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An Internet Of Things Based Intelligent Traffic Management System Using Vehicle Density

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Abstract— It is generally agreed that a smart city's traffic management system is one of its most important components. Congestion on the roadways is a common occurrence in metropolitan areas because of the fast increase in population and urban mobility that has occurred there. A smart traffic management system that makes use of the Internet of Things (IoT) is presented in this article as a means of addressing a variety of challenges related to the administration of traffic on roadways and assisting authorities in the execution of effective planning. The flow of traffic on roadways is optimized by employing a hybrid strategy, which is a blend of centralized and decentralized methods, and an algorithm is developed to effectively handle the many different types of traffic circumstances. In order to accomplish this objective, the system first maintains traffic lights after receiving information about the volume of traffic from a) cameras and b) sensors. In order to reduce the likelihood of future traffic congestion, another algorithm based on artificial intelligence is being utilized to make predictions about traffic density. During a traffic jam, RFIDs are also utilized to provide priority to emergency vehicles like ambulances and fire trucks so that they may get through the congestion more quickly. Smoke sensors are also a component of this system, and its purpose is to identify the presence of smoke in the event of a roadside blaze. In order to prove that the system for managing traffic that has been described is successful, a prototype will be constructed. This prototype will not only improve the flow of traffic, but it will also connect adjacent rescue departments with a centralized server. In addition to this, it gleans helpful information and displays it in graphical representations, which might be of use to the authorities in the process of future road planning.

Keywords- IoT, Smart City, Smart Traffic Management, Traffic Congestion, Traffic Signal Management.

I. Introduction

A city is a complex system that is made up of many different subsystems that are reliant on one another, and the transportation system is one of the city's most significant subsystems. According to one piece of research, it is the fundamental component of the global economy [1]. In addition to this, it has been recognized as one of the essential components of a smart city [2]. Because of the fast increase in the global population, there are currently more cars on the roads than ever before. As a direct result of this, the number of traffic jams on the roads is also rising at an alarming pace [3, 4]. It's important to remember that sitting in traffic isn't only a waste of time; in some situations, it's been seen that illegal actions like stealing mobile phones at traffic lights also take place in urban areas [5]. On the other hand, it is having a negative impact not only on the ecosystem (as stated in [6]), but also on the productivity of industry (as stated in [7]).

Therefore, it has been determined that there is a requirement for proactive traffic management. Fixed time signals are used to govern traffic in the majority of countries; however, in large cities of some industrialized countries, traffic is managed by centrally controlled systems. In recent years, the concept of the Internet of Things (IoT) has been implemented in systems that control traffic [8].

To the best of our knowledge, it has been established that the mechanisms that are currently in place for the control of traffic are centralized. These kinds of systems are prone to crashing in the event of problems with the networking. In addition, there is less of an emphasis placed on variations in the flow of traffic. Because of this, the system that has been presented is able to control the traffic on both local and centralized servers by combining the ideas of the Internet of Things and artificial intelligence. The statistical representation of traffic data may also be beneficial to authorities for monitoring and managing traffic in real time. This control and management can be done in real time. In addition to that, it could also be useful for making plans for the future.

The remaining portion of the paper is divided into four distinct sections. The current state of the art is discussed in Section II. In Section III, the suggested system is given and discussed, while in Section IV, a discussion on the outcomes is being carried out. The final section of the investigation is section V.

II. Literature Review

A sustainable urban transport system that has been partially implemented in the city of Cambridge. The system consists of queue detectors that are buried in the roads to detect the presence of traffic queues and inform a central control unit, which then makes decisions based on the information received. Because the system is centralized, there is potential for it to become sluggish owing to difficulties with networking [9]. The researcher employed surveillance equipment to detect traffic and optical character recognition software to identify the vehicles though the number plate recognition. Although this is an easy detection method, the system will not work in Pakistan because there are many different kinds of traffic, including cycles and donkey carts, neither of which have a number plate [10].

