Development of the Jazz History Database Virtual Museum

A Major Qualifying Project
Submitted to the Faculty of
Worcester Polytechnic Institute
In Partial Fulfillment of the
Requirements for
Interactive Media and Game Development

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JAZZ HISTORY DATABASE

Abstract

The Jazz History Database (JHDB) is an organization at Worcester Polytechnic Institute (WPI) that stores jazz resources in its archives, including live recordings. Jazz is a neglected genre of music today, garnering "a whopping 1.4% of music consumption in the United States" (Dodd, 2019). This means that the resources in the JHDB would likely long be forgotten had they not been preserved. In order to find new ways to preserve these resources and make them more approachable to modern audiences, the JHDB in collaboration with the Interactive Media and Game Development (IMGD) Department set out to build an interactive 3D environment in which a player could listen to old jazz songs on a record player. We would build this 3D environment for virtual reality (VR), where the player puts on a VR Oculus headset in which they would see and interact with the artifacts in the virtual museum. This Major Qualifying Project (MQP) was developed in Unreal Engine 5.

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Acknowledgements

Background and Introduction

As mentioned above, the JHDB is an organization at WPI that archives jazz music and history. Jazz was a celebrated genre of music, and the JHDB aims to preserve recordings of different types to preserve its impact. "The goal of JHDB is to celebrate the accomplishments of these artists, whether in music, poetry, visual art, or any other field. Decades of work have gone into preserving countless jazz artifacts since the JHDB was founded in 1999" (Matticoli & Varella, 2020). The JHDB has put in a lot of work to find and preserve different resources of jazz music and history, and has also tried to find different ways to do so, considering that most of the resources' formats are old and difficult to preserve. "While it is already difficult to digitize media in recently retired formats such as VHS tapes, a significant portion of the media is received in older forms: vinyl records, phonograph cylinders, paper manuscripts and hand-written sheet music with the original crossouts" (Matticoli & Varella, 2020). These older formats are not meant to be digitized, making them difficult to preserve today. This is why we wanted to create an MQP that would showcase some of this history in a newer format, making the recordings from the JHDB more readily available.

For our MQP, we decided to create a 3D environment where the player would listen to some of the jazz recordings that the JHDB has preserved.We believed this to be a new and effective way to preserve and showcase some of the JHDB's resources. Today, everything is digital. There is no more need for VHS tapes. Since jazz and tapes are both old and neglected, the latter's format needs to change in order for the former to be more approachable to today's technology. Instead of forcing potential audiences to find outdated formats that they would likely throw out or neglect, we are importing these resources to a 3D environment made with modern technology. With this option available, we would make the JHDB much more approachable to people who may be curious about jazz history but want more updated ways of experiencing it.

Before this project, there was another successful attempt at making the JHDB more approachable with modern technology. WPI students put together an Interactive Qualifying Project (IQP) in which they stored JHDB resources on a website. The IQP team "built a

web-based tool (a "contributor portal") where developers and remote correspondents may upload media into a simple web form" (Matticoli & Varella, 2020). This was a method of modernizing the JHDB's resources' approachability. Instead of settling on outdated formats that are rarely used today, the IQP team decided to digitize the formats on a website so that anyone with access to the Internet could visit its web portal. This was especially important since this project was finished and published in 2020, around when the COVID-19 pandemic started. It was important for people to have the ability to access the JHDB web portal from remote locations to reduce the chances of exposure to the virus. This project helped make the JHDB more approachable with modern technology. Because of this precedent, we believed that it was necessary to make the JHDB resources approachable in a different modern way.

To go a step further into modernizing the JHDB, we decided to build the 3D environment in virtual reality (VR) since it "is emerging as a readily available technology, and creating games specifically for VR has become commercially viable" (Cox et al, 2019). Using VR makes the 3D environment, and the jazz resources inside it, more approachable to modern audiences. As well as being available to a modern demographic, VR technology has reached "$3.6 billion in 2018, and is expected to grow to $16.3 billion by 2022" (Cox et al, 2019). VR technology has reached a significant financial success. This means that if we built the virtual museum in VR, we would make the JHDB resources in the virtual museum a lot more well known.

To start off this project, our advisors purchased and made available to us an Unreal Engine level called the 'Jazz Syndicate.' We opened this file in Unreal Engine, which gave us a few ideas on what we wanted our own project to look like. In the 'Jazz Syndicate,' we could move, rotatem or remove its props, change the hues and intensities of lights, and change any other textures that we wanted with Unreal Engine's material editor. Having the freedom to change and edit the 'Jazz Syndicate' level gave us many different ideas of how we wanted our own project to look. With this in mind, we got rid of most of the original props from the 'Jazz Syndicate,' and we started importing our own 3D models to make our own speakeasy.
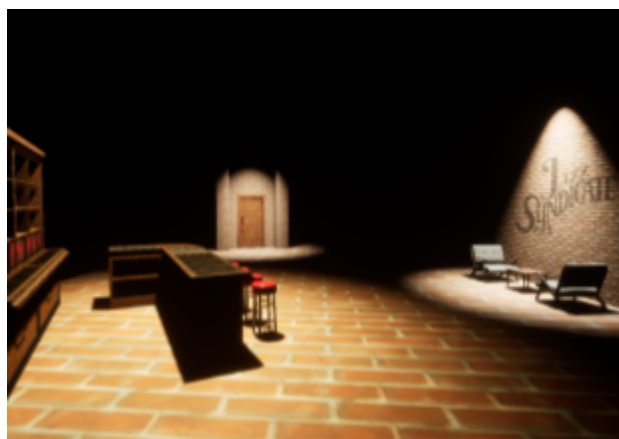
Screenshot of
Edited 'Jazz Syndicate' Level

Game Inspirations

We wanted this environment to be a 3D space where people would explore and interact with the environment that was around them. Since this environment is in VR, we wanted it to feel as much like a real place and we took inspiration from Job Simulator and similar titles.

Screenshot of Job Simulator

Job Simulator does a great job solving the classic troubles for VR games including the lack of mobility and unique interactions with the surrounding environment to enhance immersion.

Art Inspirations

The Jazz Age is mostly remembered as a time of rebellion against Prohibition in the 1920s. "Prohibition stimulated the creation and circulation of dozens of songs about liquor and drinking, most often against, but occasionally in favor of, the legislation… Most of these songs had their roots in the new canons of jazz, blues, and novelty songs that enjoyed frequent airplay on the radio and vigorous record sales across the country" (Drowne, 31). Prohibition helped popularize the Jazz Age in its protests against the alcohol ban. Because of this, we decided to build a speakeasy for our 3D environment. We believed that this would capture the essence of the Jazz Age in the 1920s.

Though jazz used to be popular, as we have stated before, the genre is unfortunately not very popular today. So in an effort to make a connection between the past and the present, we decided to use the 1980 film *The Shining* as inspiration for the speakeasy. In *The Shining*, the Overlook Hotel's abandoned history slowly reveals itself to the caretaker and his family. Stanley Kubrick, *The Shining's* director, "creates anachronistic visuals that situate people from the past in modern settings. The aesthetic disjointedness of these scenes emphasizes that the Overlook is not free of its violent past" (The Take, 2:35-2:46). Although we do not intend to put graphic depictions of violence in this 3D environment, we believed that the theme of overlapping the past and present was important to take away as inspiration from *The Shining*. The Overlook's haunted history comes to life in front of the family, just like we want the speakeasy's jazz history to come to life in front of the player.

