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Analysis Of On the Spot and Simulated Trafic Flow Density Or a Simulation Models of Trafic Flow and Its Application

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ABSTRACT: Traffic simulation is a widely used method applied in the research on traffic modeling. The five driving forces behind this simulation development are in computer hardware technology and in programming tools, the development of the general information infrastructure, and the society's demand for more detailed analysis of the consequences of traffic measures and plans.

From the literature study, a variety traffic simulation models were found in experiments and applications with aims to imaginary real traffic operations. The traffic simulation models can be categorized into three namely, microscopic modeling, macroscopic modeling and mesoscopic modeling. This report is aimed to overview these traffic simulation models, in term of its function, limitation and application using Macroscopic model calibration of Greenshield's model.

Keywords: Simulation; Microscopic; Macroscopic; Mesoscopic.

I. INTRODUCTION

Road transportation, that is, efficient movement of people and goods through physical road and street networks is a fascinating problem. Traffic systems are characterized by anumber of features that make them hard to analyze, control and optimize.In addition, road and street transportation systems are inherently dynamic in nature, that is, the number of units in the system varies according to the time, and with a considerable amount of randomness. The great number of active participants at present at the same time in the system means a great number of simultaneous interactions.

Transportation systems are typical man-machine systems, that is, the activities in the system include both human interaction (interaction between driver-vehicle-elements) and man-machine-interactions (driver interaction with the vehicle, with the traffic information and control system and with the physical road and street environment).

Representation of traffic flows is an essential adjunct to both urban and non-urban planning. This theory is most important working tools for governments and consultants. Urban traffic models have been of greatest interest, because congestion adds to the complexity,but traffic modeling is also essential for non-urban road planning and investment.Traffic flow may be treated as a fluid, without considering the individual elements, or individual vehicles may be modeled. The term 'simulation' is taken broadly to mean any model which attempts to represent or mirror actual traffic behaviour and includes equilibrium models. A common convention is to call simulation of the individual vehicles in a traffic stream 'microsimulation'.

Traffic modeling is aimed to accurately recreate traffic as observed and measured on street. Traffic modeling plays an important part in traffic engineering. It can be applied to plan and manage the traffic within certain road network. For example, making a smooth traffic at an intersection and etc. Principally, simulation models focus on three output values to solve traffic problems In traffic flows, alternative routes can be identified based on the number of vehicles. By using the simulation model, modeler can devise on how to reduce the levels of congestion of certain roads. Network element in traffic simulation consists of link, merge, link cross and other elements of the road. This is related to the geometric layout of the road. Using appropriate simulation software, the road geometric design can be changed to see how it can influence the current traffic situation. Simulations model can help to estimate the time and cost of travel. This is especially used when the assessment of traffic improvement is needed to be measured. The transport planner can easily make a

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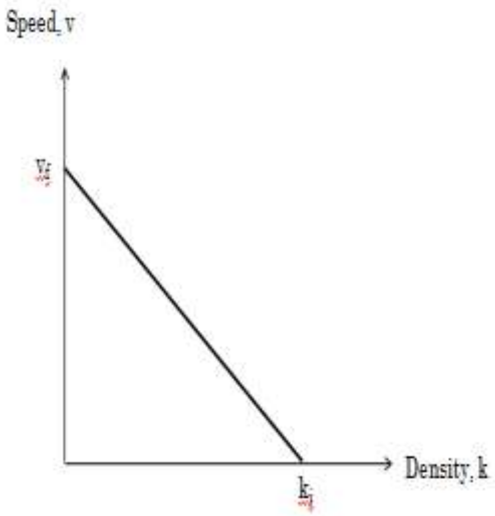
performance comparison without any extra cost of money and time.

Classification of Traffic Simulation Models The models were grouped according to their areas of application. The three classifications of traffic simulation models, are macroscopic modeling , microscopic modeling, and mesoscopic modeling.

Macroscopic Modeling

Macroscopic modeling describes the intersections at a low level of detail. In macroscopic model, traffic stream is represented in an aggregate measured in terms of characteristics like speed, flow and density. Flow, speed and density are the three main characteristics of traffic. The researchers have studied speed-flow-density relationships and have attempted to develop mathematical descriptions for these curves, which is Greenshield's Model and Greenberg Model. Greenshield's Model is used to develop a model of uninterrupted traffic flow. It is a fairly accurate and simple modeling. There are three characteristics of the graph.