Osmanetal. suggested a system in which they have employed security cameras to identify traffic density using MATLAB, a traffic controller, and a wireless transmitter that is used to deliver photos to the server after the server has estimated traffic density by utilizing those images of every area. This method makes use of preset (predefined) thresholds, which vary in response to the volume of traffic on the route. An algorithm was utilized in order to set a time span of red light for a particular lane of the junction. This time span is decided by the traffic density on the road and is then passed to the micro-controller and then the server [11] The reduction of traffic congestion was accomplished by Jadhavetal. by the use of surveillance cameras, MATLAB, and KEIL (Micro-controller coding). Additionally, the priority-based traffic clearing broker and red signal broker are both discussed in this work (Number plate detection). Because of the use of bulky gear, it is challenging to handle and quickly becomes expensive [8]. Buietal. conducted an analysis of a real-time process synchronization-based system in order to dynamically control the flow of traffic. In order to detect the traffic, sensors were utilized, and wireless communication devices were utilized in order to facilitate communication between vehicles and between vehicles and the infrastructure. The controller was located in the middle of the junction, and it was responsible for receiving information and requests from both automobiles and pedestrians, which it then processed using the first come, first served technique [12]. The intelligent traffic routing system that was presented by Swallowtail. selects the quickest route that also has the least amount of congestion. These sensors collect data regarding traffic density using solar energy as well as battery power, and they are known as sensors. The sensors continued to broadcast infrared light, and when an item approached, they determined the volume of traffic by analyzing the light that was reflected off of the passing vehicles. Nevertheless, values are subject to alter depending on the prevailing temperature and humidity [13]. Al-Sakran et al. proposed a system in which the primary objectives were to detect vehicles and obtain their locations through the use of sensors and RFIDs. Once the data was obtained, it was then transmitted to a centralized controlling center through the use of a wireless connection for additional processing. Cloud computing, radio frequency identification devices (RFIDs), global positioning systems (GPS), wireless sensor networks (WSN), agents, and various other contemporary tools and technologies were utilized by the researchers in order to collect, store, manage, and supervise the traffic information [14].

III. PROPOSED SYSTEM

The proposed system, shown in Figure 1, is designed to govern traffic at road networks, sensing through sensors, surveillance cameras, and RFIDs which are embedded on roadsides. The system works in a distributed manner, it processes sensors' data at the node level and videos' data at the local server, calculates cumulative density to regulate the traffic according to density. In addition to this, it also tackles emergency vehicles such as ambulance, fire brigade. it also helps the users to know the congestion status at a road through prediction. The system is divided into three layers. A) Data Acquisition and Collection layer. B) Data Processing and Decision-making layer C) Application and Actuation layer.

A. Data Acquisition and Collection Layer

Several ways of traffic detection have been used by the researchers in the state of the art which consists ultrasonic sensors, RFIDs, surveillance cameras and light beam. All these sources have merits as well as demerits; the suitable sources in the context of the proposed system are surveillance cameras, ultrasonic sensors, RFIDs, smoke sensors and flame sensors. A surveillance camera is the most widely used source to detect the road traffic in this field due to efficiency and ease of maintenance [15] [16] [17] [18]. Blob detection algorithm is applied to the video stream at the local server due to its performance and capability of noise reduction [18]. After traffic detection, a local server sends the density measured through image processing to the respective micro-controller.

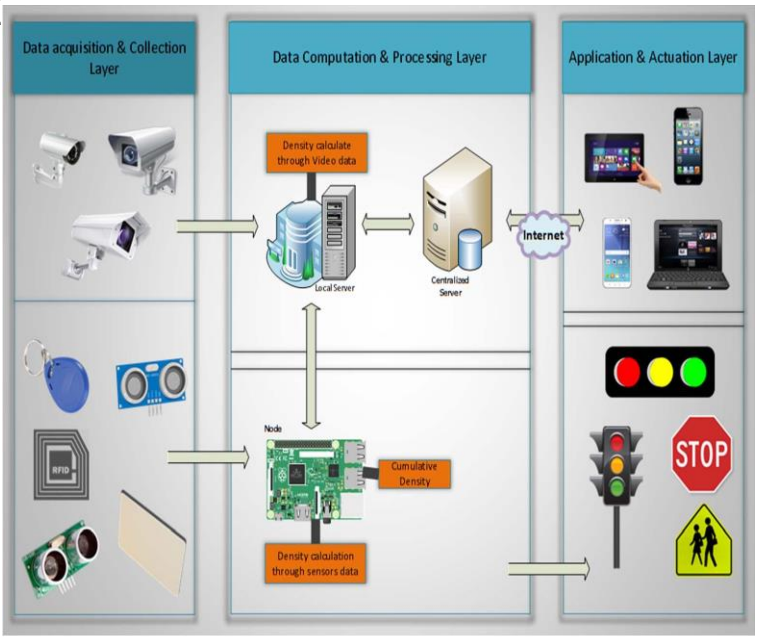

Figure 1. *The System Model*

Apart from the cameras, this system is also using ultrasonic sensors to enhance the accuracy. Sensors are integral part used to detect traffic density in many traffic management system applications [13]. It measures distance by sending out a sound wave of a specific frequency and listening for that sound wave to bounce back. This economical sensor measures the distance 2 cm to 400 cm [19]. The system calculates the distance by using the following formula:

Distance = ((a x b) / 2)
a= Speed of sound
b= time taken

As shown in Figure 2, there are three pairs of sensors at a certain distance are embedded on each roadside of an intersection to calculate the traffic density. Each sensor's reading is 1 or 0 (Either that particular sensor detects the vehicle or not). At the node side, density is calculated by considering the readings of all the sensors embedded at that particular roadside.

$$\sum_{i=1}^{3}(Pi) = \mathbf{P}_i + \mathbf{P}_{i+1} + \mathbf{P}_{i+2}$$

P is the pair of ultrasonic sensors. Table 1. shows the states of the sensors and their results are as follow:

TABLE 1. *TRAFFIC DENSITY STATES BY ULTRASONIC SENSORS*

Condition / Sensors	**P1**	**P2**	**P3**	**Status**
Condition 1	1	0	0	Low
Condition 2	1	1	0	Medium
Condition 3	1	1	1	High

The micro-controller receives results from sensors and video from a local server to calculate cumulative density using Table 2.

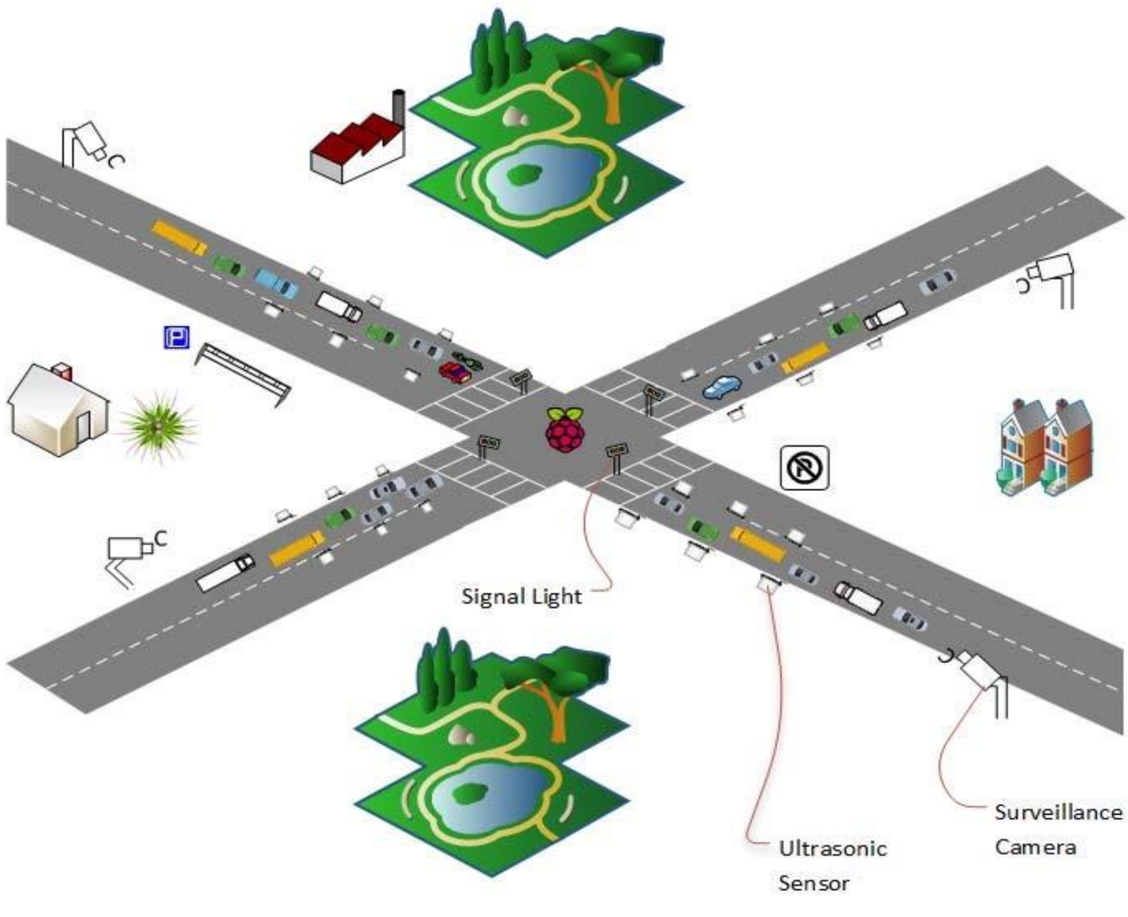

Figure 2. *Sensors Network*

TABLE 2. *CUMULATIVE DENSITY*

Situations	**Sensors' Result**	**Camera's Result**	**Traffic Density**
Situation 1	High	High	High
Situation 2	High	Medium	High
Situation 3	High	Low	Medium
Situation 4	Medium	High	High
Situation 5	Medium	Medium	Medium
Situation 6	Medium	Low	Medium
Situation 7	Low	High	Medium
Situation 8	Low	Medium	Medium
Situation 9	Low	Low	Low

B. Data Processing and Decision-Making Layer

The system manages the road traffic according to the traffic condition. a) In the first situation, each traffic signal has a preset time that is a seconds, when there is normal traffic on road. Every signal is going for green at their turn for a seconds, and rest of signals at that time remains red until all remaining traffic signal at an intersection complete their turn. Traffic ratio is increasing day by day and our current Fixed-time signal control system is not working well in this situation, there is a dire need to add a density based traffic management module which allocates