Paper

An Exploration of 360° Film and Immersive Environments for Educational Purposes

Karol Kwiatek

School of Architecture, Design and Environment

Faculty of Arts

University of Plymouth

karol.kwiatek@plymouth.ac.uk

Abstract:

The paper focuses on an exploration of immersive environments where 360° imagery and 360° films provide a potential for projects in education. 'Discover Krakow' – a 360° film produced for the display on immersive screens, has educational values as it refers to historical events and geographical facts about the city that the spectator is exploring during the navigation of space. A collaborative group-based learning environment delivered over immersive environments should motivate students to collect more information about the topic rather than memorize information. Object-based panoramic interactive narrative offers the possibility for the observer to make decisions about what supplementary information needs to be presented; therefore it seems to be a promising concept for edutainment, because it links interactive narratives with immersive environments.

An exploration of immersive environments where 360° imagery and 360° video recorded in Krakow in Poland provide a potential for projects in education.

1. Introduction

The aim of this paper is to give an account of the application of immersive video projected within immersive environments for educational purposes. The immersive systems that are in the focus of this study use a screen as a method of presenting photographic quality content. What is more, the observer's field of view creates the illusion of being in another place or taking a 'virtual journey' when viewing such a screen. These environments are used for scientific and entertainment purposes, but are similar to the 19th century panorama paintings that had educational merit. They transport spectators to different places worldwide virtually and at almost no cost. Edutainment projects for immersive environments aim at large-scale immersive screens in order to gather large audiences. A number of analog planetariums existing in the world were converted into digital projection systems [1] to fulfill the demand for immersive presentations. However, little attention has been paid to 360º cylindrical screens, in particular in combination

with polychronic narrative based on 360º video. 360º cylindrical screens were used for the presentation of transcriptive ('T_Visionarium' - [2]) and co-evolutionary ('Scenario' - [3]) narratives, but not for the presentation of polychronic narratives. Polychronic narrative is located in the context of a social space and a virtual space, which is referred to as dialogic (a concept which was introduced by Mikhail Batkin in 1984 to illustrate how fictional characters are able to speak to the authorial control of their creator) [4]. It is based on the communication between a human user and digitally generated agents (e.g. by wearing VR head-mounted displays as in *Conversations* they become avatars inhabiting the virtual space). The user is able to navigate their own path through prescripted events [5]. The existing 360º projection systems [6], envelop viewers in panoramic forms of storytelling. In the pages that follow, it will be argued that object-based panoramic interactive narrative has not been applied to such immersive cylindrical screens, therefore this paper presents a concept for motivating and facilitating more effective learning via interactive narratives. Several attempts have been made in hyper-narrative interactive cinema and non-linear presentation of films [7-9], but they refer mostly to a rectangular screen. However, Yu [10] highlights that immersive environments provide greater spatial context than rectangular screens (cinema, television) and may inspire learners by providing new pedagogical methods. In this paper, I explore Yu's concept on the example of my immersive film and I also attempt to present issues that might inspire students.

'Discover Krakow' is an example of 360° film that enables 'armchair' travel (understood as a metaphor of viewing; a new way of seeing the world) to Krakow in Poland. This city is the second largest city in Poland and is the most visited place in this country. Krakow's historic centre was inscribed to the prestigious UNESCO World Heritage List in 1978. I created a panoramic film that transports the viewer to this city. This experience of being in other space can be achieved by the use of immersive environments. The projection of this 360° film was performed on five different immersive environments. These include: (a) Cyclorama (Montreal, Canada); (b) Arena 360 (Plymouth, UK); (c) Immersive Vision Theater (Plymouth, UK); (d) ICCI360 (Plymouth, UK) and (e) iDome (Hong Kong, China). Three of them were based on 360° screens (a,b,d), one on a full-dome projection screen (c) and one on a hemispherical screen (e).

This paper has been divided into seven parts. The second section in this paper (after this introduction) describes the idea of the panoramic video as a basis for educational projects. Immersive environments are the focus of the third part of this paper. The fourth section illustrates the process of creating an interactive 360° film in Krakow in Poland. Then, the idea of interactive narrative is presented which has the potential to be applied to education for collaborative group-based learning environments delivered over immersive environments. Finally, the last part of this paper summarizes the potential of immersive environments towards educational purposes, where students could be motivated for further research.

