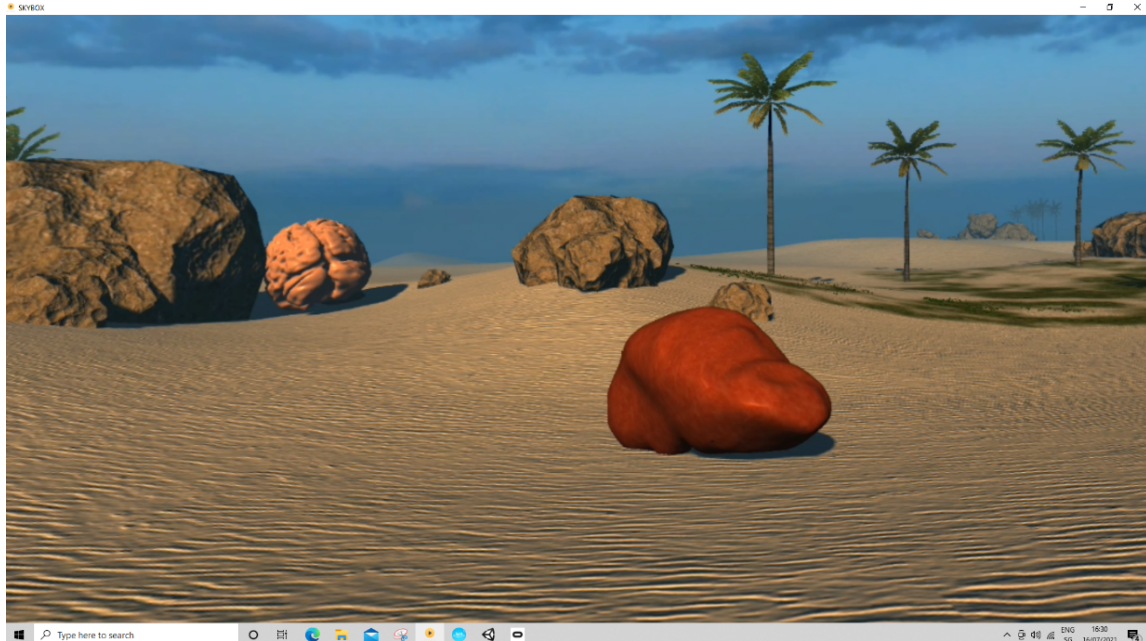


## Capturing a VR-executable as a 360-degree video. A test report.



Screenshot of the capture of *We were looking for ourselves in each other* by Mélodie Mousset (2015)

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## Introduction

This project was inspired by the “Preservation of Immersive Media Group”<sup>1</sup> and it was carried out as a yearly case study of HEK (House of Electronic Arts) in Basel. In 2017, the House of Electronic Arts in Basel acquired the VR-based artwork *We were looking for ourselves in each other* by Mélodie Mousset (2015), short *Organ Island*. The artwork was shown with a VR-headset and a controller in the past. The visitor moves in a virtual space that consists of a circular island with palm trees and beaches. In the beginning, about 10 human organs such as liver and kidneys, larger than human beings, are falling from the sky. The visitor can walk around the island, enter the organs, and explore them. It is possible to walk into the sea and continue the walk under the water surface and visit the one organ that fell into the sea.

The House of Electronic Arts acquired the work as an executable file. The game engine project files do not exist any longer. As a migration to newer or different soft- and hardware is not possible without the game engine project, it was decided to try to make a 360-degree video. This report documents the procedure and experiences when capturing the 360-degree video.

## Goal

A 360-degree video is a walkthrough through the virtual space, where the route is predetermined. The visitor wearing the VR-headset can look around and see what is above, underneath and to the right and left of the route. 360-degree videos are better transferable to different hardware gaming platforms than a VR executable as they are just video data<sup>2</sup>. Furthermore, the chance that the 360-degree video can be played back on future, more modern VR-headsets is regarded as higher than with a VR executable. Finally, a 360-degree video is closer to the VR experience than a screen recording. Thus, the goal of this project is to produce a 360-degree video of *Organ Island* that could represent the artwork, in case there was no solution in the future to run old VR games or artworks.

## Preparation

*Organ Island* was created with a Unity game engine. According to the paper “Preserving Virtual Reality Artworks”<sup>3</sup> by Tom Ensom and Jack McConchie, 360-degree videos can be exported from a game engine. As the game project does not exist any longer this option was not available. After a search on the internet, Tim Marti, technician at HEK found a promising software, “Surreal Capture”, that we tested. Surreal Capture can capture 360-degree videos from games that are made with Unreal Engine 4, 5 or Unity without the game engine project files.

