Digital and Intelligent Traffic Management System using Cross Road Technique

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Abstract
In today's time where everything is revolving around technology it demands our traffic system as well to be as per recent technologies. The aim of this research is to provide a design for establishing and managing traffic lights based on long range distribution. The system focuses on overcrowded traffic and congestion caused due to it. Proposed system is designed to run the traffic system in such a way that it does not involve any human intervention at circumstances of overcrowded traffic. The system is also built to reduce the noise pollution problem caused due to congestion of vehicles and stabilize other environmental problems caused due to it. The system also ensures that no traffic rule is violated and manages the traffic smoothly and intelligently.

Keywords: *Traffic lights, Congestion, Overcrowded traffic, Noise pollution, Environmental Problems.*

Introduction

With the evolution in time there has been rapid increase in urbanization across the globe. This has resulted in large number of vehicles all over the cities. This demanding increase in automobiles has also led to increase in traffic problems like overcrowded traffic and congestion of vehicles during rush hours [1].

It not only affects timing of people but also emergency vehicles such as ambulance, fire brigade vehicles are either stuck or delayed to their specific destination resulting in heavy loss [2].The traffic density pattern also remains irregular till the end of the day.

Though congestion can be controlled by flow structure, utilizing various models like vehicle detectors and sensors [3] but the noise pollution caused due to congestion is still a major problem in traffic management.

A noise map is a graphical representation of spatial distribution in a defined region. The aim of this system is to determine the exposure to environmental noise through the noise mapping and to implement plans based on noise to prevent environmental noise and noise pollution caused due to it [4].

Thus we need an Intelligent Traffic Management System that can overcome the above traffic related problems and work in an efficient way such that it not only reduces the congestion related problems but also monitors that there is no violation of traffic rule and manages the traffic smoothly in digital manner.

2. Literature Survey

With the rapid increase in technology digital surveillance plays a very important aspect for smooth traffic management. There are various algorithms and model designed for the traffic management control. The model such as Scoot system which was designed in order to carry out optimum utilization of time management at traffic light [5].The other model was designed for drivers to provide important information on helping them for choosing the appropriate path[6].Some models were also designed in traffic management for short term[7].

Certain algorithm and models are based on counters which are used for measuring the traffic management [8,9]. A framework was designed for automatic traffic light control expert system to analyze the traffic management [10].

The Recent studies are being focused on importance and application of RFID technologies along with its impact on business operations[11].As the traffic flow has been characterized with its randomness and uncertainty the applications of Fuzzy logic has been made for traffic signal control[12].

3. Traffic Management Model System

Traffic Management not only affects the social life significantly for drivers and pedestrians but also has meaningful influence on environmental aspects of city lifestyle but controlling autonomous entities that are capable of committing errors possess certain research challenges like finding a proper model, its assumption getting verified and reaching to certain level of usefulness through optimal schemes. These points are not only important now but it will have its importance even more in future as we are living in the dawn of the era of intelligence.

3.1 Components of traffic management system

3.1.1 Central Control System

Installed in the traffic control cabinet situated at the traffic locations.Switches the System from normal mode to intelligent mode and vice versa as per the logic.Handles the contingent cases.Receives the sensor recordings and saves in local database.

3.1.2 Sensors

This are placed at one side of road preferred with no exits. It is used to detect the presence of vehicles also used to check whether destination extensions are clear or not.

3.1.3 Contingency cases alarm

This are basically required for police vehicle, ambulance, fire trucks and other contingency cases that require open roads. Reporting of such contingency cases is done in two ways:

1.Installing an active RFID (Radio Frequency Identification) built in a specific vehicle which is detected by RFID Reader placed behind S3 sensor that sends the readings to central control system to take necessary actions.

2. Second, the driver of such vehicle is well equipped with a mobile device which sends a specific radio signal to the central control system to open the road.

