Simulation and Modelling Within the UR:BAN Project

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Urban Traffic is characterised by many interactions between different types of road users. All the applications that were developed within the UR:BAN project were developed with the aim of improving complex urban traffic situations. New driver assistance systems and intelligent transport systems influence the behaviour of their users as well as create new requirements for the models to simulate them. These applications and situations could not be handled anymore by conventional traffic and driving simulations.

Therefore, this sub-project Simulation (SIM) focuses on the analysis and descriptive modelling of the behaviour of individual road users and their interactions with one another. This is done in consideration of newly developed driver assistance systems and intelligent transportation systems. The objective of the sub-project is to improve and extend driving simulators and microscopic traffic simulation in order to simulate and study the resulting behaviour of the road users in a more realistic way.

The driver-vehicle-environment system is investigated in detail using three different research environments:

- controlled test sites,
- driving simulators,
- and microscopic traffic simulations.

At the controlled test site the interactions between various road users is observed and investigated. Behaviour data from real traffic situations is collected and interpreted to better understand interactions between drivers and crossing pedestrians. In a second phase, traffic observations of interactions between motor vehicles and bicyclists are used to analyse behaviour models.

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Connected driving simulators offer a new method for analyzing the interactions between road users in traffic. This method enables multiple test subjects (at least two) to move simultaneously in a virtual traffic scenario. In this way, the interactions between the road users are no longer modelled but rather "humanized". Detailed investigations of the following interactions are carried out within SIM: car-pedestrian, car-motorcycle, car-car, car-truck and platoons of cars.

In the area of microscopic traffic simulation, improved models of bicyclists and pedestrians as well as their interactions are developed. These models will make it possible to assess the impact of driver assistance systems and intelligent transportation systems in large and complex scenarios.

The following chapters within the simulation section of this book represent different areas of simulation and modeling. It begins with the observation of user behaviour at **controlled testsites**, then the modeling of user behaviour in **traffic simulations** is described. Finally, detailed studies using different connected driving simulations lead to general methodological considerations in building connected simulators.

In Chap. 16, insights on **pedestrian-vehicle interactions** are given based on three different methodical approaches. The conducted studies focus on the pedestrian crossing intention in situations with an approaching vehicle. Pedestrian interactions with car drivers were observed under real traffic conditions with sensor-equipped vehicles and in a controlled environment where the behaviour of the driver was systematically varied. The results serve as an important input for the interaction detection and the behaviour modelling during crossing scenarios.

Bicycle traffic continuously increases and becomes a very important aspect for the development of intelligent transport systems. Chap. 17 describes the observation of a busy traffic intersection in Braunschweig to investigate interaction patterns between **bicyclists and motorists**. As a result, the knowledge may be used to implement strategies and technologies for the prevention of fatal crashes.

The improvement of microscopic traffic simulation tools for a more realistic **simulation of bicycle traffic** is shown in Chap. 18. An integrated approach for modelling the tactical and operation behaviour of bicycles at urban intersections is presented. The integrated model was validated in a microscopic traffic simulation environment using the observed trajectory data from 5000 bicyclists.

Chap. 19 focuses on connecting a **driving simulator with real pedestrians**. A car driver in a driving simulator encounters a pedestrian in a second simulator, allowing them to meet and interact in the same simulated environment.

The influence of assisted drivers on non-equipped drivers can be studied using **multi-driver simulators**. In Chap. 20, a multi-driver simulator study is described where two naïve non-equipped drivers followed a driver equipped with a traffic light assistance system. The study shows the need for system developers and researchers to take effects on non-equipped drivers into account for the development and evaluation of ITS.

Another study based on a **multi-driver simulation** which consists of several driving stations that are used by the participants to drive through the same virtual and controlled

environment is described in Chap. 21. Using empirical data this chapter shows the additional value of the multi-driver simulation compared to the traditional simulations.

A new approach for investigating motorized two wheelers' interactions with passenger car drivers is illustrated in Chap. 22. Within the project UR:BAN, a **Motorcycle-Car Multi Driver Simulator** was developed that enables a motorcyclist and a car driver to interact in the same virtual environment. This allows deeper insights into interactions and mutual behaviour adaptation. The simulator set up will be described and advantages, potential use cases and challenges of the new tool are addressed.

Chap. 23 summarizes insights on **study methodology** that are needed for connected driving simulators to investigate social interactions in virtual study environments. Within the UR:BAN project, several studies were conducted using a variety of connected driving simulations: A connected driver-driver simulation, a connected multi-driver simulation including four participants, a connected driver-pedestrian-simulation and a connected driver-motorcyclist simulation were used. This chapter summarizes the most important methodological conclusions concerning study design, study conduction and data analysis.