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SIMULATION AND OPTIMIZING TRAFFIC FLOW AT SIGNALIZED INTERSECTION USING MATLAB

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ABSTRACT

The issue of traffic is a complex one requiring design, planning, engineering and institutional inputs for developing a proper solution. Dealing with traffic at intersection requires, many a times, the study and installation of traffic signals. Signalized intersection locations form the most common bottleneck points in cities across the world. There are many factors that affect the traffic behavior on the signalized intersection; such that number of phases, the arrival rate at the entrance, delay patterns, and the timing diagram. In this research, optimization technique by using cellular automata technique with taking the benefit of the abilities of MATLAB software. The traffic simulation models have been generally used to study traffic operations and systems impacts cause simulation is safer, less expensive and faster than field implementation and testing. Their use has also increased dramatically in recent years due to their flexibility and ability to visualize simulations. To achieve out the above objective, traffic data is collected at the network in CBD area (AL Mansur) in Baghdad city. Video recording is used to collect field data for three intersections because it provides permanent record of data with minimum manpower. These data are abstracted from video records, and processed by prepared EXCEL sheet. VISSIM simulation software V 5.0 is used to analyze the delay of these intersections by reducing the cycle length and getting less delay. A traffic Simulation program that use Nasch model was prepared and processed, the outputs of this model are very close to the output of the VISSIM, which means that the prepared program could be reliable.

INTRODUCTION

The behavior of traffic had a great deal of studies. The importance of these studies is to make the traffic behavior applicable with the solutions of mathematics and consequently could be programmable with various softwares.

The need of converting traffic behavior into software is an essential matter that helps in solving sophisticated problems in a few seconds run. There are several programs that could be used in dealing with traffic operations. Herein VISSIM software were used earlier in this study, and in this chapter the capability of MATLAB program was used to simulate the traffic operations into a model.

Traffic simulation is a process of predicting a model that may be considered as an effective tool to represent the real world situation, and then using this model to follow up the behavior of traffic operations in the transportation network. The advantage of Traffic simulation is the performance of the traffic could be estimated according to the available previous data, but it may require high programming skills and capability or using an expensive software package.

This research aims to solve the simulation of the traffic behavior at the signalized intersections by adapting another technique, the new technique contains the use of the benefit of CTM. The results of the traffic microscopic modeling packages were compared with the results of the MATLAB software microscopic model. The above process was used to propose the best timing stream that makes the less delays.

Previous Studies

Belbasi and Foulaadvand developed a Nagel-Schreckenberg cellular automata model for studying vehicular traffic flow at a single intersection. A set of traffic lights operating either in fixed time or in a traffic adaptive scheme controls the traffic flow. A closed boundary condition is applied to the streets, each of which conducts a



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unidirectional flow. Extensive Monte Carlo simulations are carried out to establish the model characteristics. They emphasized that the studied model suffers from non-realistic behaviour of car movement in some situations.

Lijun investigated the lane-changing and dwelling behaviors in a two-lane mixed traffic and conducted the simulation using the cellular automaton model under open boundary condition. He proposed that during rush hours, the queuing upstream the intersection could be stretch to the bus stop and then disturb the normal dwelling operation of buses. Therefore, it is necessary to reasonably design the position of signalized intersection and the corresponding cycle time.

Microscopic traffic flow models

Microscopic traffic flow simulation is representing the vehicle units in the traffic, based on the behavior of the driver. The variables that represent the microscopic properties of dynamic of the models are vehicle's position and velocity. There may be two models which represent the dynamic models, the Car-following model, and the Cellular automata model. The Nasch model was adapted to represent the microscopic model

Cellular Automata model

Cellular automata model is widely used as microscopic traffic model. In this model, a roadway is divided into cells. The vehicles movement may represent by moving from on cell to another. The traffic flow is occurred when vehicle moves from one cell each time step. The velocity v will added by 1 if the next cell is empty and will be slowing down by -1 if the next cell is not empty and occupied by another vehicle. In Cellular automata model, the divided street by cells is at a certain length of each cell, which represents the vehicles length and the distance to the next vehicle, in a dense density situation.. Each cell may be occupied by a vehicle or empty. There exist a and the velocity of each car can take the value between $v=0,1,2,\dots,umax$, which $umax$ is the maximum speed.

Figure:

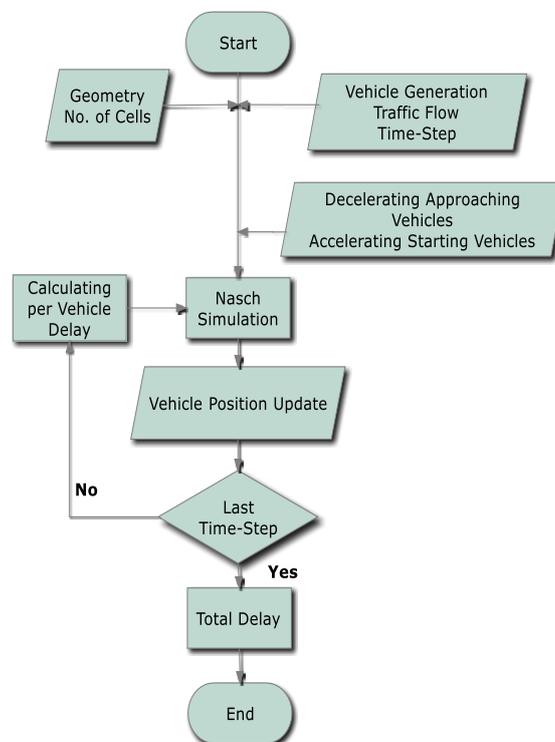


Figure (1) shows the steps of building model of NaSch microscopic model



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The Requirements of using Traffic simulation according to AASHTO Guidelines for Traffic Data Programs

