Comparison and Design of Human-Machine-Interface Concepts to Investigate Communication Between Bicycles and Automated Shuttle Busses in Dynamic Stop Scenarios

Master‘s Thesis of Dnyandeep Mandaokar

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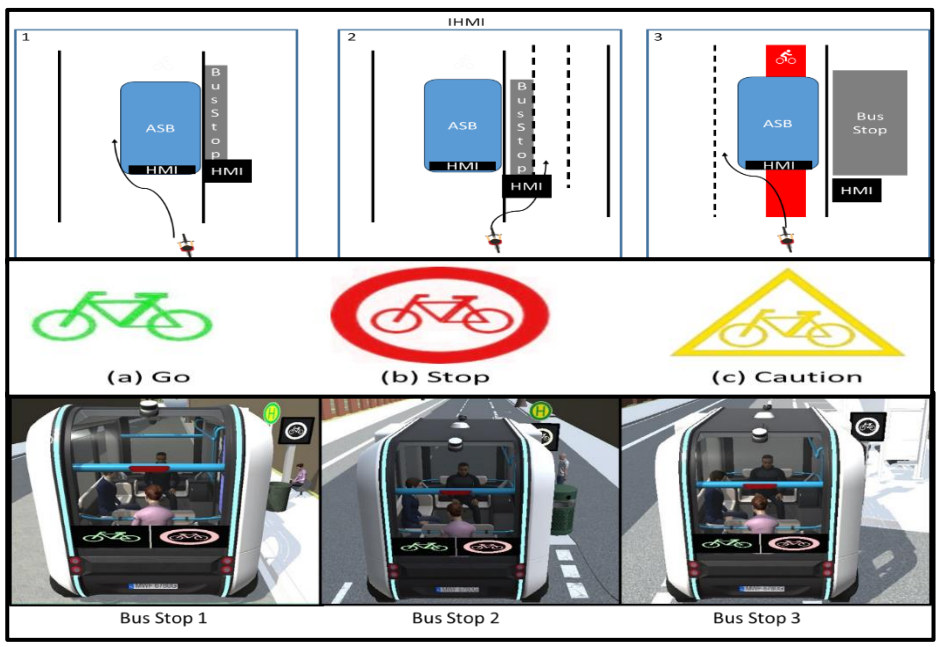
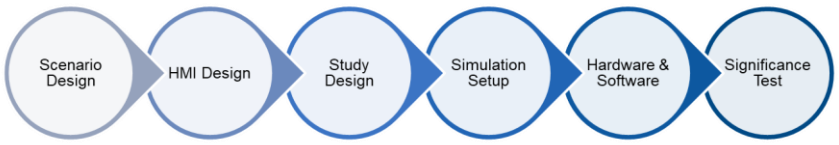


Three scenarios, HMI signs, and ASB at the three bus stops

Simulation Study



Study Variables

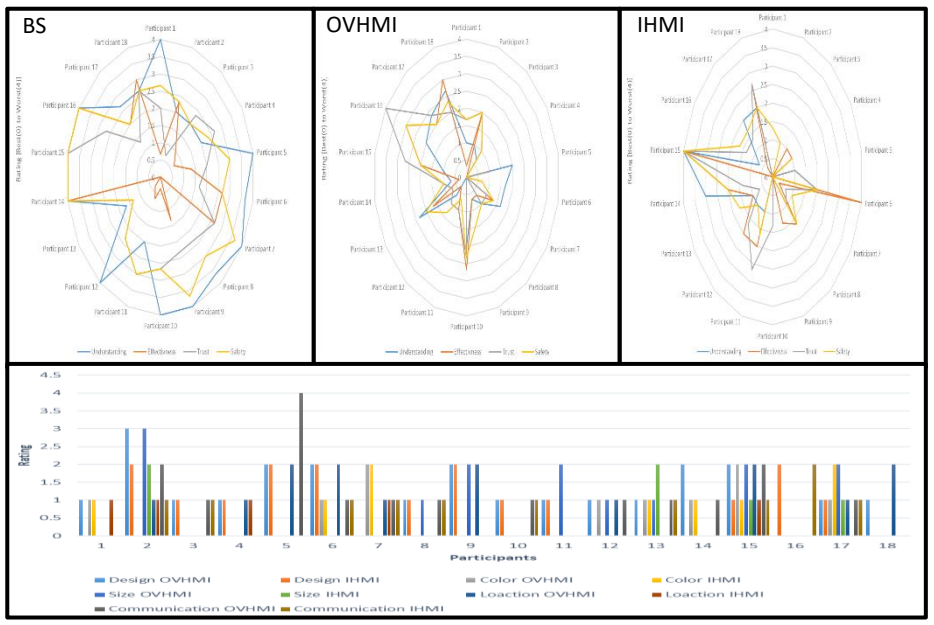
- Dependent Variables: Safety, Effectiveness, Trust, Understanding
- Independent Variables: HMI Attributes, Vehicle Factor, Environmental Factor, Participants Factor

