Biennale 4D – A Journey in Time

Virtual Reality experience to explore the archives of the Swiss pavilion at the "Biennale di Venezia" art exhibition

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***Abstract*—The Swiss pavilion at "Biennale di Venezia" offers a platform for national artists to expose their work. This well-known and well-documented white cube showcases the changes of contemporary Swiss art from the early 50s up to the present day. The aim of the "Biennale 4D" project is to make the archives of these past art exhibitions more comprehensible by creating an interactive explorative environment through the use of innovative Virtual Reality (VR) technology. The project poses multiple challenges like visualization of historic content and its documentation, dealing with the heterogeneity and incompleteness of archives, interaction design and interaction mapping in the virtual space, integration of metadata as well as realizing a Virtual Reality experience for the public space with current VR technology.**

Extensive research has been conducted regarding the state of the art of VR technology in the given application field, possible forms of visual representation and rendering methods, interaction patterns as well as suitable user experience testing methods. A pilot application has been developed that features exemplary scenes with exhibit samples of various types and materiality and model scenarios covering varying degrees of documentation levels. This prototype offers features such as time travel, spatial movement and interaction with metadata. Furthermore, the experience has been enhanced with additional archive material. At the launch of the application, the user learns within a demo environment how to apply the functionalities listed above. The application has been tested thoroughly in regards to user experience and usability and was well received by the test audience.

In this paper we highlight possible approaches using Virtual Reality in terms of user experience, interaction design and visualization, and the actual implementation of the Biennale 4D pilot application. We discuss challenges of realizing public VR environments today based on the responses gathered in a user study.

Keywords: Virtual Reality, Interaction Design, Interaction Mapping, User Experience, Cultural Heritage, Virtual Art Exhibition, Interactive Archive

I. INTRODUCTION

A. Context of the project

Since 1920, Switzerland is represented as official guest at the Italian art exhibition "Biennale di Venezia" and in 1952 the country received its own pavilion, designed by the Swiss architect Bruno Giacometti. At this bi-annual event the works of one or several featured contemporary Swiss artists are displayed in this space. The exhibitions contain heterogeneous material of various disciplines of artistic work. Exhibits include but are not limited to tableaux, photographs, sculptures, media art and installations. The content of most of these exhibitions is well documented through photographs and other artefacts, some of the exhibits are less known by catalogue-entries only. The Swiss Institute for Art Research (SIK-ISEA) has published two book volumes titled "Biennale Venedig. Die Beteiligung der Schweiz 1920-2013" [1] which contain detailed lists of the exposed works, photographs and articles. In addition, the dedicated website www.biennale-venezia.ch was launched in 2013 by SIK-ISEA as an online-archive for the presence of Swiss artists at the Biennale di Venezia.

B. Vision for the Biennale 4D project

Whilst the printed publication and the web-archive give a detailed but rather traditional overview of the past exhibitions, Biennale 4D pursues the goal of to making the archives of these past events more immersive and comprehensible by creating an interactive, explorative environment through the use of current Virtual Reality technology. A pilot

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application was created by the Institute of 4D Technologies at the University of Applied Sciences and Arts Northwestern Switzerland FHNW and SIK-ISEA together with the students Olivia Kaufmann and Kathrin Koebel [2] to test the proposed exhibition reconstruction and virtual archive experience in the virtual space. This functional prototype allows users to explore the pavilion and displayed artworks of different epochs with a VR headset and interact with the historic exhibition content by the means of motion tracking and hand controller input.

II. Materials and methods

A. *Use of Virtual Reality Technology*

We choose to use Virtual Reality technology with a Head Mounted Display (HMD) as hardware to create an interactive exploratory environment. Through this research project technical possibilities as well as limits of current consumer Virtual Reality technology were explored. Some of the benefits of the use of VR for this scenario is the high-level immersion experience that this technology offers through the means of stereoscopic real time visualisation as well as user interaction, which creates the possibility to share the historic content of the archives in a more tangible, virtually touchable form anywhere, anytime. In addition, the chosen setup offers an explorative approach to the content of the archives and grants the user the freedom to interact with the archive content at his own pace and focus on the epochs and objects according to their individual interest. Another objective was to make the content of the archives appealing to new audiences by offering an unchartered approach to display and interact with the historic material. The expectation is that the content of the Biennale archives will gain increased public awareness through this project.

