THE ROLE OF INTERNET OF THINGS ON INTELLIGENT TRANSPORT SYSTEM: A TRAFFIC OPTIMIZATION MODEL

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The road traffic congestion has become an excessive problem and a great pressure on both the governmental and social aspects especially in megacities. Hence, developing control systems that administrate the traffic flows is a vigorous solution, which can solve the problem of traffic congestion especially in megacities that should convert their services to be smart. The Intelligent Transport System (ITS) one of the Internet of Things (IoT) applications that provides a group of pioneer schemes for handling the challenges of traffic congestion. Traditionally, sensor-based structures have been used for gathering traffic information, but the coverage, cost, and real-time matters have remained unexplained. Thus, this paper aims at proposing a new model named Traffic Flow Optimization Model (TFOM) applied in Alexandria as a case study, which is considered a cost-effective and easily maintainable traffic congestion minimization method. It combines Infra-Red (IR) and active Radio Frequency Identification (RFID) technologies. TFOM is designed to minimize traffic congestion, given reroute options to the users, taken decisions regarding congestion, and finally it could be an initial step to help future predictions in linear megacities.

Keywords: Intelligent Transport System (ITS), Internet of Things (IoT), Traffic Optimization Models

INTRODUCTION

The economic growth and the increase of population with a limited traffic area cause numerous traffic congestion in megacities, which is one of the strategic difficulties in various countries around the world (Sutandi, 2020). Over the decades, many novel ideas and tools have been introduced related to the various issues regarding traffic control (Sharif *et al.*, 2019). However, developing counties such as Egypt face serious challenges that need to suggest novel ideas to optimize traffic controlling. As the technologies of smart cities develop rapidly such as the booming of the Internet of Things (IoT) devices (Nagy and Simon, 2018). Therefore, Egypt should convert its megacities such as Alexandria to be smart to overcome the overpopulation problem that reflected on road traffic.

Smart world is the main vision of IoT as the sensing technologies and smart components will be spread dominantly (Lu *et al.*, 2018; Al-Turjman and Lemayian, 2020). One of the IoT applications is called Intelligent Transport System (ITS) (Muthuramalingam *et al.*, 2019), which is a transportation system that also makes use of Information and Communication Technology (ICT) to clarify and minimize transportation and congestion problems. Therefore, recently many megacities develop and invest in ITS on a large scale to be smart (Chen *et al.*, 2016; Turner and Uludag, 2016). Thus, this paper proposes a new model named Traffic Flow Optimization Model (TFOM) to be available in all types of vehicles with high accuracy and low price, which is designed to optimize traffic control, depending on IoT broad concept while using ITS applications, considering Alexandria “the second megacity in Egypt” as a case study to apply such model.

In megacities especially in developing countries, on the one hand, the traffic flow can be smoothly achieved by the support of vehicle driver with appropriate reroute

recommendations as the drivers become uncertain about which alternative route will be the better to follow ‘even if received congestion warning’ that could be a source of disorganized traffic flow (Aldegheishem *et al.*, 2018). Hence, the main aim of this model is to design a promising congestion detection scheme that offers sensible timely warnings to the drivers about potential traffic situations and provides proper reroute recommendations accordingly. On the other hand, there are variable patterns in future traffic volumes (Ezzat *et al.*, 2014). Therefore, an accurate data collection methodology should be planned wisely to generate a reliable estimate of traffic flows and dissipation rates as in Egypt case current population is around 101 million and Alexandria population is about 5.4 million according to Egyptian Central Agency for Public Mobilization and Statistics (CAPMAS 2020), and the total number of registered vehicles according to the last statistics available in CAPMAS in 2017 were about 9.9 million vehicles.

Nowadays, in Egypt, forming vehicular ad hoc networks (VANET) would be possible as all vehicles will be equipped with novel technologies that make them capable to communicate with other adjoining vehicles (Adly, 2020). To monitor the traffic violations and accidents, Egypt's interior ministry has launched a novel technology to controlling its traffic system by sticking fixed electronic tags on the car windshields, which contains a SIM card that read by special infrared devices. It contains all the vehicle's data that allowing authorities to track violations, licence expiration and traffic congestion. Those smart tags will be one of the components for applying the proposed model.

METHODOLOGY

Preface

A traffic system is a dynamic system that is distinguished by several dynamic variables. Demand outlines change from a period to another during the day (Ezzat *et al.*, 2014). In Alexandria, the day could include five periods as shown in Table 1, which defines the rush and non-rush times. Those classifications are described according to the author experience and the surveillance via Google map of Alexandria. Also, they could be different in the summer season as Alexandria is a coastal city, which is very crowded in summer.

Table 1. The characteristic of day periods classifications

Periods	Timing	Rush/ Non-rush
First	From 07:00 to 10:00	Rush
Second	From 10:00 to 12:00	Non-rush
Third	From 12:00 to 16:00	Rush
Fourth	From 16:00 to 20:00	Non-rush
Fifth	From 20:00 to 23:00	Rush

Two kinds of traffic congestion are recognized, the first one is recurring traffic congestion, which takes place in the same area during the same time every day as it is presented in Table 1. Secondly, the non-recurring traffic congestion that arises randomly like an unplanned event such as accidents, vacations, or summer time. This non-recurring can summon an unexpected traffic volume boost. Handling of non-

recurring traffic congestion is serious compared to the recurring kind because it needs real-time traffic information and evaluation with appropriate traffic controlling decisions (Nellore and Hancke, 2016). The model proposed in this paper works on two traffic congestion types the recurring traffic and non/recurring congestion as TFOM did not work on a time basis but it works on all vehicles along the road.

