Real Virtuality

Perspectives offered by the combination of Virtual Reality headsets and Motion Capture

Real Virtuality White Paper
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The advent of virtual reality headsets

Virtual reality headsets, the recycling of an old idea
Virtual Reality (VR) headsets have been developed as early as the 1990's, in particular with Sega releasing the VR-1 in 1994 and Nintendo the Virtual Boy in 1995. However, VR did not convince at that time mostly because of motion sickness, limited screen resolution and unrealistic 3D environments, resulting in a poor user experience.

Recent advances in technology
With the popularization of the smartphone, key technological enablers such as screens, gyroscopes and processing power have greatly improved in performance and miniaturization, while their cost was drastically reduced.

In addition, key software tools such as 3D game engines, self-contained applications, API and mobile apps have made the development and dissemination of virtual environment much easier and cheaper than before.

A concept backed by leading technology firms
VR came back to prominence with the hugely successful campaign launched by Oculus in August 2012. Raising USD 2.5m in a month, Oculus was able to re-create the VR market and enthuse consumers with the perspective of cheaper and better performing VR headsets.

Recognizing the renewed potential of this technology, Facebook purchased Oculus for USD 2bn in March 2014. Samsung entered in a partnership with Oculus to adapt VR technology to mobile and launched the Samsung Gear VR in late 2014.

Other technological firms, such as Google, Sony, HTC and Valve are working on their own VR platforms which are expected to launch in the coming months.

An experience mostly limited to head and hand movements
One major caveat with the current hardware being developed is that users mostly rely on the same set of interface tools which have been developed over the past 20 years. Users still need joysticks, gamepads and keyboards to interact with the VR.

Recognizing this limitation, VR hardware manufacturers have started to add hand tracking devices on their headsets. Oculus for example purchased Nimble VR, a startup specialized in the markerless capture of hands movements. Another solution is proposed by Leap Motion which tracks users' hands by using a combination of a camera and infrared light. Lastly, Sixsense and Oculus have both released controllers which are tracked in a 3D space.

However, no solution has been developed until now to track the body and movement of VR users on a large space, which is possible by combining VR with motion capture – a system we have called *Real Virtuality*.

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Trends in motion capture technology

A mature and well understood technology
Motion capture allows recording the body movements of a real person in order to apply them to a virtual 3D character. Since the last 15 years, this technology has long been used by leading film studios and game developers.

Nowadays, this technology is becoming more democratic. With the decrease of the hardware cost, the increase interest in VR and the evolution of the technology itself, many motion capture systems or tracking devices are now available. The technology ranges from high-end optical cameras, inertial sensors (usually coupling accelerometers and gyroscopes) to low cost depth sensors (e.g., Microsoft Kinect).

However, the use of optical cameras remains the technology of choice because it offers the highest accuracy and flexibility in terms of tracking possibility – any kind of objects or bodies (body and face, fingers, props, animals, etc.) can be captured.

How it works
A motion capture space is equipped with a set of optical cameras. Reflective markers are placed on the subject's body or to any object that must be tracked in the scene. They act as reflectors and appear much brighter to the cameras than the rest of the scene.

Each camera emits infrared light. The light wave is reflected by the markers and sent back to the camera which records their position in the 2D image. Using a triangulation process, the 3D coordinates of each marker are reconstructed for each frame by combining the 2D data from each camera. As a result, the position and orientation of the body, head and objects can be computed from the markers trajectories. The data is finally input in the VR application in order to update the different elements accordingly.

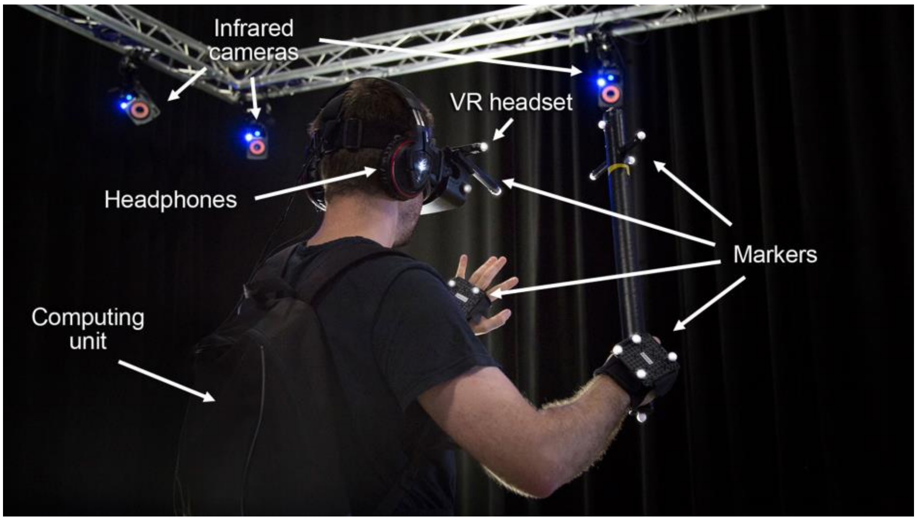

Fig.1: User with the VR headset and the reflective markers. Markers are also placed on real objects for interaction.

