the neural network receives after changing the phase. The feedback of the algorithm is again given to the system. We can solve the crucial problem of traffic congestion on traffic signals by allowing vehicles to pass but setting priorities to paths which are densely congested in comparison to all other lanes using the technique of Reinforcement learning.

2.4. Intelligent Traffic Management System based on image processing

As stated in [11] [12], live stream camera video is used for processing to determine the quantity of vehicles in a lane. The model's efficiency in capturing the number of vehicles going through that lane is determined by the location of the cameras. Therefore, the cameras are positioned at traffic lights to capture maximum frames of the lane and identify traffic. The video from the surveillance cameras serves as an input to the raspberry pi. The video frame consists of stimulation lines that act as a threshold, when the vehicle passes the subjected threshold line the algorithm evaluates the traffic density for a particular lane. If vehicle density is greater than the threshold then the decision is taken upon the suggested algorithm which controls the traffic lights. If vehicle density is less than the threshold value then the default timing algorithm works. Vehicle detection is done using the formula specified by the author in Equation (1), as mentioned below [11].

$$bgn = (gray * v) * (bgn-1 * (1-v)) \qquad (1)$$

Where “bgn-1” is the previous background image, “bgn” is the updated background, “gray” is the original video frame and “v” is the dynamic background constant. And, as stated in [12], traffic light scheduling is defined in Equation (2).

$$t_i = \omega_i\left(\frac{1}{PM_i}\right) + \omega_i'(N_i)\}T_0 \qquad (2)$$

Where "ti" is the green light timing in the ith direction, and "wi" is the weight factor for the overlapping percentage in the ith direction. “PMi” is the overlapping percentage on the ith direction and “T0” is the time unit.“ωi” is the weight factor for the number of vehicles passing through the ith direction leading to the intersection, and Ni is for the number of vehicles passing through in a given time interval.

2.5. Web Framework based emergency vehicle detection

When there is a high volume of traffic, navigating emergency vehicles through it is a big issue. Any vehicle can be in emergency mode; some vehicles, such as ambulances and fire trucks, have flashing lights and sirens that allow us to identify the vehicle and clear a path for it. However, in the case of a regular car, which also has an emergency patient who needs to hurry to the hospital for treatment, being trapped in traffic is a nightmare for him. Every vehicle either emergency or normal vehicles turn into life saver when it carriers injured patient. So, a universal system needs to be designed such that any vehicle in emergency mode can access it. A legislation should be enacted to safeguard patients' rights. If anyone damages or misuses something, he or she will be punished. All of the above algorithms make use of the Web-based Framework, which is run on the Raspberry Pi, and the performance of each algorithm has been tried and tested. A web-based architecture used in our algorithms operates in a client server mode, with the raspberry pi serving as the server and the user acting as the client. A web page for emergency services is designed, which includes the mode of emergency, whether “on or off,” and the direction of the lane in which the vehicle is arriving. Once the user enters the above details and submits the information, the traffic algorithm responds as specified by allocating some time to the emergency lane until the emergency vehicles pass through the junction [13]. The web-based framework uses the Get ( ) request method to retrieve data from a webpage and transfer it to a Python script. The above-mentioned traffic management system algorithms have been tried and validated on all of the above-mentioned algorithms, and they use a combination of a Raspberry Pi 4 and a flask based web framework.

III. COMPARATIVE ANALYSIS OF DIFFERENT TECHNOLOGIES IN INTELLIGENT TRAFFIC MANAGEMENT SYSTEMS

Table 1. Technologies of intelligent traffic management system

Index No.	Input method of data	Technology used	Traffic parameters acquired	Traffic Density Calculation	Device used in Vehicle?	Emergency vehicle detection?	Hardware Requirements?
1.	Human Visuals	Manual	Location of every vehicle, traffic density areas	Total No of Vehicles Occupied in a lane	No	--	--
2.	Ultrasonic sensors	Wireless Sensor Network	Vehicle density, average waiting time	Distance to sensor nodes from traffic signal	Yes RFID tags	Unique tag for emergency vehicle	RFID tag, RFID receiver
3.	RFID tags	RFID	Unique ID of every car	Distance from RFID tag to reader	Yes RFID tags	Unique tag for emergency vehicle	RFID tag, RFID receiver
4.	Ultrasonic sensors	Neural Networks	Queue length, queue time	Distance from RFID tag to reader	No	No	RFID sensors
5.	Video cameras	Image Processing	Traffic density by lane,	Total Number of vehicles passing though stimulus line	No	Using	Video Surveillance cameras

