Translating 2D art into Virtual Reality and comparing the user experiences

Daniel Patel[1,2] Runar Tistel[1] Atle Geitung[1] Harald Soleim[1]

[1] Bergen University College (HVL), Norway   [2] NORCE Technology, Norway

dapa@norceresearch.no

Abstract

Recent advancements in virtual reality on the hardware and software front have made high-quality virtual reality experiences both cheaper, and easier to obtain. This paper explores how virtual reality changes the way a user experiences art and if virtual reality is suited as a medium for expressing art. Based on two existing artworks, we have created VR versions using a game engine, and conducted a user study to get a comparison of how the experience of the traditional artworks differ from the VR versions. The artworks have been created in 3D using algorithmic modelling techniques.

Introduction

Displaying a computer-generated 3D scene to a user by showing stereoscopic images through a head mounted display (HMD) is a type of Virtual Reality (VR). The 3D scene can be updated based on the user's view direction, giving the user the feeling of being inside and looking around in the scene. Recent advancements in VR hardware and software have made high-quality VR both more affordable, and easier to obtain. VR has established itself in the domain of games, training and design, but has not been used much for communicating art. VR, compared to e.g. paintings, offers several additional dimensions such as stereoscopy, the ability to display arbitrarily large works of art, free and effortless movement in the virtual space, dynamic/animated 3D structures, sound, interaction between the viewer and the art, and interaction between multiple viewers. This makes VR an attractive medium for expressing art. Compared to classical museums, new digital technology such as VR is to a larger degree embraced by youngsters. Digitized content has also the advantage that it can be distributed directly to homes. Instead of bringing the youngsters to the museums, one can imagine bringing museums to the youngsters in a new and exciting format. This way of thinking has been brought forward by the Norwegian artist Bjarne Melgaard with his VR artwork "My Trip" [1]. VR can enable art to reach more people and new age segments.

As we are not artists, we decided to expand already existing artworks into VR. The artworks we chose are the recently deceased (24 April, 2018) Norwegian artist Pushwagner's paintings Selvportrett (Self-portrait), and Manhattan. We chose these two works because they are highly regular and therefore easy to reproduce with a computer program. In addition, the works are interesting as they are spatial and have lots of structure. Using existing art makes it possible for us to compare the evaluated VR version with the original version which allows us to find out how virtual reality changes the way a user experiences conventional 2D art. In this paper we also want to find out to which degree VR can be considered as an art medium and not only a digital display technology.

According to the Norwegian Copyright Act (Lov om opphavsrett til åndsverk m.v.,), artworks do not enter public domain before 70 years after the authors death (§ 11). Therefore, we do not depict the artworks but refer the user to look up the works which are easily accessible on the web. Regarding our VR versions, the copyright act (§ 6) states that translated, adapted or transferred pieces of work are under the copyright of the

original work, whereas new and independent works created by making use of existing work are not. It possible that our VR versions can be interpreted to fit under the first case, therefore we do not make our VR software available and we only show screenshots of our derived works that we consider to be sufficiently different from the original works.

Related Work

VR Hardware. A heightened sense of immersion has been sought after in the film industry for years. 3D cinema using stereoscopic image projection and higher quality surround sound systems are just some examples. An early attempt at VR was the Sensorama [2] by Morton in 1962. It attempted to give viewers a more immersive movie experience by stimulating as many senses as possible. Electric fans simulated wind, and the release of aromas and vibrating motion was produced to give the user a heightened sense of presence. Sutherland's work in 1968 [3] is considered to be the first HMD system, incorporating many of the same techniques seen in modern HMD systems such as head-tracking and stereoscopic display. However, it was so heavy that the HMD unit required to be suspended in the air through a ceiling mounted mechanical arm. The CAVE project [4] (1992) is a later attempt at VR that projects the virtual environment onto the surrounding walls of a square room using projectors, to create the illusion of a 3D environment. The CAVE project has been applied extensively in engineering environments to e.g. enhance product design and development. In 2016, several high quality and affordable HMD units together with supporting software and development kits were released to the market from companies such as Oculus, HTC, Valve and Sony. This brought VR experiences for the first time to the general public. Tracking of position and orientation is supported both on the HMDs and on hand-held input devices. Factors that define the quality of the VR experience are the pixel density and the field of view of the HMD display, the latency and polygon count of the rendering hardware as well as the need for cables required for display and tracking. In this paper, the Oculus Rift Consumer Version 1 with 1080×1200 resolution per eye and 90 Hz refresh rate was used.