An additional benefit of VR technology lies in the fact that – compared to traditional exhibitions of archive materials through physical installations –VR only poses few requirements to the physical environment where it is made available to the public and that the setup allows to scale easily to more installations of the experience.

B. *Research about State of the Art*

New application fields are on the verge of opening up fresh perspectives and markets through the use of VR technology. As part of this project extensive research was conducted regarding the state of the art of technology in the given application domain. On one hand side, there are a number interactive archives of art institutions available which are often represented in the form of web applications and associated with questions about data exploration. Some examples that provide insight into the wide spectrum of current works include

- the self-contained application for the exhibition of the works of William Kentridge [3] that has been developed by The Museum of Modern Art MoMa in New York,
- the website “Deutsche Digitale Bibliothek Visualized” [4] which puts particular emphasis on information visualisation of its inventory
- and the interactive 3D cloud created by “Schweizer Kleinmeister, an unexpected journey” [5] which opens up a new, explorative access a collection of 2300 artworks.

On the other hand, there are several exemplary samples of virtual museums and VR applications in the context of exhibition reconstruction and design that explore the possibilities of interaction with historical data sets. The following examples demonstrate the potential in this field:

- The virtual Museum of Stolen Art gives access to artworks that are no longer available through the means of immersive media [6].
- For the exhibition “First Life” at the National History Museum in London a time journey has been implemented that allows visitors to explore ancient oceans and interact with sea creatures that existed 500 million years ago [7].
- The Museum of the Future of the Europeana Foundation, also known as EUseum, is engaged in the creation of virtual museum tours through the means of VR [8].

Attention should also be paid to recent developments that allow the direct immersion into an imagery or virtual world like the examples of “Dreams of Dali” [9], “The Night Café – a VR tribute to Vincent van Gogh” [10] or the VR reconstruction of the historic town of Arnswalde [11] as well as Mat Collishaw’s VR artwork “Tresholds” [12], that transports the viewers back to the dawn of

photography and lets them as a communal experience witness a digital reconstruction of the very first photography exhibition held in 1839.

Biennale 4D however poses a unique challenge as it combines a virtual art exhibition experience with digital archive functionalities through the use of Virtual Reality technology. With this combination, we are entering into uncharted territory.

C. *Forms of Visualisation and Interaction methods*

Moreover, research included potential forms of visualization for exhibition reconstruction where learnings from the field of archaeology and cultural heritage were taken into account. Various solutions for the decisions regarding the degree of abstraction in the virtual representation of the building and handling of incomplete data were considered (see chapter III, section C). There is a phenomenon in virtual reconstruction that is similar to the theory of the uncanny valley in animation: the higher the degree of realism, the more likely the chance that a minor inaccuracy in the simulation will destroy the immersion experience and diminish the sense of presence in the virtual space. Consequently, a wide range of sources advise against photorealism and recommend to pursue experimental fidelity [13] for crafting more memorable VR experiences.

In regards to interaction patterns [14], standards deviated from science fiction film and the gaming industry – which has been leading the way in the field of VR – were examined. One of the major differences between games and our application though is the target audience. The Biennale 4D project is dealing with subjects that had no or few previous encounters with VR technology and therefore there is little prior knowledge to build on. Another difference is speed, while games are often fast paced, this project encourages contemplative exploration of the past. And lastly the goal of Biennale 4D is not solely entertainment but it also puts emphasis on the educational and scientific aspect.

Research has also been conducted in regards to navigation and user guidance in the digital space [15] as well as interaction with the time dimension in Virtual Reality applications. Particular focus was given to decisions regarding interaction mapping, degree of freedom in user movements and haptic feedback [16].

D. *Lean UX method, Rapid Prototyping and UX Testing methods*

The research project followed the Lean UX agile development method with the iterative "think" – "make" – "check" phases where a strong emphasis is placed on rapid prototyping approach. Ideas and concepts are rapidly mocked with 3D objects placed in basic scenes and immediately tested with proband users in the virtual environment in an informal manner. In addition, established methods of user experience (UX) testing from software engineering and product development were evaluated regarding their eligibility and suitability for Virtual Reality projects. Hassenzahl's AttrakDiff method [17] which helps to understand how users personally rate the usability and design of interactive products stood out. A combination of this method with a pre-test and a post-test questionnaire containing Likert scale questions as well as open-ended questions was used for ongoing qualitative user testing conducted on a regular basis during the implementation of the prototype. The test itself contained scenarios with structured tasks given to the test users as well as time to explore the environment in an unguided manner. In addition, qualitative interviews were conducted with the proband users subsequent to the tests. Particular attention was paid to the user feedback regarding their physical well-being during the VR experience. Thoughtful testing of the perception of movement and interactions in the virtual space in this matter is particularly important to prevent motion sickness.

