

University of West Bohemia
Faculty of Design and Art

Diploma Thesis

2023

Bc. Robert Poláček

University of West Bohemia
Faculty of Design and Art

Diploma Thesis

Interactive Project

Bc. Robert Polacek

Pilsen 2023

University of West Bohemia
Faculty of Design and Art
Department of Visual Arts
Study program: Audiovision
Specialization: Interactive design

Diploma Thesis

Interactive Project

Bc. Robert Polacek

Supervisor

MgA. Jan Kokolia
University of West Bohemia
Faculty of Design and Art
Department of Visual Arts

Pilsen 2023

ZÁPADOČESKÁ UNIVERZITA V PLZNI
Fakulta designu a umění Ladislava Sutnara
Akademický rok: 2022/2023

ZADÁNÍ DIPLOMOVÉ PRÁCE

(projektu, uměleckého díla, uměleckého výkonu)

Jméno a příjmení: **Bc. Robert POLÁČEK**
Osobní číslo: **D21N0012P**
Studijní program: **N0211A310006 Audiovize**
Specializace: **AU – specializace Interaktivní design / MgA.**
Téma práce: **INTERAKTIVNÍ PROJEKT**
Zadávající katedra: **Katedra výtvarného umění**

Zásady pro vypracování

Návrh originálního a inovativního designu aplikace, webu nebo hry, jejich výtvarná koncepce a interakční prototyp.

Tvůrčí záměr:

O technologie v této oblasti se dlouhodobě zajímám a současně chci navázat na svou bakalářskou práci. V rozšířené realitě vidím velký potenciál.

Způsob realizace:

Návrh prostorového rozhraní vytvořený v grafickém nástroji prezentovaný v digitální formě.

Cíl:

Vytvoření designu uživatelského rozhraní pro rozšířenou realitu, které bude sloužit jako zdroj pro ostatní designéry.

Předpokládaný charakter výstupu:

Design prostorového uživatelského rozhraní, které bude obsahovat různé druhy komponent, ze kterých bude sestavená virtuální scéna.

Rozsah průvodní zprávy:

3 normostrany.

Rozsah teoretické části: **min. 3 normostrany**
Rozsah praktické části: **vyplyne ze zpracování DP**
Forma zpracování diplomové práce: **tištěná/elektronická**

Seznam doporučené literatury:

MICROSOFT. *Mixed Reality Documentation. Mixed Reality* | Microsoft Docs [online].
[Accessed 21 May 2022]. Available from: <https://docs.microsoft.com/en-us/windows/mixed-reality/>.
MAGIC LEAP. *Developer portal: Magic leap. Developer Portal* | Magic Leap [online].
[Accessed 21 May 2022]. Available from:
<https://developer.magicleap.com/en-us/learn/guides/developer-portal>.
GOOGLE. *Material Design* [online]. [Accessed 21 May 2022]. Available from: <https://material.io/>.

Vedoucí diplomové práce: **MgA. Jan Kokolia**
Fakulta designu a umění Ladislava Sutnara

Datum zadání diplomové práce: **19. října 2022**
Termín odevzdání diplomové práce: **28. dubna 2023**



MgA. Vojtěch Aubrecht v.r.
děkan

Mgr. Jindřich Lukavský, Ph.D. v.r.
vedoucí katedry

V Plzni dne 19. října 2022

I declare that I created this work on my own and it is not plagiarized.

.....

Pilsen, April 2023

Table of Contents

1. My Previous Work in the Context of My Specialization	8
2. Artwork Description	9
2.1. Interface Library Concept	9
2.2. Smart Glasses Application	9
3. Reason of Choice	10
3.1. Interface Library Concept	10
3.2. Smart Glasses Application	10
4. Creation Process.....	11
4.1. Exploration of Augmented Reality Field.....	12
4.1.1. Research of AR Headsets	12
4.1.2. AR Design Guidelines	12
4.1.3. Outcomes	12
4.2. Design of the Interface Library.....	15
4.2.1. Seek for Funding	15
4.2.2. Interface Elements.....	15
4.2.3. Distribution	15
4.2.4. Design Tools.....	15
4.2.5. Outcomes	16
4.3. Design of the Smart Glasses Application	20
4.3.1. Funding Results.....	20
4.3.2. Need to Change the Project Scope	20
4.3.3. Agreement on the New Project Scope	20
4.3.4. Research of Urbanism.....	21
4.3.5. Research of Architecture	21
4.3.6. Research of Industrial Design	21
4.3.7. Design of the Application.....	21

4.3.8. Outcomes	22
4.4. Development.....	27
4.4.1. Scope Definition.....	27
4.4.2. Challenges.....	27
4.4.3. User Testing	27
4.4.4. Outcomes	28
5. Technology Specifics.....	31
6. Benefit of the Projects for My Specialization	32
7. Resumé	33
8. Resources.....	34
9. Table of Figures.....	38

1. My Previous Work in the Context of My Specialization

I started this project as part of my bachelor's studies at the University of Economics in Prague, specialization in Multimedia in Economic Practice. There I started to design user interfaces and became interested in the field of augmented reality. Therefore, I wrote bachelor's thesis "User Interface Concept for Smart Glasses" (1). The work consists of several parts:

- The theoretical part
 - Mapping industry of augmented reality (survey of current models and their approach to user interfaces)
 - Research of user needs, display methods and methods to improve user experience.
- The practical part
 - Design concept of smart glasses' skeleton
 - Design concept of smart glasses' home screen

My previous work also includes working as user experience designer in financial sector for a few years, working as freelance graphic designer and web designer and web developer.



Figure 1: Bachelor Thesis Outcomes (1)

2. Artwork Description

2.1. Interface Library Concept

I summarized Augmented (Mixed) Reality Design Guidelines by Microsoft (2), so designers would not need struggle creating their own designs for Smart Glasses. Part of these guidelines was made into short Design Tips, that are represented as series of Twitter posts.

I designed 2D interactive collection of user interface elements for augmented reality in Figma. These elements might be used for creating prototypes of augmented reality scenes.

I would plan to add more elements and build them in code to have fully functional software library of interface elements. It could be used by any designer or developer to build their own applications.

2.2. Smart Glasses Application

I designed and developed application for augmented reality headset HoloLens 2. This application can visualize proposal of new urban district Prague-Bubny. The buildings are based on table that floats in the center of room. Thanks to the headset, its user can grab the buildings by hand and transform them (change their size, rotation, or position on the map, etc.). User can also build any scene from basic assets like trees or primitive 3D objects. With this application, designers can create environment prototype without any physical objects. Virtual representation offers possibilities of complex simulations that can make this way of prototyping a lot more efficient.

There are many opportunities for future extensions. These are the ones, that I perceive as the most useful:

- **Real-size mode:** Right now, you can view just miniatures of the objects. In future, each object should have option to scale itself to real size. This would be helpful for architects or industrial designers, who would check if the proportions of the objects are designed well (in the means of size, ergonomics, etc.).
- **Environment simulations:** The user should be able to change set properties of the scene. For example, show the scene in the following years (e.g., trees would eventually grow larger), see the scene in winter or at night (e.g., to see if the public lights would cover the area properly) or simulate shading (e.g., by dragging sun to the preferred position).

3. Reason of Choice

I have chosen these topics because of my interest in the augmented reality technology and professional specialization in user interface design.

3.1. Interface Library Concept

Firstly, the initial goal was to help designers and developers. The technology of Augmented Reality is new, and creators might not know how to build their project properly. The goal was to create a library of user interface elements (buttons, inputs, etc.) and give creators guidelines how to properly use them. This would speed up their development or design of the virtual scene and they would learn it very quickly. The inspiration was Material Design by Google (3) that is made for web and mobile apps. The basic assumption to complete this concept was to support the development of the concept financially.

3.2. Smart Glasses Application

Considering that the assumed financial and development support (as noted above) was not provided, we have agreed with supervisor to stop building the Interface Library Concept and adjust the thesis. Fortunately, thanks to Josef Kortan's contacts to Prague urban strategists, I got opportunity to build application, that could be useful for urban planning. I took the chance to participate because the initial development would be achievable by me, and the connection for real use was more direct. The application should run on augmented reality headset "HoloLens 2" and should show virtual 3D model of new Prague Philharmonic building placed in its real environment. The inspiration was LEGO (4), videogame series The Sims (5) and IKEA Kreativ app (6).

4. Creation Process

As stated previously, the initial goal was to build User Interface Library that was converted to Smart Glasses Application during the study. Supervisor and I have agreed that it will be suitable to work on this project also during our classes and the results present as “diploma elaboration progress” at the end of each semester during my master studies. The primary reason for the decision was complexity of the project (study of design for virtual reality, search for investors, developers, and preparation of release materials).

All major decisions I made during this project were properly consulted with supervisor and other consultants.

4.1. Exploration of Augmented Reality Field

Winter Semester 2021

4.1.1. *Research of AR Headsets*

I knew since the beginning that I will need some augmented reality hardware to test design and learn the possibilities of spatial interactions. Based on the bachelor thesis (1) I selected Microsoft HoloLens 2 headset as the most usable device. Then, I started research of organizations, that got augmented reality headsets I might try – AYES (7), YORD (8), Microsoft (2), Brainz Immersive (9), Bechtle (10), Movisio (11), AR Fest (12), VR Education (13), Versino (14), Tasty Air (15). Afterwards, me and my classmate visited AYES (7) in Prague to try HoloLens. To show possibilities of HoloLens and Augmented Reality development, I arranged presentation of this technology in our class. The presenter was YORD (8). After I was convinced that this device is good option for the thesis, I consulted possibility of purchase with supervisor. He agreed and arranged purchase by the faculty.

4.1.2. *AR Design Guidelines*

In the meantime, I was doing research of the best design guidelines for augmented reality. The most extensive manuals had Magic Leap (16) and Microsoft (2). The choice was Mixed Reality Design Guidelines by Microsoft because of their level of detail. Then I studied the whole manual and created summary of the most important information – document of 113 pages, circa 10 000 words. I used this summary to create short tips for designers, who might find those useful (for this purpose I created table that counts characters in a post because of Twitter content limits). I tried to contact Microsoft to get official permission to release it under their brand, but customer support was not able to get me to the executive people. I also did research of current user interface libraries for web and mobile apps and studied their approach – Material Design (3), Human Interface Design (17), Carbon Design (18) and Fluent Design (19). Then I did research of platforms, where designers and developers are the most active (to deliver them design guidelines) – Twitter (20), LinkedIn (21), Behance (22) and Dribbble (23). I decided to use Twitter because of my design colleague's advice.

I also started to study possibilities of prototyping tools, that I finished the following semester – Reality Composer (24), Aero (25), Spark AR (26), Blender (27), Unity (28) and Snap AR (29).

