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PERSPECTIVES AND CHALLENGES OF DISTRIBUTED VIRTUAL ENVIRONMENTS IN E-LEARNING

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Abstract *Developments in Information and Communication Technologies (ICT) have had great impact on higher education,* particularly *in new forms of distant learning. With ever increasing Internet connection speed and mobile broadband, multi-media content can be transmitted in real-time and with little delay. Consequently, E-learning systems have become more accessible for synchronous communication and collaboration.* Nevertheless, problems continue to emerge, most notably in terms of user isolation. *Strong potential in overcoming such problems can be seen in distributed virtual environments. Virtual reality (VR) systems and Virtual chat applications allow users to meet up in multi-user virtual environments and engage in real-time lectures or e-learning games. This paper presents our proposals for reconstruction and extension of the VR Social Environment "Tribes" for educational purposes, considering new interaction models from both technology and user-centered perspectives.*

Keywords: *virtual reality, usability, interactive learning environments, computer mediated communication*

1. INTRODUCTION

In this paper we will explore possible use of Virtual reality (VR) technology as a medium of human communication and how it could be used to support the existing e-learning platform of Belgrade Metropolitan University (BMU).

BMU has an e-learning system that supports chat, forums and Q&A, but nevertheless, online students still feel isolated as they don't have many options to meet each other. Most of the time they communicate with their lecturer via e-mail or schedule a *Skype* meeting one-on-one. Sometimes, they might meet their fellow colleagues on forums and discussion boards, but these forms are not encouraging them to build an online community. This is why we wanted to explore possibilities that offer commercial VR headsets and applications for smartphones. We wanted to see if they could be used in communication between students and lecturers and among themselves.
In cooperation with Belgrade based company *Digital Mind*, we have developed a use case scenario for the VR Social Environment, based on their VR mobile application named *Tribes* (working title). For the user interface (UI) model we used the existing sociable VR application *V-time*, property of *vTime Holdings Limited*.

The idea was to use a VR environment for group meetings in order to reduce feelings of isolation for distant learners, and also to engage them to build an online community and help lecturers use their time more efficiently.

2. VR TECHNOLOGY

3D VR Environments have existed for some time. Ivan Sutherland implemented the first VR system in 1968, using wire-frame graphics and a head-mounted display (HMD) [1]. Since then, various VR systems have been implemented and are widely used in military, engineering, trainings, flight simulations etc. Only recently have VR systems become commercially accessible.

In 2015, several companies announced mass production of affordable VR headsets (also called Head Mounted Displays – HMD), display devices, which are worn on the head with a display optic in front of the eyes. The most popular among them were the *HTC Vive* with optional hand controllers and Oculus Rift. These devices require support of computers with powerful processors and graphic cards in order to render immersive 3D graphics and 360 degree videos, while simultaneously tracking the motion of the user. During the same year, we were introduced to even more affordable mobile VR headsets - Samsung Gear VR and Google Cardboard viewer that can be combined with compatible smartphone devices.

These two headsets are not compatible, and applications must be developed separately. Google Cardboard is the most affordable simple VR viewer, and is made of cardboard with lenses that can be assembled from low-cost components using specifications published by Google. Alternatively, it can be purchased pre-manufactured.

3. KEY FEATURES OF VR ENVIRONMENTS

In terms of functionality, virtual reality can be defined as a simulation in which computer graphics are used to create a realistic-looking world that responds to the user's input in real-time, modifying the virtual world instantaneously [2]. This definition recognizes real-time interactivity as the key feature of VR environments.

In [3] were presented four key elements of VR: (1) physical and (2) mental immersion, (3) sensory feedback and (4) interactivity. The concept of *physical and mental immersion* can be also expressed through the term *sense of presence – the sensation of being in an environment. Sensory feedback* is based on the physical position of participants. Typical VR systems track the movement of the participant's head, along with an object held by hand. There are many VR technologies for tracking movement. The fourth element -*interactivity* -also appears in several forms: one of them is the ability to affect a computer-based world (for example in *Dungeon*, a classic text-based massive multiplayer online role playing game (MMORPG) worlds were rendered via text description typed by players, and computer graphics were not required). Another form of interactivity is the ability to change one's viewpoint and move physically within the virtual world.