III. Results

A. *Implementation of functional prototype*

The result of this research is a functional prototype of the Biennale 4D Virtual Reality application, which is implemented with Unity using the VRTK framework and optimized for the high-end HTC Vive headset and hand controllers. It contains a 3D model of the pavilion in its original design and a concept for visualization of the exhibition content and its documentation (see figure 1). The current release of the prototype showcases exemplary portions of selected exhibitions in the years 1951, 1983, 2007 and 2013. Exhibition samples of various types of documentation levels are included, such as thoroughly documented and fragmentarily documented scenes, plus scenarios with proposals

how to handle lacking documentation as well as dealing with the documentation of experimental artworks such as video and interactive installations.

Fig. 1. Screenshot of the Biennale 4D prototype, showing the virtual reconstruction of the 2007 art exhibition in the "Malerei" hall of the Swiss pavilion.

B. *Interaction features of the prototype*

The prototype offers four principal dimensions of interaction. At first, it facilitates a time journey. This feature allows the user to travel intuitively through time to visit the desired exhibition in the past by means of interaction with the time machine object (see figure 2). This three-dimensional item offers affordances to the user about the exhibition content of the years he or she is passing by on their journey through time navigating to the scene of the desired year.

Fig. 2. Screenshot showing the time machine object which was created to allow the user to interact with the time dimension within the Biennale 4D application.

For spatial movement the application contains a navigation concept that allows the user to move within the virtual room either by position tracking of the user's movement in the physical space or via teleportation. In order to make the experience more realistic in regards to physics, the prototype provides basic haptic feedback in form of vibration in case of collisions with objects in the virtual space. Other forms of spatial navigation were considered (e.g. guided tour where the user follows a given track), however testing revealed a correlation between the user's degree of freedom regarding movement and the perceived user experience.

In addition, an information guide in the form of a virtual booklet offers access to metadata corresponding to the objects on display (see figure 3). This supplementary information can be accessed by pointing with a laser ray towards the desired item. And following the example of the real-life model of an exhibition guide, this digital leaflet allows to retrieve more information by simply turning over the page. Supplementary, interactive hotspots have been added to the application to enhance the experience. As the user approaches these in subtle fashion marked areas, additional material like archive photos for example appears in the given context.

Fig. 3. Screenshot of the information guide that allows interaction with the metadata of the artworks per point-and-shoot gesture. Turning over a page of this virtual exhibition booklet revels additonal information.

Furthermore, at the launch of the experience, the user is placed within a demo environment where he or she progressively becomes acquainted with all interaction functionalities provided by the application. The last step of this crash course training then triggers the users first time journey which transports him or her into the main application.

C. *Visualisation style*

The development of a consistent visual language for the heterogeneous material posed a challenge. In an effort to develop an appropriate form of representation for blending this historic material into the virtual space aspects like dealing with the incompleteness of the archive collections, uncertainty

concerning the positioning and heterogeneity of the content as well as finding adequate display modes for two-dimensional archive artefacts in a three-dimensional environment had to be considered. Numerous experiments were made to discover a suitable visualization style (see figure 4) that guides the user's focus away from the building to the artworks and their documentation. These experiments included variables such as the degree of abstraction, deliberate lack of definition and level of chromaticity of the environment.

Fig. 4. Screenshot of the Biennale 4D prototype, displaying the chosen aesthetics for the visualization of the historical content. The original design of the pavilion was reduced and blur effects have been added to the wall textures in order to intuitively guide the user's focus to the documented artworks.

Lessons from the field of archaeology have been applied for the handling of incomplete data. It is emphasised that the difference between documented facts, educated assumption and what is unknown should be communicated in a clear and unambiguous manner. In archaeology often colours, characteristics and thickness of lines, blending modes or transparencies are applied as stylistic means to visualize the difference.