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<sup>1</sup> <https://groups.io/g/pimg/>

<sup>2</sup> Ensom, McConchie (2020). White paper “Preserving Virtual Reality Artworks”, draft. P. 26

<sup>3</sup> Ensom, McConchie (2020). White paper “Preserving Virtual Reality Artworks”, draft. P. 26

Organ Island is made for Oculus Rift. When HEK acquired the work the first consumer version of the headset was current (s. figure 1). The same headset was used to make the capture. Its video resolution is 1080×1200 per eye.



Figure 1: Oculus Rift, first consumer version (CV1). Image source: Wikipedia<sup>4</sup>

Organ Island ran on a Windows7 PC. For the capture we used a Windows 10 PC (CPU: Intel® Core™ i7-6700K @ 4.00GHz, GPU Nvidia GeForce RTX 3060) and a 1920x1080 flat screen. As the Organ Island executable is dependent on the screen resolution (and not the resolution of the VR-headset), we used a second HDMI connector that “pretends” to be a 4K monitor (s. figure 2) as we did not have a 4K monitor at our disposal. This allows the capture of up to 4K resolutions.

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<sup>4</sup> <https://commons.wikimedia.org/wiki/File:Oculus-Rift-CV1-Headset-Back.jpg#/media/File:Oculus-Rift-CV1-Headset-Back.jpg> accessed 2021/08/26

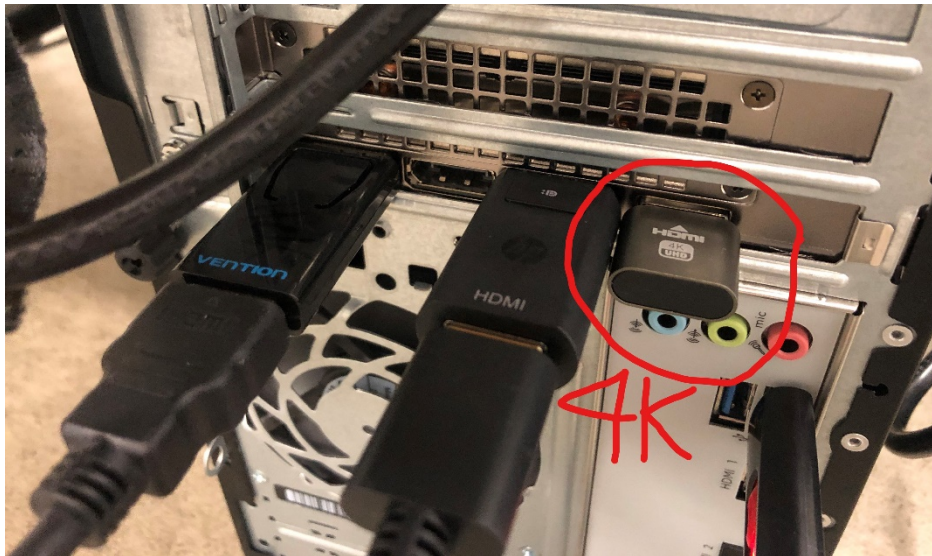


Figure 2: Use of a 4K HDMI connector that fakes a 4K monitor (“dummy plug” s. photo). The other HDMI connectors are for the headset and the monitor.

### 360-degree video capture

The Surreal software<sup>5</sup> can be downloaded as a trial version that works for two weeks. Otherwise, a license has to be purchased for 150 Dollars. We worked with version 1.03.34.

The following elements can be manipulated for the capture of a VR-work:

- Capture software options
- Game (Organ Island) options
- Navigation / selection of route and actions within the game
- Hardware (performance of CPU, graphics card, RAM and drive speed)

We did not change the computer hardware for the recording and the playback. Hence, we cannot make any statements regarding the influence of faster or slower hardware.

### Surreal Capture software options

Surreal Capture<sup>6</sup> offers the following capturing options:

- Target resolution (maximum is screen resolution, the video is shown on when captured)
- Frame rate
- 2D or 3D (stereoscopic)
- Quality of video rendering (good, better, best)

<sup>5</sup> <https://www.surrealcapture.com/> accessed 2021/07/19

<sup>6</sup> <https://www.surrealcapture.com/> accessed 2021/07/19

- Camera direction: Camera follows head direction / fixed camera direction, etc.  
**Camera faces fixed player's initial eye direction:** this option reduces the head movement. The camera faces the same direction, no matter, in which direction the visitor (capturer) is walking.  
**Camera follows player's eye direction (Yaw only):** if this option is selected, the camera follows the direction the viewer is facing (if the viewer turns the head, the camera turns with it).
- Camera position: Camera stays at starting point / camera follows player's position

### Game (Organ Island) settings

Organ Island allows to select the rendering resolution and the rendering quality. The options appear when Organ Island is started.