Hardware and Software

Bicycle Simulator to provide cycling dynamic with sensor measurement of speed and steering angle integrated with Unity3D virtual environment.

Participants

- 18 participants, aged 23-41, with a female-to-male ratio of 1:8
- Participants from India, Germany, Spain, Taiwan, and China



Participants rating from best(0) to worst(4) for scenarios and HMI design

Introduction

Human-Machine-Interface (HMI) enables Interaction of Automated Shuttle Bus (ASB) with Vulnerable Road Users (VRUs):

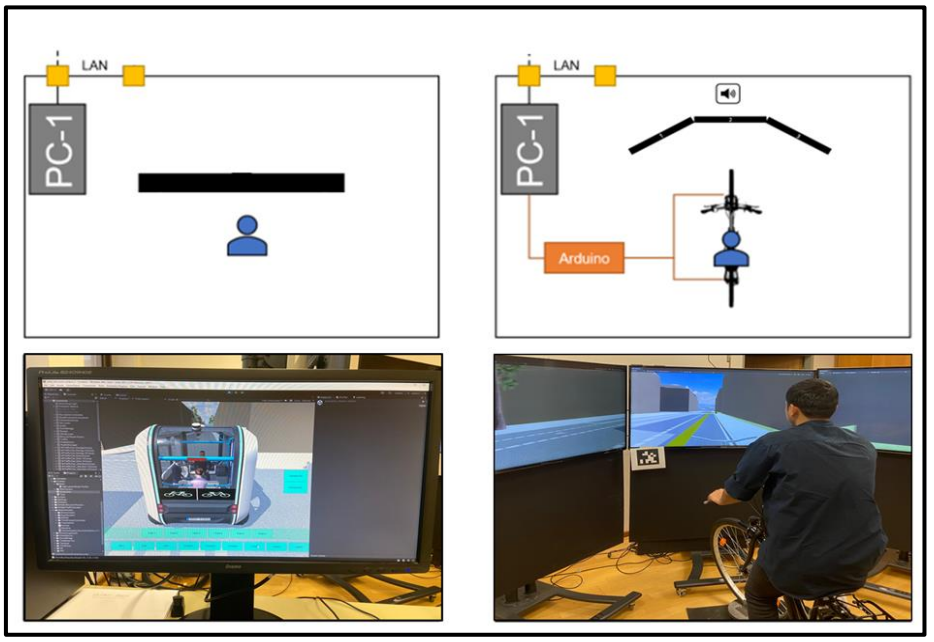
- ASB aim to improve traffic efficiency, reduce driving errors, and lower emissions
- ASB face challenges in clear communication and emotional connection, raising issues of acceptance and trust
- HMI design for AVs includes internal systems for user comfort and external HMIs (eHMI) for interaction with road users

Motivation

eHMI to facilitate ASB communication with Bicyclist in a dynamic stop situation which requires special attention due shared infrastructure and safe concerns.

Research Goals

- Propose HMI proof-of-concept for ASB to interact with bicyclist
- Perform a simulation study to record data for comparative analysis
- On Vehicle HMI (OVHMI) and Infrastructure HMI (IHMI) testing



Experimental Setup with participants interaction and ASB control display

Result

- Overall, OVHMI and IHMI had significantly better perception ratings than no HMI (BS) for understanding, trust, and safety
- OVHMI design over IHMI
- Size and location of OVHMI is highly rated
- Communication Icon-based message type is rated good
- Post-hoc Tukey test adjusted p-values for safety: OVHMI vs. BS (0.0000240), IHMI vs. BS (0.0000062), OVHMI vs. IHMI (no significant difference)

Conclusion and Outlook

- Improve communication between ASB and bicyclists using proposed eHMI designs
- HMIs, especially OVHMI, significantly enhanced user understanding, effectiveness, trust, and safety compared to no HMI
- Use of SUMO for complex scenarios