VRate: A Unity3D Asset for integrating Subjective Assessment Questionnaires in Virtual Environments

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***Abstract*—Experience assessment is a key activity for understanding and developing interactive systems and technologies. Virtual reality (VR) is no exception, considering its rising popularity and the increasing availability of affordable VR devices. However, in experience studies where participants typical have to rate multiple test conditions presented to them, having to repeatedly take off the head mounted display (HMD) just for the purpose of issuing ratings is cumbersome and breaks the immersion. As a solution we present VRate, a Unity3D asset to integrate subjective experience questionnaires directly in virtual reality environments. The suitability of VRate has been proven by successfully using the asset in a QoE and a UX study. We describe the technical implementation and suggest how to integrate the VRate in a study setup. VRate will be provided to the scientific community for research purposes, educational and noncommercial usage under a Creative Commons License.**

Keywords—Virtual Reality, Immersive Applications, Subjective Testing, Quality of Experience

I. INTRODUCTION

Virtual reality (VR) systems are widely available and affordable for researchers and consumers (cf. [1]). Therefore the question how to measure user experience (UX) and quality of experience (QoE) in fully immersive and highly interactive virtual environments (VE) (e.g. VR games, VR trainings, context simulations etc.) is gaining importance within the scientific community.

Different approaches can be found in the scientific literature for evaluating experience in VE. For subjective experience measurements often questionnaires are provided to the users after the experience. Although such post experience questionnaires are commonly used (e.g. [2], [3], [4]) there are several drawbacks. Sole-Dominguez et al. [5] argue that post experience assessment rely on the recall of memories and thus might be inaccurate or incomplete. Thus, especially if a large number of conditions is evaluated like in a typical QoE evaluation, each condition should be rated directly after the experience to minimize such recall of memory effects.

A possible solution is that the user leaves the VE after each condition to fill out a questionnaire in the real environment, as for example done by [4]. Especially for evaluations where Head Mounted Displays (HMD) are used to present a VE this is cumbersome as the user has to take the HMD on and off multiple times during the evaluation. As current commercial available VR systems, most prominent examples are the Oculus Rift[1] and the HTC Vive[2], use HMD technology this is an important aspect to consider. Another possible solution is that the study operator ask questions orally while the user is still wearing a HMD, as described in [6]. Although this is a possible solution, Bowman et al. [7] argues that an evaluator interfering with the participant during the study can influence presence, thus ideally there should be no interaction between the participant and the study operator during interaction in the VE.

Another solution could be to use only objective measures within the VR environment (biophysical signals [8], eye tracking [5], task completion time [3], etc.). But as argue by Tcha-Tokey et al. [9] subjective measures are used to understand the users point of view and thus applying only objective measurements might not be enough to capture the holistic experience.

Thus methods to integrate subjective user ratings directly into VE are needed. Upenik et al. [10] integrated a 3D immersive voting menu in an VE to rate omnidirectional video quality. Buchinger et al. [11] investigated the usage data gloves for rating in time-continuous subjective multimedia assessment, which could also be used in VE. Although subjective user ratings have been used for evaluating omnidirectional videos, methods for seamless integration of questionnaires in highly interactive VE are needed. Thus we propose VRate, a virtual questionnaire and rating environment. The main contribution of this work is the VRate Unity3D[3] asset that is provided to the scientific community[4].

II. VRATE - A UNITY3D ASSET

In this section we describe the design and technical implementation of the VRate module and propose a possible way to integrate the VRate module in UX and QoE studies.

The VRate has been developed as an asset (a term for generic Game Object) for Unity3D, thus allows integrating questionnaires, quality ratings and experience measurements in VE that are built with the Unity3D engine. Unity3D was chosen as a target (game) engine, as it is at the moment a widely used engine for developing virtual reality experiences. The presented solution consist of (A) a virtual questionnaire module, that provides the 3D environment and user interface as well as an interfaces for loading questionnaire items and

[1] https://www.oculus.com/rift/
[2] https://www.vive.com/
[3] https://unity3d.com
[4] http://vrate.tech-experience.at/

logging the answers (e.g. to a CSV file). (B) a study control module to trigger the questionnaire.

