Virtual Reality, Panoramas and 3D in arts, music and consumer electronics – overview and potentials

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ABSTRACT: Ultra High Definition (UHD) TV and Virtual Reality (VR) are currently the hot topics in consumer electronics, after the hype of 3D three years ago. Although UHD and VR are conceptualized for different types of displays, both systems have in common that they are intended to provide an immersive viewing experience, which means that the user should get the feeling to be part of a scene or of an event. In order to achieve this objective, both systems require images of very high resolutions, which are far beyond HDTV. How can arts and culture profit from these innovations? Digitization is the answer to it. Applications range from paintings over sculptures, complete rooms or monuments, which are scanned and of which 3D models are generated, towards immaterial forms of art like dance performances or concerts, which are recorded with cameras of ultra-high resolution. Once the material of all these application is available in digital formats, it can be rendered for different displays and then be visualized on different end devices.

1. INTRODUCTION

In recent years, patterns of media consumption have been changing rapidly. Video material is now viewed on screens ranging in size from an IMAX cinema, through to large domestic projection and flat-panel displays, down to tablet PCs and mobile phones. At the same time the resolution of displays is constantly increasing. Ultra High Definition (UHD) displays in 4k resolution are already state of the art and can be bought at affordable prizes. Even first 8k devices appear on the market and this trend towards higher resolution and quality will continue.

Another significant change in media consumption habits is the level of interactivity that consumers are increasingly expecting. With web-based media it is commonplace to scroll to parts of a web page that are of particular interest, or to use Google Earth to examine a particular part of the world in detail. In a 'first person shooter' computer game, the player can look around in all directions, and expects the soundscape to rotate to match his viewpoint. This level of control has not been possible with traditional video-based media, where the program director has generally determined the view of the scene with which the user is presented.

These general trends are the cradle of the recent hype in Virtual Reality (VR), which has been triggered by the acquisition of Oculus Rift by Facebook and by new VR devices like Gear VR from Samsung and others from Microsoft, Sony, Razer etc. Industry analyst firm CCS Insight has just published a report – Augmented and Virtual Reality Device Forecast, 2015-2019 – stating the amount of AR and VR devices sold will rise from 2.5 million in 2015, to 24 million in 2018 (1). It forecasts that the market will be worth more than $4 billion.

VR systems enable the user to navigate in real or virtual worlds. The dimensions of these worlds may range from 180 degree cylinders up to complete 360 degree spheres.

A number of panorama or spherical cameras are already available. They either combine a number of cameras to scan panoramas or the complete 360 degree surrounding or they use single cameras with wide angle lenses (e.g. fisheye) or curved mirrors (e.g. parabolic front mirror).

On the display side panoramas or 3D spheres may be viewed in special viewing installations such HHI's TiME Lab [1], on special VR devices like Oculus Rift, Gear VR or others or on normal stationary (e.g. TV sets, desktops) or portable (e.g. smart phones, tablets, laptops) end devices.

All this means that a number of new technologies for capturing, processing, storage, transmission and display have been developed or are on the way to be developed.

2. STATE-OF-THE-ART IN IMMERSIVE VIDEO SYSTEMS

The state-of-the-art in ultra-high-resolution video and panoramic imaging has a long tradition [2]. Basically, the creation of immersive experience by panoramic images is an old dream of humankind. Panoramic paintings have been used over the centuries to capture big historical events like battles, coronations or revolutions for ensuing ages. Some Renaissance painters even applied the Camera Obsucra to draw sub-images in right perspective and to compose them to a panoramic painting subsequently – a procedure that is already very close to today's electronic stitching technique of panoramic imaging [3][4]. In the 19th century special buildings or rooms showing panoramic paintings, so-called Cycloramas, designed to provide a viewer standing in the middle of the cylinder with a 360° view of the painting, became very popular [4][5].

First experiments with moving images, often produced by omni-directional cameras and reproduced by multi-projection systems, are known since the beginning of the 20th century and its history is as long as the history of cinema itself. The first installation of an immersive 360° projection was the Cinerama system presented at the legendary Millenium World Exposition, 1900 in Paris [6] (see Figure 1). A first commercial application entered the market with the invention of Cinerama in 1952, one of the wide-screen formats by which cinema reacted to the introduction of television and tried to make cinema more appealing than TV [7].

To provide panoramic viewing and immersive sensation, Cinerama has used a cylindrical screen with a horizontal viewing angle of 128° and an aspect ratio of almost 1:3, three cinema projectors with overlapping images and a surround sound with six channels (see Figure 2). Five persons were needed to operate the system: three projectionists, one sound control engineer and one projection control engineer who took care that the images overlapped seamlessly at the screen.