time dynamically to each lane on the base of the traffic density, in second part of algorithm when the capacity of traffic is increased and flow of traffic is not in routine, the system calculates the level of density according to Table 2. and update the time β of traffic signal on the basis of traffic density. further, undergoes to traffic management algorithm discussed in Figure 3.

Algorithm:

Part(I) When no emergency vehicle detected

if (Traffic Density == high)

if (Rush Interval==Yes)

Time= $((a\ e^{x} \sin\theta) + \beta) + y$

else

Time = $(a\ e^{x} \sin\theta) + (\cos\theta * y) + \beta$

else

Time= a

Part (II) When RFID tags detect emergency vehicle

While (vehicle Exits)

Time != 0

Figure 3. *Traffic Management Algorithm*

Where a is regular prefixed time given to a specific roadside, θ=90, x=0, β is extra time added in case of traffic congestion and y is extra time added when there is rush interval near to approach.

Moreover, if the emergency vehicle is detected, the system stops its normal operation and immediately turns the respective signal green and it remains green until that particular vehicle passes to that intersection. In addition to this, if the fire is detected on the road, the micro-controller intimates to the respective local server through which it goes to the centralized server and then this information goes to the respective department through a mobile application. The flow, how the system calculates signal time, is presented in Figure 4.

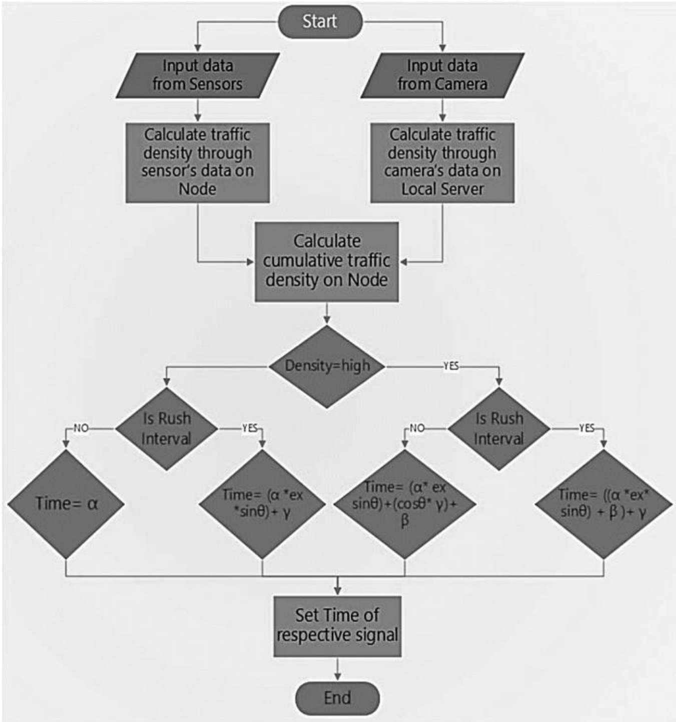

Figure 4. *Flow Chart of Traffic Management System*

C. Application and Actuation Layer

In this layer, there are two types of information delivered i) duration of a green signal from node to traffic signal and ii) daily, weekly, monthly and yearly reports to the administration of smart traffic management system through the web application from a centralized server. First of all, the system calculates rush interval by using Regression Tree algorithm on