Perspectives offered by Real Virtuality

Our vision

Our objective is to allow people to physically move within the physical space, get them out of their seats and use their real legs and arms to discover and interact with 3D.

More specifically, we aim at combining a dedicated virtual space with a real one, and merge the visual and audio input provided by the VR headsets with the sense of touch and smell that only physical objects can offer. This would be achieved by combining VR headsets with a physical decor and interactive objects.

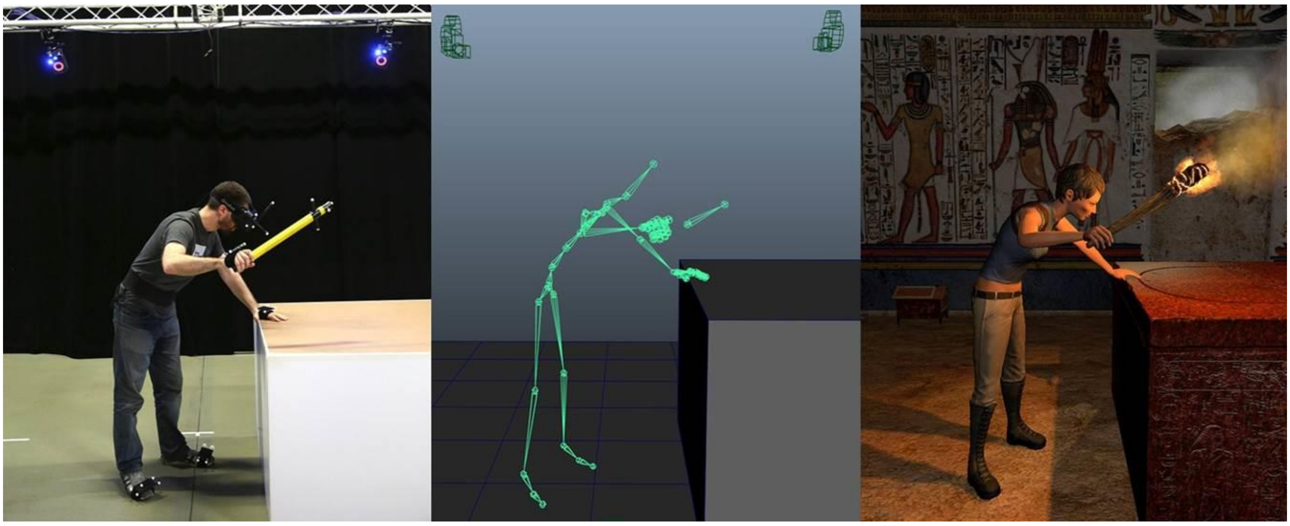

Fig.2: From Real to Virtual. How the system interprets motion capture data and renders it in a 3D environment.

Ultimately, our goal would be to create a flawless experience, which will be soon possible given the current rate of progress in both 3D environments and VR headsets technologies.

Technical setup

The setup includes a dedicated space including a decor exactly matching the virtual environment, as well as motion capture cameras covering all possible angles.

Visitors are equipped with a specially marked VR headset, a laptop backpack and slip sets of markers on their hands and feet (see fig. 1). The setup is completed in less than a minute.

The laptop carried by the visitor is running the main VR application, while a workstation is controlling the motion capture system. Data synchronization between the laptop and workstation is performed wirelessly (wifi) and allows free users movements within the dedicated space.

Several users can be present in the virtual space at the same time, as they are able to see and interact with each other. When necessary, decors and props are fitted with markers to enable interactions with the virtual reality.

Possible Applications

Theme Parks Attractions
Real Virtuality is the future platform in theme parks. Indeed, it allows users to experience "matrix-like" experiences that would be impossible in a home setting due to the lack of space.

Among the first applications possible are haunted houses, which can be made really frightening and interactive, as well as obstacle courses or mazes which will place visitors in dangerous or imaginary locations around the world or in the universe.

In a second step, elaborate physical simulators – such as driving or flying simulators – can be added to the Real Virtuality experience to create elaborate gameplays where users explore their surrounding by foot, as well as by driving vehicles.

Haptic feedback will be provided by adding vibration, heating or cooling devices, as well as haptic vests when they become available, to create a full sensorial experience.

Multiplayer Arenas
Multiplayer Arenas will merge physical experiences such as Paint-Balls & Laser Tags with 3D First Person Shooters games such as Halo or Call of Duty. The potential for "Multiplayer Arenas" is very important, drawing on a large existing user base.

Such installations will be much easier to install than full-fledged theme park attractions, as they will not require elaborate decors or structures, but simple decors which can be rearranged periodically to create new "maps" and enhance re-usability.

The same decor can be used to provide distinct 3D experiences, offering a variety of gameplays to reach a wider demographic base.