After putting together a solid idea of what we wanted for the speakeasy, we decided to collect resources to use as references. To better conceptualize what we wanted for the virtual museum, we decided that we needed physical references as well as a historical event and a horror film. As a result of this, we took photographs of what we saw around us that we thought that we could use as references for what we wanted to build for the speakeasy. We started with taking pictures inside WPI's Alden Memorial Hall, WPI's musical event and performance hall.

Photograph of Stage in Alden
Memorial Hall

Photograph of Piano in
Alden Memorial Hall

Photograph of Drum Set in
Alden Memorial Hall

We used the pictures above as references for the stage area of the speakeasy. We felt that we needed an area where musicians would have performed, making the area feel more lived in and abandoned. We wanted to emphasize that this speakeasy was once an active location where people would get together, drink, and enjoy live jazz music.

*Photograph of an
Iced Drink*

Photograph of Alcoholic Bottles

On top of taking pictures at Alden Memorial Hall, we also took pictures of glasses and bottles that we would put in the bar section of the speakeasy. We felt that this was important for emphasizing that this was a place where people would drink while hiding from the alcohol ban. Again, we thought that these little details would help make the environment look used.

Classical Guitar V.S. Jazz Guitar.
CMUSE.org

Jack Torrance Standing in a Bar
CollectiveLearning.com

Although the photographs that we took ourselves were very helpful, we wanted to find more photographs with subjects that we did not have access to ourselves. As a result, we looked for related images on Pinterest. Since we were still pursuing the idea of a speakeasy, we looked for images involving bars, which is why we decided to use *The Shining* as reference.

Collecting and taking these photographs helped give us different ideas for what we wanted for the virtual museum. Using these physical references helped us craft our own version of what we wanted the speakeasy to look like. They also served as reference when actually sculpting the 3D models themselves.

Technology

We chose to use the Oculus Quest 2. Aside from having one onhand it is also one of the best plug and play VR headsets currently on the market and makes VR easily accessible aside from the price tag. The Oculus can also be plugged into a PC using USB3 which allows for quick testing and a smoother development process.

Unreal Engine 5 was beta released in May of 2021 and it was an ambitious undertaking for this project.

Plugins:

1. Oculus OpenXR
   a. OpenXR aims to ease VR development across multiple headsets by standardizing the inputs across devices. This project takes advantage of this system but we have yet to test it on headsets other than the Quest 2.

2. GPU lightmass
    a. Stationary and static lights in the scene can take advantage of the lightmass system by precomputing lighting data and storing the information in lightmap textures. This process usually takes a while to compute; however, this plugin enables the process to be done on the GPU and uses DirectX 12 to speed up the process.

Design

Our initial concept began with brainstorming different spaces the player could visit with each space focusing on a different element of the JHDB. For this project we scoped to focus on one space in particular, the Listening Space, as a proof of concept.
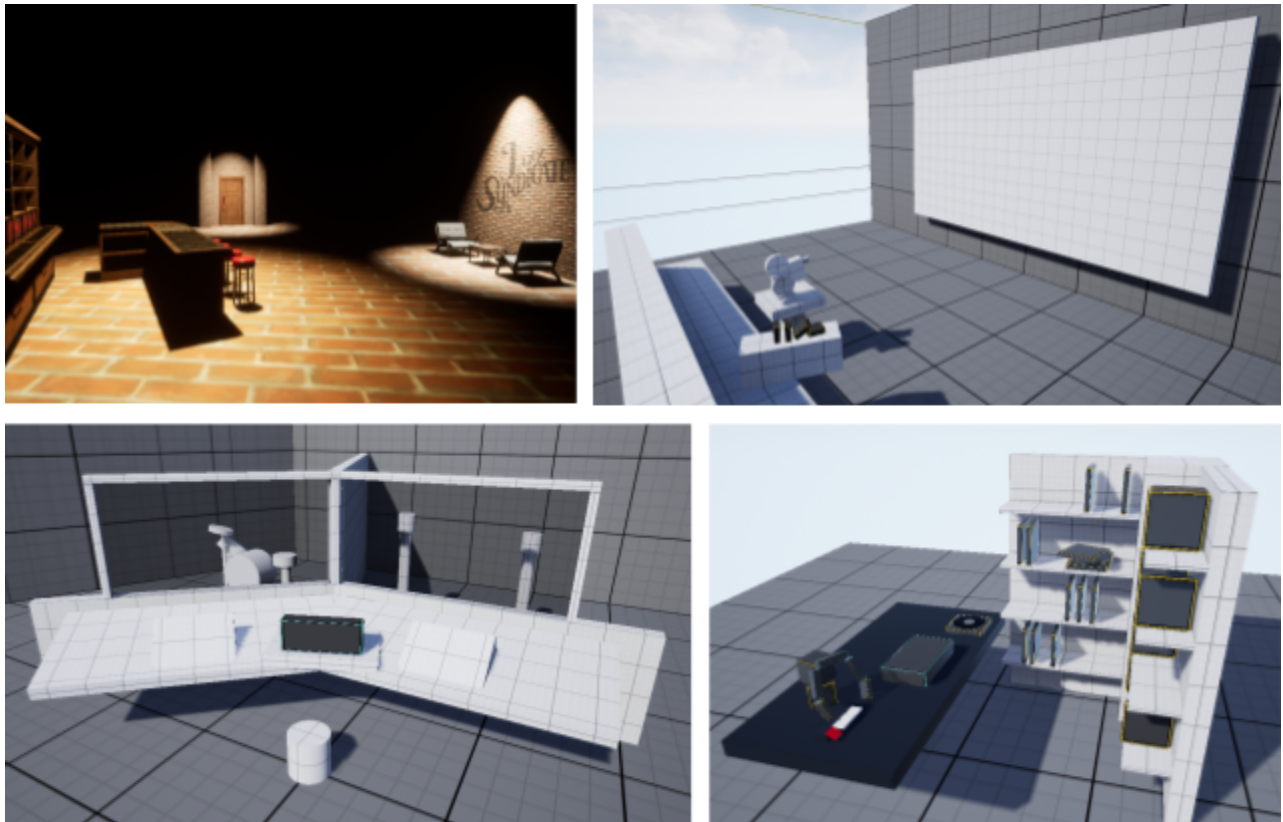
From top left: Spotlight Concept, Theater, Recording Studio, Listening Space

Iterations

Different Iterations of the Virtual Museum

The first version, or iteration, of the listening space consisted of a shelf with three vinyl disks, along with a table with the record player on it. This iteration of the listening space had all of the minimum elements needed for the player to play the jazz music available, which we presented at Alphafest. This was a good prototype, but it was simplistic. The final product needed to take up more space. People would have actively used this listening space for both recorded and live music in the past. Because of this, we decided to sculpt more models to add to the virtual museum to make it feel more like a once-active speakeasy. Bigger props included a guitar, microphone, and beer barrel in order to make the space feel more like a bar that had live music as well as vinyl disks.

