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Full Length Research Article

A SIMULATION TO MINIMIZE TRAFFIC VIOLATION IN NIGERIA THROUGH THE USE OF SMART SPIKE STRIP

Gabriel Lazarus Dams[1], Ashiru Simon[1], Salome Danjuma[1] and Pam Joseph Emmanuel[1]

[1]Department of Computer Science, Kaduna State University, Tafawa Balewa Way, Kaduna, Nigeria

Corresponding Author's Email Address: damsgabe@kasu.edu.ng Phone: +2348060137413

ABSTRACT
Traffic light violations always have negative effects on lives and environment and to quantify these negative effects is complex. For traffic light violation to be mitigated or eliminated, gathering of information on traffic incidents such as nature of the road, congestion spots, and volume of traffic on each road cannot be overemphasized. The elimination of traffic light violation particularly in developing countries like Nigeria may not be a realistic goal, but controlling or managing it to reduce the intensity of violation may be achievable. The unbearable traffic congestion is the highest cause of traffic light violation, most especially within the rush hours of the morning when individuals go to work (between 7.00am – 8.00am) and coming back in the evenings (4.00 – 5.00pm and 6.00 – 7.00pm) at most cross roads in Kaduna metropolis. In this research work, an algorithm is developed to control the traffic light violation on one lane of a traffic junction by introducing the smart spike strip which is synchronized with the traffic light control system. The implementation of the algorithm to simulate the control of the traffic light violation on a traffic junction is achieved using Visual Studio 2012 IDE as a platform for the simulation. Screenshots to illustrate the different of the vehicles and lanes which are states static, ready and motion states shown.

Keywords: Traffic Light Violation, Traffic Congestion, Smart Spike Strip, Simulation, Visual Studio.

1. INTRODUCTION

The number of vehicles plying the roads in developing countries like Nigeria is rapidly increasing. The roads being the major means of transportation are getting crowded resulting to serious traffic congestion.

Nigerian roads are the most used means of transportation in the country, carrying 80% of the population and goods. There are 60,068 km of paved roads, which follow a grid system of North - South and West – East (Olagunju, 2015). As a result, traffic congestion is on the increase due to high dependency on roads as the major medium of transportation in the country.

Road traffic congestion, according to Goodwin (2004) can be defined as the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity.

Traffic lights has been installed mostly at road intersections in most major cities around the world in order to control and manage traffic movements. However, the problem of congestion has still persisted (Udoakah and Okure, 2017). Delays created by this traffic congestions has made lawlessness to increase at most road intersections. Traffic violation has become inevitable by vehicle drivers which has led to several road traffic accidents. According to Pietrasik (2018), road traffic accidents are a major and increasing cause of injury and death around the world, with almost 1.25 million people dying annually and between 20 and 50 million more suffering non-fatal injuries, including permanent disabilities.

Traffic light violation can simply be referred to as the act of disobeying traffic light signal. Approximately, according to leadershipngr (2017), 15 people die daily in Nigeria as a result of road crashes. This equals 2,673 as released by the National Bureau of Statistics.

This research looks at the traffic light violation and mitigation strategies/control with focus on developing countries and Nigeria as a mirror. A smart spike strip will be proposed as a mitigation strategy/control for violating vehicles. The spike strip will be synchronized with the traffic light control such that when the traffic light turns red, the spike strip is activated which implies that any vehicle that attempts to violate the traffic light when it is RED will get immediate punishment – the vehicle tire will be punctured. The spike strip is deactivated only when the traffic light turns green.

Spike strip also known as "tire deflation device" is a device use to impede or stop the movement of a wheeled vehicle by puncturing their tires. They are effective when used at parking spot such as checking point, paid parking lots and parking garages.

2. Problem Statement

Road traffic congestion remains a global phenomenon that threatened the cities of the world, especially developing countries, resulting in massive delay, unpredicted travel times, increased fuel consumption, man-hour and monetary loss. The phenomenon has arisen from poorly planned road network and how traffic is control/manage, resulting in elongated and unbearable traffic jam. When the traffic becomes unbearable, some of the road users decide to violate the traffic due to impatience. Monitoring this traffic violations by human intervention over wide area is too complicated due to the increasing in the number of vehicles plying the roads, as a result, technology came up with an automated traffic light control system for efficiency, accuracy and reliability. Despite the implementation of the traffic lights system, many road users still decide to break the rules of traffic light which ends up causing accident and more traffic congestion.

