RESEARCH ARTICLE

Proposed Simple System for Road Traffic Counting

Ahmad A.A. Alkhatib, Adnan Hnaif and Tarek Kanan

Al-Zaytoonah University of Jordan

ARTICLE HISTORY

Received: September 17, 2018
Revised: October 21, 2018
Accepted: October 24, 2018

DOI: 10.2174/2210327908666181107110441

Abstract: ***Background & Objective*:** Traffic congestion is a burning issue in most countries due to the rapid growth of running vehicles and infrastructures with limited capacity. Congestion can be solved with Intelligent Transport Systems (ITS) and traffic management. Most traffic management measurement are aimed to improve the safety and flow of traffic, reduce traffic emissions and utilize traffic artery capacity more effectively. This paper proposes a new system to collect the required data for traffic management such as, number of vehicles, time and lane location information; using a cheap infrared sensors and timers.

***Conclusion*:** The proposed method can take the length of the vehicle into account of traffic statistics by measuring the car speed.

Keywords: Infrared sensors, intelligent traffic management, road traffic management, traffic congestion, traffic efficiency, traffic optimization, vehicles counting.

1. INTRODUCTION

Building new roads as a way of relieving heavy traffic is not a feasible way all the time, as it has a high construction cost and lack of space in the urban areas where it is highly needed. As reported by the US Federal Highway Administration's Highway Statistics Summary to 1995, both the number of vehicles and the number vehicle miles driven have more than doubled in the past 25 years; this will lead to reduced speeds and increased travel time. Which causes instabilities in flow, more commonly known as "stop and go traffic." [1]. On the other hand, the latest report from the Department of Transport in the UK indicate the huge increment in traffic every year since 1994 to 2018 [2] as in the below Fig. (**1**).

As a result, the trends have shifted toward Active Traffic Management Centers (ATMC) and The use of Intelligent Transportation Systems (ITS). So it's not only thinking solely on building new roads or infrastructure repair, it's about introducing Information System into transportation management. These systems enable elements within the transportation system to become intelligent by incorporating sensors and so to communicate with each other using wireless technologies, thus safety and traveler convenience would be increased. For the traffic management centers to be in the maximum efficiency, easy operations and useful information should be provided to the public and traffic control personnel in a timely manner. In order to design a smart Urban Traffic management system; it should perform the following functions: Data collection; Data fusion: Analysis and processing; Decision; Action.

Normally, traffic management project targeted some or all of the following: Congestion Avoidance; Priority-Based Traffic Management and Average Waiting Time Reduction. According to Folds *et al*. (1993), the mission of an ideal traffic management center is "to facilitate the safe movement of people and goods, with minimal delay, throughout the roadway system." [3].

*Address correspondence to this author at the Al-Zaytoonah University of Jordan; Tel: +962796822985;
E-mail: Ahmad.Alkhatib@zuj.edu.jo