4.1.3. *Outcomes*

The final presentation had positive responses from the committee, though there were doubts about the scope of this project being too large.

As the result of this semester, I created:

- Summary document of the Mixed Reality Design Guidelines
- Several Twitter posts – “Tips for design in augmented reality” (using third-party icon set (30))
 - [Figure 2: Examples of Twitter Post With Design Tips](#)
- Website, where the tips are – <https://robertpolacek.com/guidelines/index.html>
 - [Figure 4: Website with Design Tips](#)

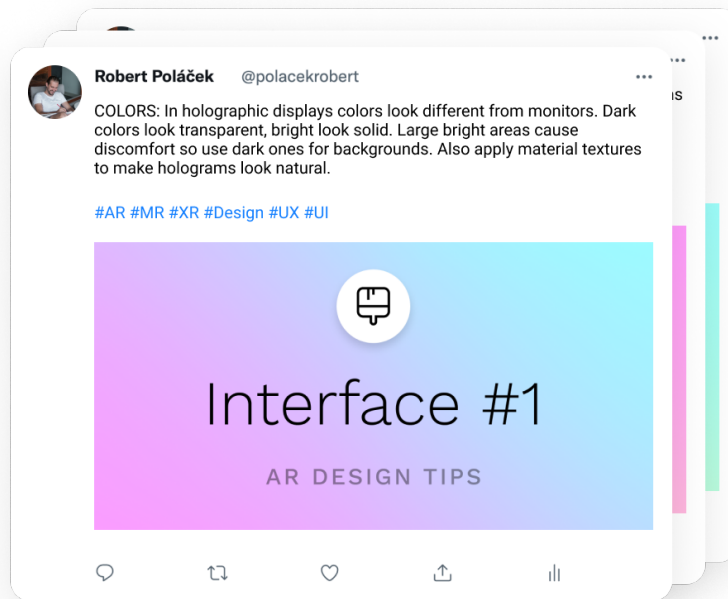


Figure 2: Examples of Twitter Post With Design Tips (31) (2) (30) (20) (32)

Calculator of characters (with spaces) in all cells. Limit is 280

201	Hi guys, in the following texts I am going to share some principles of #design for #AR 🦋 I'm sharing just the most important ones. If you are interested in more, feel free to contact me 😊	#AR #MR #XR
SPACE		
128	APP TYPES: There are flat ("floating 2D windows") and immersive (holograms are mapped on physical environment) apps.	#AR #MR #XR
254	VIEW ZONES: The most comfortable areas are -45° to 45° horizontally and 0° to -35° vertically (but you can place content up to 40° and -60° without making user feel uncomfortable). In depth, place holograms up to 45cm for near interactions.	#AR #MR #XR
21	MAPPING:	#AR #MR #XR
21	SHARING:	#AR #MR #XR
INTERFACE		
109	COLORS: In holographic displays. The darker, the more transparent. The brighter, the more solid.	#AR #MR #XR
279	TYPOGRAPHY: Use regular (or thicker weight) sans serif fonts to avoid jitter. Apply bright colors and dark background to provide sufficient contrast. Minimum font size for viewing in cca 45cm is 3mm (comfortably 6mm). For viewing in 2m it's 12mm (comfortably 26mm).	#AR #MR #XR
88	SOUND: Haptics is compensated with sound to provide at least some feedback.	#AR #MR #XR
20	STATES:	#AR #MR #XR
23	OUTER BOX:	#AR #MR #XR
INTERACTIONS		
105	HANDS: It's crucial to maintain interactions intuitive so use hands as primary input method.	#AR #MR #XR
270	EYES: When hands are busy, use gaze to target holograms. Then use voice to trigger an action with them. Alternatively action can be triggered by constant dwell. Gaze can be used to measure focus in analytics. However eyes aren't good for precise selections.	#AR #MR #XR
86	VOICE: Use voice primary to trigger action for already selected hologram.	#AR #MR #XR
239	HEAD: Use head tracking as alternative to eyes. Head direction should be made by ray with cursor at the end to show the head direction. Then actions can be triggered also by voice or by dwell. Unlike eyes this input is precise.	#AR #MR #XR

Figure 3: Counter of Characters for Twitter Posts (31) (2)

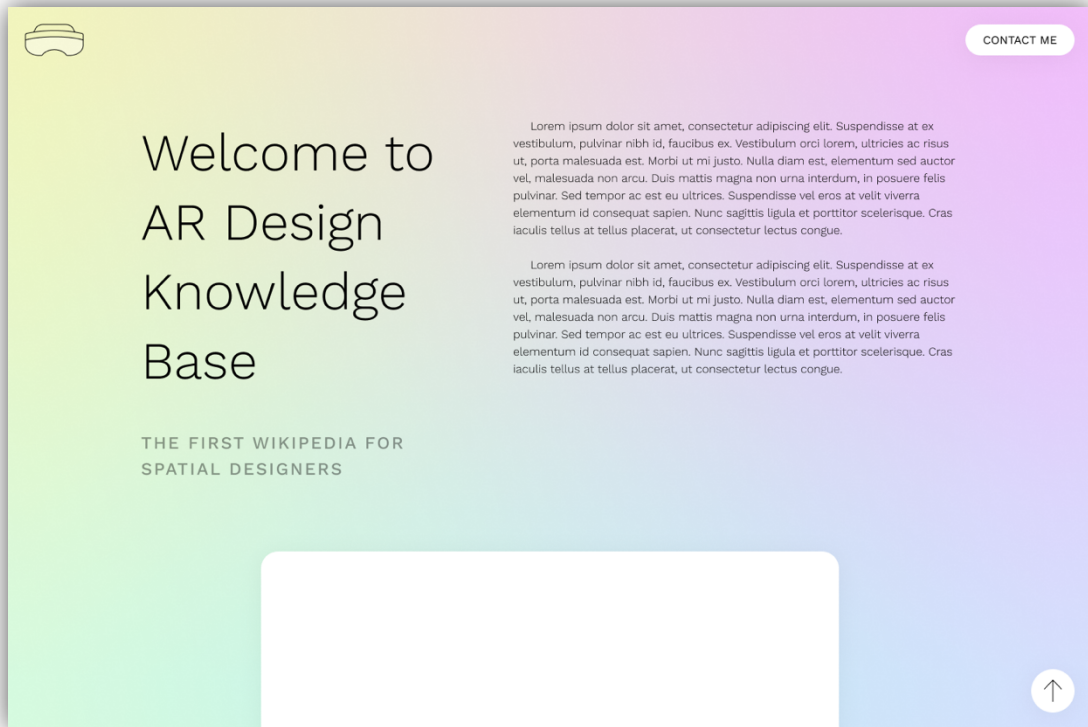


Figure 4: Website with Design Tips (31) (2) (30)

4.2. Design of the Interface Library

Summer Semester 2022

At the beginning of the semester, I received the HoloLens 2 headset, so I spend the following weeks testing the features of the device (color representations, etc.) and summarized all interaction models.

4.2.1. *Seek for Funding*

During March, I applied for scholarship to make this project possible. I created presentation of this project and asked for approximately 300 000 CZK to fund the development of this project. The scholarship committee was excited and sure they want to support the idea, but they were not sure about the target amount and ways to fund it. I was promised to get their statement until the end of June. So, I continued with the project in the prospect of future support.

4.2.2. *Interface Elements*

The goal for this semester was to create low-fidelity concept of the interface library. I started with research of third-party market competition for XR headsets. The only ones were in VR segments – Float Grids (33), Epibyte (34) and Space Bear (35) and one was in AR segment – Stereo Kit (36). Then I created compilation of all interface elements across these libraries plus Microsoft Library (2) and I selected these interface elements as the most used across them: (naming conventions reflects their sources):

- **Components:** Dropdown, Menu, Ray, Dialog, Search Bar, Progress Bar, Bounding Box, Voice Input, Backplate, Hand Coach, Tab Bar, Keyboard, Tool Tip, Form, App Bar, Mesh, Avatar, Button, Controls Cursor)
- **Styles:** Colors, Texts, Sizes, Materials, Corner Radiuses, Shadows, Materials, Border Widths, Sound Effects)

I started with visual concepts – basic styles (colors, fonts, etc.), interface elements (buttons, dialogs, etc.) and spatial layouts (the outcomes are attached at the end of this section).

4.2.3. *Distribution*

I did research of distribution methods (to see which channels and formats are best for deployment of the library to the project's target group) and I selected "Figma Community" (32) for resources for designers and "Unity Asset Store" (28) for resources for developers. Though the main platform should be the website I created last semester. There would be information for both designers and developers (documentation, guidelines, support, etc.).

4.2.4. *Design Tools*

Then I continued study of design tools – Concepts (37), Spline (38), Vectary (39), Figma (32), Blender (27), Sketchbook (40), ProCreate (41), Gravity Sketch (42), ShapesXR (43), Maquette (44) and Sketchbox (45). I selected Concepts for sketching. Spline, Vectary and Figma for prototyping and Blender for final asset assembly for developers.

At the end of semester, I visited Holon Institute of Technology in Israel (as part of school delegation) and discussed possible partnerships with local developers and designers for this project. I had presentation for Head of Visual Communications Department Faculty of Design Multidisciplinary Studies about the thesis and I got contacts to designers, researchers, and engineers I might collaborate with in near future.

4.2.5. *Outcomes*

The final presentation had critic responses from the exam committee. The main problems were the lack of visual outcomes, too much of research and the focus on commercial success of the project. The outcomes should focus more on visual, artistic, and tangible aspects instead of analytics and business approach.

