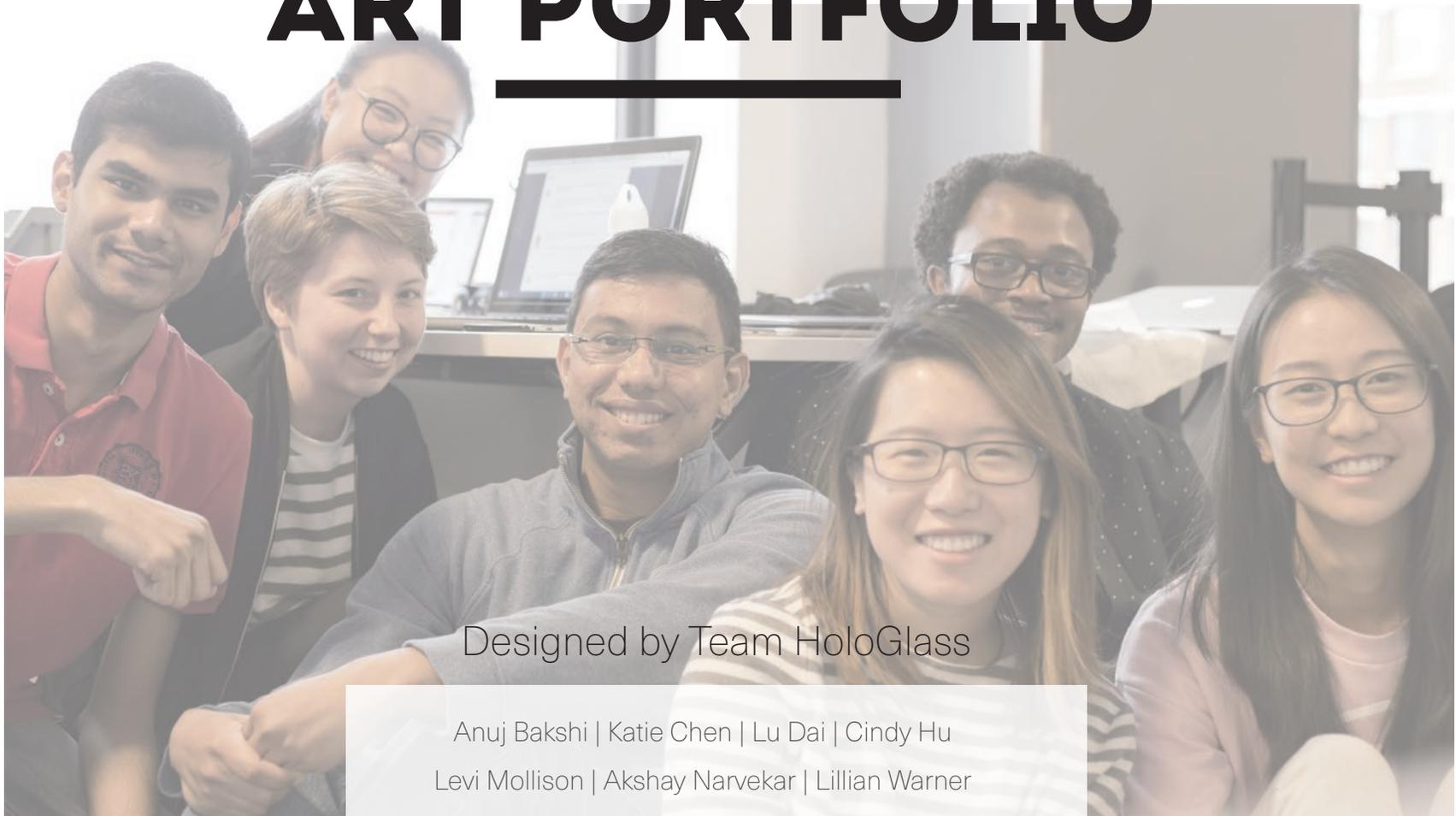


HOLO LENS DESIGN CHALLENGE



**TEAM
HOLOGGLASS**

HOLOGRAPHIC ART PORTFOLIO



Designed by Team HoloGlass

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I. INTRODUCTION

1.1 Who We Are

We are an interdisciplinary team of seven people who come from design, research, and engineering backgrounds. The goal of our holographic art portfolio is to create an intuitive mixed reality experience using new technology that showcases digital and physical artwork. We want both curators and artists to have an excellent experience using our holographic portfolio.

Our project is developed for the Microsoft HoloLens. The HoloLens is the world's first holographic computer. The device is pioneering the concept and experience of mixed reality. If virtual reality is one end of the spectrum, and reality is the other, mixed reality falls in between. Mixed reality means that digital objects are placed within the real world environment, allowing users to interact with virtual and physical elements together at the same time. The HoloLens allows holograms to interact with physical space, creating a blended world for users.

The goal of this project is to use the HoloLens to display artwork in new and engaging ways. Our holographic portfolio utilizes 360 sound, voice commands, gestures, and spatial mapping. Unlike VR, which relies on cutting out the real world, we knew we could use the HoloLens to create an immersive experience that utilizes the user's real-life environment.

This booklet is a description and analysis of our design methods, findings, and opportunities for further development of the holographic portfolio.

Reality On A Spectrum





1.2 Objective - Design Challenge

“
Imagine a holographic portfolio that enables you to experience and sense art works in a new way. Design a proof of concept for a holographic portfolio that covers the end-to-end experience of an artist’s portfolio to be viewed on the HoloLens. This is not about creating an “artwork” for the HoloLens, but rather a way to interact with different works in mixed reality on the HoloLens. The approach should be based on the experience of a studio visit. ”

-Dana Karwas



Our holographic portfolio illustrates four artworks across multiple mediums including painting, sculpture, video, and interactive installation. The holographic portfolio also includes ways for users to access information such as artist biography, artist statement, contact information, upcoming exhibitions, and event history.

We knew we wanted to create both a practical and delightful experience for curators using our holographic portfolio. We wanted the user to get all the information they would receive from a web portfolio, plus much more. Most importantly, we knew we wanted the user to be able to interact with each piece of art, place each piece of art in their real world environment, and engage with sound,

size, scale, and movement.

In order to bring our design ideas to life, we knew we would need to become familiar with current design trends in virtual and augmented reality. We also knew getting the perspective of both curators and artists would be essential to achieving our goal of creating something practical and delightful.

II. USER RESEARCH

— 2.1 Outreach and Pre-Project Interviews

In order to further understand how to approach this design challenge, we decided to get inside the minds of our potential users. We spoke to the following art professionals to gain a better understanding of what curators look for when they view an artist's work, how artists showcase their work to the public, and which areas of the curatorial experience could be improved:

1 Sarah Humphreville, Senior Curatorial Assistant, Whitney Museum of American Art

Sarah spoke to us about how she curates for exhibitions and builds the Whitney's permanent collection.

2 Emily King, Archivist, Roy Lichtenstein Foundation; formerly Registrar at Fales Library and Special Collections at NYU

Emily spoke to us about what curators look for when they visit an art foundation or art archive. She gave us a tour of Roy Lichtenstein's former studio, and also spoke to us about an art organization's responsibility to present art to the public on behalf an artist.

3 Richard Sigmund, Artist & Art Handler

Richard spoke to us about how he presents his art to the public. He also gave us a tour of his studio and spoke to us about his art making process.

Our main goal while interviewing was to get a solid understanding of the *experience* of curating art, from both the curator's perspective and the artist's perspective.

2.2 Key Insights Extracted from the Interviews

HoloLens Design Challenge

<p>Curators would like to view physical art/objects before accepting them to their spaces, but oftentimes rely on digital or print renderings of the work only.</p> <p>Viewing artwork for the first time often happens when the piece arrives at the museum or gallery.</p>	<p>Curators at large museums are either building the permanent collection or planning for an exhibit.</p> <p>The two activities are very different and require following different sets of protocol.</p>	<p>When planning for an exhibit, curators are often pressed for time.</p> <p>Curators are often working with strict deadlines.</p>	<p>Curators use non-digital methods to organize their physical spaces.</p> <p>Exhibits are often planned using a scaled foam-core rendering of the museum's walls.</p>
	<p>When building the permanent collection, curators are looking for artwork that fills a gap in their collection.</p> <p>Much of the artwork in a museum's permanent collection is not publicly displayed.</p>	<p>When planning for an exhibit, curators are often looking for art that fits into a pre-determined theme.</p> <p>This influences the type of information they are looking for when they view specific artwork.</p>	
<p>Curators present artwork to museum and gallery stakeholders in non-digital ways.</p> <p>Artwork involved in curation discussions, for both exhibits and building permanent collection, is often viewed on 8.5x11 inch printed paper.</p>	<p>The art-making process is on display in artist studios.</p> <p>Most art studios have tools and unfinished works on display. Artists want to show curators their process as well as their finished art when curators visit their studios.</p>	<p>Artwork displayed on a wall is ideally 60 inches off the ground.</p> <p>This is the best place to position art to catch a viewer's eye.</p>	<p>Artwork on display can be "spotted" with special lighting.</p> <p>Artists showing their work, especially sculptures, often shine brighter lights on areas of the piece they want to highlight.</p>

Speaking with Sarah Humphreville was illuminating. We learned about how curation works within the context of a larger institution, specifically with regard to the layers of approvals that an artwork must go through before it is acquired by a museum. We also learned details regarding how exhibits are planned from start to finish. We were especially surprised to find out that foam-core models of the Whitney's walls are used to plan exhibits. Though low-tech, this method appeared to be useful and reliable for Sarah and her team.



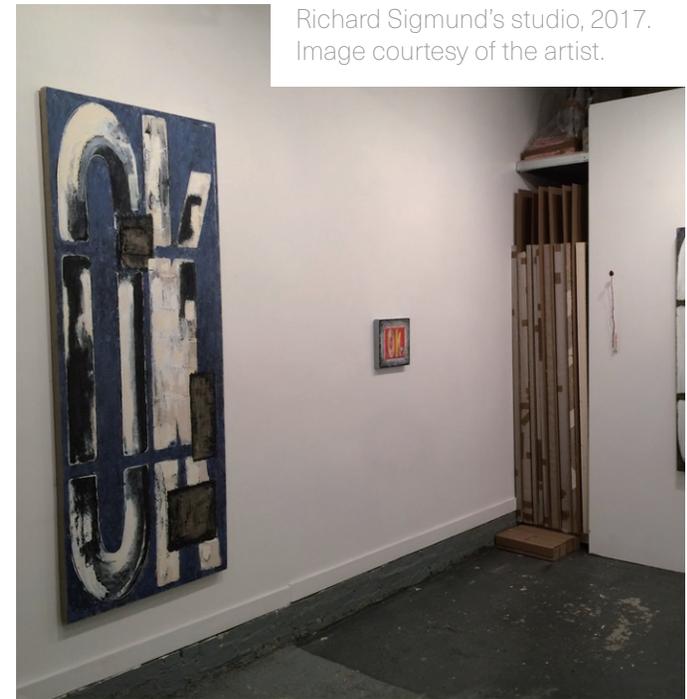
Scale of print-outs for foam-core design, Whitney Museum of American Art, 2016. Image courtesy Sarah Humphreville.



Foam-core exhibit design, Whitney Museum of American Art, 2016. Image courtesy Sarah Humphreville. This method of exhibit planning is low-tech but effective for many art curators.

On the studio tour at the Lichtenstein Foundation, we saw how important it was to the Foundation to preserve Lichtenstein's art-making process. The picture of Lichtenstein's hand-mixed paints and color palettes is just one example of how the Foundation has preserved his art-making process long after his death. The color palette to the left of the paint jars shows what it looks like for an artist experiment, test, and refine artistic methods. His studio still has the distinct feeling of activity, not only because people still work there, but also because the Foundation has intentionally saved unfinished pieces, handwritten notes, and half-used art materials. We learned that when visitors take a tour of the studio, they are primarily interested in learning about his process.

Secondly, we took in how spacious, crisp, and fresh looking Lichtenstein's former studio felt. The room was inviting with its light wood floors, white walls, tall ceiling, and natural lighting. The picture of Lichtenstein's studio floor shows how ample space and good natural lighting (including a partially visible skylight in the top right corner) are ideal conditions for many artists. The same photo also shows professional lighting equipment, again illustrating how important it is for artists to consider lighting while displaying and photographing their work for public consumption.



Richard Sigmund's studio, 2017.
Image courtesy of the artist.

Richard Sigmund's studio also felt spacious and crisp and intentional. It too had white walls and tall ceilings. The photo from Sigmund's studio shows how an artist showcases his work to the public from within his own studio. Sigmund has completed paintings mounted on his studio walls, while other art-making materials are visible in the corner. The floors of his studio are well-worn.

Roy Lichtenstein's former studio, 2017.
Image courtesy of Roy Lichtenstein Foundation.

2.3 Affinity Diagram

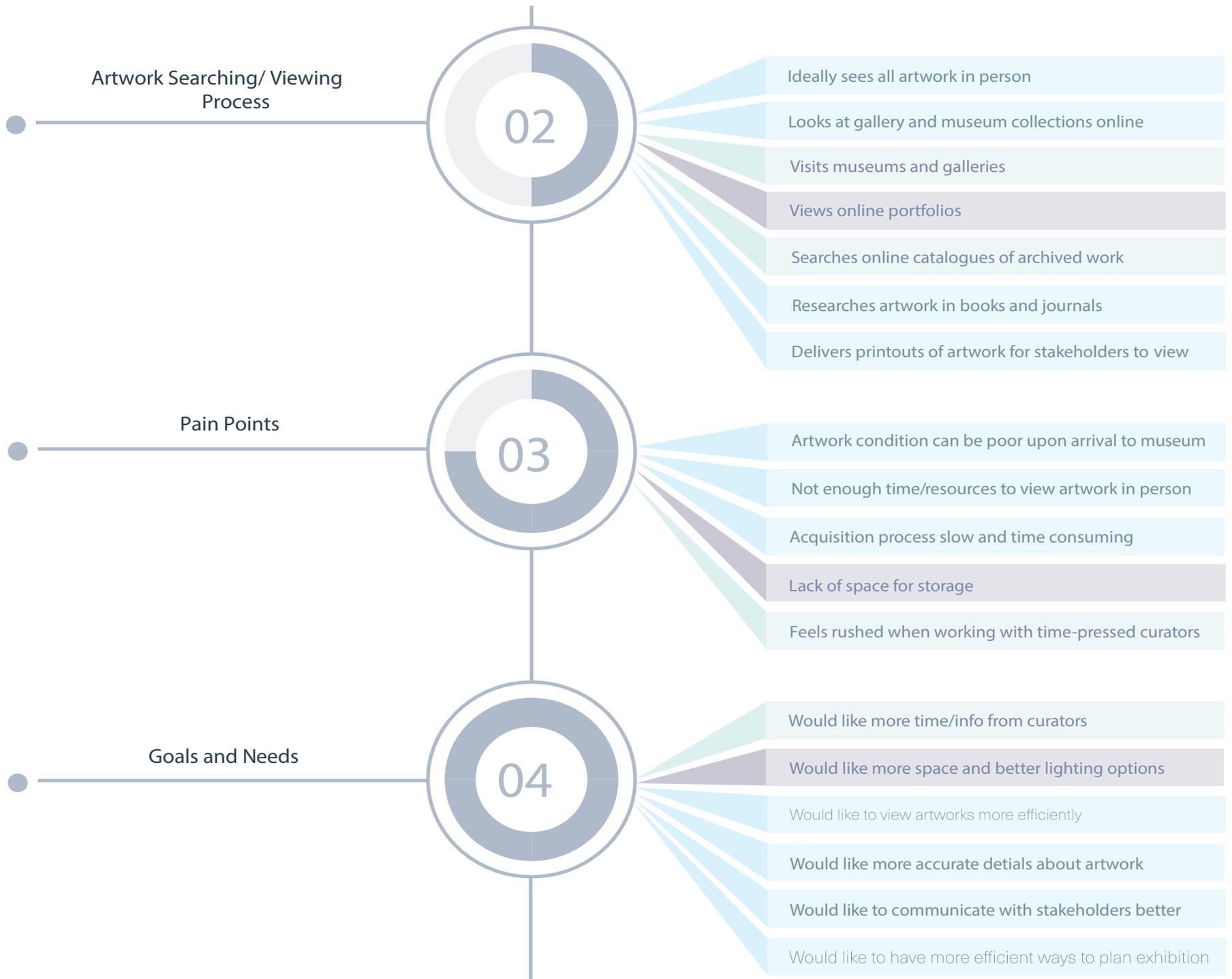
After our interviews, we synthesized our findings with an affinity diagram. Creating an affinity diagram helped us understand the overlap between artists, curators, and art professionals. Our diagram shows the professional activities they have in common, their goals and needs, and their pain points. Understanding common pain points helped us think of ways the HoloLens can make interventions into the curatorial experience to improve or enhance it.

