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Smart Traffic Light System by Using Artificial Intelligence

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Abstract: Traffic congestion is one of the most significant problems in cities rapidly growing due to increased population and urbanization rates. As a consequence stress emerging due to air and noise pollution and fuel consumption make city life more difficult. Basic traffic lights work through one of the two simple mechanisms one is pre- established timing plans that regulate green red cycles while other is pavement loop detectors which can tell when a car is waiting for a green. With heavy traffic in multiple directions and variable fluctuation these mechanisms are way too primitive for urban cities like Karachi. Traffic lights is just like smartphones or any electronics which need to evolve. These days we have cameras and wireless capability of detecting how many cars are passing and when they're passing. Once we have gathered this information live from the traffic stream the problem just becomes a big math equation where we're just looking for optimal green-red distribution and like any optimization problem the answer is intuitively simple, let artificial intelligence to take over.

Keywords: Traffic Congestion, Optimization, Artificial Intelligence

1. INTRODUCTION

With enormous increase in population, traffic congestion is becoming highlighting issue oftoday'sera. Congestion on Pakistan roadways are never been real worse, and with increasingtraffic accidents our roads are life threat of everyday routine. Plus lack of traffic sense and notfollowing traffic rules are always helping people to get into near death trouble(Cohen 2014). We waste a lot oftime sitting in our vehicles and honking for thousands of valuable hours a day. This threat isincreasing every year hence problem will be worse in future, our next generation will be gaspingfor a whiff of fresh air.

Traffic jams are the result of competition for a scarce and highly valuable resource. Living in21st era of driverless vehicles we still race for basic need for up gradation for a controlled trafficsystem.Traffic congestion are controlled effectively via traffic signals, it's a reliable way to controlintersection of everyday traffic world.Hence in this paper we are mainly focusing on traffic signal perceiving live traffic data and viahelp of AI proposing a solution on runtime.

Currently there are 3200 automotive manufacturing plants in our country Pakistan, with investment of 92billion they produce 1.8 million motorcycles and 200,000 vehicles annually (Triana *et al.* 2013). Hence precautionsare needed to be made for securing future and making life less problematic. We live in a world of technology surrounding by advanced onboard sensors such as radar andsonar, mobile phones, cameras, traffic control systems etc. We just need to compile and givethem brain (AI)(Surden and Williams 2016).

The key component to this solution will be proposing a traffic signal which can perceive heavytraffic area and highlight a schedule of which lane at what time is busy and causing congestionissue.Next step will be analyzing that data and perceive logical and minimal schedule on which intelligence can be performed. After getting appropriate congestion schedule we can make traffic lights communicate. Thiscommunication can help reduce congestion. Imagine a signal in between of intersectionroadway where traffic is coming altogether from 4 roads. So we will perform tasks of proposing atraffic signal which can act according to given data and adjust themselves to show red yellowgreen lights to reduce congestion.

This paper is organized as follows. Section 2 presents literature review and section 3 identifies the challenges faced in this area of research. In Section 4, we have discuss our proposed AI based traffic control systems and In Section 5 identifies the research discussion. Finally, In Section 6, provides conclusions and some future directions of the researchers in this area.

2. LITERATURE REVIEW

With the increase in population, the urban life is getting busy day by day which resulted tremendously increase in motor vehicles, traffic congestion is becoming highlighting issue of today's era(Carley and Christie 2017). Traffic signals are supposed to be the most convenient method of managing traffic in a hectic junction. But, we can see that these signals not performing and handling the traffic effectively when a particular lane has got more traffic than the other lanes. This will result some lanes more crowdie then the

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others. To overcome this problem we can use smart traffic lights instead of normal traffic lights.

One of the easiest ways to make the traffic signs can apportion distinctive paths to various vehicles in light of their weight, like buses, trucks and so forth in one path, cars in one path and like this the traffic blockage can be resolved by separating the traffic as needs be. In this strategy, expect to quantify the traffic by including the quantity of vehicles in every lane and their weight, at that point diverge them in like manner (Soh, *et al.* 2010).