2210-3279/19 $58.00+.00

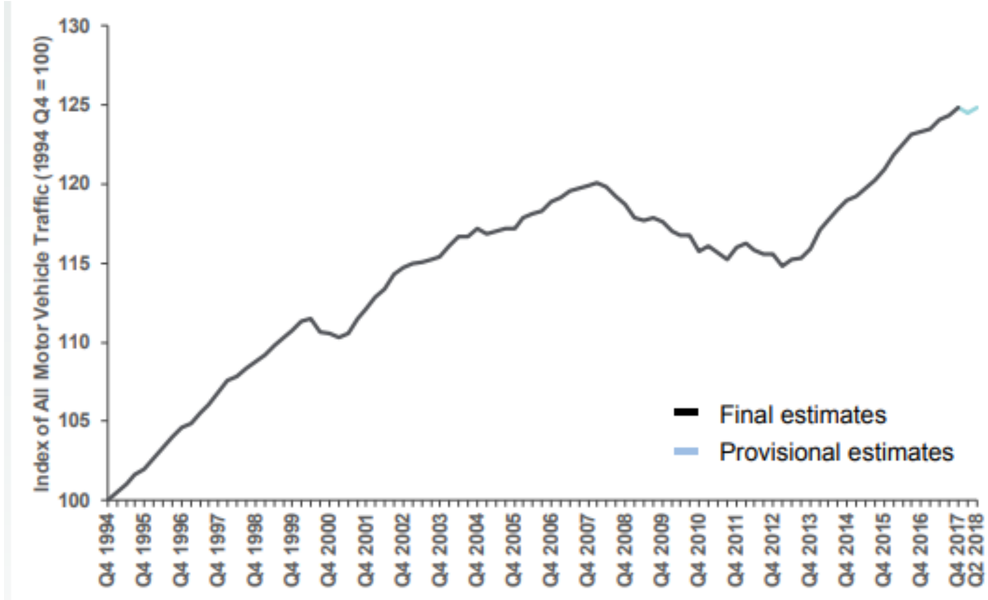

Fig. (1). The annual increment of road traffic in great britain [2].

2. LITERATURE REVIEW

The Impact of Traffic Management includes: Travel demands, Traffic flow on roads, Travel time, Journey length, Financial, Traffic flow through toll points, Toll revenue, Public transport fare revenue, environmental Impacts, Vehicle km travelled (by all modes), Emissions, Accessibility Impacts and Air Quality [4].

A comprehensive analysis of the current road traffic safety situation and assessment of the current approach to provincial management by (Oliver *et al*, 2005) was required in the development of Road Traffic Safety management strategy in the western cape. Specific issues were concluded from the analysis which includes: law enforcement, education and communication, engineering and land development, public transport and health emergency services [5]

Intelligent Transportation System (ITS) was defined by the directive of the European Union (2010) as " systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport." [6].

Many of the proposed studies in the field of intelligent transportation system (ITS) involved surveillance of road ways as a priority of homeland security. Digital technologies proliferated throughout everyday life, whether these technologies are mobile phones, GPS, cameras and so on. It tends to store data and adding a new modality to the surveillance uses. One of the Projects is concerned with reducing congestion proposed by (Downs, 2004) he concluded that traffic congestion is inevitable but it must not grow unchecked [7]. (Monahan, 2007) argued that several policies were developed that could effectively slow congestion's growth including; building more roads; High Occupancy Toll (HOT Lanes); ramp metering; intelligent transportation devices; adopt parking cash-out programs and giving regional transportation authority more power [8].

Another Project funded by the European framework research and development programs (2007) to developed traffic systems that aimed to make the transport safer, efficient and environmentally friendly, either by targeting the infrastructure or the vehicles themselves. however, there are limitations of the goals achieved by focusing on one element, so it becomes feasible to develop what is called Co-operative system in which both elements communicate with one another; I-WAY system as an example [9].

On the other hand, (Dawling *et al*, 2010) stated that Active Traffic Management (ATM) is one of

