Intelligent Traffic Monitoring System

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Abstract Traffic congestion in cities is a major problem mainly in developing countries; to encounter this, many models of traffic system have been proposed by different scholars. Different ways have been proposed to make the traffic system smarter, reliable, and robust. This paper presents the various approaches made to enhance the traffic system across the globe. A comparative study has been made of different potential researches in which intelligent traffic system (ITS) emerges as an important application area. Important key points of each research are highlighted and judged on the basis of implementing them in developing countries like India. A model is also proposed which uses infrared proximity sensors and a centrally placed microcontroller and uses vehicular length along a length to implement intelligent traffic monitoring system.

Keywords Infrared proximity sensors · RF module · Bluetooth module · ITS

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1 Introduction

The traffic jam is a daily-life problem in any metropolitan city. With the rise of standard of living, the number of vehicles is increasing at an exponential rate. In response to this, many researches are done in developing an intelligent traffic system (ITS), i.e., a traffic system which is involved in a much closer interaction with all the components of a traffic including vehicles, drivers, and even pedestrian. It not only provides safety at intersections and prevents traffic jam, but manages the traffic as a whole. Developed countries like America, Japan, and U.K. have already implemented ITS on their roads and still many researches are going on to make traffic systems more advanced and suitable for developing countries also. Apart from surveying various research works on ITS, this paper proposes a model which follows a simple algorithm based on the length of traffic on each lane. The length of traffic on the other lanes affects the time allotted to the current lane. Proximity sensors instead of WAN are to be used to determine the length of the traffic. The proposed idea can reduce the traffic in all lanes proportionately reducing the chances of congestion without the use of WANs. Besides, it also manages the occurrence of any emergency vehicles such as ambulance, fire brigade, etc. in any lane and also provides the mechanism to detect the route of a vehicle. Once implemented, it does not require any human assistance for its working.

2 Classification of ITS

ITS is being researched and implemented through various means such as the use of wireless sensor networks, RFID, applying various concepts of graph theory to find the minimized path and many other. Here, the concept of ITS has been classified into two broad domains, namely, (I) real-time system and (II) data analysis system.

Real-time systems have been further diversified into two fields:

I. Path optimization and II. Traffic density. The data analysis systems are also divided into two parts:
i. Green light optimization, ii. Information chaining systems.

2.1 Real-Time Systems

Real-time systems in case of traffic managing system take the input of the current situation through video surveillance or WSNs and deal with the situation. The traffic signals are controlled according to the presence of vehicles and are operated automatically in real time. A real-time optimization model was used by Dotolie et al. [1] that investigated the issue of traffic control in urban areas. The model took into considerations the traffic scenarios which also include pedestrians. This technique was applied for analyzing real case studies. Wenjie et al. [2] concentrate on calculating the time that a vehicle requires to reach the intersection from a particular point, dynamically, by the use of sensors. By this, data performs various calculations to find the green light length. Albers et al. [3] used real-time data to monitor current traffic flows in a junction so that the traffic could be controlled in a convenient way. Reliable short-term forecasting video captured in a recorder plays an important role in monitoring the traffic management system. The data required can be easily provided by the CCTV cameras that can be beside the roads as per requirement. Van Daniker [4] visualized the use of transportation incident management explorer (TIME) for calculating real-time data. Challal et al. [5] proposed a distributed wireless network of vehicular sensors to get a view of the actual scenario and used its various sectors to lower the congestion but not taking decisions in real time. The use of two types of sensor network was proposed, vehicular sensor network and wireless sensor network, and the combination of these two permits the monitoring as well as managing of the traffic. Chandak et al. [6] used video surveillance for realizing the real-time scenario. It deals with decreasing response time of the emergency cars by establishing communication between emergency cars and traffic lights. The data collected in real time can be used to determine the traffic density and also based on the traffic present. Several path optimization techniques can be used, which are discussed in the next two sections.