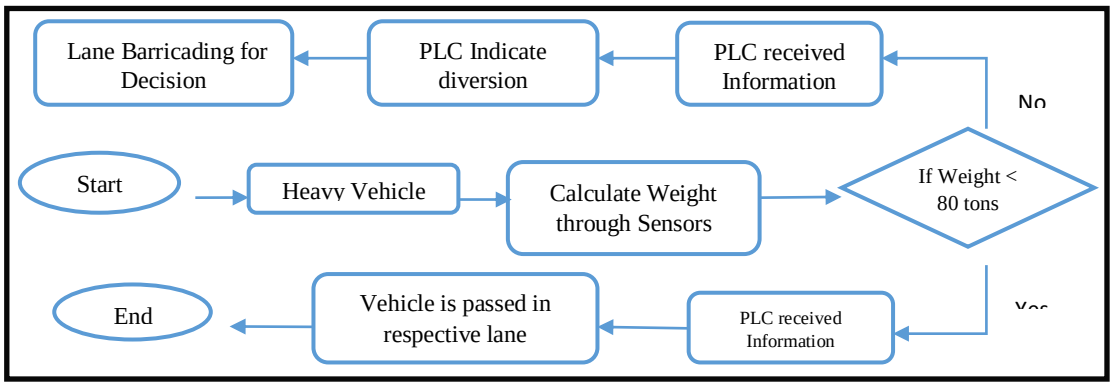

Fig. 1: Flow chart for diversion of vehicles based on weight

The core objective of designing Artificial Intelligence traffic controllers is that traffic controllers have the capabilities to adapt to the current data from sensors to perform constant optimizations on the signal timing plan for intersections in a network in order to minimize traffic congestions, which is the main issue in traffic flows control nowadays, at traffic intersections (Srivastava *et al.* 2012).For this method of reducing the heavy traffic and congestion from road we are using smarttraffic diversion system. This would function on weight measuring by using sensors whoseoutput will be get to traffic light PLC, which will control the traffic diversion. The flow of processes is shown in **(Fig. 1).**

This technique will help diminish congestion on roads and would help in adapting to mischances as the substantial vehicles and light vehicles will be in various paths. Resultantly, an answer for a much basic issue of activity blockage and lethal mischances is conceivable utilizing this framework.Cities with larger population have many different problems to tackle; Traffic control is among theone of the biggest problem of them all. "The United Nations anticipated that half of the totalpopulace would live in urban zones toward the finish of 2008"(Bloom, Canning, and Fink 2008). Nowadays, expectations saythat by 2050 in regards to 64% of the developing world and 86% of the developed world will beurbanized.Using big data for traffic control can be useful to improve traffic flow in a junction. **(Fig. 2)** shows how the adaptive urban traffic control system works.