As the result of this semester, I created:

- Summary of all the research I performed
- HoloLens Assets – 3D models (presentation, color palettes, etc.) that I uploaded into the headset native 3D viewer using Vectary (39)
 - Figure 5: Stand to HoloLens
 - Figure 6: Transparency Representation to HoloLens
 - Figure 7: Color Representation to HoloLens
- Concepts of the interface
 - Figure 8: Buttons Concepts
 - Figure 9: 2D Backplate Concepts
 - Figure 10: 3D Backplate Concepts

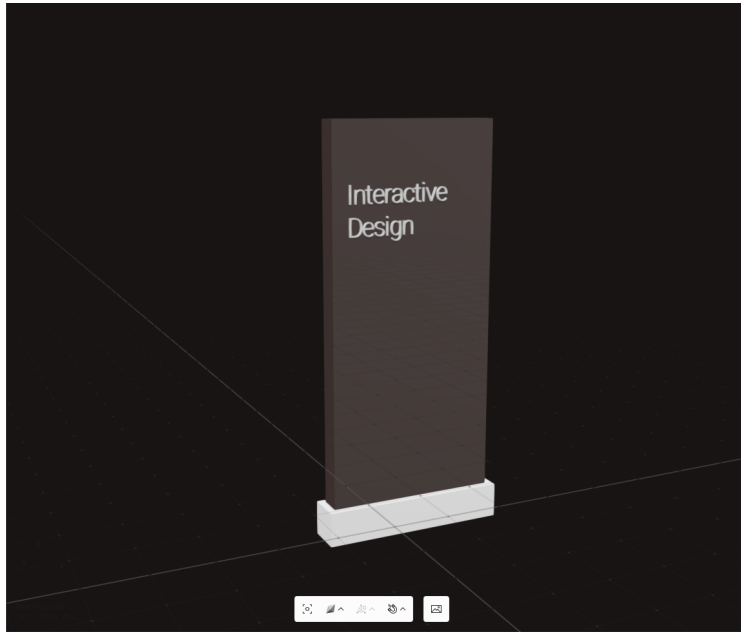


Figure 5: Stand to HoloLens (31) (39)

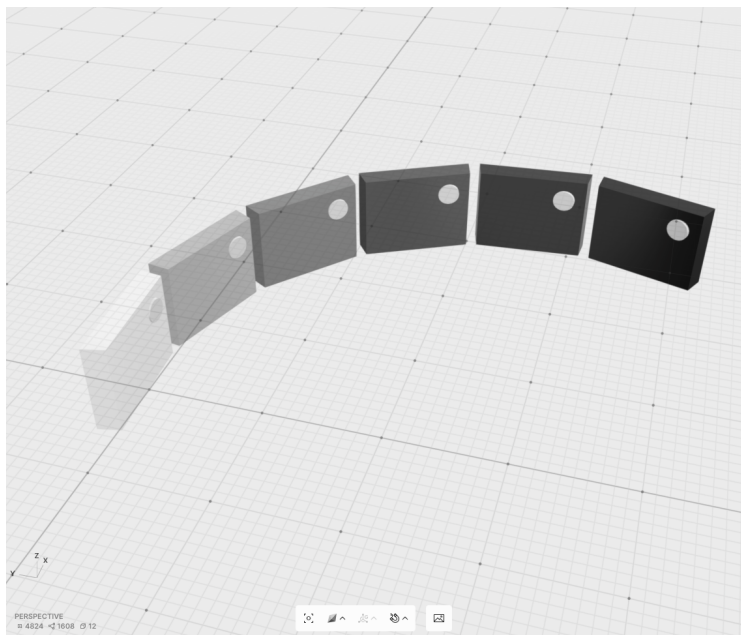


Figure 6: Transparency Representation to HoloLens (31) (39)

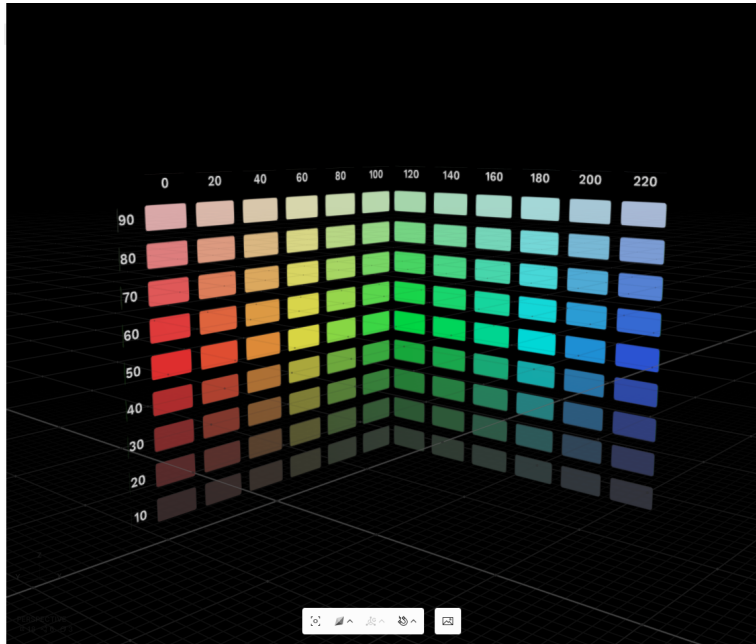


Figure 7: Color Representation to HoloLens (31) (39)

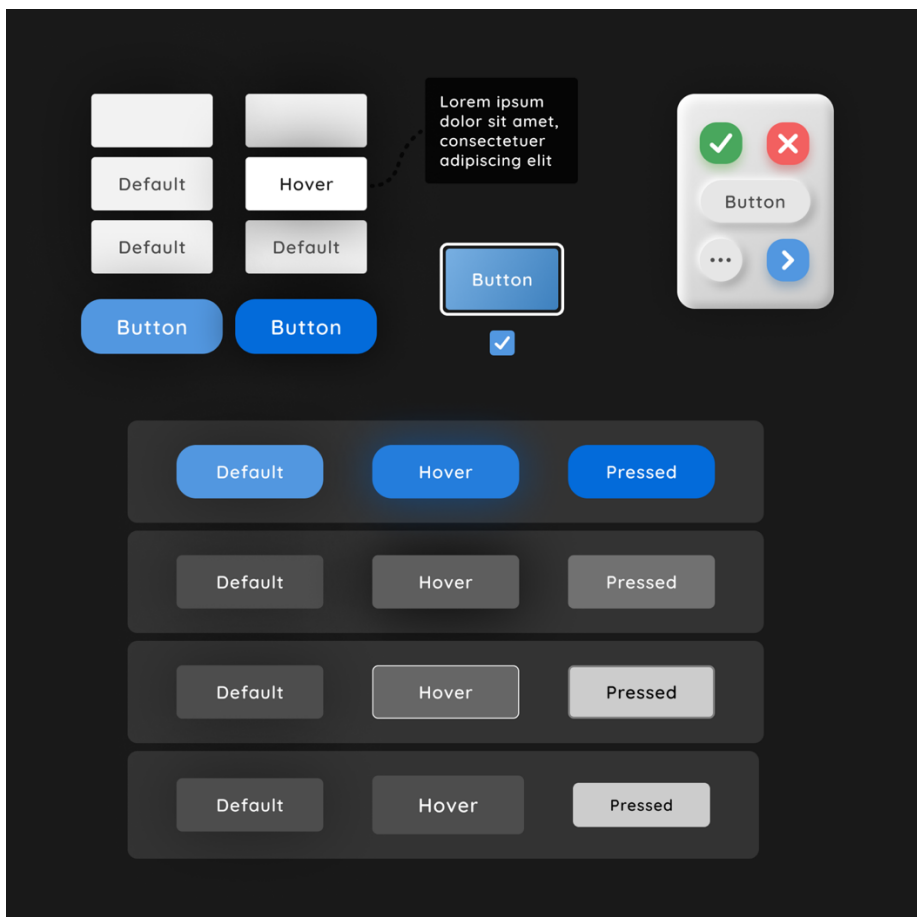


Figure 8: Buttons Concepts (31) (32)

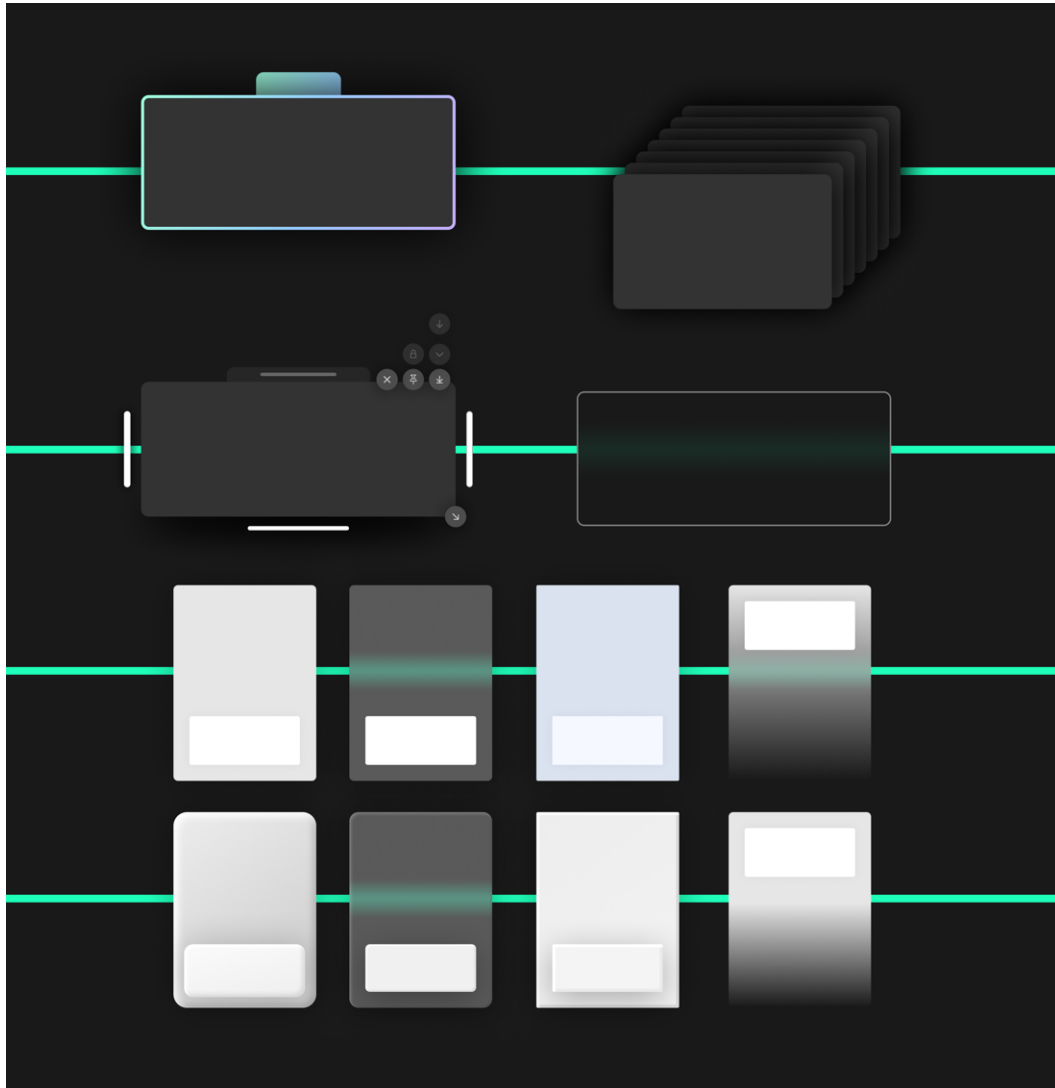


Figure 9: 2D Backplate Concepts (31) (32)

