Exploration of mixed reality tools in education and development of a best practice guide

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1. Introduction

The democratization of mixed reality and the arrival of several qualitative glasses on the market offer a whole new field of exploration in education. The interaction between real and digital space has never been so close.

Thanks to the ergonomics of the medium, the whole body is free to interact with its environment for an experience with a minimum of constraint. Accompaniment, coaching, gamification and many other subjects are to be explored.

We believe that this technology offers many possibilities, for example:
- Education through contextual and playful experiences.
- Simulation of complex scenarios.

This guide documents our learnings and main takeaways from using these technologies through the 2021-2022 spring semester.

It aims to give practical insights into creating hands-on experiences with these headsets for developing art and design education tools or projects.

Readers can gain a good understanding of the possibilities and limitations of the technologies, although more research is needed to establish objective comparisons between these methods and others.

It discusses the key features, development environments, complementary technologies, and essential know-how. The guide ends with practical case studies to highlight concrete outcomes.

This document aims to provide an overview of the appropriate applications, possibilities, and challenges of applying these technologies in the context of art and design education, ranging from creating virtual experiences, to prototyping physical exhibition layouts to creating interactive guides for specialized tools or machinery.

You can see only the Real World

You can see the Real World "Plus"

You can no longer see the Real World

REAL WORLD

COMPUTER GENERATED WORLD

Real (Physical) Environment

Augmented Reality (AR)

Augmented Virtuality (AV)

Virtual Reality (Virtual Environment) (VR)

Mixed Reality (MR)
(Blend of Physical and Virtual Environments)

The reality spectrum. Adapted from the simplified representation of a 'virtuality continuum' (Milgram & Kishino, 1994, p.3) and immersive computing spectrum (Joyce, 2018)

2. Definitions and context

Mixed reality technologies can be defined on a "virtuality continuum." This guide focuses on the use of Mixed Reality in a predefined environment, specifically focusing on the Hololens 2 and Magic Leap head-mounted displays.

Microsoft Hololens 2/ Source: Microsoft

Magic Leap One/ Source: Magic Leap

Google Map's AR waypoint system. Source: accessed June 30, 2022, https://medialist.info/2019/05/12/google-maps-ar-navigation-mittels-augmented-reality/.

3.   Mixed reality technology choice

3.1.   Holographic Head-Mounted Displays

A holographic augmented reality head-mounted display is a type of wearable computer that allows users to see virtual objects in the real world. The device typically includes a head-up display (HUD) and a tracking system that tracks the user's head movements. The HUD projects images onto the user's field of view, while the tracking system ensures that the images are correctly aligned with the real world.

Amongst the currently available holographic headsets, this document focuses on some of the most popular commercially available options, the *Magic Leap* and the Microsoft *Hololens 2*. The two devices share various features in common, which likely sets a standard of essential components for future devices.

There are a few advantages of head-mounted displays (HMDs) compared to handheld augmented reality (AR) displays. First, HMDs provide a more immersive experience since they cover a larger field of view. Additionally, HMDs can be easier to use since the user's hands are free to interact with the virtual content. Finally, HMDs tend to be more accurate since they are tracking the user's head movements rather than hand movements.

Limitations include

*   Limited field of view: holograms cannot cover the entirety of the view and are therefore clipped when appearing outside the projection rectangle. Applications need to adapt to these constraints.

*   Prohibitive cost: the Magic Leap was purchased for 2'300 CHF and the Microsoft Hololens for 4'100 CHF at the time of writing

*   Compared to smartphone enabled augmented reality development kits, resources and examples are limited

3.2.   Smartphone based augmented reality

Smartphone AR is typically delivered through a phone's camera and screen via an AR app. The apps use the phone's various sensors (accelerometer, gyroscope, GPS, lidar, etc.) to track the phone's position and orientation in the world so that the computer-generated graphics can be correctly placed.

The augmented-reality experience can vary greatly from device to device because of the different hardware present on each type of smartphone. For example, newer smartphones tend to have better processors and more RAM and specialised hardware such as LIDAR, which can lead to a smoother and more realistic augmented-reality experience. Additionally, the quality of the camera on a smartphone can also affect the augmented-reality experience, with higher-quality cameras providing a more realistic and detailed view of the virtual objects being displayed.

While augmented reality interaction on a phone can be interesting, it is ultimately less immersive than other forms of interaction because it is through a 2D screen. This means that users are not able to fully immerse themselves in the experience, and are instead limited to the size and resolution of their phone's screen. Additionally, the use of gestures and other forms of input can be more challenging to perform on a phone's small screen, making the overall experience less user-friendly.

It has the advantage of being run on readily available smartphones and can be easily distributed through app stores. This means that users do not need to purchase any special equipment to use augmented reality applications.

They can also be distributed via social media platforms in the form of filters, but necessitate them to be developed via their proprietary tools. For example, SparkAR lets developers create AR filters and effects for the Facebook app, while Snapchat's Lens Studio enables anyone to create AR Lenses for Snapchat.

The main advantage of these platforms for distribution is the ease and speed with which they can be made available. However, this is also a major disadvantage, as the experiences are limited by the platform on which they are created. For example, Snapchat filters can only be created using Snapchat's own tools, and are limited to a maximum size of 8 MB and 150 MB RAM usage.

3.3. Virtual reality

Virtual reality can be a beneficial alternative to augmented reality in situations where it is impossible or impractical to be on location. For example, suppose one wanted to plan an exhibition in a specific place but could not physically be there. In that case, virtual reality could be used to give them a realistic view of the scene and quickly explore different scenography options.

Simulating an environment in virtual reality has many advantages over other methods like creating paper scale-models. First, it is much more immersive and realistic, allowing users to make better sense of the space. Second, it is more efficient, as users can make changes and try different options quickly and easily. Finally, it is more flexible, as users can add or remove elements as they see fit.

However, virtual reality simulations require an accurate 3D model representation of the space, which can be time-consuming and expensive to create. The experience is entirely reliant on the accuracy of the virtual world, compared to AR, where the real world is used as a reference. However, once created, it has the advantages of being able to be reused for different purposes, such as 3D renders for communication purposes or can be used over and over again for other VR simulations set in that space.

The advantage of using VR over AR is that it can be easily coupled to a powerful computer, thus necessitating less work on optimisation and making it less likely that users will experience performance-related issues such as lag.

Students trying a VR experience developed during a workshop at ECAL. Photo: ECAL/Robin Bervini

4.   Existing applications

Both the *Magic Leap* and the Microsoft *Hololens 2* offer dedicated app stores with a limited number of applications, which suggests that enterprise users develop custom applications.

The most time-effective way to visualize 3D objects in space with a holographic headset is to use a 3D model visualizing app. By uploading the 3D models to the headset, users can use an app to place the models in space and scale them for inspection. Here are some apps we tested for the Hololens 2: Fologram[1], Sketchup Viewer[2], glTF viewer[3] and IF 3D Viewer[4], between which we recommend IF 3D Viewer.

Aside from this use case, we did not find any cost-effective applications that offered significant advantages over creating custom applications. We suggest directly developing bespoke applications using one of the available development environments.

1   2   3   4
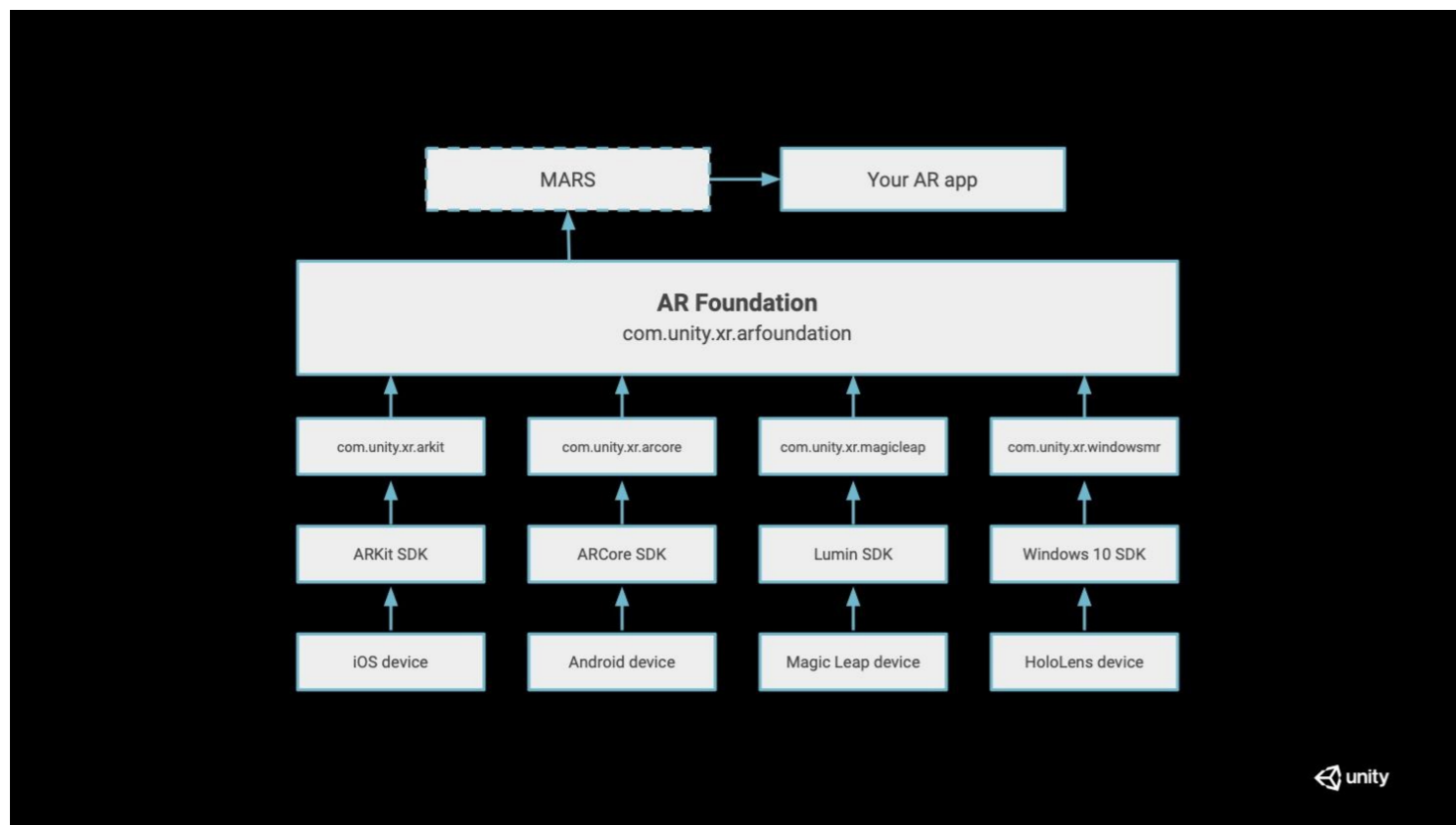
[1] https://fologram.com/
[2] https://www.microsoft.com/en-us/p/sketchup-viewer/9ngf868jkvm3?activetab=pivot:overviewtab
[3] https://www.microsoft.com/en-us/p/gltf-viewer/9mwmgknx8fkh?activetab=pivot:overviewtab
[4] https://www.immersiveform.com/products/if-3d-viewer

A 3D model being manipulated in AR space with IF 3D Viewer. Captured on Hololens 2.
All links Last accessed 4 July 2022.

5.   Development options

The major vendors offer software development kits for their headsets, *Lumin SDK* for Magic Leap's Lumin OS and *Microsoft Reality Toolkit (MRTK)* to interact with the Windows 10 Mixed Reality platform in the case of Hololens devices.

The extensive use of 3D content makes the game engines Unity or Unreal Engine the main recommended tools for authoring applications. Development SDKs are compatible with both game engines.