- Source resolution: from 320x200 to 1920x1080 if the HD screen is connected. When a higher resolution screen is connected, the max resolution corresponds to this higher resolution.
- Graphics quality ranges from Simple to Fantastic as follows:
  - Fastest and fast:* No shadows, very pixelated
  - Simple:* Including shadows, very pixelated
  - Good:* Very blurry shadows, less pixelated
  - Beautiful:* Between blurry and sharp shadows
  - Fantastic:* With sharp shadows

### Navigation / selection of route and actions

The navigation within the game is based on curatorial decisions. The person navigating needs to know the virtual space well, the hidden treasures, easter eggs and important places. A story has to be shaped. As virtual spaces tend to offer many layers and options to choose, several stories could be told by capturing several videos.

### Audio capture

The audio is recorded per default. However, it has to be made sure that the "Headphone (Rift) Audio" is selected in the Windows OS (taskbar on the bottom) to record the in-game-audio.

### Playback

To check the quality of the captured videos, we viewed them with the Skybox VR player. The Skybox VR player can be downloaded on several VR platforms. With this setup, the video can be viewed for example with an Oculus Rift headset.

We viewed up to 4K x 8K videos with the Skybox VR player and the Oculus Rift CV1 headset. If the image is distorted, the "360-degree video mode" has to be selected (sometimes Skybox does not recognize the 360-degree mode automatically). Skybox

can be installed on several VR-platforms such as Oculus Quest, HP Reverb and Valve Index (Steam).

The VLC media player can also play back 360-degree videos. We tested it with a 1920x1080 flat screen<sup>7</sup>. Videos with resolutions up to 3160x7320 played back perfectly on the screen. The viewer can pan through the video with the mouse and view things that are not in the direct field of vision. With the presentation of the video on a screen the visitor does not experience motion sickness. We were not able to playback a 4K x 8K video with VLC.

### **Playback with different VR-headsets**

We did not test different VR-headsets to capture or view 360-degree videos.

### **Playback with different video players**

There are other video players that can play back 360-degree videos such as the open-source player Whirligig<sup>8</sup>, VR Player and Opera VR Player. We did not test them, either.

## **Assessment / Results**

This project does not evaluate the possible parameters and the captured videos systematically. The report is rather a documentation of the process how we got to the end result of a captured 360-degree video that seemed good enough for presentation. It would be nice if it helped others who intend to make such a 360-degree video of their VR-works.

It was quite difficult to evaluate the influence of the single parameters on the quality of the video, as, wearing a VR-headset, a direct comparison (side to side) of videos is not possible. For direct comparisons, we made screenshots. However, as we did not have a 4K screen, but only 4K HDMI connector, we had to make the screenshots on the HD screen. Hence, the resolution of the screenshots was scaled down. Another issue was that one does each time a different walk and the screenshot depict never exactly the same scenery. To avoid this one would have to record the sensor (navigation) data and replay it while wearing the headset.

### **Quality of video and audio recording**

A main result of this project was that we were able to create a 360-degree video out of a VR-executable based on Oculus without using the game project. The 360-degree video has a reasonable quality, although it is not as good as the direct rendering of the game. The resolution is visibly lower. We also noticed that there were sudden 180-degree direction changes, which were quite annoying. We are not sure whether this

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<sup>7</sup> Whether VLC can be used to playback 360-degree videos with a VR-headset we do not know.

<sup>8</sup> <http://www.whirligig.xyz/> accessed July 2021

happens only during the capturing process or whether this is a problem of Organ Island.

When diving into the lake and walking under the water surface, the captured version contains strange artefacts: The lake surface seems to have the shape of a cube and some parts of the lake surface are pixelated (s. figure 3).