Art and VR. Long before VR hardware was made, artists had been working on related ideas. In 1792, Barker [5,6] painted the world's first panorama which depicted a full 360 view of London and was installed in a purpose-built circular building. A platform in the middle of the building allowed the viewer to look around at an uninterrupted 360 view of the painted surroundings of London. In 1849, the classical music composer Wagner described his vision in the essay "The Artwork of the future" [7] of integrating art forms such as music, dance and poetry in a single total artwork. His vision may now be possible to achieve with today's VR technology. In 1995 Char Davies who was originally a painter created one of the first VR art installation [8]. The installation consisted of an HMD displaying computer graphics that was controlled by the user's breath and balance. Breathing out caused the user to sink and breathing in caused them to float upwards. The user could move laterally by leaning in the wished direction. In 1997, Murray in her landmark book [9] predicted the rise of digital storytelling. She stated that VR enables the participant to enact stories rather than merely witnessing them since the participant is the center of the virtual world. VR's ability to give a strong sense of presence in a work, and its ability to fuse multiple art forms as was the vision of Wagner, shows that it has a large potential for use in arts. Around 2016, museums started utilizing VR to expand the availability of their art collection. The VR Museum of Fine Art [10] is a VR application that presents digital replicas of works of art from the Museum of Fine Arts Boston, in a fully explorable 3D environment. In addition, translating existing art into the VR medium has been done for the works of famous painters such as Van Gogh (2016) [11], Dali(2016)

[12], Bosch (2016) [13] and Magritte (2018) [14]. These VR adaptations have also been extended with animations and sound.

In our work we also translate existing art into VR. Our main purpose is however not the end-product itself, but to perform a systematic survey to learn more about VR as an art medium and how it differs from 2D paintings. In 2017, the exhibition "The Unframed World" [28] explored Virtual Reality as an artistic medium. The exhibition conveys the aesthetic potential of Virtual Reality and examines its role as a critical medium for reflection on states of being in the world today. Like we do, the Master's thesis [15] also explores the question about VR as an artistic medium, however only qualitatively through studying existing VR artworks and by discussing them. He concludes that "the capacity of virtual reality is not currently used to its full extent when it comes to artistic manifestation." The VR art applications reviewed so far have been created by programmers and 3D model designers, possibly guided by artists. Artists without a technical background can still create VR art directly in VR using familiar paintbrush metaphors. Tools like Tilt Brush [16], and Oculus Medium [17] give users the ability to paint and sculpt models in three dimensions using HMD's and tracked hand controllers which act as digital 3D brushes.

Programmatic and algorithmic generation of art. VR experiences found in HMD's are generated from software running on a connected PC or running in the HMD itself. Established software for creating VR applications are game engines such as Unreal [18] and Unity [19] which offer a programmatic approach and a visual user interface to the graphical assets. The solution presented in this paper was made in Unreal.

VR and 3D applications consist of a computer program that does the rendering and digital assets such as 3D models and sound clips. The 3D models can be designed in modelling software such as Blender [20] or Maya [21]. As opposed to manually creating models and content for a digital art project, there is a field of digital art called generative art where the artist creates a computer program that then automatically or semi automatically generates art, possibly seeded by a random number generator or some user defined input. The first example of such art was made by Noll in 1964 at Bell Labs [22]. He created a program that automatically generated a digital version of Mondrian's "Composition With Lines" painting.

Translating 2D art to VR

The works Selvportrett and Manhattan by Pushwagner were chosen because of their spatial structure and visual appeal. The Selvportrett scene is made with black pen/marker on white paper and depicts a large crowd of people looking out from inside of a cylindrical structure consisting of many mezzanines, reminiscent of a tall stadium. The top is domed and covered with images of faces. The bottom of the scene seems to stretch downwards endlessly. In the center of the cylindrical room there is a spiraling line of people stretching from bottom to the top. Manhattan is a colored painting of several tall and thin skyscrapers in bright colors along a passage. The buildings bend and sway in an unnatural way and stretch into infinity downwards, upwards and into the perspective. The sides of the skyscrapers have bright colors and windows with people looking out from. Both paintings have a strong sense of space and scale due to the relation between repeating structure, empty space and perspective. They portray large expansive spaces which can be represented well in VR. The artworks also feature regularity and repeated elements which makes them easier to translate to 3D than other works of less regular structure. The Manhattan painting also indicates a waving movement of the skyscrapers which we represent as animation in VR. Pushwagner typically does not want to talk about the meaning of his artworks, but willingly talks about perspective, depth and the feeling of