Rendered Image of a Guitar

*Rendered Image of Old-Fashioned Microphone*
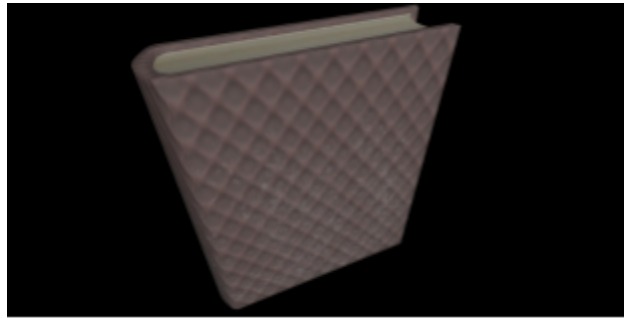

*Rendered
Image of Beer
Barrel*

We used the guitar and microphone, as shown above, to demonstrate how people played music here. We then used the barrel to demonstrate where employees would have stored the alcohol. These larger props helped solidify the narrative that this listening space was once an active speakeasy that held musical entertainment for its customers. This was more than just a listening space, which is why we added these larger props.

As important as these larger props were, smaller props were just as important to the virtual museum. We needed little details to imply everyday usage of this speakeasy. Because of this, we added props including boxes, books, and flasks to imply a narrative to the virtual museum even further. Again, this was a space where people would have drank as well as listen

to music, meaning that we needed to add these props to imply the narrative of this virtual museum even further.
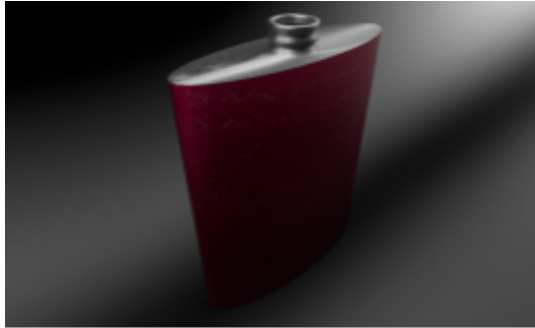
Rendered Image of Flask

Rendered Image of Book

Rendered Image of Storage Box

We added all these smaller models to contribute to the little details in the listening space as well as the bigger details. We did not want to just do the bare minimum for the listening space. We wanted a space that people could interact with AND that had a narrative. We included flasks and glasses because people would have wanted to drink. We included This is a space that people both from the past and present would have interacted with.

Also, we started to incorporate elements from the original 'Jazz Syndicate' level into our virtual museum. We decided to get rid of everything except the walls, lights, and a few stools from the 'Jazz Syndicate,' turning the level into our own museum. We liked the brick walls and the lights that came with the 'Jazz Syndicate,' so we decided to keep them while still making the virtual museum our own.

Afterward, along with adding new models to the virtual museum, we made slight changes to the models already in-engine in order to make them more detailed. For instance, we added details to the shelf and bar counter so that they would look less geometric. We dulled the edges of the bar counter and curved the edges of the shelf. Adding these details to the models in-engine made them look a lot more real.

Looking through the first iteration objects were neatly organized mainly as a result of the grid based snapping, and while it is helpful when designing the space it does not feel lively or lived in. "Messing up" the space was a key part of filling the space and made it feel more used. In addition changing the lighting of the scene helped blend together all the separate assets and direct the players gaze to the highlighted areas of the room.

Designing for VR

While we wanted players to browse and play music, using menus in VR can be quite underwhelming or even frustrating. Our solution was to design the environment to be used as an interface and take full advantage of the VR capabilities. While on a website a user may scroll through a list of songs and click on one to select it, in our Listening Space the user browses records on a shelf and can physically pick up a record of their choosing. Additionally the distance of objects from the player also needed to be considered. As This experience was designed to keep the player in a sitting position, the assets in the surrounding environment needed to remain within reach.

Art

When pursuing the artwork for the virtual museum, we followed a specific pattern to keep the flow organized. The first section of this creative pipeline was concept art. In the first term that we started this project, we designed what we wanted for the virtual museum. We created concept sketches and greybox levels to get an idea of what we wanted in the virtual museum. We wanted to have as much of a clear idea of what we wanted the museum to look like before we started making artwork. After we finished making concept art, the next step in the pattern was creating 3D models in Blender throughout the next term. After modeling, scaling, fixing pivots, and adding other details to make sure that we were satisfied with the models, we proceeded with unwrapping and texturing. We unwrapped the models in Blender so that they would have a detailed map that we could apply textures to. We then exported them to Substance 3D Painter for texturing. This way we would add details to the textures so that we would look more real in the virtual museum. Finally, for some of the models, we added an extra step, which was rigging and animating. For this, we imported the models into 3ds MAX to use the CATrig option for importing skeletal meshes and animations to different engines, and since we wanted to make sure that the player could interact with some of the objects in the virtual museum, we felt that rigging and animating a few 3D models was important for realism.

Concept Art

Using the photographs and Pinterest images as references, we made concept sketches of different rooms that we would potentially put into the virtual museum. We did not simply want to copy what we saw in the photographs. We made these sketches to make the designs for the

speakeasy our own. We also did this to scope out what we believed that we could physically make a 3D model out of. For instance, we really liked the idea of having a stage area where musicians and other jazz artists would have performed. We also liked the idea of incorporating a bar into the speakeasy since Prohibition fueled the Jazz Age.
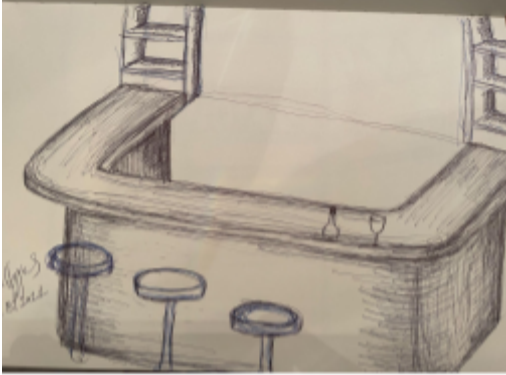

Concept Sketch of Stage Area

As much as we liked the stage area idea, we also decided that we wanted the player to have some kind of interaction in the virtual museum. We realized that the best way to execute this was if the players played different pieces of jazz music on record players. Consequently, we created a concept sketch of a listening space where the player could check out and play vinyl disks. Along with a speakeasy, the player would have access to their own library of jazz music.
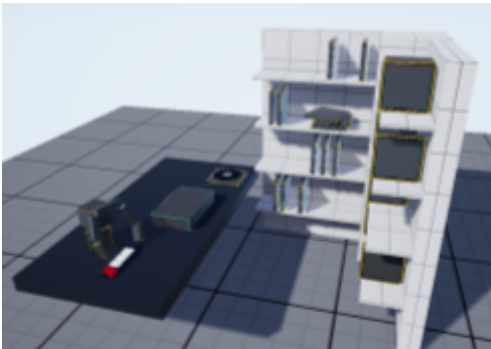

Concept Sketch of Listening
Space

Finally, we created a concept sketch of a bar. This would have been an essential part of the speakeasy.