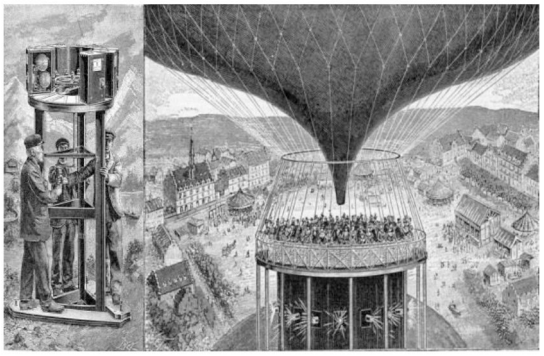

Figure 1: *The Cineorama at Millenium World Exhibition in Paris, 1900.*

When efficient single-projector solutions like Cinemascope squeezed Cinerama from the market again in 1962, immersive multi-projection systems could only survive in niche markets like theme parks (CircaVision, Iwerks 360, etc.). But even there they almost disappeared and were replaced over time by single-projector systems using either special lenses or spherical mirrors. The IMAX technology as one of the most successful ones is the best example for this development.

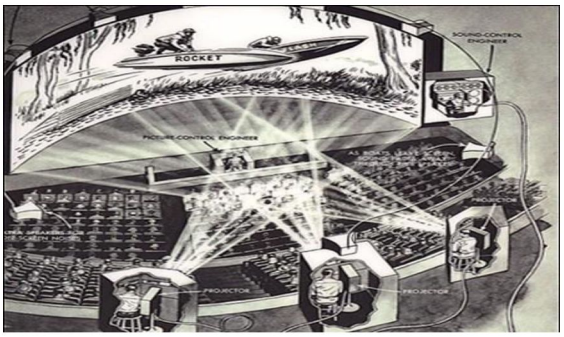

Figure 2: *Cinerama, 1952.*

The advent of Digital Television and Digital Cinema and the related progress that industry made in fields of digital production and reproduction equipment opened new markets for immersive media. In particular, the development of the DVB standard during the 90s as well as the DCI specification of the 2k and 4k standard, partly released in 2006 by SMPTE, has initiated a new era of product developments in the domain of digital cameras and projectors. Similar to 3D cinema, the high quality of these digital devices has evoked a renaissance of panoramic multi-camera and multi-projection systems for immersive media applications. Digital technology allows precise calibration of omni-directional and multi-view cameras, accurate warping and stitching for the

generation of panoramic images, exact juxtaposition and blending of multiple projector images, exact adaptation of video panoramas to arbitrarily curved screens and a distortion-free reproduction with very high resolution, brightness and contrast [8][9][10][11][12].

3. CAMERA SYSTEMS

On the production side a number of new 180 - 360 degree cameras have already been launched or have been announced. They either combine a number of cameras to scan panoramas or the complete 360 degree surrounding or they use single cameras with wide angle lenses (e.g. fisheye) or curved mirrors (e.g. parabolic front mirror). Single cameras are easy to handle, however their resolution is limited which results in rather poor image quality. If more than one camera is used, a number of technical issues occur: The cameras have to be synchronized, parallax errors may occur, different sensitivities of the cameras have to be compensated and the images of the single cameras have to be stitched together. In addition, the resulting video format may become very large, which results in problems for viewing, storage and transmission.

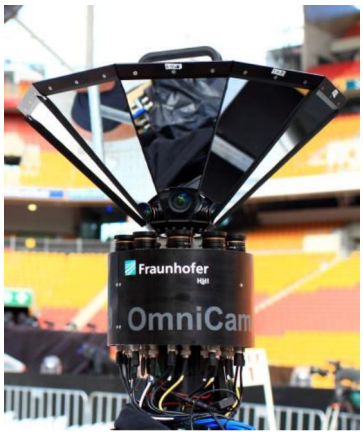

Figure 3: *OmniCam360 developed by Fraunhofer HHI*

Fraunhofer HHI has developed the OmniCam360 system, which uses 10 micro HD cameras, delivering a 360 degree panorama of about 10.000 x 1.920 pixels (Figure 3). It uses a mirror rig, which avoids the above mentioned parallax problems thanks to a special mounting technology. Details can be found in the paper of C. Weißig in these proceedings [13].

4. PRODUCTION EXAMPLES FOR PANORAMA VIDEO

During the last two years, a large number of content has been produced with HHI's OmniCam360. Different genres have been covered such as sport events, classical and pop concerts as well as documentary films. Some of the highlights are:

Sports:

[11] FIFA World Cup Qualification (Cologne)
[12] FIFA World Cup final (Rio de Janeiro)
[13] ESPN X-Games (Munich)

The FIFA World Cup Final in Rio (Figure 4) was surely the most prominent event. Besides the shooting in the stadium some further shootings took place in the Favelas and on the beaches, in order to capture the whole atmosphere in Rio.