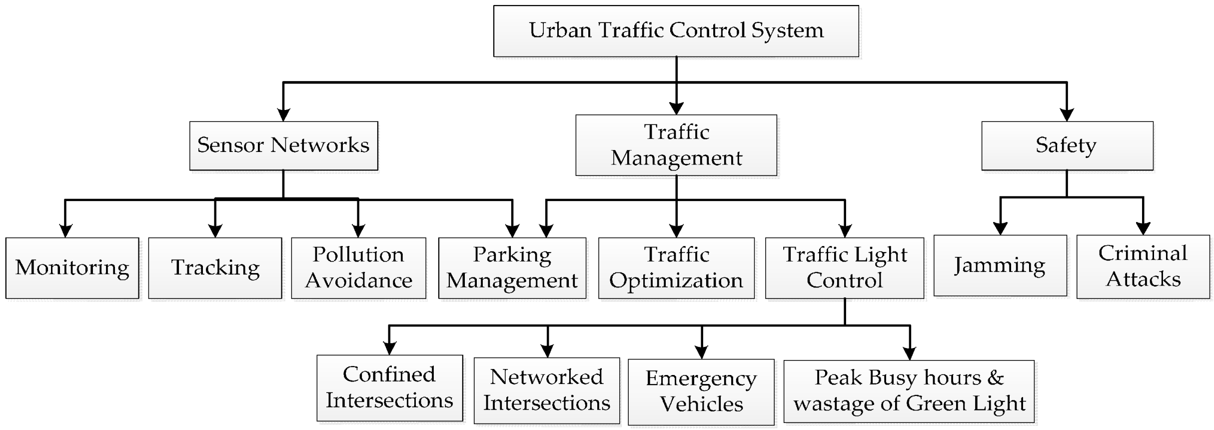

Fig. (2). Hierarchal functionality of urban traffic control system [11].

the most commonly used techniques, in which adaptation of controls in response to variations in demands, weather and changing incidents in order to maintain the maximum productivity of traffic management strategies. ATM has many elements with different objectives such as; speed and signal control, geometric configuration and demand modification [10].

In order to provide a smart urban traffic control system, a hierarchical management and functional system should be used. (Nellore *et al*, 2016) provided a view for hierarchical management in the following Fig. (**2**) [11].

(Qureshi *et al*., 2013) argued that to reduce congestion in urban areas, the design requires a new traffic management system to consider the following [12]:

- Hierarchical road infrastructures for public transportation.
- Reliable information on real-time traffic should be provided to users and traffic management systems.
- The traffic control system should be fast in taking decisions.
- The highest priority to the emergency vehicles at intersections to save lives and property.
- The system has to detect road accidents.
- A smart city traffic system should provide security

In general traffic management require real-time information like Density, Type, Average waiting time, pollution… *etc*. This information collected by different type of sensors; then using one of the communication technologies to send the collected data to traffic control module for analysis and intelligent decision. Fig. (**3**) summaries the available sensors and communication technologies for traffic management purposes.

Many projects have been designed for road traffic management to optimize traffic and reduce traffic problems in different countries. The following Table (**1**) lists some of the projects deployed by entities in different countries for road traffic management.

3. THE STATE OF THE ART

The main idea of the proposed technique is to cover the road lanes with an infrared transmitter on a suitable height, right after the intersection or at the beginning of the road. The infrared transmitter always "ON" sending infrared signal to the detector at the ground in a line of sight connection. As long as the detector receiving the signal, means no vehicles crossing through, otherwise count the number of the broken connection.

Once the vehicle breaks up the connection, a timer will start and the counter will be increased

Table 1. Road traffic management project.

