Space Wars: An AugmentedVR Game

Kyriaki Christaki[1], Konstantinos C. Apostolakis[1], Alexandros Doumanoglou[1], Nikolaos Zioulis[1], Dimitrios Zarpalas[1], and Petros Daras[1]

Visual Computing Lab, Information Technologies Institute, Centre for Research and Technology Hellas
{kchristaki, kapostol, aldoum, nzioulis, zarpalas, daras}@iti.gr
vcl.iti.gr

Abstract. Over the past couple of years, Virtual and Augmented Reality have been at the forefront of the Mixed Reality development scene, whereas Augmented Virtuality has significantly lacked behind. Widespread adoption however requires efficient low-cost platforms and minimalistic interference design. In this work we present *Space Wars*, an end-to-end proof of concept for an elegant and rapid-deployment Augmented VR platform. Through the engaging experience of *Space Wars*, we aim to demonstrate how digital games, as forerunners of innovative technology, are perfectly suited as an application area to embrace the underlying low-cost technology, and thus pave the way for other adopters (such as healthcare, education, tourism and e-commerce) to follow suit.

Keywords: · Augmented Virtuality · Virtual Reality (VR) · Mixed Reality (MR) · 3D Capture

1 Introduction

Augmented Virtuality (Augmented VR), is defined as an intermediate state of the reality-virtuality continuum, which refers predominantly to the blending of real world physical elements (such as objects or people) into virtual worlds [3]. In the context of Augmented VR [2], technological advances over the past several years have allowed the development of interactive, immersive applications where user representation utilizes 3-dimensional digitalization of their physical appearance, which is then embedded into the virtual 3D world and offers enhanced and engaging experiences. The development of such systems remains a challenging task however, at it requires an end-to-end pipeline of multiple modules tapping into different technological fields, such as computer vision, data compression and transmission, networking and computer graphics.

We have realized a portable and easy-to-deploy (indoor) platform that can be operated as a local user digitalization node for Augmented VR applications. The platform uses 4 RGB-D sensors, and utilizes an easy-to-use, multi-sensor calibration scheme, which allows for coarse sensor positioning around a predefined capturing space without restrictions. By integrating technologies from multiple fields, the user's full-body 3D appearance, as well as real-time motion

are captured and transmitted, to be used as assets in remote virtual and game environments, where interaction between the remote participants is facilitated. In this work, we demonstrate the concept and low-cost Augmented VR platform in the form of *Space Wars*, an immersive one-vs-one networked game where the physical appearance of the two players is dynamically integrated into the game world, cementing a direct, real-time link between the real world and the digital game arena. A motion-control, gesture-based interface allows exploring intuitive aspects of user movement to interact with the game world, while simultaneously maintaining seamless, real-time visual communication and consistency with the other player.

The remainder of this paper is organized as follows: An overview of the underlying platform to achieve Augmented VR experiences is presented in Section 2. Section 3 presents the *Space Wars* demonstrator. Finally. Section 4 discusses the Augmewnted VR experience and concludes with insight on future work.

2 Augmented VR Platform

Our end-to-end Augmented VR pipeline comprises three modules, each respectively responsible for i) Capturing and Reconstruction, ii) Compression and Transmission, iii) Rendering and Interaction. The overall architecture showcasing placement of these modules is shown in Figure 1. An overview of the three distinctive modules, that reflect the multidisciplinary nature of the presented platform, is presented in the following paragraphs.

Capturing and Reconstruction Each capturing station comprises 4 low-cost RGB-D sensors placed in a circular setup around the capturing area and 5 computing units. The central unit is responsible for the configuration of the setup, and acts as a hub where the sensor data are collected and processed. The 4 remaining units are assigned to operate one sensor each. At this stage, geometry and appearance reconstruction of users inside the capturing area is implemented by processing a stream of spatially and temporally aligned color and depth frames acquired by the 4 sensor units. The user mesh geometry is complemented by a multi-texturing approach which is used to embed appearance to the generated geometry [5]. To emphasize on the platform's portability and ease of use, the 4 sensors are calibrated using an automated method requiring a stack of standard packing boxes be placed at the center of the capturing area prior to the platform use [1, 5]. The output of this module is a stream of timestamped mesh data incorporating attributes such as mesh vertices, triangles, normals and texture blend weights, along with 4 RGB frame viewports to be used as texture maps [5].

Compression and Transmission AugmentedVR ve applications need to minimize end-to-end latency as it has a huge impact on the perceived Quality of Experience (QoE). Depending on the network conditions different compression

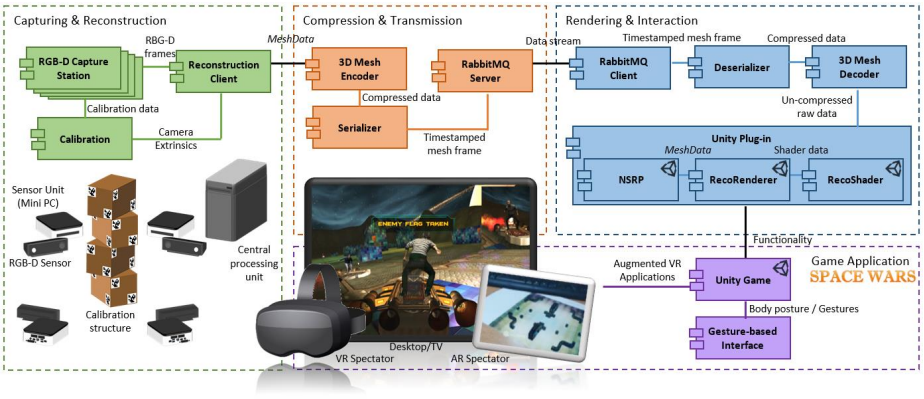

Fig. 1. Augmented VR Platform Architecture.

schemes perform optimal. On fast network lines low compression is preferable as it often means that the compression time will be minimum. For slow network links higher compression rates are required to minimize end-to-end delay. The current AugmentedVR platform employs various mesh codecs that can be chosen to be used such as OpenCTM, Draco, Corto and O3DGC. For texture compression, standard JPEG compressor is used due to the processing latency requirements.