2. 360° film

Video panoramas (also called 360° film, panoramic video or panoramic immersive video) overcome the passive limitations of the traditional video and provide the user with the possibility to interactively explore a moving image by changing the viewing direction when projected on a computer screen. The horizontal field of view (HFOV) of video panoramas covers 360 degrees,

while the vertical field of view (VFOV) is less than 100°. This type of panoramic video is necessary for 360° screen while iDome needs spherical video, where VFOV is 180°. Sarmiento and Quintero [11] focus on the creation of 360° video in 3D modeling software because panoramic video cameras are still high-priced. Ladybug cameras from Point Grey Research (Figure 1) enable the creation of spherical video. The company has released three models of spherical video cameras to date. The maximum resolution of footage recorded with the latest model (Ladybug 3) is 5400x2700 pixels (spherical format) and this resolution is also not sufficient for some projection systems, where the resolution of approx. 9000x1000 (cylindrical format) is necessary for the display of high-definition footage. The solution to this limitation is the application of a set of cameras (Sensocto camera [12], Spherecam [13], Totavision camera [14]), because they produce cylindrical panoramic video.

Figure 1 Ladybug 2 and Ladybug 3 – spherical video cameras produced by Point Grey Research

Computer-based interactive panoramas appeared in the 1990s [15], as a result of the advances in digital photography. No longer was the creation of rotundas necessary to preview the panoramic work. The first video panoramas appeared at the beginning of the 2000s [16]. It was a laborious process to present such recording in an interactive form. 360° video can be demonstrated on a computer screen (using panoramic viewers) or on various immersive screens that I present in this paper.

Panoramic viewers provide opportunity to display 360° images and 360° video on a computer monitor. The use of this type of software based mostly on Flash technology (KrPano, Lucid Viewer, Pano2VR) does not offer fully immersive experience for the viewers, because they can only perceive a miniature part of the panoramic image that is displayed on a rectangular screen. HTML5 based panoramic viewers (still in development) will improve the performance of the display of large files of video panoramas over the Internet. **Media 1** presents one frame from panoramic film 'Discover Krakow' that was converted to MOV format using Pano2VR software. Immersive environments (discussed in the next section) eliminate disadvantages of flat computer screens and provide a wide field of view, which creates the illusion and sensation for learners as in the panoramas presented in rotundas.

Media 1 - One frame from panoramic film 'Discover Krakow'

Historical panoramas failed to provide visual explanations of the images presented, whereas in digital technology, these possibilities are almost endless. The combination of panoramic images and panoramic video enhanced by elements of non-linear narratives (defined in the fifth section

of this paper) projected in immersive environments create a new potential for educational projects by inspiring observers to explore the additional information that becomes available only at specific times during the presentation. For example: an exploration of geographical spaces, heritage sites or application of history events by merging 3D modeling and video panoramas as presented in [17].

The following section focuses on application of immersive environments that are used not only for passive consumption of the story, but particularly for an active exploration of interactive narrative produced by the application of a spherical video camera.

3. Immersive environments

The idea of immersion, firstly introduced through the employment of cave paintings and panoramic baroque ceilings in churches, can now be experienced within immersive environments where digitally projected or displayed images surround the observer and enrapture its senses [18]. The effect of total immersion of the depicted scene presented in a contemporary panoramic arena has not changed in the aspect of preparing a space for panorama's illusion. The panorama cannot have visible edges and intrusive elements of the outside world (e.g. light) are blocked out in order to create dark spaces. Observation platform is no longer necessary, because the application of digital projection systems and the 360° painting does not need to be lit from the back. Figure 2 indicates the development of static and painted cave paintings to immersive spaces that present moving and often 3D content. Figure 2 also indicates technogies that, in my opinion, will be developed in the near future (gigapixel video and spherical broadcasting).

