The multi-driver simulation as a new method for researching driver behavior and traffic

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Abstract *– The aim of this poster is to present the multi-driver simulation as a new tool in traffic research. With this linked driving simulation, several drivers can be analyzed in the same situation at the same time under controlled conditions. The use of this method is shown in three studies: Study 1 demonstrates possibilities for the investigation and description of driving behavior at intersections. In study 2, a hazard warning system is evaluated. Study 3 analyzes the effects of various penetration rates (i.e. percentage of equipped vehicles in a traffic system) of a traffic light assistant. These studies show several possibilities and requirements of the multi-driver simulation. In particular, methodological aspects during the various stages of experimental research, which are necessary when using this simulation, will be discussed.*

Key words: *multi-driver simulation, methodology, driver behavior, evaluation, driver assistance systems.*

Introduction

Various disciplines of traffic sciences (e.g. traffic psychology and traffic engineering) are researching to enhance traffic safety and traffic efficiency. Besides observational techniques, crash data analyses and driver inquiries, experimental studies are conducted for this purpose. Up until now, three experimental methods are mainstream: (1) traffic flow simulation, (2) driving simulation and (3) studies in real traffic

Each of these three methods has advantages and disadvantages. The use of several human drivers in the same simulated environment helps to combine the various advantages of these methods and is realized in the multi-driver simulation which is presented by means of this poster.

Multi-driver simulation

The multi-driver simulation consists of five driving stations that are used by the subjects to drive through the same virtual environment. There is one subject at each driving station and she/he controls her/his simulated vehicle. In the virtual environment, the drivers are able to see the other vehicles and can react to the other subjects' behavior.

The visual system of each driving station provides a horizontal field of view of 150 degrees which is shown on three 22" size LCD-displays with a pixel resolution of 1680x1050. The left, right and inside mirrors are shown in the front view. The simulator is run by a software called SILAB which was developed by the Würzburg Institute for Traffic Sciences (WIVW GmbH).

The drivers control their vehicle via a high-quality PC-game-steering wheel with force feedback and pedals. They wear a headset which enables them to hear sounds of the simulated vehicle and its environment. Furthermore, the drivers are able to communicate via the headset in two possible modes which can be controlled by the operator: (1) The operator is able to communicate with one driver or with all drivers simultaneously. (2) The drivers are able to communicate with the operator or with all drivers and the operator.

Examples for studies in the multi-driver simulation

Study 1: Description of driving behavior at intersections

Study 1 was an explorative study to describe driving behavior at intersections. For this purpose, n=4 drivers absolved a country road course which consisted of several intersection elements. After the start in platoon formation, the driver group was divided in two parts at a first turn-off. While two drivers followed the left road, the other two drivers followed the right road. After that, the drivers crossed the intersection, were merged at the same road and met at a stop sign in platoon formation again. From here, the drivers approached to the next intersection. By means of time-way diagrams, this multi-driver scenario can be pictured descriptively.

Study 2: Evaluation of a hazard warning

Study 2 evaluates the effects of a driver assistance system that warns the driver in a platoon that a hazard is likely to emerge (hazard warning). For this purpose, four test drivers had to follow a simulated leading vehicle in platoon formation. In test situations, the leading vehicle made a sudden braking maneuver from 83 km/h down to 47 km/h. The hazard warning was realized via a virtual danger sign on top of the roof of the leading vehicle. Three different experimental variations (early warning, late warning, no warning) were studied.

The analysis shows that only the first driver in the platoon reacts on the early warning. The first driver following the lead car increases its time headway by 0.7s, whereas the drivers on the other positions are not influenced by the early warning in a significant way. Due to the larger headway after the early warning, the drivers on the first position have to brake less compared to both other conditions (analysis of the maximum braking after the sudden deceleration). The last drivers benefit also from the early warning: The benefit of the early warning increases with the posterior positions in the platoon. Regarding the late warning, the braking reactions of the drivers on the first and second position have the same size compared to braking without warning. The drivers on posterior positions, however, benefit from the late warning in similar way as from the early warning. Also concerning the early warning, the benefit increases with the posterior positions in the platoon.

This study demonstrates that a hazard warning has the potential to increase road safety. Especially early and anticipatory warnings seem to provide great benefits.

Study 3: Evaluation of a traffic light assistant

Study 3 analyses the effects of a traffic light assistant with various penetration rates. While approaching a traffic light, this system informs the driver via a message on the HMI display about the optimal speed to pass while the lights are green or about how long the red light will remain. Therefore, it is possible that a driver gets a recommendation to drive 30km/h, although the current speed limit is 50km/h. In particular, possible negative effects for following drivers without this system should be evaluated.

In each session, n=4 drivers took part. Within the group in each session, different penetration rates were realized:

(1) 0%: All four participants drove without system (=control group)

(2) 25%: One participant drove with system (=experimental group), three participants without system

(3) 50%: Two participants drove with system, two participants without system

(4) 75%: Three participants drove with system, one participant without system

(5) 100%: All four participants drove with system

The participants had to absolve an urban course with 18 traffic lights at intersections. At each intersection, the platoon was split into different directions which were displayed in each driver's navigation system. After a few hundred meters, the drivers were merged again at a stop-sign to approach also the next traffic light in platoon formation. This method was used to shuffle randomly the positions in the platoon.

The results show influences of the penetration rate. Within the control group, the anger about other drivers increases with the penetration rate. However, the judgments of the drivers with system are not affected by the penetration rate. Similar, in runs with higher penetration rates (50%, 75%), the drivers without system judge to be obstructed by the other drivers in an higher degree compared to the lower penetration rates. The ratings of the experimental group are not influenced by the penetration rate.

These results indicate that the launch of a traffic light assistant on the market might lead to anger at drivers without this system. Especially higher penetration rates hold this danger.

Conclusion

This paper presents the multi-driver simulation as a new tool for traffic research using the examples of three studies: Using traditional methods in experimental traffic research, these studies would be impossible or difficult. In traffic simulation, subjective data as in study 3 cannot be generated. For the studies 1 and 2 the traffic simulation needs well developed driver models which consider driving behavior and reactions of other drivers. Similarly, in the driving simulation with one driver, the driver models of the simulated surrounding traffic have to take other drivers into account. In real traffic, study 3 would be very complex and expensive. Study 2 and possibly also study 1 are too dangerous for tests with real vehicles.

Therefore, with the multi-driver simulation it is possible to analyze new research questions in an experimental way. However, due to the participation of several drivers at the same time, the test situations vary in a higher degree which might impair the internal validity. On the other hand, this increased variability leads to enhanced external validity: Because of non-standardized behavior of surrounding traffic the situations are similar to situations in real traffic. Besides the requirements concerning study design, conduction and analysis, these specifics concerning internal and external validity have to be considered in further studies using the multi-driver simulation.