Figure 4: *Shooting of FIFA final Germany vs Argentina in Rio*

Pop music:

[14] Counting Crows, UK Tour (London)
[15] Bon Jovi, 'Because We Can' Australian Tour (Brisbane)
[16] Herbert Grönemeyer, 'Dauernd Jetzt' Deutschland Tour (Berlin) (Figure 5)

Classical music:

[17] Berliner Philharmoniker, Anniversary concert "50 years of the Berlin Philharmonie"

[18] Berliner Philharmoniker, on the occasion of the 25th anniversary of the fall of the Berlin Wall
[19] Rundfunkchor Berlin, LOVER, Kraftwerk Berlin

Figure 5: *Shooting of Herbert Grönemeyer, Deutschland Tour at Waldbühne Berlin*

Figure 6: *Shooting of "Falling Walls" concert of Berliner Philharmoniker*

There is a cooperation agreement in place between Fraunhofer HHI and Berliner Philharmoniker and several events have already been recorded. The Falling Walls Concert was the first, where the OmniCam360 was hanging down from the ceiling, approximately two meters above the conductor Sir Simon Rattle and three meters in front of him (Figure 6). This is a unique position, where no spectator can ever sit and watch the concert. This means that this technology can provide a viewing experience, which might even be better than reality.

5. TRANSMISSION OF PANORAMAS

As already mentioned in the introduction, panorama streaming systems allow the transmission of huge video worlds. For fixed installations like the TiME-Lab the video streams can be transmitted over fixed lines and stored in local storage devices. However, when these data are to be viewed on VR glasses or on normal stationary (e.g. TV sets, Desktops) or portable (e.g. smart phones, tablets, laptops) end devices, normal transmission pipes are much too narrow, to stream the complete panorama. Therefore techniques have been developed to transmit only the Region of Interest (RoI), at which the user is currently looking [13](see Figure 7). Depending on the end device, the RoI may be a fixed window (e.g. an HD frame), which scans the panorama. Such an operation mode is typically used in VR devices like Oculus Rift or Samsung VR Gear. If the end device is a smart phone or a tablet, it is desirable to have a zoom function, which allows to zoom out, such that the RoI covers the complete panorama or to zoom in, such that the RoI covers only a small portion of the panorama. In both cases, the RoI is displayed in a fixed format, e.g. as an HD video. Fraunhofer HHI has developed different techniques for panorama streaming, which are explained in [14].

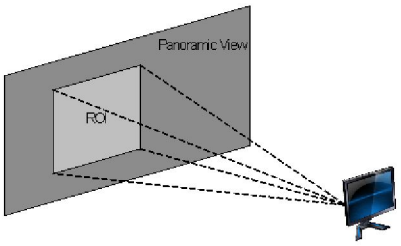

Figure 7: *Region of Interest (RoI) in a panorama to be viewed on a regular 16:9 screen.*

6. DISPLAY SYSTEMS

Ultra-high-resolution multi-projection systems, which are able to reproduce large-scale events in life size and with highest amount of realism, are considered as main key components for the successful introduction of immersive media. Even the next generation of digital high-end projectors will not be able to meet all requirements of immersive video applications such as dome projections, giant-screen theatres, large projection walls or 180° or 360° surround cinemas. Therefore a couple of multi-projection systems have been proposed for this purpose in the past (see Chapter 2).

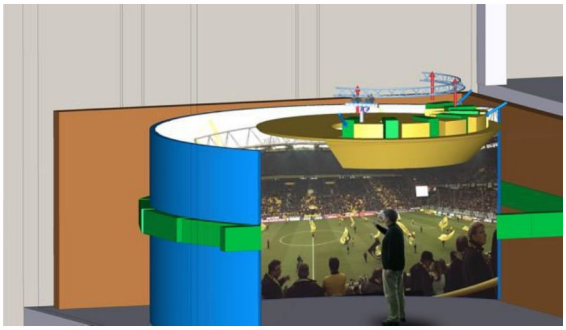

Figure 8: *Tomorrow's immersive Media Experience (TiME) Lab. It consists of a cylindric 7k 2D(3D) projection (180°) using 7(14) HD projectors and 140 loudspeakers providing spatial sound (wave field synthesis)*

The main idea of immersive multi-projection is to display panoramic video of ultra-high definition seamlessly at a large planar screen (projection wall) or at screens with a curved surface (180° or 360° panoramas or spherical domes) by using multiple projectors. Sophisticated on-board processing like alpha blending, black level adjustments, photometric, colorimetric and geometric calibration have to ensure seamless transitions between the single projection windows. Furthermore, to achieve an appropriate motion portrayal, all video streams have to be synchronized. Finally, efficient video compression techniques are required to handle the extremely large amount of video data. The TiME-Lab developed by Fraunhofer HHI, which is shown in Figure 8 provides all these techniques. Details about the underlying technologies can be found in [14].

