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VIRTUAL AND AUGMENTED REALITY IN A CULTURAL CONTEXT

Abstract. *This paper describes the prototype for an immersive virtual reality application, developed and implemented in cooperation between the Konzerthaus Berlin and the research group INKA. The prototype displays a pre-recorded concert using the Samsung GearVR, enabling its users to freely look around them in 360º.*

Keywords: *Augmented Reality, Virtual Reality, 360º Video, Head Mounted Display, Immersion, Augmentation*

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ВИРТУАЛЬНАЯ И ДОПОЛНЕННАЯ РЕАЛЬНОСТЬ В КУЛЬТУРНОМ КОНТЕКСТЕ

Аннотация. *Описывается прототип приложения виртуальной реальности с эффектом полного погружения, разработанного и внедренного в сотрудничестве между концертным залом Berlin и исследовательской группой INKA. Прототип отображает запись концерта с помощью Samsung GearVR, что дает пользователям возможность наблюдать происходящее в 360º.*

Ключевые слова: *дополненная реальность, виртуальная реальность, 360º видео, шлем виртуальной реальности, погружение, дополнение*

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ВІРТУАЛЬНА І ДОПОВНЕНА РЕАЛЬНІСТЬ В КУЛЬТУРНОМУ КОНТЕКСТІ

Анотація. *Описується прототип додатка віртуальної реальності з ефектом повного занурення, розробленого і впровадженого у співпраці між концертним залом Berlin і дослідницькою групою INKA. Прототип відображає запис концерту з допомогою Samsung GearVR, що дає користувачам можливість спостерігати, що відбувається навколо в 360º.*

Ключові слова: *доповнена реальність, віртуальна реальність, 360º відео, шлем віртуальної реальності, занурення, доповнення*

1. Introduction

Since the first version of the Oculus Rift was successfully crowd funded in 2012 [7] the topic of virtual reality (VR) is suddenly raising a lot of attention, despite not being a new concept. In fact, the first head-mounted display (HMD) comparable to the Oculus Rift was developed as early as 1968 by Ivan Sutherland [10]. However, the huge success of the Oculus Rift might be the cause for the variety of VR-capable HMDs developed by different companies that are being released in the past two years. A side effect of the increasing popularity is the availability of mass-produced, inexpensive VR-devices.

The project presented in this paper was a cooperation between the research group INKA of the University of Applied Sciences Berlin (HTW) and the Konzerthaus Berlin and uses such a consumer-oriented VR-device, namely the Samsung GearVR. It leads to a concept for a virtual experience of the Konzerthaus Berlin from a new perspective enriched with augmented reality approaches.

2. State oft he Art

First developments in the field of virtual and augmented reality (AR) had been mostly driven by military, architecture, industrial or maintenance tasks. Especially the U.S. Air Force, NASA and researchers at the MIT have built the basis for AR and VR in the 70s and 80s of the last century [8]. Heads-up-display (HUD) systems or simulations with HMDs were used in these areas. The first appearance of the concept of augmented reality is attributed to Caudell and Mizell [3] in the early 1990s. The two scientists of the Boing Corporation developed an experimental AR system to help workers put

together wiring harnesses [8].

Particularly in recent years it can be observed that VR and AR applications extend too many other fields. This may be due to the fact that display technologies such as HMDs have changed from professional and very expensive equipment to consumer electronics. Display devices such as the Oculus Rift, the Samsung Gear VR or AR Glasses by the company Epson bring this technology to many areas of life. Also in the cultural sector an increase of AR and VR-based applications can be observed. As described in [6] AR contains potentials for teaching, learning and pleasure in culture and art and can be used in interactive entertainment, interactive story telling, visual art, sound art, interactive opera or digital archives. Using the spatial augmented reality [2], opera visits are unique experiences for visitors. Examples are, for example, Mozart's "Zauberflöte" at the Komische Oper Berlin [1] or the augmentation with live video mapping of a traditional Chinese opera "Havoc the Dragon Place" [5]. With the use of modern AR techniques, visitors can imagine the story. As described in [5], "no translation is needed, and people who don't have any background in Chinese opera can also easily experience the performance".

Another example for the use of AR and VR techniques are museums. These techniques help to convey relationships and knowledge in an easy way. A great example is the Jurascope in the Naturkundemuseum Berlin. The Jurascope of Art + Com [4] shows in a virtual manner the construction of a dinosaur and extends the real existing skeleton of the dinosaur with artificial elements.

