

Small Project Proposal Virtual Reality Museum

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1 Introduction

Virtual Reality (VR) is defined by Merriam-Webster [1] as *an artificial world that consists of images and sounds created by a computer and that is affected by the actions of a person who is experiencing it*. The artificial world can either be a representation of the real world, or an imaginary world [2]. VR systems in the past were relatively specialized systems with not many users [2]. In 2012, Oculus created a Kickstarter [3] for the Rift [4], a virtual reality headset. The project was funded and introduced virtual reality to a more general public. As VR became more widely used, larger companies such as Samsung and Google developed their own VR variants [5, 8], enabling the use of VR on mobile devices.

VR can be applied in different domains, including those which do not have a direct association with computer technology. One of such domains is cultural heritage [9], and more specifically, museums. This research will be focused on virtual museums. Work in this domain has focused mainly on realistic recreation of existing museums and collections. However, VR provides many possibilities beyond this purpose. Using VR, scenarios could be created that would be impractical or even impossible to create in the real world. Therefore, this research will look beyond simply replicating museums, and will aim to find new ways of improving the user experience by using illusions in VR.

1.1 Virtual Museums

Many connections have already been made between museums and the virtual world. For example, the famous Louvre museum provides virtual tours consisting of 360 degrees pictures through which you can navigate [11]. This gives people a chance to visit the museum without physically being there. Instead of using pictures, Wojciechowski et al. [9] developed the ARCO system that provides museums to build and manage their Virtual and Augmented reality exhibitions. Whole virtual museums can be built. Additionally, museums are able to show pieces for which they do not have the physical space. The creation of a virtual space can even be taken a step further by creating a whole different virtual scene. The Westfries museum in Hoorn in the Netherlands has created a VR experience [10] as a piece of their exhibition, to relive Hoorn in the Dutch Golden Age. These projects on the domain of VR in cultural heritage focus on imitating the original environment, or on creating a new environment which portrays the environment like it was historically.

1.2 Altering the Environment of Paintings

VR is also applied to art museums that mainly display paintings. **A section about a paper about regular virtual museums has to be inserted here, but we have not read a suitable paper yet. Perhaps an article about the stolen art museum is suitable though. This needs to bridge the gap between the previously mentioned VR museums and exhibitions of paintings.**

The traditional setup of a quiet white room is not the only way to display paintings. The Tate Sensorium [6] in Tate Britain added touch, taste, smell and sound in their galleries [7]. The setting of the painting was modified by adding more modalities to change the way viewers perceive it. Using VR, these modalities can also be used, without needing to adapt the physical environment. This project however does not have the goal to imitate the Tate Sensorium in the VR space. Instead, it will make use of a different sense, vision, to enhance the experience of viewing paintings.

The IllumiRoom system [15] enhances the experience of playing a game or watching a movie by projecting additional information around the high resolution display, in the peripheral view of the user. Various illusions are discussed in the paper, all of which add extra context based on events occurring on the display. The IllumiRoom system augments the physical surrounding of the player to create a better gaming experience. In the IllumiRoom system, this augmenting feature is used with games to create a better gaming experience. However, changing the surrounding can also be done for other objects of interest. In our case, the environment of paintings will be changed in order to create a better experience while viewing paintings.

A museum usually provides different types of exhibitions pieces. This project will focus on paintings as exhibition pieces, and like the Tate Sensorium [7], changing the perception of the paintings. It will lend the idea of the IllumiRoom system [15] by changing the visual surroundings of a painting to enhance the user experience when watching a painting.

The environment of the paintings is changed by adding illusions. They can for example consist of creating new objects or showing animations. These illusions are not simple to realize in physical museums. Especially animated illusions are difficult to create in galleries without the necessary equipment. Projectors can be used to project animations on the walls, but this would result in shadows when people are walking by. The room would also have to be dark in order to make the projection properly visible. Large displays can be used to avoid these issues. However, these screens require a considerable amount of money. Due to these shortcomings, VR museums are a more suitable medium for the realization of these illusions.

2 Research Goal

The goal of this research is to find ways of improving the user experience in a virtual museum setting. Of course, there is a wide variety of museums. We focus on exhibitions of paintings in particular. We aim to find interesting illusions that could be applied in various applications related to virtual museums. Visible alterations are used to change the environment of the paintings. This might open

up new possibilities and ideas for creating new virtual museums and possibly spark interest in those who are normally not interested in visiting museums.

2.1 Research Questions

We will investigate how illusions affect the experience of viewing a painting. This leads us to the research question:

- *How do illusions affect the experience of viewing a painting in a VR setting?*

The illusions will be defined and explained in section 3.