Sarah Humphreville - Senior Curatorial Assistant at Whitney Museum of American Art

Emily King - Archivist at Roy Lichtenstein Foundation, former Registrar at NYU Fales Library and Special Collections

Richard Sigmund - Artist and Art Handler





III. OPPORTUNITY AREAS

— 3.1 Suggested Opportunities

After gaining insight into the perspective of our target users, we came up with the following opportunity areas for the development of our holographic portfolio.

First Impression

A holographic portfolio can give the artist a chance to make an extremely positive and detailed first impression of their work to any viewer. Each person we spoke to, though unfamiliar with mixed reality, expressed enthusiasm about viewing art in this medium.

Exhibit Planning

HoloLens spatial mapping capabilities can be used to plan exhibits in a digital, true-to-scale way. Instead of moving foam-core models around, curators can use the HoloLens to select and move holographic renderings of artwork around their real museum space.

Stakeholder Decision Making

Viewing a holographic art portfolio can give stakeholders a better understanding of the artwork on display during important curation meetings. Even though a curator's ideal experience involves viewing the piece before it arrives at their space, this doesn't always happen. Artwork often arrives at museums and galleries sight unseen. The Ho-

loLens can provide a way for stakeholders to have more informed and detailed conversations about artwork.

Lighting

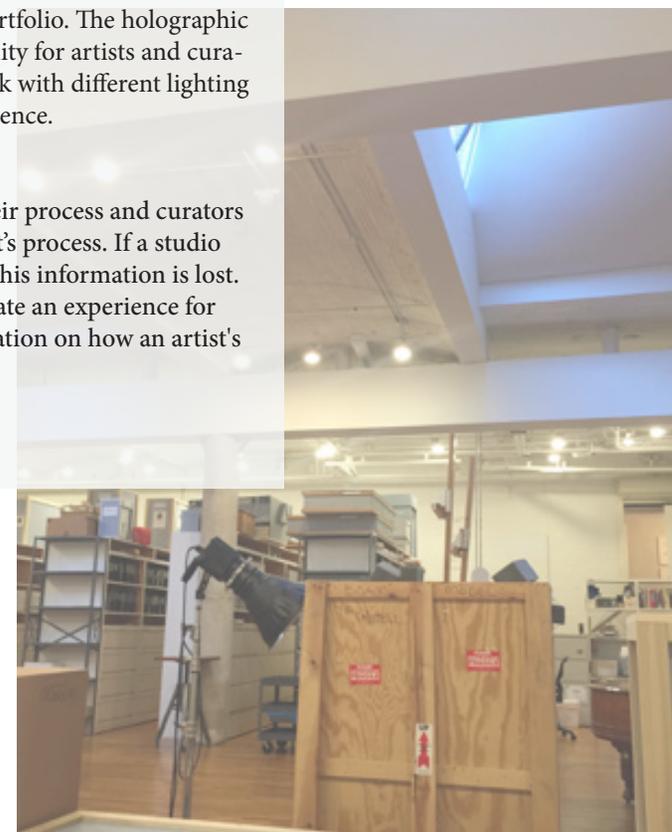
Lighting was an essential component of each studio visit we went on, and we wanted to make sure to show its importance in our holographic portfolio. The holographic portfolio offers a unique opportunity for artists and curators to showcase or view their work with different lighting techniques within the same experience.

Process

Artists often want to showcase their process and curators often want to know about an artist's process. If a studio visit cannot be made, sometimes this information is lost. The holographic portfolio can create an experience for curators looking for more information on how an artist's work is created.

This image shows the skylight in the center of the studio, extensive permanent light fixtures, and professional lighting equipment for photography.

Lighting in Roy Lichtenstein's former studio, 2017.



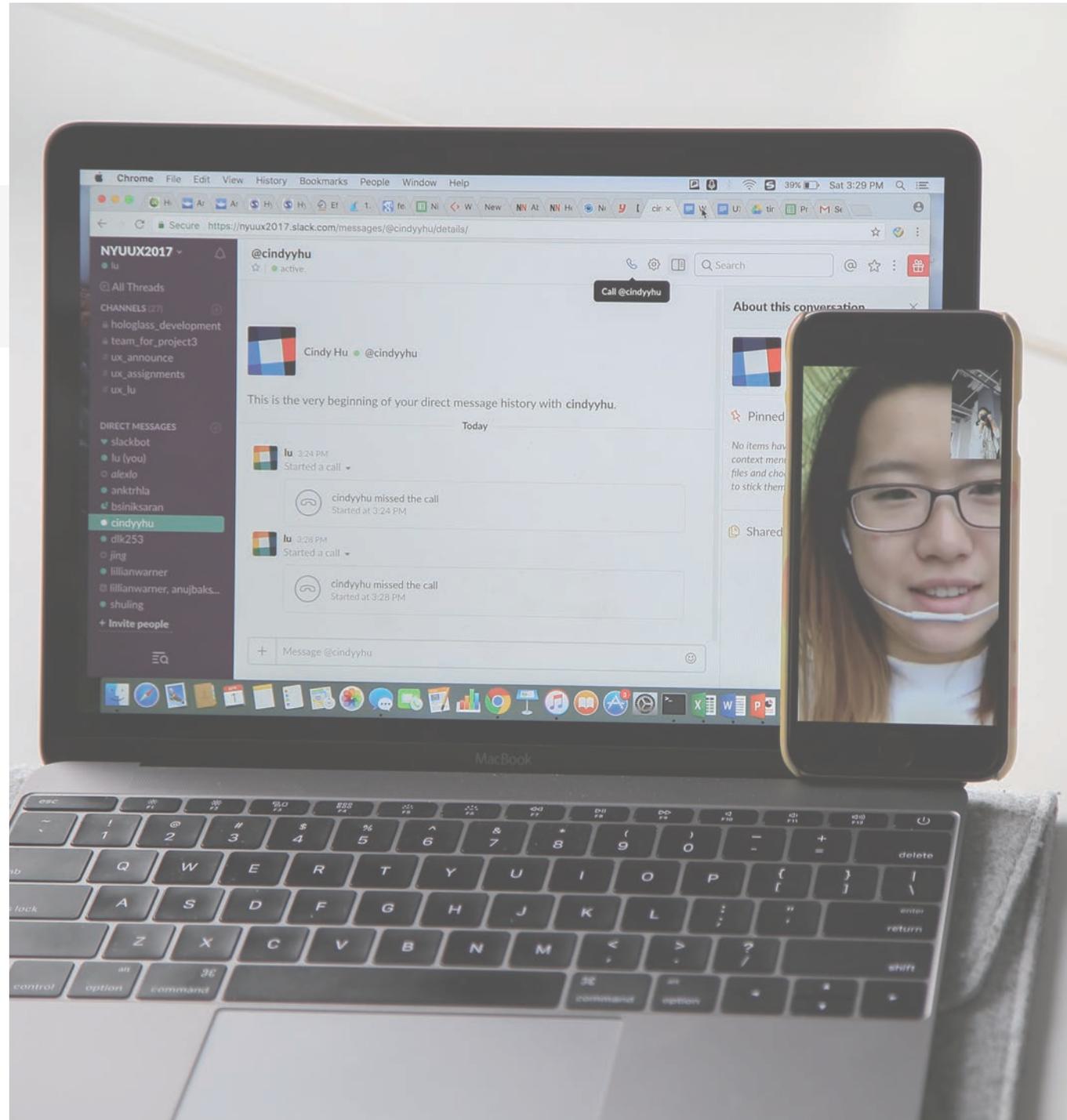
3.2 Limitations

“Curators by nature are people who are interested in objects. We need to touch, feel, and examine art in very, very close detail. The tangible aspects of a curator’s job are very important.”

-Sarah Humphreville, Senior Curatorial Assistant, Whitney Museum of American Art

Being able to see art in person is essential to the curation process, especially when building a museum’s permanent collection. Purchasing decisions for permanent collection building require detailed investigation and appraisal work. In this context, curators depend on having a tangible experience with the artwork in order to do their job. They examine every detail of an artwork, including but not limited to, cracks, tears, framing, paint layers, paint raises, deterioration of paper, and material texture.

A digital portfolio would not be able to replace the in-person process of a curator who only works on building permanent collections. However, a holographic portfolio would certainly be able to improve conversations between various stakeholders involved in the acquisition process.

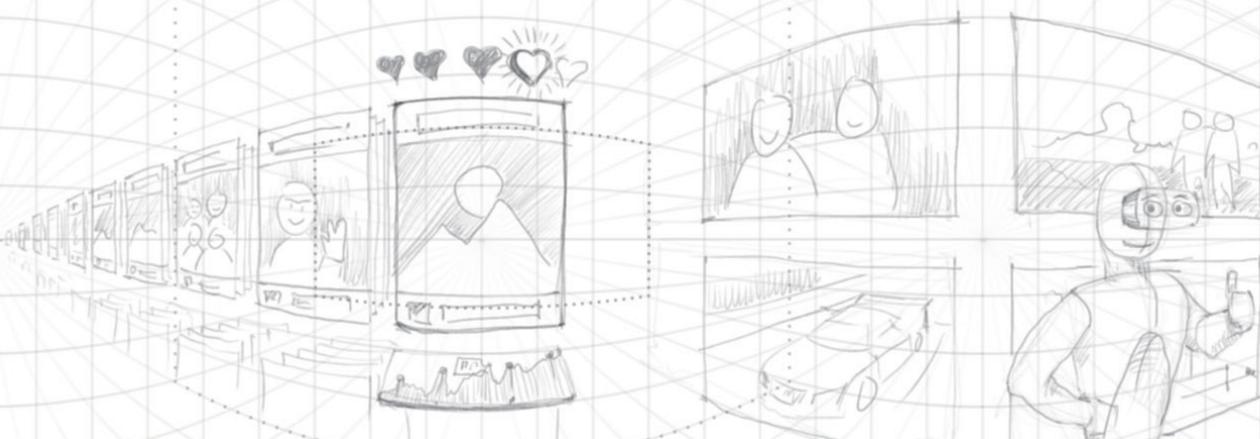


Cindy overcomes a logistical limitation by attending a design meeting virtually.

4.1. Current Trends

Best practices for designing for virtual reality and mixed reality are still being determined. Although products like the HoloLens, Oculus, and HTC Vive have generated extensive press and consumer interest, there still isn't much content available for consumption. Once more content is created, the number of consumers will increase, and we will be able to see what works and what doesn't on a large scale. Until that time comes, the rules for VR and MR content creation are still in flux.

For us, Microsoft's Interaction Fundamentals² and Designing for Mixed Reality³ documents provided the basis for all of our design decisions. We also looked on the website Medium to get a sense of what designers and developers currently do to bring their VR concepts to life. Virtual Reality Pop's article "How to Sketch for VR Like a Pro"⁴ gave us a great foundation for storyboarding. Our biggest takeaway from reviewing Medium posts on VR storyboarding was that we need to illustrate the user's frame of view in any low-fidelity prototype we create.



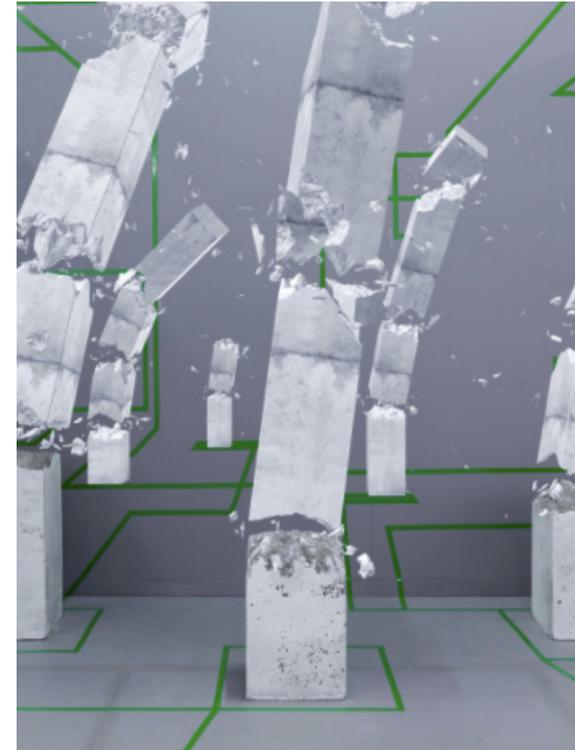
IV. DESIGN INSPIRATION

Sketch from "How to Sketch for VR Like a Pro."

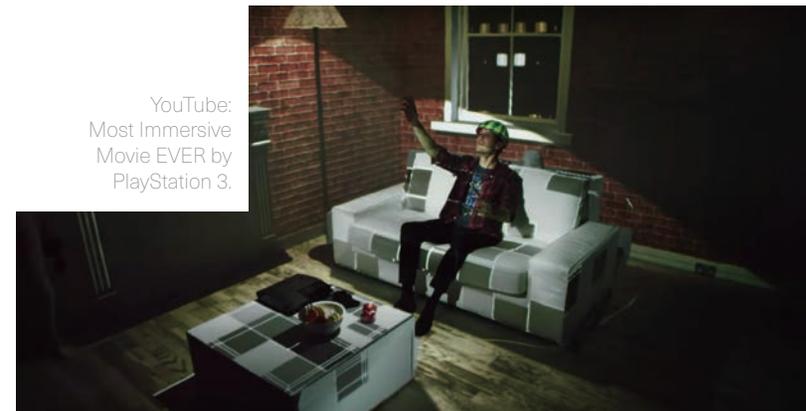
Many VR and AR projects inspired us during the development of our holographic portfolio. We spent hours watching YouTube videos showcasing VR and AR experiences. For example, the New York Times' 360 videos of artists at their home and in their studios gave us a sense of how content similar to ours is being showcased in VR.⁵ We also researched AR applications like Curioos.⁶ Curioos lets users preview artwork on their physical walls using a cell phone. Finally, we spent time viewing art created specifically for VR and AR: Artist Daniel Leighton's augmented reality art exhibit⁷ in 2015 in Los Angeles and PlayStation 3's "Most Immersive Movie EVER" videos⁸ stood out to us as examples of memorable, colorful, and immersive experiences.

Our research was also hands on. We went to the 2017 Armory Show in New York, where we experienced Concrete Storm,⁹ an art piece that requires viewers to wear the HoloLens in order to interact with concrete holographic sculptures placed around a large room. We experienced what it means to move in a blended reality landscape, responding to both virtual and physical objects in the space. The piece showed us how high definition holograms are incredibly compelling, and also how 3D holograms can play with perspective and form.

We also went to the Microsoft flagship store on 5th Avenue to experience the official HoloLens demonstration. This demo showed us the best of what the HoloLens can do, and gave us a deep understanding of how we can utilize the unique capabilities of the HoloLens effectively.



Artsy's Concrete Storm, 2017 Armory Show, New York.

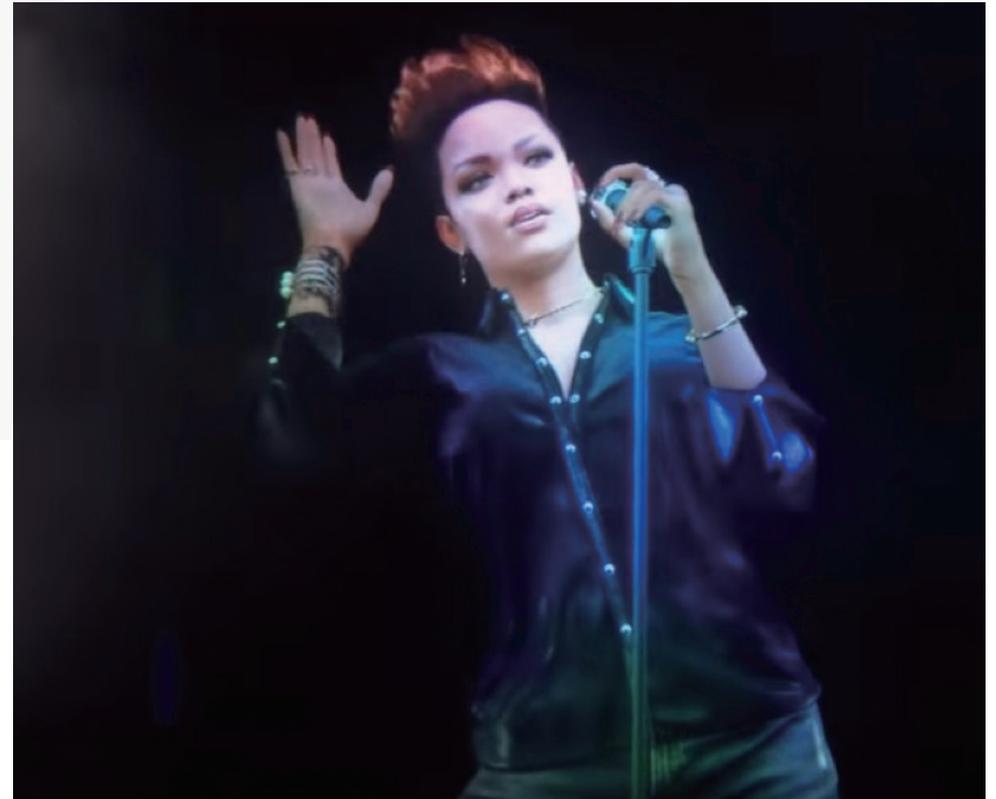
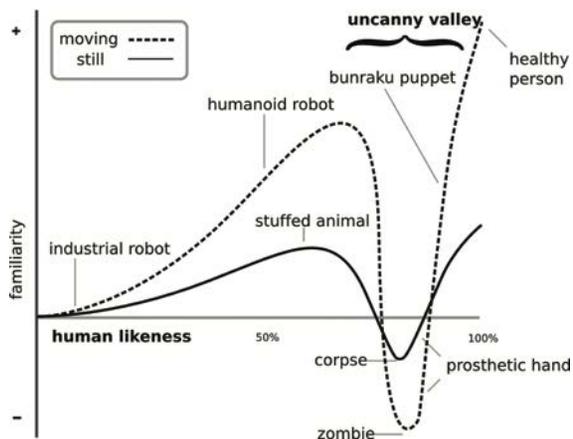


YouTube: Most Immersive Movie EVER by PlayStation 3.