3D. He wants the observer to feel he/she becomes transported into the artworks [23]. This is exactly what VR can achieve. The regularity in our two selected paintings, also found in several other works by Pushwagner, makes it possible for us to define the scenes programmatically/algorithmically instead of modelling each element in the scene manually in 3D modelling software. Programmatic definition of 3D models, also known as parametric modelling, is the act of describing a model based on input parameters and using loop counters and mathematical expressions to define it. For instance, the geometry of a chessboard can be defined by having its width and number of squares in x and y direction as input parameters, then inside a for loop, the geometry of each of the rows is created. This for loop has another for loop inside that creates each individual cuboid shaped square using two alternating color. Doing parametric modelling of our two paintings has several advantages, it is faster for the designer to create the scenes procedurally compared to manual modelling, it becomes easier to dynamically change the scenes at runtime by changing the parameters, and the scenes take up less space in memory during rendering since they can be generated on the fly.

We deconstructed the geometry in Selvportrett and Manhattan into building blocks and reconstructed them by positioning the building blocks according to e.g. number of levels in the buildings. The human geometry shown in Selvportrett was made externally in the software MakeHuman [24] which consists of an editor where a human model can be generated based on different parameters such as age, height, gender and muscularity.

The human model consists of 20K triangles, and we had 5400 humans in the scene, resulting in 109M triangles not counting in the triangles for the building. To achieve interactivity, we reduced the triangle count by representing the human mesh at three decreasing levels of detail (LOD), se right figure. Humans that are far away and have smaller footprint on the screen

20153 tris (100%)   8262 tris (40%)   1612 tris (8%)
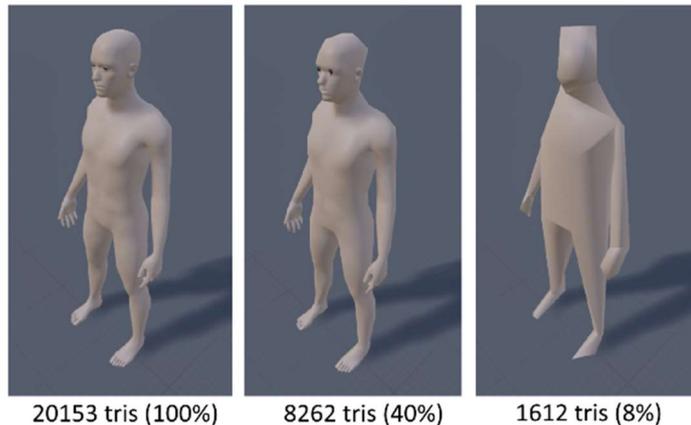
due to perspective projection, are rendered at lower level of detail than humans that are close to the viewer. Lower levels of detail are only used when the footprint is so small, that the reduced detail level is not discernable.

In addition to producing the geometry of the scene, we need to alter the drawing style of the geometry to fit the drawing medium and technique the artist has used. To replicate this style in 3D, we changed the rendering style from the default style of drawing colored surfaces to instead only draw the edges between surfaces. This was done by rendering depth values (Figure 1a) and surface normals (Figure 1b) in hidden buffers and setting pixels to black that have sufficiently different depth or normal values than its neighbor pixels, otherwise pixels are set to white (Figure 1c).

Often when an artist draws by hand, small imperfections in the lines in the form of wiggles are created from the drawing tool, the canvas, or the artists hands being unsteady. Therefore, to introduce an extra layer of realism to the artistic style, and to further replicate the style of Pushwagner, some noise is added to the lines (Figure 1d). This noise offsets the pixels in the lines slightly both vertically and horizontally. The noise is sampled from a 2D buffer of same resolution as the output image. The 2D buffer can be interpreted as unevenness in the drawing canvas which produces the wiggles in the drawn lines. Therefore, the noise values are not recalculated but stay the same from