Project	Country	Year of Completion
Intelligent Transport System (ITS) [13] http://www.roadtraffic-technology.com/projects/hong-kong A $423m Intelligent Transport System (ITS) project developed in Hong Kong's nationwide road network. The project used Traffic Control and Surveillance System (TCSS) for traffic counting, which cost $284.5m out of the full budget.	**Hong Kong**	**2010**
A Multi-Dimensional Model for Vehicle Impact on Traffic Safety, Congestion, and Environment [14] http://mioh-utc.udmercy.edu/research/ts-45/index.htm The project budget was $80,064, it focused on the vehicle to vehicle (V2V) communication and vehicle to light controller using DSRC technology, to improve the traffic flow and safety.	**US**	**2011**
FastLane: Modelling and simulation of traffic flow [15] http://www.its-edulab.nl/projects/fastlane%3A-modelling-and-simulation-traffic-flow Fastlane is a distinctive project. It is a software simulator used to simulate instant traffic and predict short term traffic flow on freeways. It relies on CCTV to collect data as input for simulation. The project helps in understanding the traffic behavior and planning for traffic management specially in the unexpected occurrences of events.	**Dutch**	**2013**
Weather-Responsive Traffic Management Concept of Operations [16] https://ops.fhwa.dot.gov/weather/best_practices/WeatherConOps0103.pdf This project concerned with the impact of weather on traffic behavior and safety. This project helps to make more effective decision to road traffic on the roadways.	**Cambridge-UK**	**2003**
Adaptive Traffic Signal Control System (ACS Lite) for Wolf Road, Albany, New York [17] https://www.utrc2.org/publications/adaptive-traffic-signal-control-system It is a dynamic optimization system to control traffic light according to the current traffic.	**New York**	**2014**
ATIS for Indian Cities [18] https://coeut.iitm.ac.in/umcsp/pdfweb/v2iitm_ATIS%20For%20indian%20cities_v2.pdf This project Deployed a 100 GPS and 32 Cameras on a 15 Km road stretch over 13 intersections with 4-6 lanes for road management and optimization.	**India**	**2014**
Integrated Transportation System Management (CITSM)[19] http://www.citsm.umd.edu/documents/abstracts-finished/milner-abstract.php The project granted $926,700 by the US Department of Transportation (USDOT) for traffic monitoring using wireless HD surveillance.	**US**	**In progress**
NEXTRANS Project: Agent-based Traffic Management and Reinforcement Learning in Congested Intersection Network [20] https://www.purdue.edu/discoverypark/nextrans/assets/pdfs/Final%20Report%20072IY03.pdf this project using a (VISSIM) Microscopic Traffic Simulation to evaluate traffic control on 20 intersections using reinforcement learning (RL) technique.	**US**	**2012**

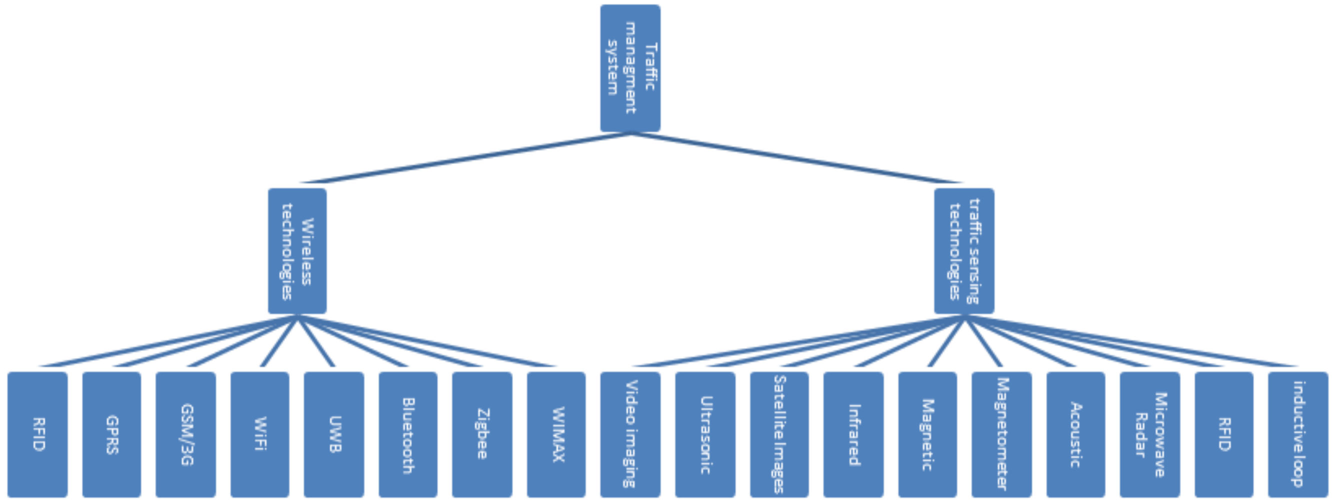

Fig. (3). Sensors and wireless technologies available for traffic management.

by one every time the timer exceeds T_{th}. This timer will help us in taking the vehicle volume counted in traffic statistic, especially when there are long vehicles or Lorries on the road it is not fair to be counted as one when it sometimes causes more traffic jam than its double size, so counting it as two or more based on the number of times of T_{th} required for this vehicle to pass through the connection. The transmitter and detector will be placed after the traffic light or the intersection, this will help in counting the only vehicles entered the lane.