2.1.1 Traffic Density

Realization of the traffic density at a particular intersection for a given time can also help in reducing traffic congestion at that point. This data can be analyzed to determine several factors like green light length, traffic at the particular time, etc. Zhou et al. [7] used the concept of adaptive traffic light control algorithm which manipulates both the sequence and length of traffic lights in accordance with the detected traffic. The algorithm uses real-time data like the waiting time of vehicles, volume of traffic in each lane, etc. to determine traffic light sequence and optimal length of green light. The algorithm produces lower vehicle's average waiting time, thus providing much higher throughput. The system proposed by Sinhmar [8] used IR sensors to determine the density of traffic based on which the traffic signals were updated to provide a smooth flow of vehicles. Hussain et al. [9] proposed a system that uses a central microcontroller at every junction which receives data wireless sensor placed along the road that determines the traffic density. The microcontroller uses this data to control the traffic using the programed algorithm to manage the traffic in an efficient manner. Srivastava et al. [10] suggested ways to determine the number of vehicles using weight sensors, then with the use of a programmable logic controller to analyze the data, and then park in automated parking or has diverge them accordingly.

2.1.2 Path Optimization Technique

Finding the best and shortest path to destination can be used as a tool to minimize the traffic along a path. The traffic along the road can be sent to the incoming vehicle proving them the idea about the traffic and thus they can take an alternative path to the destination. Gambardella [11] and Bertelle et al. [12] proposed to find an optimized path for transportation using the concept of ant colony optimization. Once an optimized path is found, we can add several other features to make it more convenient and avoid traffic jams. Ozkurt et al. [13] have proposed the use of video surveillance and neural network to reduce the traffic stress across the network. Xia [14] researched to find an optimal road network and analyze the traffic dynamics by the movement of each car and the statistical property of the whole network. Kale et al. [15] designed a system that uses the traffic information and sends it to the incoming ambulance by allowing it take way according to the situation. The various performance evaluation criteria are used such as average waiting time, the average distance traveled by vehicles, and switching frequency of green light at a junction.

2.2 Data Analysis Systems

Data analytical systems are those systems that take the present or statistical data, process them in the processor, and then act according to predefined algorithm. Like real-time systems, it may collect data in real time, but is unable to take any decision in real time, i.e., it must follow the instructions that are provided to it. Yousef et al. [16] suggested a scheme of solving traffic congestion in terms of the average waiting time and length of the queue at the isolated intersection and provide efficient flow in global traffic control on multiple intersections with the accordance of real-time data. Thus, the data collected can be used in various ways depending on the perspective of the user. The next two sections define such ways of using the data.

2.2.1 Information Chaining System

The data collected at one junction can be sent to the other junction informing it about the situation and allowing it to take measures. The same can be used in case of cars, ambulance, and other vehicles. This is quite similar to the path optimization technique, but here the path that would be taken by the user is not suggested by the system, and it just warns the others in case of any unwanted situation. Malik et al. [17] described the traffic control on a real-time basis using the traffic lights. Wireless sensors are deployed on each of the lanes that are able to detect number of vehicles passing and also the awaited vehicles and convey the information to the nearest control station. Blessy et al. [18] proposed a system that uses other vehicles to deliver messages about any congested path. They used an adjustable field radar-based system, vehicle controller sensor, which senses the count of the vehicles, rejecting the humans for certain distances. GSM service is used to send information about the congested junction to the server located in a remote location which in turn will inform its adjacent signal junction and also to other drivers about the congestion, forming a chain-like structure informing one another and suggesting them to change route if necessary.

2.2.2 Green Light Optimization

One of the main causes of traffic congestion is large red light delays, so controlling traffic signals and optimizing the length of the green light will become helpful. Chen et al. [19] have given the solution for minimizing waiting time of vehicles by testing the setting problems of traffic light. Here, the graph model is used to represent the traffic network. In order to achieve optimal solution [20–24], the paper has used particle swarm optimization [25, 26], ant colony optimization [27] and genetic algorithms which have greater importance. Soh et al. [28] presented a MATLAB simulation of fuzzy traffic controller for controlling traffic flow in the multilane isolated signalized intersection. The controller controls the traffic light timings and phase sequence to ensure smooth flow of traffic with minimal waiting time, queue length, and delay time. Jantan et al. [29] proposed monitoring system in addition to the traffic light system to determine different street cases (e.g., empty, normal, crowded) with different weather conditions using small associative memory depending on the stream of images, which are extracted from the streets' video recorders. It also gives a high flexibility to learn different street cases using different training images. Placzek [30] described a method which is designed to be implemented in an online simulation environment that enables optimization of adaptive traffic control strategies. Performance measures are computed using a fuzzy cellular traffic model, formulated as a hybrid system combining both cellular automata and fuzzy calculus. Dakhole et al. [31] used ARM7-based traffic control system that proposes a multiple traffic light control and monitoring system that reduce the possibilities of traffic jams, caused by traffic lights. This system uses ATmega16 and ARM7 for its processing. Jaiswal et al. [32] described the optimization of traffic signals by focusing on three areas—Ambulance, priority vehicles (like VIP cars, police jeeps), and Traffic density control—thus providing a stoppage free path for ambulances, preventing traffic congestion, and also managing traffic density by increasing duration of green light of the lane where density is high (Table 1).