In this research, the enjoyment of the user is seen as a big part of the user experience. As the virtual museum is a VR experience, the user's sense of presence, the feeling of being in the virtual world, might also influence the level of enjoyment. These two metrics have been shown to be correlated in related applications [17]. Though this is not definitive proof that they are correlated in the context of virtual museums, it indicates that they might be linked in more general cases. Therefore, these two metrics are a good indication of the overall user experience.

This results in two sub questions:

- *How do the illusions influence the enjoyment of viewing a painting?*
- *How do the illusions influence the sense of presence in the world of the virtual museum?*

Besides the sense of presence and enjoyment the user experiences in the virtual world, it is important to look at the user's connection to the painting specifically. With the illusions, we aim to create a stronger connection between the user and the painting by extending characteristics of the painting beyond its frame.

- *How do the illusions influence the sense of connectedness to the painting?*

Furthermore, we are also interested in whether or not the illusions can generate more interest in art for people who are generally not interested in visiting museums. For this we want to know if the illusions create more interest to users compared to the VR museum settings without illusions. The level of interest can be defined as the duration they are looking at the painting or the environment. This gives rise to the following sub question:

- *How much does the duration differ from when the user is looking at the painting with and without illusions?*

3 Design Space

There are lots of ways to alter the surroundings of the painting that could potentially enhance the experience of looking at a painting, and make it more interesting. For example, the color of the walls can be changed depending on the painting, or an image can be used to decorate the walls, instead of having a

regular wall that is painted in one color. A few more examples of these illusions with their details will be given in the next section. Generally, the illusions can be categorized as follows:

- Affecting wall behind painting
 - Directly around the painting
 - The whole wall
- Affecting the room
 - Walls of the room
 - The 3D space

3.1 Static Illusions

In this subsection we will discuss the part of the design space consisting of static illusions. These illusions will alter the surroundings of the painting without the use of animations. This will serve as an introduction to the animated illusions, which we will discuss in section 3.2.

- **Static color on the wall**

One of the most basic things to do to change the direct environment of a painting is to simply paint the wall in a color that makes the painting stand out better. The best color is a color that the user does not notice and where he only remembers the colors of the painting [19]. These colors could also affect the ambiance of the room and the mood of the person[18] viewing the painting. This illusion could affect only the wall around the borders of the painting, the whole wall the painting is hanging from, or the entire room.

- **Picture of same subjects as the painting**

Another change would be to decorate the wall with a picture. In some museums, when displaying a collection of pictures or drawings, one of the images is shown on the back wall behind the frames (fig 3.1).

- **Picture in style of the painting**

In [12], a picture is altered to be stylized in the same way as a painting is. An image is produced that still shows the content of the picture, but it appears to be painted in the same style as the painting. Instead of using a regular picture as in the example above, the picture could be processed to get the same style as the painting. Again they can be pasted on the wall behind the painting. This could make for a better backdrop to the painting than a regular picture would, as it better resembles the painting. Since the algorithm can be applied to any type of image, three different ways of applying it in our museum setting come to mind.

Firstly, the style of the painting could simply be applied to a single object in the environment, such as a picture projected on a wall. This could easily be done using preprocessing.

Secondly, the style could be applied as a post-processing effect to the user's field of view. Each frame the user sees through the VR device will



Figure 1: An exhibition piece used as wall image at the Studio Ghibli Layout Designs exhibition in the Hong Kong Heritage Museum

be processed to have the same style as the painting. However, some issues can be foreseen with this type of application, as processing might take too long to maintain a decent framerate and a very subtle change in head orientation could cause a very large change in the rendered view.

Finally, we can apply the style of the painting to the textures of all objects in the room. This way we can take advantage of preprocessing and therefore avoid the drawbacks of the previous method. A possible downside however, is that the illusion would only be applied to textures and therefore would not affect 3D shapes and shadows.

- **Extending the painting**

If a painting is a window into the world of the painter, then what is behind that museum wall? With a method called inpainting [16], it is possible to extrapolate information from the painting and apply it to the empty wall surrounding it. In this way, the wall can be made to look like an extension of the painting - like the wall and the painting are actually one big painting.

3.2 Animated Illusions

Some illusions mentioned in the previous section can also have an animated variant and some illusions can only be achieved when animated.

- **Changing colors on the wall**

In the virtual space, the wall would not need to be one color, but could change color over time to create different different moods.

- **Video related to the painting**

A video would be the more dynamic version of the still picture. For example, behind old news pictures, a news video covering the same event could be shown. The emphasis would still be on the pictures, and the video

could intensify the experience by making the surroundings supplement the displayed art.

- **Picture in style of the painting**

Another animation illusion uses a picture shown on the back wall, where the picture slowly morphs into the same style as the painting. In [12], the grade of stylization can be controlled. In this way, multiple images can be produced that are in style somewhere in between the unaltered picture and the style of the painting. With those, an animation can be made of the picture slowly changing to match the style of the painting.