frame to frame. Getting the right rendering style for the Manhattan painting required less work, we could basically use standard rendering with colored surfaces. In addition, we used 2D textures to render the windows with the people looking out. More detailed information on the rendering process is described in the master thesis [25].
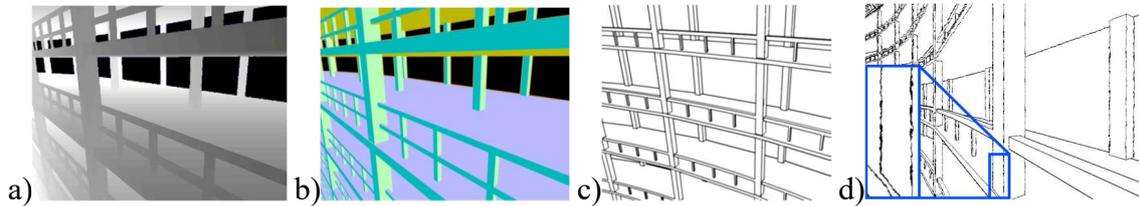

Figure 1 a) Distance from viewer to surface mapped to grayscale (depthmap). b) Surface normals mapped to RGB color. c) Resulting line drawing by using data from a) and b). d) Adding wiggles to lines by offsetting pixels in c) with random values. Blue large box shows a zoom-in on the blue small box. (Images in a)-d) are shown from slightly different viewpoints).

Evaluation of VR art

In this paper, we wanted to find out how people experience VR art compared to conventional 2D art, and if VR is suitable for expressing art (Table 1). For this we translated two existing 2D art paintings into VR, exposed both the 2D and the VR versions to respondents, and asked them to do a comparison (research question 1). By letting the respondents compare two versions of the "same" piece of art, we could formulate concise questions that would be easy to answer and analyze, as opposed to answering more open non-grounded questions. After having started a thought process in the responders, we followed up with open questions to answer our second research question.

Table 1. Research questions

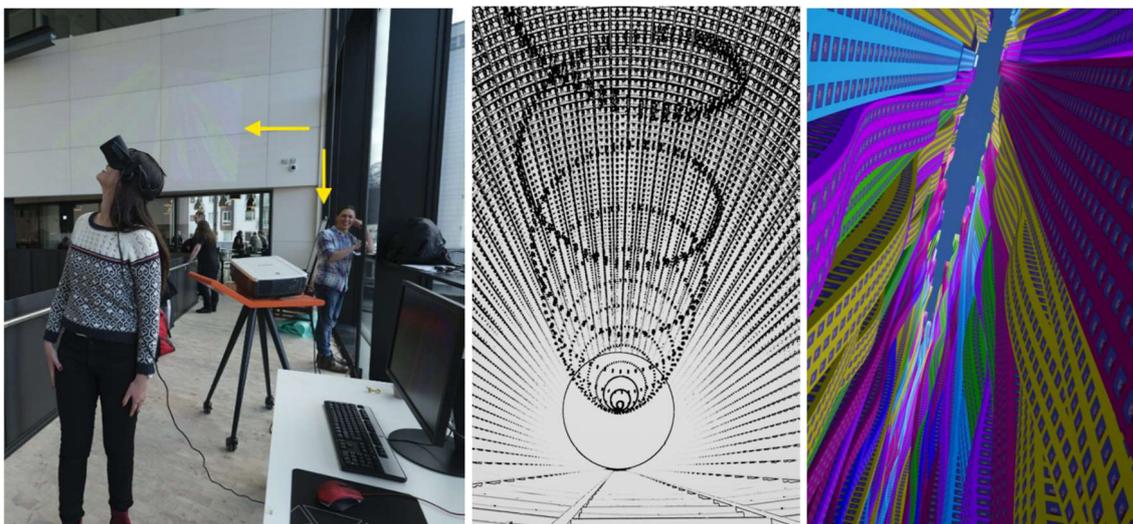| 1. How does VR change the way a user experiences art? |
| 2. Is VR suited as a medium for expressing art? |

Figure 2 Left: Public demo. Middle: Screenshot of Selvportrett. Right: Screenshot of Manhattan.