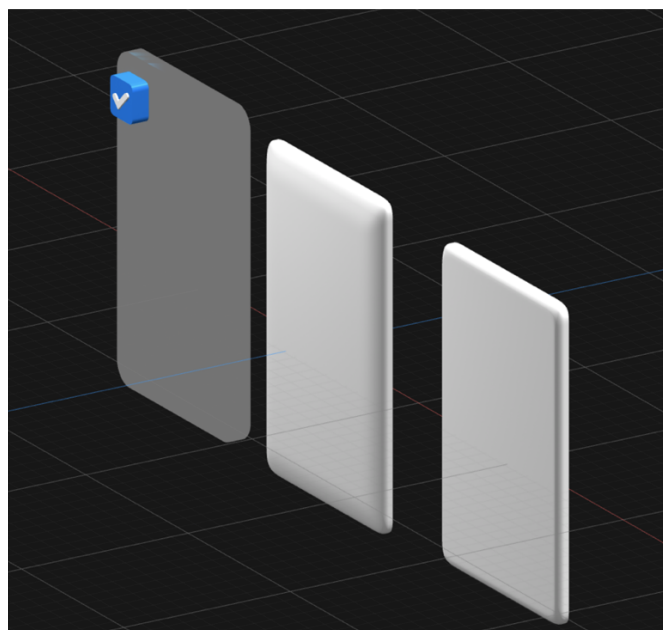


Figure 10: 3D Backplate Concepts (31) (38)

4.3. Design of the Smart Glasses Application

Winter Semester 2022

During summer holiday, I consulted the thesis with co-founder of Bohemia Interactive game corporate Jan Hovora, who is CEO of extended reality startup Pocket Virtuality. I created presentation for him showing the main features. He offered me collaboration for purpose of enhancing the diploma.

In the meantime, I created 2D Figma prototype of the interface with dynamic interactions and hand layouts using third-party photos (46) and icons (47) (the outcomes are attached at the end of this section).

4.3.1. *Funding Results*

During summer holiday, I have been writing e-mails asking for status of the scholarship application, but I received no answer. In September, the request was declined because of the requested amount. Although I stated I do not need the full amount, the information was never communicated to the scholarship committee.

4.3.2. *Need to Change the Project Scope*

Due to the feedback from the exam committee and the lack of funds to finance development of the library (since the library was too hard to code by an inexperienced person), we have agreed with supervisor to reassess the feasibility of the project. The challenge was the lack of time – I had about 5 months to come up with a new project, but the official diploma topic was already the user interface library.

My supervisor suggested shifting the topic into assembly of small projects:

- Create the library only as design resource in Figma
- Create static elements in 3D and show them in the headset's 3D viewer
- Create video-mock by placing the interface design into a video of real physical world

Another idea was to start from scratch and build augmented reality app from code samples (48). I did research of possible open-source templates and I found out, that most of them were too risky to adjust (e.g., they were built on obsolete version of operating system, their documentation was missing, or I would need extensive initial knowledge to continue).

4.3.3. *Agreement on the New Project Scope*

At this point I consulted the situation with Josef Kortan, former Unity teacher at our faculty. He suggested another project idea – to visualize new philharmonic hall in Prague. He offered to manage partnership with Prague urban planning institute, that would use this project for their own purposes. I decided to work on this project, and we arranged kick-off meeting in Prague, where I got a consultation support, study materials and hardware. Though this was a shift from the initial diploma assignment, it was supported by supervisor and by the committee at the final semester exams.

I started learning Unity development. Unity development was a challenge to learn, especially the environment setup since HoloLens headset is experimental and uses specific

technology. I was also learning Blender, which has also very steep learning curve, but at least extensive community support. I discovered official HoloLens Development Learning Paths (49) that helped me very much in the journey. At the end of semester, I was able to successfully duplicate several the tutorials.

4.3.4. *Research of Urbanism*

After learning Unity basics, I had to acquire proper urbanistic and architectural background to create usable design.

Firstly, I did research of the situation surrounding Prague Philharmonic. Firstly, I did interview with Josef Kortan and Jan Poslušný, who have knowledge about this whole situation. Secondly, I did table research of news articles (50) (51) (52) about problems that the urban plan faces. The insight was, that the philharmonic visualization might be just the tip of an iceberg. The real problem is revitalization of urban district Prague-Bubny, where the Philharmonic is situated. There are many issues to be resolved before the building phase would even start (e.g., noise, traffic, environment, investors, etc.). In conclusion, visualize just Philharmonic should not be the only feature of the application.

4.3.5. *Research of Architecture*

At the faculty, there is specialization “Architecture in Environmental Design”, that operates in the field I needed to study. Firstly, I tried to make partnership with some students there, because I needed 3D models for the augmented reality visualization. I tried several students, but they did not have time to participate because of working on their own projects. Then I arranged meeting with their supervisor František Fránek to establish collaboration through him.

Although their interests were focused more on hardware engineering than augmented reality visualizations, I arranged HoloLens presentation for students of the specialization. They tried this headset and provided feedback of possible utilization of this device in their professional field. [Figure 15: Presentation of HoloLens](#)

4.3.6. *Research of Industrial Design*

During the research in architecture, Josef Kortan told me that Industrial Design studio at our faculty might be also interested in augmented reality. So, I had meeting with the studio leader Jan Korábečný, and we arranged HoloLens presentation too. Again, the students (and the studio leaders) tried this headset and provided feedback of possible utilization in their professional field.

4.3.7. *Design of the Application*

After summarizing these outcomes, I concluded that the results convergate and I can design application, that would have benefit for all – urbanists, architects, and industrial designer together. Then, I came up with features of the application, drew concept sketches of the application (e.g., interface, layout, interactions, etc.) and then build interactive 3D prototype of the application in the Spline app – using third-party assets of photos (53) (54) (55), icons (47) and 3D objects (56) (57) (58).

The application should be a table, that behaves like a world of “god-like” possibilities with two zoom levels:

- **Mini View:** miniature of 3D object, that allows you to:
 - Change environment settings by dragging elements of nature (e.g., sun and clouds to simulate shadows)
 - Drag objects (e.g., trees, buildings, etc.) to the scene by hand to create custom environment
 - Upload custom 3D model
- **Real-Size View:** real-size view of one of the 3D models, that allows you to:
 - Place the model on precise location (in your surroundings or certain GPS location) and see it in real-world context

I used adapted 2D menu (the control panel in front of the table) to enter global feature (e.g., switch between these zoom levels) or to edit detailed simulations of the environment. For other interactions I wanted to design more creative menus such as collocated 3D widgets (e.g., slider to set daytime) or contextual hover menu to enter “Real-Size View” of one specific object.

4.3.8. *Outcomes*

The final presentation had good responses from the committee, and they supported the proposed change of the scope of the project.

As the result of this semester, I created:

- Dynamic 2D Figma prototype of the interface (with interactions) and Hand Layout
 - [Figure 11: Example of the Interface Elements](#)
 - [Figure 12: Example of the Interface Styles](#)
 - [Figure 13: Hand Layout Concept – Top](#)
 - [Figure 14: Hand Layout Concept – Bottom](#)
 - Figma File: <https://www.figma.com/community/file/1230596550300936486>
 - Interactive Prototype: <https://www.figma.com/proto/KnbGxGhzigimLELJWIT9rKq/Spatial-Design-System?node-id=510-352&scaling=scale-down&page-id=510%3A351>
- Summary of all the research I performed
- Features and design concept of the application
 - [Figure 16: Selection of Sketches](#)
- Interactive 3D prototype of the application
 - [Figure 17: Mini View](#)
 - [Figure 18: Real-Size View](#)
 - Interactive 3D Prototype: <https://my.spline.design/arappmini-7076eb5ec8f8597ebff9b28d0131a189/> (there is circa 20 second loading time)

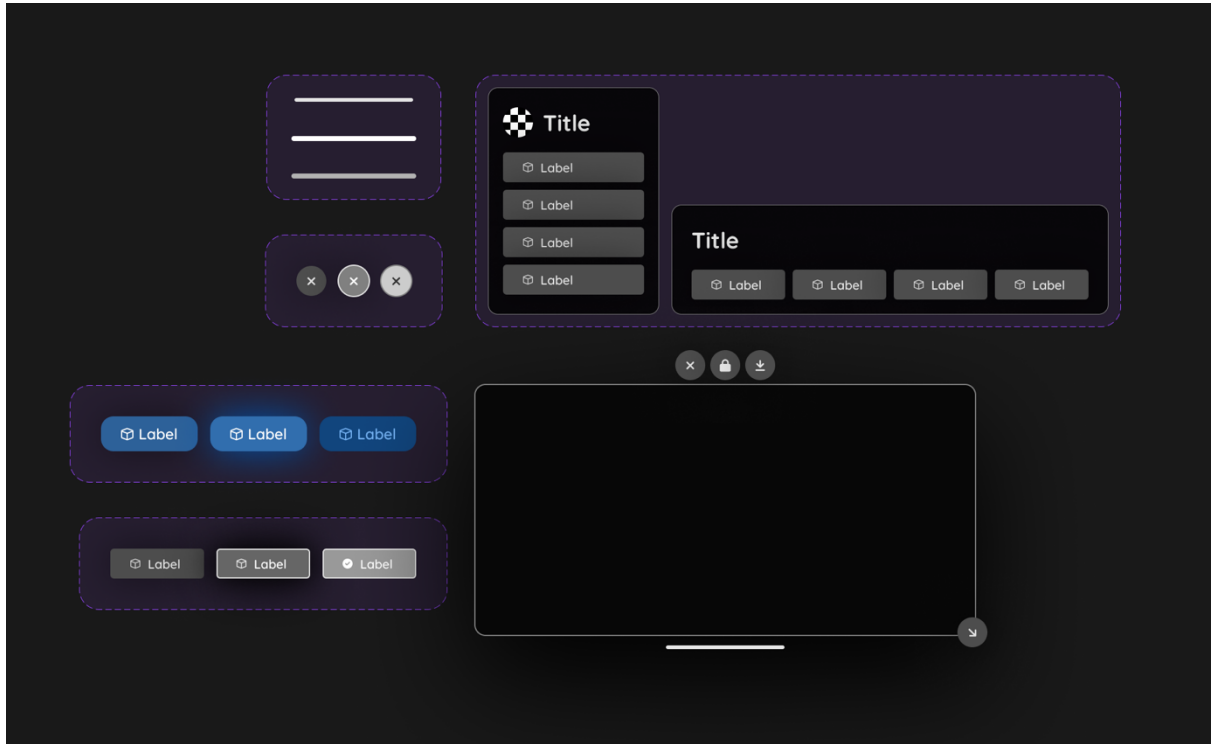


Figure 11: Example of the Interface Elements (31) (47) (32) (32)