Rendering and Interaction The Rendering and Interaction module was developed to embed user representation in the Unity3D game engine[1]. The module is based on a number of Unity3D component scripts, which transform raw data streamed over a RabbitMQ network into a Unity3D renderable asset. Its main components include:

- A **Network Stream Reconstruction Provider (NSRP)**, which handles communication with the RabbitMQ server and notifies module whenever new data arrives. Each update cycle, the component re-builds a 3D mesh into a custom *MeshData* structure using the list of attributes defined in the Capturing and Reconstruction module.
- A **Reconstruction Renderer (RecoRenderer)**: The component translates the custom *MeshData* data structure of the NSRP into standard Unity3D Mesh Renderer component data, embedding appearance through a custom RecoRenderer shader. During each update cycle, the component re-builds a standard Unity3D Mesh asset, and updates values of the Shader Material toward blending texture information and retrieving the mesh color appearance characteristics. Additional effects can be added through the shader to manipulate the resulting mesh in meaningful ways to the game logic, such

[1] https://unity3d.com

as adding a highlight to indicate team affiliation (Red or Blue) and exploding/restructuring the mesh geometry as a result of collision with projectiles.

3 Demonstrator

Space Wars is built in Unity3D and utilizes a centralized multi-player game architecture, in which a game server is responsible for game state synchronization. A client-side prediction approach is utilized in order to overcome transfer latency on the game clients that would result to an undesirable "lag" effect. An extensive event messaging system is responsible for the executing the game logic, and for synchronization and communication both locally and over the network through a server-client paradigm.

Game Setting and Goal *Space Wars* is a sci-fi, 1-vs-1 Capture the Flag (CTF) experience [4] in which two players maneuver a futuristic arena on hoverboards trying to locate and recover the opposing player's flag before theirs is captured. The first player to successfully capture the other player's flag and carry it back to his/her base wins the Round. Players can fire projectiles at one another to force their opponent back to his/her spawning ground and potentially restore their flag back to their base. The game ends when one side wins three Rounds. Example in game screenshots are illustrated in Figure 2.

Augmented VR interface Apart from integrating 3D photorealistic representations of the players on top of each hoverboard, *Space Wars* also utilizes sensor information to control movement in the virtual environment. Using an in-house developed gesture-based interface, users navigate the 3D world and play the game using their body posture. Hoverboard acceleration is controlled by bending the knees, while torso leaning left or right turns the hoverboard towards that direction. Additionally, projectiles can be fired by performing a throwing gesture using their hands.

Live Spectators The system offers the possibility to non-participating users to connect to the platform as VR spectators. In this "spectator mode", viewers, using VR headsets and controllers, can enter the virtual world of the game and view the CTF match in progress. This immersive experience adds on the attractiveness of the game.

4 Conclusion

Augmented VR technology carries a significant potential for ground-breaking innovations delivered to the currently booming Mixed Reality market. The support for photo-realistic user representation opens up opportunities for vastly broadening the MR application spectrum (e.g. immersive collaborative games,

Fig. 2. Space Wars screenshots depicting two players in action. The 3D reconstructed representations of the players appear in the game world and interact with the game and the opponent player in real-time.

tele-presence applications, etc.), while delivering a significant breakthrough in social-minded VR scenarios. Our *Space Wars* demonstrator paves the way for talented people and studios in the VR industry to experiment with the platform, resulting in a significant number of high quality products that people will be able to enjoy both with those around them as well as distant friends and family.

Acknowledgement This work was supported and received funding from the European Union Horizon 2020 Framework Programme for Research and Innovation Action under Grant Agreement no 762111 VRTogether.

References

1. Alexiadis, D.S., Chatzitofis, A., Zioulis, N., Zoidi, O., Louizis, G., Zarpalas, D., Daras, P.: An integrated platform for live 3d human reconstruction and motion capturing. IEEE Transactions on Circuits and Systems for Video Technology 27(4), 798–813 (April 2017). https://doi.org/10.1109/TCSVT.2016.2576922
2. Karakottas, A., Papachristou, A., Doumanoglou, A., Zioulis, N., Zarpalas, D., Daras, P.: Augmented VR, IEEE Virtual Reality, Mar 18 - 22, 2018, https://www.youtube.com/watch?v=7O_TrhtmP5Q
3. Milgram, P., Kishino, F.: A taxonomy of mixed reality visual displays. IEICE TRANSACTIONS on Information and Systems 77(12), 1321–1329 (1994)
4. Rocha, J.B., Mascarenhas, S., Prada, R.: Game mechanics for cooperative games. ZON Digital Games 2008 pp. 72–80 (2008)
5. Zioulis, N., Alexiadis, D., Doumanoglou, A., Louizis, G., Apostolakis, K., Zarpalas, D., Daras, P.: 3d tele-immersion platform for interactive immersive experiences between remote users. In: 2016 IEEE International Conference on Image Processing (ICIP). pp. 365–369 (Sept 2016). https://doi.org/10.1109/ICIP.2016.7532380