A Study on Road Traffic Management using Wire Less Sensors Techniques

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ABSTRACT

Traffic signals management systems (TSMS)are traffic systems based on cameras, infrared sensors and satellite systems. Such systems have been lacking the ability of real-time data collection and support. This paper proposes a solution to the traffic signal management problem using combined techniques that combines both GIS information with WSN based techniques. This combination provide appropriate techniques and tools that will enhance the capabilities of traffic jam prevention, early detection, efficient surveillance, efficient spread control, and fast termination of possible hazards. Consequently, this work proposes a new methodology thrown merging WSN and GIS techniques to produce valuable information for traffic signals management systems purposes.

Keywords– Traffic Signals Management System (TSMS),Geographical Information System (GIS), and Wireless Sensors Networks (WSN), Traffic Management.

I. INTRODUCTION

Traffic management is considered the backbone of any Intelligent Transportation Systems (ITS). Appropriate techniques and tools are to be developed to avoid problems associated with traffic, to provide better solution to these problems and to enhance the capabilities of traffic jam prevention, early detection, efficient surveillance, efficient spread control, and fast termination of such hazards [4]. In fact, recent developments in information technology have major effect on the design of traffic management systems. Recently, the advanced technologies application for the transportation infrastructure and for cars has been one of the most vital missions for improving the efficiency and safety of the transportation system known as Intelligent Transportation Systems [9]. The integration of GIS and WSN has been accessible to defeat the traffic management problems during traffic signals management. Traffic signals control is a core part of TSMS. This paper applies both GIS and WSN techniques to enhance the number of vehicles in urban network and limitation of road infrastructure [1].

A. Geographic Information Systems

A visualization map and interactive tool used for representation of a spatial configuration at a specific instant in time, or a spatial Configuration valid for an interval of time. An evolving, that initially referred to geographically managed information with component primarily stored in vector format with associated attributes .The Goal of the GIS is to graphically represent studied area in a map form. One property of GIS is that it can display studied items in the form of layers .This is a common method to represent terrain features such as mountains, water and even buildings.GIS techniques is divided into the following rules: (Storage, Analysis, Reporting of data sets and integrating various databases related to the study area).

Wireless Sensor Network (WSN)

A network of small sensor nodes (SNs) interconnecting wirelessly. It merges distributed sensing, computation and wireless communication technologies .huge number of small-power multi-functional sensor nodes, operating in various environments, including (sensing, computation and communication capabilities) .

Tiny and cheap devices that communicate wirelessly and sense their surroundings. Each device node consists of sensors, a processor, a memory, a radio, and energy source .A sensor: is a device that translates some physical actions of the environments into an electrical signal. The basic components of sensor unit: (ADC (Analog to Digital Converter), CPU (Central processing unit), power unit and communication unit) .

With the rapid developments of sensor technology there are many types of sensors: (Loop detectors, microwave, probe vehicles, cameras and cell phones are adapted to collect data for traffic state estimation).

The typical WSN architecture consists of: Huge number of sensors, wireless gateways and Access Points (APs). AP has huge computing resources, and provides radio signals connected to a power supply network. Generally, the sensor nodes sense environmental conditions, configured with a spatial density and at a sampling rate configured by the application. The access point operates as follows; the access point operates on the data gathered from all sensors within network to provide information, translated into meaningful format and forwarded to traffic controller or another control system. The sensor operates signals using cars detection algorithm; detection events are then generated and forwarded to the access point. After collecting data from these synchronized sensor nodes; the access point can measure the cars counts, occupancy and speed of the monitored traffic flow. Consequently, thedelay. The proposed schema considers the expected route flows to evade the gaming of the control. Although queue weights, cycles and phase sequences are not explicitly given, this allows the system to adapt dynamic changes of traffic arrivals at intersections.