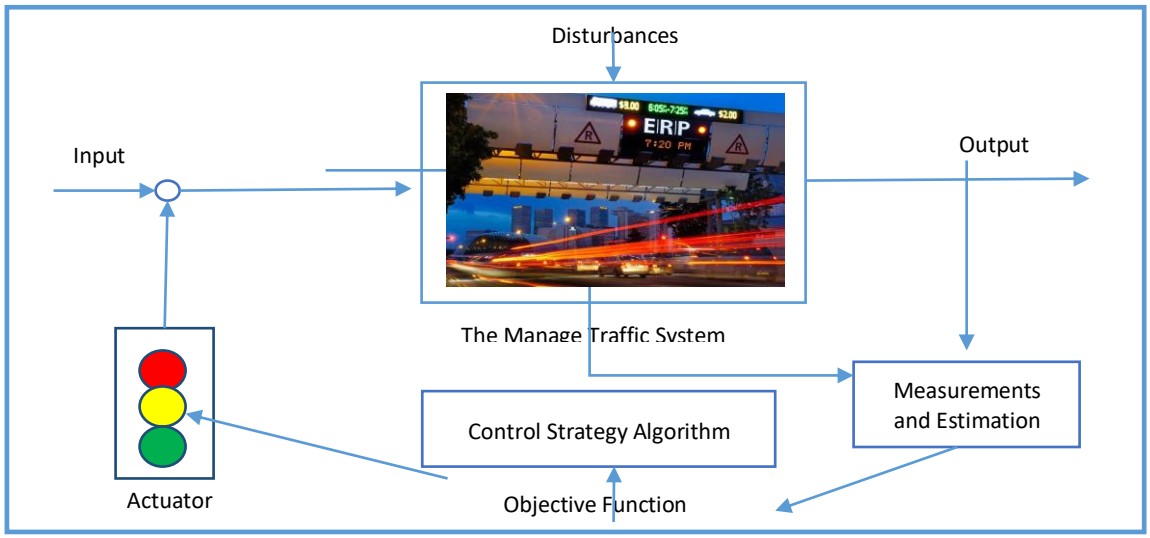

Fig. 2: Block diagram of the controlled traffic process(Prachi, Kasturi, and Priyanka 2014)

To reduce traffic junction hazards is if the smart traffic light manages the signals lights using wireless communication medium and selects nearest path with minimum congestion. All that to decrease the time taken by rescue vehicle to convey the patient to the doctor's facility in ideal time. Wireless communication frameworks have been utilized to sendand get information between the terminals. We can use GSM (Global System for Mobile Communications) which is very common (Munem and Croock 2016). This is because of ease and accessibility around the covered zone in addition to dependability. The database is utilized to store the data and in addition delivering various reports as asked for by manager. In the proposed system, the ambulances are observed, followed and guided by executed calculations at the server center.

Furthermore, this calculation chooses the ideal way for a ambulances relying upon crowded sensor readings settled on the streets to offer the most limited and safe approach to convey the patient to the emergency department. The explored system comprises of two primary parts, which are server center and ambulance. The activity of server center is clarified, while the ambulance incorporates the equipment gadget. It utilizes the microcontroller of Arduino added to GPS (Global Positioning System) and GSM (Global System for Mobile Communications) shields. The GPS (Global Positioning System) shield is utilized to get the present area of ambulance, while the GSM (Global System for Mobile Communications) shield is used to exchange the GPS (Global Positioning System) readings the server center for preparing and choice. Various programming situations have been used and online database is assembled.