Therefore it is very obvious that traffic light violation have been an inevitable habit of some of the road users in most developing countries in the world, due to impatience, ignorance and emergency that need to be addressed.

Aim and Objectives

The aim of this research is to simulate a system that can control the violation of traffic light signals using the smart spike strip (SSS). Hence the objectives of this project are as follow:

1. To model the traffic light system
2. Develop a program that will control the system functionalities
3. To synchronize the smart spike strip (SSS) with the timing of the traffic light signal.

3. Scope And Limitations

This research work will be limited to commercial and private road users only, however in the situation of emergency such as ambulance, fire engine and so on are all ignored.

4. Related Works

Many techniques has been implemented and some proposed to mitigate traffic violation at traffic junctions. The commonly mitigation technique is the use of surveillance cameras installed at the traffic junctions (Sharma and Sharm, 2016). For example, in Saha et al. (2009) work, a complete system was developed to take snapshots of vehicles violation stop-lines at road junctions. Three surveillance cameras were installed at the cross roads. The cameras were synchronized with the traffic lights signals. When the signal turned RED, the cameras will be triggered to capture video snapshots of vehicles violating the stop-lines. The cameras focused on the stop-lines to ensure that the vehicle's frontal pictures were captured. However, not all vehicles images were very clear on capture. As such, some violators could escape punishment.

Another technique by developed by Osigbemeh et al. (2017) to improve traffic light control system using hybrid lighting system. The concept relied on incandescent lamps with high energy that will complement the Light Emitting Diodes (LEDs) from the traffic lights. The incandescent lightings uses halogen bulbs which is deployed to give an instantaneous illumination that is highly efficient. The illumination is designed to be brighter than the drivers' ambient lights in order to help a driver get enough warning to avoid traffic light violation.

Olaverri-Monreal et al. (2018), developed a system known as Traffic Light Assistant (TLA) that utilizes the timing of the traffic lights on intersected roads to communicate with the vehicles approaching the intersections. The smart system known as vehicle-to-everything communication (V2X) works together with an Intelligent Transport Systems (ITS) to effectively communicate the traffic signals between vehicles known as vehicle to vehicle (V2V) connection and nearby infrastructures using similar smart systems. This aim of the system was to optimize the flow of traffic and help drivers to avoid traffic violation of the red lights at intersections which has led to accidents and serious traffic crashes (Pietrasik, 2018). The system uses the timing of the traffic light in real time to calculate the optimal speed of an incoming vehicle approaching the traffic light. The recommended velocity (after the calculation has been done) will be communicated to the vehicle depending on the vehicle's speed and state of the traffic light.

According to Sharma and Sharm (2016), techniques proposed or implemented for traffic management usually require equipment that have high cost and end up not been efficient. Besides the cost and efficiency, achieving the accuracy of a technique depends on the environmental conditions. For instance, the road networks and technological advancement in developed countries cannot be compared to developing countries. As such, the likelihood of finding traffic light violators in the developing countries will be more than that in the developed countries.

5. Traffic Light Control System

Traffic light system, also known as traffic signal are signaling devices positioned at road intersections, pedestrians crossing and other locations to control or maintain a steady and free flow of traffic.

Traffic lights are installed at roads intersections to reduce traffic congestion which when neglected can lead to traffic violation resulting to crashes between vehicles and pedestrians and end up in the loss of lives and properties, it also help to indicate when it is safe to drive, ride or walk using a universal color. Most traffic signals consist of the following components.

1. Main display with red, yellow and green lights.
2. A traffic signal cabinet containing either a traffic signal controller or a Vehicle Detection Systems.
3. Inductive loops or sensors

a. Types of Traffic Light Control System

There are several types of traffic light control system:

1. **Intelligent traffic light control system**: This is a dynamic system which control traffic light using image processing. The system will first measure the density at different signals and accordingly change the time delay for traffic light, the green light signal duration will be extended on the side at which the traffic is more.

2. **Wireless smart traffic light system**: This is also a dynamic traffic control system which is aimed at reducing the average waiting time and queue length using the wireless sensor network (WSN). The advantages of this wireless technology in this traffic light system is flexibility, reduce installation cost, low maintenance and easily realized temporary deployments such as monitoring purposes etc.