- **Extending Painting**

For this animated illusion, the painting expands over the back wall while the user is watching it. This can be done by using painting expansion software [16]. The wall around the painting is filled with textures extrapolated from the painting.

- **IllumiRoom 'weather illusions'**

Lastly, the room or walls can be filled with particles that relate in some way to the painting, like snowflakes for a snowy painting or leaves for a painting of a forest in fall. Instead of basing these illusions solely on weather, they can be generalized to various particle effects based on the setting of the painting. These illusions are based on the IllumiRoom *Snow* illusion [15] and are discussed in more detail in section 4.

For this research, the animated illusions of the stylized picture, extension of the painting and the IllumiRoom weather illusion appear to be the most promising to see as a visual effect. These illusions can be applied to almost any kind of painting and use modifications based directly on the painting. They can be customized extensively to fit the need of the user or curator, but also leave open the option of automatization. These illusions are very hard or even impossible to create in real museums. However, by utilizing the aspects of virtual reality, these illusions can be created in a virtual museum.

4 Methods

The application will be implemented using Google Cardboard. Google Cardboard is a VR device that uses a smartphone as a display. This device has the benefit of being cheap, portable and easy to use, making it easily accessible to museums or individuals.

To answer our research questions, we will implement various illusions for different paintings and use them to conduct a user study. Paintings with four different types of content, painted in two different artistic styles will be used. For each combination, two different paintings will be selected as a representation. This means we will use a total of sixteen different paintings. In order to achieve reliable results, the paintings used will be carefully selected, so that they provide a good representation of a large collection of paintings. Even though this will likely not be sufficient to represent all paintings, with this selection, we aim to provide a fair sample of a vast group of paintings they belong to.

For the content we will use the following categories:

- **Forests.** Paintings of forests, depicting trees and other foliage.
- **Seashores.** Paintings containing both sea and land.
- **Snowy environments.** Paintings of landscapes covered in snow, where snow is falling.
- **People.** Paintings depicting groups of people.

We have chosen these categories because they are general enough to represent a large subgroup of all paintings, yet they are easy to distinguish between because of their well-defined characteristics.

We will use the following artistic styles:

- **Realistic paintings.** Paintings depicting the content in an accurate and realistic way.
- **Abstract paintings.** Paintings depicting the content using shapes, colors and stylization that do not exist in realistic scenes.

We have chosen these two different styles to be able to investigate the effects of the illusions for different types of paintings. If an illusion works well for a realistic painting, this doesn't imply it also works well for an abstract painting.

As discussed in section 3.2 we will apply the following three animated illusions for each painting:

- **Stylized picture.** For this illusion we will overlay a picture on the wall behind the painting. The style of the painting will be applied to the picture using methods described in [12]. Pictures will be different for each painting and will be selected to have content similar to the painting.
- **Extending the painting.** For this illusion we will display content based on the painting on the wall behind it [16].
- **Weather-like effects.** For this illusion we will create 3D particles or objects based on the content of the painting. For paintings of landscapes with clear weather conditions, these particles will be based on the weather and will include snow or falling leaves. For other paintings, these particles will be based on other types of content. For seashores, the particles will consist of sand and water, while for paintings of people, the particles will be adapted to fit the specific situation depicted on the painting.

4.1 Experiment Setup

The animated illusions can be implemented in various ways, including different values for parameters such as speed or behaviors of animation. To get a set value for these settings, a pre-experiment will be done to find the most promising settings in terms of enjoyment and presence. This can first be done internally and then tested on three to five people, giving their opinion about the different settings of the illusions. These participants are not allowed to join the main experiment anymore as they have seen the illusions before. This can influence their final judgment.

For the main experiment, participants will be subdivided into four groups. These groups consist of at least twenty participants. We will have one group for each illusion, and one control group to which a default museum room will be presented. Each group will look at each of the sixteen paintings. For each participant, the environment for the sixteen settings will be similar. Every time they will be placed in a room based on a part of a museum. The room will contain one painting and will have some additional objects such as chairs or plants. These objects will be used to facilitate features of various illusions. Apart from this, the room will be fairly plain in order to avoid distraction.

The first three groups will each have an illusion applied during the tests. Each of these groups will be presented with one of the three illusions discussed above. The fourth group will simply be placed inside the default room with no illusion applied. After a participant has finished the tests, he will fill out a survey.

4.1.1 Measurements

Using a survey, we intend to capture the user's sense of presence and enjoyment. This survey will be an adapted and combined version of the presence questionnaire by Witmer & Singer [13] and The Groningen Enjoyment Questionnaire [14].

To measure the participants' interest in the painting and the illusion, the direction in which they are looking will be tracked during the experiment. The amount of time the participants are looking directly at the painting or at the illusion will be measured in order to determine whether or not the environment draws away the user's attention from the painting.