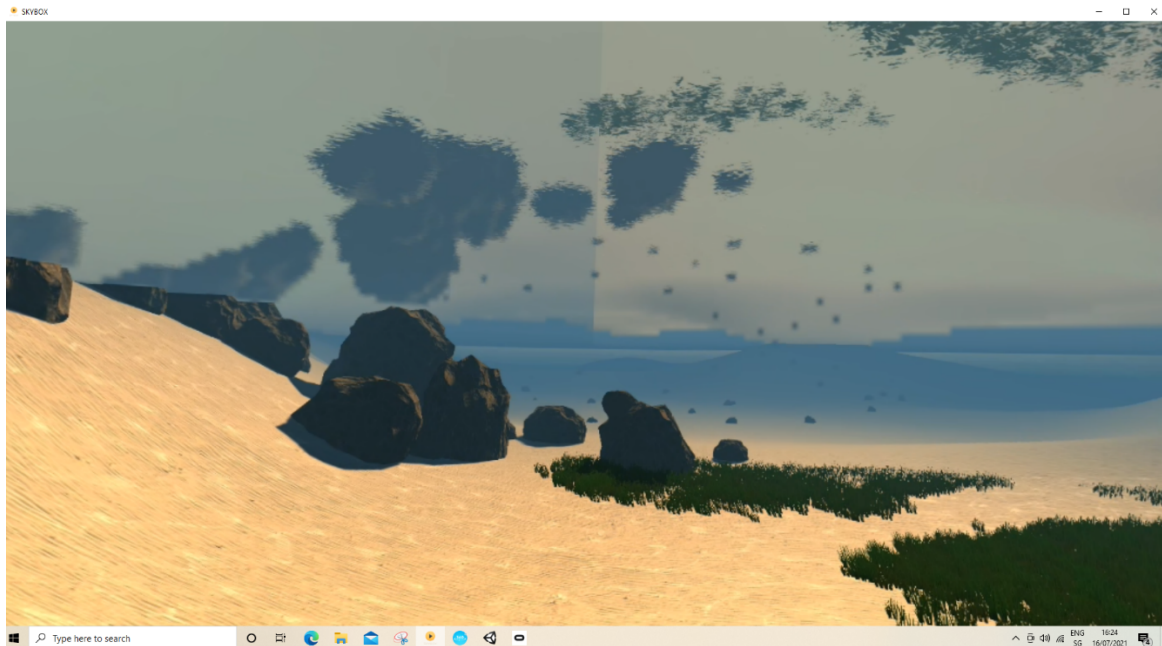


Figure 3: Screenshot of the capture *Organ Island*, landscape below the water surface. The capture shows artefacts like the vertical and pixelated horizontal line in the landscape that is mirrored on the water surface.

The captured video was recorded with the following settings and has the following technical characteristics:

Surreal Capture parameters:

capture mode: 2D (not stereoscopic), height of target video 3160 pixels, 30 frames per second, video quality: better, camera follows players eye (yaw only), camera follows player's position

Organ Island parameters:

screen resolution: 2560x1440, graphics quality: fantastic

This resulted in a 360-degree video, wrapped in mp4 and encoded in H.265, resolution 6320x3160, length 13 min 28 sec, 30 frames per second, size 16.6 GB, audio codec AAC Low Complexity.



According to the White Paper about the preservation of VR-works<sup>9</sup>, *a byproduct of bypassing the normal fixed field-of-view player camera is that certain ‘screen space’ visual effects will not be captured (e.g. vignetting, light shafts, motion blur)*<sup>26</sup>. As we did not specifically pay attention to these effects, we do not know whether these effects are missing in the captures of *Organ Island*.

The audio is recorded in stereo. There were no audio options in the Surreal Capture trial version. The white noise sounds of the captured audio sounded a bit rougher than the ones of the original *Organ Island*.

The choice of resolution and frame rate is discussed in the following sections.

### Selection of Surreal Capture software options

The 4K resolution definitely delivered the sharpest and best-defined images. However, the file size of the video became huge and the digital player on the same computer had difficulties to play it back smoothly. We also had the impression that these high resolutions made the visitor watching the video sicker than with lower resolution. However, this is not an objective observation, other influences such as the delayed playback might have caused it. Hence, we strived for a compromise between high resolution and good playback and chose 3160 pixels as the video height, which was the second highest option (4K was the highest, s. chapter “Preparation”).

We did not investigate the differences between the video quality settings “good”, “better”, “best”. Hence, we selected “better” as a middle value.

Higher frame rates than 30 fps produced proportionally larger video files and did not improve the playback much. Consequently, we did not increase the frame rate.

The stereoscopic capture (3D) did not bring any additional benefits compared to the 2D (360-degree video) capture. It creates two images next to each other to achieve a stereoscopic effect (Stereoscopic SBS (side by side) video capture). It reduced the resolution and increased the file size significantly but did not look more like the original *Organ Island* (directly rendered from the executable, not captured) than the 2D capture.

