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A Multi-Platform Collaborative Architecture for Multi-User eXtended Reality Applications

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Abstract

In the last years, new visualization devices related to technologies like AR, MR and VR have emerged. Such devices have proven to be useful for numerous medical, industrial and manufacturing processes, but the technologies they use tend to be platform dependent. Currently, the Khronos group is making an effort to change this thanks to the OpenXR framework, which provides tools to standardize the development for different XR (Extended Reality) platforms. However, many processes and tasks require multiple users to interact with the same virtual environment simultaneously. To tackle this issue, this paper presents an XR solution that allows for the creation of collaborative applications that can be used at the same time by different platforms, such as computers (i.e., Windows, Mac or Linux PCs) and Mixed Reality smart glasses (e.g., Microsoft HoloLens 2). The proposed architecture is based on Unity and Mirror, a high-level networking tool for the mentioned game engine. The solution allows developers to design just one application that could be compiled and deployed to different platform devices without the need for changing any configuration or for adapting the project to each of the platform requisites. The proposed system also allows for using multiple devices simultaneously, providing a new way for collaborative interaction with the application, showing all the visual components synchronized in the same position and in the same state, thus facilitating communications and awareness of the environment for the developed XR experiences.

1 Introduction

Extended Reality (XR) technologies, including Augmented Reality (AR), Mixed Reality (MR) and Virtual Reality (VR), are currently being used in numerous commercial applications for different fields such as industry, healthcare, entertainment, product design or marketing. The release of new XR devices increases the range of devices that can run the same application.

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Moreover, the use of multi-user XR brings the immersiveness of the developed applications to a whole new level, significantly improving the experience and favoring the communications among different participants in a seamless way [1].

The development of XR applications is a topic that has already been covered in different studies [2, 3, 4]. However, making the same XR application able to run on devices with different characteristics is a major challenge due to the peculiarities of each type of visualization and the development frameworks for each device. Luckily, relevant efforts are being made to standardize and homogenize the development for different XR applications. The OpenXR framework is one of the major standards embraced by the most important stakeholders in the XR world. Nonetheless, there are still an important number of aspects to consider when developing multi-platform applications, which do not make such a task easy.

This paper describes a novel architecture for developing multi-platform multi-user XR applications by using the latest available standards, open-source tools and libraries to ease such a development and thus provide guidelines for future applications. In addition, it is presented an MR and desktop computer multi-platform application that was developed as a proof of concept. In such an application, multiple users of MR glasses or desktop computers can collaborate in real time in order to achieve the different challenges of a collaborative game.

2 Design of the System

The proposed system architecture is depicted in Figure 1. As it can be observed, the system consists of four modules: Network Manager, which uses the Mirror framework, is in charge of exchanging messages between clients and the server and keeping all objects synchronized; Multiplatform Manager is responsible for managing platform-dependent components, deactivating unnecessary packages and provisioning the corresponding ones; Input Manager, which includes Mixed Reality Toolkit 2 (MRTK), is used for handling the different user inputs depending on the hardware platform; finally, the User Interface (UI) module is in charge of displaying the corresponding interface depending on the device.

In addition, the system server is responsible for handling all communications exchanged among the clients, as well as for transmitting the information that is necessary to keep the position of all the objects in the scene up to date. It is worth mentioning that user devices can act as servers or clients, so if it is needed, two or more devices can be connected directly through a local network, without needing to have an Internet connection.

3 Results

In order to show the capabilities of the proposed system, as an example of its potential, a multi-player and multi-platform collaborative game was developed. In such a game, users have to work together in a virtual restaurant in order to get the food prepared on time.

A couple of screenshots of the developed application are shown in Figure 2. Specifically, Figure 2 shows two scenarios where multiple users are connected to the same server and playing from different platforms. The application can be executed simultaneously and in a synchronized way through different devices, so that all users see the same scene adapted to the platform of their device.

