Applications of the Automobile Simulator

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An automobile simulator has been used in driver behavior studies. It is shown that these studies would have been difficult or even impossible if attempted on the actual highway. The simulator and the various applications of the simulator to driver behavior studies are described.

•DRIVER BEHAVIOR studies can either be conducted on the highway or on an automobile simulator in a laboratory. Many problems develop if highway studies are attempted. Control of traffic and measurement of variables are the major complications that arise. These problems become non-existent if an automobile simulator is used and the possibility of a real accident is eliminated. However a simulator is an approximation, and consequently, results of simulator studies will also be approximate.

DESCRIPTION OF SIMULATOR

The simulator used was a two-car type (1). One vehicle was driven by the subject and the other was controlled by an analog computer. The driven vehicle was a full scale mock-up of an automobile while the lead vehicle was a small toy. This toy together with the scaled down road and roadway scenery was viewed by a TV camera. The image was presented to the driver of the rear vehicle by a TV monitor mounted on the hood of his automobile. Figure 1 shows the simulator; Figure 2 is a block diagram.

ADVANTAGES AND LIMITATIONS

The most serious limitation of the present simulator is that the driver senses no acceleration forces. Other limitations are that the maximum distance between the two automobiles is limited, the roadway is straight and level with no intersections, and passing is not possible although the driver can swing out into the left lane.

This simulator uses an analog computer as an integral component. With the computer it is possible to program the lead automobile for many different types of driving experiments. In studying driver models it is a simple matter to replace the driver with his analog on the computer and test the validity of the driver model.

APPLICATIONS

Direct

The simulator was directly used to good advantage in driver behavior studies. In one investigation the driver was trying to follow the lead vehicle (traveling at a constant velocity) at a constant headway. Headway is defined as the distance between the front bumper of the rear vehicle and the front bumper of the lead vehicle. As would be expected, the driver was not able to follow at a constant headway but instead deviated randomly about a mean headway. Many models have been proposed for this car-following situation.

Barbosa (2), in studying Herman's equation of car following (as well as many others) with the aid of the automobile simulator, was able to show that these equations gave only

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an approximate fit under limited variations of the variables. Under the restraint of these limitations, he found that a large class of functions would give the same approximate fit. In his attempts to devise a more general model, Barbosa considered constant acceleration levels of varying amplitudes and sense, and was able to propose a decision point model. Later studies justified his model and led to what is now called the action point model.

Figure 1. The complete simulator.

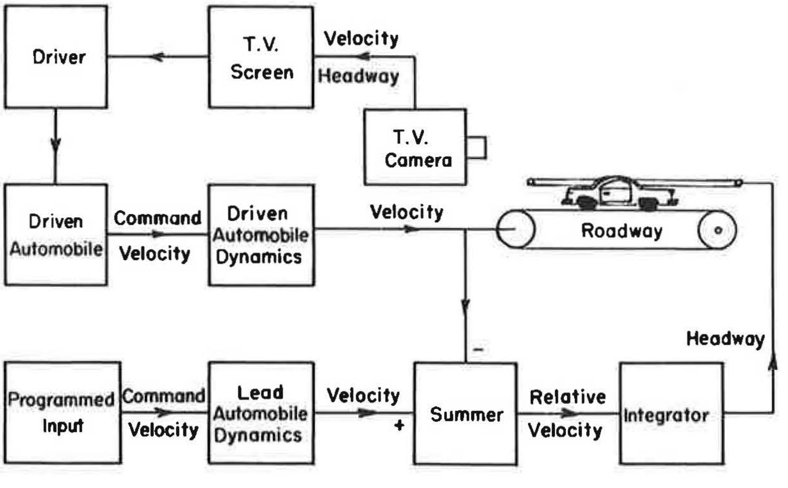

Figure 2. Block diagram of simulator.

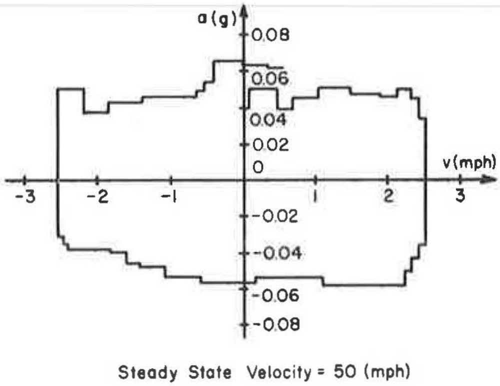

Figure 3. Typical a-v trajectory.

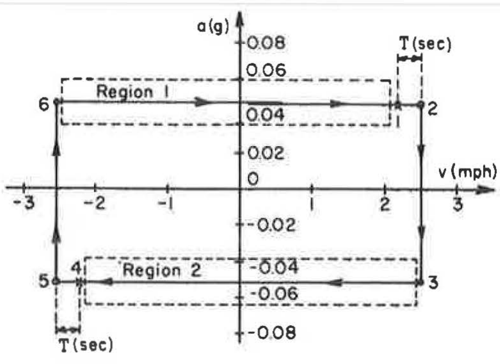

Figure 4. Expected response of decision point model.

The justification of the action point model is evident if the trajectory shown in Figure 3 is analyzed. This trajectory is typical of that obtained if the driver's acceleration is plotted against the relative velocity existing between the driver's vehicle and the vehicle being followed. The trajectory shown in Figure 4 is the response expected from the action point model and it is evident that this is just a smoothed version of the actual trajectory, that is, the small variations in the positive and negative acceleration levels have been averaged out. In Region 1, the driver is accelerating at a constant value of 0. 05 g. At point 1, the driver makes a decision to decelerate at a rate of 0. 05 g. This point is called a decision point. After an undetermined delay of T seconds the driver takes action at point 2 and instantly decelerates to a value of 0. 05 g at point 3. Point 2 is termed the action point. In Region 2, the vehicle slows down with a constant deceleration of 0. 05 g. At point 4, the driver makes a decision to change his acceleration and then acts on his decision at point 5. The driver is now back in Region 1 and has completed one cycle in the trajectory.

This particular model is quite simple and appears to give a more reasonable explanation of the car-following situation for a wider variety of conditions. The action point model is under active study and the exact nature of this model will be the subject of a future report in which the dependence of the action points on the independent variables will be made clear by considering the means of the variables as well as the varianees of these means.

Another direct application of the simulator was in a preliminary study of the effect of large changes in lead car velocity on the driver. This preliminary study has shown that the action point model can again be used to explain the behavior of the driver. In the experimentation for this study the lead car velocity had to be abruptly changed and the resultant transient variables of the driven car measured. No difficulty was encountered with the simulator in making these measurements.

Indirect

Indirect applications of the simulator were made in visual thresholds studies. The lead vehicle was made to undergo changes in range, velocity, and acceleration and the corresponding visual thresholds of the driver in the rear vehicle were measured. In these studies, the velocity threshold has received most consideration. A statistical study of this threshold has been partially completed. Results of the complete study will be the subject of a future report. Preliminary investigations of the range and acceleration thresholds have also been made. The threshold studies demanded a multitude of precise measurements under varying conditions and these were readily obtainable from the simulator.

CONCLUSIONS

Through the use of an automobile simulator, a new model of the driver has been found. This action point model is radically different from any other model that has been proposed for the human driver. Preliminary studies have shown that this model in its most general form is probably the most complete model so far developed.

The simulator has also made visual threshold studies possible. Present studies on the velocity threshold indicate that fundamental contributions to pyschophysics will result. It is thought that these fundamental contributions will have immediate applications in highway design (both conventional and electronic), traffic flow, and virtually every area where a human is concerned with the velocity of an object that he is watching.

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