3. Application Concept

The concert hall wanted a prototype that would encourage new users to visit their house while also being a new experience for regular visitors to enjoy. The general direction, set in the early stages of the project, was to record a live concert with a spherical 360º camera and present the footage in an HMD as an immersive virtual experience. As the size of the camera used for recording the concert was relatively small, it was placed above the musicians. This granted the benefit that even regular visitors could enjoy the concert from a whole new point of view and added significance to the filming in 360º, as points of interests are located all around the users.

The application was split into two modes, and a menu to select one of them was added. The first of these modes is called "360° Musik", which simply displays the recorded video as an immersive experience. The second mode is called "360° Musik plus" and is meant as an expert mode that contains the augmented information.

The expert mode tries to visualise the different, repeating themes in the symphony as several musicians performs them.

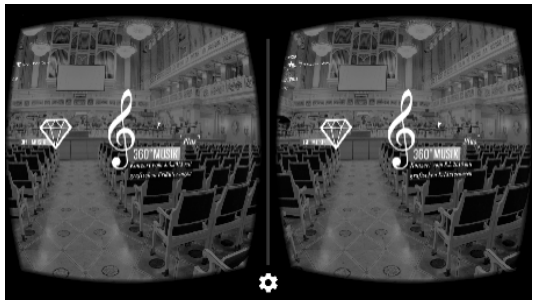

Fig. 1. Concert Hall view with menu on an HMD

This way a user may follow a melody from the lead violin to the violas that follow up one cadence later. These themes are visually represented by small animations that are displayed above the respective musicians in time. Overall four different themes were prepared and visualized throughout the play (see Fig. 2). Besides the two modes described above, a third was planned that would visualise the story, told by the music, in a cartoonish way and was meant to appeal to younger audiences. However, the third mode was discarded due to the limited time available for the project as a prototype had to be finished in time for the opening ceremony for the new season of the concert hall.

Fig. 2. Concert with Augmentation

Finally, a last addition was made to the prototype, which allowed to stream the view of the current user to a standard monitor, as the content experienced through an HMD is only visible to the current user it is ineligible to attract passers-by. This stream was also used during the opening ceremony to present the developed solutions to all guests.

4. Filming and Editorial Process

The filming took place during the Jupiter Symphony by W. A. Mozart on 8th May 2015. To record a spherical video, a special hardware is required. For the recording, the team decided to take the solution from "360 Heros". This device is a rig that creates fully spherical 3D video using 12 GoPro cameras. The sphere is divided into six sectors. Two cameras do create the stereoscopic part of the 360-degree movie record for each of these sectors.

After recording the movies, the individual videos have been reviewed and were stitched with the software Video Stitch Studio V2 to a 360º video.

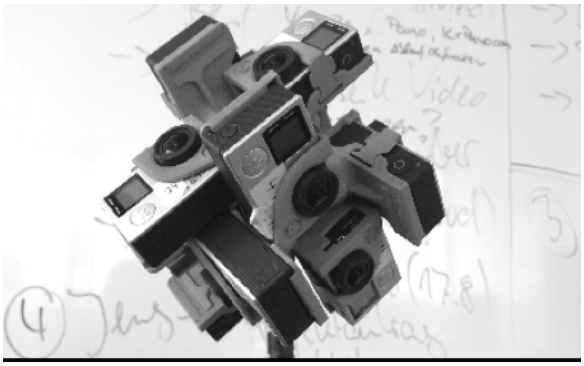

Fig. 3. Rig with mounted GoPros

After the process of stitching, the videos were combined to one Top-and-Bottom video to enable stereoscopic viewing on the VR-device. These videos were compressed in height and arranged one above the other. Because the audio tracks are recorded separately with the standard concert hall equipment, the final video track had to be synchronised with the externally recorded audio track. Finally, some colour and brightness corrections have been made. In order to view the final video with the chosen VR-device, the video was limited to a maximum width of 4096 and a maximum height of 2048 pixels. To achieve an optimum ratio between the file size and the display quality, different bit rates were tested in the compression of the video.

5. Application Development

The project was realised using the Samsung GearVR, which is a not a typical HMD. The GearVR is designed to be accompanied by a Samsung smartphone, which can be mounted in the front of the device. It uses the smartphone's display and computation power to run and visualise its content. To develop applications for the GearVR, different approaches are possible. Besides a software developer kit (SDK) published by Oculus and native Android-based development, the Unreal Engine and Unity include support for VR devices.