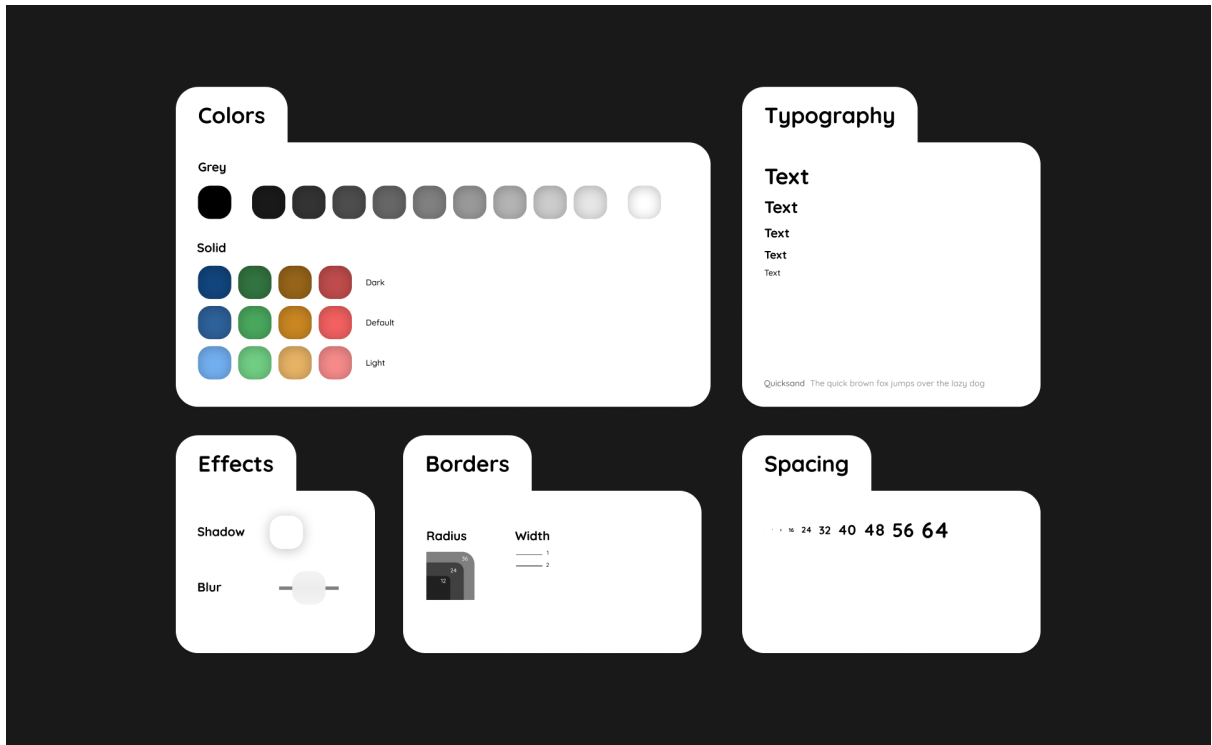


Figure 12: Example of the Interface Styles (31) (32) (32)

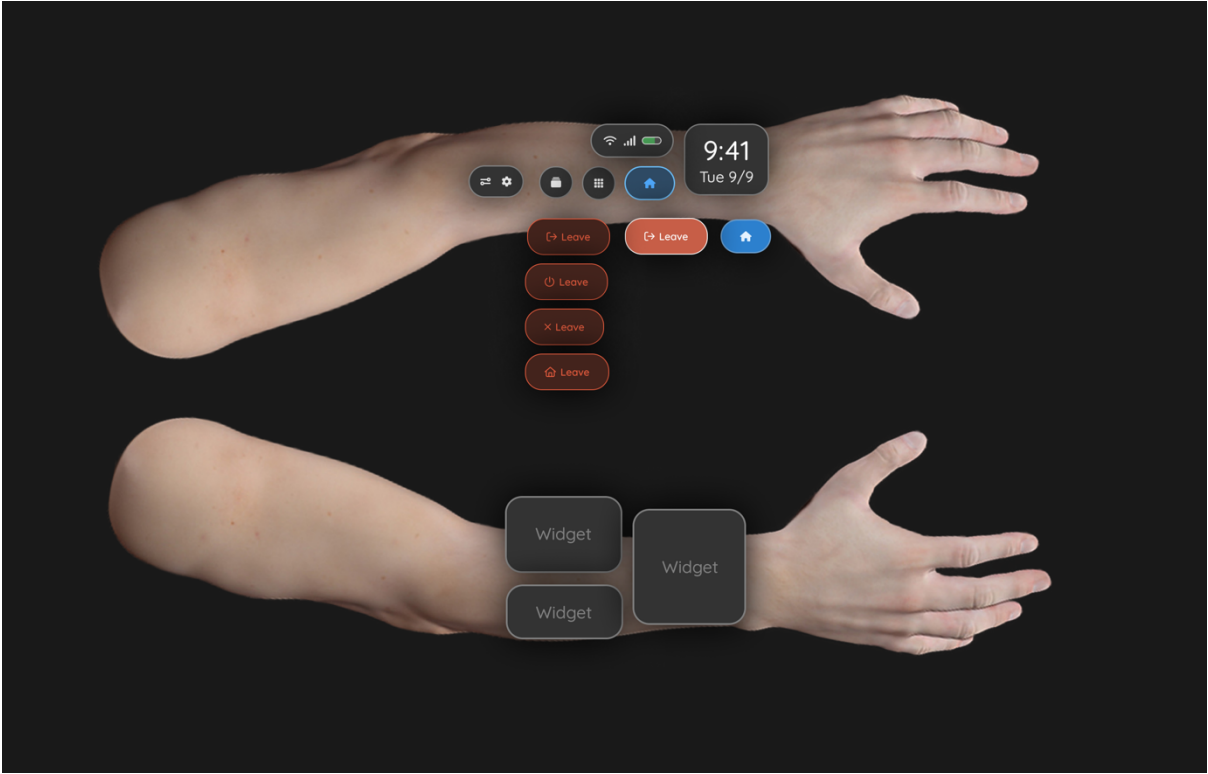


Figure 13: Hand Layout Concept – Top (31) (46) (32) (32)

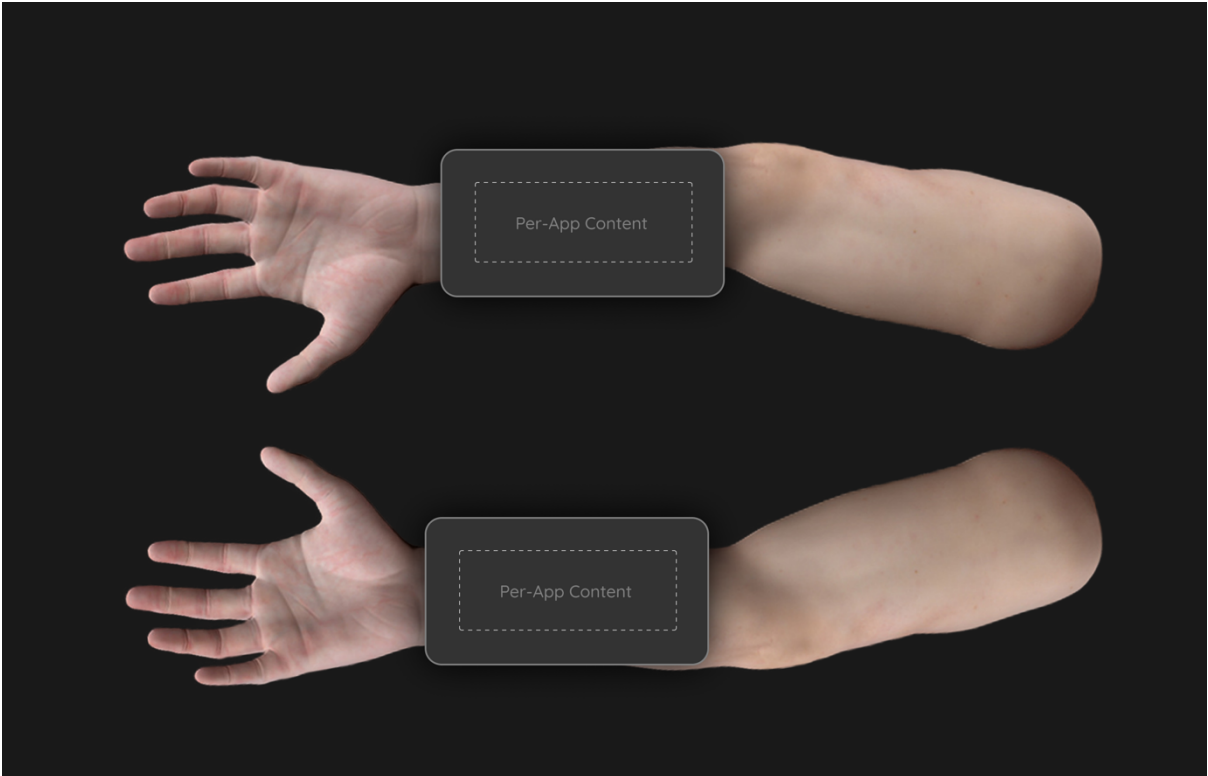


Figure 14: Hand Layout Concept – Bottom (31) (46) (32) (32)



Figure 17: Mini View (31) (57) (58) (56) (47) (38)

