Virtual Reality in On-line Education

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Abstract - **This document discusses on implementation of modern techniques in education field. It includes description of several methods and principles such as gamification, student oriented model or using virtual, augmented and mixed reality, which have been scientifically proven to be very effective way how to increase students 'motivation. All of them are explained further. Significant part of this thesis is also designing VR game which implements most of the mentioned principles. This game is intended to help university and high school students with learning basic network subnetting. It consists of 3 main parts – learning mode, game mode and quiz mode. (*Abstract*)**

Keywords – E–Learning; Gamification; Virtual eality; Subnetting; Networking

I. INTRODUCTION

Recently it has become more and more important to place emphasis on young people s education. Comparing the current situation to the past, we can observe significant change in young people s attitude towards studying / learning. There may be several causes of this change, one of the most probable is the fact that modern age offers many means of distraction such as television, PC games, serials and movies. People, especially students, tend to waste most of their free time doing these activities instead of studying.

This document discusses on implementation of modern techniques in education field. It includes description of several methods and principles such as gamification, student oriented model or using virtual, augmented and mixed reality, which have been proofed to be very effective way how to increase motivation in the education field. All of them are explained further

Significant part of this document is also designing VR game which implements most of the mentioned principles. This game is intended to help university and high school students with learning basic network subnetting. It consists of 3 main parts – learning mode, game mode and quiz mode.

II. VIRTUAL, AUGMENTED AND MIXED REALITY

The first milestone on the long way to invention of virtual reality technology could be Charles Wheatson's invention of stereoscope in 1838 [1]. The invention is based on Wheatstone's research which demonstrated that brain processes two different 2D images (one for every eye) to one 3D image. Viewing these two images using stereoscope can create in user's perception illusion of depth. This principle is used in current virtual reality devices.

Virtual reality definition: Virtual reality is technology which has been invented and designed to simulate 3D illusion of real or fictional world. For simulating VR, it is usually used head mounted display or HMD. Using this device user can see simulated 3D environment usually displayed on stereoscopic display. The movement of the HMD is tracked in order to make sure that when user moves his head the view of scene changes as well.

In 1960 Morton Heilig invented first prototype of Head Mounted Display or HMD called "Stereoscopic-Television Apparatus For Individual Use"[2]. His patent besides 3D image includes also stereo sound, however this device did not provide any tracking of head movement.

The tracking of head movement was accomplished one year later by two engineers from Philco Corpration when they invented Headsight. This device was not portable, it was installed in the building and did not include any interactivity because it was used exclusively for military purposes. The military used this device for remote watching of very dangerous war situations.

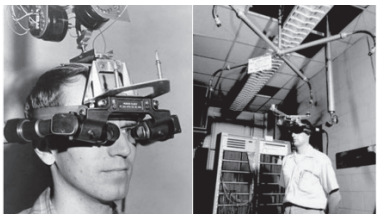

Figure 1. Headsight device

A. Virtual Reality

As per [3] there exist 2 basic hardware VR platform types:

1) Consumer Head-Mounted Displays

Using mobile systems, the HMD is connected to the computer or laptop by cable. The package usually also contains one or two wireless controllers. Benefits of this type of system are high resolution, high frame rate, attractive environments, and support for many options for interaction. Despite all of the advantages, these systems are less accessible than mobile virtual reality systems largely because they require significant computational power, are tethered to limited area, and are more expensive. Nowadays there are 3 biggest manufacturers of these devices: Oculus Rift, HTC Vive, Sony PlayStation VR.

2) Mobile Systems

The mobile virtual reality systems use an individual's smartphone to provide a display and the basic sensor suite for tracking head orientation. Advantages of this type of systems are their relatively low price and the fact that they are portable and wireless and user does not need computer or laptop with several requirements such as significant computational power.

