Demo

Simulation of a virtual reality environment for cognitive and motoric testing with Unity and a mechanical treadmill

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Abstract

In many virtual reality applications the movement is done with simple pointing and teleportation to the designated location. On the other side there is a need of combining treadmill walking with virtual reality environments to train participants in demanding but controlled walking scenarios. In this demonstration we therefore combined the VR capabilities of the Oculus Quest system with a mechanical treadmill in order to create a framework for cognitive and motoric testing and training. A test subject has the control over increasing and decreasing the speed at any given time during the experiment. A supervisor can actively communicate with the test subject with simple lines of text and also has the means to intervene in case of emergency.

CCS Concepts
• *Human-centered computing → Virtual reality;*

1. Introduction

The presented demo features a combination of different hardware and software components in order to create an laboratory evaluation framework for cognitive and motoric tests and training. The aim for the project is the creation of a framework in which outside influences are minimized in order to analyse the gait. In this setup we use a virtual environment with a treadmill-based walking interface in order to increase the degree of physical motion of test users. Here we decided to use endless paths to imitate walking on a treadmill. In this first iteration of the experiment the user walks along a forest road.

In contrast to other works we wanted to use a real virtual environment where the test subject will be fully immersed into. Therefore we did not use a screen in front of the treadmill as used in previous experiments [SSLW14]. Moreover we did not use a feedback-controlled treadmill [CSvO08] and gave the test subjects a controller in order to freely adjust their walking speed. This brought new challenges for both the safety of the user and the setup of the experiment.

2. Simulation setup

The key component of the project is a Woodway PPS55 med treadmill which is connected to a Windows 10 PC over a serial interface. The PC is used as a control unit in order to monitor the treadmill. A graphical interface can be used to start or stop the treadmill. Stopping the treadmill is necessary if a dangerous situation is about to happen.

The test subject uses an Oculus Quest virtual reality headset and a Xsens motion capture suit that can be seen in Figure 2. The motion capture data is transferred to the VR system, so that the test subjects can see their own movements while wearing the VR headset. The Oculus Quest works as a standalone system and can be used without any dangerous cables.

The Oculus Quest system runs a Unity3D application. In this application a first person character walks along an infinite road within a forest. There is no actual interaction between the test subject and the application itself. The test subject uses a hand controller of the Oculus System in order to change the speed of the treadmill.

The information about the current speed is then transferred to an external service running on a Raspberry Pi microcomputer. This service holds the current speed information of the treadmill and a script within Unity will ask this service every frame if the speed was changed. If a change in speed was made, the speed within the game will be adjusted.

The absolute camera position of the Unity3D application is set to the head position of the first person character. The first person character is based on a Xsens plugin while the relative head movement is tracked by the Oculus Quest. The reset functionality of the Oculus Quest will bring the camera back to the starting location, facing forward.

The speed of the treadmill can be adjusted by both the test subject and the supervisor using the right and left controllers. The speed can be changed by 0.1 km/h up or down per click. There is also a button to instantly stop the treadmill. This will not stop the

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treadmill abruptly as would an emergency stop. Here the treadmill will change gradually from the current speed to zero.
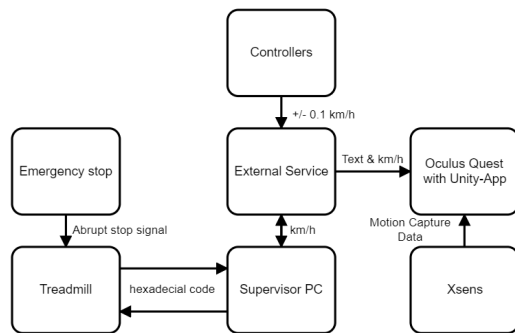

Figure 1: *Data flows between the different systems*

Figure 1 shows a diagram of the different systems used in this setup. As shown here, the treadmill is directly connected to the supervisors PC by cable. A program will read the information given by the treadmill and translates the hexadecimal information in m/s and km/h. A service running on a Raspberry Pi is located between the treadmill and the VR system. The service receives the speed information from the treadmill and saves this value. After starting the treadmill, it will tell the service that the current speed is zero. Due to this modular approach the used treadmill can be changed to another model with minimal implementation efforts.

The VR system will receive the speed information from the service, which is zero by default and will update the in game speed when a change occurs. A change will only occur due to an input by either the test subject or the supervisor. These inputs are made with the two controllers. If the speed was changed from zero to 0.1 the new information will be saved by the service, which will then forward the speed to the program that translates the 0.1 to an hexadecimal value.

The Unity3D application can read and process new information per frame, which is to fast for the treadmill. Therefore the service will always hold the current speed value and notifies the treadmill if a change in speed was requested. The motion capture data is transmitted directly from the sensors to the Unity3D application.

3. Results of technical testing

Without a doubt, it is strange to walk on a treadmill without seeing the ground. In order to compensate for this there is a visual marker within the game application to show the middle of the available walking space. Moreover the test subject can stop the treadmill with a single button press on the hand controller.

The left and right controllers both have the same functionalities. One controller will always stay with the superviser of the experiment. The superviser can stop the treadmill at any time. In addition to this, the treadmill will automatically stop if the VR-Headset was removed from the test subjects head. This happens if a sensor on the Oculus Quest loses the signal.

In order to communicate with a test subject at any given time, a

Figure 2: *Test subject with Oculus Quest VR headset and Xsens motion capture suit on the PPS55 med*

supervisor can send text messages to the VR interface. These can be instructions or tasks that the test subject has to solve. The test subject always can see the current speed which is displayed within the games user interface. Additionally the test subjects didn't notice any latency issues between the visual flow and the treadmill walking while changing the speed variable.

4. Upcoming Work

The used setup is not ideal for further testing, a treadmill on ground level would be safer. Moreover the short nature of the PPS55 med is an obstacle and a longer treadmill would increase the comfortable walking area. In order to stop the treadmill a photoelectric barrier could be used. In addition a feedback-controlled locomotion should be used as an alternative setup. Furthermore the movement speed of the test person should be measured to control the speed of the environment more directly.

References

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