Based on the very well-known concept of time= Distance / Speed, the more the speed is the less time required to cross the infrared scanners. T_{th} will depend on car speed and the (D) distance between the traffic light and the infrared scanner. The vehicles might have speed range between (5 to 80) km or more regardless the speed limit at that road. The distance will be different between intersections so it should be measured manually in between the traffic light and the infrared scanners. See the below Fig. (**4**).

In order to measure the speed of the car, the 'one Meter Check' should be done. To do so, another sensor and detector is required to be added at a one-meter distance from the first one, to calculate the speed, also to check in case the car is not moving status for any reason like traffic jam or accidents *etc*. So Timer (T_{1meter}) started once the first connection is broken, and ends at the broken moment of the second connection.

$$\text{Car Speed (m/s)} = 1\text{meter}/\ T_{1meter} \quad (1)$$

$$\text{Car Speed (km/h)} = (1\text{meter}/\ 1000)\ /\ (T_{1meter}/3600) \quad (2)$$

In case of car speed (km/h) less than 5km/h then the car in considered to be in slow movement and the counter will be added only one time. If the speed is more than this then:

$$T_{broken\ connection} = \text{D (between the intersection and the sensor) /car speed (m/s)} \quad (3)$$

Normal cars are 4-6 meters long as in [21]; cars with longer length should be counted as a multiple number for normal cars; so T_{th} is equal to the time period of the broken connection for approximately 5 meters car to pass through the connection on the previously calculated car speed.

$$T_{th} = 5\ \text{meter/car speed (m/s)}. \quad (4)$$

Now to take the volume of the traffic as a part of the statistics the counter should be increased for cars more than 5 meters long. This can be done as follows:

$$K = T_{broken\ connection}\ /T_{th} \quad (5)$$

In case of $K > 1$ then counter increased by (integer K) otherwise the counter increased by one. Calculating K helps in deciding Small and Medium Vehicle to be counted as one, while the very large and multi- carriages will be counted based on how many times T_{th} passed while the connection is still disconnected. The numbers will be sent with