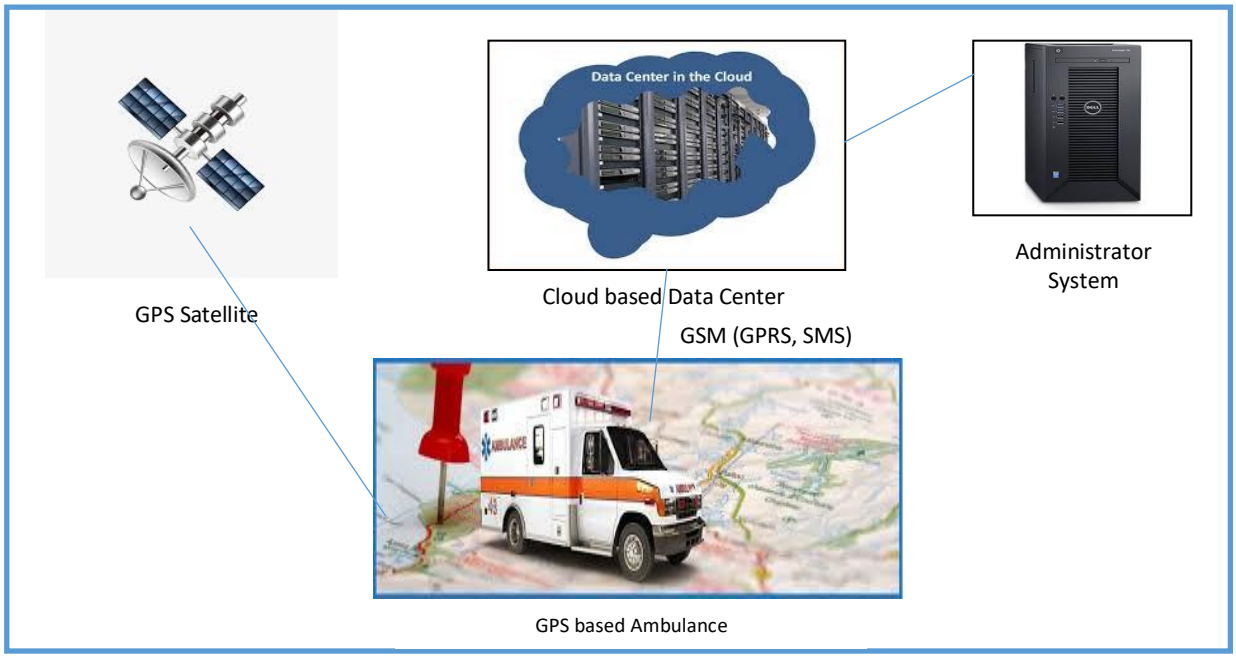

Fig. 3: Framework for ambulance or emergency traffic flow

3. Challenges

Following are some challenges faced in this area (Mohanty, Choppali, and Kougianos 2016):

3.1 Emergency Vehicle Stuck In Jam

At certain roads, even if there is no traffic due to wrong alignment sometimes emergency vehicles like ambulance, fire brigade etc. stuck on roadway. Because traffic light shows red for time being, and it shouldn't emergency vehicle has to waits until the light turnsgreen. It sounds a critical problem because human life is at stake here.

A problem was raised how to detect pathway of emergency vehicles. After detecting here pathway how those signals should collaborate to each other and provide traffic-less route.

3.2 Reduce Traffic Data on 4 Way Junction

A 4 way junction is where traffic is incoming and outgoing from all the ways. It was difficult to map a route and understand a functionality for it. How many Sensors will connect to achieve data from 4-way? How will central server map a formula to achieve a reliable solution for 4-way junction?

3.3 Central Server Location

Every traffic signals are connected to sensors, who sends information to central server. Problem occur to decide should there be only one giant server situated on any one location or there should be servers situated area-wise.

3.4 Human Free Smart Traffic System

System that handles traffic based on AI technique or there should be a human for keeping an eye on it.

4. AI based Traffic Control System

AI based traffic control system is to reduce the heavy traffic and congestion on the road by using real time traffic data to give optimal green red distribution(Bacon *et al.* 2011).

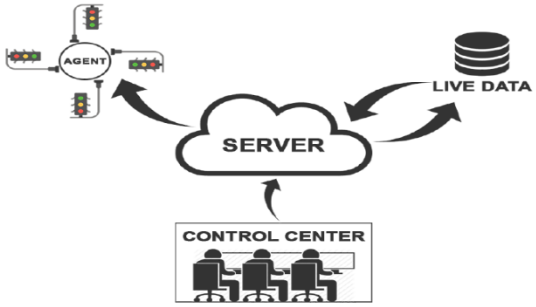

Fig. 4: Framework of the proposed system model

Fig. 4 shows the framework of the proposed system model which consists of four elements:

- Live Data
- Computational Server
- Intersection Control Agentand
- Control Center

4.1 Live Data

It is the source of real time traffic data which is representing the current traffic situation in the area. There are many sources and methods suggested by researchers from where we can obtain this data like placing sensors and cameras at the junctions to capture the traffic flow and applying algorithm to obtain the intensity of the traffic but all these approaches are so much cost effective and complex to implement(Castillo *et al.* 2015). Also the accuracy of this data is the most important ingredient of our proposed solution.Google Maps APIs is the easy and reliable source from where we can drive the traffic intensity for our optimal distribution(Fairfield and Urmson 2011).Travel time in current and future traffic is now available through the Distance Matrix and Directions APIs of Google Maps which is requested by server after every threshold time.This threshold time is configurable as it is inversely proportional to networkcommunication cost.