Table 1 Summarization of classification of ITS

		Name	Summarization	Remarks
Intelligent traffic system	Real-time system	Traffic density	Finding the density of vehicles along a road and follow a certain algorithm to direct the vehicles	On spot detection and handling of traffic. Requires good financial investment
		Path optimization	Deciding an optimal path, for an incoming vehicle based on the traffic present at the approaching junction	Real-time analysis of data to find an easy path, but not applicable for all situations where alternative path is not present
	Data analysis system	Information chaining system	To inform the vehicles about the traffic along any lane and directing them to change to another route if necessary	Useful in routing of vehicles in an optimized path, but highly developed and error-free system is required else ambiguous situation may arise
		Green light optimization	Use of different logics like fuzzy logic and other simulation techniques to determine the green light length so that every lane is provided with some appropriate time slot	Highly efficient system. Requires large capital for implementation

3 Proposed Method

The proposed model mainly concentrates on the following factors:

(i) Unnecessary consumption of the time slice in a certain lane, when there are fewer vehicles.
(ii) If any lane has any emergency vehicle such as ambulance, it also has to wait for its turn.
(iii) A lane with less or more traffic has to wait for the same time span.

Normally, the green signal in the traffic light remains on for a fixed interval for each road. In the existing system, congestion of vehicles may happen if lots of vehicles are waiting in a particular lane and the other lane which has fewer numbers of vehicles is made free.

3.1 Hardware Implementation of the Method

In the proposed model, infrared proximity sensor, AT Mega 2560, and RF modules have been used to design the system. The infrared sensors will be used to collect data from the lane and fetch the collected data to the microcontroller. In each road, there will be four infrared sensors which will be placed at a certain distance from the intersection, placed on either side of the roads in pair dividing the considered length of the road from the intersection into two zones—a high density zone and low density zone. The presence of vehicles in each region is sensed by two proximity infrared sensors placed at either side of the road in the opposite direction. The sensors are placed by keeping a certain distance so that they do not have an intersection point. The use of two sensors eliminates the factor if "vehicles are present along one side only," i.e., it gives us the real view in what manner the vehicles are aligned along the road. The sensors are connected to the analog pins of the microprocessor and the traffic lights to the digital pins. While placing the sensors, it is to be kept in mind that the range of the sensors does not intersect, which will result in erroneous data read (Fig. 1).

