Intermittent Control Properties of Car Following: I. Driving Simulator Experiments

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ABSTRACT

A rather simple car driving simulator was created based on the available open source engine TORCS and used to analyze the basic features of human behavior in car driving within the car-following and free-driving setups. Four drivers with different skill in driving real cars participated in these experiments. They were instructed to driver a virtual car without overtaking the lead car driven by computer at a fixed speed and not to lose sight of it as well as to drive a virtual car on empty road in a style convenient individually. Based on the collected data the distribution of the headway, velocity, acceleration, and jerk are constructed and compared with available experimental data collected previously by the analysis of the real traffic flow. As the main results we draw a conclusion that the human behavior in car driving should be categorized as a generalized intermittent control with noise-driven activation of the active phase. Besides, we hypothesize that the car jerk is an individual phase variable required for describing car dynamics.

Categories and Subject Descriptors

J.4 [**Social and Behavioral Sciences**]: psychology; H.1.2 [**User/Machine Systems**]: human factors

General Terms

Experiment

Keywords

Human behavior, status quo bias, intermittent control, car-following dynamics, car-driving simulator

1. INTRODUCTION

In the last decades a new concept of how human operators stabilizing mechanical systems, called human intermittent control, was developed (e.g., [1]). It considers human operators not to be capable of controlling system dynamics continuously and, as a result, their actions must be a sequence of alternate phases of active and passive behavior, with the switching between these phases being event-driven. Recently, we developed a concept of noise-driven control activation as a more advanced alternative to the conventional threshold-driven activation [2]. In this concept the transition from passive to active phases is probabilistic and reflects human perception and fuzzy evaluation of the current system state before making decision concerning the necessity of correcting the system dynamics. During the passive phase the control is halted and the system moves on its own, broadly speaking, during the passive phase the operator accumulates the information about the system state. The periods of active phase can be regarded as fragments of open-loop control, which is due to the delay in human reaction (e.g., [1]).

Driving a car in following a lead car is a characteristic example of human control, which allows us to suppose that the intermittency of human control should be pronounced in the driver behavior and affect the motion dynamics essentially. We have expected that the characteristics of human intermittent control found in stick balancing [2] should be pronounced also in car driving.

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IWAIT '15, Oct. 8 – 10, 2015, Aizu-Wakamatsu, Japan.
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2. EXPERIMENTAL SETUP

Figure 1: Car-following setup.

To verify this statement we created a rather simple driving simulator using the open source engine 'TORCS' [3] and conducted virtual experiments on car following and driving on empty road. A screenshot in Fig. 1 illustrates the typical situation in the car-following experiments and the track geometry. Four drivers with different skill of driving real cars were involved. The results of these experiments were

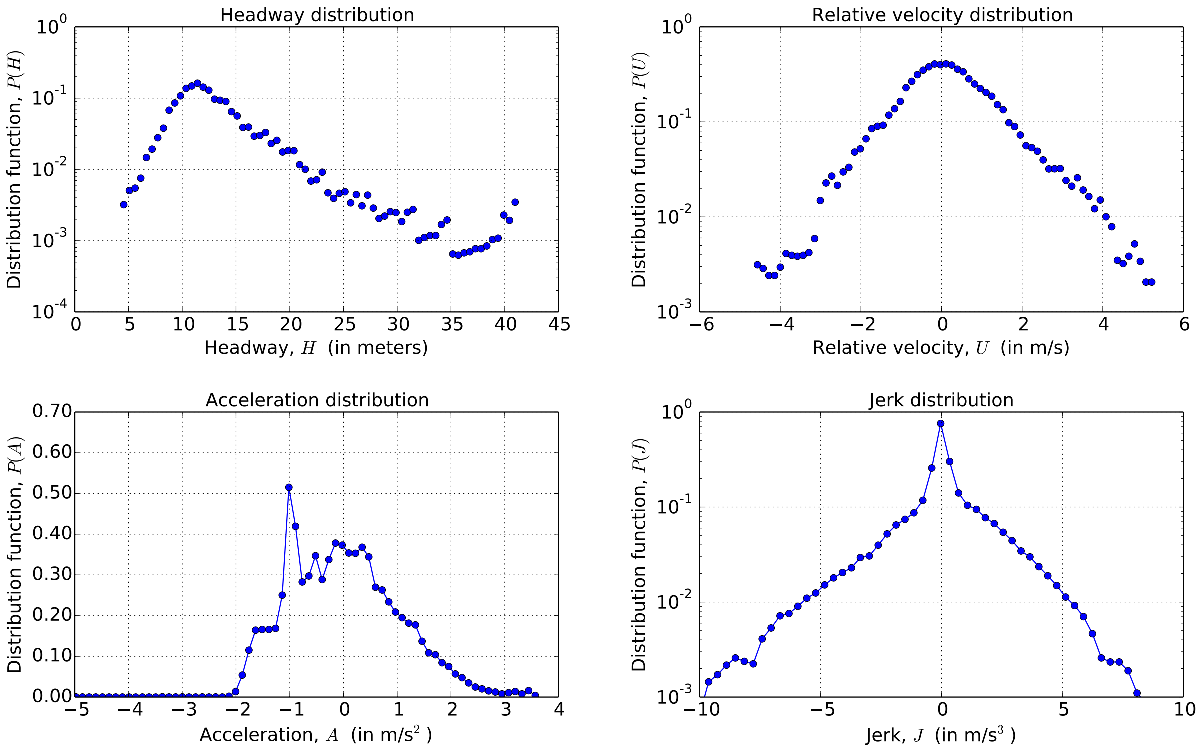

Figure 2: Some characteristics of car-following found in the driving simulator experiments. The shown forms are typical for experienced drivers.

compared with our previous results obtained in balancing a virtual over-damped pendulum to single out the characteristic features caused by the control intermittency.

3. RESULTS AND CONCLUSION

Figure 2 depicts some results obtained by experienced drivers in following a lead car moving with an effective speed about 150 km/h in the virtual environment. The obtained distributions of the headway distance and the car velocity are rather close to the results found for single car data as well as GPS data [4]. In particular, the shown forms demonstrate that the headway distance and the velocity difference are distributed according to the asymmetric Laplace law; the experience of drivers is reflected mainly in the scales. It allows us to state that the anomalous shape of these characteristics is mainly due to the basic properties of human perception, whereas mechanical details of real cars are not too significant.

The distribution functions of the acceleration and jerk (two lower rows in Fig. 2) depend substantially on the driver's individuality and reflect their personal styles of driving which seem to be rather similar for the three drivers with some driving experience. Nevertheless, as a general feature, we note the bimodal form of the acceleration distribution and a certain rather sharp peak all the jerk distributions possess at the origin, $j = 0$. The existence of this peak is a characteristic feature of human control intermittency [2]. The jerk distribution peak signals that the jerk is the main control parameter changing which drivers govern the car motion. For the real traffic data the acceleration distribution is also of bimodal form [4].

Based on the obtained results we draw a conclusion that the car dynamics, at least, in the car-following setup has to be described using *four* phase variables, namely, the car position, velocity, acceleration, and jerk. It also meets our previous hypothesis based on the theory of rational drive behavior [5]. The distribution of car velocity found for the free-motion setup possesses a number of anomalous properties, in particular, is characterized by an extremely large thickness.

4. REFERENCES

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