A. Virtual Questionnaire Module

The VRate interface is shown in Figure 1. It consists of a 2D Canvas placed as a static billboard in the virtual environment. Although different modalities for implementing a questionnaire (chatbots, 3D interfaces, gestures, etc.) are possible, we decided to use a 2D graphical user interface (GUI). Manipulation of 2D GUI is known by users from interaction with standard desktop programs and therefore does not add an additional interaction difficulty for novice VR users. Questions that contain rating scales can be implemented either as contentious values (slider without discrete steps - see figure 1a) or as discrete values (separate buttons - see figure 1a / or a slider with discrete steps) or as continuous

For interaction with the 2D GUI a visually rendered raycast beam [12] attached to the users physical controller is used. For selection and manipulation the physical trigger button of the controller is used. To implement such a functionality we used the VRTK Virtual reality Toolkit[5]. The VRTK toolkit allows multiple platforms and controller based approaches like Oculus Rift and HTC Vive, but also the usage of a head mounted beam and a dwell time based interaction as for example used by the Samsung Galaxy Gear is possible.

The questionnaire can be integrated directly into the condition environment (Figure 1a) or used in a separate neutral questionnaire environment (Figure 1b). The separate neutral questionnaire environment is designed as a neutral room (dark gray floor and light gray walls). The intention for designing a neutral room was that the rating environment itself should not influence the users (quality-) perception of the condition scene.

For questionnaire administration and documentation local files in the CSV respectively JSON format are used. Questions can be loaded from a JSON file and the questionnaire answers are persistently stored in a CSV file. In future implementations an interfaces for loading and storing date from a database is planned.

B. Study Control Module

We used a study control interface that allows the study operator to control the questionnaire. A scheme of the proposed study control implementation is illustrated in Fig. 2.To trigger the questionnaire respectively the study conditions we use a JSON file. This allows integration of the VRate module into a broad range of existing study control approaches used in the UX and QoE community. For example the JSON file can be set by using a dedicated control program on the same computer or via a remote connection.

To control the levels and change between the questionnaire level and the condition levels a *FileChangeListener* (provided by Unity3D resp. C# - *System.IO.FileSystemWatcher*) is used. When the JSON file is changed by the control interface, the *FileChangeListener* detects that change and triggers the desired action by starting either a condition level or the questionnaire level. Of course it is also possible to automatically trigger the questionnaire environment based on user action, in this case the study administration interface and the *OnFileChangeListener* is not needed.

[5]https://vrtoolkit.readme.io/

III. DISCUSSION

The developed VRate module has been successfully used in a QoE Study (cf. [13]) with 27 users and a UX Study with 48 users, thus we could prove its suitability for using the VRate asset in a real world study.

Apart from providing a proof of concept we could used the QoE study to gather feedback from the users by asking the users ”How much did you like the VR Question Space?” after the study. No user encountered problems when interacting with VRate. Five users explicitly mentioned that the VRate questionnaire is ”super”, five users mentioned ”very good”, six users mentioned ”good” and seven users stated that it is ”ok”. Two users did not provide positive statements and issued only possible improvements. One users did not answer the question. Additional feedback was provided as for example on user stated that ”I like it because it’s embedded in the simulation.” and another user mentioned that ”Putting off and putting off the glasses would be annoying.”

In the QoE study we presented the rating questionnaire to the participants in a separate environment (Fig. 1b). Some users criticized the concrete design of the questionnaire environment ”The room was a little boring.” Another user suggested a different, more appealing design for the questionnaire environment, ”Remove the wallpaper and paint the room white. Add a ceiling light and a door.” Four users stated that they would have preferred to provide the rating in the same environment (e.g. ”I would rather answer questions in the same environment by means of a blackboard or faded in console”) and one user mentioned that ”Only the change [...] to the interrogation room I found too abrupt.”