3.1.4 Traffic Lights

Connected to the central control cabinet and works according to the received instructions from the central control system

3.2 Operation of Traffic Management System

The proposed model of Intelligent cross road traffic management system depends on using photoelectric sensors on one side of the road preferred that they are not located on the side with more than one exits. These sensors are located on varying distances in the following order (from S0 to S3) as shown in fig. 2. The system also depends on usage of sensors DS j where j represents the possible extensions for a specific road after the traffic, their main function is:

- To give information regarding capability of opening a traffic in these destinations.
- The readings are provided to the central traffic control system at the traffic control cabinet.

The proposed system also requires the relative weights of roads priorities to be set by the traffic management authority to the directions as per the importance of each road. To explain the operation of the proposed system the following symbols are defined

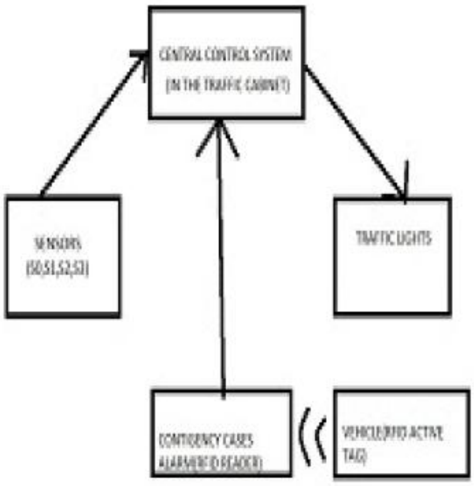

Figure 1: Model of Traffic Management System

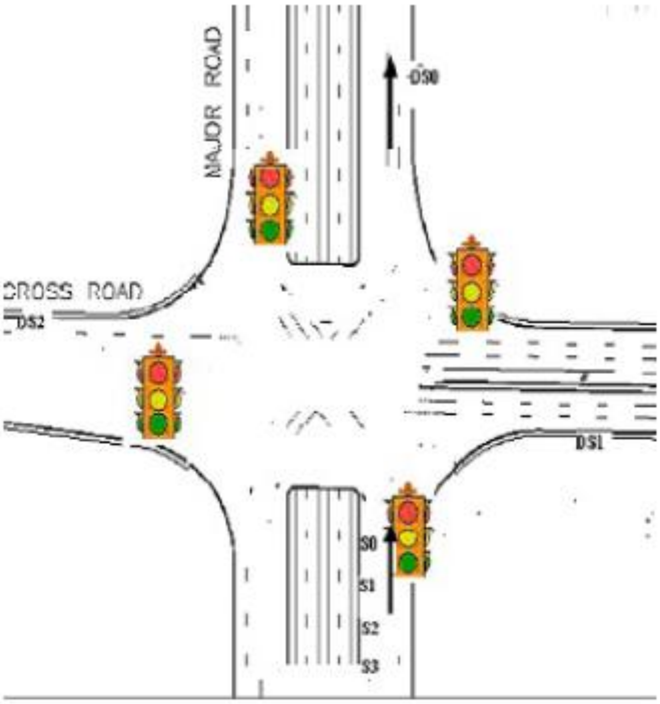

Figure 2: Cross Road Traffic Opertation

Ri: R represents the road, and i represents the road no from 1 to 4.
Pi: P represents the relative weight of a road Ri priority, which represents the importance of road i to be opened). Also, a fixed weight is given to each sensor from S0 to S3.
The Total Weight (TW) that the opening priority of a specific direction i in the cross road traffic is calculated according to the following equation (1):

$$TW_{(Ri)} = \sum_{m} {}_{=0}^{3} S_m + P_i \quad (1)$$

With the condition that the traffic is required to open to one destination that the destination emptiness sensors readings, DSj are positive where j takes the values from 0 to 3, if we have a cross road traffic as the one shown in fig. 2. Flow chart showing the algorithm which is applied by the traffic system for its management is shown in fig. 3.