5.1.   Unity Engine

Unity is a popular game engine widely used by independent developers based on the C# programming language. Thanks to this engine's several tools and features, it is possible to create 3D environments for video games and immersive and interactive experiences. Many AR and VR apps are developed in Unity due to its flexibility, support for multiple platforms, and accessibility.

5.2.   Unity MARS

Unity MARS is a powerful tool for simulating realistic environments and scenarios. It is used by professionals in various fields, such as game development, architecture, and product design. The cost of Unity MARS at the time of writing is $600 per year.

Problem-solving with Unity MARS is quite challenging, as encountered bugs are reported in a more obscure way than it happens with the base Unity engine, but the power and unique features of it are the constraint-based anchors/proxies that make it an interesting candidate for many projects. The «write once, deploy everywhere» nature of Unity MARS makes it a very attractive option for developers who want to create cross-platform applications, although from our experience, we would not recommend it without a deep understanding of coding and project deployment, which are necessary to be able to debug possible errors.

5.3.   Unreal Engine

Unreal Engines is an industry-standard game engine based on C++ programming language but allows the use of the Blueprint visual scripting interface, a simplified and more intuitive way to create game logic unique to the engine. Blueprints are a simplified visual scripting interface that allows users without coding experience to access scripting more intuitively but can become cumbersome when making complex experiences. Unreal Engine's source code is open to the public and accessible via GitHub. There are over 700 plugins on the Unreal Engine marketplace, including dedicated ones to develop for the Hololens 2 and Magic Leap. These allow developers to create applications and games specifically for these platforms.

6.   Modeling the physical space

When creating spatially based scenes for mixed reality, it can be advantageous to create a 3D model of the environment in which the 3D objects will be displayed. It is essential to have an accurate scale and geometric references of the space so that the virtual content can be accurately mapped in the real space.

We discuss different options in the next section.

Screenshots of a gallery space reconstructed in Blender software.
This reconstruction was the first step for an exhibition planning for an upcoming ECAL project.

6.1. 3D scanning smartphone applications

Smartphones or tablets with a LIDAR sensor, such as the iPhone 13, are ideal for rapidly creating to-scale 3D representations. The resulting meshes typically have a large polygon and filesize. They present imperfect surfaces but can be accurate enough for some use cases. Using this method is generally the most time-effective.

Most apps don't perform well on large areas or parts of scans that have to be stitched together. Reflective surfaces can also prove challenging.

We suggest one of the following applications for iOS

- Polycam—LiDAR & 3D Scanner
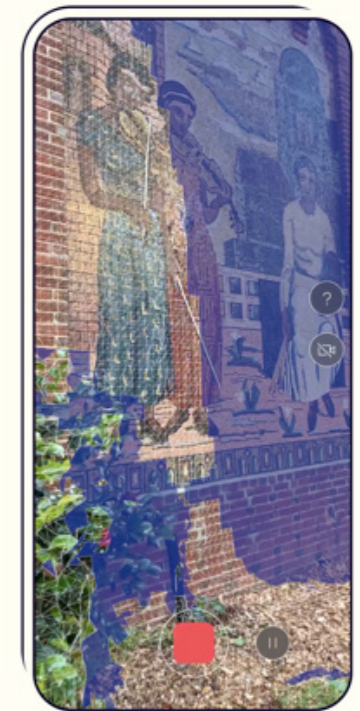- 3d Scanner App™
- Scaniverse—LiDAR 3D Scanner

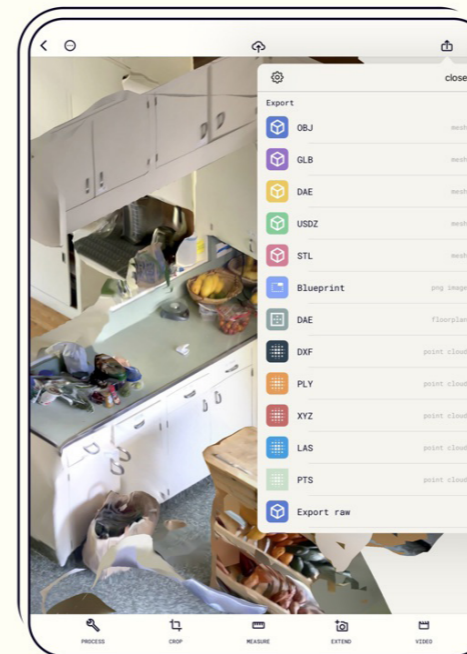**measure**

Grab distances, floorplans and blueprints.

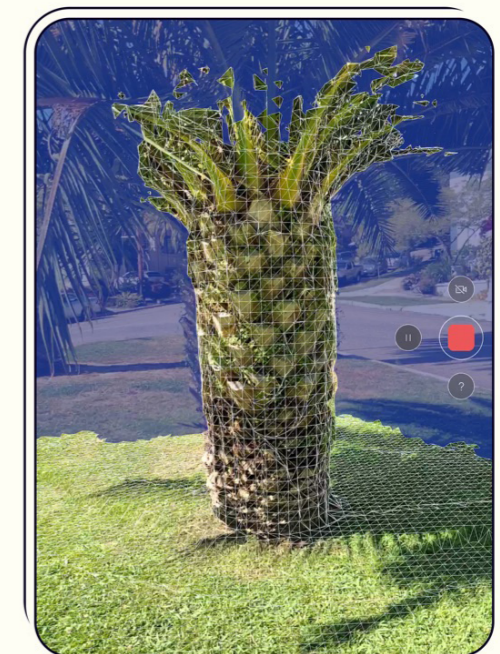**capture**

Instant, accurate 3D.

export

OBJ, DAE, gLTF, and many more.

capture

Instant, accurate 3D.

Polycam interface images. Source: Apple
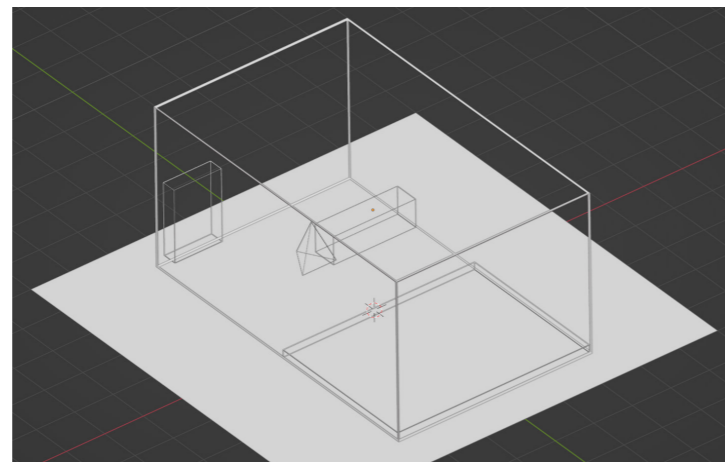
6.2. White boxing

White boxing is a quick and approximative approach to 3D model a space. It consists in a minimal, schematic draft of a space, by placing boxes and planes. The measures of the space can be mesured in real life. Once the space has been white boxed, the second step consists in aligning the 3D model to the space. This model can then be made invisible at runtime, and used in the editor as a placeholder and spatial reference on which to place holograms. In the example below, the white boxing of the room was then rendered as wireframe to be able to overlay it efficiently to match the room by aligning the edges.The following images show different approaches to representing the same room in 3D. The first image is a wireframe model built from measuring the room. The second image is the rough LIDAR scan of the same room, and the third image is a minimal clean up of the LIDAR scan made in Blender.

ECAL Live Room wireframe from whiteboxing
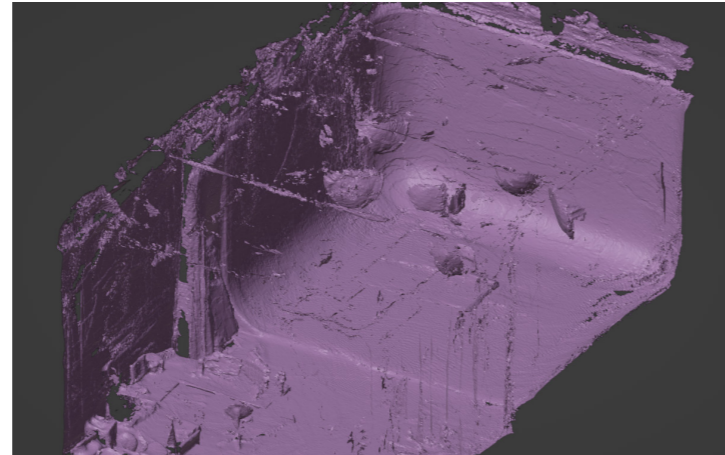
The unprocessed iPhone LIDAR scan of the room
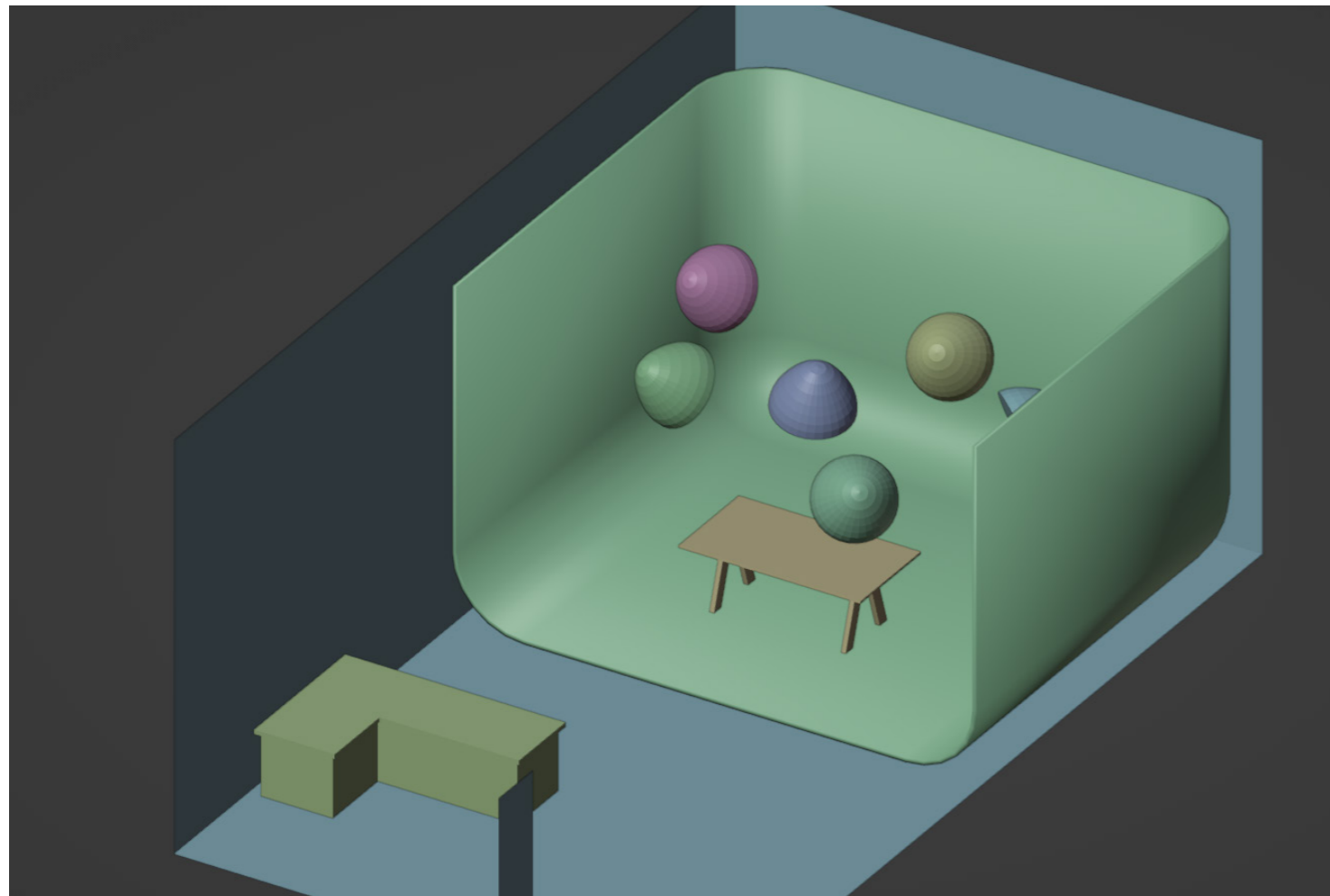
20   A simplified model based on the LIDAR scan.

