Virtual vehicle test platform for human-machine interfaces

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***Abstract*—Within the realm of vehicle interaction, the focus is based on examining the human-machine interface. By using a mixed mock-up, consisting of VR glasses and a seating box, it is possible to experience and further develop virtual prototypes and human-machine-interface concepts in early stages of development in a driving simulator. The created virtual reality model of a car, an environment and a real traffic scenario in Unity 3D is used as a test scenario to artificially create stress. The measured eye movements with the help of the eye tracking technology and heart rate data of the driver can be saved as a research base.**

I. Introduction

Current developments such as electric vehicles and autonomous driving raise questions about how communication between people, the vehicle and the environment will look in the future. The aim of the project is to develop and test new concepts in vivid and tangible prototype form. [1] Virtual prototyping or real-time 3D based on virtual reality technology is a promising technique, especially for the design testing of products that are characterised by interaction with users. Reduced time, minimised development costs, but also better quality and product reliability and faster time-to-market are some of the advantages compared to conventional physical prototypes. [2]
Looking at the field of autonomous driving, it is almost impossible not to discuss artificial intelligence. It deals with the interaction of the emotional context of humans and computers. A feedback of a computer that is tuned to the emotion of the human user enables an emotional intelligence of the machine. The project aims to develop various use cases on the basis of interdisciplinary collaboration. [3] With the use of various human machine interfaces like already developed driving communication and information systems, the driving experience should be made less stressful. Sound signals, lights and a voice assistant, are used to reduce artificially generated stress during the virtual driving experience. In addition, the physiological effect and recording of stress on various test subjects will be investigated using eye tracking and heart rate measurements.
With the help of a simulated driving simulator, a real environment can be illustrated with an artificial intelligent traffic scenario. By means of an artificially created stress scenario, the effectiveness of this experiment can be examined using suitable measuring methods on the basis of test persons utilizing different human machine interface concepts.

A driving simulation is not limited by space or time and can simulate every scenario while ensuring the process is safe and inexpensive. It is the best option to simulate and research emotional stress during a test drive without real dangerous road conditions. [4] In addition it allows measuring the mood and analyzing whether this scenario actually creates an impact or not.

II. System Architecture

A. Driving Scenario

Research has not yet shown, whether it is possible to induce simulated stress via a user scenario, e.g. being late for an exam, job interview or the start of a traffic jam. The research topic simulates a driving scenario on a highway. Fig. 1 shows a part of the created road system from the driver's point of view in Unity 3D.

Figure 1. Road System

With the start of an unexpected traffic jam the user should find himself in a stressful situation. During this situation the user will have access to various content adjusted to his mood. Artificial stress should be generated as realistically as possible through an unpredictable scenario with different environmental conditions. The car will drive autonomously, but the test person will still be asked to control it in various situations. There is a developed voice assistant in the car that will support the user while driving. With different signals like affective light signals (visuals), affective sound effects the mood of the test person will be measured with the use of eye tracking technology and the wristband Empatica E4.

B. Experimental Set Up

1) Hardware architecture and applications: A driving simulator consisting of a self-developed car with different human machine interface options, a driving unit (G25 Logitech steering wheel kit), Varjo VR-2 Headset, wristband Empatica E4 and simulation gaming software (Unity 3D) was utilized for emotion stimulation. An experimental virtual highway with grass, trees, buildings, streets and weather changes was set up.

The stress scenario consists of a Highway Road System with a generated AI traffic flow, including an artificial traffic jam on various lanes and roads. All streets, vehicles and the whole environment were implemented into and developed in Unity to create a real virtual reality interface. The Varjo VR-2 and the wristband Empatica E4 are used to detect continious eye tracking data and to get more information about the user behaviour. Through various tests based on the eye tracking evaluation, a heat map, shown in Fig. 2, for the detection of increased gaze behavior was developed in Matlab.

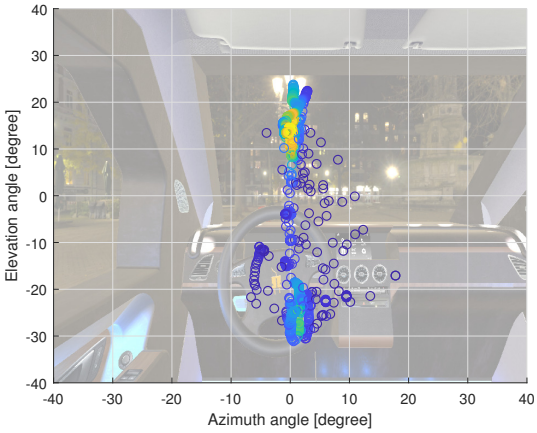

Figure 2. Eyetracking Heatmap [5]

2) Simulation process: The whole test situation will take about 15 minutes. At the beginning the driver will have to answer a few questions and the measuring instruments have to be properly calibrated.

3) Measurements: During the process the aim is to measure the mood of the driver. With the eye tracking technology of the Varjo VR-2 it is possible to examine the gaze behaviour of the test person. Using pupil dilatation evaluation, heat maps and point clouds, some of the generated stress can be measured by eye tracking data. The user behaviour and the system output will be evolved with the software Matlab and IMotions. Fig. 3 shows the dependence of the measured pupil diameter on the measured luminance over time. This dependency will be examined more in detail in further simulations regarding to emotional reactions and light.

With the wristband Empatica E4 it will be possible to measure the level of arousal and level of valence during the test drive. It is a medical-grade wearable device that offers real-time physiological data acquisition to enable analysis and visualization. In addition, reaction speeds and user behavior should be analyzed more in detail.

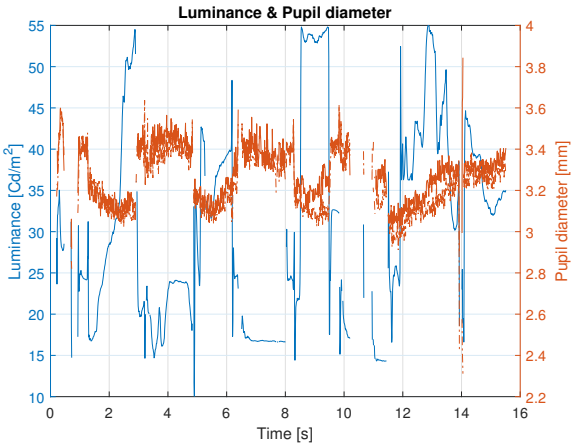

Figure 3. Luminance and Pupil diameter [5]

III. Conclusion

In order to improve the driver's user experience, a test environment and an effective driving simulator are used. First, a test person study is to be carried out with the test scenario that has been set up. Next, the aim of further research work in the upcoming semesters will be to test new artificially generated scenarios in the virtual driving simulator. This is done with different developments of new driving information and communication systems that accompany the driver while driving. The simulation should be an approach to capture a large amount of data from the real world and to modify it on this basis. If the tried and tested systems do not show any influences in the emotional measurements, new scenarios would be set up and tested. Additionally the test simulator would have to be optimized with additional human machine interfaces. In the future, the interfaces between human and machine have to be improved through new system developments and further implementations.

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