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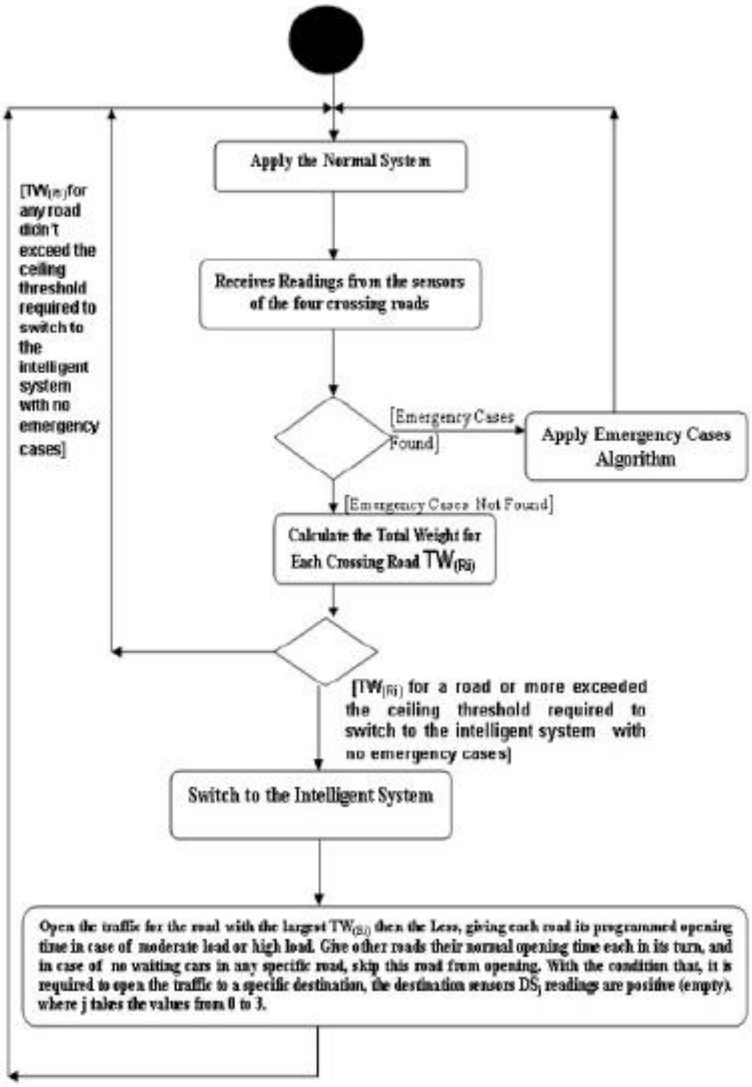


Figure 3: Operation of Central Control System

The flowchart of traffic management system for fire vehicles, ambulances and police vehicle like emergency cases is explain in fig. 4. In this first RFID Reader Detects the emergency cases and sends the request to Central control system which switches to smart mode from normal mode. The Central Control System gives the emergency request highest priority and opens the traffic in highest priority sequence such that the emergency vehicles can come over the traffic congestion and be used for in emergency cases for helpful purposes. Then after clearing the queue the central control system switches to normal mode. Thus by this working of the traffic management system the emergency cases vehicle can be used to secure the life of citizens without any delay by which the city does not suffer from any problem where there is need for an emergency vehicle.

3.3 Models and Approaches for traffic management System

3.3.1 Nagel-Schreckenberg model

Nagel-Schreckenberg recognized as one of the best microscopic traffic models. It is mainly based on cellular automata. In its basic version (presented in Fig. 5), it operates on a single dimensional array of cells where each can be in one of two states: free or occupied by one of the cars.
All cars have a current speed expressed as an integer belonging to the [0, Vmax] range.

The actualization of the system is realized according to the four steps below (for all cars simultaneously):

- accelerating: if the speed of the car is slower than Vmax and the distance to the preceding car is greater than v+1 the car's speed is increased by 1 $[V \leftarrow V + 1]$;
- deceleration: if the car in cell i can see the car in cell i + j (where j v), it decelerates to v = j 1;
- randomizing: if the car speed is greater than 0, it is randomly reduced by 1 $[V \leftarrow v \; 1]$;
- car movement: the car is moved forward by v cells.

This approach simplifies the process of model updating however, it also leads to the unrealistic behaviour of cars but its second rule guarantees a lack of collisions, because the value of deceleration is unlimited. The basic version of Nagel-Schreckenberg reflects only for the simplest possible situation i.e.one-way traffic with neither overtaking cars nor changing lanes.