The setup of the scene in Unity is user-centric and based on multiple spheres. These spheres are placed around the users point of view and are rendered using a shader that paints their textures on the inside of the spheres instead of their outside. The 3D-scene uses a simple lighting model where textures are rendered unlit. This means they are unaffected by light sources and shadow and are simply rendered in a specific colour which is derived from the respective pixel of the footage of the live concert. As all rendering and other computations are calculated on the smartphone, complex lighting calculations were avoided as they are not necessary. Particularly regarding the video texture, specular lights and shadows are not only unnecessary but also contra-productive. Shadows might imply depth perception in the wrong places as the two dimensional texture is actually representing a three dimensional space.

Another important feature is the ability to stream the current view of the VR application to the additional display, so that passers-by can see what the current user is experiencing. This could be implemented by setting up a video stream that sends the currently rendered content of the smartphone to a second computer. However, this would consume nearly all system resources of the smartphone and would negatively influence the system performance and is not viable for a real-time application. Therefore, we decided to develop another approach.

Instead, the smartphone only transmits the current orientation of the player object in the 3D scene and a signal to start and stop the video synchronously. This orientation is updated whenever the user rotates its head and can be send to a second computer using only a fraction of the computation power and amount of data needed to stream the current view as a video. The second computer has a copy of the smartphone application, modified to be controlled using the networks input instead of a local controller.

6. Webpage

In order to present the project to the public and visitors who are interested in getting an impression of the virtual concert, a

complementing webpage was developed and linked to the Konzerthaus homepage. The responsive single page website is divided in sections and gives an overview of the purpose and usage of the AR-application.

Following a short introduction to the project, the four selected themes of the application's expert mode "360° Musik plus" are explained by their visual and acoustical representation. As described in chapter 3, each animation visualises a different theme of the Jupiter symphony ("Das Motto", "Das Fanal", "Das Tänzerische", "Lyrisch") by using corresponding graphical symbols, which were synchronised with the sound file. Thus, and by a displayed short textual definition, an improved insight into the structure of the composition is provided.

Fig. 4. Visualisation of different themes

In the section "Impressions", there are two types of videos implemented to illustrate the functionality of the AR-application. The first video allows looking in every direction of the 360° Video (3D-scene) and the user is able to view the groups of musicians or the conductor, who are performing the concert. The second video guides through the 3d-scene in a scripted sequence and is specially produced for the website. The line of sight is focused on the relevant area and is supported by the visualised theme symbols as augmentations.

For the implementation of the 360° videos on the stationary website a plugin (Panoplayer) was used. Due to some difficulties playing the video on mobile devices, the final implementation of the 360° video is made with the provided Youtube plugin.

The section "Making Of" contains a slideshow, which illustrates the work process of the 360° video recording and software implementation as well as the physical installation in the Konzerthaus vestibule.

7. Future Work

Regarding the fact that the field of virtual reality in combination with GearVR was a new topic for the research group and the Konzerthaus Berlin, the resulting prototype has to be evaluated as a success. Nevertheless, there are features that could be improved. First of all, the video used currently is monoscopic. The stereoscopic version had to be discarded due to of multiple reasons, which leaves the video texture without actual depth information. Another factor that would greatly enhance the spatial impression of the virtual reality, if implemented correctly, is a three-dimensional sound experience. Currently, the prototype uses a simple stereo sound sample that is rotational invariant. This means that the sound does not change, regardless of the direction the user is facing towards.

Besides these improvements, the concert hall would wish for an implementation for cardboard-based VR. While it is possible to build for these simple VR-mounts that can be equipped with a wide range of smartphones, the high resolution of the video used to texture the inside of the sphere in the virtual reality is hard to handle for slightly older smartphone models. The general computation power needed has to be decreased to enable more smartphones to execute the project.

Finally, the idea of visualising the themes of a performance, as implemented in the expert mode of the project, was received so well that the concert hall is planning to start a new project with the INKA research group that focuses on this visualisation, but instead of displaying them in a pre-recorded concert in a virtual reality it is planned to augment a live concert in the concert hall using techniques from the field of augmented reality.

For more details and results of the projects SIGNAL and IKAROS please refer to [9].

8. Acknowledgement

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