4.3 Theoretical Inspiration

Theoretically, selections from Marshall McLuhan's *Understanding Media*¹⁰ and Freud's essay "Das Unheimliche (The Uncanny)"¹¹ helped ground us. In describing the concept of sense ratios, McLuhan writes, "The effects of technology do not occur at the level of opinion or concepts, but alter sense ratios or patterns of perception steadily and without any resistance." From a psychological perspective, technologies help people focus their attention to the selected object and information, and blur objects in the background. This creates a narrowing effect where selected feelings become enhanced and peripheral feelings become weakened. As we designed our holographic portfolio, McLuhan's concept of sense ratios underpinned our UX decisions.

Freud's essay on the "Uncanny" influenced us in a different way. While McLuhan's ideas pushed us to think about engaging our users' senses in new and creative ways, Freud's essay reminded us that there is often a certain amount of cognitive dissonance that people experience when they encounter something that is "scarily familiar," ultimately causing them to reject the encounter entirely.



Rihanna the life-size hologram performs.

This idea resonated with us when we discussed the possibility of creating a human avatar to guide the user through the holographic portfolio experience. Some of our initial sketches included a human avatar, both in the form of a guide and in the form of the artist. An avatar certainly has benefits when considering a streamlined user flow and an easy, comfortable

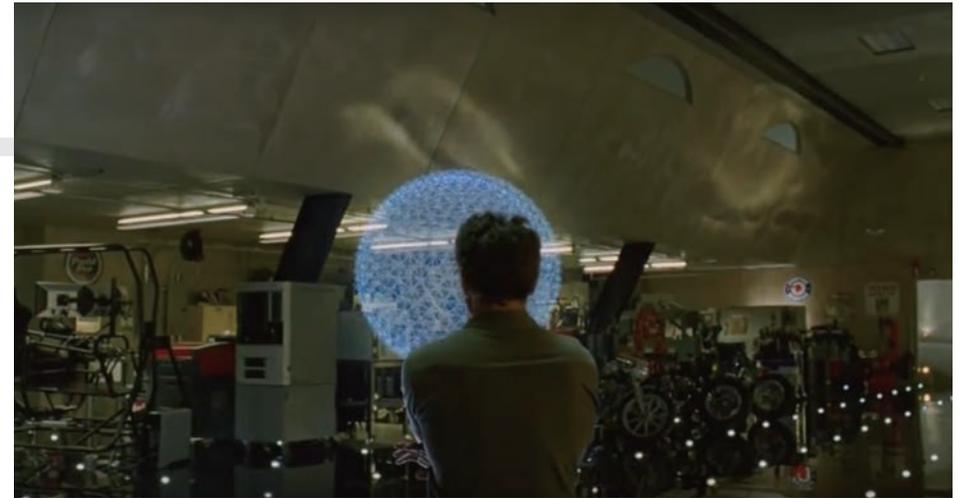
and fun user experience. However, we ultimately decided against using a human avatar. A video we watched of a life-size Rihanna hologram performing "Umbrella" for HoloLens users¹² affirmed both our decision and Freud's theory. However, we think using a non-human avatar could be a great option for a narrative holographic portfolio experience.

V. IDENTIFYING A CONCEPT

The following section illustrates our conceptual approach to the project. We came up with 12 different concepts for our holographic art portfolio. We feel the one we chose most clearly addressed the opportunity areas we identified during our research.



Tony Stark views the holographic sphere.



5.1 Immersive Web

“Immersive Web” is the name we gave to the final concept that emerged from our brainstorming. The Immersive Web shows a web diagram of artists, with visualizations of their work connected to their name in a web format. In our heads, we pictured this:



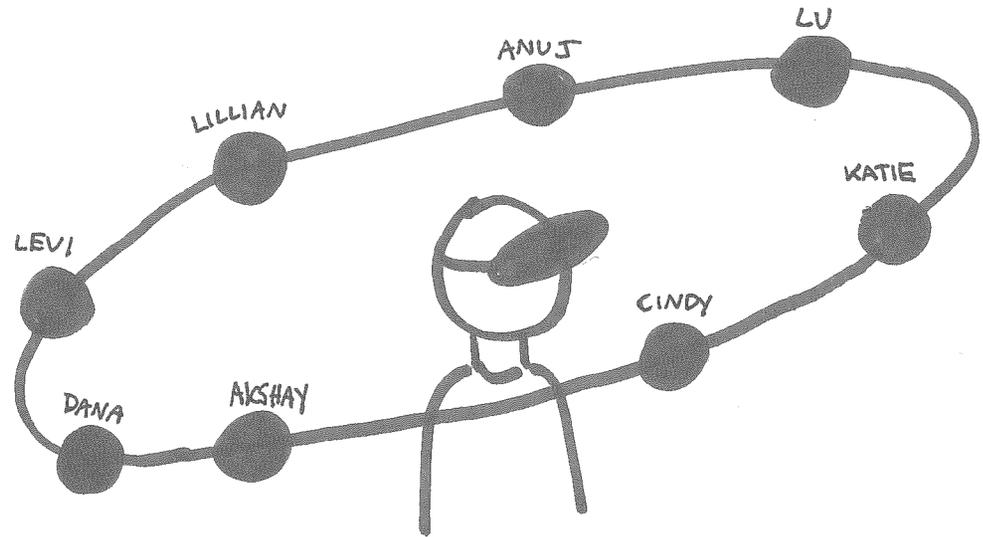
Tony Stark looks at many holographic options.



Tony Stark activates the sphere.

These pictures are from a scene in *Iron Man 2*.¹³ This design is the main inspiration for our holographic portfolio experience. Here, the user sees a large, active sphere. They click it, and are immersed in dozens of smaller spheres all around. Each smaller sphere represents a different artist. The user is immersed in a sphere of different portfolios. The user then selects one small sphere and is introduced to the artist’s artwork.

5.2 Design Principles



The Immersive Web concept.

Minimalism

Our concept is aesthetically minimal. We want the focus of the experience to be the artwork and the artwork's ability to interact with physical space. We kept the number of visual distractions to a minimum. For example, instead of having many icons on display at all times, we incorporated most of our icons into a hamburger menu. We also kept text display to a minimum, designing workarounds for user access to important text-based information.

Intuition

We want the user to rely on their intuition during our mixed reality portfolio experience. For this reason, we kept audio instructions to a minimum and avoided repetitive information and commands.

Consistency

The features in our portfolio are standardized, meaning that each feature can be applied to every artwork. This creates a streamlined user experience, and also allows for our idea to be applied to broader contexts.

5.3 Features

Our holographic portfolio has the following features:



Rotate

When viewing an artwork, users can rotate holographic objects.



Adjust Size

Users can adjust the size of the artwork they are viewing. This is helpful if the artwork on display is very large--users can scale down the size in order to get a sense of the piece.



True-to-Size

When viewing an artwork, users can select the true-to-size button to experience the artwork's real size. They can adjust the size at any point during the art-viewing process, but the true-to-size button will always be available to return to if desired.



Process

When viewing an artwork, users can tap the process icon to learn about an artist's process. Information can be delivered via a mix of audio and holographic visuals.

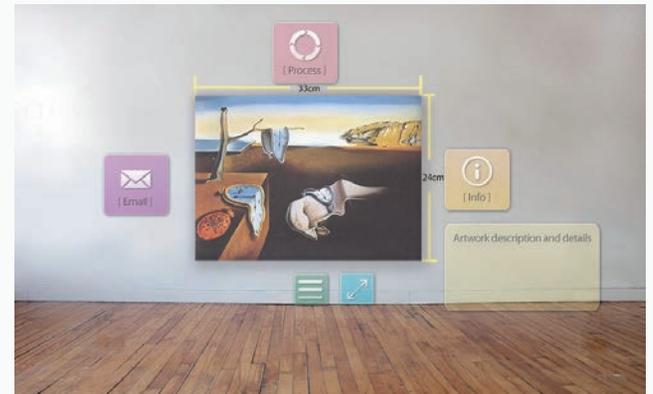


Process for the painting is selected.



Information

Users can tap the information icon to hear and see an artwork's basic information.



Information about painting is selected.



Email

Artists need to convey details about their work experience, exhibit history, and contact information to curators. All these details are text-based. However, we wanted to avoid a text-heavy user experience for our holographic portfolio, so we designed a workaround. We chose to have information like a CV, contact information and exhibition history only accessible via email. Longer narrations like the artist bio and artwork statement also have the option of being emailed to the user.

We designed based on the assumption that a HoloLens user is already logged into their HoloLens account, which includes their email information, before they enter the holographic portfolio experience (i.e. we did not design an email input feature). Once they enter the holographic portfolio, they have the option of emailing certain text-based information to themselves, so they can review it on their phone or desktop later. We think this feature will be useful for anyone conducting professional work with our portfolio.



Information about sculpture has been emailed.

Instructional Audio

In windows where new actions are available to the user, we include instructional audio. The instructional audio does not repeat itself. Instead, we created a hierarchy in which the user can assume that any instruction they hear at the top of a window will be applicable to subsequent windows.

Narrative Audio

Some information, like the artist biography and artwork statement, we want the user to hear. In our design, if "biography" is selected, a narration of the artist's biography begins playing. This information is experienced by the user while they are simultaneously interacting with the holographic artwork. The user can have a transcript of the audio emailed to them if they select the email icon.



Instructional Audio in our Marvel Prototype.

5.4 How the Holographic Portfolio Addresses Opportunity Areas

Our Immersive Web design is minimal and focuses on the experience of the artwork. We have reduced the number of additional features in order to provide the curator with a powerful, straightforward experience for viewing artwork. Our research insights allowed us to understand how the holographic portfolio for the HoloLens can add to and improve the curatorial experience.

1. Exhibit Planning

The HoloLens is particularly well-suited for curators planning exhibits for these reasons:

A. Tag Along: The Tag Along feature allows artwork to move with the curator as the curator moves around a space. This allows the curators to view the artwork in a variety of spaces.

B. Placement: Whether it is a sculpture or a painting, holographic artworks can be placed on real surfaces and walls. Instead of working with foam-core models of museum walls, curators can place holographic artwork directly in their real-life environment. This allows for more accurate planning, and lets curators see how artwork looks in their space before expensive and time-consuming installation work takes place.

C. True-to-size: In our holographic portfolio, an artwork's size can be experienced instantly, as it would in real life. This allows curators to be able to place a 100% accurate representation of the artwork in their museum or gallery before receiving the artwork. Instead of relying on scaled down foam-core designs, they can see how the artwork fits in their space and decide where and how they want to place it in relation to the architecture and other works on display. Importantly, they can also experience how an artwork feels based on its size.

D. Shared Environments: The shared environments feature of the HoloLens can help groups of curators working on the same project work more efficiently. If a large institution like the Whitney has multiple HoloLens headsets, each individual curator can interact with the same holographic artworks and plan exhibits together in real time, using their physical space.

2. First Impression

Holograms are not only a novel and delightful experience for users in 2017, they are also colorful and detailed. Artists using the holographic portfolio format have a unique opportunity to give curators a 3D experience of their artwork. This allows the artist to showcase more unique details, and helps the curator have a more accurate impression of the work.

3. Stakeholder Decision Making

When large institutions build their permanent collections, they conduct extensive research before acquiring artwork. Artworks that are being considered for acquisition usually go through several rounds of review, by multiple groups of people: employees at the institution, select donors, and various committees. Sarah Humphreville from the Whitney indicated that although artwork must be inspected thoroughly in person before being acquired, usually only museum employees (e.g. curators and conservators) perform that work. When conversations about an acquisition occur between other stakeholders, they often only have a high quality color image of the artwork printed on a regular piece of paper to reference.

The holographic portfolio can improve important curatorial conversations between stakeholders. Instead of referring to a paper packet for visual information about the artwork, stakeholders can experience the artwork in the HoloLens. They can interact with it, see its true size, and even see accurate details related to its condition and quality. The holographic portfolio offers users a much more complete viewing of the work than a piece of paper or a website. For digital artwork,

the holographic portfolio can offer a 100% accurate experience of the artwork.

4. Lighting

Speaking with artists gave us insight into how essential lighting is to artwork. Our holographic portfolio offers a way to experience a variety of lighting options for physical and digital art alike. If the artist wants to showcase art with a particular light setting, they can do so. If the curator wants to adjust the lighting themselves, that option is available, too. Lighting options within a portfolio harness the power of the mixed reality platform to create a more immersive and detailed user experience.

5. Process

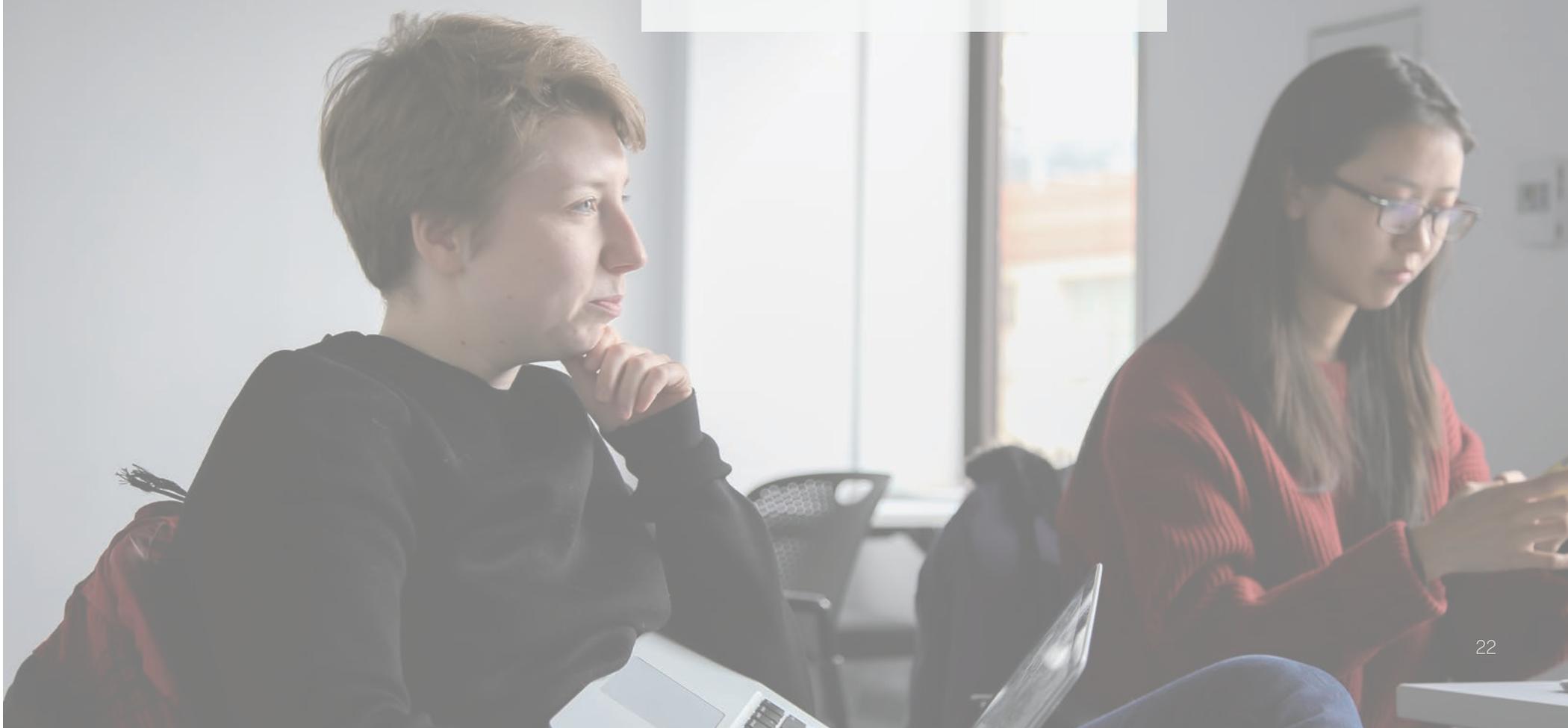
Because our portfolio is modeled after a studio visit, where an artist's process is usually an essential part of the experience, we knew we wanted the artist's process to be central. Our portfolio's "Process" feature applies to each medium of artwork displayed. We interpreted process in multiple ways: for example, the process for a painting is showcased through holographic animations and a voiceover. For our piece of video art, the process is displayed through a behind-the-scenes 360 video.

