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Reference	FP09
Project Title	Virtual reality interactions with autonomous vehicles
Coordinator	Lund University
Project Manager	Carmelo D'agostino (carmelo.dagostino@tft.lth.se)
Project Duration	2021-02-01 – 2021-08-31

Contents

Summary

Re-SAFE focuses on using virtual reality (VR) to study interactions with connected and automated vehicles (CAVs) from the perspective of a vulnerable road user (VRUs). The project is based in the newly established virtual reality hub on Traffic Safety at LTH and aims to explore how a VR environment can be used to study interactions between CAVs and VRUs.

The Re-SAFE's main aim was to investigate how different infrastructure designs and/or CAV behavior affect the safety perceptions of vulnerable road users. The expected further outcomes of the pre-study are to set up relevant research questions to be investigated with the use of Virtual Reality in the field of traffic safety involving CAVs.

The project consisted of three main parts: (I) a workshop in which previous experiences with CAVs and/or VR were discussed among the project partners. The workshop also included a discussion on potential future ideas for project and applications in which all partners presented some of their ideas. (II) Follow-up meetings with the partners with the explicit aim to explore the potential for writing an application based on the project ideas from the workshop and (III) the writing of two applications that have been submitted to FFI – Vinnova.

Virtual reality interactions with autonomous vehicles

1. Background

The project was based in the newly established virtual reality hub on Traffic Safety and integration at LTH and aims to explore how a VR environment can be used to study interactions between connected and autonomous vehicles CAVs and both pedestrians and bicyclists. The virtual reality hub on Traffic Safety at LTH is a newly established VR hub managed by the Transport and Roads division at the Department of Technology and Society and working together with the Fire Safety Engineering Division and the Department of Design Sciences. The main aim of the VR hub is to investigate the safety issues of novel sustainable transportation means including CAVs, e-scooters and e-bikes, the hub is focused on providing analyses from the perspective of the vulnerable road users using a pedestrian- and bicyclist VR simulator.

The main need of newly established hub was to formulate relevant research areas and plans for potential projects. The hub also needs a foundation of potential partners from both academia and industry. This was the main needs and challenges that were used to create and formulate the project.

2. Project set-up

2.3 Purpose

The main purpose of the project was to create necessary foundation for larger projects which focus on how different infrastructure designs and/or CAV behavior affect the behavior and perceptions of vulnerable road users. A secondary aim was to formulate the future research areas of the virtual reality hub.

2.4 Objectives

The expected outcomes of the pre-study were to set up a relevant research question, plan the activities and equipment to acquire in the LTH “Traffic Safety VR Hub”, and prepare a research idea and the consortium that can fit in future calls.

2.5 Project period

2021-02-01 – 2021-08-31

2.6 Partners

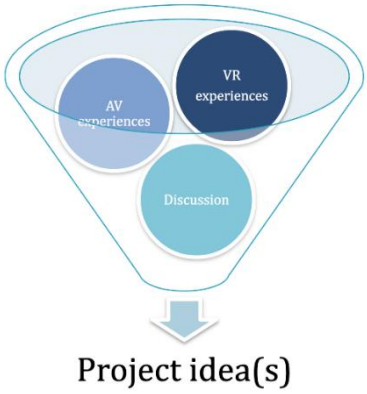
I. **VTI**: Jan Andersson (jan.andersson@vti.se) and Anna Niska (anna.niska@vti.se)
II. **Volvo Group Trucks Technology**: Christer Lundevall (christer.lundevall@volvo.com)
III. **Autoliv**: Johan Karlsson (Johan.G.Karlsson@autoliv.com)
IV. **Trafikverket**: Ruggero Ceci (ruggero.ceci@trafikverket.se)

3. Method and activities

The project consisted of four main activities. (I) A kick-off meeting, (II) a workshop in which previous experiences with CAVs and/or VR were discussed among the project partners. The workshop also included a discussion on potential future ideas for project and applications in which all partners presented some of their ideas. (III) Follow-up meetings with the partners with the explicit aim to explore the potential for writing an application based on the project ideas from the workshop and (IV) the writing of two applications that have been submitted to FFI – Vinnova.

The workshop approach.

