Real Virtuality: A Multi-User Immersive Platform Connecting Real and Virtual Worlds

Sylvain Chagué
Artanim
40, chemin du Grand-Puits
1217 Meyrin, Switzerland
+41 22 980 91 12
sylvain@artanim.ch

Caecilia Charbonnier
Artanim
40, chemin du Grand-Puits
1217 Meyrin, Switzerland
+41 22 980 91 12
caecilia@artanim.ch

ABSTRACT
Real Virtuality is a multi-user immersive platform combining motion capture with virtual reality (VR) headsets: users can freely move within the physical space while virtually visiting a virtual world and interacting with 3D objects or other users using the sense of touch.

Categories and Subject Descriptors
H.5.1 [**Multimedia Information Systems**]: Artificial, augmented, and virtual realities.

General Terms
Algorithms, Design, Experimentation, Human Factors

Keywords
Virtual Reality, Motion Capture, Interaction, Passive Haptic

1. INTRODUCTION
Reaching a strong feeling of presence is a necessary step to an effective and natural VR experience. This sensation can be divided into four pillars [1]: 1) the illusion of being in a stable spatial space, 2) the illusion of self-embodiment, 3) the illusion of physical interaction, and 4) the illusion of social communication. The first element, also called place illusion [2], is considered the most important one and is relatively easy to achieve with current consumer VR hardware and game engines. The last three elements can be more difficult to reach.

In this paper, we present a novel multi-user immersive platform, called Real Virtuality, which offers a variety of VR experiences with a strong feeling of presence by successfully building upon the four aforementioned elements. Users of the platform are tracked by a Vicon motion capture system [3] allowing them to see their own bodies and move physically in the virtual environment. They can also interact with physical objects in the virtual world. The next sections describe into more details the different challenges tackled by our solution.

VRIC 2016, March 23-25, 2016, Laval, France

DOI: http://dx.doi.org/10.1145/2927929.2927945

2. TECHNICAL CHALLENGES
2.1 Simple full-body immersion setup
To make this platform available to a large public, we need to keep the user's setup time as short as possible (< 1 minute), while maintaining a good tracking accuracy and animation quality. We therefore use a minimal set of rigid bodies positioned on the user's hands and feet. The user is also equipped with a VR headset and a backpack containing a portable computing unit (see Figure 1 and Figure 2), both covered with reflective markers.

The position and orientation of the rigid bodies are tracked at 250Hz by the motion capture system, and then fed to an inverse kinematic algorithm allowing the computation of a full body character animation. A calibration pose (T-pose) is required at the beginning of the experience to fit the virtual avatar to the users' dimensions and thus improve the animation quality.

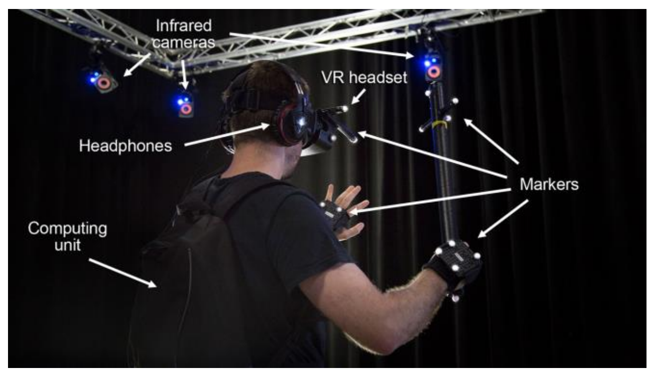

Figure 1. User setup

2.2 Combining real and virtual environments
Users can naturally interact with 3D objects using the sense of touch that only physical objects can offer. The physical objects are either statically registered to the virtual environment (object not tracked) or dynamically registered to the environment (tracked object, Figure 2). In the latter case, the placement of optical markers on the object has to be carefully though so that it doesn't create a break in presence or suffer too much from occlusions. Markers can be integrated in the design of the virtual object or positioned in areas that users are unlikely to touch (e.g., the torch in Figure 1). Using this kind of passive haptics significantly improves the feeling of presence in virtual environments [1] [5].

Figure 2. Two users interacting with a physical object: in the virtual world the users can see an Egyptian chest, whereas it is a simple cardboard box in the real world.

2.3 Wireless and multi-user platform

Cables running between the computer and the VR headset are an obvious source of break in presence and greatly limit the freedom of movement. To solve this issue, the backpack computer connected to the VR headset communicates wirelessly (Wi-Fi) with the motion capture workstation (Figure 3). This provides a simple 1-to-n server/client architecture allowing multiple users to share the same physical space and virtual environment.