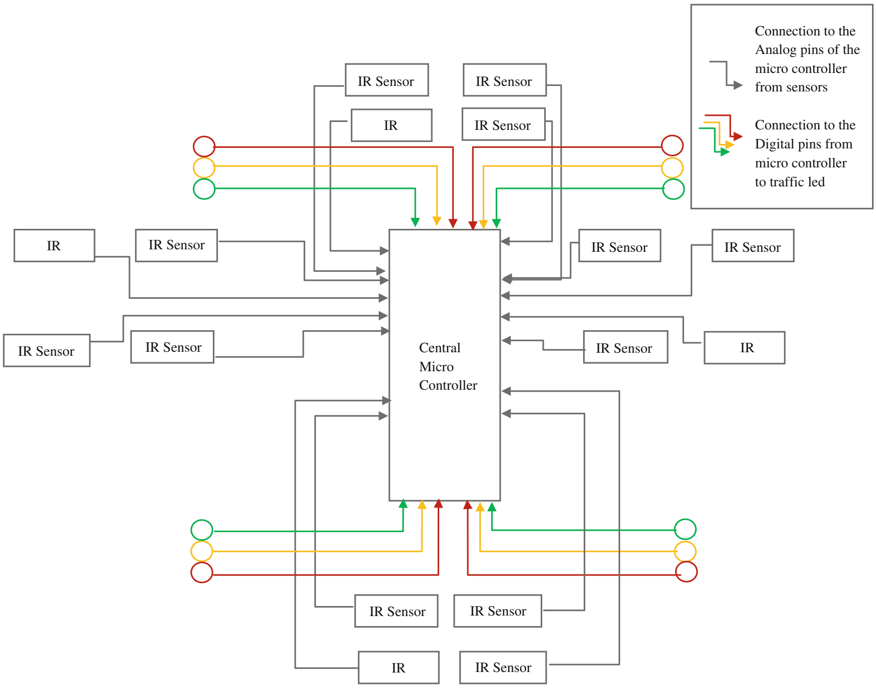

Fig. 1 Schematic circuit diagram of the proposed model

3.2 Prioritizing the Lanes

Moreover, it gives us the option to classify the density into multiple values. Like, if all the four sensors of one lane sense the value low, then there will be no traffic and the priority assigned is zero in this case. When both the two sensors in low intensity zone sense the value as low, but both the sensors in high intensity zone sense the value as high, then this case will not be considered, and it is not possible. Suppose one of the two sensors in low intensity zones gives the value as high, but the two sensors in high intensity zone sense the value as low, which will indicate that the traffic is very less in this lane and the priority assigned is one. If two sensors from the same side one from low and the other from the high intensity zone sense the value as high, then it will indicate that one side of both zones is full and the other side is free from traffic and the priority assigned is two. Then if both the sensors in low intensity zone sense the value as high, but the sensors in high intensity zone sense the value as low, then the low intensity zone is full but no vehicle in the high intensity zone and the priority assigned is three. When both the sensors in low intensity zone sense the value as high and one of the sensors in high intensity zone senses the value as high, then it will indicate that low intensity zone is full but no vehicle in one side of the high intensity zone and the priority assigned is four. If all the four sensors provide the value as high, then it will indicate that there is vehicle in both the zones, i.e., both is full which gives high alert and priority assigned to this case is five (Fig. 2).

Fig. 2 Conceptual view of the proposed model

3.3 Algorithm for the Control of Traffic Lights

The proposed algorithm initially senses the vehicular length of each lane and sets its priority and pushes it into the stack.

The sequence in which the lanes are pushed will be executed in this sequence only. Sense_and_Set check the length of the vehicles and set their time accordingly, also keeps a check that the lane with lower priority initially may have acquired a higher priority than its preceding lane; in such case, the green light duration T_i, to be provided to the present lane, is decreased. The stack is popped after execution of each lane. Once the stack is empty, the lanes are once again pushed into the stack according to priority and executed accordingly.

```
Control_Algo
        P_STACK [4]: Stack to store the lane according to priority.
        Ti: Green Time assigned to the lane.
        Pi, Pi-1: Priority assigned to the top two lanes.


        While (true) repeat
            Sense_and_Push (): for setting the P_STACK          .
            While (Length.P_STACK not equal to 0) repeat
                Sense_and_Set (P_STACK): sense the priority for the lane at the top of the
                P_STACK and setting the green light time of the lane at the top of the
                P_STACK.
                Execute (P_STACK, Ti): Execute the green Light of the lane at the top of the
                P_STACK.
End.

Sense_and_Push ()
    Sense each lane and prioritize them.
    Push the lane according to their priority into P_STACK, the lane at the top of the P_STACK has maximum
    priority.

End.
Sense_and_Set (P_STACK)
    If there is an emergency vehicle across any lane
        Bring it to the top of the P_STACK, Set Ti
    Return.
    Else
        Sense the priority of the top two elements of the stack.
        Pi= Priority of the lane at the top of the stack.
        If (i=0)
            Pi-1 =0.
        Else
            Pi-1 = Priority of the lane next to the top of the stack.
        Set Ti according to Pi
        If (Pi < Pi-1)
            Indicating that the vehicle length has increased after setting the P_STACK.
            Update Ti
End.

Execute (P_STACK, Ti)
    Set the green light for the lane at the top of P_STACK for time Ti.
    Set the yellow light for the lane next to the top of the P_STACK for time Ti, indicating that it will be
    executed next and red to the other two lanes..
    Pop P_STACK
    End.
```