The data saved at the local server and updates this report to the centralized server on the daily basis (after 24 hours). The rush interval is the time span of thirty minutes. This report is then displayed on the web application which is linked to a centralized server which is for the administration of smart traffic management system, that shows daily, weekly, monthly and yearly graphs of rush intervals for roads. This graphical information is fruitful for the future road planning and resource management.

Secondly in the actuation module, whenever the rush interval is identified, the local server intimates to the respective micro-controller along with the road id. After receiving the rush interval intimation, the decision-making module updates the duration of the green signal to the respective traffic signal.

In this modern era, where time is money and wastage of time are not affordable, there is a need to know the traffic condition on the particular road prior to travel on that road by using mobile application. Moreover, this system is also capable of managing emergency situations like if the smoke and fire are detected on the road. In case of fire on the road, which is detected by flame sensors and extensive smoke through smoke sensors, the system intimates to the nearby relevant department through a mobile application for further actions.

III. Results and Discussion

A prototype was developed to demonstrate the applicability of our proposed system. Several experiments on real traffic data were carried out to evaluate the efficiency of the proposed algorithm. The traffic density was monitored and calculated by vehicle detection as shown in Figure 5. As soon as the traffic density crosses the specified threshold on a road, the system stopped the normal operation and kept the green light on till the situation on the road became normal. The real-time data was also being sent to the local and central server as well.

***Figure 5**. Vehicles Detection*

Besides this, a web interface was also developed for the authorities to show them the statistics of traffic on the roads so that they could make real-time and future decisions as discussed in section III. Figure 6 shows the statistical traffic data ie. number of vehicles passed in a particular time span at a particular road. The bar graph is representing real-time traffic data. Different bar graphs based on historical and real-time data are being drawn in this application which is helpful for traffic department and other related authorities for i) managing traffic congestion's on roads ii) and future planning.

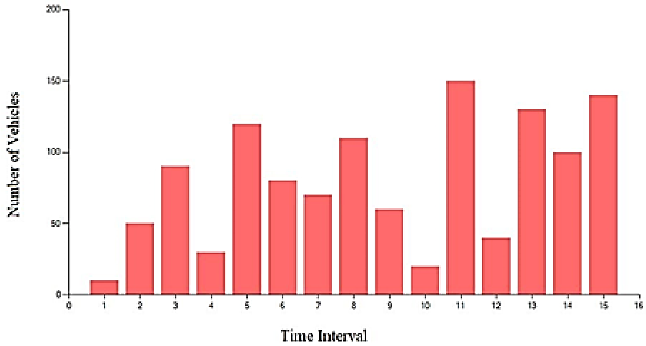

***Figure 6**. Statistical data on traffic*

IV. Conclusion

This research offers a practical solution to the problem of rapidly increasing traffic flow, which is particularly problematic in large cities where the problem is worsening day by day and traditional traffic management systems have some limitations because they are unable to manage the flow of traffic effectively. A state-of-the-art strategy for traffic management systems has been taken into consideration in the development of a smart traffic management system that is intended to regulate road traffic problems in a more effective and efficient manner. It manages traffic flow by interacting with a local server in a more effective manner than has ever been possible, and it intelligently adjusts the timing of the signal in accordance with the amount of traffic that is present on the specific roadside. Because it uses a decentralized method, it is optimized and effective, despite the fact that it continues to function even in the event that a local server or a centralized server fails. In the event of an emergency, the centralized server is responsible for communicating with the closest rescue agency, which in turn ensures prompt human safety. In addition, a user may inquire about the anticipated volume of traffic on a certain road, which allows them to avoid wasting time in traffic congestion. Additionally, the system gives vital information to higher authorities that may be utilised in the planning of roads, which helps to make the most efficient use of available resources.

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