Comparison of bicycle communication and operation behavior strategies between empirical and simulation studies

Master's Thesis of Denis Grigorenko

Mentoring:
M.Sc. Georgios Grigoropoulos
Dr. rer. nat. Andreas Keler
M.Sc. Patrick Malcolm

Bicycle traffic represents an important and growing share of traffic in all countries of the European Union. In addition, with its positive effects on the environment, the climate, the quality of life in cities and towns, and the health of people, it provides contributions to many current and future transport and social challenges. Nevertheless, de-spite all its advantages and support from the authorities, the bicycle is far from the most common mode of transport in the urban environment. According to statistics from [European Road Safety Observatory, 2018] the decrease of bicycle fatalities in the EU between 2007 and 2016 was 24%. The development and widespread use of autonomous vehicles promise to reduce the number of accidents associated with driver errors and this in turn should completely solve the problem of road safety around the world. Despite the high technological level of human progress, there are still many problems facing the development of AVs, especially in difficult urban conditions. One of the main challenges for autonomous vehicles is the ability to communicate with many other types of road users, such as public transport, non-automated vehicles, pedestrians and cyclists. This issue is especially relevant for cyclists and pedestrians who are vulnerable road users (VRUs). Due to the fact that VRUs use implicit communication strategies that are context-sensitive, in different situations the same signal can be decoded by AVs differently (for example, hazard warning lights when the car is stationary as an indication of danger).

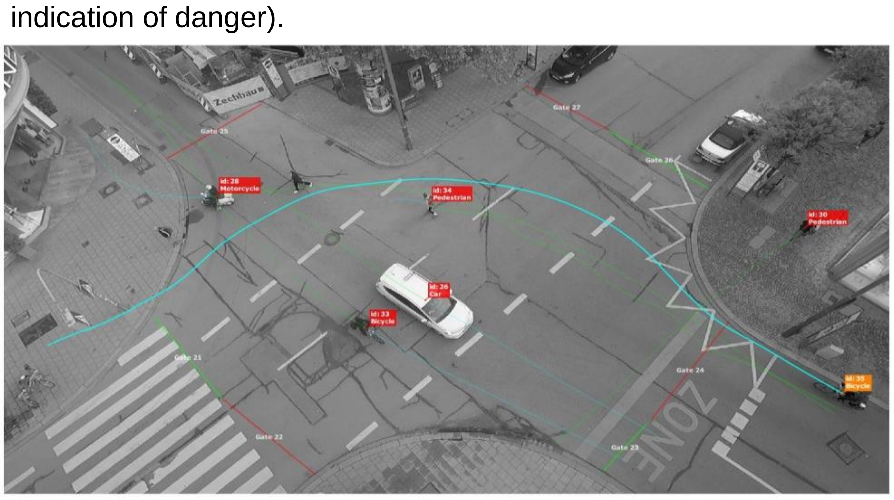

Fig. 2: Video analysis of data

The results of the analyses showed that on the one hand, at this stage, simulation studies cannot be so realistic as to completely replace video analysis. Simulations must become more complex, so that manual analysis of video data can be completely eliminated. In addition, not only the simulations themselves need to be improved, but also the methods of entering information. The research participants should be in the same conditions as in reality. The simulation environment should not only look like real, but also feel like something completely existent. On the other hand, simulation studies are already making data collection and processing much easier. There is no doubt that simulation has much more potential for obtaining the final result than video analysis. From a financial point of view, simulation studies also look much more attractive than video analyzes. After all, one well-made simulator can serve to investigate thousands of scenarios, while spending a minimum of human resources.

Fig. 1: Comparison of an intersection in the real world and in a simulation environment (top) and a participant while driving in a simulated traffic environment (bottom).

This thesis mainly focuses on evaluation of communication strategies of cyclists in specific traffic situations using a bicycle simulation and assessing the differences between the implementation of communication strategies in a bicycle simulator environment and real traffic data. The data provided by the chair of traffic engineering and control included a video recorded at one of the intersections of the city of Munich. Using the obtained video data, the explicit and implicit communicative behavior of cyclists in a real environment was analyzed. Then the study was carried out in a simulation environment. During the trials, the participants were recorded on a video camera. From this data, gestures and the communication patterns of the participants are extracted and analyzed. Participants also filled out a questionnaire to collect general information related to cycling, and they were also asked to indicate what kind of communication behavior they would use both in various simulation scenarios and at a real intersection. Then the results of empirical and simulation research were compared with each other.

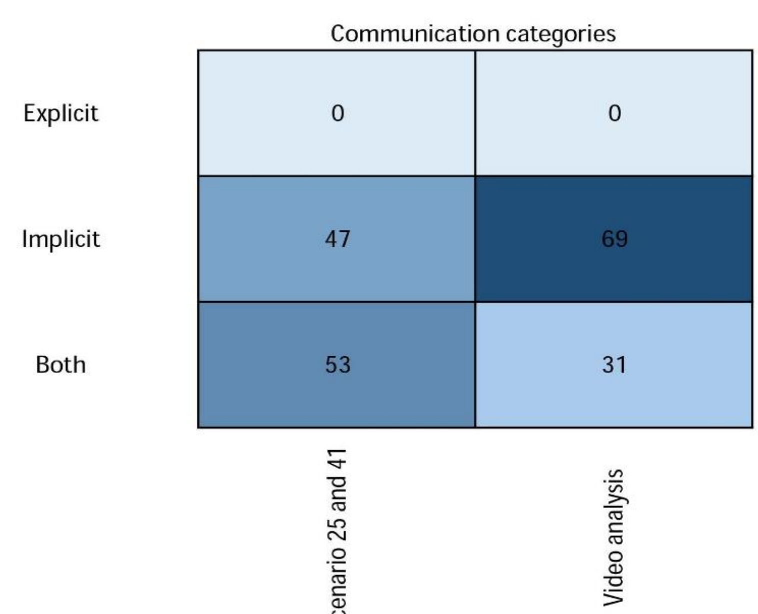

Fig. 3: Comparison of communication categories at empirical and simulation studies

Technische Universität München
Lehrstuhl für Verkehrstechnik
Univ.-Prof. Dr.-Ing. Fritz Busch