4 Conclusion

The work presents review of the existing research done in field and tries to develop a system suitable for developing countries. The project has two objectives, which are, first, calculating the length of the vehicles on the road for the flow of the traffic smoothly without congestion and, second, developing priority-based signaling which will help to give the priority to the emergency vehicles such as ambulance. The microcontroller can be programed easily which gives scope for deployment better algorithms in future. The sensors are to be fitted on the side of the roads and connected to the controller at the intersection. These are some hectic jobs which are to be dealt before implementing the system, but once implemented, it will make our traffic system more convenient and cities smarter.

References

1. Mariagrazia, D., Pia, F.M., Carlo, M.: Real time traffic signal control: application to coordinated intersections. In: IEEE International Conference, vol. 4, pp. 3288, 3295. 5–8 Oct 2003
2. Wenjie, C., Lifeng, C., Zhanglong, C., Shiliang, T.: A realtime dynamic traffic control system based on wireless sensor network, parallel processing, 2005. In: International Conference on ICPP Workshops, pp. 258–264. 14–17 June 2005, ISSN: 1530-2016, Print ISBN: 0-7695-2381-1
3. Queen, C.M., Albers, C.J., Forecasting traffic flows in road networks: a graphical dynamic model approach, 29 July 2008
4. VanDaniker M.: Visualizing real time and archived traffic incident data. In: Proceedings of the 10th IEEE International Conference on Information Reuse and Integration, pp. 206–211. IEEE Press Piscataway, ©2009, ISBN: 978-1-4244-4114-3
5. Sharma, A., Chaki, R., Bhattacharya, U.: Wireless sensor networks. In: 3rd International Conference on ICECT, Jan 2011. doi:10.1109/ICECTECH.2011.5941955
6. Amine Kafi, M., Challal, Y., Djenouri, D., Bouabdallah, A., Khelladi, L., Badache, N.: A study of wireless sensor network architectures and projects for traffic light monitoring. In: International Conference on Ambient Systems, Networks and Technologies, pp. 543–552, 28 Aug 2012
7. Zhou, B., Cao, J., Zeng, X., Wu, H.: Adaptive traffic light control in wireless sensor network-based intelligent transportation MATLAB. In: Vehicular Technology Conference Fall, IEEE 72nd, pp. 1–5, 6 Sept 2010
8. Promila Sinhmar, A.: Intelligent traffic light and density control using ir sensors and microcontroller. Int. J. Adv. Technol. Eng. Res. **2**(2), 30–35 (2012)
9. Hussian, R., Sharma, S., Sharma, V., Sharma, S.: WSN applications: automated intelligent traffic control system using sensors. Int. J. Soft Comput. Eng. **3**(3), 77–81 (2013)
10. Srivastava, M.D., Prerna, Sachin, S., Sharma, S., Tyagi, U.: Smart traffic control system using PLC and SCADA. Int. J. Innov. Sci. Eng. Technol. **1**(2), Dec 2012
11. Gambardella Luca M.: Ant colony optimization for ad-hoc networks. In: The first MICS workshop on routing for Mobile Ad-Hoc Networks, Zurich, 13 Feb 2003
12. Cyrille, B., Antoine, D., Sylvain, L., Damien, O.: Road traffic management based on ant system and regulation method (2006)
13. Ozkurt, C., Camci, F.: Automatic traffic density estimation and vehicle classification for traffic surveillance systems using neural network. Math. Comput. Appl. **14**(3), 187–196 (2009)

