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USER INTERFACE IN INTERACTIVE VIRTUAL ENVIRONMENT BASED ON REAL LOCATION

Abstract
Nowadays we see an increase of interest in immersive technologies connected with new modes of communication. With novel devices possibilities open for research in the field of Human-Computer Interfaces (HCI) and Virtual Reality (VR). This project is focused on the creation of interactive virtual reality scenery and on the verification of usefulness of different interfaces in such contexts. We designed a virtual urban space that is accessible to users through VR goggles: Oculus Rift paired with Leap Motion. We prepared an experiment to test how well users can interact in proposed virtual environment through this setup. Results show that in simple tasks users can quickly learn on their own how to use given interface without tutoring.

Key words
human-computer interaction, virtual reality, interface, three-dimensional imaging, Leap Motion, Oculus Rift.

Introduction

Virtual reality is a concept that is getting more and more traction. The idea itself, however, is nothing new. For hundreds of years, humanity questioned reality in various ways. Philosophers and even physicists have tried and are constantly struggling to answer how one can distinguish whether reality or a simulation was witnessed. Meanwhile, computer scientists are developing better methods to fool our perception and to immerse users into virtual worlds. Such attempts are getting more and more traction with the help of new devices and approaches to alter the way users perceive and possibly interact in virtual environments. [1]

Examples of such endeavors are easily seen in technology standing behind Leap Motion [2] and Oculus Rift [3]. Those devices allow the user to experience simulated reality. Both are accessible for domestic purposes in activities such as computer games. Other novel solutions worth mentioning are Virtuix Omni [4], which lets the user realistically stride through a virtual environment. CAVE (Cave Automatic Virtual Environment — vide [5]) setups freeing the user from equipment other than simple VR glasses and input devices are also often utilized in visualization within the field of virtual reality. Another interesting approach is the use of force feedback driven devices. Those tools allow the user to feel the hardness of virtual object and to assess its shape and weight. It is possible through various means for example, for a user to wear a special glove which not only tracks gestures of wearer but restricts movement when user touches virtual object. Naturally, depending on the relative position of a virtual object and glove-device. Obviously, those are just examples of constantly developing market solutions joined in one goal: making virtual reality immersive for users to fulfill particular tasks [6].

Among the uses of those devices and computer programs connected with them one can find not only computer games but also industrial applications. A designer with a tool allowing him to walk beside his future creation can spot features to improve that hardly would have been obvious to him in such a fashion without virtual reality solutions [7]. Workflow of fast prototypes can be further simplified with prototyping of virtual objects [8].

Human-Computer Interaction (HCI) is area of research avidly interested in mechanisms used and developed for the purpose of virtual reality (VR). Deciding which solution is better for an assigned task demands assessment of multiple mechanisms and development of common measures. Obviously, if computer simulation can mimic the real world for a human, that means that the interaction between user and computer is seamless. However, it is not necessarily the aim of user of the application. For the time being, a common obstacle in VR projects which keeps players from delving into an artificial environment is not only the lack of an intuitive interface, but also the need for better data visualization. While there are solutions to those problems, developing new ones and researching which are more suitable to a particular task is important. In such broadly defined areas HCI research can help VR based projects in reaching some of their goals [9].

Goals and method

This paper presents the achievements of our project. The fulfilled goals of this project and contributions were defined as follows:

- Construct a virtual environment based on real location for the user to investigate,
- Create a scenario for the user to take part in,
- Set up a user interface with paired devices: Leap Motion and Oculus Rift,
- Test how well a user can interact with given scenario and interface.

To fulfill the goals, we prepared an interactive application. Users can experience virtual environment through paired Leap Motion controller and Oculus Rift goggles. This setup is a popular approach [10]. In this application, the user is placed in a virtual environment and faces the task of painting the surrounding objects. In the course of the interaction the user is meant to discover that it can be done through hand movements.

Tab. 1. Goals and corresponding technology used.

