

Studying the Interaction of Cyclists and Autonomous Shuttle Buses in Dynamic Stop Scenarios Using a Bicycle Simulator

Master's Thesis of Markus Böckle

Mentoring:

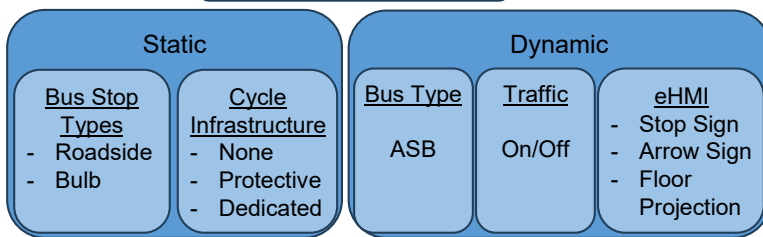
M. Sc. Johannes Lindner
Dr.-Ing. Mathias Pechinger

Vulnerable road users (VRU) have received limited attention in the development of autonomous vehicle systems. Therefore, we conducted a user study highlighting the interaction between cyclists and Automated Shuttle Buses (ASB), seen in Figure 1, using a CAVE-based bicycle simulator setup. We put a special focus on the operational and tactical behavior changes of participants during the test drives.

Research Goals:

- Understand participants' behavior while interacting with Automated Shuttle Buses (ASB).
- Investigate the influence of different bus stops on participants' behavior
- Examine the impact of different external Human Machine Interfaces (eHMI) on the cycling-ASB interaction.

Independent Variables



Simulator Setup:

- CAVE-based bicycle Simulator with fitness bike and four screens surrounding the participants
- The simulator framework is seen in Figure 2
- Static Independent Variables used in Map Setup
- Dynamic Independent Variables implemented in Unity
- Increase physical and behavioral validity with different mechanics, like the wind machine or implementations in SUMO.

Trajectories of B1, B7 at BulbStopProtective for Scenario 1

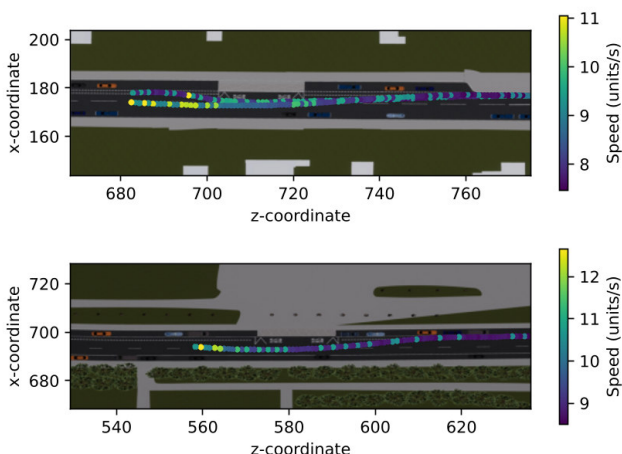


Figure 3: Trajectories of two participants at a bulb stop with a protective cycling infrastructure and only the ASB present



Figure 1: The used ASB showing the stop sign at a roadside stop in the same way as presented during the study drives

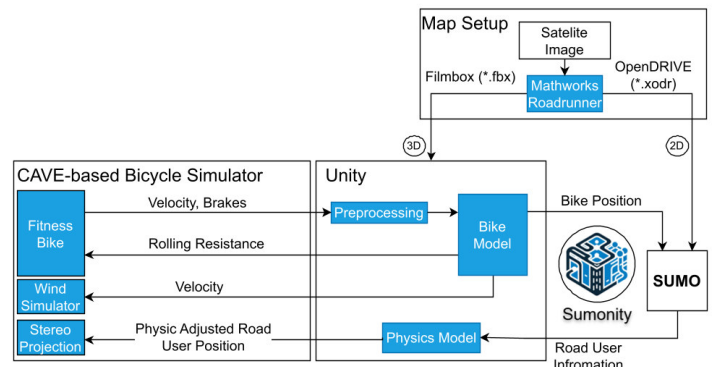


Figure 2: Simulator framework with all steps needed for the Sumonity based simulator

Study design:

- 5 Questionnaires regarding cycling experience, well-being, distance perception, opinion on eHMI, and experience inside the simulator
- 3 study drives checking 32 unique combinations of independent variables
- Logging participants' data during driving to evaluate behavior

Results:

- 50 participants, with 34 finishing the whole study
- Most dropouts due to simulator sickness
- Data has physical and behavioral validity
- Evaluation Tool created with multiple analysis functions. An example function can be seen in Figure 3.
- Participants' tactical behavior changes when approaching a bus that shows the stop sign with no dedicated bike infrastructure

Future Work:

- Evaluate data further
- Broaden demography
- Further develop the simulator setup