Extended reality to support product development in makerspaces
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73

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Abstract

The poster delivers an overview of extended realities' potential for usage in makerspaces to support relevant processes like product development. Further, it gives an overview of a possible setup and use cases on the example of the implementation within the Schumpeter Laboratory for Innovation at Graz University of Technology.

Introduction

Despite the development of the first head-mounted display (HMD) already in the mid-20th century, the technology of virtual reality (VR) has emerged and been significantly enhanced throughout recent years [1]. It is now considered a mature technology and not further classified as an emerging technology [2]. By using extended reality (XR) in product development, it is possible to reduce the time-to-market, with simultaneous cost reduction and higher quality [3,4]. Furthermore, it provides flexibility and reusability for virtual prototypes [5]. It is still a rapidly growing technology, with an expected compound annual growth rate (CAGR) of 42,9% during the years 2020-2030 [6]. In industry, several use cases of extended reality concerning product development can already be observed. The BMW Group uses augmented reality (AR) in the development of vehicle concepts and prototypes, speeding up the design phase up to 12 months [7], design engineers at Lockheed Martin Space Systems use design concepts to virtually walk through possible assembly or maintenance situations [8] and Volkswagen is developing a virtual reality-based digital customer check for ergonomic evaluation during the design phase in their virtual reality competence center [9]. In addition, XR offers new possibilities for remote and virtual communication and collaboration – a field that gained increased significance throughout the last years – in the industry as well as at the academic level. Several product development projects of the Institute of Innovation and Industrial Management (IIM institute) at the Graz University of Technology were impacted by COVID-19 and new processes needed to be developed to transfer those projects to full or partly online conduction [10]. For academic makerspaces such as the Schumpeter Laboratory for Innovation (SLFI), XR provides new possibilities and potential to enhance existing processes and support product development. Academic makerspaces allow collaboration, design, fabrication, and learning in shared spaces. [11] They also foster product development [12] and additionally provide an approach to learning and teaching [13]. Yet, common equipment lists mainly contain physical prototyping equipment. The poster depicts a potential setup and modules/use cases for the usage of XR in an academic makerspace on the example of the SLFI. Further, ongoing research activities are briefly described.

Terminology

The term XR represents technologies that combine virtual elements with reality for various purposes. The taxonomy of Milgram – namely the reality-virtuality continuum, depicted in Fig.1 – is used [14].

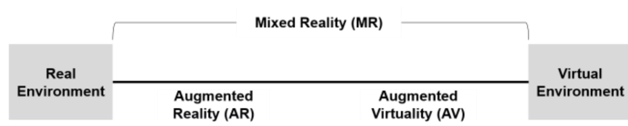

Fig.1 Reality-Virtuality Continuum (according to Milgram) [14]

Everything in between the two extrema of the reality-virtuality continuum is defined as mixed reality. Distinctions are made regarding the ratio of the virtual and the real content. Another distinction to make is regarding the type of display used, which correlates highly with the immersion the XR experience is going to provide. The types of displays with relevance for this poster are (1) head-mounted-devices (HMDs), which deliver the most immersive experience and put the virtual content directly into the user's field of view, and (2) Powerwalls – big displays with a stereoscopic view – that allow easy integration of several users at the same time.

Extended reality at the Schumpeter Laboratory for Innovation

The SLFI is an academic makerspace with multimedia presentation technology, conferencing and social rooms as well as modern production machinery. Its machine park for prototyping includes laser cutters, 3D printers, electronic workspaces, a waterjet cutter, CNC milling machines, as well as various hand tools. It serves as a central base for the innovation department of the IIM Institute including several product development courses with different time spans. All courses have in common that the teams consist of students with varied backgrounds in terms of nationality and study discipline – some participating as remote members – and furthermore, all courses have a focus on actively developing a product.