3.3.2 Multi-variant approach for crossroad management

1.Introduction:
One of the main difficulties while considering crossroad planning and management is the unpredictability of driver behaviour. This has been taken in consideration of the models like Nagel-Schreckenberg. They have introduced a special

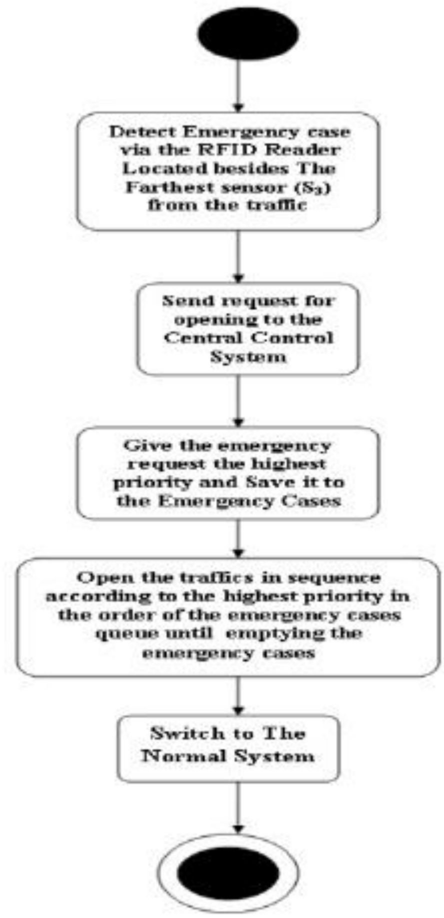


Figure 4: Working in an emergency cases

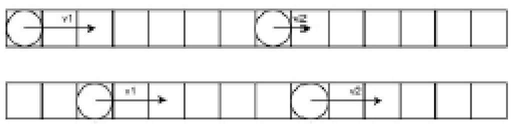
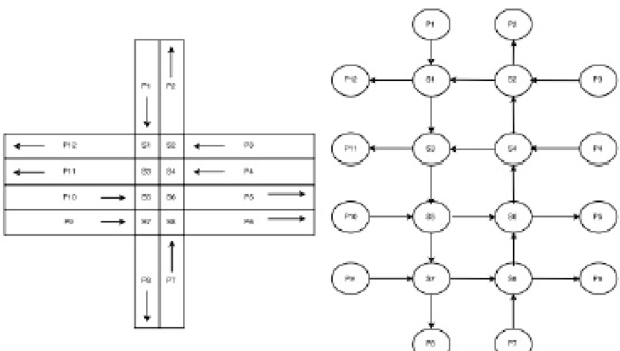


Figure 5: Nagel-Schreckenberg Model for V-max =2



(a) Crossroad scheme

(b) Crossroad model

Figure 6: Crossroad and its model

random factor p representing the probability that a driver will spontaneously slow down within a given time unit while the other cross-road management models assumes that driver will behave in deterministic manner.
So from the above points a natural hypothesis can be formulated:

When the non-deterministic driver behaviour is taken into consideration, applying multi-variant planning along with an evolutionary multi-agent system allows in reducing the total time needed to cross a crossroad

2.Model of Crossroad Management:

In this simulation, crossroads are pictured as a directed graph with two kinds of nodes: semaphores and lanes. The first type of node is semaphore representing a portion of the road that can be accessed from more than one place.
The another node is a lane which represents the portion of the road where a car can be driven in only one direction. Every individual lane has a list of semaphores that have to be crossed in order to access the other lane when the current one is abandoned.
The sample crossroad in Fig. 6a is depicted as presented in Fig. 6b. The Nodes S1–S8 are semaphores which are arranged to reduce number of accidents occur. Nodes P1–P12 are the traffic lanes. For lane P3 List S2,S1,P12 can be defined as example, which means that to access lane P12 from lane P3, the subsequent semaphores must be driven through: S2 and S1—checking, while they can be driven through the time window allotted.

