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Experimental Survey and Modeling for the Driver Behavior in Vehicle Platoons

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Abstract

The objective of this paper is study the driver behaviors in the vehicle platoons starting from a traffic light. This study is necessary to model the changes in the shape of the vehicle platoons at different sections along the road. It is need to understand these changes in order to define an adequate programming of the traffic light phases. The study started from a survey of traffic flows on a road section of about 650 m.: all vehicles have been followed from the start section and for each of them were recorded the transit times on next sections at known distance. The data have been analyzed with two different methods: Cyclic Flow Profiles and the Weibull distribution. The calibrated CFP, with correct parameter values, well represent the trend and the dispersion of vehicle platoons at the observed road section. The Weibull distribution, basic used to describe life-time reliability characteristics in model failure testing, can be a powerful tool also for the prediction of vehicle platoons on the road sections. Fact, starting from the flow study in a number of sections, it is possible to know the trend of distribution parameters as function of the start distance. The variation of two parameters along the road from the first section (first signal light) appears to be linear for the first parameter (position), almost linear for the second (form).

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Keywords: light coordination; green time; traffic flow; platoons; driver behavior

1. Objective

The objective of this work is to investigate the driver behavior in traffic platoons that depart from a traffic light. This study is required to right model the shape changes of the traffic platoons on different sections along road. This

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allows to understand and to foresee the evolution of traffic platoons over a road segment aiming, for example, at defining an adequate phase plan to following traffic lights. It is well known in practice that traffic light coordination works well only for short length. This can be due to many factors among which the hypothesis of constant platoon characteristics is relevant.

In this work has been studied the dispersion of vehicular platoons, starting from a traffic light, by a survey of the transit flows on a road section of about 650 meters with moderate interferences. The data have been analyzed according to the Cyclic Flow Profiles (CFP, with the recurrence relation; Robertson, 1969). The experimental CFP show, in some control sections along the road, the trend of the average flow transit time as a function of fixed time intervals that sum to the entire cycle time. The CFP, which parameter values have calibrated to fit flow profiles, well represent the trend and dispersion of platoons of vehicles on the road section observed. The values of the calibration parameters provided in the literature for this function by experiments with equivalent geometric conditions have been compared with those taken from the actual experimentation.

Data of traffic platoons are been fitted also with Weibull function. This function is basic used to describe life-time reliability characteristics in model failure testing, but, for its adaptability, can be used as powerful tool for the prediction of behavior of vehicle platoons on the road sections. From this point of view the current work may be regarded as a continuation and extension of the previous works.

2. Cyclic Flow Profiles and Robertson Model

Vehicles starting from the first green lamp at intersection travelling at different speeds, the flows vary from cycle to cycle and the saturation flow is not constant during the entire green time. The cyclic flow profiles, moreover, vary with the layout of the road section and with the characteristics of the traffic flows.

The analysis of cyclic flow profiles provides information about:

- average traffic flows: the graph area is proportional to the average flow: examining the graphs of different sections of urban road it can easily identify sections with greater flows;
- coordination of traffic lights cycles: the height variations of the cyclic flow profiles are a measure of the coordination need of the traffic light cycles: does not have considerable advantages when the heights of the profiles are kept sufficiently uniform during the whole cycle, conversely if peaks of the cyclic flow profiles are pronounced, corresponding to well-defined platoons, then these indicate situations that can take advantage from coordination of traffic lights cycles;
- saturation flows by the trend cyclic flow profiles, if exists a sufficiently large number of vehicles waiting for the green time, it is possible to derive the saturation flow: during some parts of the cycle it will probably a decrease of the flows and knowing the duration of the green time and the height of the peaks can check the duration of the saturation flow;
- dispersion of platoons: the hypothesis that all vehicles travelling within a platoon at the same speed is very unrealistic; if it measures the cyclic flow profiles along a road section at different distances from the first stop line then is obtained profiles of different shape; these vary their shape «scattering» more when the distance from the starting line increases.

The dispersion of flow platoons downstream of an intersection with traffic light depends, in same geometric conditions and environmental factors, both from the differences in performance of road vehicles and from the driver behavior. This has been studied through the kinematic wave theory (Lighthill, 1955), the diffusion theory (Pacey, 1956) and the recurrence relation (Robertson, 1969). The platoon model based on the recurrence relation is simple, from numerical point of view, but it requires an experimental data base on which this cans be setting. It is basic adopted in the «fixed time» simulation program TRANSIT-7F. The recurrence relation is:

$$q_2[i+\beta \cdot t] = F \cdot q_1[i] + (1-F) \cdot q_2[i+\beta \cdot t-1] \quad (1)$$

where: $q_1[i]$ is traffic flow measured in the starting section, during the interval $[i]$, including the transit time of the platoon; $q_2[i+t]$ is expected traffic flow at interval $[i+t]$ in control section; t is average travel time on the distance between the two sections (measured in the same intervals used for q_1 and q_2); α is experimental factor of dispersion,