Concept Sketch of Bar

Sketching these different areas gave us an idea of what we wanted and could pursue to bring to life in a 3D environment. It gave us ideas of what to incorporate into a jazz scene.

Afterward, we began building greybox levels in Unreal Engine 5 to figure out how to structure these 2D sketches into a 3D space. The greybox levels gave us ideas on where to place and how to scale the actual props that we would have wanted for this project. Putting basic geometric blocks into the greybox level gave us more detailed pictures of what we wanted for our final product.

Screenshot of Listening Space's
Greybox Level

3D Models

After drafting together these concept sketches, we finally pursued 3D modeling of the props that we would import into the virtual museum. We used Blender for the sculpting of these models because it is free to install as opposed to Zbrush. Since all the models were meant to be pieces of furniture or other environmental objects, we sculpted the models from geometric shapes with "Edit Mode." Depending on the different props, we used edge loops, extruded

regions, or other options in order to create the details for the different props used for the virtual museum.

Before narrowing down which specific room we wanted as our minimum viable product (MVP), we started sculpting different models that we believed would be useful for the virtual museum. We wanted to try to cover our bases to stay prepared for what we wanted to pursue for the environment. Because the space was supposed to be a speakeasy, we modeled props that people would typically find in a bar, including bar counters and bottles.

*Progress Screenshot of Bar Table*

Progress Screenshot of Stool

*Progress Screenshot of Initial
Wine Glass*

Above are some progress screenshots we took of potential models that we thought would work in the virtual museum, since we believed that it fit the 'speakeasy' aspect that we were aiming for. We sculpted different models such as wine glasses and beer bottles to put in the speakeasy section of the virtual museum.

However, we decided that the record player and vinyl disks were the most important parts of the virtual museum, so we decided to focus on those models. We came to this conclusion by realizing that it was important for the players to only surround themselves with the 3D environment, but also to listen to the jazz songs on the record player. Because of this, we decided to focus on the listening space, and ultimately decided to cut the other rooms. This meant that the actual bar part of the speakeasy would have been cut out. As a result, most of the 3D models that we had made or were in the middle of making had been dropped from the virtual museum. This meant that the above screenshots of the bar counter, wine glass and beer bottle were dropped for a time, since we were no longer incorporating a bar room into the virtual museum.

Because we wanted to create a full listening space, we sculpted different pieces of furniture to add to it. We did not want the player to feel like they were in an empty space. Instead, we wanted the player to feel like they were in a real room, so adding the furniture helped create a full, lived-in room.
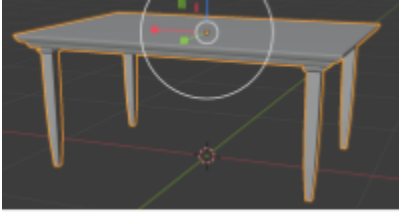
Screenshot of Finalized
Listening Table

Screenshot
of
Finalized
*Stool*

Screenshot of
Finalized Shelf

There was another artist who lended help in modeling extra props to fill the space in the virtual museum. But she was officially a part of another MQP, so as helpful as her contributions were, they were also limited.

UV Unwrapping and Texturing

After we finished sculpting the models in Blender, we needed to prepare them for textures. This would help make them look more realistic in Unreal Engine. In order to do this, we unwrapped the models' UVs in Blender to make sure that they would have an accurate texture

map. This way, we could accurately apply textures to the models' more detailed texture map instead of letting the textures look slapped onto them, risking great inaccuracy.

Afterward, we exported the models as FBX or OBJ files, then imported them into Substance 3D Painter. This allowed us to create and export textures to make the models look more real in Unreal Engine. After a while, we decided to export the textures using the UE4 Packaging available on Substance 3D Painter. This allowed for fewer texture maps that took up less space in our project. Afterward, we imported the meshes and the textures in Unreal Engine to set them up for the virtual museum listening space.
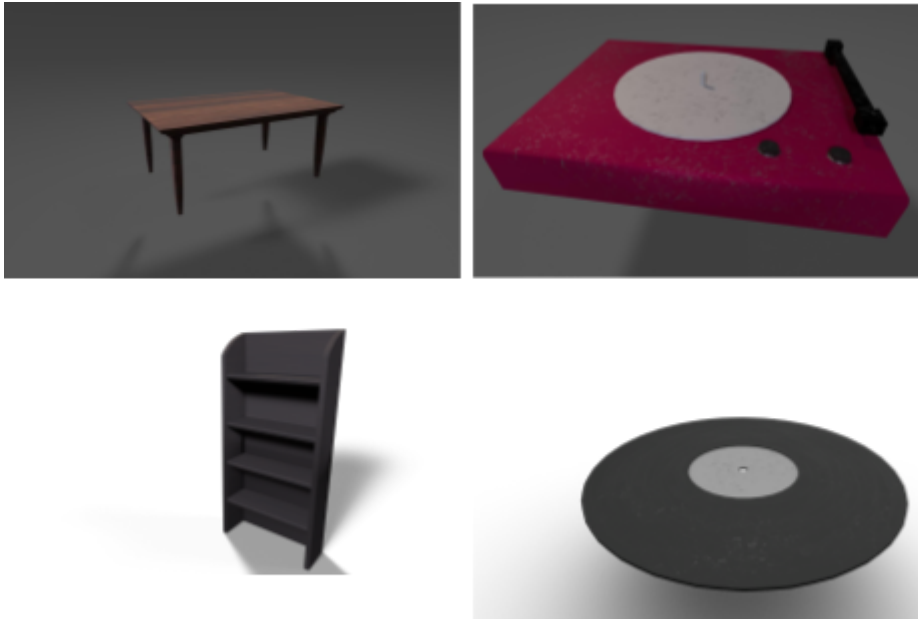

Rendered Images of Textured 3D Models

We decided to use a combination of warm and Autumn-colored textures for the furniture models in the virtual museum. We wanted to give the environment a warm and inviting tone. Since Prohibition was active in the Jazz Age, we wanted the speakeasy to look like a sanctuary for those who wanted to enjoy drinks and music. The customers needed this speakeasy to be a safe haven from the law. Because of this, we textured the furniture and other props with a warm Autumn color palette, using varying shades of reds, oranges, yellows and browns. This Autumn palette gave a sense of welcoming to the virtual museum. Below are screenshots of the 3D models in Substance 3D Painter's material editor.
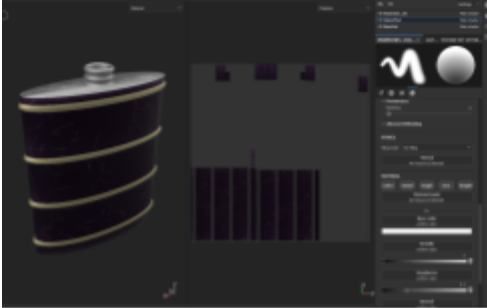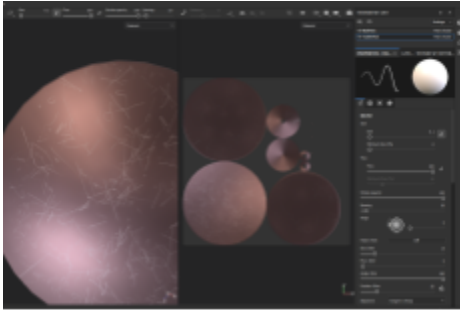
Screenshot of Flask in Substance 3D Painter
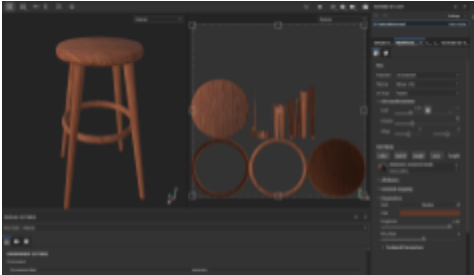
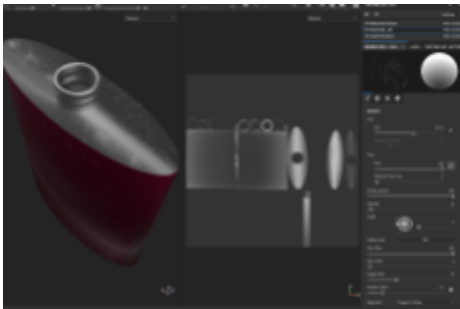*Screenshot of Stool in Substance 3D Painter*

