An Interconnected Motorist-Cyclist Simulator Study for Observing Communication at a Static Bottleneck – First Insights

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Abstract *– In this research, we present an interconnected (static) simulator setup for inspecting potential communication between two test subjects at an urban static bottleneck, depicted in a virtual environment. The virtual bottleneck is a construction site blocking the right lane and the two test subjects respectively cycle on a bicycle simulator or drive in a driving simulator in the same direction on the same lane one after another (motorist behind cyclist). After they meet in front of the static bottleneck, we intend to create a situation of experienced uncertainty, which starts the process of communication between the two test subjects. Our proof of concept shows several important factors limiting the virtual experience, as related to scenario design, used equipment (VR glasses and monitors), audio signals and visualization.*

Keywords: *Interconnected Simulator Studies, Bicycle Simulator, Interaction and Communication, Virtual Reality, Traffic Bottleneck Scenarios.*

Introduction

Physical bicycle simulators connected to displays representing VR environments are since the early 2000s the topic of research with numerous different applications (Keler, Grigoropoulos et al., 2020). There are additionally other simulator setups focusing on the interaction of different types of vulnerable road users with motorists, be it autonomous, automated or manually-driving. One of the options of measuring interactions and communications at situations that are too dangerous to reproduce is to design an interconnection between numerous simulators. Already implemented simulator studies include an interconnection between a manually-driving test subject at a driving simulator and an automated vehicle simulator with another test subject (Feierle, Rettenmaier et al., 2020). Besides this, it is possible to interconnect three simulators simultaneously including a pedestrian simulator (Bazilinskyy, Kooijman et al., 2020).

In this research, we focus on designing an interconnected simulator study with a bicycle simulator (test subjects act as cyclists) and a driving simulator (test subjects act as motorists) at an urban static bottleneck, where we expect to observe lengthy communication activities and sequences during the experiments. We want to find out how cyclists and motorists would usually solve a conflict of indicating giving or ignoring right of way and which factors influence their decisions.

Simulator Setup and Methodology

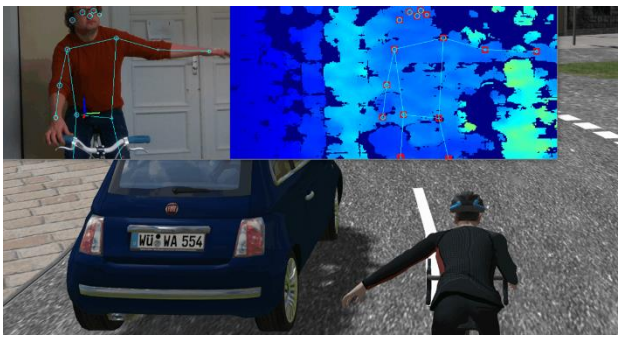

Figure 1. Visualized gestures of a cyclist test subject within a VR environment based on skeleton estimation and gesture classification

Our bicycle simulator bases on previous research (Keler, Kaths et al., 2018), but is extended via VR glasses usage and the possibility to translate personal hand gestures into VR animations as pictured in Fig. 1. The latter is realized via skeleton estimation and on-the-fly gesture classification from an ongoing data-acquisition via a depth camera (of the type Intel® RealSense™ D435) during every experiment.

Furthermore, a static driving simulator without actuators serves as the counterpart for the interconnected simulator experiment as pictured in Fig. 2.

Figure 2. The bicycle simulator (left) and the driving simulator (right) used for the interconnected simulator study at the static bottleneck scenario

The visualized gestures of every cyclist test subject appear in front the driving simulator test subject, since the static bottleneck scenario relies on providing a specific distance of the two test subjects moving on the same lane in the same direction. The distance is adjusted at a specific location where the cyclist uses a specified bike way and triggers a green light for a waiting motorist at a traffic light (as pictured in Fig. 3 with T3 and T4).

Subsequently, both test subjects meet in front of a static bottleneck, which is in our case a usual construction site as pictured in Fig. 3 at number 6.

The respectively two test subjects in every interconnected simulator study run retry the same scenario, which is pictured in Fig. 3, 5 times, as it is set in a loop. As it is derivable in Fig. 3, there are other simulated road users in our scenario including an oncoming vehicle triggered at flow point T5. This vehicle should restrict the possibility that one or both test subjects use the opposite lane for their trips. Additionally, there are simulated pedestrians in the park area between the motorist road and the bike path (point 3) mainly used for generating a realistic scenery of the scenario.

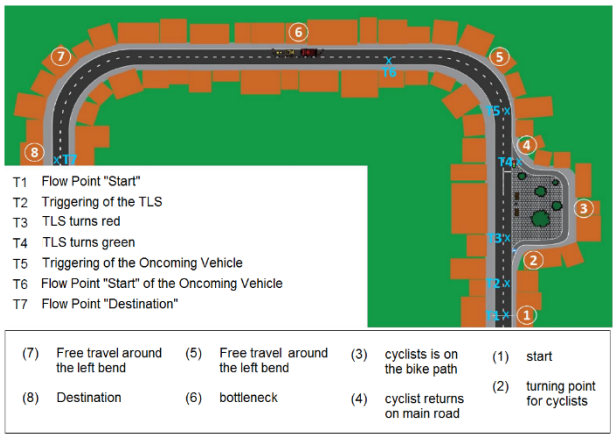

Figure 3. Overview on the static bottleneck scenario used for the interconnected simulator study with ascending numbers representing the cyclist route and flow points triggering events (Tn)

In our proof of concept, we focused on the cyclist gestures and head movements and less on the gestures of the motorist. We use currently the software SILAB by WIVW, but experiment with non-commercial tools for translating the scenario.

First Insights

First insights show that communication starts only in a few cases, mainly due to indicators not present in the virtual reality application.

One of the most important of them is the generated sound coming from the vehicle test subject approaching the bicycle test subject from behind. In most cases, the cyclist, even though wearing stereo headphones attached to the VR glasses, can not localize the vehicle driving behind. Motor and driving sounds occur averaged throughout the whole scenario. This appearance together with evaluating visibilities, especially those where the two test subjects see each other, was tested in numerous experiments.

In case the bicycle test subject recognizes the vehicle test subject behind her- or himself, it is seldom the case that he or she starts looking around but increases speed for performing an overtaking maneuver. This means the cyclist test subject is not aware of the location, movement or speed of the, non-visible, motorist test subject.

References

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