6.3. High fidelity digital twin

There are times where accessing a space can be impossible or limited, for instance if the space is distant or if there are already exhibitions happening, or ongoing works. The best practice in these cases is to create a high fidelity digital twin on which to extensively prototype and test. A digital twin can be reconstructed with photogrammetry, professional-grade LIDAR scanners or with a device such as Matterport, a a three-dimensional camera system that captures images and creates 3D models of physical spaces. Creating a digital twin from one of the mentioned scanning methods is more time consuming in the making and in the post processing than white boxing, as intensive model optimization is required after capture.

A wide angle photograph of an exhibition space in Milan
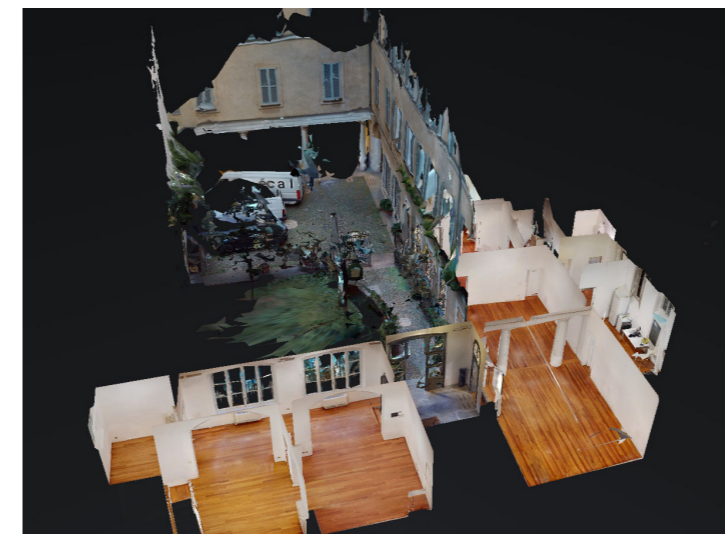
Subsequent 3D reconstruction made with Matterport.
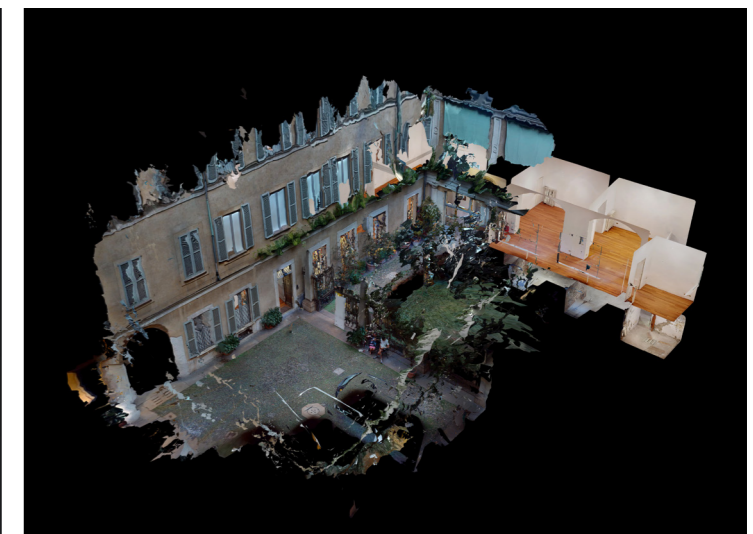
Subsequent 3D reconstruction made with Matterport.   21

7. Aligning virtual content in real space

7.1. Image target

Image targets are an AR technique that allows digital content to be aligned to a physical space. By tracking an image, AR content can be placed in the real world and remain correctly positioned, no matter where the user moves.

When considering what makes a good image target in augmented reality applications, there are a few key factors to keep in mind. Firstly, the image should be easily recognizable and distinctive, so that it can be quickly and accurately detected by the AR system. Secondly, it should be of sufficient size and resolution to allow for reliable tracking and robust recognition. Finally, the image should be textured and have sufficient contrast to allow for effective feature tracking.

A proxy object should be created in the form of an image target inside the 3D model of the space. This will help preview the correct relative position of the image within the real-world environment.

If the headset's position and orientation change suddenly, mainly when the image target is not in the camera range, the headset position in the digital world may offset or drift away from the real-world references. However, the position can be reset by orienting the HMD cameras at the image target again. If the user is using AR in a large environment, they should use multiple image targets to keep the position of individual or groups of holograms aligned with the real world.

As digital objects get larger or move further away from image targets, it becomes more likely that users will notice misalignments. This can negatively affect the overall experience, as it can be disruptive and cause confusion. It is essential to consider this when designing AR experiences, and to take steps to avoid or mitigate these issues.

7.2. Spatial mapping, meshing and anchoring

The headset can map and store a three-dimensional mesh of its surroundings, which is then used to locate itself in specific places. Additionally, this mesh information can be used to occlude holograms or align them on surfaces. This proves helpful for creating spatial-based experiences, such as an application that lets the user place 3D objects in space and have them maintain their position between sessions.

This mapping allows for persistent anchoring of holograms in rooms stored in memory. Both tested devices can map spaces and memorize user-defined positions, called spatial anchors. This information is persisted on the headset and needs to be handled by client applications. With spatial anchors, users can place digital content in real time without creating a separate 3D model representation. The limitation in putting content this way is that a headset needs to be worn again to see the results of the applications, as it is impossible to load these anchors in the editor. Additionally, anchored content cannot be easily shared across different headsets, platforms or technologies.

We recommend this approach if creating a 3D spatial reconstruction is not desirable or the application is used simply in a rapid simulation environment.

Technically, it is recommended to use these anchors sparsely as they are computationally expensive. These anchors are called Persistent Coordinate Frames (PCFs) on Magic Leap. On Hololens 2, these are called spatial anchors.

An image captured from the Hololens 2, showing a wireframe room matching closely the real space. A slight offset is unavoidable when capturing mixed reality images.

Illustrative image of a man using the Hololens.
Source: https://www.heise.de/ct/artikel/Microsoft-HoloLens-im-Test-Tolle-Software-schwaches-Display-3248670.html

8. Interaction options

8.1. Voice commands

Developers can create custom voice commands for their apps. The voice control feature can perform various tasks, such as opening apps, controlling the camera, and even interacting with holograms. Some apps have functions that are only activated by voice control.

There are many potential advantages of creating voice-

 enabled applications. One key benefit is that it can help free up the user's hands while using the device, which can be important when working on tasks that require both hands. Additionally, voice control can help you more easily navigate through menus rapidly and can also be used to input text or commands without using a virtual keyboard.
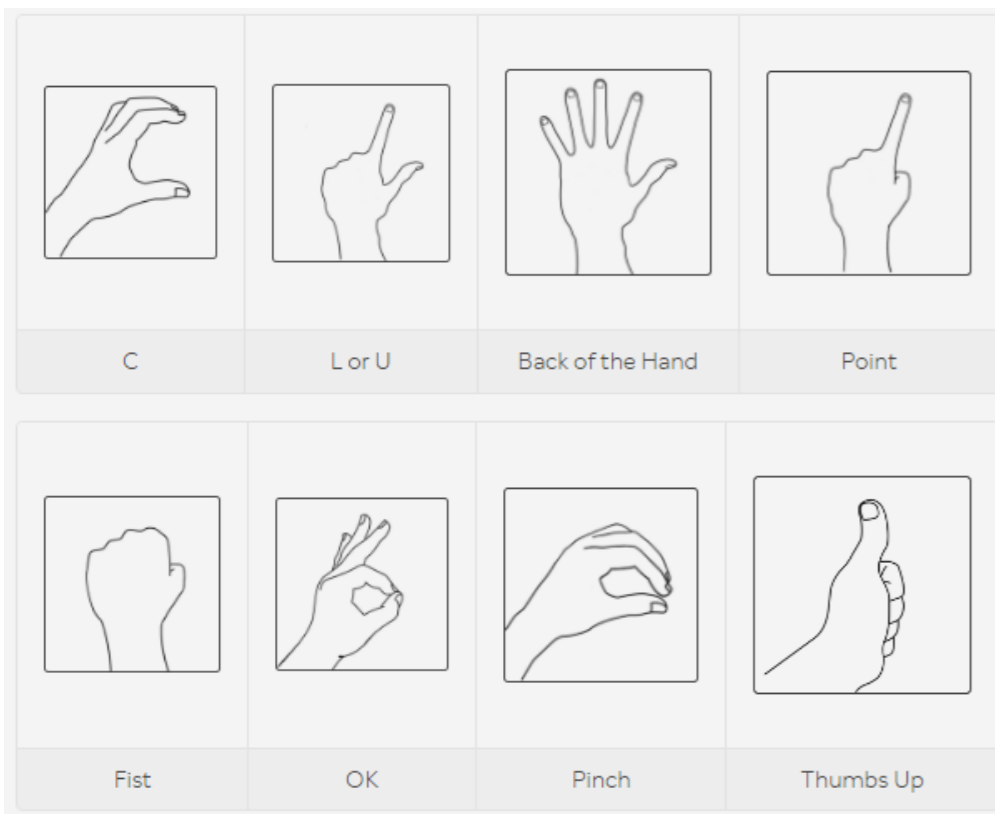
Voice commands can be a quick way to prototype an application as they can be used to control various aspects of the application without needing to build out an entire user interface. This can be useful when there is a need to get a basic prototype up and running in as little time as possible.
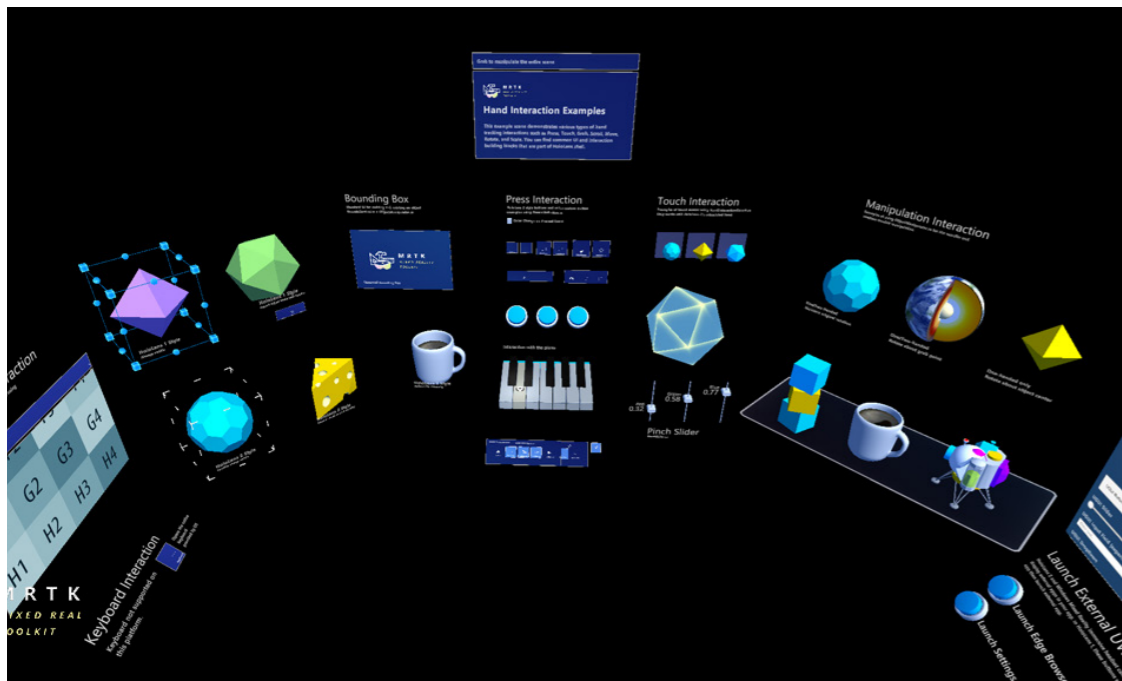
There are a few disadvantages to using voice commands. First, it can be difficult to be heard over the noise of the environment, especially if there are multiple people talking. Second, the voice recognition software can sometimes have difficulty understanding accents or dialects. Finally, voice commands can be easily misinterpreted, leading to incorrect results.