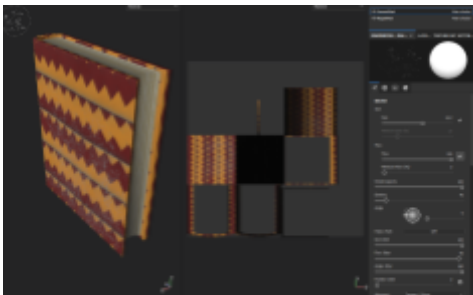*Screenshot of Bar Counter in Substance 3D Painter*

Though the virtual museum is welcoming, it is also supposed to be abandoned. Jazz was very popular during Prohibition, but it is not popular today. Because of this, we also created paint layers on top of the texture layers in Substance 3D Painter to add dust and scratches to the models. These items in the virtual museum are supposed to be abandoned. No one would have come into this space for a long time, which means that dust would have collected onto the furniture and other props. The screenshots below show models that have dust and scratches on them, showing off their age and neglect.

*Screenshot of Bar Table's Scratch Layer in
Substance 3D Painter*

*Screenshot of Flask's Scratch Layer in
Substance 3D Painter*

*Screenshot of Book's Dust Layer in
Substance 3D Painter*

For the vinyl disk, we ran into some texturing difficulties. How the vinyl disk looked in Substance 3D Painter was different from how it looked from Unreal Engine. Vinyl disks have radial grooves that the record player's needle slides along in order for the music to play. They are an important part of the disk's texture. Because of this, we needed to figure out how to make the anisotropy angle texture map appear on the vinyl disk. Our advisors then told us about UE4 texture packaging, an export setting in Substance 3D Painter that would have made the textures in Substance 3D Painter look a lot more similar to the textures in Unreal Engine with less texture maps taking up space in the material editor. We tried this method, but we did not realize that we missed an important step in the export settings, making the textures look the same. Because of this, we needed to figure out how to get the anisotropy angle texture map to appear on the outer texture. Initially, we thought that making this texture map as the base color would be enough. Below are the results of this specific process.
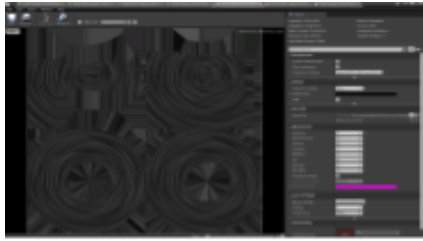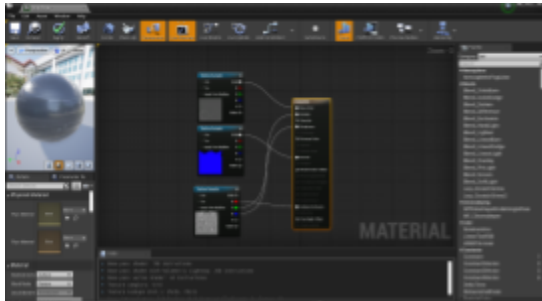
Screenshot of Anisotropy Angle Texture

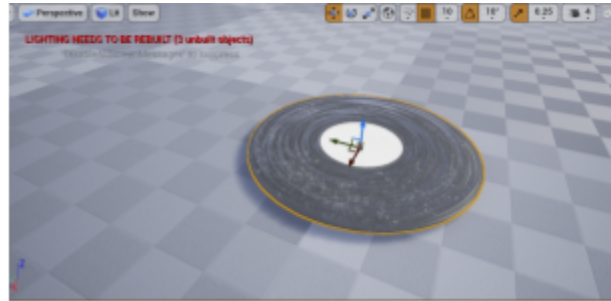Screenshot of Anisotropy Angle as Base Color in Material Editor
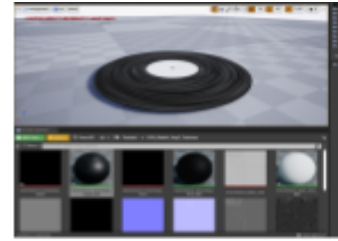
Screenshot of Anisotropy Angle applied as the Base Color of the Vinyl Disk

Doing this made the radial grooves appear on top of the outer part of the vinyl disk, but it did not actually bake the grooves into the disk. For a while, we could not figure out how to actually bake the grooves into the texture. We then remembered that UE4 Texture Packaging involved connecting RGB channels to the ambient occlusion, roughness, and metallic channels in the material editor. Because of this, we decided to set the outer texture's original base texture map as the base color again. We then set the anisotropy angle's texture map's RGB channels to connect with the ambient occlusion, roughness and metallic channel in the material editor. Doing this baked the radial grooves into the vinyl disk, making it look a lot more realistic.

Screenshot of Anisotropy Angle Applied Correctly to Material Editor

Screenshot of Anisotropy Angle Applied Correctly to Vinyl Disk

Rigging and Animating

Since the first room we decided to pursue was the listening space, one of the main important assets that we pursued relatively quickly was the record player. This model was especially important because not only did we need to model and texture it like we did for the listening space's furniture, we also needed to rig it for animation. The main purpose of this virtual space is for players to listen to the vinyl disks. Because of this, the record player needed to spin. We wanted the table on the record player to constantly spin while the virtual museum

was in play. This way, when the player put the vinyl disk on the record player, the disk would spin along.

After sculpting the record player in Blender, we imported it to 3ds MAX, which allows users to use the CAT rigging system to rig their models and import the skeletal meshes and animations into different game engines, such as Unreal Engine. We used this rigging tool because it is the one that we were most familiar with in terms of setting up an animation to be used in another engine. For rigging, we assigned bones to the record player's different meshes, creating one skeletal mesh. After exporting the meshes and their bones, we animated the spinning table so that there would be a continuous looping animation.