Goals	**Technology**
Virtual Environment creation	3DS Max Studio, Unity 3D Game Engine
User Interface Hardware	Leap Motion, Oculus Rift
User Interface Software, tests	Unity 3D Game Engine

Source: Author's

The virtual environment was based on "Off Piotrkowska" restaurant area, which is, recognizable place in Lodz, Poland. It is an architecture piece with industrial character, currently with restaurants around and similar meeting places. The user is standing in the heart of the object, so he can freely look around the buildings in a 360 degrees fashion. Thanks to such localization, we are able to create the feeling of familiarity in the viewer and ensure that there are interesting objects in the scene. We made movement unavailable, but the application tracks hand and head movements. The former allows us to recognize gestures with which users can paint the environment. Head traction enables looking around in a natural manner.

Photographs taken by the authors are the base and inspiration to create 3D models (Fig. 1 and 2). We modeled buildings as well as detailed elements like windows, street lamps, chairs and tables. The realism of the models was kept in terms of proportions and overall likeness to the real object. At the same time models were prepared to be used in real-time experiences which means relatively low count of polygons. The quality of our work can be categorized as a low poly because of this. It is a rather common, standard approach in the area of real-time applications [11]. Models were created within a 3DS Max application [12] and later moved to a Unity 3D Game Engine [13] where we set up the scene. The virtual environment is utilizing only basic, mono-color textures to allow the user to see the effect of his actions easily and to encourage him to paint. Details of the surroundings were exposed through lightning, which itself is not bright enough to distract the user but makes object recognition easy. (Fig. 1, Fig. 2).

Fig. 1. Real picture of location used and render of modeled location
Source: Author's

Fig. 2. Details of environment.
Source: Author's

Scenario, and the whole interaction were developed within the Unity game engine. The use of an existing game engine allowed us to focus on designing the experience and is sufficiently robust and open to further alterations. Suitably, it has the official support for Leap Motion and Oculus Rift. However, since we utilized the DK2 version of Rift (development kit 2), not everything was out-of-the-box and some work was required to assure that both devices are working together properly. The effect of paint was achieved with particle effects. Emitters were set to trigger paint emissions when a swipe gesture is recognized with the Leap Motion controller. The generated particle colors were randomized to make the whole experience more interesting. "Paint" stuck to the surface of our models on touch and was affected by gravity. This idea for the scenario is based on the thought that among the basic needs common to humans is the need to create, alter the surroundings. Changing the color of the environment through movement is easily recognizable. We believe that users will easily link those in cause-effect chains, which should result in further acceptance of the presented virtual environment. To assure that user is undistracted and focused on his surrounding and task given no Head-Up Display (HUD) was used. That means that interface consisted of modeled world, paint (visible after proper gesture is executed), hands models, and input devices.

Leap Motion device is a controller utilizing IR cameras to track users hands in a hemisphere of 1 meter radius. It is possible to record with a frequency of 200 frames per second with a precision of up to 1 mm. Thanks to two cameras recording 2D images, the firmware generates a 3D view of the hands' movement. We implemented a simple gesture recognition based on swipes and their direction. Our application recognized the directions of user gestures and simulated paint being thrown in the same direction. After tests, we find out that a sufficient solution is to use 9 basic directions as presented in the attached table (Tab. 1). This solution proved to seem natural and it did not cause errors or delays. Unfortunately, bigger resolution was problematic because the Leap Motion gesture detection, which tended to ignore the swipe altogether if the required precision of the direction was not assured. Some research was made with the use of a Leap Motion controller and different solutions are already known to bolster the possibilities of this device [14]. Our aim in this experiment was to use a simple solution to not only lower the expected time of training of a new user but also to keep our solution open for future improvements. Leap Motion controller was used because of its simplicity of use and because it can be easily paired with Oculus Rift through Unity game engine.

Oculus Rift is virtual reality headset. In the project, we used a DK2 model. It has a stereoscopic OLED display, 960×1080 per eye resolution, a 90 Hz refresh rate, and 110° field of view with rotational and positional tracking. We used Oculus Rift among set of similar displays because it is one of the first such tools available for day to day use. Thanks to pairing with Leap Motion, we rendered through Oculus a view of hand movement to mirror user gestures. Rotational and positional tracking allowed the user to look around. This device is often used in research dealing with virtual reality. The difference between the Leap Motion controller and other movement-based controllers, or even a traditional mouse, is mainly based on giving the user more freedom; it does not affect onlookers. Sole use of the head-mounted display (HMD) already changes the reception of the experience [15]. Traditionally, a third-person not involved in the application usage is able to easily track the actions of the user. Here it is not that simple because the main screen is visible only to one person. Furthermore, in traditional screens the user can easily look away from the application and communicate with those not involved. While wearing VR goggles it is not that easy and this isolation of the user from real-world can be further reinforced through use of headphones.