5.5 Scaling the Immersive Web

The ideal Immersive Web is scalable. A curator would be able to view as many portfolios as the platform could hold. This format also makes this technology more accessible to artists. For example, a group of artists could collectively buy a HoloLens and submit their work to curators in hologram form at a lower cost. Portfolios can be customized, but live within the larger framework of the Immersive Web. This format is also more time efficient for curators because it allows them to view multiple artist portfolios in a single experience.

VI. DESIGN PROCESS

Our design process focused on creating an excellent experience for our end user. This is why we spent a significant amount of time researching our ideal users and understanding how users currently respond to mixed reality and virtual reality experiences. We continued to prioritize our end user's experience during the development phase by testing early and often. Every part of our project, from our visualizations to our storyboards to our HoloLens prototype was subject to many revisions based on feedback.



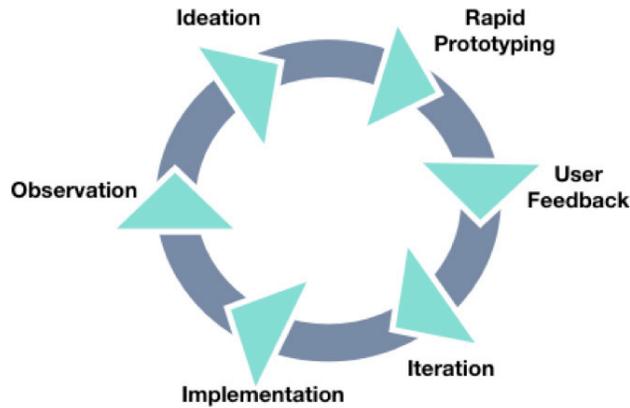
6.1 Human-Centered Design

Our workflow was inspired by IDEO's Six-Step Human Centered Design Process.¹⁴ Because we learned about mixed reality along with our testers, we spent a significant amount of time ideating and prototyping before actually implementing our findings into our holographic prototype

in Unity. We also did not experience a true implementation phase.

Our iterative process diagram gives specific examples of what we did when we brainstormed, prototyped, and responded to user feedback.

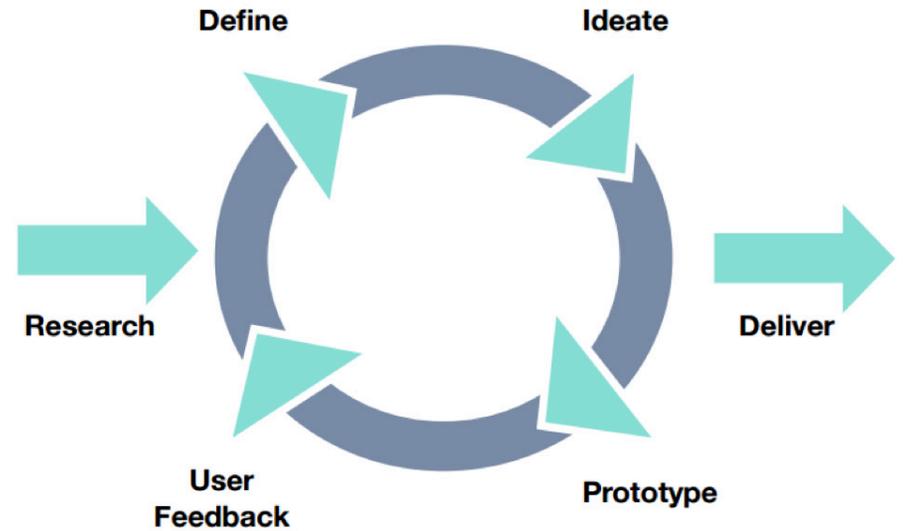
IDEO's 6 Step Human Centered Design Process



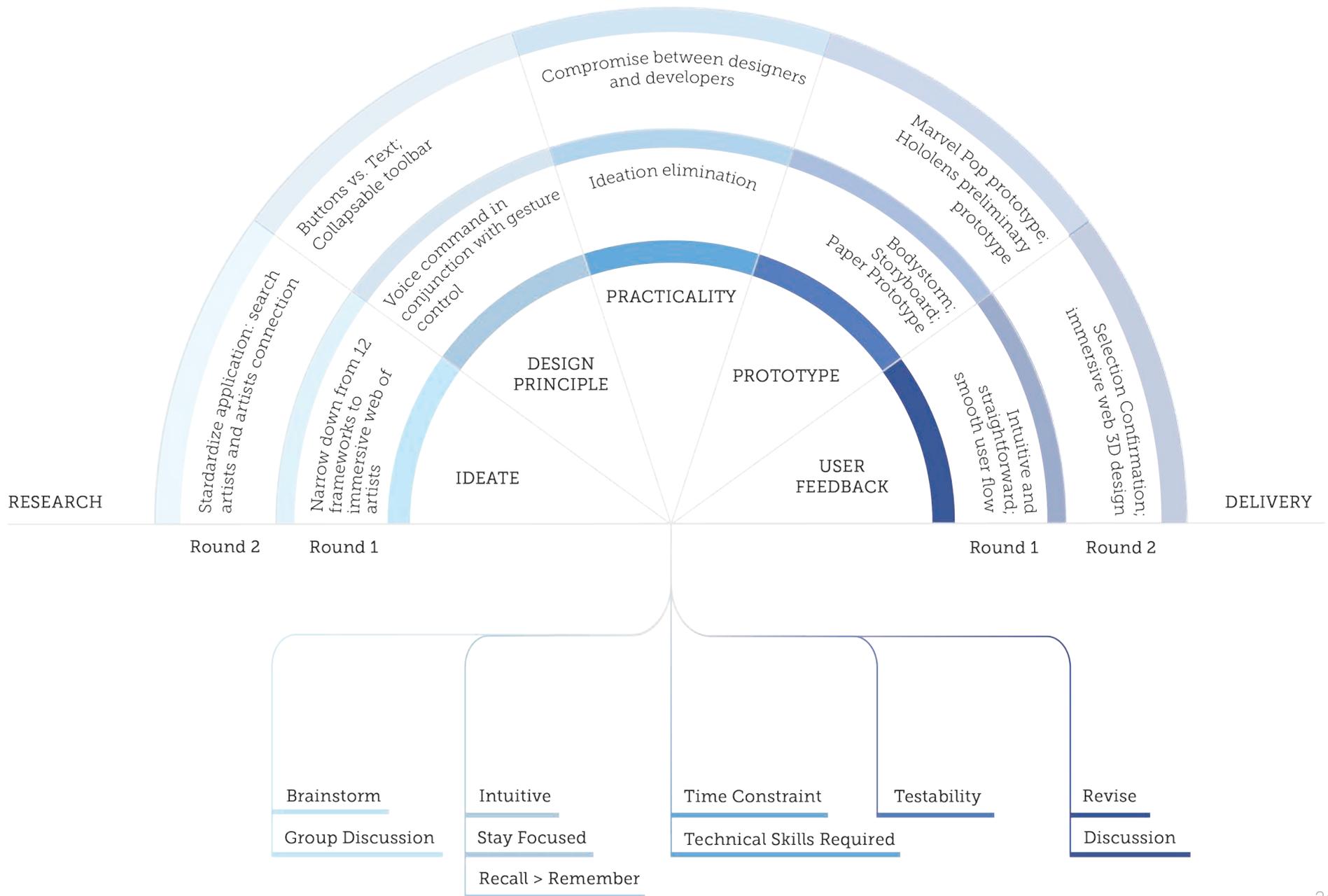
¹⁴ IDEO's six step human-centered design process.

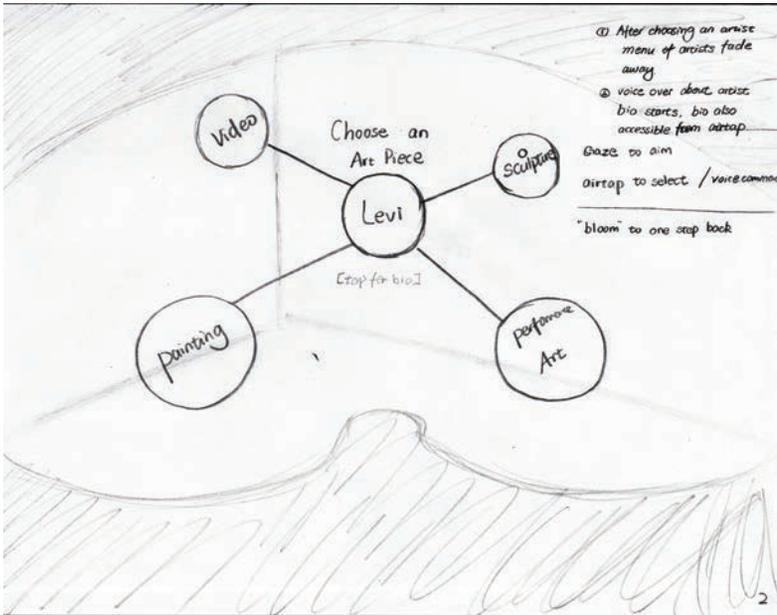
OUR ITERATIVE PROCESS

Team HoloGlass

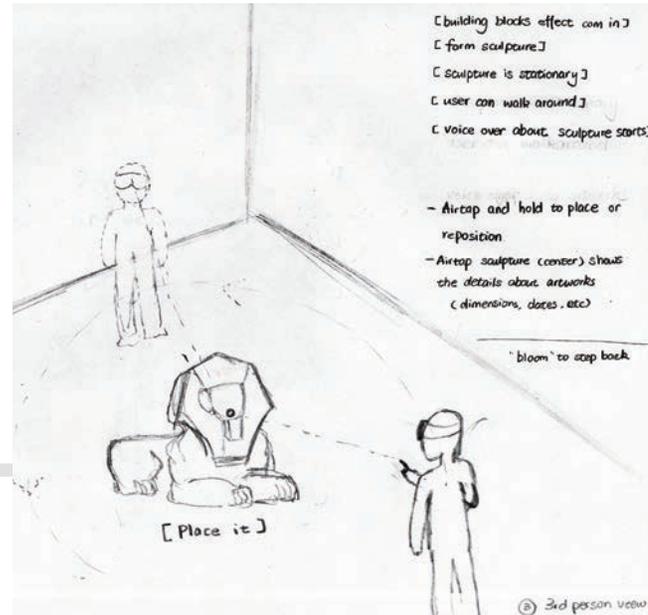


6.2 Iteration Diagram

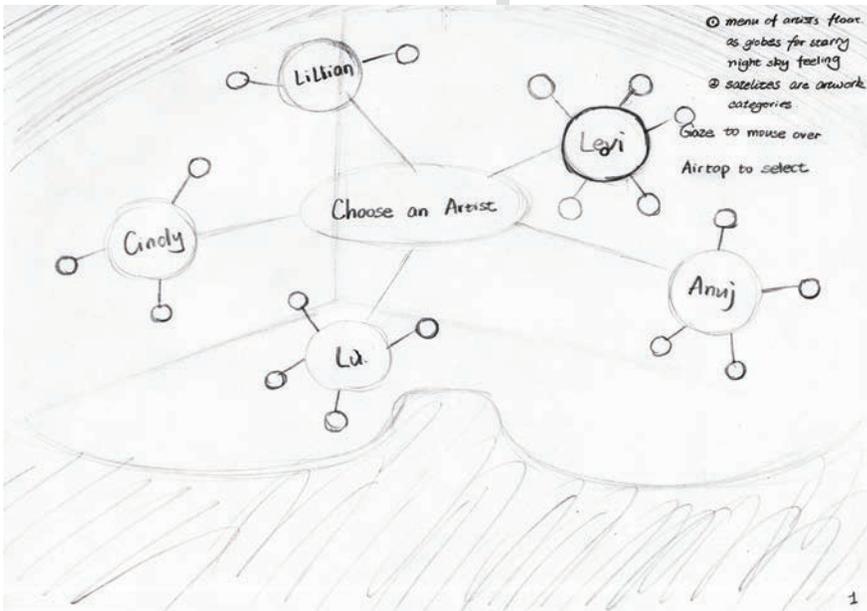




First person view of the artist's web.



Third person view of user viewing sculpture.



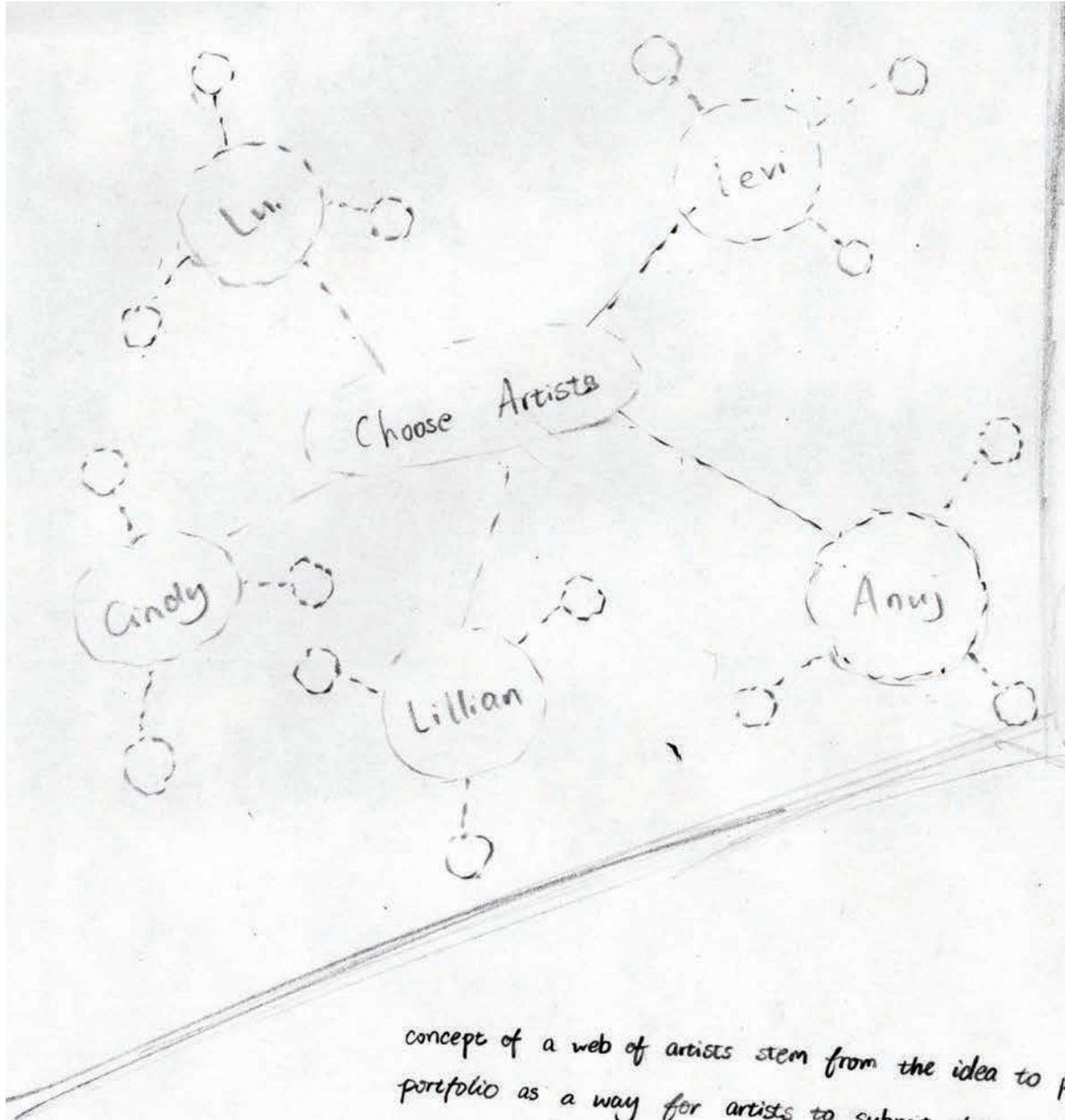
First person view of the web of many artists.

Using pencil and paper, we made storyboards for each of our four mediums.