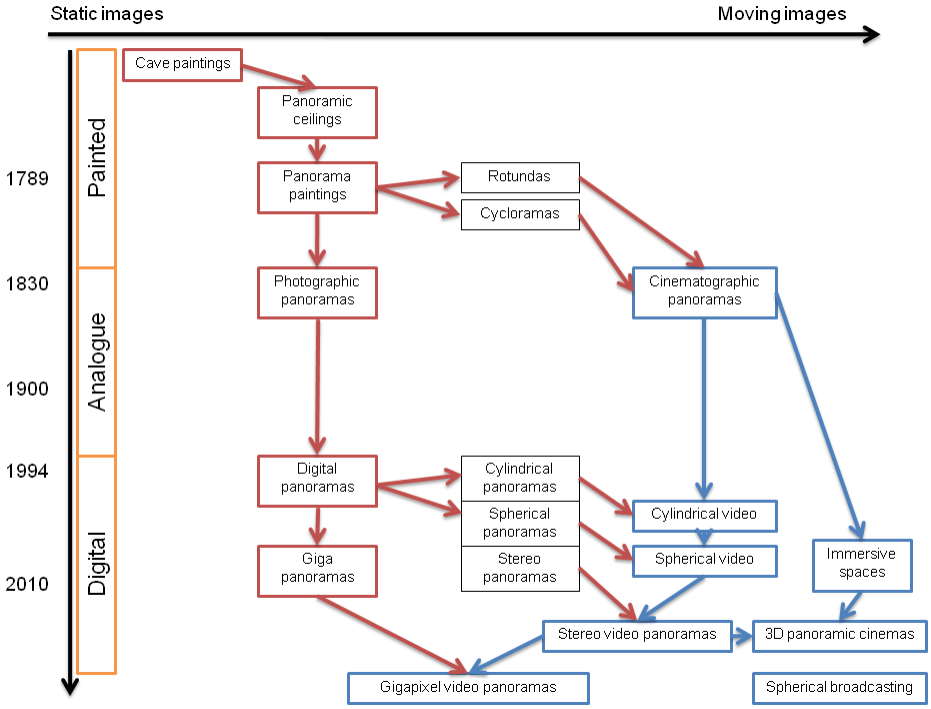

Figure 2 The development of immersive environments till and beyond 2010.

The production of contemporary wrap-around spaces is based on panoramic rotundas, but no longer are solely static images presented for the observers. Immersive environments discussed in this paper are based on the high quality photographic visual content. The 360° films are not created in 3D modelling software. This paper attempts to indicate that immersive screens provide an appropriate method of presenting non-linear narratives that can motivate learners. This method is based on traversing presented on an immersive screen. For several years researchers have aimed to construct environments that would enable people to believe that they are in a different location or that they participate in a narrative. The idea of such an imaginary space was realized via CAVE [19], however cylindrical environments with stereo projection [20-22] seem to realize the dream of first panorama painters to localize viewers inside a presented story.

One of the aims of contemporary creators is to involve the audience so they are hypnotized by an immersive screen and a 360° film seems to provide the strongest impression of being at the different location. This stimulating process generates the unity of space and time. For the purpose of this paper, the immersion is interpreted as the impression of being surrounded by 360° panoramic imagery and video. Therefore, immersive environments are spaces that facilitate this impression and offer the display of interactive narratives and new forms of digital presentations. This paper explores the opportunity for the inclusion of interactive narratives within a high quality photographic environment. What is more, this study consolidates the findings from practical research and proposes the potential of educational values in such environments.

The ultimate goal of immersive environments that improve the process of learning is to provide opportunities for the creation of spaces that:

- are high resolution displays for presenting seamless images;
- a viewer no longer determines the number of projectors involved in the creation of the illusion of reality [23];
- reach a large number of audiences;
- generate possibilities to access supplementary information;
- provide an audience an opportunity to collaborate.

These factors explain that immersive spaces with polychronic narratives are challenging pedagogical methods. However, in order to design a transportable panoramic immersive environment for a classroom in a school a few aspects have to be considered in advance. These are:

- desired size of audience;
- number of projectors;
- software;
- position of projectors;
- specification of projectors (brightness, resolution etc.);
- size and the curvature of the screen;
- powerful computers for running software and controlling projectors and speakers;
- type of spatial sound;
- material of the screen;
- room (size, shape and facilities) or a temporary building for accommodating the immersive screen.

A budget is another factor that should appear in the list above, because educational projects have to be always created within a limited time-scale and money. The application of computers and

digital HD projectors is commonly used for enveloping the observer in the image space, however new technologies such as LED or OLED screens could be potentially employed in the creation of immersive spaces in the near future and reduce the cost of these enterprises in the education sector. Digital projections cause a number of problems:

- shadows created by intersecting the light created by projectors;
- differences in brightness, caused by different working periods of expensive projector lamps;
- limited resolution;
- dividing sections;
- geometric misalignments;
- color variations.

Google Liquid Galaxy has already presented an immersive arena based on a number of LCD screens that are arranged in a circle and offer an immersive effect for Google StreetView and Google Earth imagery [24]. The website of the project describes how to build and synchronize computers in order to create 360° immersion.