Collaborative environment

The collaborative environment is an extension of the interactive element and refers to multiple users interacting in the same virtual space or simulation, and can be referred to as multi-presence or multi-participant [3].
One of the earliest online social networks, *Second Life* (launched by Linden Lab in 2003.) is a 3D virtual world where users interact via avatars (their virtual representations). They meet other residents, socialize, participate in individual and group activities, build, create, shop and trade virtual property and services with one another using virtual currency known as the Linden dollar (that can be exchanged for real currency). In [4] virtual words are defined as a combination of these elements: 1. synchrony: collaborative activities need synchronous communication, 2. persistence: a virtual world does not cease to function when users log off, 3. networked people: users interact with one another and/or with the environment, 4. avatar representation: any action taken by the user is actually presented as an action taken by the avatar, that is to say her/his digital representation, 5. networked computers: the required technical infrastructure.
Film Director Peter Greenaway gave a speech in *Second Life o*n September 23, 2010, at the opening of the 48HFP Machinima film festival. He was represented by his 3D avatar. At the end of his talk, there was room for some Q & A for the audience [5].
In *Second Life*, users see their avatars as a second person and they use a desktop interface. With VR headsets, users can have a camera point of view – a first person view, as if they were in the head of their avatar. Sometimes they can see their hands, if the motion tracking is provided by additional controllers or other tracking technology.

Image 1: Peter Greenaway's avatar gives a lecture in Second Life

4. SUPPORTING HUMAN COMMUNICATION

In Computer Mediated Communication (CMC) we distinguish synchronous and asynchronous communication, where synchronous is live and uninterrupted (audio, video chat, instant messaging, chat rooms), and in asynchronous, response time varies (e-mails, sms, weblogs). Some of the forms are more or less persistent since not all messages are logged, and we lose all the content when the dialog box is closed (for example, video chats are not logged in most applications).

A very important issue in CMC is the non-verbal part of human communication. Many CMC applications widely support the use of emoticons as a new means of online social communications. There are also technological challenges in CMC since the access to technology-based resources necessary for participating may be a challenge for some users. That is why it is necessary to prepare participants for CMC events via virtual tours and tutorials about technology and interfaces that will be used. They must be prepared for what they will experience in CMC. Misconceptions may result in participants falling behind and never recovering [6].

The main idea and the purpose of implementing the mobile VR application in the BMU online learning system is to facilitate group meetings (consultations) between online students and lecturers within VR environments on a weekly basis. Students would be able to present their work in a VR environment, ask questions and discuss certain topics with their lecturers and colleagues. These VR meetings would eventually reduce the number of one-on-one Skype meetings that students have with lecturers, and they would also reduce the number of e-mails that lecturers exchange with online students.

Conclusively, the goal of the VR app is to enhance communication between distant learners and to reduce their sense of isolation. This application is not aiming to introduce new forms of learning materials.

5. GATHERING REQUIREMENTS

There are several requirements we had to gather: requirements of the end users – students and lecturers and system requirements of the institution, BMU.

The application *Tribes* is meant to be an open social VR network, rendered using the VR Unity engine. Custom tailored solutions for business and education would also be available. In order to gather requirements for the implementation of *Tribes* in the BMU communication and learning system, we conducted user testing on existing VR chat apps. Participants were introduced to VR mobile technology in the laboratory, i.e. in the production studio, *Digital Mind (DM)*. The participants were six students and four lecturers.

In our research we used a Samsung Gear VR with a powerful smartphone - the Samsung Galaxy S7 Edge. The Samsung Gear VR headset includes a touchpad and back button on the side, a proximity sensor to detect when the headset is on, and an accelerometer and gyroscope to detect when users tilt or move their head. User interface is controlled by eye gaze, tapping and swiping on the touchpad or with additional controllers that can be connected via bluetooth. When using the headset it is favorable to stand up or use a swivel chair for a better 360 degree experience. Users also had earphones with microphones for verbal communication inside the VR chat rooms. We tested the VR chat applications *Vtime* and *AltSpace*, but ultimately decided to use Vtime as our UI model. These VR apps provide options to upload pictures, play videos or 360° images that can be displayed and shared with other participants.

Competencies of students and lecturers: Only a few students had prior experience in using this technology, but it was used for entertainment purposes - they played computer games and watched 360-video demonstrations. Other users had no prior experience in using VR technology. All users were introduced to the technology by a demonstrator, and they were encouraged to try the virtual tour of the Samsung VR Gear to learn how to navigate thorough VR space. After the presentation they got their task list.

Their task list was: to start the application on the smartphone, to attach the smartphone to the headset, to put on earphones, to enter the chat application, to create an account, to confirm an email (on the/their desktop or other mobile device with web access), to put the headset back on, to log in, create a username, to choose or create a custom avatar, enter a chat-room and participate in a conversation.

Students handled technology much easier and completed their tasks with more success. Everybody had difficulty with registration since eye gaze and the touch pad on the side of headset are not designed for typing on a keyboard (users had to type in an e-mail address and their name in 3 input fields). That means that the GUI has to be simple and easy to use. Using a virtual keyboard for typing in this environment should be avoided or reduced to a minimum. Participants also found it useful to have web support of the app on the/their desktop (or other mobile device) so that they can check their status and profile online, after they finish the chat session, or before they put the headset on, as it is provided by *Vtime* chat on the web address vtime.net.