4.2 Computational Server

This is the entity of our framework with all the heavy duty computing and communication to achieve the desired result. It has two major roles.

4.2.1 Compute Traffic Intensity

In order to compute traffic intensity in terms of speed at every intersection weneed to have travel time of all downstream of an intersection.

$$travel\ time = t = [t_{d1}, t_{d2}, \dots\dots\dots t_{dn}] \qquad eq.(i)$$

Once we get these time from live data source we then can calculate speed ofevery downstream and representing it as the intensity of the intersection.

$$d_d = distance\ of\ a\ downstream$$

$$speed = s_d = \frac{d_d}{t_d} \qquad eq.(ii)$$

$$intensity = i_d = \frac{1}{s_d} \qquad eq.(iii)$$

$$intensity = i = [i_{d1}, i_{d2}, \dots\dots\dots i_{dn}] \quad eq.(iv)$$

The lower the speed is the higher the intensity of a downstream, that's why wetake the reciprocal of speed.

All these intensities are then stored in a local database of server for mainly tworeasons.One is to visualize the traffic flow with respect to time. Other reason is to calculate the variation with previous data. If the variation ismore than a threshold value then we should continue the process and computeoptimal distribution otherwise we neglect the change and allow agent to continuewith the current distribution.

4.2.2 Optimal Distribution

For optimal distribution, calculate green red timings that is the greater the intensity is the higher the percentage of available time it needs.

$$available\ time = a_t = l - s_n \qquad eq\ (v)$$

Where,

L = distribution time limit

S = switching time from green to red

n = no. of downstream at an intersection

Now calculate the percentage of every downstream intensity and assign availabletime with respect to it.

$$total\ intensity = i_t = i_{d1} + i_{d2} + \cdots + i_{dn} \qquad eq\ (vi)$$

$$\%\ of\ downstream = \%\ d_n = \frac{i_{d1} + i_{d2} + \cdots + i_{dn}}{i_t} \qquad eq.(vii)$$

$$Optimal\ distribution = O = [a_t \times (d_1 + d_2 + \cdots + d_n)] \qquad eq.(viii)$$

4.3 Intersection Control Agent

These are the software agents placed at every intersection to control their traffic lights smartly by receiving optimal green red distribution from server whenever there is a significant change in the traffic flow (Mishra *et al.* 2018).

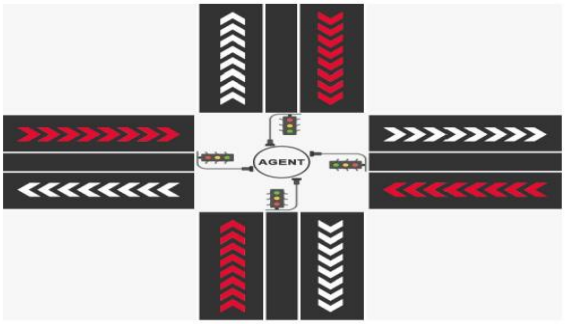

Fig. 5: Software Agents

Being an agent it has:

- Cameras covering all downstream of an intersection to monitor it by control center.
- Memory to record distributions so that it can avoid one point failure of our system. By applying an algorithm of AI we can extract traffic pattern from previous data and act on it. Choice of algorithm is not in the scope of this proposed solution.
- Actuators in the shape of traffic lights by which it controls the traffic flow.

In order to get global optimal solution that is smooth traffic flow of an area having multiple intersections we use downstream of every intersection so that they could work in a collaboratively manner (Kowshik, *et al.,* 2011).