Exhibitions
Real Virtuality will enable museums to expose inaccessible or destroyed places to the public, and create interactive and educational experiences. They can also use it to display their collection in their original state, before it was brought within the museum's walls.

In our proof of concept demonstration released in April 2015 called "Walking through a Pharaoh's tomb", we allow users to explore an ancient Pharaoh's tomb in its initial splendor, before it was looted centuries ago. Users explore by foot the tomb, carrying a (virtual) torch to explore their surroundings. They can learn the meaning of the hieroglyphs by touching them, which displays an additional layer of information, and interact with the installation to gain access to the main room.

Many other applications are possible. It is possible for example to visit the wreck of the Titanic, allowing users to see a photorealistic 3D rendering of the inside of the ship, while walking through a matching decor. Scientific exhibitions can use Real Virtuality to transport to an alien planet surface, which visitors can explore by foot in a (virtual) suit.

Medical Applications
Real Virtuality can be used as a rehabilitation platform to help and guide patients in

their training program. For instance, combining motion capture with interactive audiovisual feedback (e.g., virtual coach) can support rehabilitation training with rewarding mechanisms (gamification) and reliable monitoring of patient's progress.

Another application could be the use of VR for the training of future surgeons or as an educational platform to navigate and learn the complex anatomical human body.

Additionally, exposing patients to immersive virtual environments can be an effective tool in the treatment of phobia (e.g., fear of height, claustrophobia, agoraphobia, etc.) or more complex pathologies (e.g., Alzheimer) in secure conditions. Applications in cognitive science and neuroscience are also of great interest.

Artistic Installation
Using Real Virtuality, visitors can create 3D sculptures with their hand or using interactive tools. Sculptures can later be physically produced, using 3D printing or any other manufacturing technique. Fully interactive artistic installations can be imagined, such as interactive instruments, which produce sounds as well as images. Sculptures can react to visitors presence, and change color depending on their pace or actions for example. Real Virtuality is a new artistic medium, and the possibilities offered are only limited by artist's imaginations.

Industrial Design
Real Virtuality can be used to design complex installation design, for example by validating the accessibility of critical components in large vessels, chemical plants or off-shore platforms. It can also be used by architects to provide the most immersive rendering of future buildings, and offers buyers to explore the space by foot before it is being built.

Technical Challenges

Integration of motion capture data into the VR application
Motion capture data must be streamed to the 3D game engine as fast as possible to minimize latency and hence possible discomfort with the VR headset. Indeed, special care must be taken while positioning and orientating the user's head in the virtual space.

On the one hand, orientation data calculated by using the sensor of the VR headset presents very low latency, but is subject to drift over time. On the other hand, positioning data provided wirelessly by the motion capture system is very accurate, but might have more latency due to data streaming.

To combine the advantages of the two technologies, we developed fusion algorithms which preserve both the low latency and high positioning accuracy, ensuring a smooth wireless user experience.

Minimizing the motion capture setup
The number of markers used must be reduced to the minimal number in order to keep the visitors setup as short as possible, while ensuring a good tracking accuracy.

We have designed a markers configuration that only relies on a set of rigid plates and fabric bands placed on the hands and feet, in addition to markers fixed on the VR headset. The overall setup is completed in less than a minute.

Our powerful retargeting algorithms then recreated the full user body movements using the partial information provided by the markers. We thus obtain all the information needed to compute the position and orientation of the visitor in space, the head's orientation (where the visitor is looking at), as well as the movements of the hands and feet to provide real time feedback in the virtual environment when looking at ourselves or interacting with objects.

Interactive objects
Each moveable object with which the visitor can interact in the physical space can be connected with the virtual reality space. To this end, markers are placed on the object to provide information about its absolute and relative movement.

About us

Artanim
Artanim is a non-profit foundation founded in 2011 and located in Geneva. As one of the largest motion capture centers in Switzerland, the foundation is dedicated to the development and promotion of this technology. In particular, the main activity of the foundation is to conduct R&D projects in the field of computer graphics according to two strategic axes of research: virtual reality, mainly the creation and animation of realistic digital avatars and the development of interactive virtual and augmented reality applications; and medical research including joint biomechanics, orthopedics, sports medicine and movement science.

Artanim has a long-term expertise in various motion capture technologies, including high-end optical systems, inertial and markerless motion tracking devices, as well as in 3D scanning solutions to digitize objects or human bodies. More generally, Artanim aims at using motion capture and 3D scanning solutions to facilitate 3D content creation and improve industrial design strategies. One focus of the foundation is to conceive innovative interactive applications using human motion as a medium or controller to derive immersive user experience.

Artanim participated to several R&D projects developed in partnership with universities and with the industry (national projects funded by the Swiss confederation, public and private funds).

Artanim Interactive
Artanim Interactive is the spin-off of the Artanim Foundation. One of the goals of Artanim Interactive is to make Artanim Foundation's research available to users across the world by creating and distributing innovative products and services. In addition, Artanim Interactive develops interactive installations, multimedia events and custom-made products combining motion capture technology, 3D visualizations and context responsive sound designs.

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