8.2. Hand Tracking & Gestures

Hand tracking allows for a controller-free interaction with the UI and holograms. It works as long as the users' hands are in the field of view of the dedicated cameras. The devices can recognize the hands' orientation, each finger, and several pre-configured gestures, also referred to as key poses. Some example gestures for the Magic Leap are seen in the image below.

Hand tracking is the most intuitive and direct option to move, rotate, resize, and interact with digital 3D objects.

C	L or U	Back of the Hand	Point
Fist	OK	Pinch	Thumbs Up

Magic Leap's standard hand gestures according to official documentation.

Hololens 2 captured image from the demonstrative MRTK sample project streaming from Unreal Engine 4. The demo lays out all type of preset button, slider and interaction graphics that can be tested and easily applied in other projects.

8.3. User interfaces

The user interface on Magic Leap and HoloLens is designed to be familiar and easy for those accustomed to using screen-based interfaces. The icons and menus are laid out in a way similar to what you would find on a smartphone or tablet, and the overall look and feel is similar to that of a traditional computer desktop. However, there are some significant differences to keep in mind. For example, you interact with the interface through gestures and voice commands rather than through touch or mouse input.

They should be avoided in favour of direct interaction with the 3D experience for a few reasons. First, these interfaces are platform-specific, meaning that they can only be used on one type of device. This can make it difficult to port an experience to other devices, such as smartphone AR. Second, these interfaces can be distracting and take away from the immersion of the experience. Third, direct interaction with the 3D experience can provide a more natural and intuitive way to interact with your content.

8.4. Eye-tracking

Inside-facing cameras placed next to the nose rest of the headsets allow for tracking the user's eyes. This tracking is used to measure the eyes' distance to adjust the parallax position of the rendered views for each lens and can also be used to track where the user is watching (gaze tracking) and if their eyes are open or close.

Gaze tracking and blink recognition can be used to interact with UI elements; however, from testing, it was found that using gaze and blink to control holographic interfaces and objects can be fatiguing and imprecise. The accessibility potential is certainly a positive aspect, but otherwise, it doesn't seem like a good solution. Gaze tracking is better suited to highlight UI elements or holograms when looking at them, rather than more active interactions. For creative projects, it can provide a conceptually interesting mechanic.
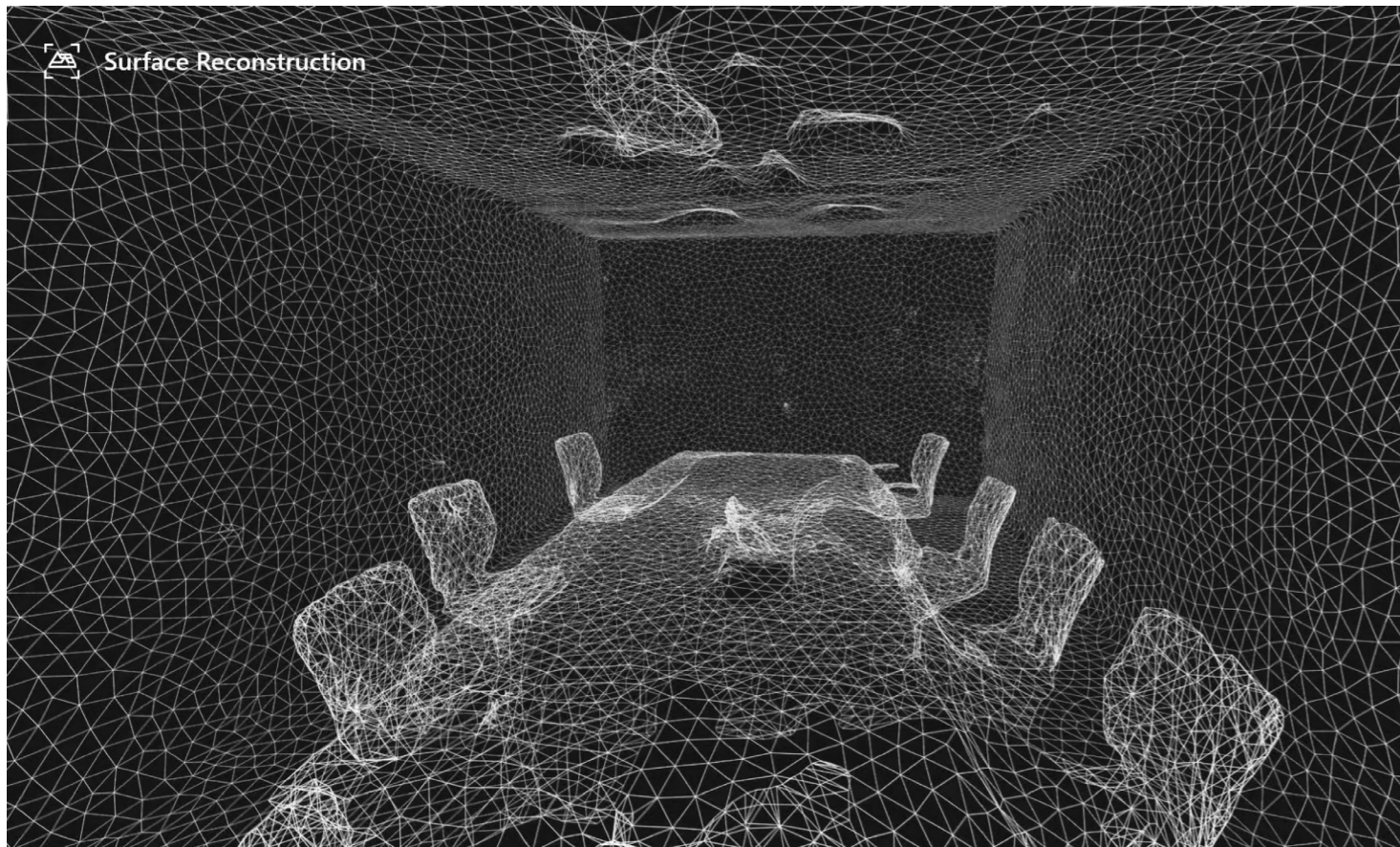
Magic Leap's surface reconstruction of an office room.
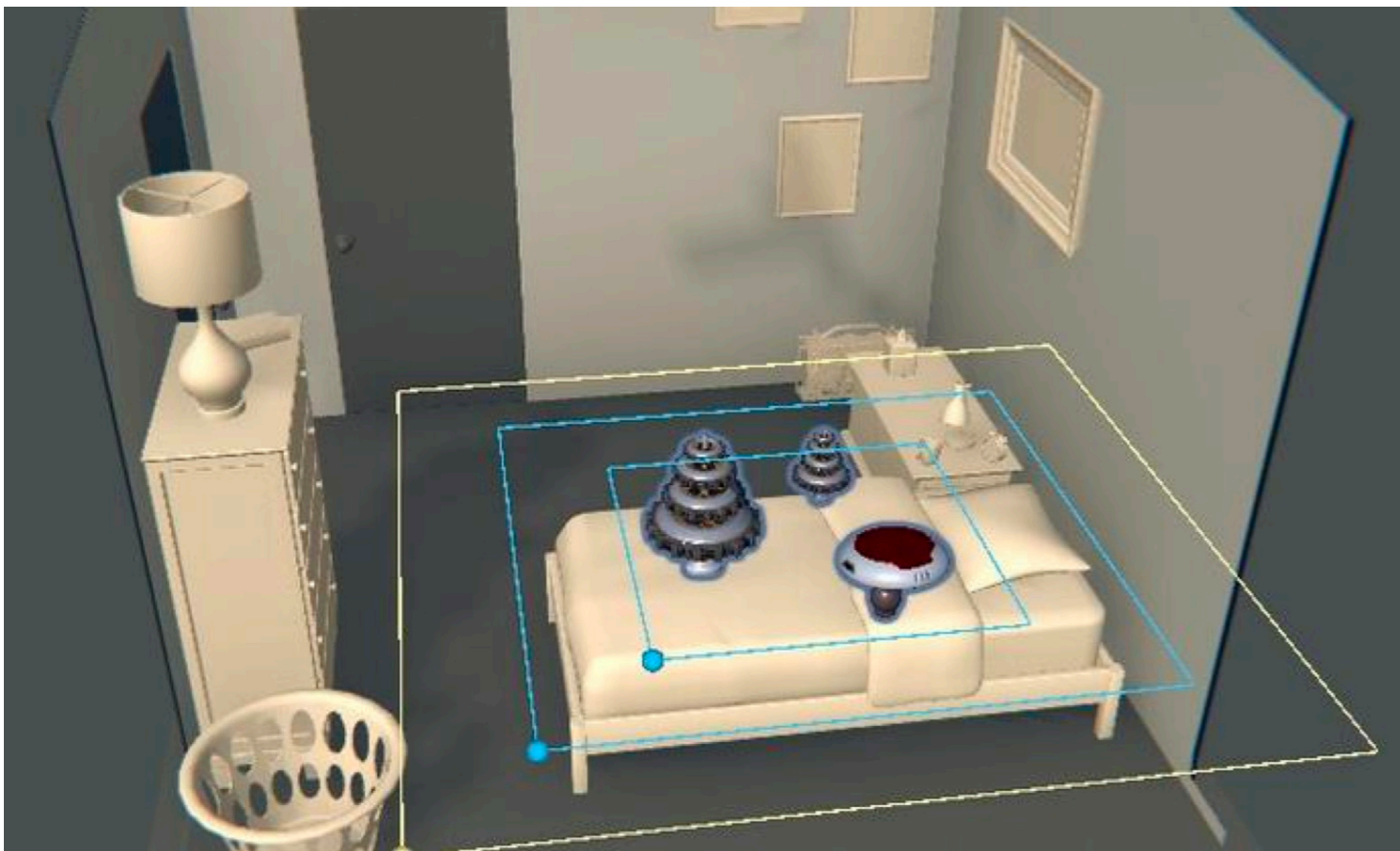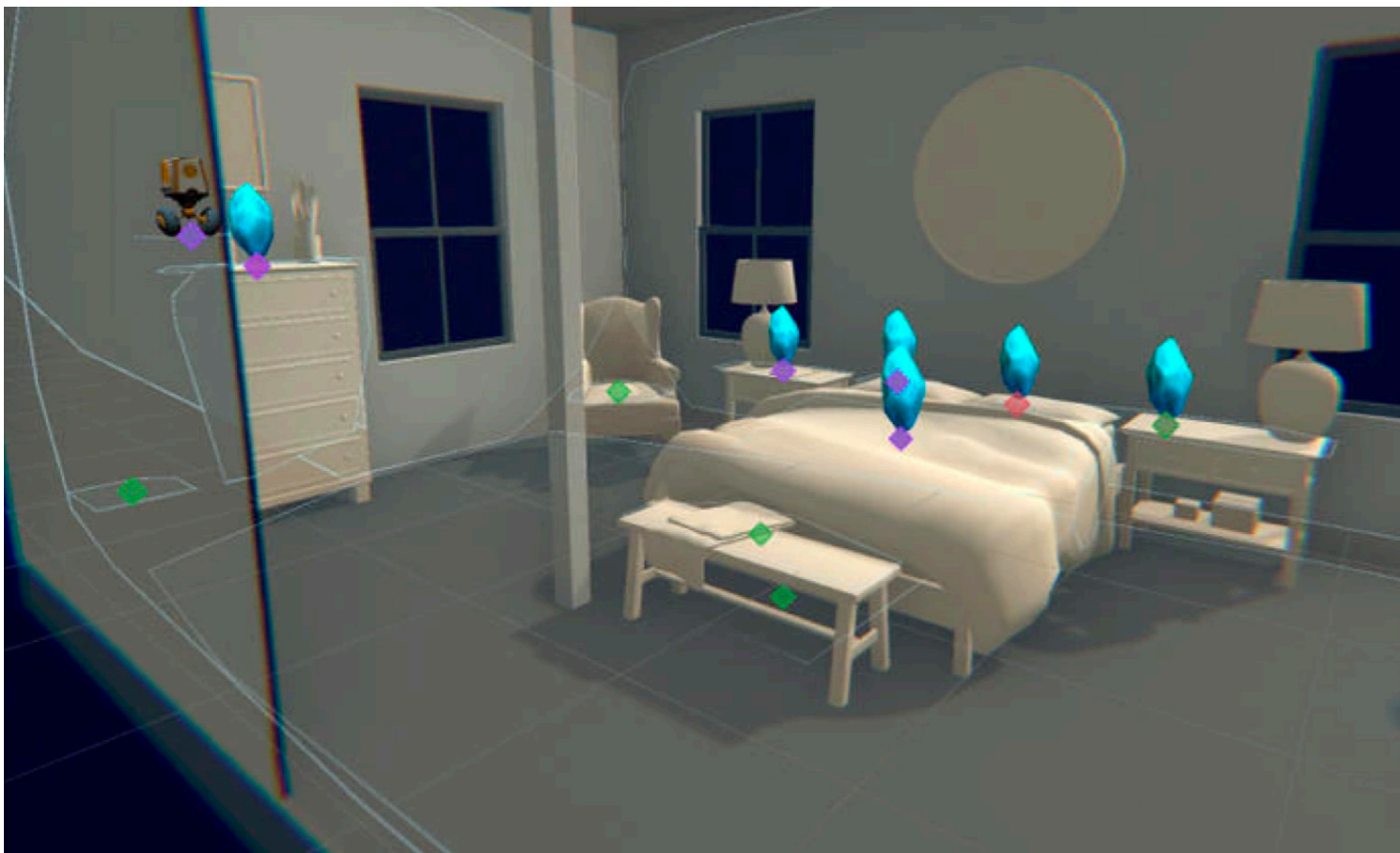
9.   Development features