In computer-based 3D reconstruction within the domain of Cultural Heritage additional consider-ations are being made regarding the differentiation between the semantic level of detail (LoD) and the level of information (LoI). While the LoD refers to the detail degree of the graphical content of a model, the LoI refers to the density of information contained and the credibility of the data sources. Hauck offers the simple formula "LoI – LoD = LoH" to compute the hypothesis ratio within a reconstructed object, where the difference between the two values leads to the level of hypothesis (LoH) [17].

According to this schema, if the LoH is less than or equal to zero, the visualisation is compliant to the source. The higher the value, the more the model tends to shift starting from feasible assumption towards complete speculation. Hence, in the realm of Cultural Heritage modelling an object is not only a question of technical and artistic visualisation requirements but it is also a scientific instrument of insight with a special focus on the reconstruction's sources. While the Cultural Heritage Markup Language offers a framework to add these values to the metadata of an object, there is no standardised practice yet for the visualisation of these metrics. Through the insight obtained from this research project, motion blur or other distortion effects, transparencies or adjustments of the colour scheme could be an appropriate presentation of these computed values.

D. *User Experience and Usability Testing*

Moreover, the prototype has been extensively tested in terms of user experience and usability. Through qualitative survey conducted using Hassenzahl's AttrakDiff method, the prototype received excellent results. It disposes of high scores on both axes (hedonistic qualities as well as pragmatic qualities) which is an indication that the current version of the prototype is not only considered delightful but also useful and ranks the product in the "desired" category of the AttrakDiff portfolio. Out of 28 dimensions merely two were rated with negative values. To be specific the two outliner were the dimensions "isolierend – verbindend" (engl. isolating – connectional) and "trennt mich – bringt mich näher" (engl. separates me – brings me closer), both relating to the social aspect. While the app allows users to experience uninterrupted immersion and to interact with artworks, the current pilot doesn't support any form of interaction with other visitors. Some test users commented to the point that the application separates them from their surrounding but brings them closer to the art.

IV. Discussion

Virtual Reality technology discloses novel approaches of exhibition reconstruction by creating an experimental world and offering an incomparable immersion experience. However, suitable processes for editing of exhibition content in this new medium

need to be developed for a conclusive incorporation of historical material in this experimental digital pictorial space. The nature of this application field requires thoughtful examination of aspects like substantiality, aesthetics as well as the concept of time.

A. Working with multiple layers of materials

One of the major challenges is posed by the work with diverse materials. The application consists of three material layers (see figure 5): first the historical content, second the dimension of its documentation and last the medium of the virtual room.