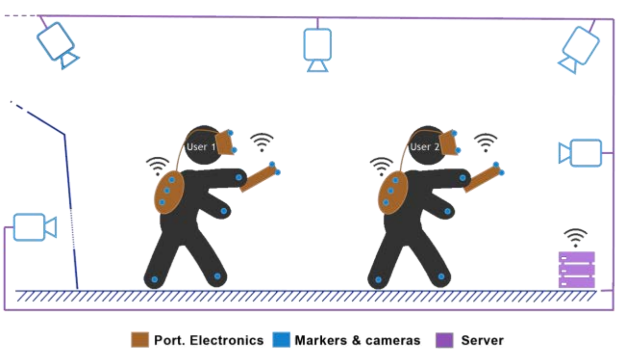

Figure 3. Multi-user wireless VR setup

2.4 Tracking data fusion

Special care must be taken while positioning and orientating the user's head in the virtual space to avoid simulation sickness. On the one hand, orientation data calculated by using the inertial measurement unit (IMU) of the VR headset presents very low latency, but is subject to drift over time. On the other hand, positional data provided wirelessly by the motion capture system is very accurate, but shows more latency due to data streaming. The advantages of the two technologies are thus combined by fusing the two types of data. This allows us to preserve both the low latency and high positioning accuracy, ensuring a smooth wireless user experience.

3. EXPERIMENTS

Three scenarios were developed to showcase various use cases targeting different applications such as cultural heritage, entertainment and art. These scenarios are for two users, but the platform is scalable and could accommodate more players.

The first scenario is a virtual visit of an Egyptian tomb where the users are able to walk through the tomb using a virtual torch to light the way and illuminate their surroundings. This scenario forces the users to collaborate, since the environment is very dark and only one torch is available.

Figure 4. "Prepare to be amazed" experience

The second scenario puts the users in the middle of a contemporary dance performance, so that they are no longer passive observers, but are themselves actors on stage where they can watch the piece from every point of view. The two dancers were first digitalized using 3D body scanning technology and their motion recorded while performing a short choreography.

In the last scenario (Figure 4), users progress through a maze and must use their dexterity to avoid traps and surprises. Elements susceptible to generate fears such as holes, spiders and confined spaces are placed along the way. APPLICATIONS

The simplicity of the user setup opens up new possible use cases for multi-user full-body immersive VR. In particular, this platform can be used in numerous applications, such as for virtual visits (e.g., long lost historical sites, architectural places, telepresence), entertainment (e.g., games, theme-park attractions, story-telling experiences) or medical projects (e.g., phobia treatment, rehabilitation).

4. CONCLUSION

The Real Virtuality platform allows users to reach a strong feeling of presence by successfully building upon the 4 following pillars. First, the combination of a wireless setup with optical / inertial sensor fusion allows for a fast and accurate tracking generating a strong "place illusion". Second, the illusion of embodiment is reached thanks to the full body tracking and inverse kinematic. Third, our passive haptic setup connecting the real world with the virtual world brings the sense of touch to the experience. Finally, the possibility to have multiple users sharing the same virtual world and interacting together adds a social component to the experience.

5. ACKNOWLEDGMENTS

We would like to thank Bart Kevelham and David Hodgetts for their participation to the development of the VR platform. We also thank Kenzan SA for the modelling of the Egyptian tomb and the Cie Gilles Jobin for the virtual dance performance.

6. REFERENCES

[1] Jason Jerald. 2015. *The VR Book: Human-Centered Design for Virtual Reality*. Association for Computing Machinery and Morgan & Claypool, New York, NY, USA.

[2] Slater M. 2009. Place illusion and plausibility can lead to realistic behavior. In *immersive virtual Environments. Philos Trans R Soc Lond B Biol Sci 364*: 1535. 3549-3557 Dec.

[3] Vicon system, http://vicon.com/

[4] Brent Edward Insko. 2001. *Passive Haptics Significantly Enhances Virtual Environments*. Ph.D. Dissertation. The University of North Carolina at Chapel Hill. Advisor(s) Frederick P. Brooks, Jr.. AAI3007820.

[5] Adalberto L. Simeone, Eduardo Velloso, and Hans Gellersen. 2015. Substitutional Reality: Using the Physical Environment to Design Virtual Reality Experiences. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (CHI '15). ACM, New York, NY, USA, 3307-3316. DOI=http://dx.doi.org/10.1145/2702123.2702389