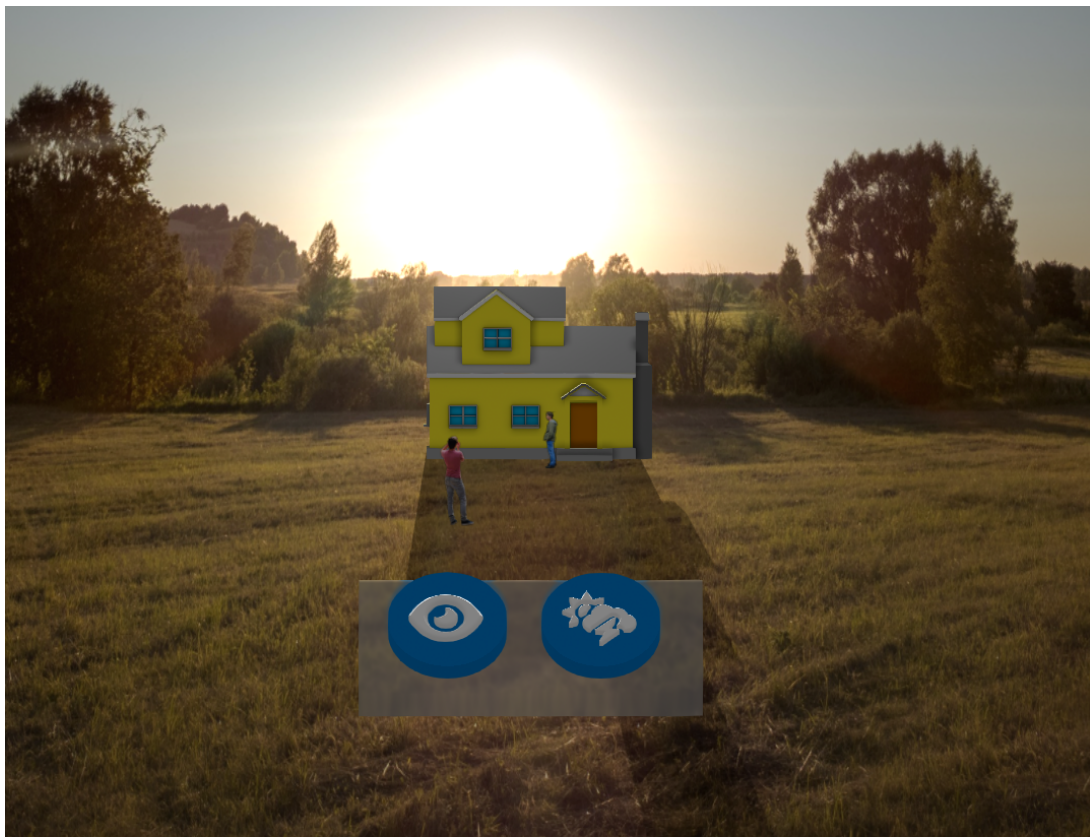


Figure 18: Real-Size View (31) (47) (56) (55) (53) (54) (38)

4.4. Development

Summer Semester 2023

This semester was designated to develop the application in Unity (28) using Mixed Reality Toolkit (59) and carry out user testing.

4.4.1. *Scope Definition*

The previous concept was designed as the ideal state of the application. For the development part I had to program only the features that are most useful and feasible at the same time (because of short period designated for the development phase). I arranged meeting with the faculty Unity teacher Klára Klánová, who helped me with understanding the Unity interaction system. Together we defined the features that I should keep for the development. I decided to work mostly with natural hand interactions since it is the most common mean of spatial interaction (60) (2) and Microsoft offers support for this feature (59). Based on conversations with supervisor and consultants, we agreed to keep only the “Mini View” and release the first demo as a “tool for environment building”.

4.4.2. *Challenges*

In the development phase, I faced a few development challenges. Firstly, the previous 3D prototype was not compatible with Unity, so I had to create the scene once again from the scratch inside Unity. Most of the bugs I got were caused by hand manipulation feature. I also had to resolve compilation issues because Microsoft uses their own compilation and deployment engine in Visual Studio (61). Apart from errors I faced in Unity, I got many in Visual Studio errors and after deployment I got some of them in the HoloLens itself.

I encountered a lot of development issues, for most of them I was able to find solution on the internet and for some of them I did not get any result, so I had to use a lot of workarounds. But some of them I have not been able to fix so I have not implemented the whole feature, where the problem appeared (e.g., dynamic shadows made by sun transformations and cloud positioning). In the scene I used 3D model of Prague Philharmonic Hall designed by Bjarke Ingels Group (62).

4.4.3. *User Testing*

After compilation of the initial build, I carried out user testing with designers at our faculty. In general, participants valued the whole augmented reality environment and the possibility to manipulate holograms by their hands. People, who have not tried this technology before, were enthusiastic about the whole device itself.

On the other hand, users were bothered by virtual mesh covering all the physical objects or static appearance of the scene. Also, they were disappointed that they can place only one object from the asset panel. Some people would like to see holograms to respect the laws of gravity and do not get through the ground. Other missing features were “reset button” (that would return the scene to its original state) and lack of animations.

I incorporated all these requests into the final build.

4.4.4. Outcomes

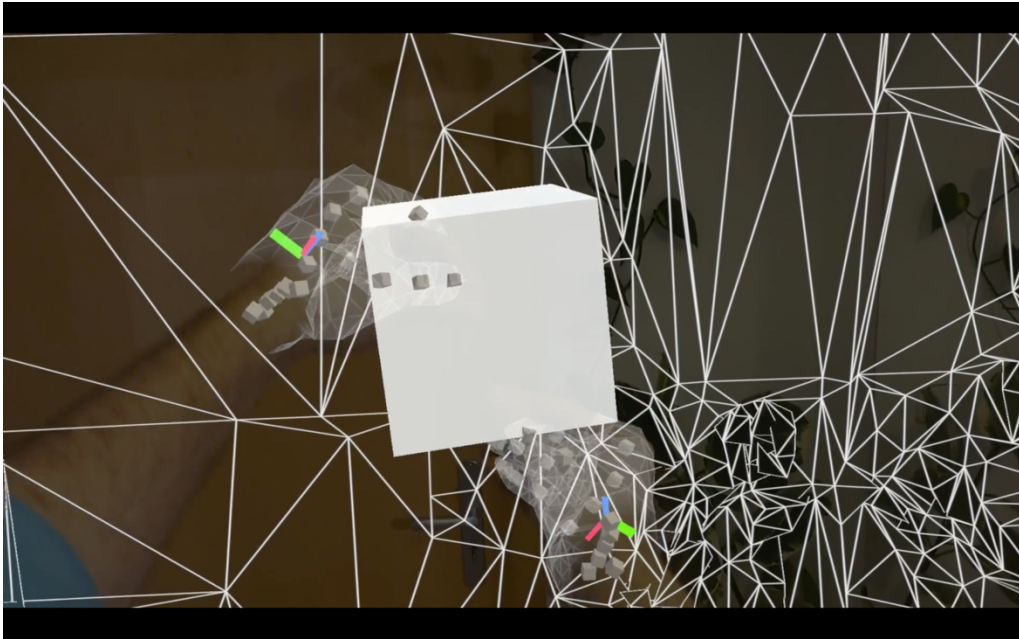


Figure 19: First Successful Deployment (31) (59)

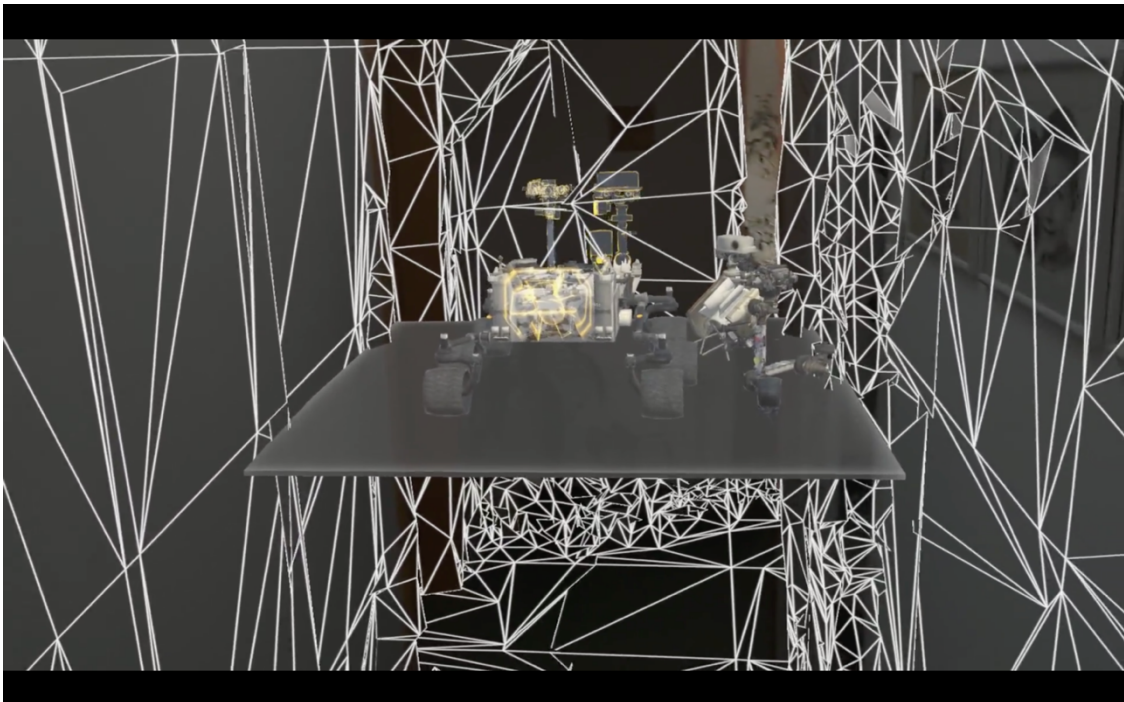


Figure 20: Outcome from Microsoft's Tutorial (31) (49)

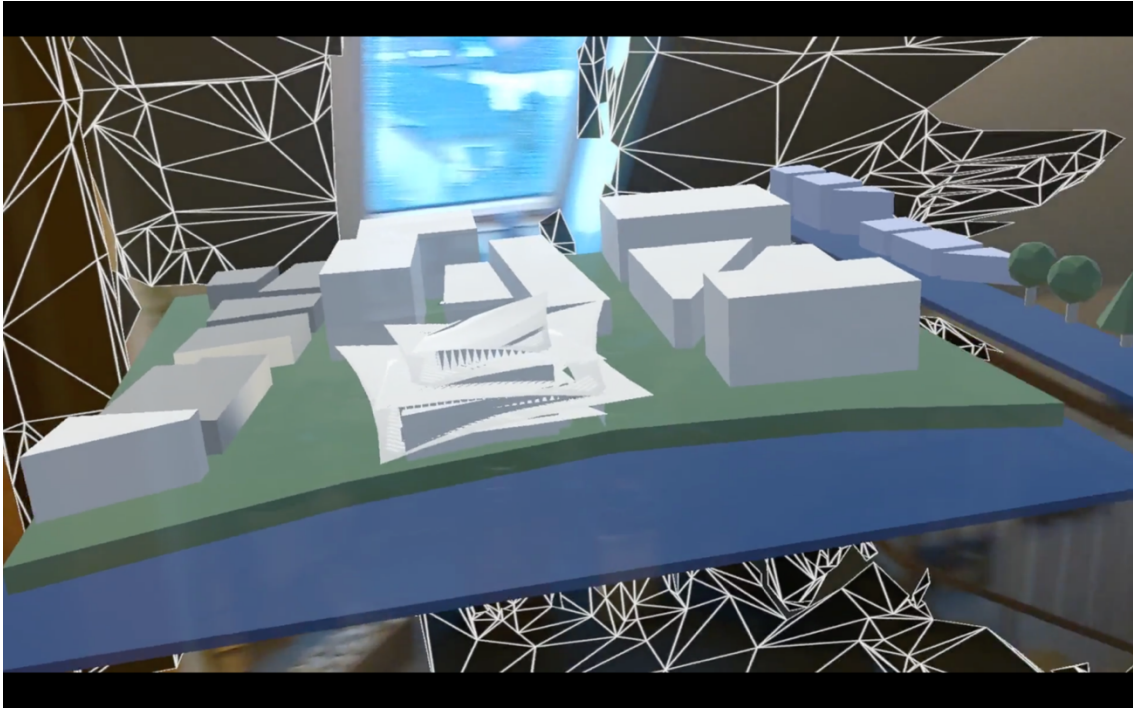


Figure 21: First Static Assembly of the Application (31) (62)