9.1.   Simulation environments

Simulation environments provide a great way to develop and test augmented reality applications. By creating a virtual world that mimics the real world, developers can test how their applications respond to different situations and user interactions. This allows for a more efficient and effective development process and a more polished and reliable final product.

Simulation environments provide a safe and controlled environment for developing augmented reality applications. By simulating real-world conditions, developers can test and iterate on their applications without the risk of damaging expensive equipment.

The simulation also allows for the easy creation of repeatable conditions, which is essential for debugging purposes. By quickly and easily reproducing a problem, developers can identify and fix issues much more efficiently.

Overall, simulation environments offer plenty of advantages for developing augmented reality applications. They are safe, controllable and allow for rapid iteration and debugging. This makes them an essential tool for any developer looking to create high-quality augmented reality applications.

9.2.   Streaming from an editor

While developing on Unreal Engine or Unity, it is possible to connect to the headset and stream back and forth wirelessly. This methodology allows the developer to have immediate feedback while testing without the need to package and deploy the project at each step. By doing this, all calculation is made on the PC side, which means that the developer can focus on functionalities instead of optimization. However, we encountered two significant limitations: as previously mentioned, accessing the local anchor stored on the headset is impossible, and it is challenging to access runtime debug information.

9.3.   Streaming from a desktop application

Creating a standalone app for the holographic headset usually is the main goal for projects, but not the only one. A project can be packaged as PC executable app and therefore run from the PC that will do the heavy lifting in processing and rendering. Streaming over Wi-Fi will allow the device to run the app remotely.

9.4.   Mixed reality capture

Mixed reality capture is valuable for project diffusion and for creating tutorials. Holographic headsets have embedded mixed reality capture features that take snapshots or video recordings of the full-colour view from the user's perspective with an overlay of the holograms. Recordings can be done internally on the headset, or the live feed can be streamed and recorded from a PC wirelessly connected to the HMD.

A virtual exhibition taking place in the digital reconstruction of the Master Photography open space at ECAL.
Made to show the results of a workshop during the 2020 lockdown.
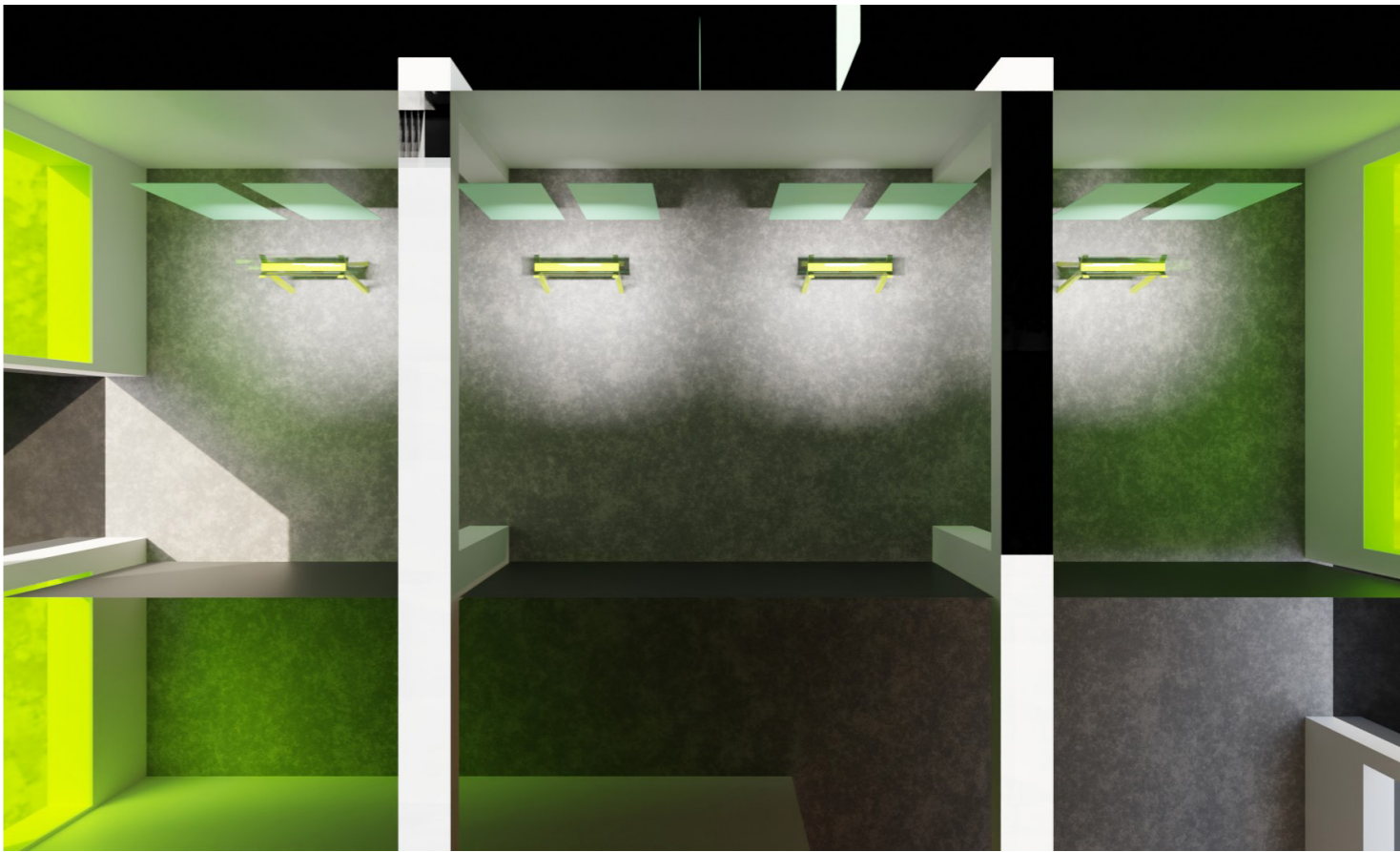
Scaled model for an exhibition in the same open space. Students make exhibition proposals for a contemporary
photography course by presenting their ideas with such models.

Screenshots of a gallery space reconstructed in the Blender 3D modelling software

10. Adapted use cases at ECAL

The use cases examined here are practical examples where Mixed Reality applications could offer added value compared to existing solutions.

10.1. Virtual exhibition / scenography prototyping

When planning installation views or whole exhibitions, the planning typically starts from an architectural plan or visuals of the location. In the best cases, a 3D model is provided. This allows the user to start prototyping by creating and inserting their 3D models in the scene to visualize it and adjust it while in virtual reality or augmented reality. Augmented Reality solutions are the perfect tools to use when planning exhibitions and installations on location, as there is no need for a manually made 3D model. The user can get an idea of how the installation will look in real life and adjust it accordingly. Still, having a scan or model of the location proves helpful to start the planning on the computer with correct relative positions before the AR inspection.

There are two main approaches to prototyping scenography in augmented reality we considered: anchoring objects in the world in real-time, and editing placements in the editor. Each approach has its own advantages and disadvantages.

The first approach, anchoring objects in the world in real-time, has the advantage of being able to save spatial anchors persistently. This means that once the project is deployed, users can move the objects around and see how they look in the world without having to redeploy the project at each change. However, this approach also has the disadvantage of requiring more coding, and being subject to the reliability of the anchoring system, which might be affected by changes in the position of furniture or people in the space. In addition, each 3D object has to be manually spawned and positioned.

The second approach, editing placements during development, has the advantage of being a zero-iteration workflow, which means that users can edit the placements of objects in the editor and see how they look in the world without having to wait minutes for the project to be packaged and uploaded to the HMD as an application at each change. This approach also has the advantage of being more precise, as users can position objects with precision in the editor. In addition, this approach requires less code, and allows for faster iteration. However, this approach also has the disadvantage of positioning objects relying on a visual tracker or whole spatial recognition, and requiring a relatively accurate model of the space.

10.2. Exhibition planning in an arts and design school

In the context of an applied school such as ECAL, most students present their finalized projects in physical installations. Often, works from several students are collected and shown together as exhibitions within ECAL's and external spaces and galleries. Before starting the production or when projects already exist, students dedicate significant time to planning the installation layouts. Currently, the planning usually happens in one or more of the following ways:

1. Intuitive sketches with approximate measurements and volumes

2. Drawings based on top-down planimetry of the spaces

3. Scaled paper model

4. In-place tryouts

5. 3D rendered mockups

As our students increasingly use 3D tools, rendered mockups are becoming more prevalent. They are a cost-less way to make proposals with any amount of artwork, scenographic element, material and size. They allow for rapid modifications and produce several alternate proposals. The time this takes depends on students' skill and project complexity, and the availability of a 3D model of the space they will use.

Holographic layout planning has become an accessible option. As long as the elements to include in the exhibition spaces are available as compatible 3D objects, students and staff can walk to the location of their installation or otherwise similar space and start placing 3D elements onto the physical space. With the immersive quality of a holographic headset, the planning can be done on a real-life scale and be easily manipulated. Augmented reality also allows others to give feedback by entering the same immersive experience or looking at mixed reality captured photos and videos. Given the basic 3D knowledge needed to upload the 3D objects, the advantages of mixed reality exhibition planning are many: from on-location, real-scale preview to the shareability of the layouts, the low-cost and fast iteration make holographic AR planning very efficient. The spatial understanding and screen-free approach are valuable advantages compared to phone-based AR.