To sum up this section, a painted panorama changed the way of narrating events. Artworks, presented as circular paintings, were not created for an individual, but rather for a significant audience. Furthermore, the point of view was not fixed, but mobile. Additionally, the spectators were surrounded by the 360° painting which was no longer just in front of the observer. The same rules for perceiving 360° artworks are applied to digital immersive environments where a significant number of viewers are hermetically enclosed within the screen and have the opportunity to move inside this space in order to experience the same narrative from different perspectives. The educational merit of painted panoramas presented in rotundas has widely been researched [18, 25, 26], however pedagogical aspects of new immersive environments still need to be explored.

The 360° film discussed in the next section challenges the traditional rules that were established with the invention of cinema more than 100 years ago. These are a sitting arrangement and a rectangular screen. These two factors apply partially to full-dome screens (the audience still has to sit in order to experience immersive presentations) and fully to cylindrical screens, because spectators can freely move and no longer observe a rectangular display. 'Discover Krakow' proposes a new method of experiencing films.

Table 1 compares the dimensions and technical details of the five immersive environments where ‘Discover Krakow’ was presented. Cyclorama (a) was developed by Vision3D lab at the University of Montreal [27]. Arena360 (b) and ICCI360 (d) were 360° screens provided by Igloo Vision to the University of Plymouth. Immersive Vision Theater (c) – IVT – is a permanent 40 seat structure at the University of Plymouth and enables a digital full-dome projection. iDome (e) [28] is a hemispherical projection system that provides a fully immersive experience for a small group of spectators. It was developed at the UNSW iCinema Research Centre and I tested it at the City University of Hong Kong in the School of Creative Media (ALiVE lab). As shown in Table 1, Arena360 and ICCI360 have similar structures, but the second immersive environment is larger and is designed for larger audience. Only IVT is equipped with seats, other screens are experienced in standing position - which is one of the significant aspects of education within immersive environments, discussed later in the paper.

Immersive environment	Dimensions	Number of projectors	Date tested	Image
(a) Cyclorama	Height: 1.5m Diameter: 4.6m Length:14.4m	7 / 14 for stereo	August 2009	
(b) Arena360	Height: 3m Diameter: 12.5m Length: 39m	5	February 2010	
(c) Immersive Vision Theater	9m full dome digital projection	1	August 2010	
(d) ICCI360	Height: 6m Diameter: 20m Length: 63m	5	September 2010	
(e) iDome	3m diameter projection hemisphere	1	October 2010	

Table 1. The comparison of immersive environments discussed in this paper in chronological order.

4. 'Discover Krakow'

'Discover Krakow' is the title of the 360° film recorded using a spherical video camera – Ladybug2. My hometown has one of the largest squares in Europe and this is also a location where the immersive film starts and finishes. The touristic approach was a leading idea for the generation of a panoramic linear film which was then extended to create non-linear 360° stories around this city.

The aspect of non-linearity helps the audience gathered within the immersive environment to collaborate in order to acquire additional information about the city. The audience assembled within an image arena is encouraged to solve clues and puzzles in the different parts of the city and in this way expand their understanding of the site that they have never visited before. The observers can gain knowledge not only of the history of the city and well-known buildings, but also they have an opportunity to study about historical people who used to live here.

The spectators have an opportunity to explore additional information that appears as they are watching an immersive film. The audience is encouraged to remember reference numbers that appear during the linear story which represent additional stories that could be played immediately as they appear on the screen or at the end of the 360° video. This 360° recording of

a 45-minute tour on a horse carriage through the streets of the historical centre of Krakow was adequately planned and an additional four persons participated in this experiment. Their task was to keep the tripod in the middle of the horse carriage. The setting time of Ladybug camera is at least 15 minutes, due to numerous cables that have to be connected and a laptop to be powered up and this creates a number of restrictions during the recording outside the office (limited capacities of a battery and a hard drive).

The process of recording 360° films can be equated with the production of films in the early cinema period (beginning of the 20th century), where movie makers struggled with transporting heavy camera equipment. This caused a number of restrictions. Similarly, a Ladybug camera does not allow a number of experiments because of the use of a laptop that constantly captures data coming from the camera (approx. 2-3 GB/min). More flexible recordings were possible due to a number of technological advances in camera technology so the cameras became smaller and more portable. This is also a route for further developments of devices that can record 360° video.