(KAFI, Mohamed Amine, et al, 2013) propose an intelligent transportation system (ITS) based on Wireless sensor networks (WSN) as an effective solution to overcome present traffic jam and incremental number of accidents. Therefore, it enables new range of smart applications including control traffic congestion, monitoring road state, vehicular warning services, and traffic safety and parking management. Finally, WSN helps to avoid the traditional ITS system drawbacks, due to its cheap price and scalable nature [8]. (ABDOOS, Monireh, et al, 2013) suppose traffic control system that applies detectors data to determine the boundary conditions of all incoming and exit links. They developed control system capable of handling many boundary conditions of the recurrent, non-recurrent congestion, transited signal priority and downstream blockage conditions to enhance the overall traffic n etwork productivity and efficiency. In conclusion one of th e constraints of the proposed logic is its inability to account for development among traffic signals, and it's note d that such development would be fruitful in arterial type of control networks and not in a typical grid operation that most of the intersecting arterials are heavily worked [2].

(MASON, A., et al, 2010) consider the Road Transport system as the main causes of air pollutions in urban environments. By measuring the effects at regional and national levels that show bleak pictures helping people to be capable of tackling or mitigating the air problems .It is important to locate and verify air pollution places and conditions, to help manage traffic according conditions. Their job applies the integration of Wireless Sensor Networks (WSNs) and Geographic Information System (GIS) to display real time pollution map to make decisions towards traffic management. This system enables authorities to promote route traffic in urban areas [9].

(DE LOTTOA, Roberto, et al) apply Wireless Sensor Networks (WSNs) by listing the broad range of applications to urbanist problems, thus sensing their relevant parameters like building strains, level of noise, level of pollutions, and video feeds. Their job shows two-folds; first, introducing Wireless Sensor Network technologies as an attractive solution to many monitoring applications in urban scenarios. Then, producing preliminary set of experimental results to assess the main involved parameters. Finally, they discussed the integration of a WSN with the GIS; in order to associate physical measurements with geographical information. They also discussed the characteristics and challenges of WSNs [7].

Traffic Signals management System (TSMS):

Traffic network is supposed to be complicated systems consisting of many different agents interacting together with their actions are strongly coupled. Traffic networks are supposed to be a system consisting of smart agents that each one control intersection. Practically, traffic signal controllers have been located at intersections that can be seen as autonomous agents, since the number of agents is high in real urban networks [1].

Traffic Management: The main objective of such system is to reduce congestion of traffic network and optimizing the usage of road capacity. This is performed by traffic optimization and real-time traffic light control. Challenges of ITS applications: (Reliability, Real-Time., Heterogeneity, Security and Multimodal sensing) [8].

Traffic Signals Management Methodology

Conditions including average speed, max speed and time interval of each link monitored on a large scale using a spatially distributed WSN, which can count from tens to thousands of nodes to help avoid traffic jams and move within traffic signs as fast as possible. TSMDC algorithm has been developed to detect and avoid these problems.

According to Software Science Traffic signals control Use Case can be stated as follow:

Traffic Signals control Use Case: Main Success Scenario (Basic flow):

1. Cars stop at the traffic signs waiting for permission to move.
2. Sign detects the stopping cars then estimates all available paths for those cars.
3. TSMDC check the states of the other paths and next hops intersections states.
4. The other signs respond with their states.
5. If there are no problems the sign gives the permission to the cars to move.

6. After cars pass sign returns to its initial state (closed state).
7. Repeat the above steps finitely.

Extensions (Alternative Flows): the last algorithm may be stopped according to the following exceptions; any exception that occurs in the above mentioned steps can be shown as follows, each with previous corresponding step number.

Step 1: Sign detects no cars stop, the sign then sign keepon its initial state (closed state).

Step 2: Next sign of the current sign is congested:

1. Keep the current sign closed in this direction only but open the other directions.
2. Send message to the next sign again to change its state when possible.
3. Change the moving direction for that direction to the open sign.