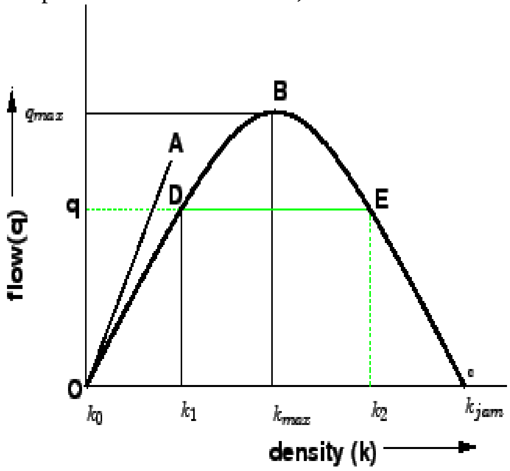
Speed, v versus Density, k

Greenshied's Model shows the relationship between speed and density is linear. When density increases, flow decreases to an optimum when more vehicles were on the road. The speed also decreases due to the interaction of vehicles.

$$v = v_f - v_f \frac{k}{k_j} \qquad (1)$$

Where,
v = speed (km/h)
k = density (veh/km)
vf = free mean speed (veh/km)
kj = jam density (veh/km)
Eq. 1. Speed, v

Once the relation between speed and flow is established, the relation with flow can be derived. This relation between flow and density is parabolic in shape and is shown in Also,



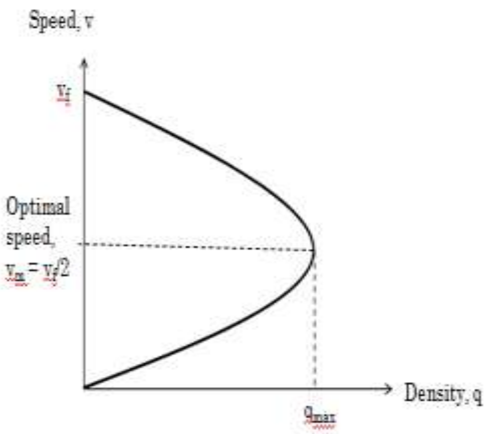
Flow, q versus Density, k

Greenshield's model shows that the relationship between flow and density is a parabolic curve.

$$Q = \left(v_f - v_f \frac{k}{k_j} \right) k \text{ or } q = kv \qquad (2)$$

Where,
q = flow
Eq. 2. Flow, q

When flow is very low, speed is higher. The drivers are able to travel at a desired speed. As the flow increases, speed gradually decreases. The highest flow shows the transition of non-congested to congested condition.



Speed, v versus Density, k

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Greenshield's model shows the relationship between speed and density.

$q_m = v_m k_m$ or $q_m = \frac{v_f k_f}{4}$ (3)

Where,

qmax = maximum flow
vmax = optimal speed
kmax = optimal density

Eq. 3. Maximum flow

When the capacity (qmax) is in the maximum flow, the density is increasing and the speed will decrease due to the maximum number of vehicles passing to a certain point. The characteristics of congested unstable flow is high density and low speed. There is no gap for vehicles to enter. The characteristics of uncongested stable flow is slow density and high speed, when there are gaps for merging lane.

Now substituting equation 1 in equation 2, we get

$$q = v_f.k - \left[\frac{v_f}{k_j}\right] k^2 \qquad (3)$$

Similarly we can find the relation between speed and flow. For this, put $k = \frac{q}{v}$ in equation 1 and solving, we get $q = k_j .v - \left[\frac{k_j}{v_f}\right] v^2$ (4)

This relationship is again parabolic . Once the relationship between the fundamental variables of traffic flow is established, the boundary conditions can be derived. The boundary conditions that are of interest are jam density, freeflow speed, and maximum flow. To find density at maximum flow, differentiate equation 3 with respect to k and equate it to zero. ie.,

$$\frac{dq}{dk} = 0$$

$$v_f - \left[\frac{v_f}{k_j}\right] 2k = 0$$

$$k = \frac{k_j}{2}$$

Denoting the density corresponding to maximum flow as k_0, when $k_0 = \frac{k_j}{2}$ (5)

Therefore, density corresponding to maximum flow is half the jam density Once we get k_0, we can derive for maximum flow, q_{max}. Substituting equation 5 in equation 3

$$q_{max} = v_f \frac{k_j}{2} - \left[\frac{v_f}{k_j}\right]\left[\frac{k_j}{2}\right]^2 = v_f \frac{k_j}{2} - v_f \frac{k_j}{4} = \frac{v_f k_j}{4}$$

Thus the maximum flow is one fourth the product of free flow and jam density. Finally to get the speed at maximum flow, v_0 , substitute equation 5 in equation 1 and solving we get,

$$v_0 = v_f - \frac{v_f}{k_j}\frac{k_j}{2}$$

$$v_0 = \frac{v_f}{2} \qquad (6)$$

Therefore, speed at maximum flow is half of the free speed.