The creation of the 360° film ‘Discover Krakow’ offers a number of possibilities for further development, both for a panoramic viewer and an immersive screen. Individual frames presented in Figure 3, taken from the edited 360° film, are appropriate for the panoramic viewer, iDome and a full-dome projection system. In order to prepare video files for the multi-projector presentation in a 360° cylindrical image environment, they have to be cropped to the cylindrical format and by doing this the vertical field of view (VFOV) of images has to be changed (Figure 4).

Figure 3 Four frames in a spherical format from 'Discover Krakow' that are suitable for Immersive Vision Theater or iDome.

Figure 4 Four frames in a cylindrical format from 'Discover Krakow' that are suitable for Arena360, ICCI360 or Cyclorama.

The visual part of the film had to be enriched with a voice-over that was recorded in a studio. The audio recording provides explanations of objects of interest and presents legends related to specific places in the city. This is a third-person narration of the ‘omniscient’ narrator and as the narrative progresses from the beginning to the end, the voice-over seems to unfold stories, and also possible alternatives, before the observers. The spectators located in the centre of a

panoramic screen could, in fact, feel that they are situated in a horse carriage and they are on a journey through the city.

The following section focuses on the conversion of a linear 360° video recorded with a 360° video camera to an interactive narrative which has the potential to be used in schools or as a training material for groups that manage the city.

5. 360° interactive narrative for education

Interactive storytelling is an important cross-disciplinary area for research and entertainment [29]. It is also an ambitious form of art because it links interactivity, visual art and traditional narrative [30]. This is a crucial element in a new approach to teaching methods. Ozkeskin and Tunc [31] have already presented an inspiring approach to teaching students about the risk of earthquakes and my 360° film about Krakow was used for this purpose (the authors do not mention the source of the video of Krakow and New York in their article) in order to evaluate the risk for people during unexpected disaster. Ozkeskin and Tunc's study would have been far more useful if the author had considered an interactive storytelling approach to understanding potential earthquakes in different locations.

Ryan [32], in the theory of story graphs, does not fully examine the inclusion of additional narratives that are only available during the specific times of the narrative journeys. In this paper, I propose the concept of object-based panoramic interactive narrative. As shown in Figure 5 the line between points A and B consists of a linear narrative (this is a 360° video that is played between two still panoramas: A and B). This paradigm is based on a number of objects situated on the way from A to B. Circles in Figure 5 indicate the distance to the particular objects (points of interest; additional stories) in the city. These points appear only if they are visible from the point of view (C or D) of the spherical camera and contain reference numbers (E, F, H, I) which change their position on the screen because of the traversing between points A to B. Object G is not visible from points of view (C or D), but is in a range when the camera is on the way between points C and D. **Media 2** and **Media 3** presents the panoramic views from points C and D with the indication of objects E, F, G, H and I.

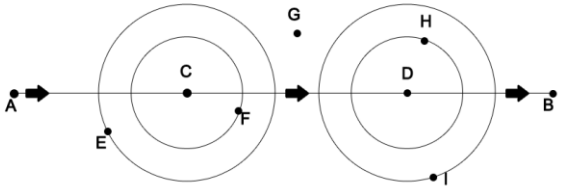

Figure 5 The graph of object-based panoramic interactive narrative

Media 2 - interactive panorama presents the environment from point C.
Media 3 - interactive panorama presents the environment from point D.

This type of narrative can be a part of a map-based panoramic interactive narrative described in [33], where video panoramas are used to move from one point in the city to another. Here, in the concept defined in this paper, such panoramic video is enhanced with more detailed non-linear narratives that are orbiting around the line A-B and appear only in the specific points and for a

specific time. For instance, in the case of ‘Discover Krakow’ additional narrative about the trumpeter from the tower of St Mary’s Church is available to watch (also as 360° film) when the church is visible in the film. Most viewers wanted to watch the main journey from the beginning to the end, returning to the additional narratives at the end of the presentation.

6. An exploration of immersive environments towards educational purposes

This section explores the potential and technical details of five immersive environments. The Cyclorama in Vision3D lab (Montreal) covered the natural part of the field of view of the observer. The observers were watching panoramic content at a natural angle. Comparing the screen in Montreal (a) to Arena360 (b) or ICCI360 (d) a few issues are noticeable. The position of the 360° screen was much above heads of the spectators in the Arena360 and ICCI360 and instead of looking in front as in Cyclorama; the audience within screens installed in Plymouth had to watch the content with their heads looking up (Figure 6). What is more, Arena360 and ICCI360 had dividing bars and the audience could see five separate screens instead of one seamless wrap-around screen as the one in Montreal. In my opinion, the use of dividing bars does not present seamless content and the immersive effect is limited.