We conducted a public demo session at the Faculty of Fine Art, Music and Design, University of Bergen (Figure 2). This location was chosen to attract qualified respondents that more likely had knowledge on aesthetic and arts and the ability to formulate insightful answers. Each respondent was first shown an original print of Selvportrett (positioned below the yellow vertical arrow in Figure 2), followed by a picture of Manhattan, on a

computer monitor. We were not able to get hold of an original print of Manhattan, and posters do not exist, therefore the answers to question 3 and 4 shown below may have been influenced by this situation. However, several respondents were already familiar with this painting. The respondent was then shown our VR version of Selvportrett, and of Manhattan. The rendering in the VR headset was also displayed on a wall, vaguely visible at the yellow horizontal arrow in Figure 2 left. Afterwards, the user was given the seven questions shown in Table 2. A total of 18 people tried the VR application, and 15 completed questionnaires were returned to us.

Table 2 Questions given after having experienced the VR artworks.

1. Are you a student or do you have higher academic rank?
2. What are your initial impressions of the scenes?
3. How do you think the scenes work, compared to the original art?
4. Do you think the scenes capture the spatial experience of the original scenes?
5. Do you think virtual reality changes the possibilities in artistic expression?
6. Do you use, or do you think you will use VR tools to create art? If so, why?
7. What do you think my role is in this production, am I an artist?

The first question was made to get the educational background of the responder so we could evaluate if the answers were influenced by this. We found no clear correlations between the answers and the background and have therefore not further analyzed the responses on this question. Questions 2, 3 and 4 were designed to get shed light on research question 1 by getting the responders' feedback on the impression of our VR scenes compared to the original 2D work of art. Question 2 was an open question, while the following were more specific. The open question enabled us to capture additional information which would not have been captured from the answers on the specific questions. Finally, questions 5, 6 and 7 were meant to get feedback on research question 2 regarding VR as an art medium in itself as opposed to only a digital presentation tool. All individual answers can be found in the Master's thesis [25]. In addition to the written feedback on the questions, we noted down exclamations and comments given during the demonstration. Examples of noticeable oral feedback was

- "Yes, now I really am inside it!"
- "Woa, I don't dare look down!"
- "With the movement (in the scene) I could look at this for a long time."
- "Freaky! So you've made this in 3D? That must have taken a lot of time!"

Research question 1: How does VR change the way a user experiences art?

To answer this question, we specifically asked responders to compare an original work with a derived VR version of it that we had made. This was done for two works. Basing our work on existing art, gives us a baseline to do the comparison against and enabled us to create VR art without being artists. We will start reviewing the answers on questions 3 and 4 while taking material from question 2 for detailing the answers.

For question 3, "How do you think the scenes work, compared to the original art?", we have listed the most prominent parts from individual answers: "something entirely different"; "feeling of height, space"; "adds a dimension"; "you have truly entered the artworks"; "we are integrated in the work"; "from reading the art to being apart of it"; "added a new layer (but kinda blurry)"; "much more vivid"; "better depth"; "makes you feel small and not important"; "much better 3D feeling … different

perspective"; "pulls in the observer as part of the work"[1] ; "compliments each other"; "you're part of it .. different perspective.". No respondent was negative or stating that the original art was better. Twelve out of 15 specified some sort of added value in the VR versions. The three that did not explicitly state an added value were the respondents writing: "something entirely different", "added a new layer (but kinda blurry)" and "compliments each other". The added value stated from the twelve others can be categorized in these categories:

Improved spatial feeling (4 respondents): "feeling of height, space"; "adds a dimension"; "better depth"; "much better 3D feeling … different perspective".

Being inside the artwork (5 respondents): "you have truly entered the artworks"; "we are integrated in the work"; "from reading the art to being part of it"; "pulls in the observer as part of the work"; "you're part of it .. different perspective".

Feeling of insignificance in relation to something larger (4 respondents): "it makes you feel small and not important. You are just a small piece of a big pie"; "Massive, kinda scary. It feels like I'm being part of a cell"; "I felt small"; "I feel the scenes focus on that I am only a small part of an infinitely large universe"[2]. Other sorts of additional contribution not categorized were "good added value"[3]; "much more vivid"

For question 4, "Do you think the scenes capture the spatial experience of the original scenes?", 14 out of 15 respondents answered positively, where four of these stated that it was even better. The only respondent answering negatively stated: "Not quite. In the original it seems like the viewer has a lot more in a fisheye perspective". The perspective is indeed different and more exaggerated in the original Selvportrett work, however we decided not to use it as the unnatural fish-eye lens perspective distortion combined with interactive change of viewpoint reduced realism and had a nauseatic effect. The answers show that the spatial experience is at least as good or better than in the original work and this further supports the observation of improved spatial feeling from question 3. In retrospect, we see that this question might have been too narrow as the spatial dimension is only one of the many aspects when observing art.