	Oculus Rift	**HTC Vive**
Display	OLED	OLED
Resolution	2160 x 1200	2160 x 1200
Refresh Rate	90Hz	90Hz
Platform	Oculus Home	SteamVR, VivePort
Field of view	110 degrees	110 degrees
Tracking area	5 x 5 feet (two sensors), 8 x 8 feet (three)	15 x 15 feet
Built-in audio	Yes	Yes
Built-in mic	Yes	Yes
Controller	Oculus Touch, Xbox One controller	Vive controller, any PC compatible gamepad
Sensors	Accelerometer, gyroscope, magnetometer, Constellation tracking camera.	Accelerometer, gyroscope, Lighthouse laser tracking system, front-facing camera
Connections	HDMI, USB 2.0, USB 3.0	HDMI, USB 2.0, USB 3.0
Requirements	NVIDIA GeForce GTX 960 / AMD Radeon RX 470 or greater Intel Core i3-6100 / AMD FX4350 or greater 8GB+ RAM Compatible HDMI 1.3 video output 2x USB 3.0 ports Windows 7 SP1 or newer	NVIDIA GeForce GTX 970 /AMD Radeon RX 480 equivalent or greater Intel Core i5-4590 equivalent or greater 4GB+ of RAM Compatible HDMI 1.3 video output 1x USB 2.0 port Windows 7 SP1 or greater

TABLE I. Comparison of Oculus Rift and HTC Vive [4]

B. Augmented Reality

1) Optical see-through HMD [5]

Optical see-through HMDs work on the principle of placing optical combiners in front of user's eyes. These combines are partially transmissive which allows user to look directly through it and see real world and partially reflective which allows user to see virtual image reflected from the combiners as well. These combiners reduce light coming from the rea world.

It is not easy task to design the optimal level coming from real and virtual world. Advanced combiners determine this level depending on light wavelengths.

2) Video see-through HMD[5]

This system works on principle of combination of HMD and one or two cameras, which provide image of user's perception of real world. This image is combined with image created by scene generator. There are several techniques to combine virtual and real content. One of the oldest methods is chrome keying – setting background of graphic images to some color, such as green, which is not used by any other virtual object. Then all the green parts are replaced by real world image. More sophisticated solution is using depth information. If the system has the pixel depth information it can combines real and virtual images by comparing depth of the pixels. This system allows to cover real object by virtual ones or vice versa.

As per [6] there are 4 types of AR:

1) Marker-based AR

uses image recognition, it requires special sign or QR code in real world, which. After scanning it by camera the system recognizes and load 3D model it is associated with.

2) Markerless AR

A.k.a. location-based, or position-based augmented reality, that utilizes a GPS, a compass, a gyroscope and an accelerometer to provide data based on user's location. This data then determines what AR content you find or get in a certain area. With availability of smartphones this type of AR typically produces maps and directions, nearby businesses info. Applications include events and information, business ads pop-ups, navigation support.

3) Projection-based AR.

Projecting synthetic light to physical surfaces, and in some cases allows to interact with it. These are the holograms we have all seen in sci-fi movies like Star Wars. It detects user interaction with a projection by its alterations.

4) Superimposition-based AR.

Replaces the original view with an augmented, fully or partially. Object recognition plays a key role, without it the whole concept is simply impossible. We've all seen the example of superimposed augmented reality in IKEA Catalog app, that allows users to place virtual items of their furniture catalog in their rooms.

C. Mixed Reality

Mixed Reality (MR) environments are defined by Milgram as those in which real world and virtual world objects are presented together on a single display [7] The physical and virtual objects can coexist and interact in real time.

The most famous device for stimulating Mixed Reality is Microsoft Hololens. This device supplied by battery which lasts up to 3 hours of active use and includes multiple sensors such as environment understanding cameras, depth camera,

1 2MP photo / HD video camera, Mixed reality capture, microphones, ambient light sensor. The optics includes see-through holographic lenses (waveguides), 2 HD 16:9 light engines, automatic pupillary distance calibration and provides Holographic Resolution: 2.3M total light points, Holographic Density: >2.5k radiants (light points per radian). The device can be controlled by user in multiple ways such as spatial sound, gaze tracking, gesture input, voice support.

Figure 2. Microsoft Hololens

III. VIRTUAL LABORATORIES

Virtual laboratories allow teachers to educate students virtually and also to practice activities that would be not possible or appropriate to implement to school classroom.

This method also supports learning based on cooperation with classmates while key element of collaboration is social interaction. Students have possibility to communicate and cooperate with class mates virtually. Additionally, virtual environment supports innovative teaching strategies. Students are not limited by learning pace because everyone can determine the pace that fits best for them.