3. **Conventional or semi-automated traffic light system**: This Traffic Light system Controllers are based on the microcontrollers and the microprocessors. The Traffic Light Controllers have some limitations due to using a pre-defined hardware, which is programmed according to fixed time that never change. Hence, there is no flexibility of modification on real time basis. Due to the fixed time for the three color signals (green, amber and red), the waiting time is more and cars waste more fuel which makes it a static system.

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6. TRAFFIC LIGHT VIOLATION

A traffic light violation which is also known as red light violation/running (RLR) is commonly defined as when the front wheels of a vehicle enter the defining boundary of an intersection (usually the stop bar or crosswalk) after the traffic signal changes to the red phase and the vehicle proceeds through the intersection while the signal is red (Kabit et al., 2016). The common phrase used to describe when vehicles proceed through an intersection after the traffic signal turns red is running a red light.

Red light running is a frequent cause of crashes at signalized Intersections (Farguson, 2010). Between1992–98, almost 6,000 people (about 850 each year) of dead was recorded due to red light running crashes in the United States, and annually approximately 500,000 accident involving trucks occur (IIHS_News, 2000).

a. Traffic Light Violation Control Measures

They are measures in which government agencies and problem solvers have put effort to solve the problem of traffic light violation in order to reduce the rate of vehicle crashes at intersections, these measures include the following:

1. Traditional Police Enforcement:

The traditional means of using police personal was adopted to control red light running, where a police officer is expected to be at the traffic signal to observed violation, the police is also expected to pursue any violator for citation or fine. Pursuing red light violators can also be dangerous to police officers, motorists, pedestrians, and bicyclists.

As such, the approach used is a team approach which involves having at least three officers present at an intersection together. One officer is positioned upstream of the traffic signal in an unmarked vehicle to observe violations and two officers are positioned downstream of the intersection to pull-over the violators when radioed by the upstream officer. Although the team enforcement method is safer for officers and is successful in citing red light violators, the cost to have many officers at one location is difficult to justify (Passetti, 1997).

2. Automated Enforcement Camera (RLC)

An automated enforcement system is an electronic camera used to enforce traffic laws through the electronic detection of infraction and photo documentation of the vehicle at fault.

Red light cameras (RLC) take photographs of vehicles entering intersections after the traffic signal has turned red which in most cases are detected by sensors in the pavement, which are tied to a timing system that connects the traffic signal and pole-mounted camera. Photographs of the vehicle, the license plate number, and/or the driver are taken, usually when the vehicle enters the intersection on red as well as while it is in the intersection (Fereiro, 2017).

7. Proposed System Algorithm

Figure 1 below is a flowchart showing the process of time allocation to vehicles plying the road at a given junction. The algorithm describes the timing process for one lane at the junction which is replicated at different time intervals in the actual implementation.

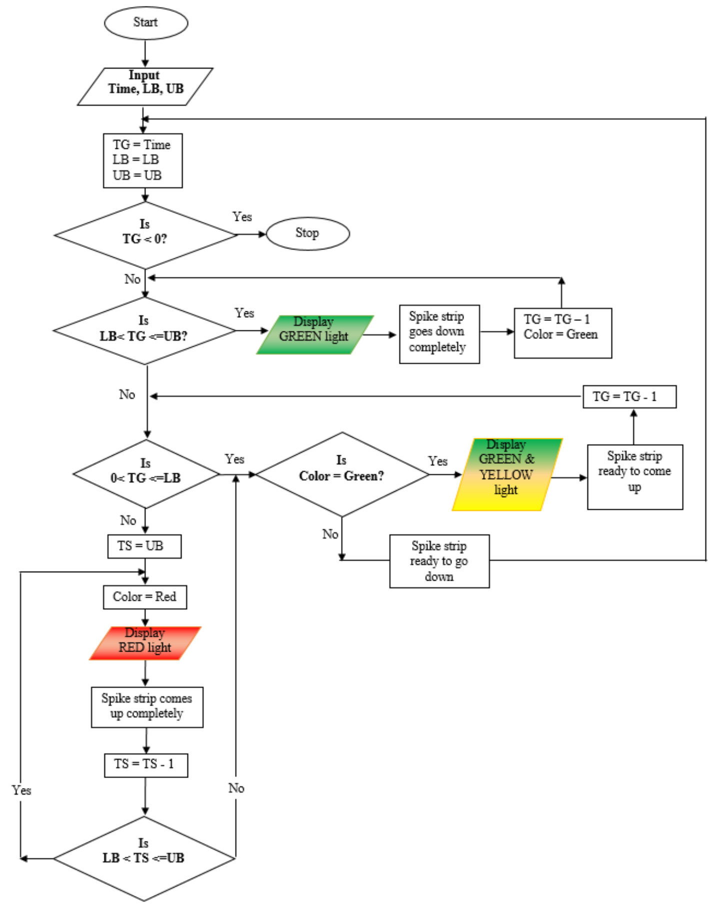

Figure 1: Flowchart Diagram for Traffic Light System using Smart Spike Strip (SSS) for one lane at the traffic Junction

Figure 1 above illustrate the flow of events or data and how they respond with the timer when they are scheduled on different time interval.