Still frame from a virtual exhibition taking place in the digital reconstruction of the Master Photography open space at ECAL. Made to show the results of a workshop during the 2020 lockdown.

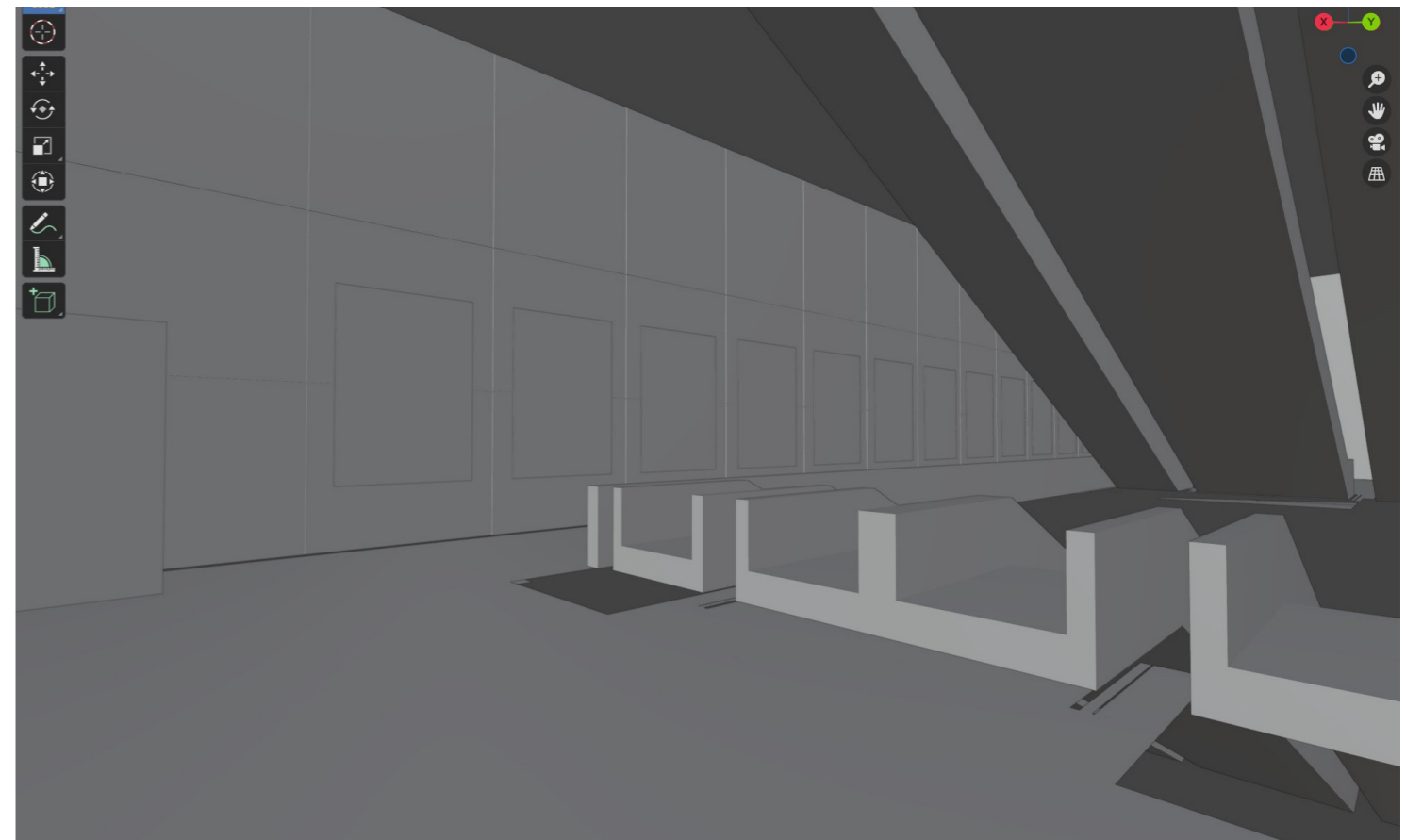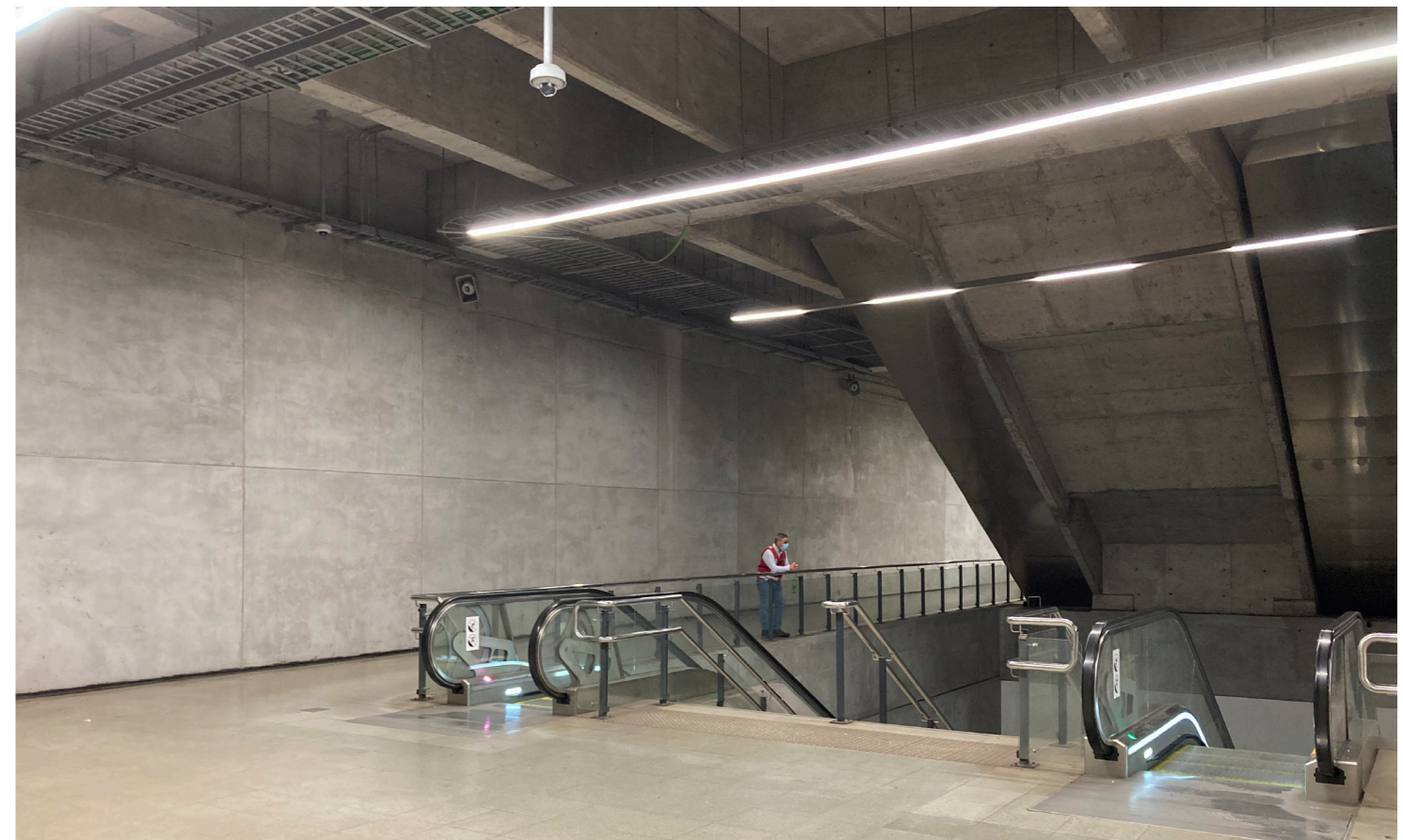Full video available at https://vimeo.com/488123626

11. Practical case studies

We applied what we learned in real-world practical use cases to give us firsthand knowledge developing applications for these technologies. In this section, we detail these experiences.
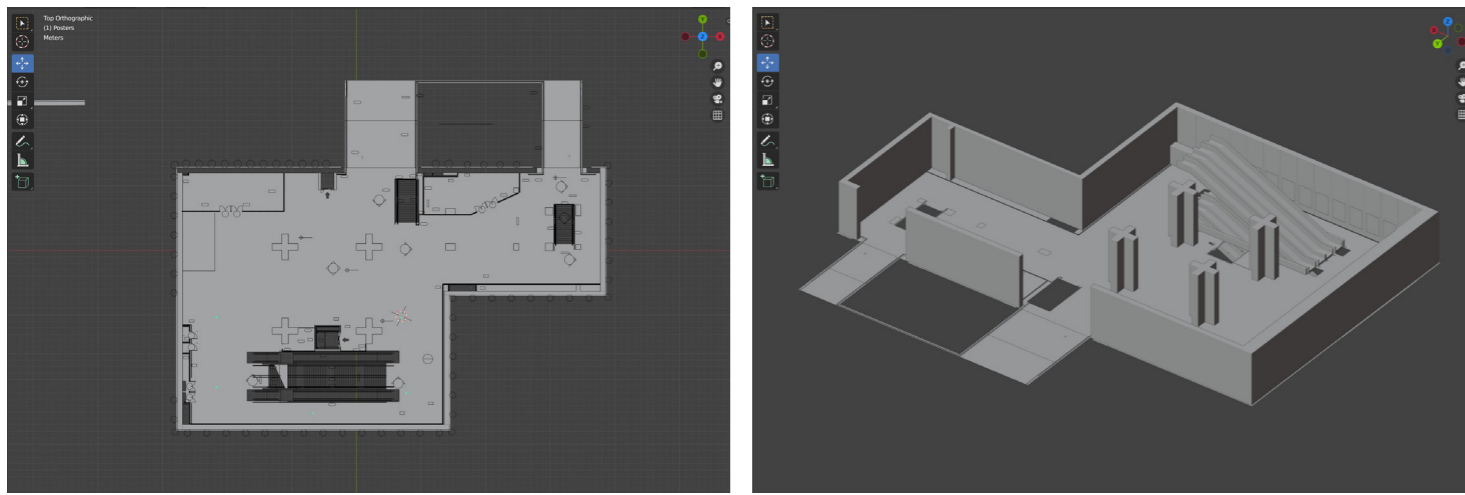
11.1. Suizpacio — VR design