- Data collection
- Programming language

To conduct data collection several prepares are to be made. The check list of the step of Data collection requires the following:

- The concepts of the operation are to be understood.
- Team work is to be established with distributed responsibilities.
- A well benefit tools should be occupied.
- The study area should be defined.
- A plan for the collected data should be ready.
- The data collection cost should be estimated.
- An overall work schedule with proper data sheet should be over handed.

Transportation network representation

The Transportation network may include the routes, junction, and any other transportation facility and their location that consists the transportation system in the area. The usually, the transportation network may represents the most important system of the microscopic simulation, it requires a detailed geometry and movements, also some researches need to make the geometry of Transportation network applied with other software packages such as GIS softwares.

Transportation network may include the following

- Nodes
- Links
- Vehicle types
- The scenario of movement

For the purpose of traffic modelling at the intersection the following algorithms may be used

Traffic flow modeling

In the current situation of local street network of the case study, signalized intersection suffers from traffic delays and low level of services. To make detailed studies that include the current situations and the proposed developments, there is a need to model the traffic behavior and study it virtually.

The proposed model should represent the actual operations in the study area, the included parameters of the model should reflect the characteristics of transportation network operations, and the output of the model and the real world should be converged.

In the study case, the length of the approach lanes to the signalized intersection may divided into smaller sections, which may called cells, also the time of the operations may divided into small periods of time, which called time steps, then as we have distance and time segments, the speed could be calculated. Some constraints need to be added, the speed should not exceed the speed limit, first there is acceleration to the desired speed and then deceleration when the desired speed reached, also the driver have to react according to front vehicle situation.

Model Building

Herein, an obvious need in developing the traffic behavior. The importance of traffic modelling in its capability of presenting the real world phenomena into a model that could be applied to find the critical points or events in the transportation network, also by using models the traffic behavior could be predicted according to the changed geometries, movements, and growth matters. One of the widely used models is Nasch Model. figure (2) shows the out put of NaSch model, that represent the relationship between the density of the cells and the velocity, this behavior is similar to the standard relationship between flow, density and speed.



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The Nasch Model may consist of 4 steps [Nagel und Schreckenberg, 1992] as follows:

- Acceleration: when the speed is not the maximum speed, it could be accelerated by +1 unit
- Deceleration: the velocity may be reduced or slowing down to avoid collision with the front vehicle.
- Fluctuation: a probability may be entered to study the randomization of vehicles in the streets especially urban arterials which may subject to random behavior. In the case of this work, the behavior of vehicles at the intersection according to sequent of signal lights may be known for great extent and the probability effects may eliminated.
- Vehicle progressing: the vehicle movement ahead after the above 3 steps at each time step.

The Nasch Model is an easy and fast method of simulation, it is designed first for one dimensional movement, also every cell in the street section may represent a tiny section with full boundary conditions. Since all the major parameters (time, space, and movement) of this model is discrete and not continuous, the a discrete mathematical function could represent the movement of vehicle from one cell to another cell. herein this model may be very applicable with signalized intersections.

Simulating signal controlled junction

Vehicles tend to move according to the available gaps that lie in front of them according to the following:

- Slowing down (speed is reduced) if the front traffic is close.
- Stopping (speed is zero) if the front traffic is stopped.

When the red light is acting, then the first vehicle is stopped at the stop line of the junction and it may be considered the first headway between the intersection and the lagging vehicles. The number of empty cells between two adjacent vehicles represent the length of the headway between leading and lagging vehicle at time t .

Deterministic model

In the case of signalized intersection, at the beginning of the red light the vehicles are to be packed up at the entrance of the intersection confirming a queue of vehicles. At the beginning of the green light the vehicles move into the intersection slowly until they reach the saturation flow with a starting delay and ending delay.

The saturation flow could be defined as the maximum flow of vehicles that could pass per green time. The advantage of using Matlab is the Matlab language Script is simple to use. Another very important aspect is the huge built-in functions that could be used. With these functions that provided by Matlab a lot of time and efforts could be spared compared with the other programs. Therefore, when a special operations is needed beside a software package like Vissim, it is highly advisable to use the Matlab Script as beside Vissim program.