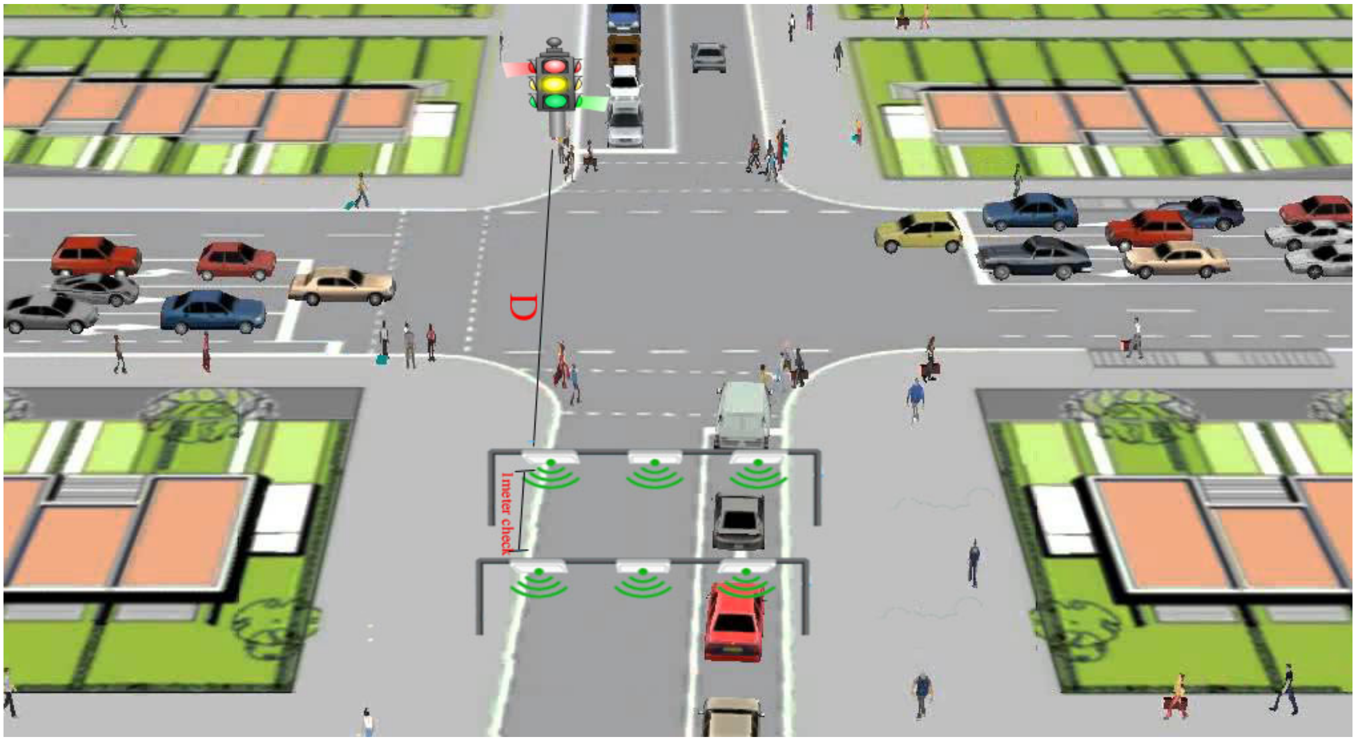

Fig. (4). Vehicle counting technique.

time details and lane information for further processing using other Algorithms and techniques for traffic optimization. See Flow Chart in Fig. (**5**).

4. DISCUSSION

The proposed technique will provide the necessary advice to the responsible authorities on matters of statistical traffic and traffic counting. The system can provide information about the number of traffic, taking into account the vehicle volume, then using this information along with time, lanes number and location information to use it as a raw data for road traffic optimization algorithms such as genetic or multi- agent algorithm. *etc*. Furthermore, Traffic Counting can help in finding a way to reach the maximum road benefit to the biggest number of users with minimum expenditure, and focusing the maintenance operations on the vital roads.

Road Traffic Counting devices are very expensive, the cost varied from 200- as in ROSIM magnetometer detector; to thousands per device- such as Zerzega traffic detection device cost up to €1600. The cost is crucial for traffic management systems, since traffic optimization requires a knowledge of a number of before and after intersections to make decisions and controlling traffic lights. Thus, the cost of the chosen system devices such as; Cheap infrared sensors; can reduce the projects budget.

The proposed method provides all the required information for traffic controlling in low cost compared to other systems components, which normally are CCTV cameras or magnetometer or even ultrasonic sensors. The distinctive benefit of this work, other than simplicity and low cost, is that it is able to consider the vehicle volume in traffic counting. The long vehicle should be considered as multiple number of normal cars, to give more accurate figure on the traffic status.