There are four (4) acronyms used namely:
"*Time to go*" represented as "*TG*"
"*Time to stop*" represented as "*TS*"
"*Lower bound*" represented as "*LB*"
"*Upper bound*" represented as "*UB*"

TG is the time frame for the motion lane to be active – that is, vehicles are granted the right of way while the spike strip stays down completely. *TS* is the waiting time frame for the vehicles on a static lane as the spike strip is up completely. *LB* and *UB* is the time frame or boundaries set for vehicles to either get ready to stop or get ready to go depending on the situation of the time.

The pseudocode for the flowchart in figure 1 is shown in table 1 below with a brief explanation of the process.

Table 1: Pseudocode for Traffic Light System using Smart Spike Strip (SSS) for one lane at the traffic juncation

S/N	Pseudo code	Brief Explanation
1.	*Start*	
2.	***INPUT** Time, UB and LB*	User sets timer (Time) Upper Bound (UB), Lower Bound (LB) where UB and LB are the boundaries for Time
3.	***LET** TG = Time* ***LET** LB = LB* ***LET** UB = UB*	Variables are assigned from the inputs made in 2.
4.	***IF** TG < 0* *Stop*	If TG is set or goes below zero (0), then the program terminates.
5.	***ELSEIF** TG> LB and TG < UB* a. *Spike Strip is down* b. *Display GREEN light* c. ***LET** Color = Green* d. *Decrement TG by 1* /	If TG is within the boundaries UB and LB, steps 5a to 5d will continue to run until TG becomes less than LB. This implies that vehicles on the lane can move.
6.	***IF** TG > 0 and TG < LB* a. ***IF** Color = GREEN* i. *Spike Strip begins to come up* ii. *Display GREEN and YELLOW light* iii. *Decrement TG by 1* b. ***ELSE*** i. *Spike Strip begins to go down* ii. *Run Step 3*	If TG is within the boundaries of 0 and LB and the light Color = Green, then the Spike should begin to come up. This implies that vehicles on the lane should get ready to stop. Else if the light Color ≠ Green, then the Spike should begin to go down and Timers are reset using step 3. This implies that vehicles on the lane should get ready to go.
7.	***ELSE*** a. *LET TS = UB* b. *Spike Strip is up* c. *Display RED light* d. ***LET** Color = RED* e. *Decrement TS by 1*	Once TG is not within the boundaries of 0 and LB, steps 7a to 7d will continue to run until TS becomes less than LB. This implies that vehicles on the lane cannot move.
8.	***IF** TS > LB and TS < UB* *Run Steps 7b, 7c, 7d and 7e* ***ELSE*** *Run Step 6b.*	As long as TS is within the boundaries of LB and UB, steps 7b to 7e otherwise run step 6b.

8.1 Algorithm Demonstration

A simple demonstration will be created for illustration purpose of the algorithm designed in section 8 above using the variables in table 2.

Table 2: Variables used for traffic control mechanism

Variables	Values (Seconds)
Time	30
Upper Bound (UB)	30
Lower Bound (LB)	5

Once the variables "*Time*", "*UB*" and "*LB*" are entered as 30, 30 and 5 respectively for instance. The values are initialized and assigned to the variables accordingly. The units of the values are in seconds.

As long as "*TG*" is within "*LB*" and "*UB*", which is 5secs and 30secs respectively, two things will take place:

- The green light is displayed and
- Spike strip is completely down

On the other hand, once "*TG*" fall within the zero (0) and "*LB*" which is 5secs, two things will happen:

- The green light and yellow light is displayed to mean "*get ready to stop*" and
- Spike strip will be getting ready to come up.