Test basis was to introduce the user into a virtual environment with Oculus Rift and a head-mounted Leap Motion. Leap Motion tracked hand gestures and overall hand positioning, while Rift defined user's view perspective. The users were presented with a virtual environment in which they need to color. We supervised the tests and measured how fast users find out that with hand movements paint-like particles will be emitted in the direction of their movements and how well users utilize that ability (Fig. 3 and Fig. 4). Additionally, we conducted a poll to find out how users assess the solution offered in terms of simplicity of use and feel of control. Simple use meant that the solution is easy to learn, while feel of control meant that the solution is easy to master. The goal was to assess if users felt that the application allowed them to accomplish the task efficiently, without making mistakes. Test users were students: women (2) and men (4), 20-25 years old.

Tests were conducted on Windows 7 operating system with following specification: CPU Intel Core i5, GPU AMD Radeon HD 6850M, RAM 8GB DDR3. The number of individual particles peaked at 10 000 and the application was running smoothly.

Tab. 2. Recognized directions of swipes and directions of emissions.

left-up	up	right-up
left	forward	right
left-down	down	right-down

Source: Author's

Fig. 3. User interacting with environment - painting the location with gestures.
Source: Author's

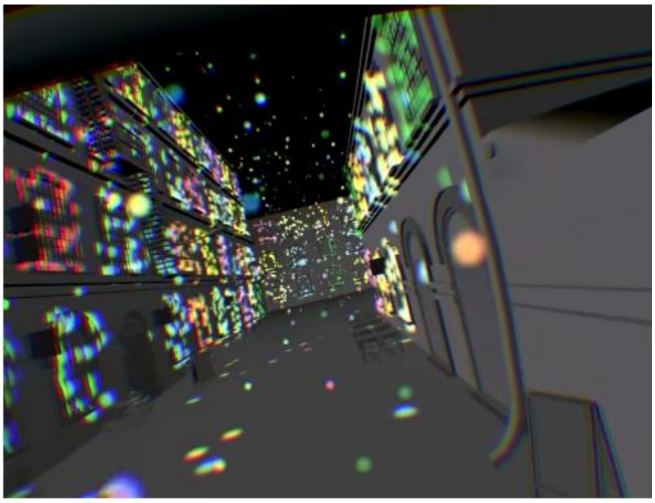

Fig. 4. End of scenario.
Source: Author's

Results

The virtual environment created for the project was real-life location which allowed users to act more natural. The place was chosen to be recognizable as place where one could go and the lack of elaborate textures did not affect this. Moreover, it allowed us to embrace the aesthetic part of the project, and the concept of painting the location was understandable, according to users. All test users knew what does it mean to paint the scene. The scenario ended with an animation of paint being emitted from the windows present in the location, which placed the user in the middle of colorful explosions as a sort of prize for taking part in the test. The whole experience took 5 minutes for each user. There is a video uploaded presenting fragments of recorded tests [16].

Pairing devices ended successfully. Leap Motion was safely attached to Oculus Rift HMD (head mounted display). In the application, hand gestures recognized by Leap Motion were visualized as floating hands which were suitably placed in relation to the camera as the hands of the user were placed in relation to his eyes in the real world. Such placement of cameras allowed the user to operate in a virtual environment in natural fashion, as if seeing his own hands. We managed to avoid any problems with the performance of the test environment, despite it being set up on a standard general-purpose laptop with average computational power. We feel that this alone shows how affordable this technology is and worth further development.

Interaction between the user and environment was immediate. Users saw outright that their hands were visible in virtual reality and started to wave. The first paint emission occurred shortly after, and after a while the user was fully accustomed to the presented user interface. Users had not used such a combination of devices before, which in conclusion implies that the proposed interface was intuitive. All users appeared engaged in the experience for the duration of the test.