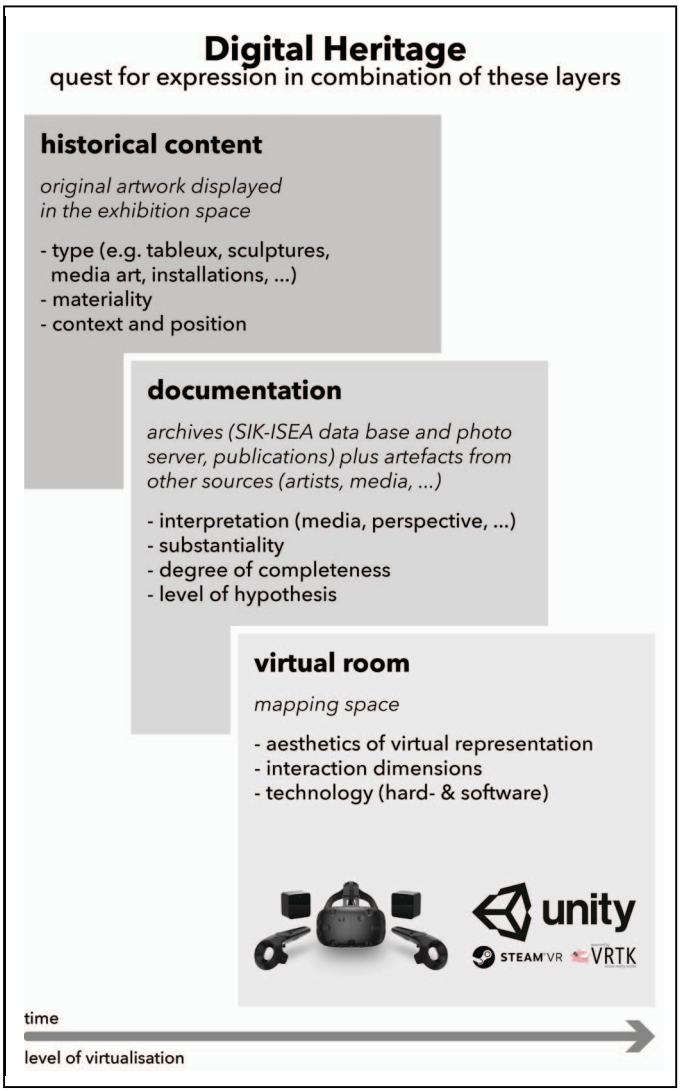

Fig. 5. Material layers of the Biennale 4D application.

- The historical content layer builds the basis. It comprises details about the original artwork in the exhibition space such as the physical type of the given exhibit sample (e.g. canvas, sculpture, installation), its materiality, its properties regarding quality as well as the context and position within the exhibition.
- The documentation layer adds additional information through archive photos from the SIK-ISEA database and photo server as well as supplementary artefacts from other sources. However, these materials already contain some aspects of interpretation such as the chosen media or perspective for documentation, its substantiality, degree of completeness or level of hypothesis.
- The layer of the virtual room – the mapping space – deals with aspects like aesthetics of the virtual representation and the elaboration of suitable forms of interaction. It is also concerned with hardware and software and guarantees that technology serves the user experience.

There is a quest for expression in the combination of these three layers. While the first layer is in most cases of substantive nature, the materiality becomes increasingly digital with each addition and the handling of the second and third layer in particular leave much room for interpretation and exploration. Therefore, the blending of the layers is to some extent a curative process itself and results not just in a reconstruction, but a new interactive virtual exhibition experience.

B. Dimensions of interaction

Another challenge lies in the interaction mapping of three dimensions of interaction (time dimension, navigation with virtual space and interaction with metadata, see figure 6) which had to be reduced onto the two hand controllers of the user. In the initial prototype one hand was assigned with time travel (switching between exhibition years) whereas the other hand was designated for interaction with the virtual space (spatial movement within the virtual room by means of teleportation) and interaction with the metadata of objects (displaying additional information on the information guide). The “time machine” metaphor was accordingly introduced for the first controller. And because the latter interactions are evoked by pointing a laser ray in direction of a location or an object, the second controller was nicknamed “pointer”. On top of interactions triggered through touch or push events on the hand controllers,

the application allows an additional form of interaction which is provoked by the user's position within the virtual room: when a user approaches a hotspot, the experience is enhanced by displaying additional content like archive photos or other artefacts. As the application is targeting an audience with no or little previous experience with Virtual Reality technology nor knowledge of the prevalent interaction patterns within similar applications, simplicity and intuitiveness are key. User testing has revealed that there is still room for improvement to make the interaction mapping even more intuitive.