At this point, a variable *Color* would have been initialized to green to be used to differentiate the time vehicles are to stop and the time vehicles are to go. If *Color* = "*green*" and the time frame is within zero (0) and 5, it implies that, the traffic light display is green and yellow indicating that vehicles should get ready to stop as the spike strip will be getting ready to come up as well. On the other hand, if the *Color* = "*red*" and the time frame is within zero (0) and 5, it implies that, the traffic light display is yellow indicating that vehicles should get ready to go as the spike strip will be getting ready to go down as well.

8.2 Simulation Tool

The simulation of the traffic light violation control with smart spike strip (SSS) was implemented using the Visual Studio 2012. The software can be used to create an environment that illustrates the proposed concept. For instance, the road intersection, vehicle pictures, vehicle movements, spike strips and traffic lights was created using this tool.

9. SYSTEM IMPLEMENTATION

At implementation of the traffic light system, the tool that was used to achieve the goal of simulating traffic light violation control using smart spike strip (SSS) is Visual Studio 2012. Figures 2 shows a screenshot of a typical simulation of the traffic light system with different events. There are three (3) different states shown namely:

1. Static state
2. Ready state
3. Motion state

A demonstration of the states are shown in the figure 1, 2 and 3.

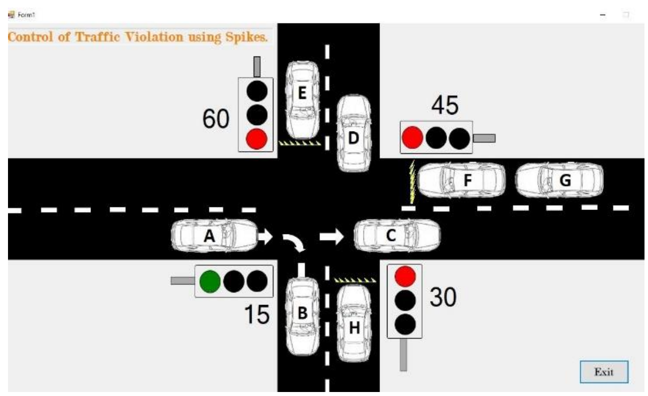

Figure 2: Typical Simulation of a Traffic Light System Screenshot showing Motion and Static State

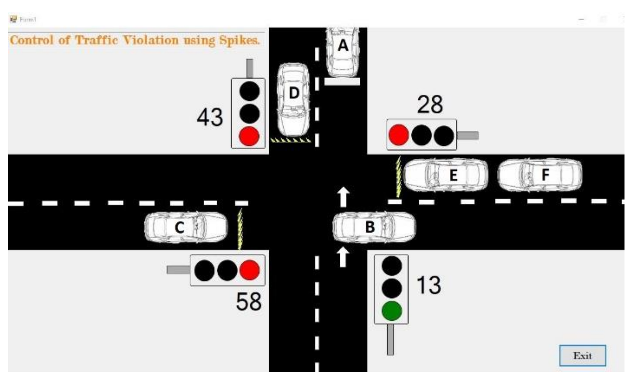

Figure 3: Typical Simulation of a Traffic Light System Screenshot showing Motion and Static States

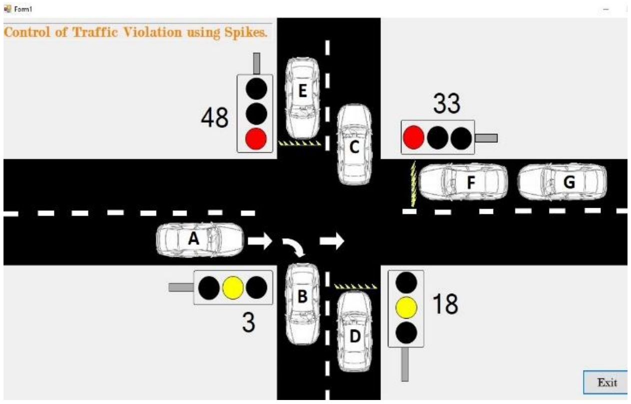

Figure 4: Typical Simulation of a Traffic Light System Screenshot showing Ready and Static States

The vehicles labeled A, B, C, D in figure 2 and A, B in figure 3 above are said to be on motion state, which means that the traffic light control system has given all vehicles on the lanes the signal to go while the spike is down. The time remaining for vehicles on the motion lane in figure 2 before changing to static state is 15 seconds while the time remaining for vehicles on the motion lane in figure 3 before changing to static state is 13 seconds. The lane with vehicles labeled E, F, G, H in figure 2 and C, D, E, F in figure 3 above are said to be on static state which means that the traffic light control system has signaled all the vehicles on their lane to stop while the spike is up.
The lane with vehicles labeled A, D in figure 4 are said to be on ready states. This means that vehicle A has 3 seconds to use the lane as the traffic light control system is getting ready to change to static state and bring up the spikes. Vehicle D on the other hand is on ready to go state. This means that the traffic light control system on that lane has signaled the vehicles to get ready to move as the spike is getting ready to go down.