Storyboarding was a good way of getting out all our ideas on paper. Not all the ideas made sense when written out, and it was difficult to identify essential ideas. However, feedback from our professor helped us realize we weren't prototyping the Immersive Web experience. In other words, a storyboard is

not a prototype! Our next step involved making our prototype come to life.

It was essential for our storyboard to include the field of view of the HoloLens. This helped us understand what information can be fit into the frame, and helped us prioritize the size of each hologram in each given experience window/page.



- ① menu of artists locked on a wall.
- ② Airtop to select or voice command "select"
- Decision for web of artists.



concept of a web of artists stem from the idea to push the holographic portfolio as a way for artists to submit their works to curators. We aim to gradually introduce the holographic world to curators and ensure that the curator will have access to information crucial to the curating process.

① 3rd person view

Third person view of user viewing the web of many artists

VII. PROTOTYPING ROUND ONE

7.1 Bodystorming

How can we prototype 3D experiences using paper?

Our answer: Bodystorming.

Before we began developing in Unity, we wanted to express our concept in a low-fidelity prototype. Using Post-It notes, an old sandwich box and classroom whiteboards, we made a video acting out the most basic interactions of our Immersive Web experience. Levi acted out the part of the user, while Lu acted as the user-controlled sculpture. We mapped out initial voice commands and airtap and bloom gestures. We showed the user rotating and enlarging the sculpture.



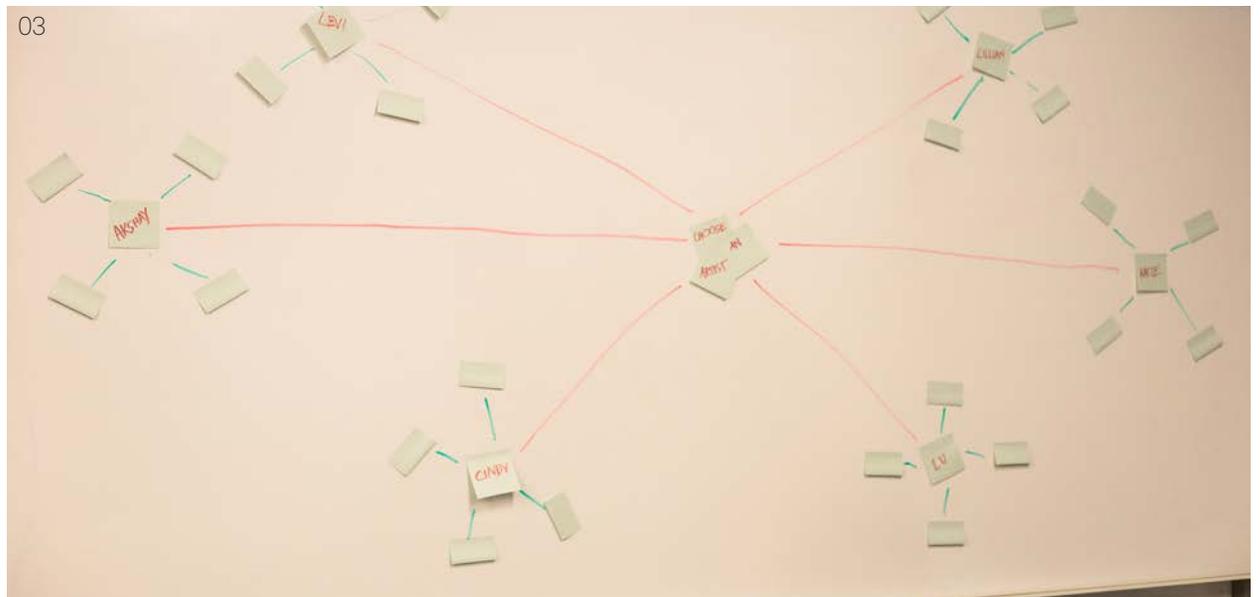
Levi and the "HoloLens."

7.2 Takeaway

This paper prototype gave us a good sense of what it would feel like for the user to control the artwork via air taps. It also gave us a good sense of how the instructional and informational audio would function and where it would be placed in the user flow.

Our bodystorming video can be viewed [here](#).

01 Lu "rotating" as a sculpture.
02 Paper HoloLens.
03 Immersive Web of Artists.



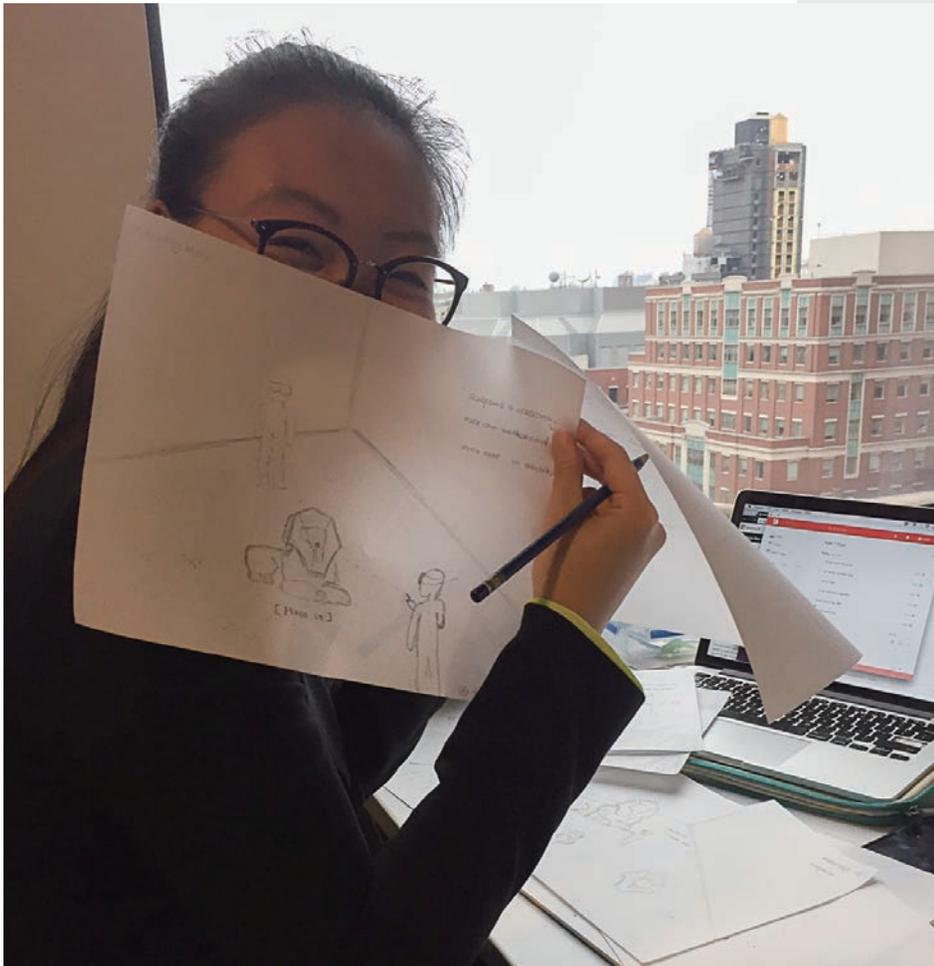
7.3 User Testing

We asked our testing participants to narrate their understanding of the experience. A quick round of user feedback alerted us to the fact that users may want to search or filter artists in the initial large display of many portfolios. While this prototype was good for getting a sense of how our concept would feel, we quickly realized it wasn't detailed enough.



VIII. PROTOTYPING ROUND TWO

After bodystorming, our developers had enough material to begin programming in Unity. The designers in the group broke off and refined the prototype further, this time creating an interactive experience with Marvel. We began again with storyboarding and broke down every interaction in writing. We decided exactly which features would be present, and whether they would be buttons, voice commands, or both.



8.1 UX Writing

During this process, we realized how essential UX writing is for new, multi-sensory technologies like the HoloLens. The HoloLens allows users to interact with it using their sight, voice, hearing, and hand gesture capabilities. Because this level of sensory interaction is still new to most users, the ideal HoloLens experience is clear and informative, without being overly explanatory.

Finding this balance of clear, concise instruction and figuring out where (and how) in the experience to place it was challenging. We considered how best to deliver instructions to the user: Only text? Only voice command? Visually? All three at the same time? Where in

the flow would instructions be placed? Ultimately, we decided we would deliver interaction instructions via audio only. This required writing a detailed script. We created an instructional hierarchy, meaning that the user can assume that any instructions heard at the top of an experience are accessible during subsequent interactions. We chose this method in order to avoid repetition.

8.2 Voice Commands

We knew we wanted to limit the amount of text in the holographic portfolio user experience. One reason for this is that the HoloLens does not render text in the most clear way. Additionally, because our design utilizes the HoloLens Tag Along feature, much of the text a user reads is floating in the air, making it potentially difficult to read. More importantly, we wanted to avoid over-using text in order to fully embrace the possibilities of mixed reality. We did not want to translate a web portfolio into the HoloLens. Rather, we wanted to create a new experience and explore new ways of creating user interactions.

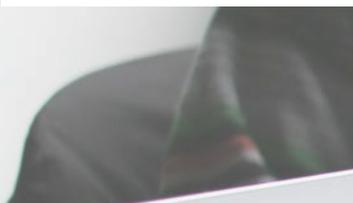
For example, we chose to inform the user that all text associated with an icon also works as a voice command. We chose to design this based on the Microsoft documentation outlining efficient ways of utilizing voice command for the HoloLens.¹⁵ An icon without associated text is not accessible via voice command, only by airtap.



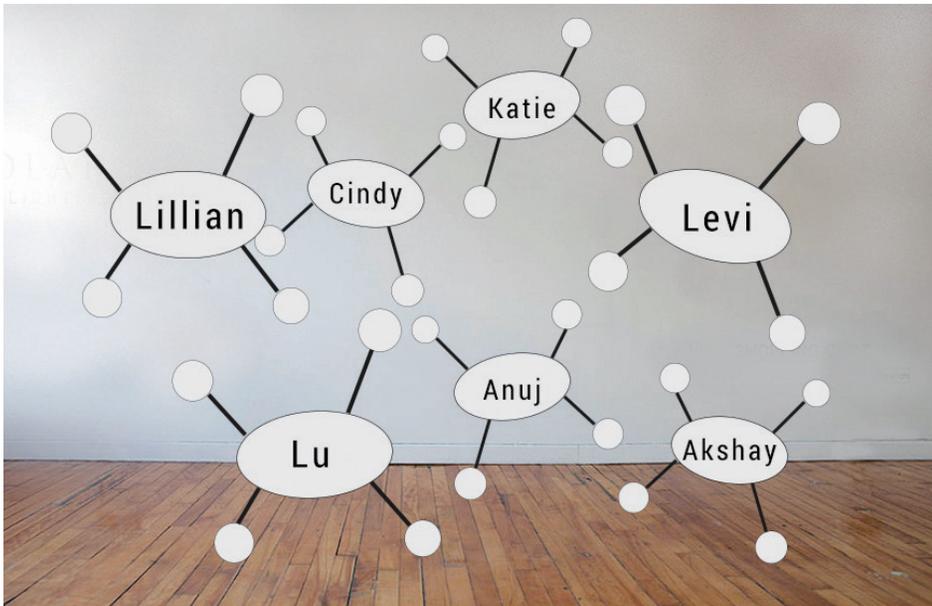
8.3 Displaying Information

From our research and our project brief, we knew that the “tombstone” information (i.e. title, date, medium, location, owner) was essential to display on each separate artwork. We also knew that we wanted to incorporate a Process feature.

We debated which information should be displayed on the default view of each artwork. This was difficult because the four mediums (painting, sculpture, video, interactive installation) have different constraints and capabilities. At first, we thought different mediums would have different options for the user. For example, we debated the pros and cons of a magnifying glass feature specific to viewing a painting. Our concept was that users could use a holographic magnifying glass to inspect the holographic painting in detail. However, using a magnifying glass would not work when viewing a video or interactive installation. Through conversation, we realized we were only considering the magnifying glass as a tool to showcase process, so we scrapped it and made the universal Process feature. Process can apply to any artwork in any medium.



8.4 Interactive Prototype



The web of many artists.



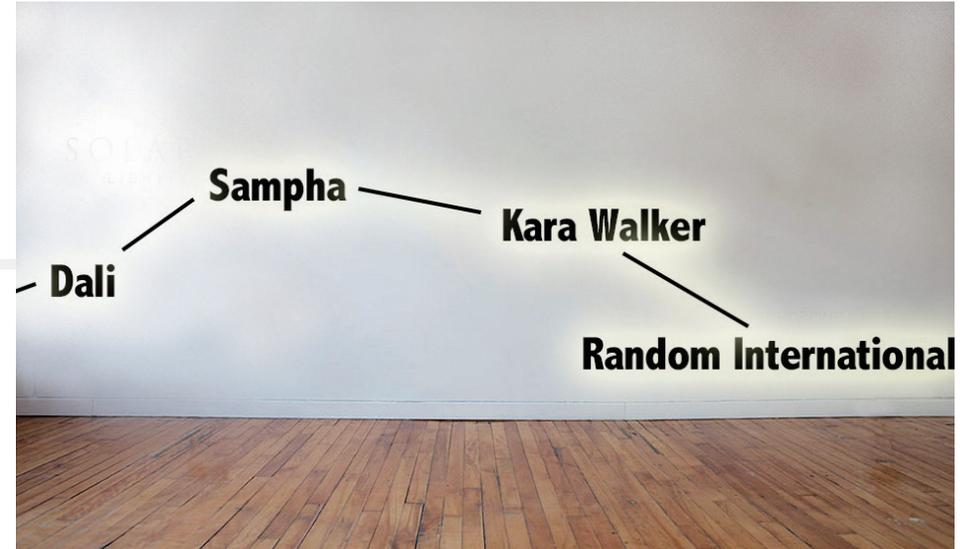
Artist is selected.



Painting is selected.

After the designers hashed out these details, we incorporated our decisions into a new interactive prototype. We used Marvel's POP application.

We then made a second Marvel prototype using icons and images designed in Photoshop. We also updated the artist web visualisation according to our development outcome.



Web of artists.



Lighting panel for sculpture.



Process highlight for sculpture.

8.5 Reflection

The 2D nature of our prototype was our main constraint while designing on Marvel. We used Photoshop to provide a 3D representation of our sculpture, interactive installation, and video, but certain elements of our portfolio were lost in translation. Marvel was great for concretizing each interaction available in our portfolio experience, but it lacked the feeling of our bodystorming prototype. Bodystorming was far more effective at emulating the flow and feel of our final HoloLens prototype.

Our Marvel prototype can be viewed [here](#).



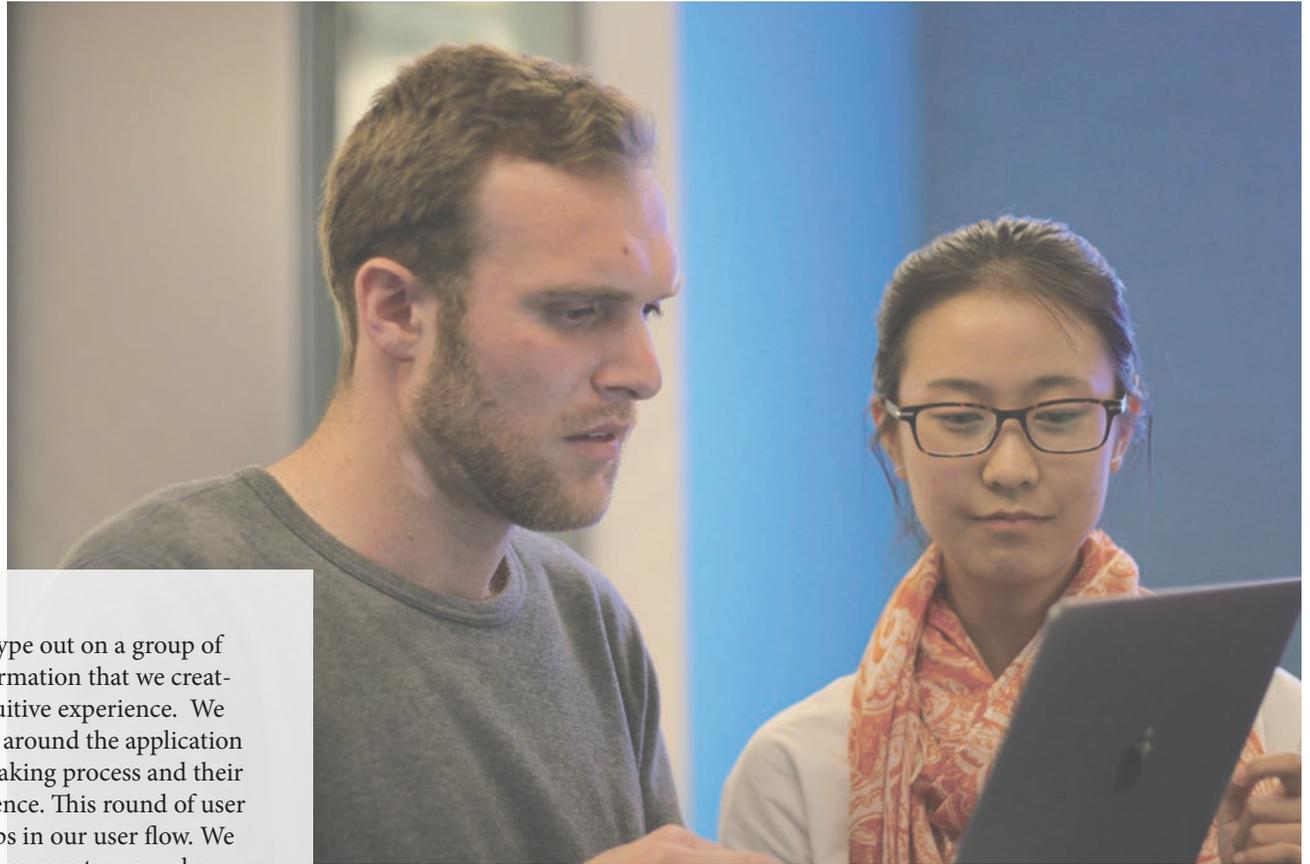
Interactive installation is selected. The menu has also been selected, displaying icons.