One of the four lecturers that participated in testing apps didn't feel comfortable with this technology and had a very negative attitude towards VR technology in general. Most of the participants felt uncomfortable speaking first in the chat-rooms and they needed encouragement to use the microphone and speak. It was very important for them to find the person (avatar) who would explain how things work once they were inside the VR environment. Furthermore, *Vtime* is public space, so they never knew who they would meet in the room. That resulted in additional fear and anxiety.

We believed that this anxiety would be reduced if they knew that the application is dedicated and tailored for their University. In the interviews after their first VR chat experience, they confirmed that they would feel more comfortable speaking in their mother language and if they knew that all users were part of the BMU community.

The concept and architecture of the application *Tribes* would be similar to *Vtime*. It would combine a desktop web application with a mobile VR application. The desktop application would also provide asynchronous CMC via message boards, so that users could discuss certain topics, upload media and send invites and messages to users on their list in order to schedule their meetings in a/the VR environment.

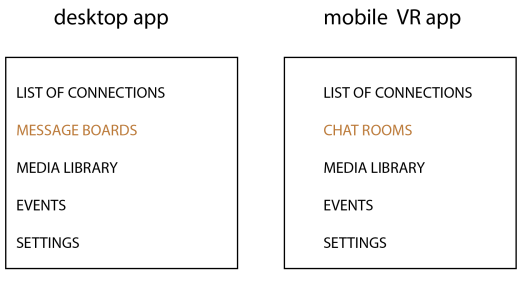

Image 2: Content proposal for the VR application

Security and media requirements

In order to implement the *Tribes* app in the BMU system, we had to collect more specific requirements. The first issue was concerning secure access to the mobile VR app. BMU has a database of students so that all login data could be automatically generated and sent to users via e-

mail. Users would be advised to change their passwords upon logging in.

In VR, users are represented by avatars which are usually custom built. In the BMU VR app, we should have avatars which look similar to the real people they represent – both lecturers and learners. This could be communicated as a recommendation for users in the tutorial. All users have their names floating above their head when they enter the VR chat-room.
The second issue concerns media sharing. When in chat rooms, students and lecturers should be able to share and present media files – such as images, presentations, videos, and PDF files. When wearing a headset, participants can't concentrate on text and reading, so the media should be more visually oriented.

Image 3: Avatars sharing media files in in the *Vtime*

Uploading images and media should be possible through a mobile device connected to a headset, but also via the desktop web app. Every user would have a unique media library that could be accessed from both platforms.

While testing the *Vtime app*, most participatns successfully performed the task of uploading and sharing media.

There are also issues concerning client-server architecture. Most Distributed Virtual Environments (DVEs) broadly deployed today are online games with significant scalability limitations. For example, first person shooters are typically limited to between 8 and 16 mutually interacting players. MMORPGs blur this line, as *World of Warcraft* allows thousands of active avatars to share the same server, but in practice no more than a few hundred can gather within mutual interaction distance of each other without causing performance problems, or even crashing the server [7]. These desktop applications and mobile devices have additional issues due to wi-fi connectability. The servers are responsible for connecting users to the environment and keeping all users updated about any changes that occur [8]. In order to provide functional communication and smooth rendering of multimedia in a VR environment, chat rooms would be limited to 4-5 participants.

6. USE CASE SCENARIOS

Scenario 1, Student - First time log in
The student gets instructions and login parameters via e-mail. The student installs the application on his/her mobile device and connects it to the VR headset. Student logs in and watches the application tutorial. The student creates his/her avatar and goes to the display board to see who is online. The student clicks on the online connection and asks permission to join the chat room or invites other users to his/her room. When in the room, the student can start a verbal conversation with other participants, upload or share media.

Scenario 2, Lecturer- Experienced user
The lecturer gets a request via e-mail to schedule an online meeting in the VR chat-room. The lecturer logs in to the web application to set the time for the event. Students get a notification about the meeting time. The lecturer activates the mobile app and puts the headset on. He/She invites students or gets requests from students to join the chat room (maximum four students). They start conversation, upload and share media. When the meeting is over, the lecturer logs out. In this formal conversation, it is important to follow the communication conventions such as not to interrupt someone when they speak.

These two scenarios revealed to us that we should distinguish between student - user and lecturer-user, both within graphics and sets of permissions.

7. CONCLUSION

Although mobile VR headsets have become increasingly affordable, they are still not widely used and people should adjust to the idea of introducing VR environments in higher education institutions.

In this research, we gathered requirements for implementation of a VR chat application in the BMU learning system. Based on the literature review and laboratory tests that we conducted with target users, we concluded that participants need to be well prepared for the technology and interface they will be using. In order to achieve a satifying security level and better user experience, VR applications should be connected with the BMU database of students and lecturers. Before creating server architecture and continuing with futher implementation in BMU system architecture, we will test the beta version of *Tribes* chat and measure its usability effects. Acquiring VR equipment still requires serious investments both for the institution and its students, so we must be sure that the application will be efficient and effective.

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