The workshop consisted of two parts. In the first part, each partner was asked to present their experiences with virtual reality and/or connected and autonomous vehicles. The idea being that this provides interesting material for future directions, but it also provides an insight into how the different partners view the subject.



The second part of the workshop consisted of a discussion in which the goal was to generate several potential project ideas with an early idea of what the project would be like and who might be interested in such an endeavor.

4. Results and Deliverables

The main outcome of the project is three interesting ideas for future research project which in the end turned into two applications for feasibility studies submitted in June to FFI – Vinnova. The three project ideas are summarized below:

- External HMI focused on communicating CAV intention to VRU. This project would focus on developing multi modal external HMI solutions which focus on how a CAV can communicate its intention and future actions to nearby bicyclists and pedestrians. A secondary goal is to investigate how the CAV can inform the nearby road users that they are "seen" by the CAV and at the same time help in predicting their behavior. [*submitted in June to FFI – Vinnova*]

- Smart bicycle handlebar/wearable as ADAS for the interaction with bike rider with other road users when there is lack of verbal and nonverbal communication. This project aims to develop an idea for a smart handlebar for bicyclists which can be used to both warn a bicyclist of a potentially dangerous situation or the presence and/or intention of a nearby CAV (or other connected vehicles). [*submitted in June to FFI – Vinnova*]

- Secondary interactions caused by the introduction of AVs. This project focus on interactions which occur because of the unique presence of a slow-moving CAV, especially interactions which occur after a bicyclist and/or motor vehicle has overtaken the CAV. These overtaking's can cause secondary interactions between road users in places where this did not happen before. The project aims to understand how common secondary events are depending on both the speed of the AV and the type of infrastructure in which they interact. The project will also attempt to investigate whether these types of events pose a potential safety concern.

A note about the small pilot

The project application included the following sentence: "All this through a workshop, meetings, and possibly a small pilot." Due to the large variation in the different ideas that were the outcome of the workshop, we decided that it was not practical to create a meaningful pilot. We did however explore how simulation studies are typically made from in a technical sense and did create a showcase which demonstrates what this could look like, see the figure below.

The most straightforward approach to create a virtual reality simulation environment is to use software already developed for the creation of virtual reality games. Based on the workshop, the most used programs are the Unity game engine or the unreal engine. Both programs provide an already developed connection between a virtual reality headset and the programs themselves. They also provide a framework for handling graphics, animations, and anything else that is required to create a virtual reality simulation environment. Using the Unity game engine, a showcase scenario was created and recorded using the Unity game engine to provide an example of what a simulation created this way can look like. These programs provide a straightforward way to create a functioning simulation environment, but they do not provide any help in creating the actual scenario to be tested or instruction on how to best design and carry out a virtual reality experiment.

Virtual reality technology and nausea

In addition to the project ideas and the showcase scenario, the project has also included several interesting presentations about virtual reality technology and the problem of nausea. Experiences with VR from especially VTI sees to suggest that how people are moving in the virtual landscape is crucial and an important problem since bad locomotion easily makes people feel nausea. Overall, the presentations suggest that the physical simulator is more difficult to get right compared to the software aspects of the simulator which seems to be much more flexible.

5. Conclusions, Lessons Learnt and Next Steps

The projects main take-aways are that there is significant virtual reality research being conducted in some form at many institutions and companies but there is no real consistency in what form the VR research is conducted. The research topics also vary but they seem to be divided into two main categories: (I) virtual reality studies of how people experience ADAS solutions, usually from inside a vehicle, and (II) studies about how people react in specific situations in a virtual environment. Finally, the challenges of developing the technology required for VR seems to be larger for the physical equipment than the software part of the simulator.

The next step following this project depends on the outcome of the project application but there are somethings that are already clear. The future of virtual reality hub on Traffic Safety will build on the results from this project regardless of how the project application turn out.

6. Dissemination and Publications

There will be no direct dissemination of the project but some of its outcomes will be visible of the upcoming webpage about the virtual reality hub on Traffic Safety and integration at LTH, mainly in the form of the hubs research areas.

7. Acknowledgement

We want to acknowledge the Virtual Reality Traffic Safety Hub at Lund University that had provided the mock of the simulation based on the workshop results.