We also decided to CATrig a guitar that we modeled in Blender. We wanted to incorporate musical instruments into the virtual museum so that there would be more evidence of this environment being used. We CATrigged this guitar so that the player would have the option to play with its strings. We wanted the player to have more than one source of interaction in the environment.
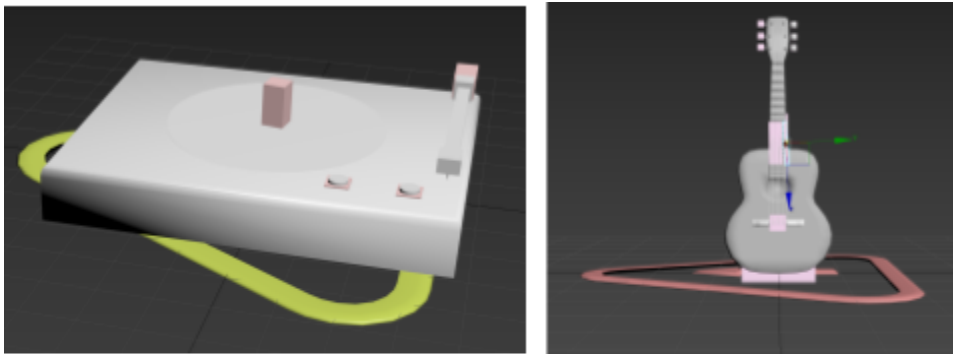

Screenshots of CATrigged 3D Models in 3ds MAX

.**Technical Implementation**
   VR Interaction
   Utilizing the Oculus OpenXR and OpenXR plugins to do a lot of the heavy lifting inside the Unreal Engine VR Template, specifically the VRPawn and the GrabComponent Blueprints.
   The GrabComponent can be attached to any simple objects such as the vinyl record and enables the object to be picked up and thrown by the motion controllers. Additional behavior can then be added to the object for more complex interactions. For example, to create the vinyl records the GrabComponent was attached to a static mesh and a song variable was added so that a specific song could be attached to the object.
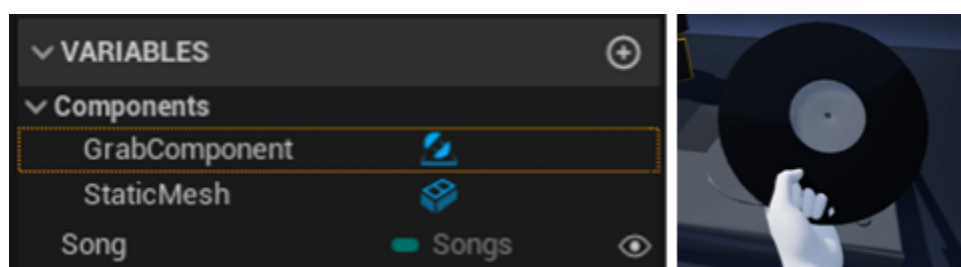
Vinyl record using GrabComponent

Vinyl Folder

The vinyl folder was added to organize and better manage the growing list of songs/records in the space. This blueprint consists of a text label, trigger volume, and placeholder. In addition the VinylFolder requires a reference to the VinylRecord blueprint and for a default song to be selected. The folder can then be placed within the space and on start the blueprint will initialize a vinyl in the location of the placeholder and assign it the selected song. The text label on the side of the folder will always display the name of the song of the last vinyl that it was holding. This means that if a new vinyl is placed into an empty folder the name will update to the correct song.
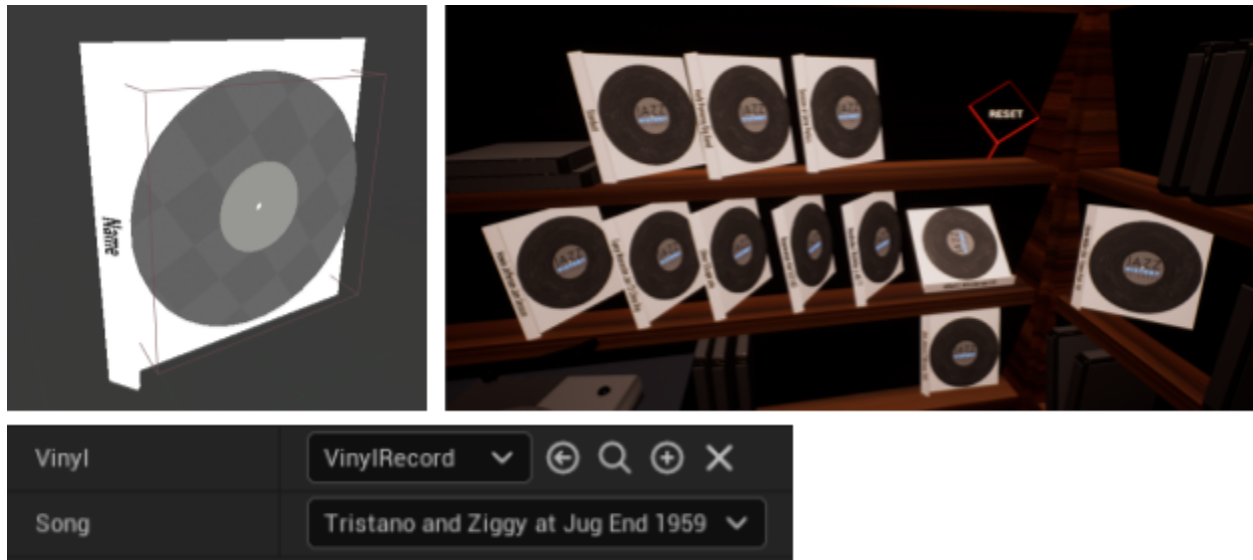

Vinyl Folders

One difficulty with multiple items trying to grab the same component is communication between the multiple grabbers so that they don't interfere with each other. This problem arose a few times within the record player, vinyl folder, and the motion controllers. One solution is to always check if the grabbable object is already being held, and if it is, leave it be. Unfortunately if the folder was holding an item the motion controller would never be able to take it. As a result the motion controller needed to take priority over these other holders, and the folder and record player would need to wait for the item to be released prior to taking the item for themselves.

**Skeletal Mesh Interaction**
Record Player

Working with a skeletal model can be really nice as like the Oculus hand models you have access to each bone individually and you can get a lot of complex behavior out of them. For this model the record plate was given a spinning animation while the record head is grabbable. The record player
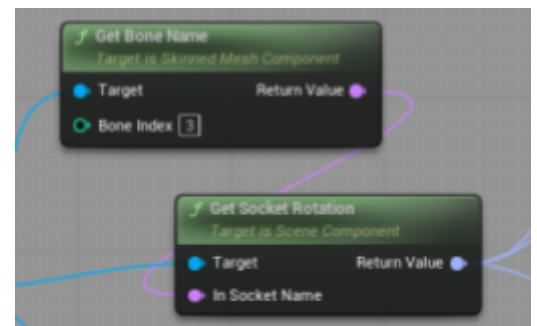
RecordPlayer Blueprint getting skeletal mesh bones

inherits from the GrabComponent but uses a custom grab type to avoid being picked up. Rather it uses the GrabComponent to get access to the MotionController. This way when the player tries to grab the record player the Blueprint sends the MotionController position to the RecordPlayer_AnimBlueprint so that the record head bone can point towards it.
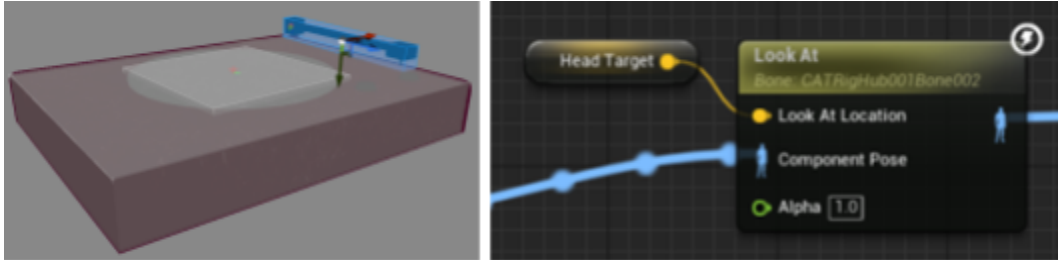
RecordPlayer needle bone and Animation Blueprint.