In particular, the picture on the left of Figure 2 shows the scene view captured from a desktop platform where four players were playing collaboratively (blue and green players used a PC; while the red and yellow player used Microsoft HoloLens 2 glasses). Both player types

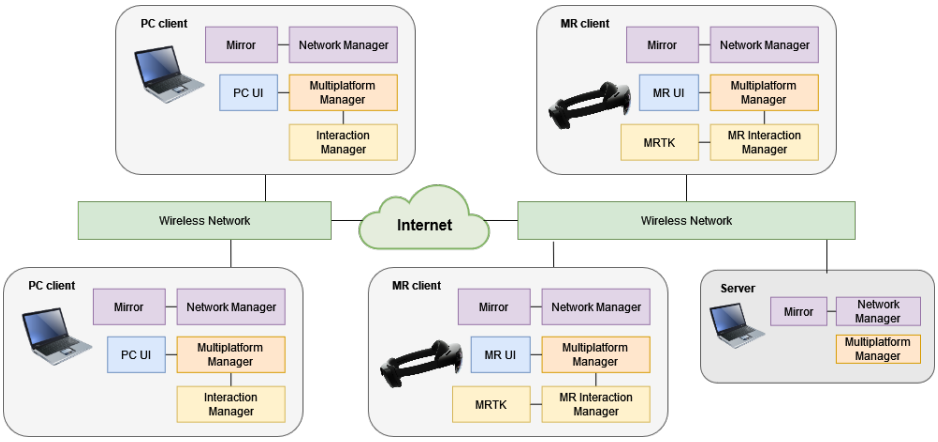

Figure 1: Architecture of the system.

can be recognized because each platform has its unique representation, considering both the local user's platform and the remote user's platform. As an example, Figure 2, on the right, shows the perspective of a user when using an MR device.

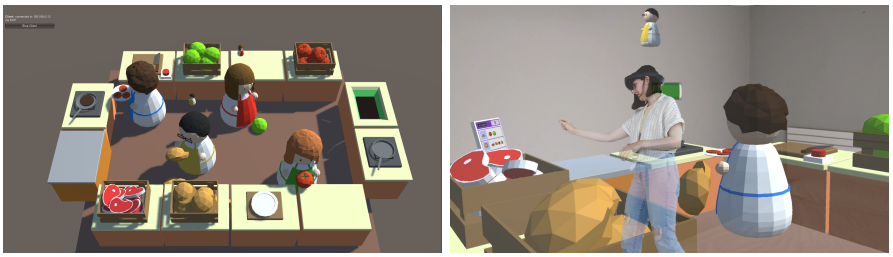

Figure 2: Two screenshots of the developed application seen from a PC (left) and MR smart-glasses (right).

4 Conclusion

This paper proposed an XR system that was designed for developing multi-platform collaborative applications for multi-user experiences. The provided architecture along the proposed functionalities allow for the development of applications that enable synchronized experiences among users, no matter what platform the devices are using. Moreover, this system provides an easy way of developing only one unique application that can be compiled for multiple platforms, without the need for changing its internal configuration each time the application is compiled.

References

[1] Huyen Nguyen and Tomasz Bednarz. User experience in collaborative extended reality: Overview study. In *International Conference on Virtual Reality and Augmented Reality*, pages 41–70. Springer, 2020.

[2] Aida Vidal-Balea, Óscar Blanco-Novoa, Paula Fraga-Lamas, and Tiago M. Fernández-Caramés. Developing the next generation of augmented reality games for pediatric healthcare: an open-source collaborative framework based on arcore for implementing teaching, training and monitoring applications. *Sensors*, 21(5):1865, 2021.

[3] Pei Ren, Xiuquan Qiao, Yakun Huang, Ling Liu, Calton Pu, Schahram Dustdar, and Jun-Liang Chen. Edge ar x5: An edge-assisted multi-user collaborative framework for mobile web augmented reality in 5g and beyond. *IEEE Transactions on Cloud Computing*, 2020.

[4] Aida Vidal-Balea, Oscar Blanco-Novoa, Paula Fraga-Lamas, Miguel Vilar-Montesinos, and Tiago M. Fernández-Caramés. Creating collaborative augmented reality experiences for industry 4.0 training and assistance applications: Performance evaluation in the shipyard of the future. *Applied Sciences*, 10(24):9073, 2020.