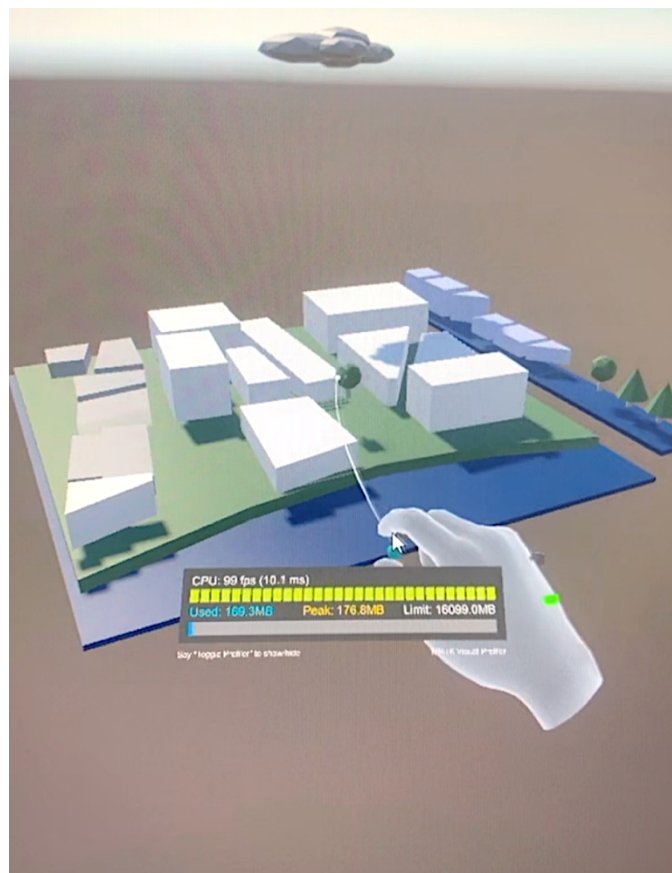


Figure 22: Desktop Preview of the Application (31) (59) (28)

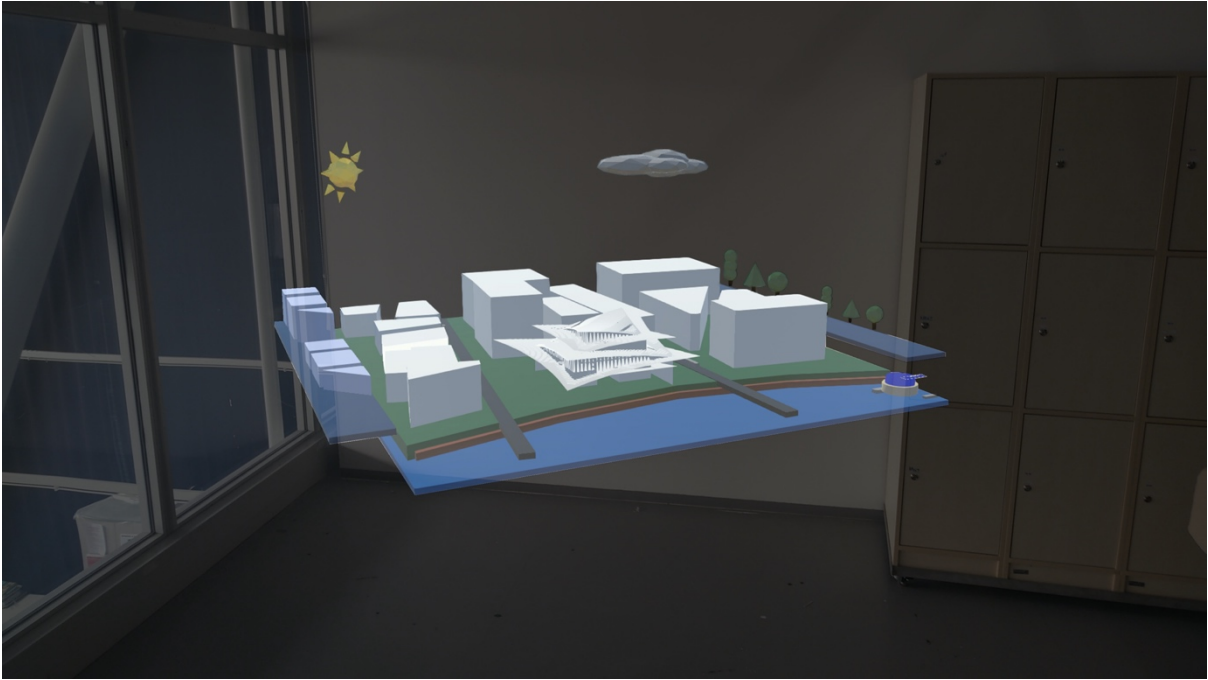


Figure 23: Final Application Overview (31) (62) (59)

Video of the final application:

<https://youtu.be/999Uh9dnK9k>

5. Technology Specifics

Augmented Reality is part of Extended Reality technology. Most people around me have already heard of immersive VR headsets for playing videogames. Or mobile apps, that render virtual objects in your camera view, so you can place e.g., virtual sofa to empty corner in your living room (6).

In my opinion, the future is in combination of both these devices in one – Smart Glasses. Imagine you can see holograms around you through these glasses. For this experience, our faculty bought experimental “smart glasses” headset Microsoft HoloLens 2 that I am using for the diploma thesis. Due to the youth and experimental nature of this technology, working with it was not easy for me.

This device is powerful in delivering natural experiences. You can interact with virtual objects using hands (e.g., pressing virtual 3D buttons using your finger in space) or sight (e.g., trigger action by gazing at certain element). This experience is extremely immersive. However, as every experimental technology, this device has also weaknesses.

- **Field of View:** The area where you can watch holograms is very small
- **Color representation:** The colors inside the headset appear transparent and desaturated
- **Performance:** The device is not able to render high-quality scenes (unless it is done remotely in cloud) because of low computing power
- **Third-party usage:** As this technology is not common yet, the development is hard and without proper technical support.



Figure 24: Microsoft HoloLens 2 (7)

6. Benefit of the Projects for My Specialization

The benefit is primary in breaking through of development for this platform. As I stated, I perceive augmented reality headsets (smart glasses) as one of the most anticipated technologies nowadays (alongside with blockchain, artificial intelligence, etc.). I believe that in the following five to ten years we will all be walking with smart glasses, that projects holograms into real environment. With this prospect, Faculty of Design and Art might be the first art school in Czechia, that creates design for this platform.

I hope I opened doors for other students to start using this technology. Also, this project or technology might serve as a fine presentation of modern approach of the school for people outside university, such as new students or foreign universities.

7. Resumé

Despite a lot of challenges, I found this work very inspiring. This was the most interesting technology I have ever worked with. I would like to continue designing for augmented reality, because it enables almost endless possibilities for creativity. For me this is inevitable part of the future, and I would like to be a part of this “revolution” in design segment.

Although I worked alone, this project could be never viable without tremendous support of people around me. Specifically, because of Jan Kokolia and his significant support thorough this whole project and Josef Kortan for providing opportunities for the application of the project and consultations. Likewise, to other teachers and the management of the Faculty of Design and Art, who helped me by consultations or providing the necessary tools or devices.

And finally, I would like to thank my family for their great support throughout my entire studies.

8. Resources

1. **Polacek, Robert.** User Interface Concept for Smart Glasses . *Research Gate*. [Online] [Cited: 4 12, 2023.] https://www.researchgate.net/publication/343980281_User_Interface_Concept_for_Smart_Glasses.
2. **Microsoft.** Mixed Reality Documentation. *Mixed Reality*. [Online] [Cited: 4 12, 2023.] <https://learn.microsoft.com/en-gb/windows/mixed-reality/>.
3. **Google.** Overview. *Material Design*. [Online] [Cited: 4 12, 2023.] <https://material.io>.
4. **LEGO.** Home. *Official LEGO Shop*. [Online] [Cited: 4 12, 2023.] <https://www.lego.com/en-cz>.
5. **Electronic Arts.** The Sims Video Games. *Official EA Site*. [Online] [Cited: 4 12, 2023.] <https://www.ea.com/en-gb/games/the-sims>.
6. **IKEA.** IKEA Kreativ. *Virtual and Mixed Reality Room Design*. [Online] [Cited: 4 12, 2023.] <https://www.ikea.com/ca/en/home-design/>.
7. **AYES.** Microsoft HoloLens 2 . *AYES*. [Online] [Cited: 4 12, 2023.] <https://www.ayes.cz/produkty/microsoft-hololens-2/>.
8. **Yord, s.r.o.** AR, VR & Metaverse Studio. *YORD*. [Online] [Cited: 4 13, 2023.] <https://yordstudio.com>.
9. **Brainz Immersive s.r.o.** . Virtual & Augmented Reality Agency. *BRAINZ IMMERSIVE*. [Online] [Cited: 4 13, 2023.] <https://immersive.cz>.
10. **Bechtel AG.** Your Strong IT Partner. Today and Tomorrow. *Bechtel*. [Online] [Cited: 4 13, 2023.] <https://www.bechtle.com>.
11. **Movisio.** Spolehlivé IT projekty. *Movisio*. [Online] [Cited: 4 13, 2023.] <https://www.movisio.com/cs>.
12. **AR Fest.** Home. *The ARFest*. [Online] [Cited: 4 13, 2023.] <https://arfest.cz>.
13. **VR Education.** Vzdělávání ve virtuální a rozšířené realitě. *VR Education*. [Online] [Cited: 4 13, 2023.] <https://vreducation.cz/?>.
14. **Versino.** Informační systémy pro malé a střední firmy, SAP Gold Partner. *Versino CZ*. [Online] [Cited: 4 13, 2023.] <https://www.versino.cz/cs-cz/>.
15. **TASTY AIR.** Tvoříme aplikace na virtuální a rozšířenou realitu. *Tasty Air*. [Online] [Cited: 4 13, 2023.] <https://www.tastyair.cz>.