When the vinyl is secured on the plate it will not initially play music, instead to get the vinyl to play the record head must be set in the proper position. Using the object's forward vector and the record head bone forward vector the cross product can be used to find the range in which the head is over the plate. The same process must also be done with the up and right vectors to make sure the height and quadrant respectively are also within the desired range. A fun trick is to then use the possible forward vector cross product range to select the starting time of the song. As a result the record player will function very similarly to a real record player where the location of the head on the outside of the track will be the start of the song and the inside will be the end of the song.

RecordPlayer Blueprint: using cross product to start song based off needle bone possition.

VR Hand Animation
        The Oculus Quest hand models are available on the developer website
https://developer.oculus.com/downloads/package/oculus-hand-models/
        The Oculus hands are rigged and can be used to make multiple poses using Unreals animation sequence. Combined with a 1D blendspace you can interpolate between the poses with a 0-1 value. For our purpose this creates a very satisfying feedback between the amount the player pulls on the grip of the oculus controller and the amount that the hand model closes. This

simple system could be expanded into a 3D blendspace with multiple inputs for a variety of poses and in future iterations could make for some unique interactions and experiences.
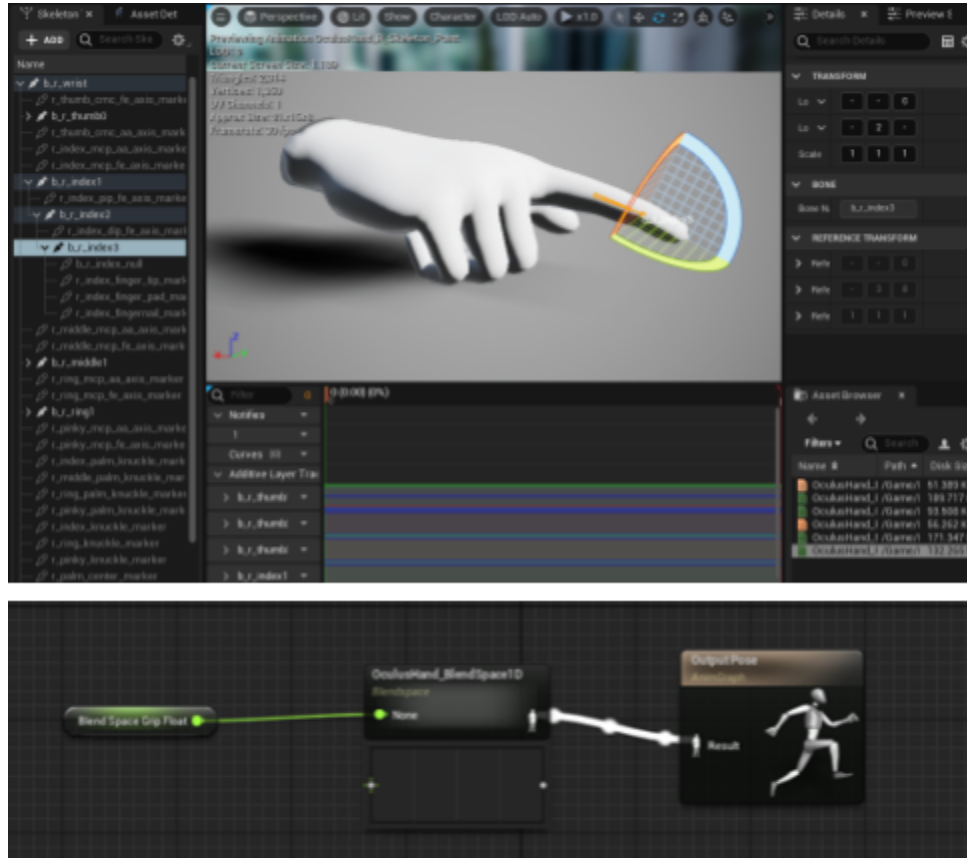
Hand point pose and simple BlendSpace animation blueprint.

Sound

The purpose of this project is to preserve the JHDB's resources in a way that is more approachable with modern technology. Because of this, along with building models for the virtual museum, we also needed recordings from the JHDB to make it an actual museum.

As a result of this, Benjamin Young and Richard Falco provided recordings that we could put into the virtual museum. We made it so these recordings played whenever we placed a vinyl disk on the spinning record player and applied the record player's needle to said disk. Every vinyl disk had a different musical or interview recording applied to it. This way, if the player wanted to listen to something different, they could simply replace the current vinyl disk on the record player with another.

Playtesting

WPI requires IMGD MQP teams to present their projects at Alphafest, which is an event where IMGD students present their games to other students who need playtesting credit. Playtesting is when people test games before they are finished so that development teams can figure out which aspects of their games work and which do not. We wanted to make sure that we were heading in the right direction with our virtual museum, so multiple outsiders' different pieces of feedback were important to us.

Anyone can present their games at Alphafest, but in order to actually write about the results, we needed official permission from the Institutional Review Board (IRB). Because of this, we had to go through a training program to learn about conducting surveys properly. When writing about results that we get from playtesting, it is important that we protect the participants' privacy and confidentiality.

Along with following general procedures for surveying participants, we needed to know to inform them about physical risks. VR equipment can cause uncomfortable side effects, which means that if we were careless, we could cause physical as well as mental harm for any participants whom we did not inform properly. Side-effects include eyestrain, disorientation, and nausea (Riva, 1997). We had to make sure that the participants were informed about these side effects before they agreed to playtest the virtual museum. Finally, because we were, and still are, in the middle of the COVID-19 pandemic, we had to make sure to maintain a sanitary environment and a social distance. Because of this, we had to go through an IRB training course in order to certify ourselves. We needed to make sure that we knew the specific procedures to follow in order to make sure that we protect the participants in our playtesting session at Alphafest.

After taking the IRB training course, we created an Informed Consent Agreement, a Study Protocol, and a COVID-19 Mitigation sheet for participants to read at Alphafest before they agreed to playtest the virtual museum. If we wanted to discuss our playtesting results in this paper, we needed to make sure that our documents were thorough to the point where the participants knew the procedure and that they were allowed to stop at any point. Afterward, we submitted our documents to the IRB for approval. Although we had to edit the Informed Consent Agreement, we eventually earned IRB approval. As a result, we can discuss the Alphafest results.