CONCLUSION

Road Traffic management still is a challenging issue for all countries. The first step for traffic management is statistics and obtaining the number of vehicle on the roads and its direction. We proposed a new low cost and simple system by using cheap infrared sensors to count the traffic on each lane of the road. The technique based on installing two infrared scanners on each lane at the beginning of the road to calculate car speed by using the”1-meter check”. Then finding the K value to

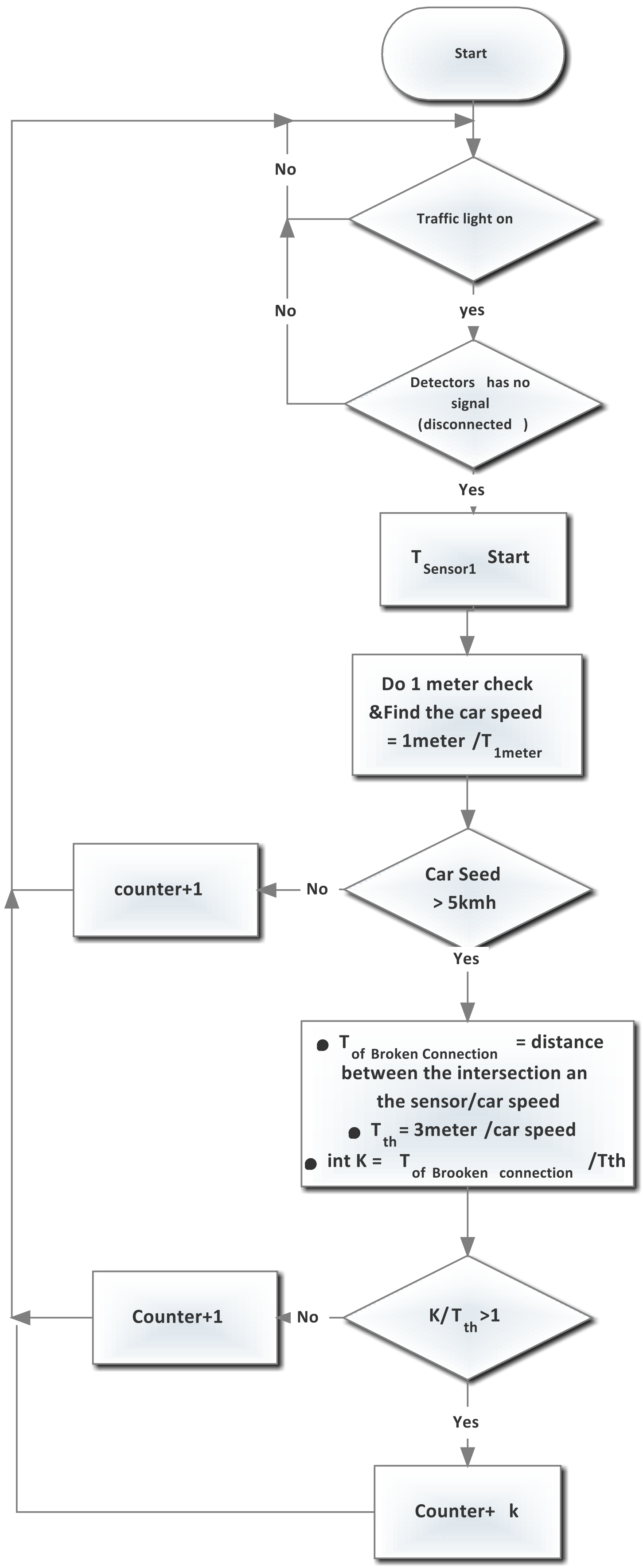

Fig. (5). Vehicle counting algorithm.

take the length of the vehicle into account, where long vehicles should be counted as more than one to set a real figure of the traffic jam.

The resulted information can be used later for traffic light controlling to reduce time waiting and avoid congestion. The numbers help to attract authorities' attention on which roads are vital and require maintenance and expansion, so it takes a priority on authorities' schedule.

Future work will be focused on using the observed information in a suitable traffic optimization algorithm to create a smart traffic management system, such as; genetic algorithms, or multi-agent and other suitable AI technique to create a full traffic management system.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

[1] Federal Highway Administration Office of Highway Information Management (1995) *Highway Statistics Summary To 1995*, United states: Federal Highway Administration.

[2] Department of Transport -UK (2018) *Provisional Road Traffic Estimates Great Britain*, UK: Department of Transport.