The answers from Question 2, "What are your initial impressions of the scenes?" can be categorized into that of feeling small and unimportant as already discussed, feeling dizzy or vertigo and the following generic positive feedback: "Interesting and fascinating"[4]; "very realistic despite the simplicity"; "huge, large space"; "Well thought out and executed"; "Very impressive"; "Properly executed"[5]; "very exiting", "Impressive and describing"[6]; "interesting".

It is evident from both immediate oral response, and written response, that a viewer of our VR scenes is transported to an active viewing position inside the artwork. This active viewing position brings a different perspective on the art, and can help an artist invoke emotions, such as that of feeling insignificant and small. Feelings of space, scale, and movement are transmitted well in VR. The responders were also in general very positive to our VR works. The respondents stated that the VR version closely resembled the original art when seen from the original viewpoint. We do however not to show comparison images in the article due to copyrights.

Research question 2. Is VR suited as a medium for expressing art?

Questions 5-7 were used to shed light on research question 2. For question 5, "Do you think virtual reality changes the possibilities in artistic expression?**", 12 out of 15

Original quotes: [1]*«dra inn betrakter som ein del av verket. [2]«eg føler at scenene fokuserer på at eg berre er ein liten del i eit uendelig stort univers» [3]«god merverdi». [4]"Interessant og fascinerende" [5]"Fullført skikkelig" [6]"Imponerende og beskrivende"*

answered yes, 2 answered maybe, where one stated "maybe. It will give a new dimension and experience so that you can find new ways.", and one answered blank. Responders that also gave additional information stated: "I think the future will be exciting"[7]; "opens up new worlds of opportunities never ever imagined before"; "new mode of expression"; "It will come to people directly"; "It will give a new dimension and experience so that you can find new ways."; "Definitely, but also makes you depend on more tools like cables, glasses, pc etc."; "VR does exactly this by moving the observer from a static position to an almost active role in the work. This gives the audience a completely different role, so yes! I think VR will change the expression dramatically."[8]; "Yes you can do things that otherwise would be impossible. (Would have been even cooler with sound)"[9]; "Yep! It will not replace anything but creates a different kind of artistic expression". The respondents answered very positively and pointed out that VR expands the possibility of artistic expression.

Question 6, "Do you use, or do you think you will use VR tools to create art? If so, why?" received five yes answers, three maybe answers and five no answers. One answered "Not me, but my students" and one answered blank. One responding no, stated he did not like digital art and that he got dizzy, another pointed out the need for cables and setup: "Personally, no, I neither have the tools or the knowledge or the motivation to". This was also pointed out by another in question 4: "makes you depend on more tools like cables, glasses, pc etc.". Equally many answered yes as no. Two answering no pointed out the need for equipment and one didn't like digital art. It is probably natural to be critical to using a technique for creating art that one is not trained in. As demonstrated in this paper, it is not trivial to create custom VR experiences. Knowledge of programming, computer graphics and mathematics is required. When simpler content-creation tools and equipment will be available, it is possible that the adoption in arts will be higher. This view is also expressed by one of the responders: «This is still relatively new and for a special interest group. In my opinion the possibilities and use of VR will explode and become a natural way to communicate and interact with each other»[10]

Question 7, "What do you think my role is in this production, am I an artist?" received two yes answers, four answers that could be categorized as maybe ("yes and no"; "kinda half way"; "not sure"; "somehow"[11]), eight no answers, and one blank answer. Responders answering no, argued that the VR work is not original but derived from existing art. This may implicitly indicate that the respondents would have answered yes if the VR work was original and that they therefore do consider VR as a medium for expressing art. Some responders stated this explicitly. One of the two respondents answering yes, argued that although the work is a copy, the result is sufficiently different to consider the creator an artist. The other respondent answering yes stated" Well yeah, isn't all art about imitation? To give form to a shape where there was none? To create is to be a creator and that is to be an artist, coding or not.". As we know, there are many definitions of what art is. To create the VR artwork, we had to do a certain degree of creative work as opposed to only performing a mechanic and methodical translation. A 2D figurative drawing is a projection of an underlying 3D scene. The VR creator had to reproject the 2D drawing into 3D. Also, he had to decide on what should exist behind the viewer in case the viewer rotates 180 degrees. For the second artwork he had to decide

