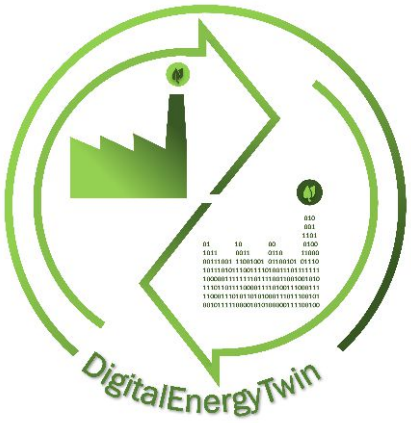
DigitalEnergyTwin



Documentation of requirements for educational VR experience

D7.3

DIGITAL ENERGY TWIN – OPTIMISED OPERATION AND DESIGN OF INDUSTRIAL ENERGY SYSTEMS

Project Number: 873599

eCall Number: 21527440

Date: 23.12.2021

ENERGIEFORSCHUNG (E!MISSION)

5. AUSSCHREIBUNG ENERGIEFORSCHUNG 2018

Report Prepared by:

Name: Johanna Pirker (a), Saeed Safikhani (a)

Company: (a) TU Graz

This project has received funding from the *Klima und Energiefonds* under grant agreement No 873599.

Content

1 Executive summary

The main goal of this deliverable is to describe use cases for the Virtual reality scenarios and use these to describe requirements for hardware and software choices.

Virtual reality has a great potential to visualize experiences and elements which are usually not seen, not possible or limited due to remote access. Potential use cases can be described as educational scenarios, interactive visualization strategies, evaluations and user studies, and remote operation or collaboration. The focus of this work is to build and evaluation educational experiences.

To this date, a lot of new VR HMDs are being released with different capabilities but also limitations. The main requirements here are usability and flexibility. As a results, the evaluated VR HMDs include the Oculus Quest 2, the Valve Index, and the HTC Vive. In regards of software choice, a first prototype has been explored with the Unreal engine. However, based on the results of deliverables 7.1. And 7.2., the next step will include an implementation of the prototype in Unity.

2 Definition of VR Use Cases

Virtual reality is a promising technology for various scenarios and use cases in the field of industry 4.0 and the potential of using virtual reality for digital twins is manifold. Compared to augmented reality, VR allows the interaction with scenarios and machines either remotely or interacting with full virtual representations. In this chapter we describe potential relevant use cases for both scenarios (connected to the digital twin and only representing the digital twin). Additional possibilities for both use cases enable the additional visualization of extra-information of various data augmentations (see AR use cases).

2.1 Interacting with a virtual representation

In digital twin environments, the objects and machines often have been already represented as 3D models/3D objects. With a virtual reality representation of the digital twins in VR, which does *not* has a direct impact on the actual object, various scenarios in the field of training, design, evaluation, and understanding are possible. We can see advantages such as low-cost interactions, advanced visualization methods in an immersive 3D space, natural and direct forms of interactions, possibility to collect interactions data, and interact with scenarios in a safe and cost-effective way.

2.1.1 Evaluation and User Studies

Digital twins can provide a safe environment to assess behaviors and processes with a scenario/a machine/an object. Additionally, data can be collected from different users (e.g. expert users vs. novice users) and visualized in the immersive space.

2.1.2 Educational and Training Tool

Digital twins in VR can be a great tool to educate different users group about complex systems. The potential of the immersive and visual experiences of VR can help users

obtaining an understanding of the interaction with the digital twin without interacting with the real device. This makes is cheaper, safer, and more accessible as it allows training at all times. Also training scenarios can be added that are usually not feasible.

2.1.3 Understanding and Decision-Making

Virtual reality environments can be used to help decision-makers to understand better current situations and constraints. It can also be used to show the current development to e.g. the general public (e.g. virtual company tour) to understand better the developments and machineries.

2.2 Interacting and communicating with the twin

Digital twin environments can allow a direct communication with the real twin. This supports new and more intuitive forms of interacting with the environment.

2.2.1 Remote Operation

Remote operation applications allow users to remotely operate the digital twin (digital twins are often complex machines and mechanical systems). However, often the interaction with remote interfaces and the visualization of the results is an issue of remote operations. Virtual reality environments can offer a more natural and intuitive interaction and also visualization form.

2.2.2 Remote Collaboration and Guidance

Many traditional digital collaboration tools split the ”person space” (verbal and nonverbal cues) and the ”task space” (space where they work together), which often leads to misunderstandings, errors, and delays. Environments that allow a direct communication when working together (e.g. physical pointing on parts of an object) have been shown to be faster and more productive. Virtual reality environments support a space which allows co-located collaboration and communication. VR environments allow teams to work collaboratively despite being in a remote setting. The members of the teams are immersed in an environment that is the digital twin of the real one.

Figure 1. Representation in VR, implemented with the Unreal Engine.

3 Definition of requirements regarding (educational) VR experience

For the use case, an educational VR experience is planned, as it allows training scenarios with the twin in a safe and cost-effective way. The environment should be easy to use also for non-VR experts. Typical issues and challenges of VR include cybersickness, acceptance of the VR technology, cables, network challenges, and hardware and controls. These challenges should be addresses when designing the VR experience.

3.1 Hardware

- VR HMD with a high display resolution (to read texts)
- User-friendly and intuitive controls and interactions
- High performance (rendering of large models)
- Easy to setup

3.2 Software

For implementing the virtual environment, the following requirements should be considered:

- Intuitive locomotion in a large room
- Performance optimization when rendering and interacting with large models
- Data exchange interface
- Intuitive interaction with the in-world objects
- Flexibility and adaption of the environment and use cases
- Feedback based on the interactions (for training purpose)

4 Evaluation and testing of VR devices, interfaces, etc.

4.1 Devices

Based on the defined requirements, several devices have been compared and discussed by the Game Lab Graz and evaluated based on their applicability to the defined scenario. In the following, pros and cons of the various devices are discussed.

Table 1. VR Hardware pros and cons.

Device	Pros	Cons
HTC Vive Pro	_high frame rate _user-friendly controllers	_external PC necessary _cables _costly with 1.400€
Oculus Rift S	_ergonomic controllers _lightweight _fast set up _cost-effective with 400€	_external PC necessary _cables
Oculus Quest 2	_standalone mobile headset (can be conntected to PC) _lack of wires and mobile _cost-effective with 350€	_not so powerful _cables for connection might be necessary _Facebook account necessary
Valve Index	_high frame rate _wider field of view _controller technology	_external PC necessary _cables _costly with 1.000€

4.2 Digital Twin interface and communication

For a VR implementation, the state-of-the-art workflow involves an integration through the game engines Unity or Unreal. As described in 7.1./7.2., possibilities to connect the digital twin software TWIN (digifai) are already explored and working with a Unity integration. In a first prototype we used the Unreal engine, as it allows a fast and graphically optimized representation. In a next step, a Unity integration will be explored based on the deliverables from 7.1. and 7.2.