We experimented a bit with the camera direction, as a fixed camera direction makes the visitor/viewer less sick. However, this seemed slightly boring and unnatural. The visitor would have to turn around, for instance when the camera navigates backwards. We preferred very slow head movements to change the direction of the camera. Thus, we chose the setting “camera follows players eye (yaw only)”. For this setting, it is necessary to wear the VR-headset to navigate<sup>10</sup>.

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<sup>9</sup> Ensom, McConchie (2020). White paper “Preserving Virtual Reality Artworks”, draft 2020. P. 26

<sup>10</sup> For the setting “Fixed camera direction” it would be possible to navigate based on the screen without VR-headset, as the head movements are not relevant for this setting.

### Selection of Game (Organ Island) settings

The Surreal Capture software suggested to not run the game with the highest graphical rendering options, as the capture might result in jerky videos. When we checked the options directly from the executable, we realised that the quality of the executable output would be significantly compromised (for instance no object shadows) if we selected graphics quality lower than “fantastic” (s. section “Game (Organ Island) settings”). Hence, we selected “fantastic” although it was not recommended.

In order to allow a rendering with a high resolution we connected a 4K HDMI plug which pretended to be a 4K screen (s. section “preparation”). We finally selected a resolution of 2560x1440 as a compromise that allows the software to capture enough video data so that it can be played back smoothly later.

### Experiences with navigation and selection of a route and actions

On the one hand, the navigation was tricky from a “movement” point of view. Fast head movements lead to 360-degree videos that made people sick when watching. Fast movements in general were not so beautifully captured. Hence, it was better to move slowly and keep the head movements to a minimum while capturing (s. also section “Selection of Surreal Capture software options”). These slow movements have to be practised.

The most important challenge is to choose a route out of an unlimited number of possibilities. As described in the introduction, about 10 organs are falling from the sky in the beginning. We took a route that gave an overview of the location of the organs and of the island. It led to the sea and allowed a stroll under water where another organ is discovered. Above the water, one organ, the brain, was inspected more closely. The visitor enters the brain and experiences the structure inside the brain. The walk ends on a hill where the visitor can oversee the island and the sea. Evidently, other routes could be chosen and other versions of 360-degree video of Organ Island produced. As the visitor has probably less patience to follow a given walkthrough than exploring the space on his/her own, it is an option to create several shorter 360-degree videos with different routes and let the visitor choose which route to follow.

### Conclusions

The 360-degree video capture of a VR-executable worked. It is technically not perfect, but surprisingly good. Time needs to be factored in to select the right recording parameters, to figure out one or several routes that make sense to the viewer and to practice the movements and actions that are to be recorded.

It was not obvious to us how the Organ Island executable transforms the selected Organ Island resolution settings into an image and projects it on the VR-headset and how the capture software transforms/extrapolates/compresses the executable output into a video of a chosen resolution. Neither was it clear to us, what data the capture

software receives from the headset, whether it only receives the sensor data (movement and position of the head), or whether the optics of the headset also play into it. Hence, it is possible that there are better settings than the ones we chose. Besides the lack of understanding how the executable and the capture software work, we did not have enough time to systematically explore the influences of all the parameters and their combinations.

We only found one software, Surreal Capture, that was able to capture a 360-degree video of a VR executable. This software is not open source. We don't know whether there are other softwares that can capture 360-degree videos from an executable. We asked this question in the "Preservation of Immersive Media" group and in the time-based-media group of the AIC (American Institute of Conservation) and did not receive a response. Hence, relying on Surreal Capture entails a certain risk that they might not maintain their software in the future. It is therefore recommended to ask for a 3D-walkthrough of a VR piece at the time of acquisition. This also brings the advantage that the artists choose what locations and actions are important to them and they can export the walkthrough directly from their game engine without a loss of quality.

We did not research the sustainability of the 360-degree video file format and how big the chance is that the videos will still be compatible with future VR-headsets or other types of VR-presentations. However, the 360-degree video is more hardware independent than the VR-executable and the fact that it can be played back with the open-source-based VLC-media player is very positive.

## Feedback

We are happy to receive feedback and information about other people's experiences with the capture of VR-executables.

## Acknowledgment

The project was funded by the House of Electronic Arts. We also want to thank the Preservation of Immersive Media Group for their work on the preservation of VR-based artworks that inspired us for this project.