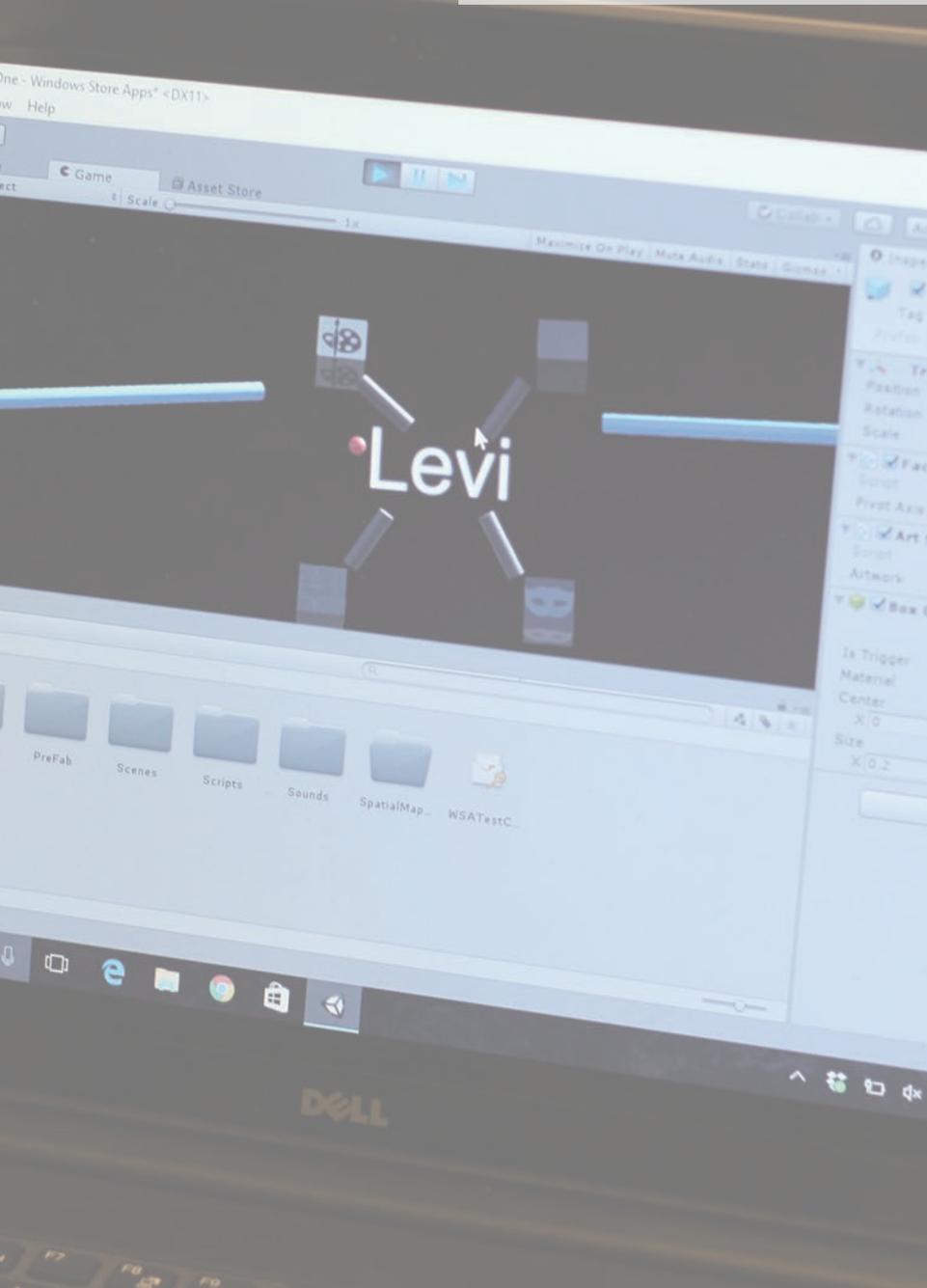
User enters interactive installation.

8.7 User Testing Our Marvel Prototype

We tested our Marvel prototype out on a group of our peers. We received confirmation that we created a straightforward and intuitive experience. We asked our users to fully click around the application and narrate their decision making process and their understanding of the experience. This round of user testing helped us identify gaps in our user flow. We realized that we needed to incorporate more clear exit instructions for our immersive experiences. We also realized that we could more clearly explicate features specific to the HoloLens, like holographic placement and the Tag Along feature. One user said she kept expecting to “see more stuff”--by which she meant visual cues indications that actions had been performed. Lastly, we realized we should have icons accompanying any text. Feedback from our peers gave us more than enough material to take back to the drawing board.



IX. DEVELOPMENT



9.1 Approach

We used the Unity gaming engine to develop our prototype. Developing holograms in Unity was new to us when we began this project. Our development team got started by reading through Microsoft documentation¹⁶ on installing the necessary tools on a Windows 10 Pro computer.

Next, the developers completed the Lynda course on using C# in Unity.¹⁷ Completing this tutorial helped clarify how Unity reads and uses scripts. Next, our developers reviewed Microsoft and Unity documentation on the following topics:

World Anchors¹⁸

A feature that allows holographic objects to lock onto a surface in the real world environment. Prevents holographic drift.

Spatial Mapping¹⁹

Provides a detailed representation of real-world surfaces in the environment around the HoloLens.

Transferring HoloLens States²⁰

Allows the same holographic environment to be shared by multiple users at the same time.

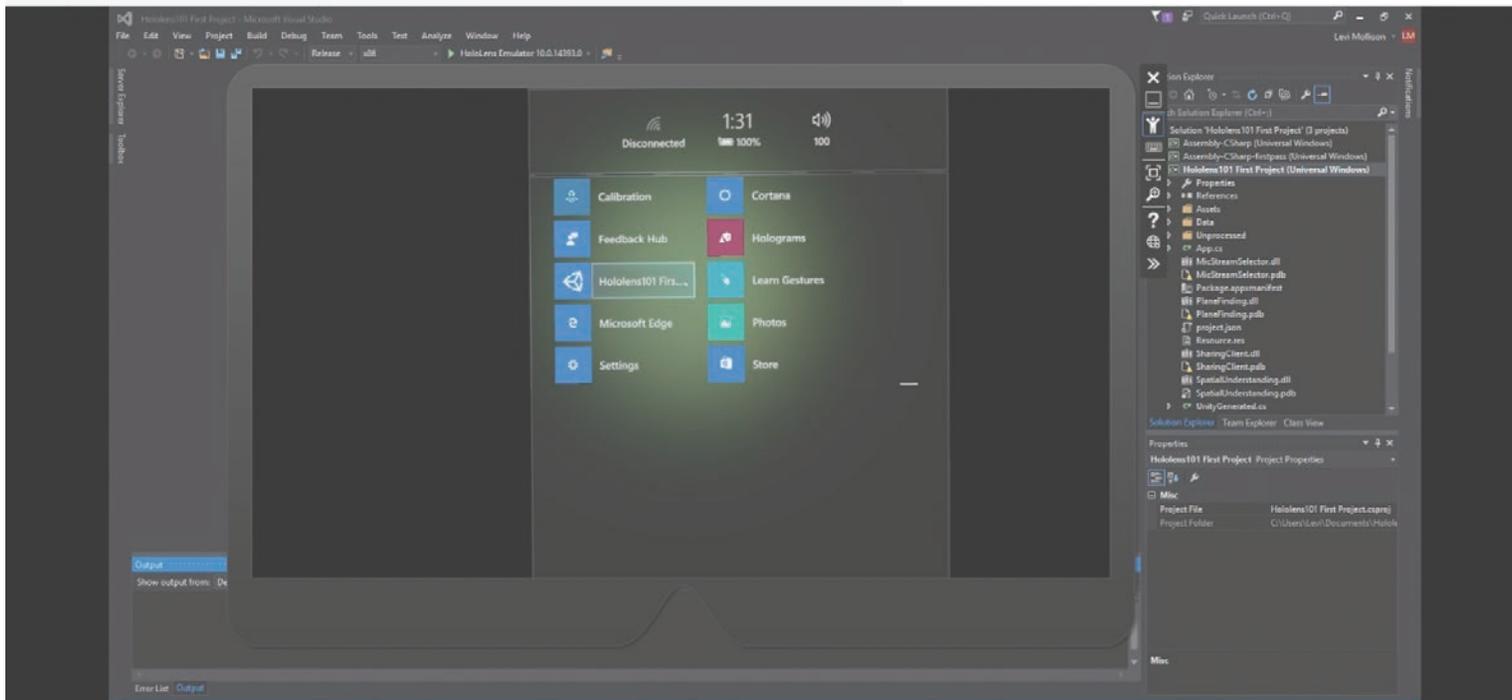
Next, our developers created objects in the HoloLens emulator. On the Next Reality website, we found a streamlined flow of how to create a Unity project for the HoloLens.²¹ The tutorial on Next Reality provided a downloadable Unity package that automatically sets up HoloLens development for each new Unity project.

9.2 Pain Points

The hardest thing our developers encountered was navigating the spatial mapping feature. In order for spatial mapping to occur, the device has to be given time to scan its surroundings. Currently, the user knows that spatial mapping is occurring because a wireframe of the room appears. However, our developers had difficulties making all of the wireframes disappear at the appropriate time. The code they wrote consistently left behind wireframe remnants, creating a disjointed and confusing user experience.

To overcome the wireframe remnants issue, we disabled the beginning of the spatial map render, and prepped our users to wait ~10 seconds before interacting with holographic objects.

Later, we fixed the issue when we realized planes did not need to be drawn on every object in the real world environment. Once we did this, we were able to place holographic objects on empty walls, tables, and floors.





9.3 Communication Between Designers & Developers

Beginning with the second prototype, the designers and developers split up to complete different tasks. While our groups worked apart, the designers made many interaction and flow decisions and the developers realized additional capabilities and specific constraints related to the HoloLens and Unity.

The designers justified decisions by showcasing the interactive Marvel prototype. The developers gave feedback. For example, in the Marvel prototype, there are back arrows. The developers quickly noted that we do not need this icon in the HoloLens prototype, because a double airtap will suffice. Using storyboards, user flow revisions were explained and clarified. On the developer side, a detailed document was maintained with clear, nontechnical language used to describe development decisions and realizations.



X. USER TESTING ON THE HOLOLENS

Testing our prototype on the HoloLens affirmed that the artist web actually feels immersive. For the designers working in 2D, this was a huge win. Working with Marvel made the designers feel like they were straying from the *Iron Man 2* inspiration. However, once everyone put on the HoloLens, it was clear that our experience utilized the 3D space. Users testing our prototype moved their heads around to see the whole “web,” and confirmed that they felt they were “inside” the portfolio experience, instead of simply viewing it.

We realized we didn't need lines indicating that the holographic structure is a web--users said it was clunky and unnecessary. We again heard that we need to incorporate audio or visual cues indicating that an action has been selected. We also were encouraged to make our portfolio more 3D and to

play with polygonic shape and structure more. This feedback gave our developers a lot of material to use as they finished up our prototype.

We also received feedback that we should not have any objects that are above or below the field of view. Having objects that are horizontally not in the field of view was fine--users knew to look to their left and right to uncover objects. However, users did not know to look up or down to view additional objects.

Lastly, we heard that users would like to be able to scroll through the available artworks, instead of having to go back to the artist web every time they want to move on to the next piece.

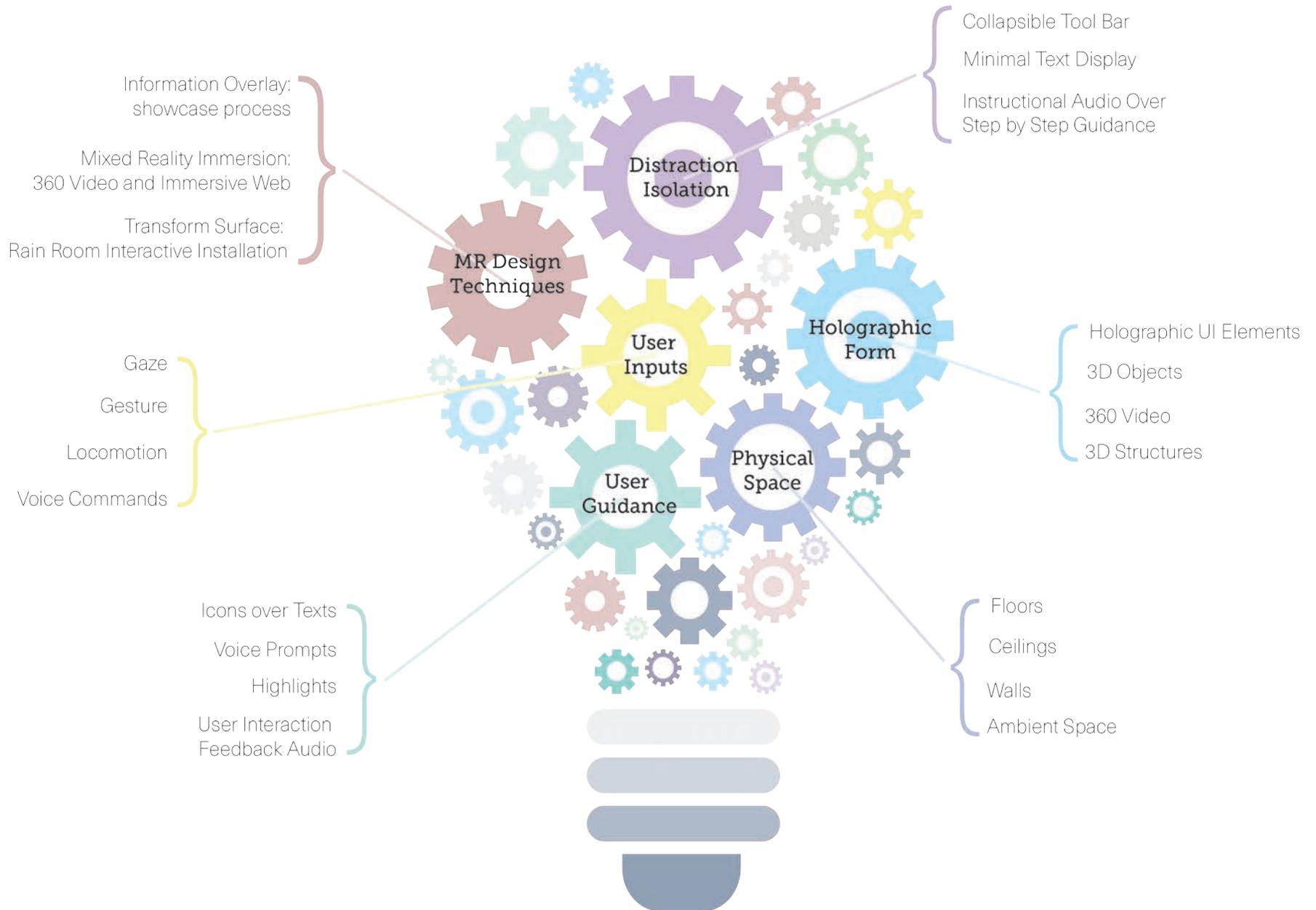




XI. PROJECT OUTCOMES

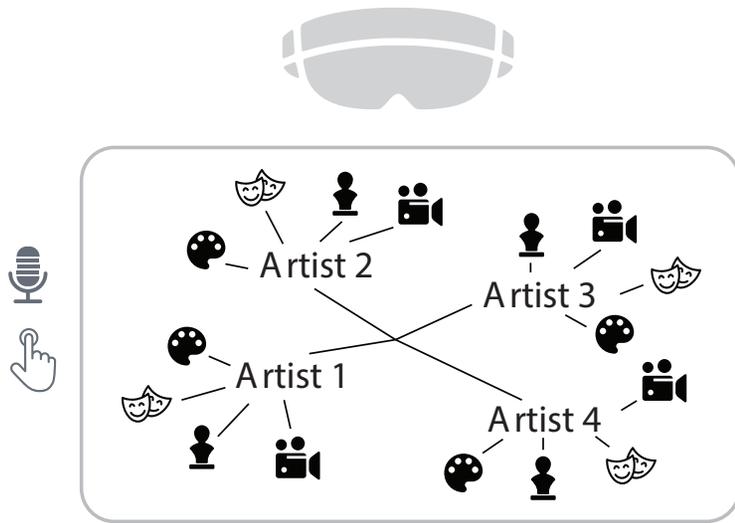
11.1 Table of Elements

Below is our table of elements. It is inspired by 8ninth's mixed reality table of elements.²² The table of elements collects all methods and technique available in mixed reality design. We have customized our table of elements to highlight the methods implemented in our holographic portfolio design. We included a category called "Distraction Isolation." This category indicates the methods we use to keep our experience aesthetically minimal. For example, our collapsible toolbar is a "distraction isolation" method. Instead of having all the icon options visible all the time, they are contained within the general menu hamburger icon.