Step 3: The next sign of any of the four neighbors' signsis congested:

1. Keep the sign closed in that direction.
2. Change the moving direction for that direction to the open sign.

Proposed System Algorithm (TSMDC)

Traditionally, Traffic management at the current trafficsigns occurs according to the number of cars stopping at the signs and the time period those cars spend waiting.

a. The initial state is all signals are red at all intersections.
b. The sensor detects car at any link.
c. TSMDC checks the states of all available destinations for the current path.
d. The paths that has no collision are open for the current

path and signals change to green light.

All these steps are stated in TSMDC algorithm ,TSMDC variables:

SLM(L,A,B): spatial location matrix.

ast : algorithm start time.

RS(X) : Reservation State. CS :collision State.

Vs(max, min) : Vehicle speed.

ad: available destinations.

tGl: time of Green light.

II. EXPERIMENTAL RESULTS

2.1.Data Measurements

The proposed methods have been tested on a large network. (Mat lab R2013a Simulink module, Core I5 CPU, 4 GB RAM and Windows 10 OS) has been used to create the network topology. The lanes' number for each path is 4. Pre-data files (paths, routing protocols and light tables) are configured randomly to simulate the real time systems. The case-study scenario consists of rounded and cross intersection, as displayed in (Figure 4). The cars have arrived or departed within 4 paths, through 2 lanes of inflow/outflow per link and 2 lanes per road (see Fig ure 5). The methods performance depends on the parameters value. During Experiment, each car has sent via the communications module, (its speed, location, time stopped, travel time, and travelled distance). Most of them affect the system performance. Using the car's position, the system has measured the distance from the car to the intersection. When the car has been entered in a predetermined control radius, for all car requests, the algorithm has produced a collision free path to be performed by the car, during travelling the intersection.

2.2.Data Presentation

At the beginning of the experiment, the system prints car states as follows:

Time = 0/50 (s) | Cars created = 0/Inf | Cars active = 0 | Computation time = 0.000000 (s)

While experiment processing system continuously print its states:

Time = 28/50 (s) | Cars created = 10/Inf | Cars active = 8 | Computation time = 48.570924 (s).

The simulation has been performed for 50 Cycles and the following results has been shown:

The application results can be seen in Figure 6(shows the velocities of cars respect to time for all paths during simulations); “X_Axis” represents the occupation ce lls of the path, “Y_axis” represents the time of occupatio n of the cells and color map represents the Velocity values of the paths. Then the summary of the simulation can be show as follow:

Table 1: show the numbers of cars in the simulation during execution cycles.

Table 1: Number of cars in simulation and their status

Car Status	No.of Cars
Created	17
Waiting to enter	0
In Simulator	5
Exit From simulator	12

The total Distance [m] = 124.5184 m during simulation execution cycles

The total Time in simulator [s] = 18.3358 Time in simulator per dist. [s/m]= 0.13252

Table 2: Time status in the simulator

Time	Value (Seconds)
Move [s]	18.0725 (98.9558 %)
stopped [s]	0.26333 (1.0442 %)
stopped per car [s/car]	0.021944
stopped per dist. [s/m]	0.0016471

The average velocity [m/s] = 6.8671

The average velocity while moving [m/s]= 6.9385

Table 3: Velocities times in the simulator

Velocity	Time Value (Seconds)
vel < 10Km/h [s]	2.5283 (13.3724 %)
vel < 20Km/h [s]	7.1333 (38.7197 %)
vel < 30Km/h [s]	9.205 (49.9445 %)

Time accelerating = 16.0567 [s] / 87.9233 % Time breaking = 2.2792 [s] / 12.0767 % Average time cars are stopped = 0.275 (s) Percentage of time cars are stopped = 1.1072 (%) Average time cars are in motion =

18.0608 (s) Percentage of time cars are in motion = 98.8928 (%) Average velocity during all route = 24.7523 (Km/h) Average velocity only when cars are in motion = 25.0253 (Km/h).

the proposed system reduces the waiting time of all cars, manages traffic signals in dynamic ways and reduces traffic at traffic sections. More improvement needs to be performed and system needs to be applied on a large number of intersections and a large number of vehicles.

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