[3] Folds, D., Brooks, J., Stocks, D., Fain, W., Courtney, T., & Blankenship, S. (1993). Functional Definition of an Ideal Traffic Management System. Atlanta, Georgia: Georgia Tech Research Institute

[4] O'Brien A. (2011) *National Roads Traffic Management Study*, : *AECOM. [online] Available at:https://www.engineersireland.ie/EngineersIreland/media/SiteMedia/groups/societies/roads-tranport/National-Roads-Traffic-Management-Strategy-September-21-2011.pdf?ext=.pdf [Accessed 2 Jan. 2018].*

[5] Oliver, P. , DE BEER, E., and Ribbens, H. Road Safety Management Strategy for Westren Cape Province . Proceeding of (SATC) the 24th Southern African Transport Conference.Pretoria, South Africa, (2005).

[6] THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION (2010) 'DIRECTIVE 2010/40/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport', *Official Journal of the European Union,* (), pp. .

[7] Monahan, T. (2007) '"WAR ROOMS" OF THE STREET: SURVEILLANCE PRACTICES IN TRANSPORTATION CONTROL CENTERS', *The Communication Review,* 10(), pp. 367–389.

[8] Downs, A. (2004) 'Why Traffic Congestion is Here to Stay....and Will Get Worse', Transportation Research at the University of California, *ACCESS Magazine*. 25, pp.19-25.

[9] Rusconi, G., Brugnoli, M., Dosso, P. "I-WAY, intelligent co-operative system for road safety," 2007 IEEE Intelligent Vehicles Symposium, Istanbul, 2007, pp. 1056-1061.

[10] Dowling, R. G., & Elias, A. (2013). Active traffic management for arterials. Washington, D.C.: Transportation Research Board.

[11] Nellore, K.and Hancke, G.P. (2016) 'A Survey on Urban Traffic Management System Using Wireless Sensor Networks', *Sensors,* (), pp. .

[12] Qureshi, K. N., & Abdullah, A. H. (2013). A survey on intelligent transportation systems. Middle East Journal of Scientific Research, 15(5), 629-642.

[13] *Hong Kong Intelligent Transport System (ITS),* Available at: *http://www.roadtraffic-technology.com/projects/hong-kong/* (Accessed: 18th February 2018).

[14] Dr. Nizar Al-Holou (2012) *A Multi dimensional Model for Vehicle Impact on Traffic Safety, Congestion, and Environment,* Available at: *http://mioh-utc.udmercy.edu/research/ts-45/index.htm* (Accessed: 18th February 2018).

[15] ITS Edulab () *FastLane: modelling and simulation of traffic flow,* Available at: *http://www.its-edulab.nl/projects/fastlane%3A-modelling-and-simulation-traffic-flow*(Accessed: 18th February 2018).

[16] Cambridge Systematics, Inc. (2013) *Weather-Responsive Traffic Management Concept of Operations* , : .

[17] Ban, X., Kamga C. , Wang X. and Mouskos, K. (2014) *Adaptive Traffic Signal Control System (ACS Lite) for Wolf Road, Albany, New York*, : .

[18] Sivanandan, R., *et al* (2012) 'ATIS for Indian Cities', *UMCSP Conference,* (), pp. .

[19] Davis, C. and Milner S., (2008) A proof-of-concept and demonstration of a high definition, digital video surveillance and wireless transmission system for traffic monitoring and analysis, Available at: http://www.citsm.umd.edu/documents/abstracts-finished/milner-abstract.php (Accessed: 18th February 2018).

[20] Medina, J. and Benekohal, R. (2012) Agent-based Traffic Management and Reinforcement Learning in Congested Intersection Network, USDOT Region V Regional University Transportation Center Final Report.

[21] Ministry of Works and Transport Roads Department, Road Department report, (2004).*Traffic Data Collection and Analysis*, Gaborone, Botswana .