While such observations alone convinced us that the chosen setup of gestures is a sufficient mode of interaction for the user in a virtual environment, we also attempted to gather more objective data. During the scenario we measured the time it took for the user to get accustomed to the system. We recorded the time from the start of the application to the first paint emission and until the first controlled paint emission. Naturally, the assessment concerning whether the paint emission is controlled by the user or not is arbitrary. The attached table (Tab. 2) presents the time that passed from the start of the simulation until the first unintended paint emission happened and intended paint emission took place. In same table, we also present the average value and median.

Tab. 3. Time when users accustomed with interface

user Id	**emission [s]**	**intended emission [s]**
user1	5s	7s
user2	3s	7s
user3	5s	10s
user4	4s	9s
user5	7s	12s
user6	6s	9s
average	5s	9s
median	5s	9s

Source: Author's

Additionally, a simple poll was conducted among users who took part in the experiment. The questionnaire has two questions:

- How do you assess the simplicity of learning how to paint?
- How much control over mechanism did you feel?

For each of the questions there was a numerical scale from 1 (the lowest score) to 5 (the highest score). The responses of the users are presented in table below (Tab. 3).

Tab. 4. Poll results

User Id	Question 1	Question 2
user 1	5	5
user 2	5	5
user 3	4	4
user 4	5	5
user 5	4	4
user 6	4	4
average	4,5	4,5
median	4,5	4,5

Source: Author's

Discussion

The test results are satisfactory to us. We see clearly that the proposed approach is well-received by the users. Table 2 shows that despite a big variance, the average and median results are similar to what was expected. It is natural that it takes some time for a user to become accustomed to the given tool set. The most positive conclusion from this small sample is that all users were able to properly use the interface.

Table 3 provides the users' opinion about their experiences. The responses clearly show that the application is well-received and that such a solution is both easy enough and error-proof enough in the minds of the users. Again, the most exciting part of the questionnaire results is that even though the users had experience with traditional interfaces like a mouse and keyboard, they still assessed our solution as giving them the feel of control.

The results show that the time to learn a new interface depends on the user. Even in such natural scenario, reaction times between users varied greatly. This suggests that in further research, one should gather more users for tests and new scenarios should be more rigorous and elaborate to enforce greater discipline with respect to time.

Though solutions using similar technology were developed before as in [17] or [18], we created a scenario utilizing both devices to allow the user to interact in a virtual environment based on a real location. We believe that such an endeavor has rich potential for further research as well. As discussed in [6] and [9], areas of HCI and VR are increasingly rich in opportunities to incorporate novel, commercial devices. This massed movement is in need of tested solutions to allow users to immerse in virtual reality. Further research in this area can lead to better understanding of factors influencing learning augmented with virtual environments which is interesting field for VR what was proved in [19].

The use of not only Leap Motion but also Oculus Rift as devices used for the user interface is an interesting and popular approach. For future research, it would be interesting to utilize other devices to track user movement and to compare them.

Conclusions

In sum, the conclusions coming from discussion of results and the plans for future experiments are as follows:

- Increase the pool of test users.
- Develop more complex tasks.

- Involve actions demanding more precision.
- Conduct the same tests with the use of traditional user interfaces.
- Explore other ways of evaluating virtual reality user interfaces [20].
- Compare solutions based on those devices with different ones.
- Develop and compare different ways of interaction with the use of the same device in the same scenario.

We assess the obtained results as a sign of success. Rapid development of this branch of HCI and VR and these initial steps encourage us to delve deeper into the field and broaden the scope of research. We see potential in developing new, natural ways of interaction with the use of existing and new devices. Immediate plans for the next steps are to enhance application, possibly including more complicated tasks that depend on accuracy and timing and test more users in new scenarios. Enthusiasm of the test users and the specific nature of available devices offers great opportunity for research but also can cause problems. Most probably, the majority of available test users will not be accustomed to new devices. Even though test results from such users can be interesting and can put the usefulness of certain solutions in a new perspective, they are also likely to be inconsistent. Some users will be fast learners, and some might grasp the new solution in a longer time span. However, it can be hard to distinguish whether the delay will be caused by the personal characteristics of the user or due to the peculiarity of the virtual environment that distracts them. Our project and this article show that the field of virtual reality still offers rich material for further research.

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