4.4 Control Center

To provide a little bit human assistance to the system we have control centers at every distance covering several intersections. Their job is to continuously monitor the system by seeing from agent's eyes(cameras) and cater emergency cases by generating a signal for the server which then respond to the agent by sending the distribution having priority for the emergency downstream.

Experts at control center also visualizing the traffic flow which server continuously generates by consuming live data. **(Fig. 6)** depict the visualization.

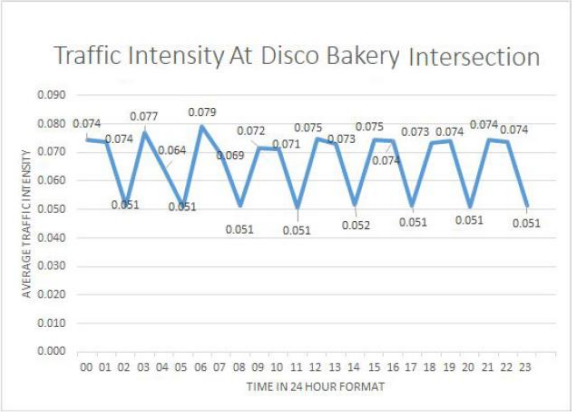

Fig. 6: Traffic Intensity at Disco Bakery Intersection

5. RESEARCH DISCUSSION

Traffic is one the biggest problem of urban cities. To handle traffic flow in old fashion stationary control system is not a good option. Computer science is increasing day by day, through the use of this new coming technology we can design our traffic signals in more smart and effective(Harrison *et al.* 2010). Today, most of the traffic signal utilizes the old techniques which are; each directional flow in a conjunction is allotted a specific time for red, yellow and green. There are no smart techniques to carry out to solve this problem.

"Currently there are 3200 automotive manufacturing plants in our country; with investment of 92 billion they produce 1.8 million motorcycles and 200,000 vehicles annually. Hence precautions are needed to be made for securing future and making life less problematic" (Neirotti *et al.* 2014).

Previously, few techniques are used to reduces traffic delay in conjunction; which includes big data analysis, counting traffic intensity by using image processing further explanations are: One of the most common techniques is counting vehicles in a lane with higher number of quantity will be given maximum time to pass while the lower number of quantity of vehicles will be given minimum crossing time. In previous paper the author suggest using image processing in which a camera is responsible for data gathering from the live traffic where it capture every single vehicle and pass this data to algorithm where this data is evaluated and as result traffic intensity of a lane is output. This same process is for the other three directions as well. And with the maximum number of intensity lane is given maximum time to pass through the signal and vice versa. This is so far a good technique to reduce traffic flow but the main issue with this technique are; it must have to do image processing 24/7 which is time taking procedure, and may cause delay in providing the output. Image processing also depends upon the climate conditions. The light factor may cause the result value. There is no proper described solution for emergency or critical situations.

Fig. 7: Traffic simulation of Disco Bakery Intersection

In this paper we have proposed the solution with different technique i.e. we use live data to calculate traffic intensity of a lane, this is possible by Google traffic in which we take two conjunction and mark them as one as source and another one as destination through which we have live traffic intensity of a lane. Similarly this is used for all four downstream traffic. And with higher intensity have the maximum passing time. Cameras are used to monitor any emergency problems which are control by the human in control center. We tested this solution by simulating the real traffic environment of Disco Bakery Intersection in Karachi using Any Logic Simulation Modeling Software Tool(Macal and North 2010). During rush hour of 6 p.m. heavy traffic noticed from all directions except North which has the normal flow.

By assigning our proposed model distribution to the system we successful to:

- Reduce the number of cars in specified time interval by 55%.
- Increase average speed of cars in the system by 55%.
- Decrease number of stops a car had to make while in the system by 29%.
- Decrease average time a car had to spend in a system by 65%.
- Decrease average waiting time of cars to pass the intersection by 38%.