My website [34] presents five videos of the discussed immersive environments. Four videos were recorded inside these image spaces using Ladybug2 or Ladybug3 camera. Only one video was recorded using normal camcorder and presents 'Discover Krakow' projected on iDome at City University of Hong Kong (**Media 4**).

Figure 6 The relation of spectators’ position to the Arena360 in Plymouth.

These are the interactive media:
Cyclorama (Montreal):
http://360stories.net/krakow-cyclorama
Arena 360 (Plymouth):
http://360stories.net/krakow
Immersive Vision Theater (Plymouth)
http://360stories.net/krakow-ivt
ICCI360 (Plymouth)
http://360stories.net/krakow-icci360
iDome (Hong Kong)
http://360stories.net/krakow-idome

Media 4 - The presentation of ‘Discover Krakow’ on iDome to group of students in Hong Kong.

The fully rendered movie about Krakow was demonstrated to the students at the University of Plymouth in Arena360. The time of journey was shortened from about 45 minutes to 13 minutes and 46 seconds by changing the frame rate in video editing software. A questionnaire was provided to these students in order to receive feedback about their experience of the immersive video projected within immersive environment.

Kenderdine et. al. [35] proposed a method of evaluating specific qualities of the experience of spectators of the PLACE-Hampi project and offered a new strategy for evaluation of immersive environments. The PLACE-Hampi - project uses only a part of 360° screen, where one projector mounted on a motorized platform is used, whereas in the researcher's approach full 360° display system is filled with not only panoramic images, but mainly panoramic video. The researcher in his questionnaire was interested in the potential of 360° films and user's reactions to a virtual journey to a new place, rather than in the reactions of the body or awareness of other visitors within 360° space or dwelling time as asked by creators of the PLACE-Hampi.

The feedback from students (who were invited to the Arena360) suggests that the video panorama kept their interest as 74% (14 of 19) of participants were satisfied with the length of 360-degree story. There were 19 students who filled in the questionnaire. Moreover, students agreed that such a presentation is an appropriate way for creating a tourist guide (17/19 = 89%) encouraging them to visit the presented location.

The next event (ICCI360 Festival in September 2010) improved some issues of the presentation, but the screen (much bigger than in Arena360) remained in the same position in relation to the audience (they have to look up to see panoramic works).

In order to have confirmation of the explored issues above, I decided to record the audience using 360° video camera located in the centre of 360° arenas (a, b, c, d). **Media 5** presents panoramic views from the interior of Arena360. The recording of the audience while they are watching 360º content using spherical video camera provides additional information which is worthy of further examination (the direction of looking or their interest in particular parts of the presentation). There are a few conclusions after watching this panoramic narrative on a 360° screen:

- there is no singular direction of observation in the circular screen; when the movement is presented it took some members of the audience (especially for those who were far from the centre) about 1-2 minutes to realize what is demonstrated and where to look to follow the narrative journey;
- long gaps between speeches where no information or no object was provided are also noticeable; the audience starts to explore other parts of the content projected, not focusing in one direction (mainly the direction of the movement);
- a great part of the audience were not aware of the possibility to move during the presentation and stayed for most of the time in the same place for the period of the display.

Media 5 - a panoramic view from the interior of Arena360

However, these findings are limited to a 360º screen (Arena360 was very similar in construction to ICCI360). There are numerous factors that need to be taken into account when exploring iDome (e) and IVT (c) because of different approaches to presenting 360º stories. The CAVE environments could be the next environment for testing the 360º film.

Immersive Vision Theater (c) allowed the audience to sit and admire the narrative about Krakow, while other environments do not seat the audience. Here, the attachment to a chair is evident, however no longer is there an attachment to a rectangular screen. One of the aims of immersive environments was to encourage the collaboration between users or students gathered in front or inside the environment in order to motivate them for further investigation. A standing position in immersive environments brings new opportunities for education. IVT does not provide the opportunity for spectators to contact each other and change positions which is one of the main tasks of collaborative watching and interaction with the panoramic video.

iDome (e), that the researcher had an opportunity to test in October 2010 is a much different environment than the screens discussed so far. This 3m diameter projection hemisphere enables a small group of viewers not only to experience the immersiveness, but also to interact with the panoramic video. This interaction is created for example by the use of a navigable ball situated in front of the screen. When a person from the audience notices something important (e.g. a point of interest) he or she can change the field of view. This means that all users will see the result of his/her action, while within 360° screens or in fulldome environments such a problem does not exist because every spectator can watch different parts of 360° film.