Calibration of Greenshield's model

Inorder to use this model for any traffic stream, one should get the boundary values, especially free flow speed (v_f) and jam density (k_j). This has to be obtained by field survey and this is called calibration process. Although it is difficult to determine exact free flow speed and jam density directly from the field, approximate values can be obtained from a number of speed and density observations and then fitting a linear equation between them. Let the linear equation be y = a +bx such that "y" is density "k" and "x"denotes the speed "v". Using linear regression method, coefficients "a" and "b" can be solved as,

$$b = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2} \qquad (7)$$

$$a = \bar{y} - b\,\bar{x} \qquad (8)$$

Alternate method of solving for b is,

$$b = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \qquad (9)$$

where $x_i$and $y_i$are the samples, n is the number of samples, and $\bar{x}$ and $\bar{y}$ are the mean of $x_i$and $y_i$respectively.

Observation :

I observed one of the busy traffic square of Bhatapara , which is a medium city of population about 90000 for two days between 7:30 am to 9:30 am and 5:00 pm to 7: 00 pm. and noted down the frequencies of vehicles to apply simulation model. Square is near bus stand. It is junction of five roads, presence of two traffic police and traffic signals, traffic controlled.

date	time	No. of vehicles	speed
24/12/2019	7:30 am to 9:30 am	70	25
25/12/2019	7:30 am to 9:30 am	20	40
24/12/2019	5:00 pm to 7:00 pm	171	5
25/12/2019	5:00 pm to 7:00 pm	129	15

The above data on speed and density, determine the parameters of the Greenshields' model. Also find the maximum flow and density corresponding to a speed of 30 km/hr.

k	171	129	20	70
v	5	15	40	25

Solution

Denoting y = v and x = k, solve for a and b using equation 8 and equation 9. The solution is tabulated as shown below.

x(k)	y(v)	$(x_i - \bar{x})$	$(y_i - \bar{y})$	$(x_i - \bar{x})(y_i - \bar{y})$	$(x_i - \bar{x})^2$
171	5	73.5	-16.3	-1198.1	5402.3
129	15	31.5	-6.3	-198.5	992.3
20	40	-77.5	18.7	-1449.3	6006.3
70	25	-27.5	3.7	-101.8	756.3
390	85			-2947.7	13157.2

$\bar{x} = \frac{\sum x}{n}$ 390/4= 97.5, $\bar{y} = \frac{\sum y}{n}$ = 85/4 = 21.3. From equation 9, b = $\frac{-2947.7}{13157.2}$ = -0.2

a = y - b$\bar{x}$= 21.3 + 0.2x97.5 = 40.8. So the linear regression equation will be,

$$v = 40.8 - 0.2\,k \qquad (10)$$

Here v_f = 40.8 and $\frac{v_f}{k_j}$= 0.2 This implies, k_j 40.8/0.2= 204 veh/km The basic parameters of Greenshield's model are free flow speed and jam density and they are obtained as 40.8 kmph and 204 veh/km respectively. To find maximum flow, use equation 6, i.e.,

q_{max}= $\frac{40.8 \times 204}{4}$ = 2080.8 veh/hr Density corresponding to the speed 30 km/hr can be found out by substituting v = 30 in equation 10.

i.e, 30 = 40.8 - 0.2 k Therefore, k =$\frac{40.8-30}{0.2}$ = 54 veh/km

II. CONCLUSION:

In Greenshield's model, linear relationship between speed and density was assumed. But in field we can hardly find such a relationship between speed and density.

The main aim of simulation model is to presents a real traffic situation in to dynamic model. There are three simulation model available to be used in traffic engineering namely macroscopic, microscopic and mesoscopic. The application on each model is depending on the aim of study to be conducted. Selecting the right model according to study aims is an important step towards traffic problem resolution. strong indications that microsimulation will be for better than macrosimulation and come to dominate traffic modeling as the use of parallel computing becomes widespread. Observed Density, corresponding to the speed 30 km/hr is 54 veh/km, which is suitable as per locality.

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