The measured variables will be statistically analyzed. We will compare the results of all groups to determine the difference between each illusion and the default case. Our results will show the differences in terms of interest, presence and enjoyment for each combination of groups. These results will grant insight into the impact of the different illusions.

5 Hypothesis & Conclusion

We expect that every illusion will captivate users more than a regular painting in a white room would, causing them to use the application for a longer period of time. Adding these illusions will create a new virtual museum experience, resulting that it might pique the interest of those who are normally not interested in museums. They might go take the virtual museum tour for the illusions, however, they will be exposed to the paintings nevertheless providing a chance to raise their interest in art.

This research will help expand the world of digital museums. In virtual reality, not everything has to behave like it would in the real world. This research explores and tries to expand the borders of virtual museums by adding illusions that would be impractical without the use of VR. This specific area is largely unexplored. Research in this area could open up a lot of possibilities.

Real life museums could make their exhibits more interesting to people who would normally not visit them. This research could tell them what kind of illusion would be interesting to those people. These people could then look at

the paintings through an Augmented Reality headset, or through the camera of their smartphone, while the regular visitors can still enjoy the painting on a bland wall. Alternatively, they could visit parts of the museum in VR, and visit the real museum afterwards.

References

- [1] Merriam-Webster: *Dictionary* Web [Last accessed on October 19, 2015] <http://www.merriam-webster.com/dictionary/virtual%20reality>
- [2] Jon Martens & Pavlo D. Antonenko: *Narrowing gender-based performance gaps in virtual environment navigation*, Computers in Human Behavior 28, p 809-819, 2012
- [3] *Oculus Rift: Step Into the Game* Web [Last accessed on November 5, 2015] <https://www.kickstarter.com/projects/1523379957/oculus-rift-step-into-the-game/description>
- [4] *Rift* Web [Last accessed on October 20, 2015] <https://www.oculus.com/ja/rift/>
- [5] *Samsung Gear VR* Web [Last accessed on October 20, 2015] <http://www.samsung.com/global/microsite/gearvr/index.html>
- [6] *IK Prize 2015: Tate Sensorium* Web [Last accessed on November 5, 2015] <http://www.tate.org.uk/whats-on/tate-britain/display/ik-prize-2015-tate-sensorium>
- [7] *Welcome to Tate Sensorium: taste, touch and smell art - video*, The Guardian, 25 August 2015. Web [Last accessed on November 5, 2015] <http://www.theguardian.com/artanddesign/video/2015/aug/25/welcome-tate-sensorium-taste-touch-smell-art-video>
- [8] *Google Cardboard* Web [Last accessed on October 20, 2015] <https://www.google.com/get/cardboard/>
- [9] Rafal Wojcieszowski, Krzysztof Walczak, Martin White & Wojciech Cellary *Building Virtual and Augmented Reality museum exhibitions*, The Poznan University of Economics, Poland, University of Sussex, UK, 2014
- [10] *Kaap Varen* Web [Last accessed on October 19, 2015] <http://wfm.nl/kaap-varen/>
- [11] *Online Tours* Web [Last accessed on October 19, 2015] <http://www.louvre.fr/en/visites-en-ligne>
- [12] Leon A. Gatys, Alexander S. Ecker & Matthias Bethge: *A Neural Algorithm of Artistic Style*, CoRR, 2015
- [13] Bob G. Witmer & Michael J. Singer: *Measuring Presence in Virtual Environments: A Presence Questionnaire*, U.S. Army Research Institute for the Behavioral and Social Sciences, 1994

- [14] Stevens et. al.: *The Groningen Enjoyment Questionnaire: A measure of enjoyment in leisure-time physical activity*, Perceptual and Motor Skills, 200
- [15] Brett R. Jones, Hrvoje Benko, Eyal Ofek, Andrew D. Wilson: *IllumiRoom: Peripheral Projected Illusions for Interactive Experiences*, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, p 869-878, 2013
- [16] *Extending Van Gogh's Starry Night with Inpainting* Web [Last accessed on October 19, 2015] <http://blog.wolfram.com/2014/12/01/extending-van-goghs-starry-night-with-inpainting/>
- [17] Sylaiou et. al.: *Exploring the relationship between presence and enjoyment in a virtual museum*, Int. J. Human-Computer Studies 68, 2010, pp. 243–253
- [18] *Colour Therapy*, The Guardian, 6 July 2008. Web [Last accessed on November 5, 2015] <http://www.theguardian.com/lifeandstyle/2008/jul/06/healthandwellbeing.relaxation31>
- [19] Jonathan Jones *What colour should gallery walls be?* The Guardian, 21 October 2011. Web [Last accessed on November 11, 2015] <http://www.theguardian.com/artanddesign/jonathanjonesblog/2011/oct/21/colour-gallery-walls-musee-d-orsay>