If I was given a task to create the immersive screen for panoramic works that would be of assistance for teachers and lecturers (provided with an adequate budget), I would select the following features from the cylindrical screens, which have been visited and tested:

- the size and the shape of the screen that occupies large amount of the observers' field of view and also the precision of the display (e.g. from iDome);
- interaction / navigational interface;
- free software (e.g. LightTwist from Vision 3D lab);
- the social aspect of watching panoramic movies together; presentation of the work not only created by one person or an institute but with the international artists contribution in the form of time-lapse photography; animations and films created with different 360° cameras.

The researcher's visits to these panoramic screens have facilitated the following conclusions about the generation of an idealized immersive screen based on a digital projection. The findings from this study have a number of significant implications for future practice. The target screen should have:

- a device for choosing alternative films;
- a surround-sound audio system;
- potential for interaction with the content displayed;
- calibration techniques for improving the misalignments in projections;
- a seamless structure (no divisions between screens).

It has been already indicated that the budget is the limitation for the creation of such an idealized immersive projection surface, especially for educational projects.

7. Conclusion

Returning to the hypotheses posed at the beginning of this paper, it is now possible to state that object-based panoramic interactive narrative is a new approach for motivating students for further explorations about the presented topic using immersive environments.

To sum up, the researcher projected his 360° film "Discover Krakow" on five immersive environments on three continents, mostly to the spectators that have never visited the Polish city. Almost all viewers were interested in going to this place to explore the site on their own. This study has shown that 360° film was not a substitute to their travel but rather encouraged them for further exploration, for example, of the history of the country.

Large field of view and interaction with the 360° film provided in order to create unique interactive narratives that can enhance learning processes because the spectators participate in collaborative group-based learning environments delivered over immersive environments.

Bibliography

[1] E. Lantz, "A survey of large-scale immersive displays," in Proceedings of the 2007 workshop on Emerging displays technologies: images and beyond: the future of displays and interacton, San Diego, California, 2007, pp. 1.

[2] J. Bennett, *T_Visionarium: A User's Guide*, Sydney: University of New South Wales Press, 2008.

[3] E. Scheer, and S. Sewell, *Scenario*, Sydney: University of New South Wales Press, 2011.

[4] S. Kenderdine, "iNSITU: Immersive Architectures for the Embodiment of Culture and Heritage. Volume 1: Suppositions and Transformations," PhD thesis, School of Art, College of Design and Social Context, RMIT University, Melbourne, 2009.

[5] N. C. M. Brown, T. S. Barker, and D. Del Favero, "Performing Digital Aesthetics: The Framework for a Theory of the Formation of Interactive Narratives," *Leonardo*, vol. 44, no. 3, pp. 212-219, 2011.

[6] S. Kenderdine, "Immersive Visualization Architectures and Situated Embodiments of Culture and Heritage." pp. 408-414.

[7] N. ben Shaul, *Hyper-Narrative. Interactive Cinema. Problems and Solutions.*, Amsterdam: Rodopi B.V., 2008.

[8] N. Knoller, and U. Ben Arie, "Turbulence – A User Study of a Hypernarrative Interactive Movie," *Interactive Storytelling*, Lecture Notes in Computer Science I. Iurgel, N. Zagalo and P. Petta, eds., pp. 44-49: Springer Berlin / Heidelberg, 2009.

[9] V. Havranek, "Laterna Magika, Polyekran, Kinoautomat," *Future cinema: the cinematic imaginary after film*, J. Shaw and P. Weibel, eds., pp. 102-107, Cambridge, Mass.: MIT Press, 2003.

[10] K. C. Yu, "Digital full-domes: The future of virtual astronomy education," *Journal of the International Planetarium Society - Planetarian*, vol. 34, no. 3, pp. 6-9, 2005.

[11] W. J. Sarmiento, and C. Quintero, *Panoramic Immersive Video 3D Production and Visualization Framework*, Setubal: Insticc-Inst Syst Technologies Information Control & Communication, 2009.

[12] M. Luczynski. "SENSOCTO - 360-degree camera," 19.05.2010; http://milosh.uzik.com/blog/?p=1429.