10. Conclusion

This research work has brought into focus the issue of traffic light violation in major urban cities of Nigeria. The causes of traffic light violation have been considered indicating that poor driving habits, poor road network, inadequate road capacity, and lack of patience are the greatest causes of traffic light violation at intersections in Nigeria. Although previous approach represents efficient techniques to control the traffic light violation but in one way or the other it has not sufficiently overcome the problems enumerated. In this approach, a police officer will not be required to chase violators or a camera to capture violator's details in order to be fined at the end of the day. In this system, punishment of a violator is immediately served. Therefore it is important to understand that the implementation and application of spike strip technology on traffic light system is necessary for easy, safe, efficient, effective and free flow of traffic.

REFERENCES

FARGUSON (2010). Effect of Red Light Running. *International Journal of Transportation Institute*.

FEREIRO, S. (2017). *How Red Light Cameras Work* [Online]. Economical Insurance. Available: https://www.economical.com/en/blog/economical-blog/january-2017/how-red-light-cameras-work-to-prevent-collisions [Accessed 18/06 /2018].

GOODWIN, P. (2004). Solving Congestion. *In:* Terry, F., (2004) (ed.) *Turning the corner? A reader in contemporary transport policy.* UK: Wiley Blackwell.

IIHS_NEWS. (2000). *Red Light Running Factors into More Than 800 Deaths Annually* [Online]. Insurance Institute for Highway Safety, Highway Loss Data Institute. Available: http://www.iihs.org/iihs/news/desktopnews/red-light-running-factors-into-more-than-800-deaths-annually-more-than-half-of-those-who-die-are-hit-by-red-light-violators [Accessed 21/05/2018.

KABIT, M. R., SABIHIN, N. A. & WAN IBRAHIM, W. H. (2016). Effectiveness of Automated Enforcement System (AES) in Reducing Red Light Violation (RLV) Behaviours: A Case Study In Kuala Lumpur. *Journal of Civil Engineering, Science and Technology (JCEST),* Vol. 7 (1)**,** pp. 39-44.

LEADERSHIPNGR. (2017). *Alarming Statistics from Road Accidents* [Online]. Leadership. Available: https://leadership.ng/2017/08/12/alarming-statistics-road-accidents/ [Accessed 14/06 /2018].

OLAGUNJU, K. (2015). Evaluating Traffic Congestion in Developing Countries – A Case Study of Nigeria. *Chartered Institute Of Logistics And Transport (CILT) Africa.* Arusha, Tanzania.

OLAVERRI-MONREAL, C., ERREA-MORENO, J. & DÍAZ-ÁLVAREZ, A. (2018). Implementation and Evaluation of a Traffic Light Assistance System Based on V2I Communication in a Simulation Framework. *Journal of Advanced Transportation,* 2018**,** pp. 1-11.

OSIGBEMEH, M., ONUU, M. & ASAOLU, O. (2017). Design and Development of an Improved Traffic Light Control System Using Hybrid Lighting System. *Journal of Traffic and Transportation Engineering (English Edition)***,** pp. 1-8.

PASSETTI, K. A. (1997). Use of Automated Enforcement for Red Light Violations. *United States. Federal Highway Administration*.

PIETRASIK, T. (2018). *Road Traffic Injuries* [Online]. India: World Health Organization. Available: http://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries [Accessed 13/08 /2018].

SAHA, S., BASU, S., NASIPURI, M. & BASU, D. K. (2009). Development of an automated Red Light Violation Detection System (RLVDS) for Indian vehicles. *IEEE National Conference on Computing and Communication Systems (COCOSYS-09).*

SHARMA, N. & SHARM, P. (2016). Intelligent Traffic Light Control System. *International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE),* Vol. 5(7)**,** pp. 2025-2028.

UDOAKAH, Y. N. & OKURE, I. G. (2017). Design and Implementation of a Density-Based Traffic Light Control with Surveillance System. *Nigerian Journal of Technology (NIJOTECH),* Vol. 36 (4)**,** pp. 1239-1248.