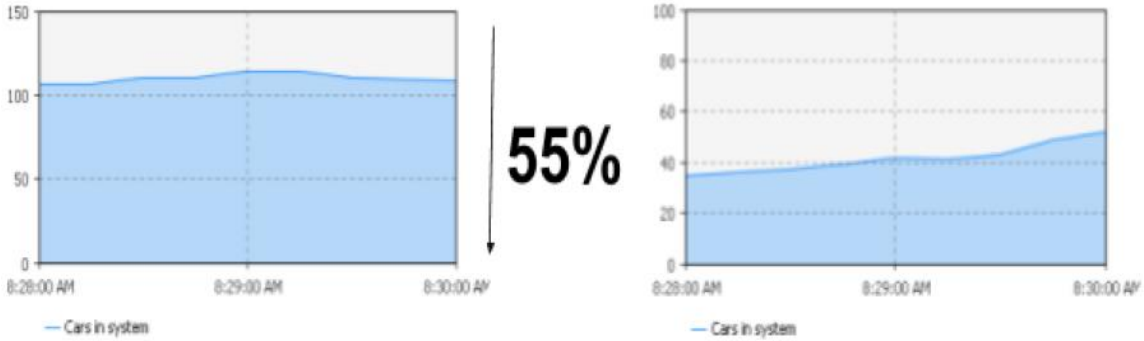

Fig. 8: Number of cars in traditional system vs smart system

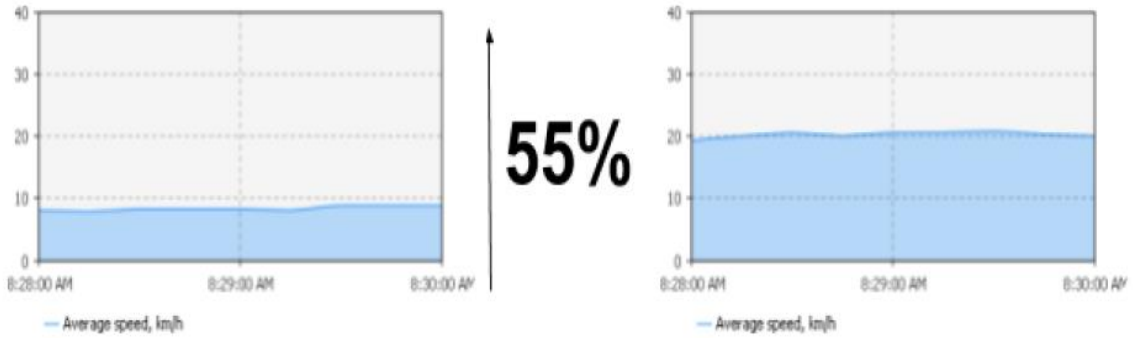

Fig. 9: Average speed of cars in traditional system vs smart system

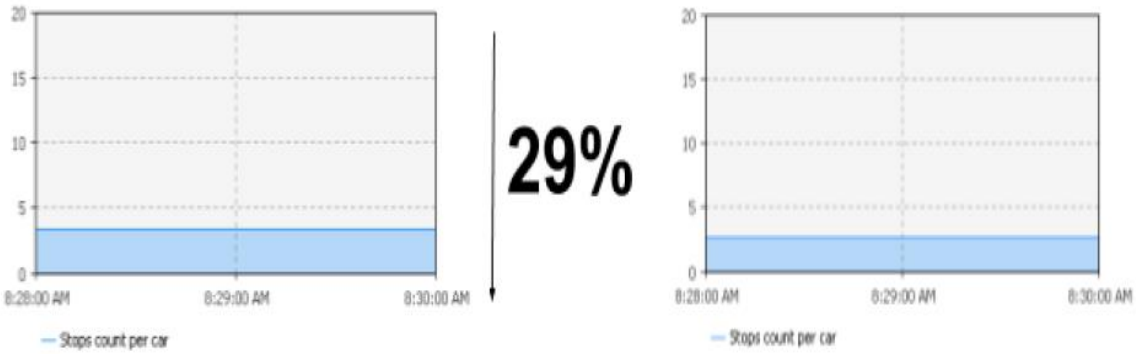

Fig. 10: Stops count per car in traditional system vs smart system

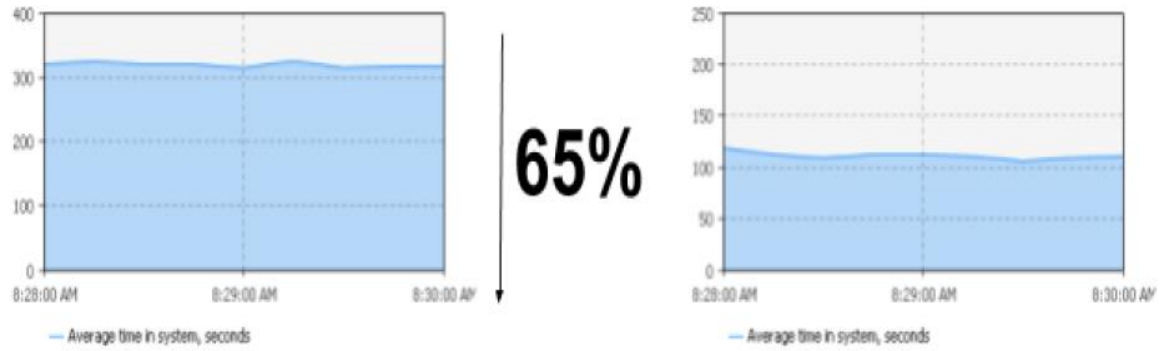

Fig. 11: Average time spent by cars in traditional system vs smart system

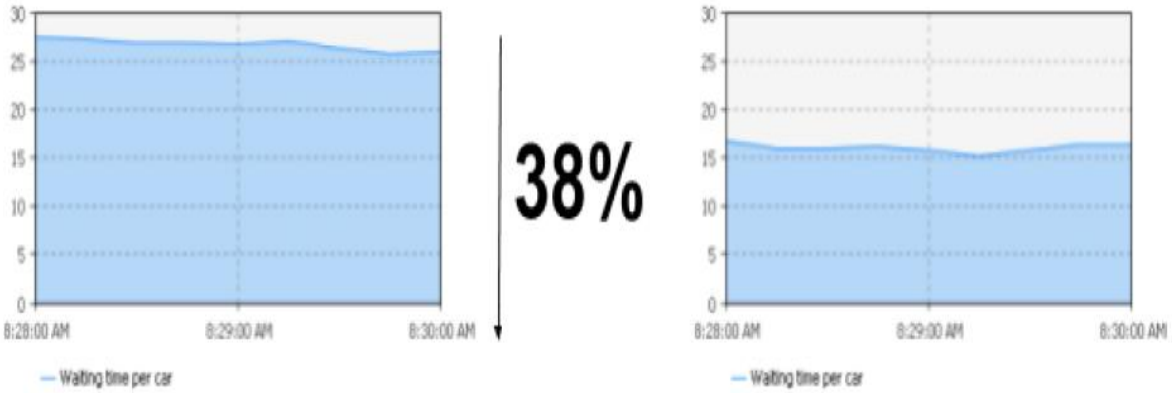

Fig. 12: Waiting time per car in traditional system vs smart system

6. CONCLUSION

Our method is proposing a solution to lessen down congestion on roads and will also look after to reduce accidents. We proved here the solution of daily traffic and fatal accidents. Thus above proposed theory will make our roads safer place to travel.

In future, detectors can be placed in emergency vehicles so our traffic signal can easily detect. Control center can work automated removing all manual help.

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