For the project Suizpacio, in collaboration with the Swiss Embassy in Chile, Umwelt Architects, Professor Bisama, and Metro Santiago, the class of second-year Graphic Design Students designed large-scale posters to be hung inside the Metro station of Santiago, Chile. The posters are based on contemporary Chilean Poetry. As the problem space was very similar to our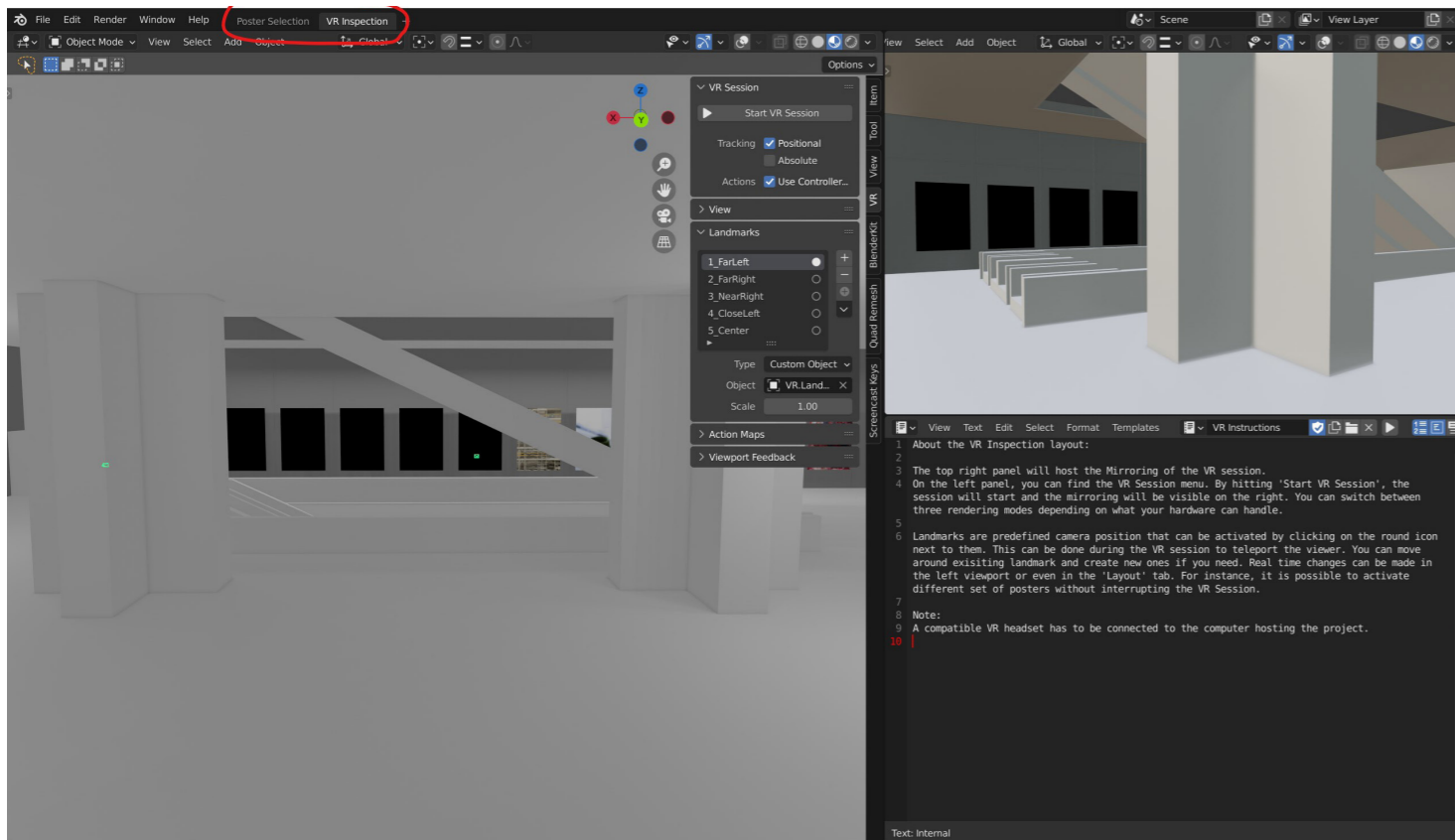 use case, we attempted to provide a user-friendly, quick and interactive solution to visualize the layout of the posters. We have been provided with 2D architectural plans and reference photos.

A view of the reconstructed space with images inserted in the poster's placeholders.

The photographs provided were used as a reference for camera placement to verify the accuracy of the 3D model.

The modelling has been done by performing simple extrusions and loop cuts starting from a cube. The height has been adjusted according to the given plans.

Goals

- Let students get in touch with Virtual Reality in a simple way, yet in a project-oriented scenario.

- Provide a ready-to-use solution that does not require particular skills in 3D or VR beforehand.

- Facilitating the teacher in viewing the layout proposals made by students in a streamlined way while being able to direct changes and view them in real-time.

- Save time

- Save on costs (mockups printing)

Tools

The open-source 3D content creation suite **Blender** is a user-friendly, single-package solution for modelling, customizable interface, and real-time scene editing on PC while a VR inspection session is undergoing. It is possible to add details and materials to render high-quality visuals. We decided to use Blender to deliver a ready to use solution, going through the following steps:

1. 3D model the environment to scale based on the 2D CAD files the partner provided.

2. Add some basic coloring and details to use as reference.

3. Insert posters place-holder in a 1:1 scale

4. Prepare materials to facilitate the insertion of images for the posters

5. Add basic lighting to the scene for depth

6. Set-up VR integration

7. Prepare VR location landmarks

8. Record a how-to-use captioned video for students[1]

Screenshot of the VR Inspection layout. On the top-right panel, it is possible to see a mirrored view from the VR session, while on the left panel, it is possible to move around the scene, see the VR user and interact with the scene (i.e. change poster images, move objects around, change lighting). On the bottom right, there are the written instructions.

Modelling and VR inspection

Blender 3.0 has been used to whitebox the environment based on the 2D plans that we have been provided with. Thanks to a free add-on, we could open the proprietary CAD format in Blender at a 1:1 scale to base the whiteboxing on. Once the basic modelling was finished, we enabled the VR Inspection add-on and placed some pre-set camera positions from which to look at the scene in immersive mode. We set up everything so that when a compatible headset is connected to the computer, it only takes clicking on the "Start VR session" button to be instantly projected into the scene. While in immersive mode, the user can move around with the VR controls, and another person can make changes to the scene in real-time or teleport the VR camera to the different pre-set positions.

How-to-use for students

To give the students the most direct experience, we took advantage of Blender's flexible and customizable interface. Two different window layouts have been created: one to easily change the images in the poster placeholders, and one for the VR inspection. In each layout, there is a panel with a written guide in it. In addition to the text instructions inside the project layout, a 4 minutes video has been recorded with the platform Loom, with a screen-recorded tutorial showing precisely how to use the layouts. The video includes bookmarks for each important step and close captions.

Conclusion on VR design

This solution has proven effective, considering the short amount of time in which it was built. The possibility of inspecting the scene in VR while in the same software used to model the architecture greatly simplifies this use case. In these circumstances, this was possible so effectively because the scene was prepared by a proficient Blender user for students who never used Blender.

With Blender becoming increasingly more relevant and used, it seems like more students from various departments will start using it. In future scenarios, it will just take a short introduction to the software or to the specific pre-made scene. The simplicity with which it is possible to load a Blender project and inspect it in virtual reality makes this method very appealing.

[1]

[1]Project code: https://github.com/ecal-mid/metro-station

11.2. Media & Interaction Design workshop

A one-week workshop on experimenting with mixed reality using the Magicleap One headset was held for second-year Media & Interaction Design students, led by Mario von Rickenbach and Alain Bellet.

Students were tasked to create experimental projects leveraging the possibilities of mixed reality headsets. Users could interact with the digital environment through their movement in space as well as through a simple controller developed especially for the project.

A stairwell was chosen as a predefined environment that would be shared between all the projects. The space had the following advantages

- Predictable lighting

- Cut-off points at the railing to leverage occlusion

- A maximum distance where the entire mesh could be detected at one time so that content got occluded correctly

The space was modelled in 3D with an iPhone equipped with lidar. The alignment was done manually through custom-created controls, meaning it had to be performed at the beginning of the experiences. The spatial anchor functionality didn't prove reliable in this case.

Students were given example projects and code snippets that leveraged the main functionalities of the Magic Leap. To leverage the controls, the projects interacted through custom-made simplified hardware controllers so students could focus on the graphics and experience.

Students were divided into groups, each producing a functioning experience at the end of the week. To get an immersive experience, most of them focused on raycasting onto the generated mesh, giving an immersive experience to the users. In contrast, others created site-specific projects that used the specific space.

We found that participants with less proficiency in game engines and real-time 3D know-how had more technical difficulties. However, they could still overcome the challenges and produce working experiences.

Resulting 3D model from an iPhone-based LIDAR scan.
These models have been used as a reference for alignment to create location-based experiences.

Media & Interaction design assistant Kylan Luginbühl testing a student's Magic Leap project during a workshop week.

11.3. Live Room Interactive guide

We have identified potential use cases for interactive guides for tools in the workshop, the printing centre, binding machines, and other complex machinery for which students need a formation before being allowed to use them. It remains to be determined by further research which applications could benefit the most from interactive mixed reality guides over traditional training or written guides.

We focused on a minimal implementation of this use case for our live streaming studio, as video and text documentation was already being produced. The mixed reality interactive guide complements this documentation by giving an overview and quickly introducing the numerous components in the studio space.

Our focus was to create a template that could be easily edited and expanded, using Unity engine to develop for the Magic Leap. We created a system based on waypoints, where a 3D object leads the attention of the user and approaches key elements in the scene. Specifically, in our case, the 3D object would lead the user to the lighting fix-

tures, the different cameras, and the control station playing explanative contextual audio at each step.

For the audio, we considered recording it directly with the headset but decided to create it with speech synthesis through the Amazon Polly service. With an API connection, this could be generated directly in the Unity Editor.

We created an image target to align the virtual space to the real world because it could also act as an introduction to the experience, with the added benefit of repositioning the experience in case of misalignment. To ensure the alignment was correct, we added a debug phase where the 3D scan was superimposed on the real world.