IV. ADVANTAGES AND DISADVANTAGES OF VARIOUS INTELLIGENT TRAFFIC MANAGEMENT SYSTEMS

Table 2. Pros and cons of different traffic management system

S. No.	Input method used	Description	Pros	Cons
1	Manual Mode	This method uses simple Timers to control traffic signals. Signals can be controlled manually in case of emergency With the help of traffic police.	**1.** Traffic during peak time can be handled efficiently with the help of traffic police.	**1.** Possibility of human error **2.** Less efficient in case of emergency
2	Wireless Sensor Network(WSN)	The WSN uses sensor deployment along the road, resulting in efficient data collection which enhance the traffic modelling.	**1.** Economically cost effective **2.** Easy Installation and high accuracy	**1.** Small communication range **2.** Effects due to harsh environments
3	Rfid	This system works on principle of RFID tracking of vehicles, operates in real-time with improved traffic flow with full automation, without any human involvement.	**1.** Human intervention is limited **2.** Cannot be affected by environmental changes	**1.** RFID may be easily intercepted, even if it is encrypted. **2.** Low range

4	Neural Networks	Neural Networks uses ultrasonic sensors which are installed along the road to collect data and compile that using controller to decide the traffic condition and manage traffic signals accordingly.	**1.** Highly efficient **2.** Parallel processing capability	**1.** More complex **2.** Harsh environmental conditions can affect working of sensors.
5	Image Processing	This method uses background removal which detects the moving vehicles and calculates the traffic density using stimulus line.	**1.** Reasonably priced **2.** Scalable **3.** Low installation and maintenance costs	**1.** In order to deal with change in outdoor environments, a static background is insufficient. **2.** For day and night traffic detection, separate algorithms are needed.

V. CONCLUSION

This paper included a comprehensive description of all approaches used to create an intelligent traffic management system. These included RFID applications with tags and readers, as well as technologies such as Wireless Sensor Networks (WSN) and Neural Networks, as well as image processing techniques. Additionally, the use of a manual traffic control system was also debated. The additional use of Web based framework was also carried out on different traffic management systems. From the above table (1) which compares different traffic management technologies and table (2) differentiates different pros and cons of the traffic systems, we can get insights from the above comparisons that using image processing technique increases efficiency and reduce cost of the system. Further improvisations can be done in image processing technique to reduce shadowing effect and increase processing speed.

References

[1] Swathi, G., Rizwana, J., Safreen, S., &K.Manikandan (2018). IOT based Stolen Vehicle Detection and Ambulance Clearance System. International journal of engineering research and technology, 5.

[2] Nation, "20 per cent of emergency patient deaths blamed on traffic jam delays," Nation Thailand, 2017.[Online].Available:https://www.nationthailand.

com/national/30304268. [Accessed: 29-Jan-2020].

[3] Wani, M. M., Khan, S., &Alam, M. (2020). IoT Based Traffic Management System for Ambulances. arXiv preprint arXiv:2005.07596.

[4] Siddamma. G. Pashupatimath , Prof. Shilpa. Madhavanavar, 2018, Different Techniques Used in Traffic Control System: An Introduction, INTERNATIONAL JOURNAL OF ENGINEERING

RESEARCH & TECHNOLOGY (IJERT) NCICCT – 2018

(Volume 6 – Issue 03).

[5] Nellore, K., & Hancke, G. P. (2016). A survey on urban traffic management system using wireless sensor networks. Sensors, 16(2), 157.

[6] Singh, H., Kumar, K., & Kaur, H. (2012). Intelligent traffic lights based on RFID. International Journal of Computing and Business Research, 2012, 1-10.

[7] mir, S., Kamal, M. S., Khan, S. S., & Salam, K. A. (2017, July). PLC based traffic control system with emergency vehicle detection and management. In 2017 International Conference on Intelligent Computing,

Instrumentation and Control Technologies (ICICICT) (pp. 1467-1472). IEEE.

[8] Natafgi, M. B., Osman, M., Haidar, A. S., &Hamandi, L. (2018, November). Smart traffic light system using machine learning. In 2018 IEEE International Multidisciplinary Conference on Engineering

Technology (IMCET) (pp. 1-6). IEEE.

[9] Araghi, S., Khosravi, A., Johnstone, M., & Creighton, D. (2013, October). Intelligent traffic light control of isolated intersections using machine learning methods. In 2013 IEEE International Conference on Systems, Man, and Cybernetics (pp. 3621-3626). IEEE.

[10] Abdulhai, B., Pringle, R., &Karakoulas, G. J. (2003). Reinforcement learning for true adaptive traffic signal control. Journal of Transportation Engineering, 129(3), 278285.

[11] Malhi, M. H., Aslam, M. H., Saeed, F., Javed, O., &Fraz, M. (2011, December). Vision based intelligent traffic management system. In 2011 Frontiers of Information Technology (pp. 137141). IEEE.

[12] Razavi, M., Hamidkhani, M., & Sadeghi, R. (2019, April). Smart traffic light scheduling in smart city using image and video processing. In 2019 3rd International Conference on Internet of Things and Applications (IoT) (pp. 1-4). IEEE.

[13] Andalis, E. L. (1997). Web-based network management tools for US Navy mission-centric applications. NAVAL POSTGRADUATE SCHOOL MONTEREY CA.