A. *XR Setup*

To enable the use of XR within the SLFI, a setup had to be developed first. Already existing infrastructure should be used and integrated into the setup if possible. Therefore, the already existing LED video wall, with around 30m² (~320ft²) should be used. In order to make it VR-ready, the wall is updated to stereoscopic view, thus making it a Powerwall to show 3D content to a large number of users at the same time. For use cases that require more interaction and potentially benefit from a high immersion level, HMDs are used. Within AR the institute already has pre-experience with the Microsoft HoloLens2, thus making it the preferred AR HMD. In terms of VR, the 2012 introduced Oculus Rift DK1 allowed consumers for the first time to enter VR at a reasonable price and provided many use cases as well as easily accessible content. [15] Since then, several manufacturers have developed the technology further. The newest generation of HMDs has enough computing power to work without any additional hardware enabling a new degree of freedom in terms of usage. Because of its versatility to use it both with external computing power or without, the Meta (former Oculus) Quest 2 was chosen as VR HMD. Fig.2 depicts a scheme of the hardware set-up integrated within the SLFI.

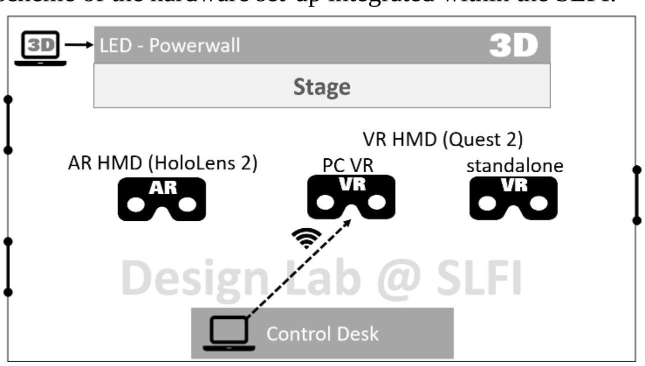

Fig.2 Hardware Set Up @ SLFI

B. *Teaching modules, use cases, and application*

Several use cases with the potential to be conducted in XR have been identified in the underlying courses of the IIM Institute. One important aspect of the implementation was to use already existing applications and therefore keep the development efforts on an efficient level. Another aspect was to structure the use cases in a clear and easily understandable way. Further, for each use case, training is required for first-time users. This has led to the arrangement of the following teaching modules, representing the use cases:

Module 0 – AR/VR Basics: no specific use case, but an overview on how to interact with XR and more specifically with HMDs. Tutorial applications pre-installed on the HMDs are used.

Module 1 – Visualization: import (virtual) objects into XR for visualization. Various options, of the in-house developed application, allow to zoom in, zoom out, place objects in the environment or show dimensions and cross-sections (as shown in figure 3).

Module 2 – Prototyping and Sculpting: manipulate and adapt existing objects and sculpt new objects from scratch. Develop own prototypes and export the data to slicer software. Gravity Sketch (publicly available/free use) is the application in use.

Module 3 – Meetings and Collaboration: set up meetings, know the potentials and possibilities for content visualization within virtual meetings, collaborate with remote colleagues, and document meetings. Currently, several publicly available applications are being investigated.

Module 4 – VR Tear Down: virtually tear down an existing product (coffee machine). The application was developed in-house.

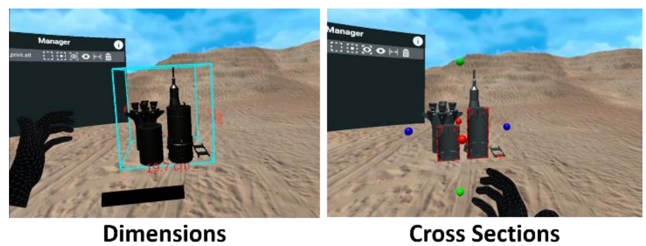

Fig.3 Impressions from Module 1 (Visualization)

C. *Research Activities*

In the course of summer 2022, the implementation for the hardware as well as the described modules is finished. In the winter term (October 2022), experiments are to start. Several student groups, including the IIM Institute´s product development courses, are going to experience XR modules firsthand. Pre- and post-tests will be used to gain insights into the effectiveness and usability of the described setup and modules. Observations and questionnaires are planned in order to evaluate XR's perceived usability as well as its impact on product development.

Discussion and Outlook

The SLFI with its usage by students as well as the industry delivers a great opportunity to conduct research on the topic of implementing XR in makerspaces. Providing easily accessible XR equipment and know-how in a makerspace enables new potential for product development and allows for further investigation and research. The findings and conclusions for the use of XR in makerspaces contribute to space design, planning processes, and emerging hardware and software tools for makers. Insights may be used as a first step towards defining best practices for various use cases. In terms of collaboration, it could become easier to connect users from different makerspaces worldwide to work on a joint project.

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