Because of the linear interaction of the guide, we needed three controls: forward, backwards and repeat. We implemented them using hand gestures, so there would be no need for a user interface. When the guide starts, the voice explains how to use these controls.
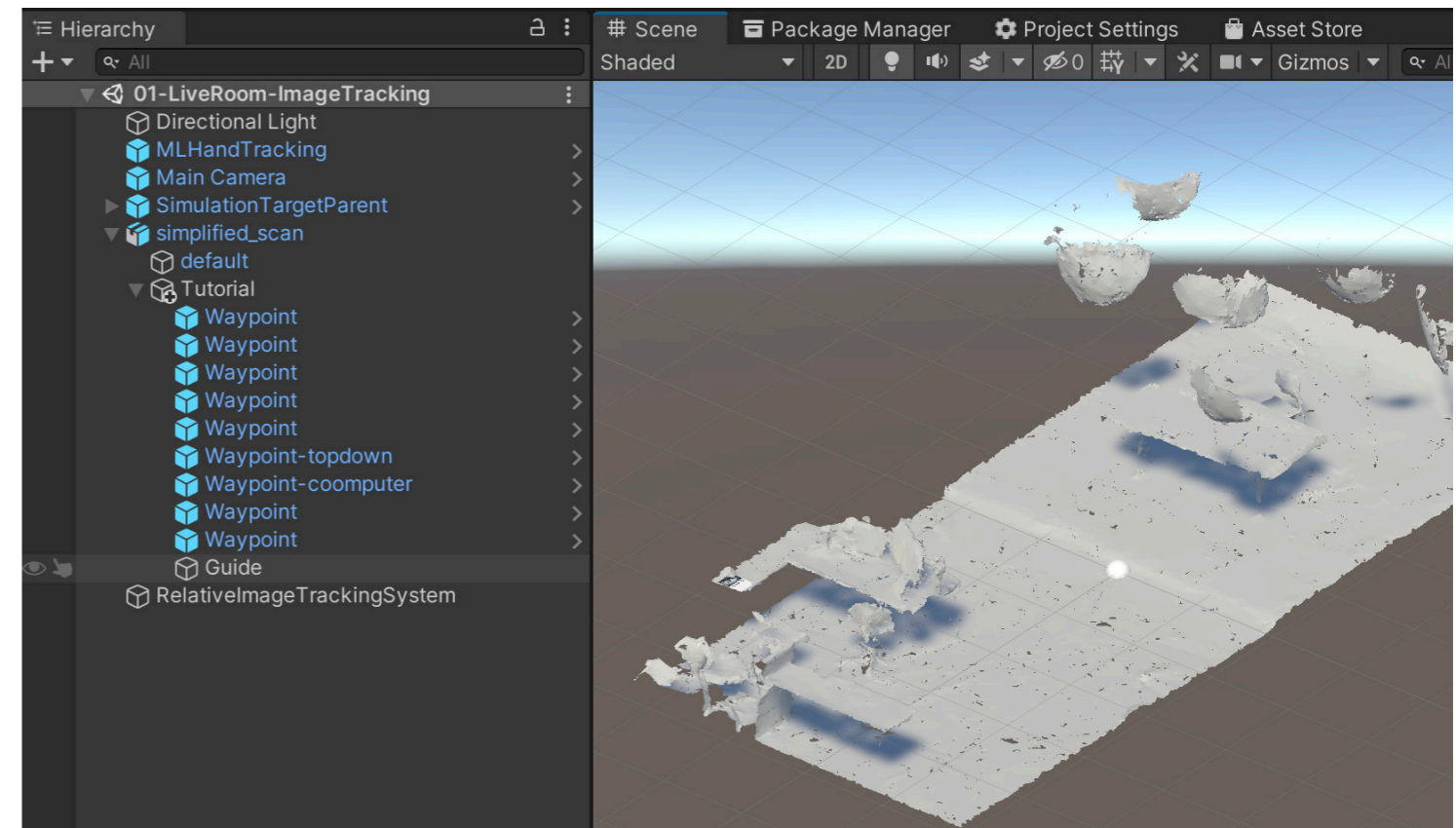
A screenshot from within Unity. The 3D scan of the room is used for alignment relative to the position of the image target.
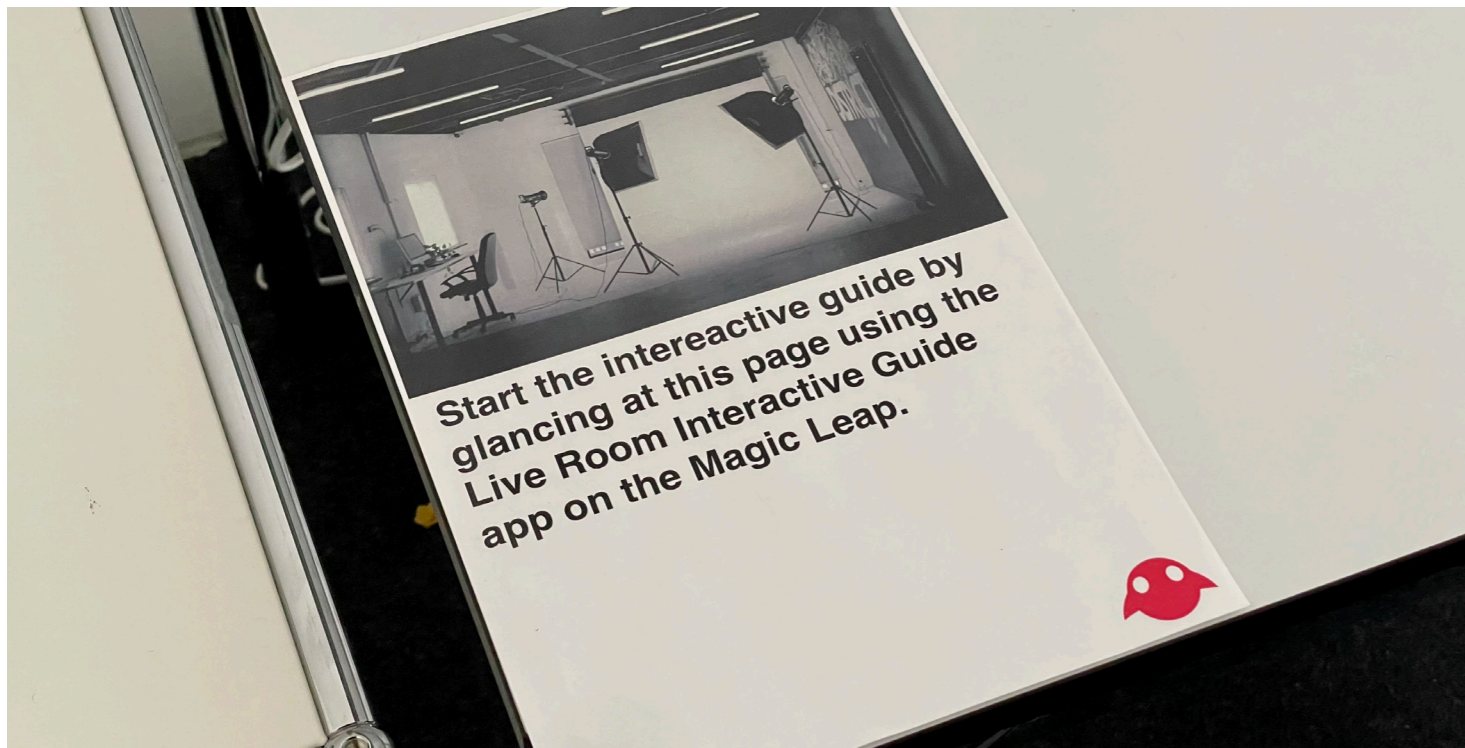

Image target printed out on an A4 paper sheet.
The image is placed on a table to trigger the tutorial and align the experience to the room.

Close-up of the image target placed in the 3D space.

12. Bibliography

"4.0 Image Tracking - Unity | Magic Leap." N.p., n.d. Web. 2 June 2022. <https://developer.magicleap.com/en-us/learn/guides/image-tracking-overview-unity>.

Antonioli, Misty, Corinne Blake, and Kelly Sparks. "Augmented Reality Applications in Education." The Journal of Technology Studies 40.1/2 (2014): 96–107. Print.

C5Drones. HoloLens Actual Field of View FOV Captured. N.p., 2016. Film.

Chao, Kuo-Hung et al. "Integration of Mobile AR Technology in Performance Assessment." Journal of Educational Technology & Society 19.4 (2016): 239–251. Print.

"Create 3D Models for Use in the Home - Mixed Reality." N.p., n.d. Web. 2 June 2022. <https://docs.microsoft.com/en-us/windows/mixed-reality/distribute/creating-3d-models-for-use-in-the-windows-mixed-reality-home>.

"Developer Portal | Magic Leap." N.p., n.d. Web. 12 May 2022. <https://developer.magicleap.com/en-us/home>.

"Device Stream | Magic Leap." N.p., n.d. Web. 2 June 2022. <https://developer.magicleap.com/en-us/learn/guides/lab-device-stream>.

"Get Started with Unity | Magic Leap." N.p., n.d. Web. 12 May 2022. <https://developer.magicleap.com/en-us/learn/guides/unity-overview>.

Glenn, J. K., and J. Goldman. "Task Delegation to Physician Extenders--Some Comparisons." American Journal of Public Health 66.1 (1976): 64–66. PubMed. Web.

"Hand Tracking | Magic Leap." N.p., n.d. Web. 2 June 2022. <https://developer.magicleap.com/en-us/learn/guides/lumin-sdk-handtracking>.

Harley, Jason M. "Comparing Virtual and Location-Based Augmented Reality Mobile Learning: Emotions and Learning Outcomes." Educational Technology Research and Development 64.3 (2016): 359–388. Print.

HoloLens 2 Hand Tracking Accuracy Stress Test 3 (hands farther; recorded alignment slightly better). N.p. Film.

"HoloLens 2 Mixed Reality Production for Unreal Engine." N.p., n.d. Web. 3 June 2022. <https://www.unrealengine.com/id/login?client_id=17ce2d2864834898ab71847859286c81&response_type=code>.

"HoloLens 2 vs Magic Leap Features: Battle of XR Headsets." Unity Developers 30 June 2020. Web. 10 June 2022. <https://unitydevelopers.co.uk/hololens-2-vs-magic-leap-features-battle-of-xr-headsets/>.

"HoloLens 2–Pricing and Options | Microsoft HoloLens." N.p., n.d. Web. 14 June 2022. <https://www.microsoft.com/en-us/hololens/buy>.

Kapp, Craig, and Mary Mcaleer Balkun. "Teaching on the Virtuality Continuum: Augmented Reality in the Classroom." Transformations: The Journal of Inclusive Scholarship and Pedagogy 22.1 (2011): 100–113. Print.

Magic Leap. Control Input in Unity - Magic Leap Dev Guide. N.p., 2019. Film.

---. Hand Tracking Input in Unity - Magic Leap Dev Guide. N.p., 2019. Film.

Magic Leap Example Project. ecal-mid, 2022. GitHub. Web. 13 May 2022. <https://github.com/ecal-mid/magic-2022>.

Magic Leap Unity Examples. Magic Leap, 2022. GitHub. Web. 13 May 2022. <https://github.com/magicleap/MagicLeapUnityExamples>.

Microsoft. "Hand Interaction Examples - MRTK 2." Microsoft Technical Documentation. N.p., n.d. Web. 30 June 2022. <https://docs.microsoft.com/en-us/windows/mixed-reality/mrtk-unity/mrtk2/features/example-scenes/hand-interaction-examples>.

"Microsoft HoloLens." N.p., n.d. Web. 3 June 2022. <https://docs.microsoft.com/en-us/hololens/>.

Panciroli, Chiara, Anita Macauda, and Veronica Russo. "Educating about Art by Augmented Reality: New Didactic Mediation Perspectives at School and in Museums." Proceedings 2017 1.9 (2018): n. pag. Web. 14 June 2022. <https://doi.org/10.3390/proceedings1091107>.

"Performance Guidelines for Mobile Devices." N.p., n.d. Web. 27 June 2022. <https://docs.unrealengine.com/5.0/en-US/performance-guidelines-for-mobile-devices-in-unreal-engine/>.

Pinker, Alexander. "Google Maps AR - Navigation mittels Augmented Reality." Medialist 12 May 2019. Web. 30 June 2022. <https://medialist.info/2019/05/12/google-maps-ar-navigation-mittels-augmented-reality/>.

Prasanna Sudhakar, Paigude. "A Survey on the Effectiveness of Hololens and Augmented Reality in Education." International Journal for Research in Applied Science and Engineering Technology 7.1 (2019): 293–296. Print.

"Prepare a New HoloLens 2." N.p., n.d. Web. 20 May 2022. <https://docs.microsoft.com/en-us/hololens/hololens2-setup>.

"Previewing with Unity Play Mode | Magic Leap." N.p., n.d. Web. 2 June 2022. <https://developer.magicleap.com/en-us/learn/guides/1-3-zero-iteration-unity>.

"Recevoir glTF Viewer - Microsoft Store fr-CH." Microsoft Store. N.p., n.d. Web. 14 June 2022. <https://www.microsoft.com/fr-ch/p/gltf-viewer/9mwmgknx8fkh>.

Sebeom, Park. "Review of Microsoft HoloLens Applications over the Past Five Years." Applied Sciences 11.16 (2021): 7259. Print.

Tang, Y. M. et al. "Evaluating the Effectiveness of Learning Design with Mixed Reality (MR) in Higher Education." Virtual Reality 24 (2020): 797–807. DOI.org (Crossref). Web.

"Unity - Manual: Graphics Performance Fundamentals." N.p., n.d. Web. 27 June 2022. <https://docs.unity3d.com/Manual/OptimizingGraphicsPerformance.html>.

"Welcome to UX Tools | UXT Documentation." N.p., n.d. Web. 20 May 2022. <https://microsoft.github.io/MixedReality-UXTools-Unreal/Docs/WelcomeToUXTools.html>.

"What Is Mixed Reality? - Mixed Reality." N.p., n.d. Web. 14 June 2022. <https://docs.microsoft.com/en-us/windows/mixed-reality/discover/mixed-reality>.

Xiong, Jianghao et al. "Augmented Reality and Virtual Reality Displays: Emerging Technologies and Future Perspectives." Light: Science & Applications 10.1 (2021): 216. www.nature.com. Web.

13. Credits and acknowledgments

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Special thanks to Amaury Hamon
for the Graphic Design help.

Support

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