16. **Magic Leap.** Welcome to Magic Leap 2. *Magic Leap Documentation*. [Online] [Cited: 4 12, 2023.] <https://developer-docs.magicleap.cloud/docs/guides/ml2-overview>.
17. **Apple, Inc.** Human Interface Guidelines. *Apple Developer*. [Online] [Cited: 4 13, 2023.] <https://developer.apple.com/design/human-interface-guidelines/guidelines/overview/>.
18. **IBM.** *Carbon Design System*. [Online] [Cited: 4 13, 2023.] <https://carbondesignteam.com>.
19. **Microsoft.** Get Started. *Fluent UI*. [Online] [Cited: 4 13, 2023.] <https://developer.microsoft.com/en-us/fluentui#/>.
20. **Twitter.** *Twitter*. [Online] [Cited: 4 13, 2023.] <https://twitter.com>.
21. **LinkedIn.** *LinkedIn*. [Online] [Cited: 4 13, 2023.] <https://www.linkedin.com/>.
22. **Adobe.** *Behance*. [Online] [Cited: 4 13, 2023.] <https://www.behance.net>.
23. **Dribbble.** Discover the World's Top Designers & Creative Professionals. *Dribbble*. [Online] [Cited: 4 13, 2023.] <https://dribbble.com>.
24. **Apple, Inc.** Reality Composer. *App Store*. [Online] [Cited: 4 13, 2023.] <https://apps.apple.com/us/app/reality-composer/id1462358802>.
25. **Adobe.** Create augmented reality with AR software. *Adobe Aero*. [Online] [Cited: 4 13, 2023.] <https://www.adobe.com/products/aero.html>.
26. **Facebook.** Create Immersive AR Experiences. *Meta Spark Studio*. [Online] [Cited: 4 13, 2023.] <https://sparkar.facebook.com/ar-studio/>.
27. **The Blender Foundation.** blender.org - Home of the Blender project - Free and Open 3D Creation Software. *Blender*. [Online] [Cited: 4 13, 2023.] <https://www.blender.org>.
28. **Unity Technologies.** Unity Real-Time Development Platform | 3D, 2D, VR & AR Engine. *Unity*. [Online] [Cited: 4 13, 2023.] <https://unity.com>.
29. **Snap, Inc.** Creativity Powered by AR. *Snap AR*. [Online] [Cited: 4 13, 2023.] <https://ar.snap.com/lens-studio>.
30. **Staden, Anja van.** Teenyicons 1.0 (Free Icon Set). *Figma*. [Online] [Cited: 4 13, 2023.] <https://www.figma.com/community/file/866420896007969754>.
31. **Polacek, Robert.** *Diploma Thesis – Interactive Project*. University of West Bohemia, Pilsen : 2023.
32. **Figma, Inc.** Free Design Tool for Websites, Graphic Design and More. *Figma*. [Online] [Cited: 4 13, 2023.] <https://www.figma.com/design/>.
33. **FloatGrids.** FloatGrids VR Design System. *Figma*. [Online] [Cited: 4 12, 2023.] <https://www.figma.com/community/file/1087168911388362853>.

34. **Epibyte**. VR UIKit - Bootstrap Your VR App with Ease! *Unity Asset Store*. [Online] [Cited: 4 12, 2023.] <https://assetstore.unity.com/packages/tools/gui/vr-UIKit-bootstrap-your-vr-app-with-ease-128236>.
35. **Space Bear, Inc.** VR UI Kit: Material Design System. *Unity Asset Store*. [Online] [Cited: 4 12, 2023.] <https://assetstore.unity.com/packages/tools/gui/vr-ui-kit-material-design-system-135769>.
36. **maluoi**. StereoKit. *Github*. [Online] [Cited: 4 14, 2023.] <https://github.com/StereoKit/StereoKit>.
37. **TopHatch, Inc.** Homepage. *Concepts App*. [Online] [Cited: 4 13, 2023.] <https://concepts.app/en/>.
38. **Spline, Inc.** Design tool for 3D web browser experiences. *Spline*. [Online] [Cited: 4 13, 2023.] <https://spline.design>.
39. **Vectary, Inc.** Vectary - Create 3D interactive experiences for Web, Augmented Reality and Metaverse. *Vectary*. [Online] [Cited: 4 13, 2023.] <https://www.vectary.com>.
40. **Sketchbook**. For everyone who loves to draw. *Sketchbook*. [Online] [Cited: 4 14, 2023.] <https://www.sketchbook.com>.
41. **Procreate**. Sketch, Paint, Create. *Procreate*. [Online] [Cited: 4 14, 2023.] <https://procreate.com>.
42. **Gravity Sketch**. 3D design and modelling software. *Gravity Sketch*. [Online] [Cited: 4 14, 2023.] <https://www.gravitysketch.com>.
43. **ShapesXR**. VR Creation and Collaboration Platform for Remote Teams. *ShapesXR*. [Online] [Cited: 4 14, 2023.] <https://www.shapesxr.com>.
44. **Microsoft**. Microsoft Maquette. *Steam*. [Online] [Cited: 4 14, 2023.] https://store.steampowered.com/app/967490/Microsoft_Maquette/.
45. **Sketchbox**. The Leading, Virtual Reality Training & Assessment Platform. *Sketchbox*. [Online] [Cited: 4 14, 2023.] <https://www.sketchbox3d.com>.
46. **Webb, Chris**. VR Arm Models / Torso Study. *ArtStation*. [Online] [Cited: 4 12, 2023.] <https://www.artstation.com/artwork/a8mR2>.
47. **Fonticons, Inc.** *Font Awesome*. [Online] [Cited: 4 13, 2023.] <https://fontawesome.com>.
48. **Github, Inc.** Hololens Github Topics. *Github*. [Online] [Cited: 4 13, 2023.] <https://github.com/topics/hololens>.
49. **Microsoft**. Browse all learning paths and modules. *Microsoft Learn*. [Online] [Cited: 4 13, 2023.] <https://learn.microsoft.com/en-us/training/browse/?products=hololens>.

50. **IPR Praha.** Bubny-Zátory. *IPR Praha*. [Online] [Cited: 4 12, 2023.] <https://iprpraha.cz/project/4/bubny-zatory>.
51. **Zabloudilova, Tatiana.** Bubny-Zátory: Nová „hustá“ čtvrť pro 50 000 lidí. Jaké přinese bydlení? *A2larm*. [Online] *A2larm*, 10 15, 2021. [Cited: 4 12, 2023.] <https://a2larm.cz/2021/10/bubny-zatory-prazska-postmoderni-ctvrt-pro-50-tisic-lidi-jake-nabidne-bydleni/>.
52. **Praha 7.** Praha už ví, jak budou vypadat nové Bubny, stavět se začne do 5 let . *Praha 7*. [Online] 6 11, 2019. [Cited: 4 12, 2023.] <https://www.praha7.cz/praha-uz-vi-jak-budou-vypadat-nove-bubny-stavet-se-zacne-do-5-let/>.
53. **Reshetov, Andrew.** *Unsplash*. [Online] 7 14, 2020. [Cited: 4 18, 2023.] <https://unsplash.com/photos/Fmkj7qZ1Jgl>.
54. **SeekPNG.** Man Png Image - Free Png People. *SeekPNG*. [Online] [Cited: 4 18, 2023.] https://www.seekpng.com/ipng/u2q8a9a9a9y3u2i1_man-png-image-free-png-people/.
55. **Raastawala.** People Take A Picture Png, Transparent Png. *KindPNG*. [Online] [Cited: 4 18, 2023.] https://www.kindpng.com/imgv/hJohoim_people-take-a-picture-png-transparent-png/.
56. **_its_sagar_bro.** Low poly house. *Sketchfab*. [Online] 5 13, 2021. [Cited: 4 18, 2023.] <https://sketchfab.com/3d-models/low-poly-house-796232a307d24b6881f4f42476058701>.
57. **Kim, Hyungjung.** Low Poly Cloud. *Sketchfab*. [Online] 10 28, 2017. [Cited: 4 18, 2023.] <https://sketchfab.com/3d-models/low-poly-cloud-81910476b24d4fc5a73c908d6c2a38a2>.
58. **Jassi.** Lowpoly Forest. *Sketchfab*. [Online] 12 9, 2018. [Cited: 4 18, 2023.] <https://sketchfab.com/3d-models/lowpoly-forest-7a249aba33484437b385de17a228a814>.
59. **Microsoft.** What is Mixed Reality Toolkit 2? . *Microsoft Learn*. [Online] [Cited: 4 13, 2023.] <https://learn.microsoft.com/en-us/windows/mixed-reality/mrtk-unity/mrtk2/?view=mrtkunity-2022-05>.
60. **Fictum, Casey.** *VR UX*. s.l. : CreateSpace Independent Publishing Platform, 2016. 1533273022.
61. **Microsoft.** IDE and Code Editor for Software Developers and Teams. *Visual Studio*. [Online] [Cited: 4 14, 2023.] <https://visualstudio.microsoft.com>.
62. **Group, Bjarke Ingels.** *Vltava Philharmonic Hall*. Center for Architecture and Metropolitan Planning, Prague : 2022.
63. **LaViola, Joseph, et al.** *3D User Interfaces*. s.l. : Pearson Education, 2017. 9780134034461.

9. Table of Figures

Figure 1: Bachelor Thesis Outcomes (1)	8
Figure 2: Examples of Twitter Post With Design Tips (31) (2) (30) (20) (32).....	13
Figure 3: Counter of Characters for Twitter Posts (31) (2)	13
Figure 4: Website with Design Tips (31) (2) (30)	14
Figure 5: Stand to HoloLens (31) (39).....	17
Figure 6: Transparency Representation to HoloLens (31) (39).....	17
Figure 7: Color Representation to HoloLens (31) (39).....	18
Figure 8: Buttons Concepts (31) (32).....	18
Figure 9: 2D Backplate Concepts (31) (32)	19
Figure 10: 3D Backplate Concepts (31) (38)	19
Figure 11: Example of the Interface Elements (31) (47) (32) (32)	23
Figure 12: Example of the Interface Styles (31) (32) (32)	23
Figure 13: Hand Layout Concept – Top (31) (46) (32) (32)	24
Figure 14: Hand Layout Concept – Bottom (31) (46) (32) (32)	24
Figure 15: Presentation of HoloLens (31)	25
Figure 16: Selection of Sketches (31) (37)	25
Figure 17: Mini View (31) (57) (58) (56) (47) (38).....	26
Figure 18: Real-Size View (31) (47) (56) (55) (53) (54) (38)	26
Figure 19: First Successful Deployment (31) (59)	28
Figure 20: Outcome from Microsoft's Tutorial (31) (49)	28
Figure 21: First Static Assembly of the Application (31) (62).....	29
Figure 22: Desktop Preview of the Application (31) (59) (28)	29
Figure 23: Final Application Overview (31) (62) (59).....	30
Figure 24: Microsoft HoloLens 2 (7)	31