3)The Model of the Drivers:

In this Crossroad model, the drivers are represented with following set of parameters:

- v—the current speed of the driver.
- vmax—the maximum speed of the driver.
- a—the maximum acceleration of the driver.
- m—the maximum deceleration of the driver (car).
- p—the probability of spontaneously slowing down by 1 within the given time unit.
- pos—the actual position of the driver in the crossroad;

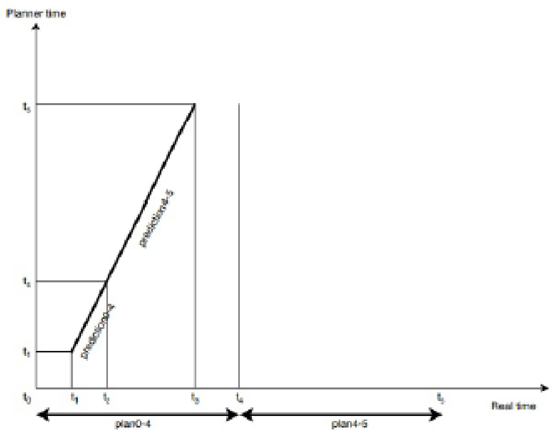


Figure 7: Idea of multi-variant planning

. id—the identifier of the destination lane (the node on the graph) to which the driver is aiming in the simulation;
As per above set of parameters, drivers make decisions about speeding up, slowing down, or holding their current speed in consecutive time units by which model and planning method becomes more realistic than the Nagel-Schreckenberg model, that assumes an immediate stopping of car.
The idea of the multi-variant planning in Fig. 7 can be depicted as follows in the case of crossroad management:

1.For the actual distribution of cars before the crossing at moment t1, the Nagel-Schreckenberg simulation is realized n-times, according to the assumed parameter p, obtaining n possible positions at moment t4
2. For each of the n-generated car distributions, an independent meta-heuristic based optimization (in the described case, EMAS was employed) is performed (from the time moment of t2 to t3).
3. For the actual distribution observed at t3, the simulation with p = 0 is performed, obtaining the most-probable car distribution in the t4 time moment.
4. The best of the n-obtained solutions (considering the fitness values) is selected before t4 passes, and this is applied during the period of t4 to t5.

No. of. cars	p=0.001	p=0.05	p=0.01
10	0.98	0.74	0.41
20	0.94	0.41	0.09
30	0.88	0.20	0.02
40	0.81	0.09	0.003
50	0.74	0.04	0.0005
60	0.66	0.02	0.00008

Table 1: The probability of preparing the variant according to the situation in moment t4

Table 1 shows the probabilities for the optimized n variants, the one actually occurring at t4 is shown, considering the number of cars and the p parameter, assuming that it is possible to conduct an optimization for the number of variants equal to the number of cars plus one, for 20 time steps.Table 1 makes it possible to state that the differences in the observed optimizations for certain values of p becomes negligible when the number of cars exceeds 40. For lower traffic density, a lower value of p equals higher predictability of the driver's behavior, thus hampering the optimization results. Moreover, by increasing the number of cars, the gain from the multi-variant planning decreases when compared to sequential crossroad lights (although it is still several percentage points higher, even for 60 cars).Thus the work of multi-variant approach is shown in the crossroad model of traffic management system.

4. Conclusion

In this paper an intelligent cross road traffic management and control system has been introduced along with it the components of model has been described. The proposed system aims to :

- 1. Overcome the traffic jam.
- 2. Create a smooth flow of traffic in city streets.
- 3. represent the total calculated relative weight of a specific direction in a cross road traffic.
- 4.Reduce the pollution caused due to congestion of vehicles.
- 5. Present an adaptive model to provide efficient and near-to-the-optimal traffic management for local intersections supporting any number of phases and fully parameterized.
- 6.Studied the effectiveness of our proposed system in different traffic scenarios

5. Future Scope

This traffic management system needs to be applied first on experimental traffics, then can be used all across the cities . In the coming time the traffic management system model gets integrated with various types of transportation sources, along with stationary and moving cameras ,GPS devices, historical databases and providing coherent and integrated information to users through web-based interface. Future work may include the proposed algorithm for global traffic management, that includes the optimization of all the intersections in Smart Cities. In future the Deep Learning and AI can be used in optimization process for traffic management by using the speed and current location of the village

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