Simulation of Traditional Cellular Automaton Model

In this work, the model used is a single lane highway based on the Cellular Automata model, because the lane changing maneuvers are very seldom to happened in the congested signalized intersections as observed in the signalized intersection field. The roadway may divide into fixed size cells. Each cell may have one vehicle or have no vehicle. A vehicle, like i th vehicle could be represented in the network by position x_i of i th vehicle, and the velocity u_i is the velocity of the i th vehicle.

Rules and Algorithm

To conduct the simulation of the non-lane changing traffic model, parameters are needed to be input: the length of the roadway, the length of the cell, numbers of vehicles, and velocity. We set the number of cells equal to the length of the roadway approach. Each cell could be either occupied or empty.

The position and speed of vehicles are generated. The rules of the Nasch model are applied (Acceleration, Deceleration, Randomization, and Movement). The Time-Space Diagrams was used to show the movements of vehicles. Figure (2) shows the Time-Space diagram of the 1st intersection in the range of effective green.



Figure:

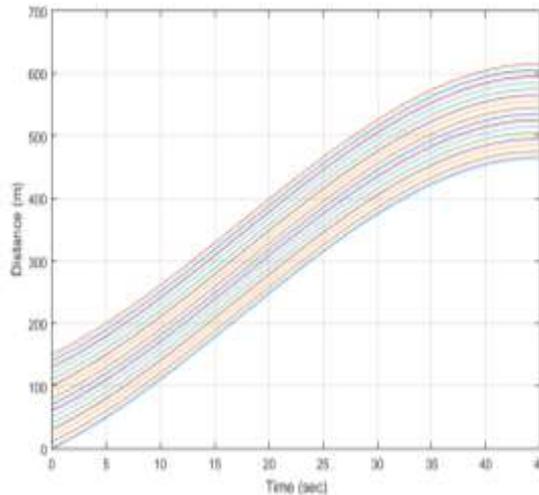


Figure (2) :Time-Space diagram of the 1st intersection in the range of effective green.

A comparison is made between two different methods of calculating the stopped delay, the first method is the output of the VISSIM software using the conditions explained earlier in chapter 4, the second method is the output of Nasch Method programmed using MATLAB software for each approach of the case study intersections. The results are shown in Table (1).

Figure (3) shows the comparison for each individual approach that explained in Table (1) the data used herein is that before the improvement.

Tables

Table (1): The results of the VISSIM software and the results of the Nasch Method for each approach of the case study intersections

Name of intersection	Approach Number	name of approaches	Stop delay(veh/hr) VISSIM output	Stop delay(veh/hr) Nasch Method
14 ramadan intersection	1	North	228.75	226.5017
	2	South	225.82	221.1752
	3	East	262.98	242.7641
	4	West	302.7	277.3125
AL Mansur intersection	5	North	141.4	131.0363
	6	South	171.21	162.8661
	7	East	229.09	206.947
Al yarmouk intersection	8	North	184.77	172.0897
	9	East	286.27	282.086
	10	west	304.38	289.0013



The Chi square value for the comparison of the stopped delay between VISSIM output and Nasch Method is 0.38 which means that with the 2 degree of freedom (space and time) .the chi square value here in was due to the high differences between the sequential processes, in the intersection with different cycle time, the traffic maneuver may be varied according to many parameters beside the standard parameters (like the effect of weather, drivers, vehicles and pedestrian).also the different philosophy between the vissim model and the NaSch model results in a slightly different outputs at each run.

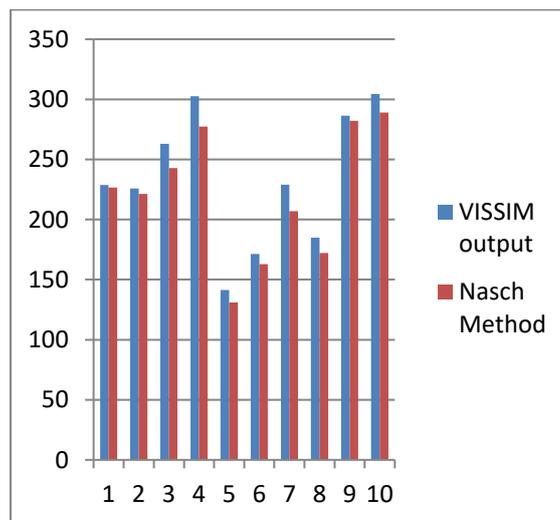


Figure (3) :comparison between the output of the VISSIM and the output of Nasch Method programmed using MATLAB software for each approach of the case study intersections

CONCLUSIONS

The main conclusions that can be drawn from this study are summarized, as follows

A proposed CTM model that is called NaSch model was modified to contain the case of the study area situation. the model calculates the total delay at the intersection with several cycle time and the results was compared with previous chapter output .A statistical evaluation was carried out and the model was sufficient .it will be concluded that, the NaSch model could be applied to the local cases of signalized intersections, and the model could be generated to the intersections in the area.

The use of modified NaSch model in this study concluded that the delay at the signalized intersections could be calculated by using a small MATLAB software instead of using a traffic simulation package to an acceptable results

Recommendations for Future Work

- Comparative Study of VISSIM and paramics on Signalized Intersection.
- Developing the microscopic program to use with lane changing operations like freeways and arterials.

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