7. OTHER CULTURAL APPLICATIONS

How can the immersive technologies described above be used for other cultural applications? Digitization is the answer to it. Applications range from paintings over sculptures, complete rooms or monuments, which are scanned and of which 3D models are generated, towards immaterial forms of art like dance performances or concerts, which are recorded with cameras of ultra-high resolution. Once the material of all these application is available in digital formats, it can be rendered for different displays and then be visualized on the different end devices described above.

Typical examples for dance performances are the Carmen - dance performance by Berlin Philharmonic Orchestra and Sasha Waltz & guests, which took place in the Arena, Berlin in May 2012 (Figure 9) or Christan Jost's "LOVER" with Rundfunkchor Berlin and U-Theatre Taiwan in Kraftwerk Berlin (Figure 10).

Figure 9: *Carmen - dance performance by Berlin Philharmonic Orchestra and Sasha Waltz & friends*

"LOVER" became then part of the 23-minute documentary PLAYING THE SPACE in 180°, a production which combines shootings of the premiere of Wolfgang Rihm's "IN-SCHRIFT 2" in the Berliner Philharmonie, of the Andromeda Mega Express Orchestra in Stattbad Wedding and of "LOVER" during the preparations of the concerts, during the rehearsals and the during the performances. In addition the film shows the locations of the concerts and their surroundings.

Figure 10: *Panorama of LOVER at Kraftwerk Berlin.*

The Production of PLAYING THE SPACE will be described in detail in the contribution of Corinna Volkmann to these Proceedings [15].

Another example for an immersive presentation is the performance of Berliner Rundfunkchor singing the Human Requiem of Brahms, about which Jochen Sandig reports in these Proceedings [16]. This performance was recorded with the OmniCam360 standing in the middle of Neue Nationalgalerie in Berlin. The choir was surrounding the camera and the singers were moving while singing. Figure 11 shows of snapshot of the choir towards the end of the performance, when the choir surrounded the camera in a closed circle. In the TiME-Lab the members of the choir are displayed in live size and one gets the impression to be encircled by them.

Figure 11: Unwound 360° *panorama of Rundfunkchor Berlin performing Human Requiem of Brahms in the Neue Nationalgalerie.*

Other examples are paintings. Usually museums can only exhibit a small percentage of all the paintings they possess due to space limitations. Therefore museums put a lot of effort in digitizing their paintings, because this offers several possibilities to use the content. As the resolution of digitized paintings may be as high as several ten thousands pixels in horizontal and vertical directions, they can also be shown in an immersive manner as indicated by the following examples:

- Visitors can view large paintings in their original size on immersive screens without losing any detail, as shown in Figure 11
- It would even be possible to zoom into the painting and see more details than it would be possible in a normal exhibition (Figure 12).
- Visitors can display metadata about the painting while pointing on details on the screen (Figure 13)
- Once a database is available, people could walk with their tablets through the regular exhibition and point to certain parts of the painting so that metadata appear on the tablet (Figure 14)

Figure 11: *Display of ultra-high resolution digitized painting in the TiME-Lab.*

Figure 12: *Zooming (bottom) into an ultra-high resolution digitized painting (top).*

Figure 13: *Pointing on a detail in an ultra-high resolution digitized painting and getting metadata.*

All these examples show, that there is an enormous potential, once painting, sculptures or other art objects have been digitized. Visitors can look at details without coming to close to the objects or touching them. Metadata shown on large screens or on tablets/phones can be used to explain art objects.

8. CONCLUSIONS

Immersive imaging technologies and especially Virtual Reality are currently hot topics in Consumer Electronics. Curved Ultra High Definition Displays or VR glasses transport the viewers to virtual worlds and to recorded or live events. The development of these technologies is very fast and prices for devices are dropping rapidly.

There is also a high potential for these technologies in art. These range from archiving immaterial art like concerts or dance performances to the display of live performances on large immersive screens, so that the viewers get the impression to be live at the event. But these technologies offer also a great potential for other kind of art objects like paintings and sculptures. Visitors can look at them and study details without coming to close to the objects or touching them. Metadata explaining the art objects can be displayed directly on large screens or on tablets/phones, which visitors carry with them.
In the PLAYING THE SPACE Session of EVA 2015 the underlying technologies and some applications are presented in detail.

Figure 14: *Retrieving metadata while pointing with a tablet on a real painting in a museum*

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