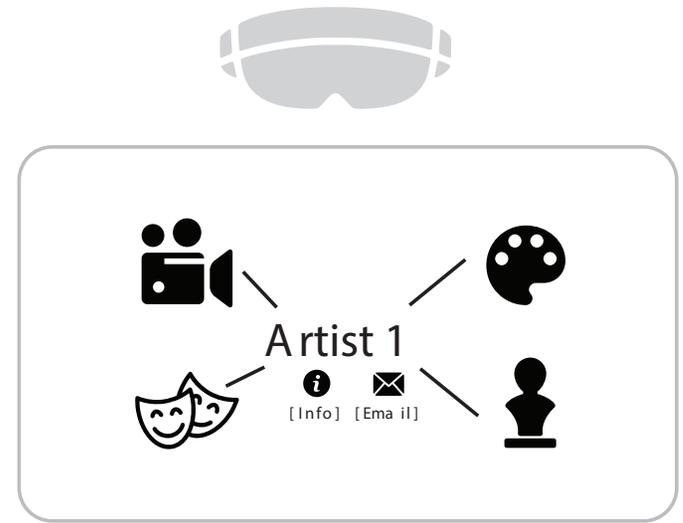


11.2 User Flows for Painting, Sculpture, Interactive Installation and 360 Video

PAINTING



User selects Artist 1 via airtap or voice command.



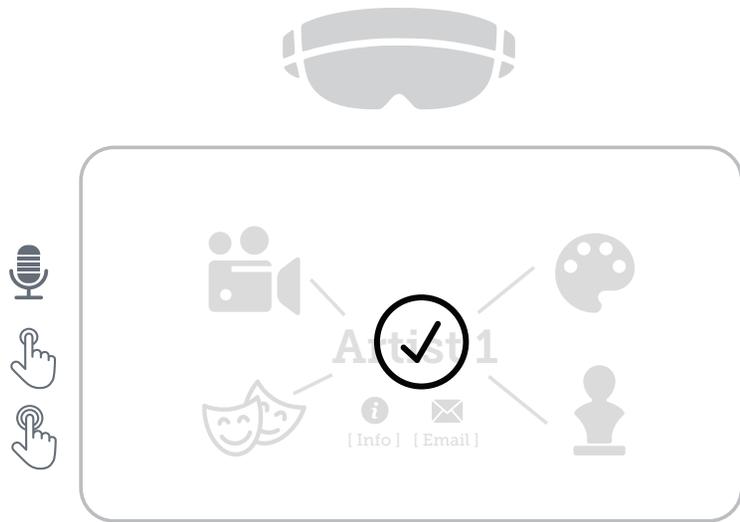
To make a selection, gaze at the target and airtap or say 'Select.' To move an artwork, airtap and hold. To adjust an artwork's size, airtap, hold and drag. Double airtap to go back. To email an audio transcript to yourself, airtap the email icon or say 'Email.' To activate a voice command, say the words in the bracket underneath an icon.



To hear the artist biography, contact information and exhibition history, airtap the artist's name or say 'Info.' To email the artist biography to yourself, airtap the email icon, or say 'Email.'

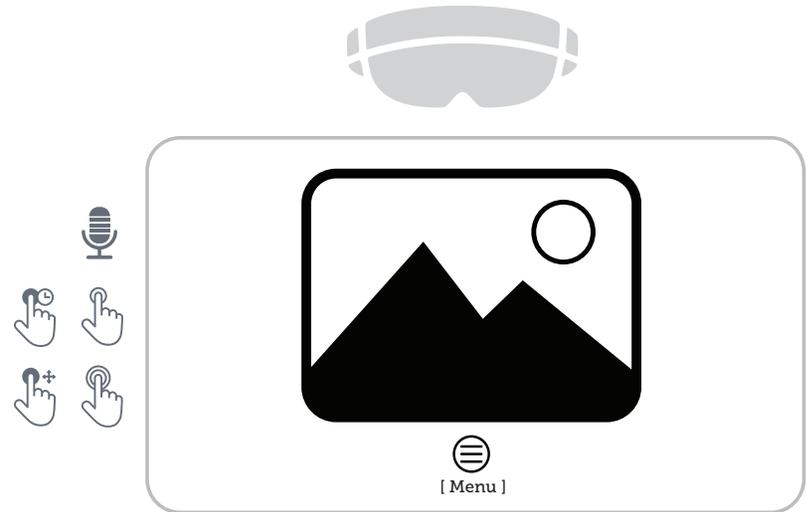


User emails the artist bio transcript to himself via airtap or voice command, and receives audio confirmation.



Artist biography has been emailed to you.

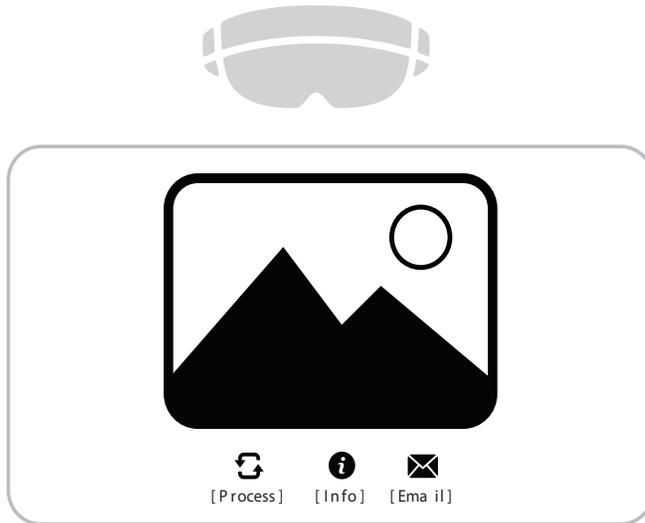
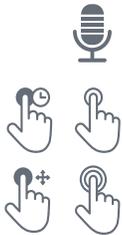
User selects painting.



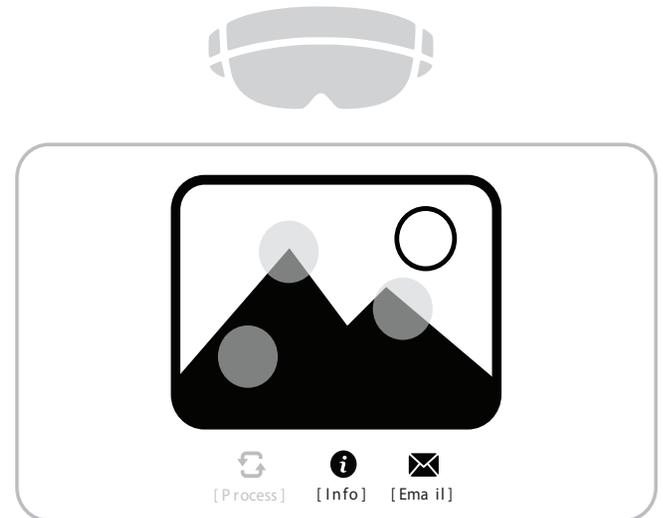
To adjust the size of the painting, airtap, hold and drag the corners. To rotate the painting, airtap and hold. To access the tool bar, gaze at the bottom of the painting and airtap the menu icon.



User looks at the painting and interacts with painting via gestures. User expands the menu via airtap or voice command.



User selects Process via airtap or voice command.



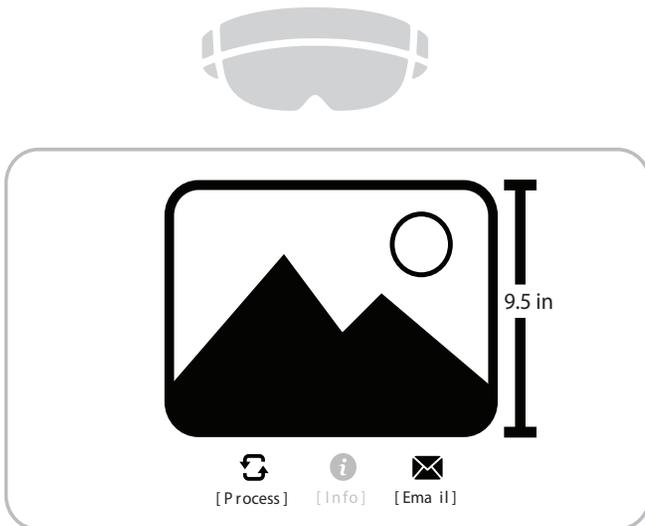
(No instructional audio playing)



Airtap the highlighted areas to see the art making process. To email the audio transcript, airtap the email icon or say 'Email.'



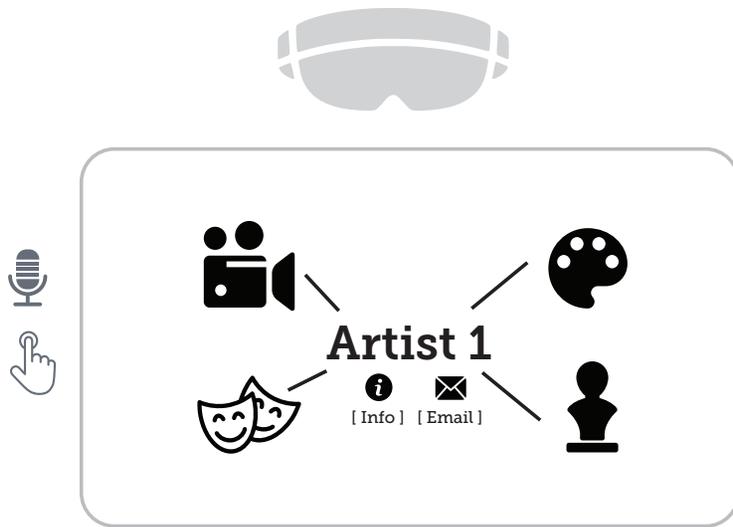
User double airtaps to hide the highlighted area (exit the process interface). User accesses artwork info via airtap or voice command.



(Artwork Info): 'This is Salvador Dali's The Persistence of Memory. It was painted in 1931. The painting is 9.5 inches by 13 inches. You may now email the audio transcript.'



SCULPTURE



User selects sculpture.



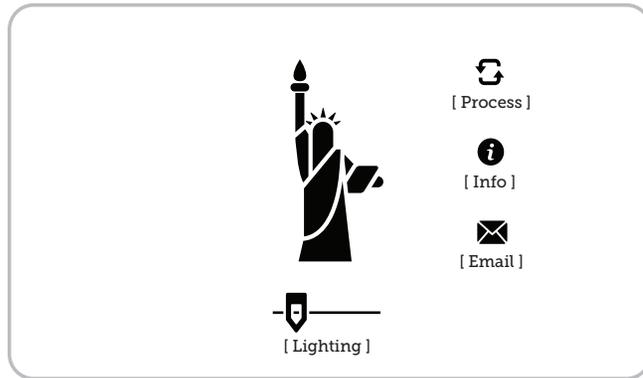
To hear the artist biography, contact information and exhibition history, airtap the artist's name or say 'Info.' To email the artist biography to yourself, airtap the email icon, or say 'Email.'



To adjust the sculpture size, airtap, hold and drag the corners. To rotate the sculpture, airtap and hold. To access the tool bar, gaze at the bottom of the painting and airtap the menu icon.

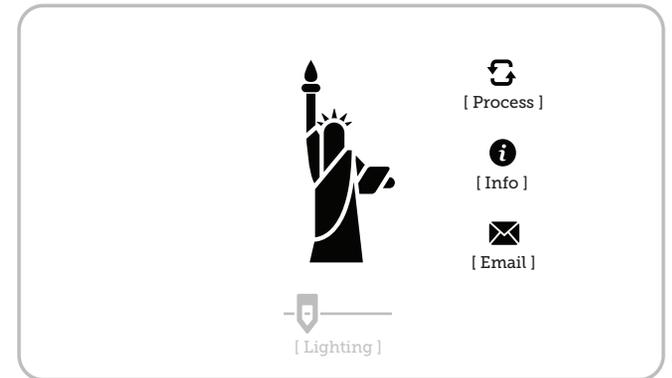


User selects menu via airtap or voice commands.



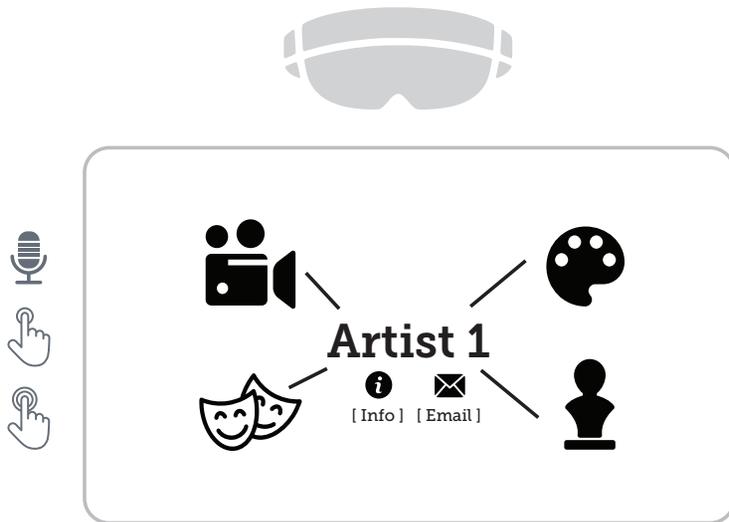
(No instructional audio playing)

User airtaps, holds and drags the slider bar to adjust the lighting.

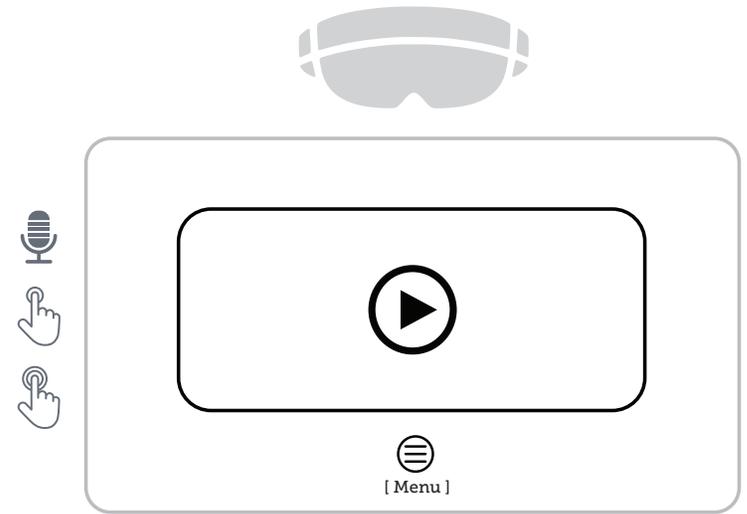


To adjust the lighting, airtap, hold and drag the slider bar.





User selects video.

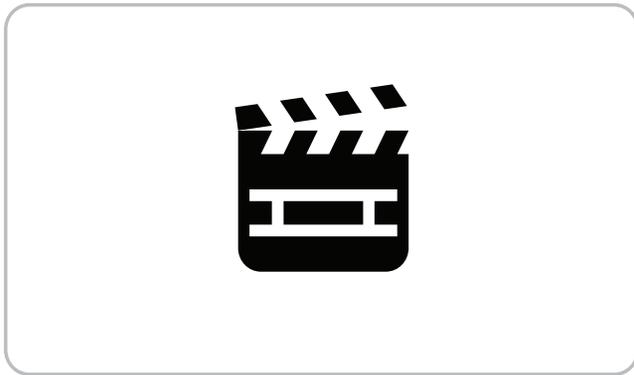


To hear the artist biography, contact information and exhibition history, airtap the artist's name or say 'Info.' To email the artist biography to yourself, airtap the email icon, or say 'Email.'