Traffic Flow Optimization Model (TFOM) uses both infrared (IR) and Radio Frequency Identification (RFID) technology. As TFOM cannot rely on IR only as it always needs line-of-sight to work properly and it is not effective for long distances. Therefore, TFOM merges RFID as it can pass through obstacles and work over much longer distances, hence, TFOM model can be a solution for congestion as well as covering the main aim of the Egyptian government which minimizing accidents and monitoring violations.

The vehicle data will be saved in the smart stickers for further processing and decision making to help in keeping traffic records for further use as in Egypt there are no yet traffic records, as keeping traffic records will help in the future prediction. At the meantime, Egypt starts tracking vehicles with the usage of GPS that have some potential errors, which may be returned particularly in megacities with high-rise buildings, multipath issues, few visible satellites, the possibility of missing data (Basyoni, 2016). In addition, a GPS sensor can only track one vehicle at a time. Therefore, comprehensive statistics (for example, the density of the traffic flow or the number of vehicles), which can only be estimated relying on the number of available moving sensors in the area (Nagy and Simon, 2018). Thus, the main reasons behind employing TFOM model for RFID is that it is considered fixed position sensor and the biggest advantage of traditional fixed position sensors is that they are accurate data sources and detecting all vehicles moving within their ranges.

TFOM Initialization

TFOM Assumptions

The following assumptions are generated to facilitate the flow of the proposed model:

1. For homogenous congestion measurements, RFID tags should be attached parallel with the smart stickers to ensure that TFOM model is recording all the data.
2. Annually, with the vehicles licence renewal, all the traffic data and information will be saved in the smart stickers for further processing, to observe the traffic history of each vehicle that help traffic department to predict the whole traffic system in the city.

TFOM Setup Phase

1. IR setup: The Egyptian government already setup IR technology in all renewing license or new vehicles and force other vehicles to attach by the end of October 2020.
2. RFID setup: The system depends on the manageability and reliability of wireless data communication. The 'unit system' can measure the traffic congestion of a single part of the road. And next is the steps regarding TFOM RFID setup:
 - i. One active RFID tag to be kept in all type of vehicles attached on the car number plate.

- ii. One wireless router (R) and one wireless coordinator (C) (both acting as RFID readers) to be installed at the roadside (for examples, on Lamppost), as it is recommended by reference (Mandal *et al.*, 2011) the distance between R and C around 200 m to calculate the Safety Distance (SD) and average Waiting Time (WT) of vehicles at the road. The goal is to implement a system that would measure the SD between two vehicles moving on the same lane to measure the lane velocity and the average WT.
 - iii. Two Global System for Mobile Communications (GSM) modems (which is a special modem type that works with a SIM card, and runs by a mobile operator, just like a mobile phone. A new available version that supports SMS and capable of using smartphones, as those devices for both receiving and sending SMS and/or MMS messages). One of them will be settled with the coordinator and the other one will be in central monitoring station for wireless data transmission between gateway and software monitoring system (Mandal *et al.*, 2011).
3. Placement of devices
- i. 100 meters away should be the distance between the coordinator and the router, as routers work as readers as mentioned before so they must be placed before the coordinator that recording the absolute occurrence time of events, which is called timestamps.
 - ii. The computer system that works as a central admin, which is connected to a GSM modem. In practice, the communicating range of an RF system is limited by the interference of the signal delivered directly from emitter to reader, and the one reflected by the ground plane. For ranges more than a considered distance, these two signals cancel each other out, and quickly the strength of the received signal will be decreased. An approximation to the suitable range of a RF transmitting system is given by equation (1), Where λ is the wavelength of the RF signal, and h_T and h_R are respectively the heights of the emitter and the receiver (Perez *et al.*, 2010).
- $$d_T = 2\pi h_T h_R / \lambda \quad (1)$$

Execution Phase

To trace the congestion for a road, RFID readers will be used to receive signals from active RFID tags attached to the vehicles. The processes will be explained in the following points:

1. Tags incessantly transmit RF beacons. Then the central station collects the trip time when the vehicle attached with RFID tag moves across the router (the distance between the coordinator and the router), and determine the lane velocity, waiting time, and safety distance to measure possible congestion. The coordinator determines the vehicular trip time by using equation (2):
- $$Tt = t_2 - t_1 \quad (2)$$
- The coordinator will send SMS to the central admin that contains trip time and tag ID. The SMS will be distributed by the software, extracts the trip time, tag ID and its current location. From the trip time, the lane speed can be computed through equation (3), where d is the distance between the router and the coordinator:
- $$v = Tt/d \quad (3)$$

CONCLUSION

In high population city like Alexandria, traffic prediction is an advantage as connected devices (sensors and tags) will make it easier to shorten the travel time, or it might in the future help in finding a solution for the crowded areas like downtown. Therefore, the proposed model suggested in this paper might be fitting with the main roads in Alexandria such as El-Gaiesh, El-Horria, Ring roads to detect the predicted bottlenecks spots and find a smart solution before the consignment occurred. As TFOM is considered a cost-effective scheme so it is reasonable to be afforded by municipalities and the maintenance strategy could be administered and monitored by them.

Prospective researches could be addressing such issues that related to smart cities especially converting megacities to facilitate its provided services and enhance the quality of life. It is recommended that the research community should highlight the role of IoT and its applications in the conversion processes using appropriate methodologies, highlighting the effect of BDA in different aspects. In addition, the need for more novel methods and mechanizes to be developed in order to sustain traffic flows that could be positively affecting economic, environmental, and social aspects.

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