Basic features of virtual laboratory:

- Course outline – brief description of overall structure of the laboratory, explanation of principle and rules of the program
- E-mail –contact on the teacher so in case of need the user can contact him directly
- Conference room – place for discussing several topics, where users can help each other
- Education content – the data for the user to use for learning
- Tasks – teacher publishes here the tasks which should be completed and sent him for evaluation.
- Tests – automated tests as simple way of examining the learned knowledge and skills
- Multimedia resources – large advantage of virtual laboratories is possibility to integrate multimedia features as part of the course
- Place for recording files - students should not be only recipients of learning content, they should also have possibility to create their own materials and files and upload them. Some laboratories offer possibility for users to add their own materials to the program
- Bookmarks
- Search tool

Currently there are many platforms on the world market used by schools or other institutions which allow simple creation of these virtual laboratories such as Learning space, Web Course in a Box, CoMentor, etc.

IV. GAMIFICATION

Gamification could be defined as using game elements and ideas in the context that is different than classic games with objective to increase user s motivation and to effect user s behavior [7] .

There are several features [8] which play key role in gamification process:

- users are all participants – employees or clients (for companies), students (for educational institutions);
- challenges – the point of challenge is to complete some objective
- points – user gets point for fulfilling the objective
- levels – increasing of difficulty level
- badges – another form of reward for completing the objective
- user assessment based on his performance

V. MEASUREMENT OF USER EXOERIENCE

Currently there are many methods how to make learning process more effective. Inevitable feature in the research of these methods and techniques is measurement of user experience. It is important to not only have some feedback from the users but also to measure it with help of devices which can monitor several processes in the human body as reaction to some experience.

We can find one laboratory for measuring user experience in Bratislava, Slovak University of Technology – Faculty of Information and Information Technology, its name is Engelbartovo laboratórium skúmania používateľského zážitku (UX lab). Its main goal is research and verification of conclusions in the field of user experience in web applications, PC, tablets, smartphones and other multimedia interactions.

Laboratory is equipped physiologic sensors such as EEG, temperature, breathing, skin conductance and machines for observing face emotions, eye look, etc.

VI. APPLICATION

Important part of this document is also application which objective is to help university and high school student with learning basic principles of network subnetting. It includes definition of terms such as IPv4 address, IPv6 address, LAN, WAN, classful subnetting, VLSM, subnetting classes, etc.

The application implements several methods and techniques of online learning such as gamification, using virtual reality or using virtual laboratories.

For developing the application, it was used software: game engine UNITY 3D, object oriented programming language C#, software development kit GVR SDK for Unity v1.130.0, programming environment Visual Studio 2017 and hardware: Samsung Gear VR, Samsung S7 Edge. The application consists of 3 main parts:

A. Learning Mode

All of the scenes are marked by certain number of stars depending on how difficult to understand are.

This scene includes basic description of terms:

- IP address -definition, example, network model layers, assignment of IP address
- IPv4 address - format, example, assignment of IPv4 address
- IPv6 address -format, example, assignment of IPv6 address
- Public and private IP address - dfference between them and network ranges
- Classful subnetting - Network mask, principle and explanation of classful subnetting process

- VLSM - Network mask, principle and explanation of classful subnetting process, benefits

B. Game Mode

1) Public or private IP address

A room where there is a strict number of freely moving objects which represent IP addresses. The user is in role of a router, his objective is to determine whether the very IP address is public or private.

In center of the scene user can always see pointer so he can point at objects with IP addresses. His job is to mark it as public with right swipe or as private with left swipe using Samsung Gear VR touchpad.

Besides pointer, there is another always visible object in the scene – router, which shows instructions (if public address, swipe right, if private address – swipe left).

While user is pointing on object, the router shows IP address of the object and after user s swipe the color of the router changes to green or red depending on whether the choice is right or wrong. There are also other effects implemented after the swap: counting points and correct or incorrect sound played. In the scene, there is also always visible how much time is left since the scene is time limited.

Figure 3. Game mode

2) IPv4 types

This scene uses the same principle as the „Public or private IP address "– the objective of this game for user is to identify correctly whether the very IP address is network, host or broadcast.

3) IPv6 address types

This scene uses the same principle as the „Public or private IP address "– the objective of this game for user is to identify correctly whether the very IP address is Global Unicast, Link-local or multicast.

4) VLSM

Term VLSM stands for Variable Length Subnet Mask. The user is this scene is in the position of network administrator. In the scene user can see building which represents company with several departments. The admin has one C class network available and his job is to create smaller subnets for every department out of the C class correctly depending on number hosts in the department.

C. Quiz

This theme includes short quiz to examine obtained knowledge and skills. User gets points and badge as reward.

VII. Conclusion

In this article several methods and techniques of using virtual reality in education field are discussed in order to increase students' motivation. Some of them were also successfully implemented in the application aimed to help students with learning principles of network subnetting.

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