To experience the 360 video, airtap the play button or say 'play.' To access the toolbar, airtap the menu icon. To pause the video, airtap or say 'Pause.' To exit the video, double airtap or say 'Exit.'



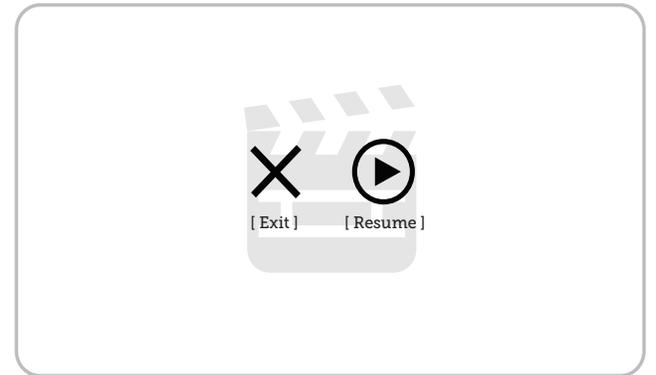


User enters 360 video.



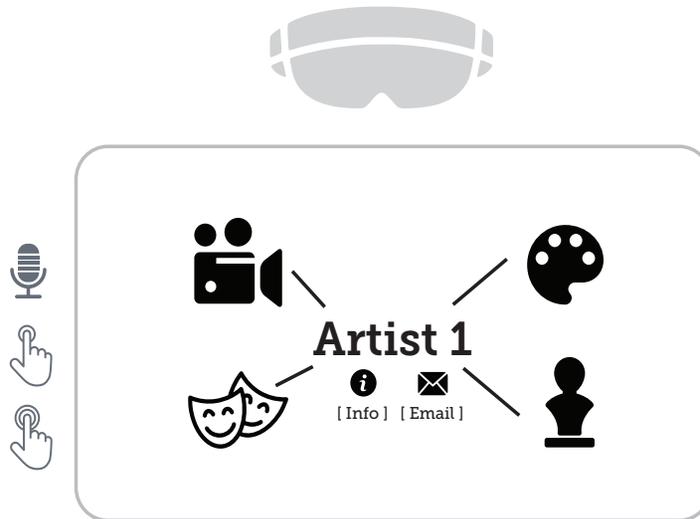
(No instructional audio playing)

User looks around, watches the video and then pauses the video via an airtap or voice command.



To exit the video, airtap the exit icon or say 'Exit.' To resume the video, airtap the play button or say 'Resume.'

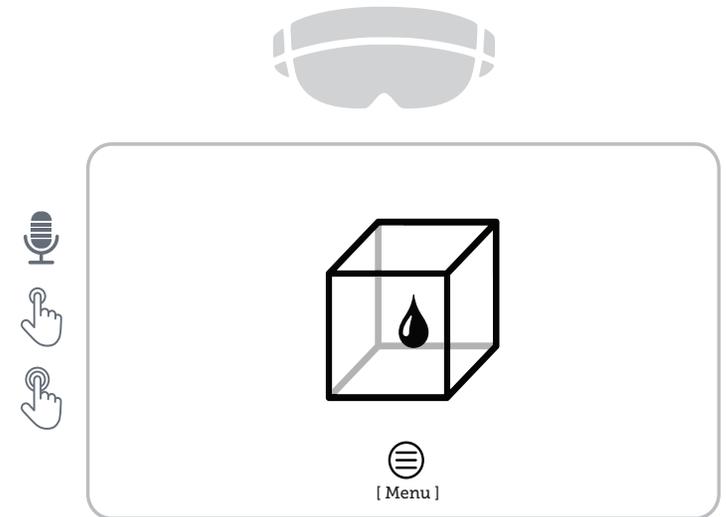




User selects
interactive
installation.



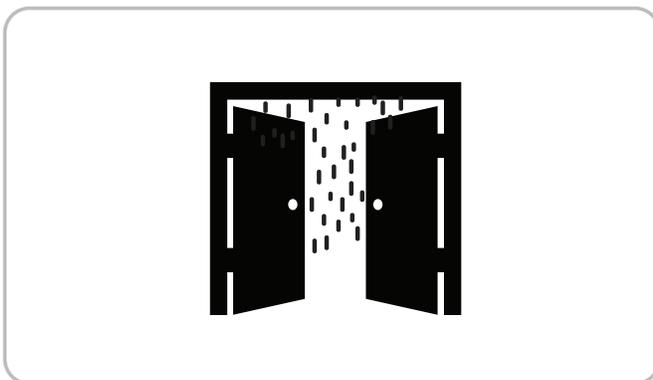
To hear the artist biography, contact information and exhibition history, airtap the artist's name or say 'Info.' To email the artist biography to yourself, airtap the email icon, or say 'Email.'



To enter the Rain Room, airtap the rain drop. To access information about the rain room, airtap the menu icon.



User selects menu via airtap or voice command.

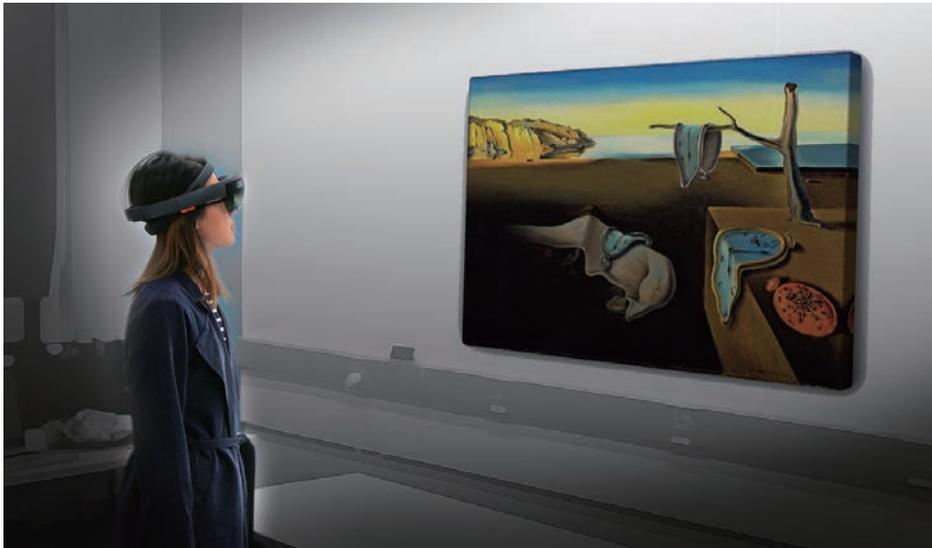


To exit the Rain Room, double airtap or say 'Exit.'



11.3 Digital Visualizations

Our digital visualizations show each medium reflected in our portfolio: painting, sculpture, interactive installation, and video. We selected real artwork that we feel highlights the possibilities of viewing art in a mixed reality format on the HoloLens.



Painting: Salvador Dalí's *Persistence of Memory*

We chose this Dalí painting because it has rich colors that can be rendered well on the HoloLens. Holographic art representations play with space, dimension, and perspective. We feel the melting clocks and distorted landscape in Dalí's painting represent these ideas. We also feel that showing a piece by Dalí, a Surrealist artist, illustrates our Process feature well. Dalí and other Surrealists are known for embedding every detail of their work with layers of meaning. The Process feature in our mixed reality portfolio is a way of bringing this information to light in an interactive and meaningful way.



Sculpture: *A Subtlety, or the Marvelous Sugar Baby*

This visualization shows Kara Walker's 2014 sculpture *A Subtlety, or the Marvelous Sugar Baby*. The sculpture was installed at the Domino Sugar Factory in Brooklyn, NY. Standing at 35 feet tall and 75 feet long, the sculpture was made specifically for the factory's space.

We feel that viewing the *Sugar Baby* sculpture on the HoloLens showcases the HoloLens' unique capability to both augment space and scale holographic objects. In the ideal experience, the user can be in any room and view the sculpture at a scaled down size by default. However,

they can also view the sculpture (and any other piece of art) at its true size. This allows the user to experience the enormity of the *Sugar Baby* from any size room. The user can also walk around the sculpture, as they would be able to in real life. Lastly, *Sugar Baby* was a tempo-

rary installation. Viewing the sculpture in holographic form gives people the opportunity to experience the sculpture again.



Interactive Installation: *Rain Room*

This visualization shows Random International's Rain Room immersive installation. The Rain Room came to MoMA in New York in 2013. Viewers entered a room with water falling from the ceiling. Using motion sensor technology, water drops moved out of the way of any object walking in the room.

On the HoloLens, the Rain Room is fully immersive--the user is in a 360 environment where their room is fully transformed into the installation. They can experience the visual sensation of seeing water fall from the top of their field of vision, and experience the water drops moving out of their way as they move around their space. This

example shows how mixed reality platforms like the HoloLens offer a fully immersive experience that also embraces interaction with the physical space and the user's body.



360 Video: Sampha's "(No One Knows Me) Like the Piano" (music video)

Instead of simply projecting a holographic video onto a wall, we chose to take advantage of the immersive potential of the HoloLens by selecting a 360 video to showcase. HoloTour videos inspired our choice. In our visualization, a viewer sees a holographic thumbnail, presses play, and is fully immersed in a 360 video experience. We chose to show a music video in order to highlight the benefits of 360 sound.

11.4 Project Case Study

Below are two visualizations indicating which elements are being utilized by the user in their experience. The project case study brings together the table of elements, the digital visualizations, and the user flow. It is a snapshot of everything that is happening in a single action.



Physical Space	Distraction Isolation	Holographic Form	User Guidance	User Inputs	MR Design Techniques
Floor Ceiling Walls Ambient Space	Collapsible Tool Bar Minimal Text Display Instructional Audio Over Step by Step Guidance	Holographic UI Elements 3D Objects 3D Structures 360 Video	Icons Over Texts Voice Prompts Highlights User Interaction Feedback Audio	Gaze Gesture Voice Commands Locomotion	Information Overlay Transform Surface Mixed Reality Immersion

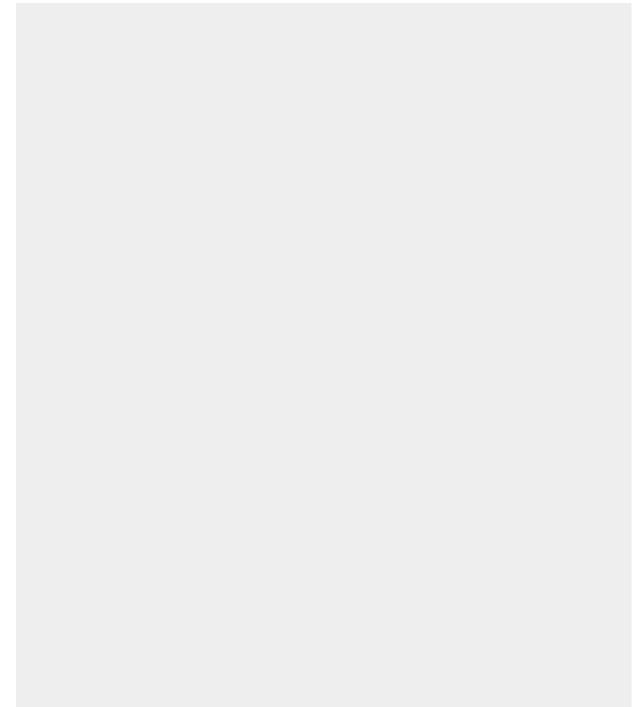
Physical Space	Distraction Isolation	Holographic Form	User Guidance	User Inputs	MR Design Techniques
Floor Ceiling Walls Ambient Space	Collapsible Tool Bar Minimal Text Display Instructional Audio Over Step by Step Guidance	Holographic UI Elements 3D Objects 3D Structures	Icons Over Texts Voice Prompts Highlights User Interaction Feedback Audio	Gaze Gesture Voice Commands	Information Overlay Transform Surface Mixed Reality Immersion

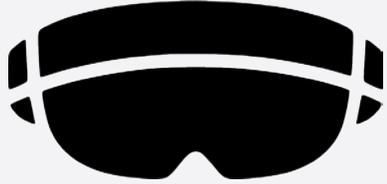
11.5 Comparative Analysis

On the next page is a table that compares our product with other art viewing technologies. We compared our holographic portfolio to VR, AR, Web, and real life ways of viewing art. We used the Harvey Balls²³ method of rating. Each circle represents a number between 0 and 4. Next to an in-person studio visit, our product is the most interactive and informative.

Our portfolio's ideal experience gives curators the most accurate information, especially because curators can experience the real size of each artwork and put the holographic artwork on display in their own environment.

Our experience is clear and straightforward, while also being new and easy to use. One way this is accomplished is by including instructional audio that is applicable to every experience window/page. The number of different instructions is kept to an absolute minimum, in order to allow the user to feel in control.



	Usability							Art Viewing Experience	 Total Score
	 User Control & Freedom: Provides choice and undo capability to users	 Access to Artist: User can view essential and relevant information about artist	 Accuracy: Information received about artwork is accurate	 Exit for Error: User can understand and correct errors	 Consistency: Same interface and language throughout experience	 Access to Artwork: Essential information about artwork is displayed, and user can interact with artwork	 Learnable: Easy for users to navigate the system	 Aesthetic: The platform is elegant and fun to use	
Holographic Portolio (MR)									28
NYTimes 360 Video Tour of Art Studio (VR)									20
Curioos Art Viewing App (AR)									19
Traditional Web Portfolio									25
Art Studio Tour									

— 0 points
 — 1 point
 — 2 points
 — 3 points
 — 4 points
 Not Applicable

XII. NEXT STEPS

Research

We focused on exploring how traditional, tactile artwork can be experienced in mixed reality. However, we didn't speak to any digital artists or curators. Their perspective is essential for improving the user experience of the holographic portfolio. Digital art likely presents different opportunity areas and limitations.

Design

During user testing, we heard from our testers that it might be useful to be able to scroll through artwork in a portfolio, instead of having to go back to the artist page every time a user wants to select a new piece to view. We think a "next" command, via both an icon and voice command could be useful.

We also think developing a feature for users to "save" or favorite artworks could be useful. Many people we tested indicated that if they were viewing many works in the same experience, they'd like to be able to return to the ones that they liked in an easy, straightforward way. We think this feature would be key to any scaled version of our prototype.

Testing

We would like to do more testing on how our instructional audio is received. We think our idea is straightforward, but most of our testing occurred without instructional audio in place. Future versions of our prototype would likely need to refine the language and placement of audio instructions in the user flow.

Also, we would like to hear more from users about how they experienced narrative audio, like the artist's biography, in our holographic portfolio. Narrative audio could be a great addition to the experience, or it could detract from the user's ability to view the artwork. More user testing can give us a better sense of how this feature is received by others.

Development

Using 3D modeling, we want to work on the process of bringing more physical artwork into mixed reality. Our current HoloLens prototype uses art images that were readily available to us, but in order for our holographic portfolio to progress, we need to do more 3D modeling to understand more deeply how artwork can be adopted to the medium of mixed reality. This endeavor would also allow us to better understand how our art portfolio can be adopted for widespread use in the future. Further development of our prototype would include making the true-to-size and rotate icons draggable. Currently, the tools have to be "held" by the object while the user interacts with them. Allowing the icons to move with the user would be essential to a smooth user flow.

Lastly, we anticipate encountering issues with voice commands. Currently, icons accompanied by text indicate that a voice command option is available. However, the way that spatial mapping currently places objects may make it difficult for our text to appear next to the correct icons. We think it could be difficult to ensure the appropriate text is always in the user's field of view. More user testing will help us with this issue.

XIII.

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XIV. ABOUT OUR TEAM



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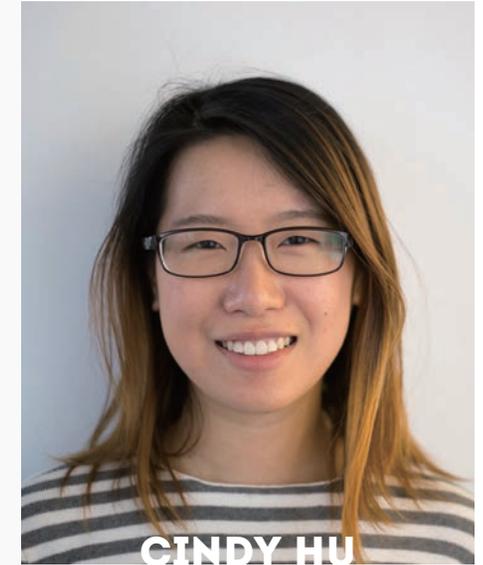
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Levi Mollison is an undergrad majoring in Integrated Digital Media at NYU Tandon with a minor in Computer Science, focusing on full-stack development.

Fun Fact: One summer, Levi taught kids JavaScript. One 10 year old, who started out hating coding, ended the class by leaving Levi a teacher review that said, "I LOVE JAVASCRIPT!!!!"

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