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Original quotes: [7] *"Tror vi går en spennende tid i møte"* [8] *"VR gjer nettopp dette med å forflytte betrakter frå ei statisk stilling til ei nesten aktiv rolle i verket. Dette gjer at ein får ei heilt anna rolle som publikum, så ja! Eg trur VR endrar uttrykka ganske så voldsomt"* [9] *"Ja du kan gjøre ting som vanligvis ville vært umulig. (Hadde blitt enda kulere med lyd)"* [10] *«Ennå er dette relativt nytt og for en spesielt interessert gruppe. Etter min mening kommer mulighetene og bruken at VR til å eksplodere og bli en naturlig del i hvordan vi kommer til å kommunisere og samhandle med hverandre»* [11] *"på sett og vis"* [12] *"Et sterkt utrykk som gir en god merverdi til originalverket. Denne form for kunstformidling har et stort potensiale i å formidle kunst til et nytt publikum"*

how animation of the buildings should behave. These can be considered the VR creator's interpretation of the art and may be the reason why respondents stated that the VR version was something more than the original artwork. ("A strong expression that gives added value to the original work. This form of art mediation has a substantial potential in communicating art to a new audience"[12])

For the second research question, we registered enthusiasm and 12 out of 15 respondents stated that VR expands the possibilities in artistic expression. When asked if they use or will use VR, there was an even distribution of opinions with five yes, three maybe, and five no answers. VR is under rapid development, and the responses point towards that when the technology has advanced further, it will become viable for users that are used to more traditional artistic tools. The question "Am I an artist?" received mostly negative response since very little original content was added in the VR version. However, from the answers one can deduce that if the VR work had been more independent from the original work, the producer would be considered as an artist. In conclusion, the answers indicate that the responders do consider VR as an art medium, and as an exciting and promising one.

Discussion and Conclusions

Our user survey showed that VR is able to get a user more involved in a piece of art than when looking at a painting. We also showed that VR is good at representing 3D space and movement. In an interview [26], the VR artist Zakarian summarizes the experience by stating "With VR art people can visit the world in my head instead of looking at it through a window". These findings may not be surprising as they are qualities inherent in the technology itself. More interesting is the open and positive attitudes of the responders regarding art in VR. They find VR to be a fascinating and promising new medium but are reluctant to start using it before it has matured more. Chung, the CEO of a virtual reality film production studio states about VR: "You have to basically define the medium as you go. It's almost like you're trying to create the paintbrush while trying to create a painting." [27]. The VR hardware and software technology are evolving fast, and it is therefore hard to learn something that is still changing. In addition, the art medium has not established its own terminology, visual expression and set of techniques yet and it is complex to use. Zakarian states "I had to teach myself about 12 different programs and extensions and to get intimate with the hardware. It seems a bit crazy, since I could as well hire a team to produce VR art for me like other artists do, but I think a lot of the original vision gets lost when the artist doesn't get their hands dirty." [26]. It is interesting to notice that in VR, the art consumer gets a direct access to an artist's vision, while producing VR art is hard as the artist does not have a very direct access to the medium the art is created in. It is easier to express oneself in a medium one is so trained in that it becomes an extension of oneself, and here VR still has a way to go.

Also, worth pointing out is the additional creative process needed for translating a 2D piece of art into VR. This required more individual decisions than we had anticipated. This process required extending the art and therefore captures an individual interpretation of the art, which may deviate from the artists original vision.

Although not the main topic, an example of the deconstruction of (figurative) art into its geometry and drawing style and the parameterization of each component has been demonstrated in this paper. The parameterization can be considered a capture of the essence of an artwork and opens up for changing the parameters to create variations of the artwork. This aspect was to a larger degree explored in the Master's thesis this work builds on [25]. For most types of figurative art, it can be hard to find parameterizations that facilitate the creation of a 3D model. This is possibly true for art depicting irregular

and organic shapes such as the ones found in nature. However, in the Master's thesis we demonstrated the recreation of the organic effect of Salvador Dali's melting watches by using soft-body physics simulation in real-time through NVIDIA's FleX simulator. This enabled us also to interact and touch the watches in VR while they behaved as thick cloth-like objects.

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