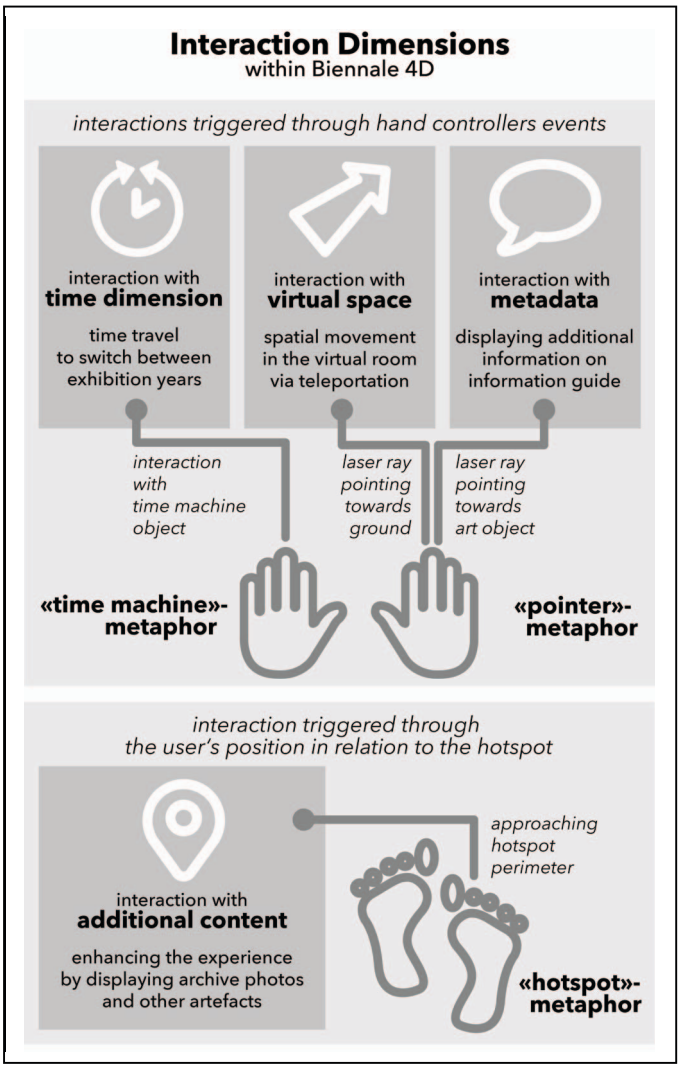

Fig. 6. Interaction dimensions with their corresponding actions, triggers and metaphors

C. *Learnings about User Interface and Interaction Design for VR*

When it comes to user interface and interaction design, there is a massive difference between the 2D and 3D paradigm. Nowadays established best practices from web and software engineering shouldn't be transported into the virtual space without proper reflection, since the prevalent design patters in that area have a long history and have evolved into the now familiar visual language over time. Looking back to the early days of computing, when the first GUI's were introduced, metaphors of concrete tangible objects from the analogue world were employed and displayed in a very realistic representation style (even though there were some restrictions caused by screen resolution and the 2D limitation of the computer display), because skeuomorphism creates familiarity that leads to more intuitive operation and consequently fosters ease of use. For instance, the imagery of a folder was chosen for mapping hierarchic data structures, a disk as analogy for saving data or a trash bin for deleting data. Over time a consistent, more abstract visual language for digital technology has evolved from this. Even though floppy disks are no more longer used as storage media today and therefore the disk icon has lost its literal meaning, the figurative meaning remained and a more abstract icon derived from the original pictograph has prevailed.

Virtual Reality is still in the initial stages, and there are no established standards yet. Similar to the early period of GUI in the computers industry, there exists little previous experience among the users. Therefore, if metaphors from their familiar surroundings are employed, users are better and faster at acquiring new skills. One of the major learnings from the project in this regard is that interaction through physical objects are easier to understand for inexperience users and fit better into the three-dimensional virtual environment. Another insight regarding UI design concerns dealing with text: reading of large amounts of text is rather arduous with the current resolution of Head Mounted Display and diminishes user experience. The Biennale 4D experience contains only little amounts of printed text on the display, and it is considered to replace these with voice overs recordings in the future.

V. Conclusion

The initial research has provided a favorable proof of concept and is affirmed through user tests. The vision for the ongoing work consists in offering access to the full content of the Biennale archives in

an even more interactive and immersive way and let a wider audience experience this valuable portion of Swiss art and cultural history. The work will be opening up new vistas for the exploration of image archives and exposition reconstruction and showing new prospects for the use of Virtual Reality in the realm of digital humanities.

Some areas of focus for further work include the aesthetics of the visualization and finding suitable ways to intuitively convey insights regarding the level of detail, level of information and level of hypothesis through the visual design. Secondly, improving the storytelling aspect, in particular within the initial currently rather technical demo scene, where the user learns basic skills before he or she launches into this virtual time journey. Keeping the right balance between scientific reconstruction, knowledge transfer and gamification will contribute to the attractiveness of the product. Interactive media technology like Virtual Reality has a unique role in sharing knowledge in an entertaining format. Additional criterions for the success of the ongoing project include intuitiveness and simplicity of the application design and the navigation concept, which will cater for a high user experience and notably assure feasibility for usage in public space on a broader scale.

In order to further improve the user experience, the objective will be to look more holistically at aspects beyond that short time frame when the user is wearing the HMD headset and consider the user experience pre and post the core application. The aim is to design the transition from reality into virtuality and vice versa in the most fluid, non-disruptive manner possible. This includes practical issues on the setup and presentation of the installation (e.g. how will cables be handled) as well as the design of a suitable environment for this experience that prepares the frame of mind of the users lining up and frames their expectations even before the on-boarding into the VR experience itself. In addition, elaboration is needed on the concept how the application will be embedded into the context of a larger exhibition.

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