14. Yongxiang, X., Traffic control and optimization in road networks, 4 Sept 2009
15. Kale, S.B., Dhok, G.P.: Design of intelligent ambulance and traffic control. Int. J. Comput. Electron. Res. **2**(2) 2013
16. Yousef, K.M., Al-Karaki, J.N., Shatnawi, A.M.: Intelligent traffic light flow control system using wireless sensors networks (2010)
17. Malik, T., Yi, S., Hongchi, S.: Adaptive traffic light control with wireless sensor networks. In: Proceedings of IEEE Consumer Communications and Networking Conference, pp. 187–191, 2007/1
18. Blessy, A., Devi, Reeona: An automatic traffic light management using vehicle sensor and GSM model. Int. J. Sci. Eng. Res. **4**(6), 2354–2358 (2013)
19. Shiuan-Wen, C., Chang-Biau, Y., Yung-Hsing, P.: Algorithms for the traffic light setting problem on the graph model (1996)
20. Dey, N., Samanta, S., Yang, X.-S., Chaudhri, S.S., Das, A.: Optimisation of scaling factors in electrocardiogram signal watermarking using cuckoo search. Int. J. Bio-Inspired Comput. (IJBIC) **5**(5), 315–326 (2013). (Impact Factor: 1.681) (Science Citation Index, Scopus)
21. Day, N., Samanta, S., Chakraborty, S., Das, A., Chaudhuri, S.S. Suri, J.S.: Firefly algorithm for optimization of scaling factors during embedding of manifold medical information: an application in ophthalmology imaging. J. Med. Imaging Health Inform. (Impact Factor: 0.623) (Science Citation Index Expanded (SciSearch), Scopus)
22. Samanta, S., Acharjee, S., Mukherjee, A., Das, D., Dey, D.: Ant Weight Lifting Algorithm for Image Segmentation, 2013 IEEE International Conference on Computational Intelligence and Computing Research(ICCIC), Madurai, Dec 26–28 2013 [IEEE Xplore]
23. Samanta, S., Chakraborty, S., Acharjee, S., Mukherjee, A., Dey, N.: Solving 0/1 Knapsack Problem using Ant Weight Lifting Algorithm. In: 2013 IEEE International Conference on Computational Intelligence and Computing Research(ICCIC), Madurai, Dec 26–28 2013 [IEEE Xplore]
24. Chakraborty, S., Pal, A.K., Dey, N., Das, D., Acharjee, S.: Foliage Area Computation using Monarch Butterfly Algorithm. In: 2014 International Conference on Non Conventional Energy (ICONCE 2014), JIS college of Engineering, Kalyani, January 16–17, 2014. [IEEE Xplore]
25. Dey, N., Chakraborty, S., Samanta, S.: Optimization of watermarking in biomedical signal. Lambert Publication, Heinrich-Böcking-Straße 6, 66121 Saarbrücken, ISBN-13: 978-3-659-46460-7
26. Chakraborty, S., Samanta, S., Mukherjee, A., Dey, N., Chaudhuri, S.S.: Particle Swarm Optimization Based Parameter Optimization Technique in Medical Information Hiding. In: 2013 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), Madurai, Dec 26–28 2013 [IEEE Xplore]
27. Jagatheesan, K., Anand, B., Dey, N.: Automatic Generation Control of Thermal-Thermal-Hydro power systems with PID controller using Ant Colony Optimization, International Journal of Service Science, Management, Engineering, and Technology (IJSSMET), Vol 6, Issue 2
28. Azura Che Soh/Lai Guan Rhung: MATLAB simulation of fuzzy traffic controller for multilane isolated intersection. Int. J. Comput. Sci. Eng. **02**(04), 924–933 (2010)
29. Emad, I., Kareem, A., Jantan, A.: An intelligent traffic light monitor system using an adaptive associative memory. Int. J. Inf. Process. Manag. **2, 2**(2.4), 23–39 (2011)
30. Placzek, B.: Performance evaluation of road traffic control using a fuzzy cellular model. In: 6th International Conference on HAIS, Wroclaw, pp. 59–66. Proceedings, Part II, 23–25 May 2011
31. Dakhole, A.Y., Moon, M.P.: Design of intelligent traffic control system based on ARM. J. VLSI Signal Proc. **4**(4), 37–40 (2014). Ver. I
32. Jaiswal, S., Agarwal, T., Singh, A., Lakshita, : Intelligent traffic control unit. Int. J. Electr. Electron. (ISSN NO. (Online): 27-2626 and Computer Engineering **2**(2), 6–72 (2013)