[13] J. Shaw, D. Del Favero, N. Brown *et al.* "Infrastructure Spherecam," 7.12.2009; http://icinema.cofa.unsw.edu.au/projects/infra_spherecam_1.html.

[14] P. Garlot. "Totavision," 8.03.2010; http://www.totavision.fr/.

[15] C. Jacobs, *Interactive Panoramas: Techniques for Digital Panoramic Photography*, Berlin: Springer-Verlag, 2004.

[16] A. Griffiths, "'The largest picture ever executed by man': panoramas and the emergence of large-screen and 360-degree technologies," *Screen Culture: History and Textuality*, J. Fullerton, ed., pp. 199-220, Stockholm: John Libbey Publishing 2004.

[17] K. Kwiatek, "Charles Church and 360º filming," Narrative and the built heritage : papers in tourism research, C. Mansfield and S. Seligman, eds., pp. 116-128, Saarbrücken: VDM Verlag, 2011.

[18] O. Grau, *Virtual art : from illusion to immersion*, Cambridge, Mass.: MIT, 2003.

[19] C. Cruz-Neira, D. J. Sandin, and T. A. DeFanti, "Surround-screen projection-based virtual reality: the design and implementation of the CAVE," in Proceedings of the 20th annual conference on Computer graphics and interactive techniques, Anaheim, CA, 1993, pp. 135-142.

[20] D. Del Favero, and T. S. Barker, "Scenario: Co-evolution, shared autonomy and mixed reality." pp. 11-18.

[21] S. Kenderdine, "Speaking in Rama: Panoramic Vision in Cultural Heritage Visualization," *Theorizing digital cultural heritage: a critical discourse*, F. Cameron and S. Kenderdine, eds., pp. 301-331, Cambridge, Mass.; London: MIT, 2007.

[22] W. Schoor, S. Masik, R. Mecke *et al.*, "Extended color gamut and adaptive pixel resolution with the immersive laser projection system Elbe Dom," in International Conference on Computer Graphics and Interactive Techniques, Los Angeles, California, August 9-10,2008, 2008.

[23] A. Majumder, and M. S. Brown, *Practical Multi-Projector Display Design*, Wellesley, Massachusetts.: A K Peters Ltd., 2007.

[24] M. G. Siegler. "Google's Coolest 20% Project: Liquid Galaxy," 17.03.2010; http://techcrunch.com/2009/12/07/google-liquid-galaxy/.

[25] S. Oettermann, *The panorama : history of a mass medium*, New York: Zone Books ; London : MIT Press, 1997.

[26] B. Comment, *The Panorama*, London: Reaktion Books, 1999.

[27] V. Chapdelaine-Couture. "Lab Vision3D - Archive for cyclorama," 15.12.2009; http://vision3d.iro.umontreal.ca/author/chapdelv/.

[28] P. Bourke, *iDome workshop - prepared for the School of Creative Media, City University, Hong Kong.* , 2010.

[29] R. Swanson, and A. S. Gordon, "Say Anything: A Massively Collaborative Open Domain Story Writing Companion," *Interactive storytelling : First Joint International Conference on Interactive Digital Storytelling, ICIDS 2008, Erfurt, Germany, November 26-29, 2008 Proceedings*, Lecture notes in computer science, 0302-9743 U. Spierling and N. Szilas, eds., pp. 32-40, Berlin: Springer, 2008.

[30] M. S. Meadows, *Pause & effect : the art of interactive narrative*, Indianapolis: New Riders, 2003.

[31] E. E. Ozkeskin, and T. Tunc, "Spherical Video Recording and Possible interactive Educational Uses," *International Journal on New Trends in Education and Their Implications*, vol. 1, no. 1, pp. 69-79, 2010.

[32] M.-L. Ryan, *Narrative as virtual reality : immersion and interactivity in literature and electronic media*, Baltimore: Johns Hopkins University Press, 2001.

[33] K. Kwiatek, and M. Woolner, "Let me understand the poetry. Embedding interactive storytelling within panoramic virtual environments," in EVA 2010, London, 2010, pp. 199-205.

[34] K. Kwiatek. "360stories.net," 22.06.2010; http://www.360stories.net.

[35] S. Kenderdine, J. Shaw, and A. Kocsis, "Dramaturgies of PLACE: evaluation, embodiment and performance in PLACE-Hampi," in Proceedings of the International Conference on Advances in Computer Enterntainment Technology, Athens, Greece, 2009, pp. 249-256.