IV. FUTURE WORK

The focus of VRate is to provide an environment for subjective self-reported experience measures. Nevertheless we think that this should be complemented by objective measures (cf. [5]), e.g. task completion time, logging of user position and head movement. Therefore we also suggest using a logging solution for interaction, head tracking and movement, which could be easily implemented in Unity3D.

Future research is needed to investigate if the questionnaire should be embedded in a separate environment or the same environment. Also other placement modalities than a static billboard, e.g. heads up display are possible. In future work we will implement different questionnaire integration modalities and investigate the influence on user experience. A possible further direction for future research is the suitability of VRate for longer questionnaires, e.g. the ITC-SOPI presence questionnaire [14]. So far we used VRate only for rating questionnaires consisting of four questions, which is a realistic setting for a QoE evaluation. From a technical point of view VRate is also suitable for longer questionnaires but it is unclear if long questionnaires are similar accepted by the users. The suitability for longer questionnaires shall be evaluated in future work.

Figure 1: The VRate Questionnaire Module in (a) the condition environment, (b) a dedicated questionnaire environment

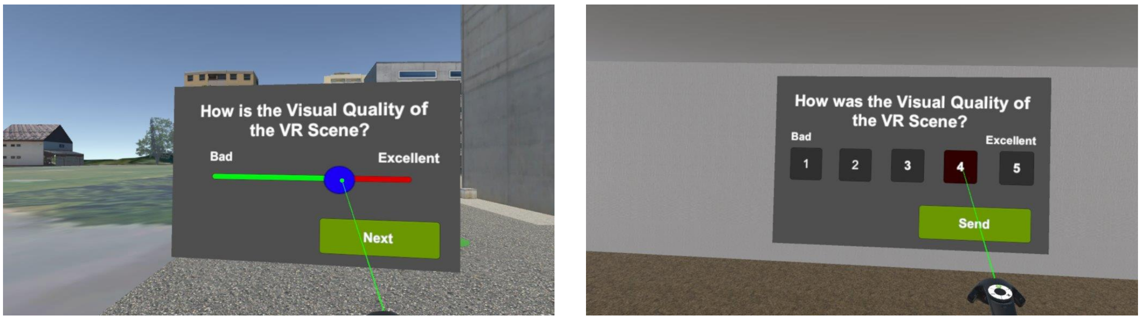
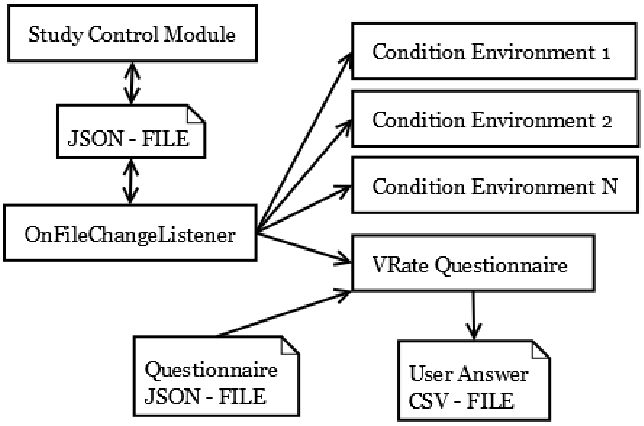


Figure 2: Technical Implementation Scheme



V. CONCLUSION

In this paper we presented VRate, a Unity3D asset that allows seamless integration of questionnaires in interactive virtual environments. Moreover we presented a control interface to administer UX and QoE studies in virtual environments. The VRate module provides a unity level with a questionnaire environment that can be used to integrate subjective ratings and questionnaires into fully immersive virtual environments, like e.g. computer games, training applications etc.

We would like to encourage the scientific community to apply the provided asset in future studies of QoE in immersive virtual environments. The developed VRate module is provided to the scientific community under Creative Commons License, Attribution, Non Commercial (CC BY-NC) and can be downloaded from the VRate Website[6].

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[6]http://vrate.tech-experience.at/

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