We presented our virtual museum at Alphafest and got thirteen responses from people who tested it. Since we were aiming for realism in this environment, we asked questions about the environment and the VR hand's movements. Below are screenshots of some of the questions and their responses.
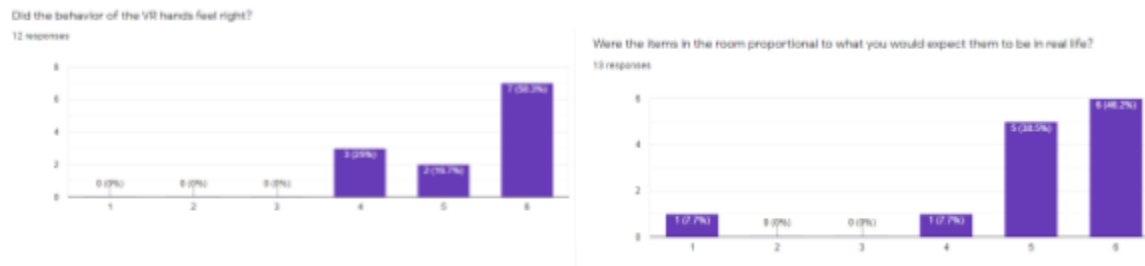
Screenshots of Histograms Showcasing Satisfaction with
Specific Factors in Virtual Museum

Responses skewed to the positive side. Most of the participants thought that our listening space's furniture and other props were proportional to what would be realistic to real life. Most of them also thought that the VR hand's animated behavior felt realistic to real life. We wanted the virtual to feel realistic, so knowing these opinions from our participants was important.

Although we received mostly positive responses from the participants, we made sure to include comment sections so that they could tell us their specific opinions on how we could make the virtual museum better. We were curious about how to move forward with our project, so these more specific pieces of feedback were important to us.

Screenshots of Participants' Specific Feedback

This feedback gave us ideas on how to make the virtual museum feel more real. For instance, one participant stated that they thought that we should add more details to the room. Another participant said that they struggled to grab things with the VR hands. Another participant said that they struggled with the needle on the record player. These individual bits of feedback told us that although the participants enjoyed our virtual museum, we could do little things to make it better.

We also made sure to ask if the participants felt any side effects from the VR headset. The participants' responses were more varied. None of the participants experienced headaches, but 8.3% experienced severe dizziness, 27.3% experienced slight eye strain, 8.4% experienced slight general discomfort, and 8.3% experienced moderate discomfort.
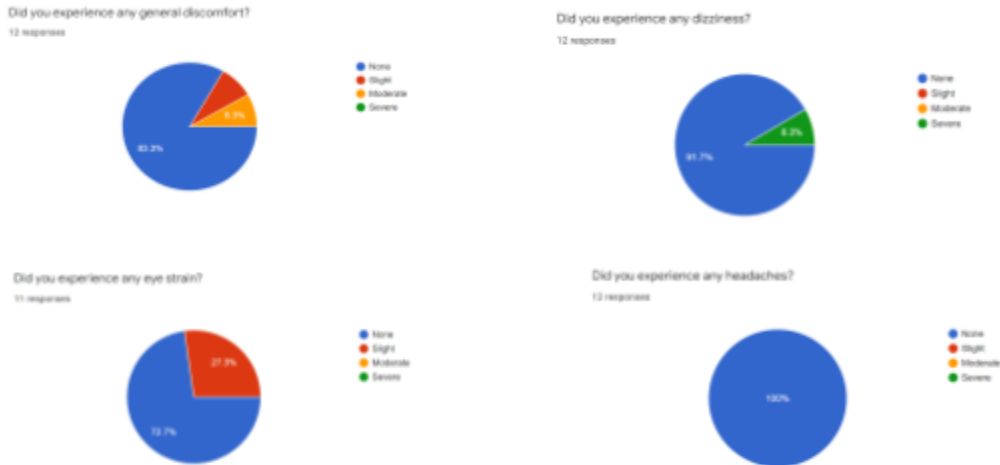
*Screenshots of Pie Charts Showcasing
Participants' Varying Degrees of
Physical Side Effects*

Although most of the participants enjoyed our virtual museum overall, some experienced varying levels of different kinds of physical discomfort. If we had not gone through the effort of IRB training, then we would not have known to inform the participants about the side effects.

Overall, our playtesting session at Alphafest was very informative. Although people liked our virtual museum, we had pointers on how to make it better. Because we took the time to go through the IRB training, our participants were safe enough to give their constructive feedback to us.

Post Mortem

Although we are proud of what we accomplished for this virtual museum, there are a number of things that went wrong in building this environment. For instance, we did not know what was a good number of 3D models to make for this listening space. The art pipeline stalled a bit because we could not figure out what else to add, so for a time, we thought that it would be better to simply focus on what we had already built. We thought that this was a good idea especially since we had decided to build one room instead of multiple rooms, in turn cutting out a lot of models that were already built. However, this left our room more empty than it should have been for the majority of the time that we have worked on it. We were able to fix this by adding the models that would have gone into other rooms, plus a few more to fill in more space. We added books, picture frames, alcoholic glasses, and other models to fill in the space. This helped solve the problem of empty space in the virtual museum, but we should have resolved this problem earlier in the project instead of dropping the 3D models for the other rooms. These models filled the virtual museum's space, giving it more of a narrative context.
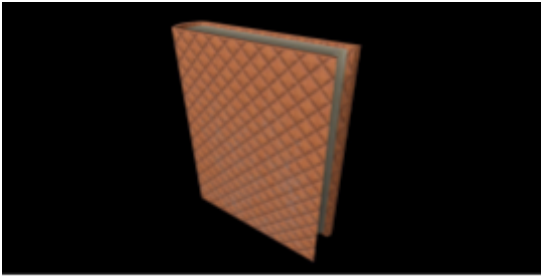
Rendered Image of Book

Rendered Image of Storage Box
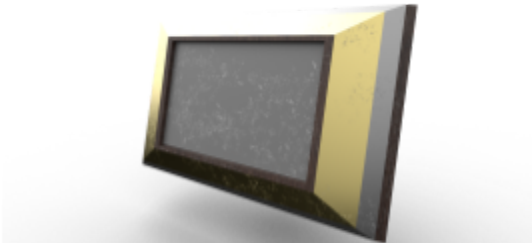
Rendered Image of Picture Frame

Another thing that went wrong in the project is that there were a lot of FBX files that had incorrect origins and missing portions when imported into Unreal Engine. The origin is the pivot point where the 3D model can rotate. We needed these origins to be on the part of the 3D model that would make contact with a supporting surface. We did not always check the origin before importing into Unreal Engine, making them more difficult to maneuver in-engine. As for the missing faces, sometimes adding and deleting faces in Blender made the 3D model look fine in Blender, but in other software, the model would have important sections that were missing. Because of this, we had to redo a lot of models so that they would look okay in Unreal Engine. This also slowed down the building process. Although we could eventually import the 3D

models that we wanted, we could have made this process a lot faster if we had always taken the extra steps to make sure that the models were how we wanted them to look.

Although a lot of things in this project went wrong, we still believe that it was a success. What went well for this project is that when we imported models correctly, the virtual museum looked really good. The texturing on the models and the lighting in the environment created the old-fashioned and abandoned mood that we were aiming for in this project. We accomplished this even as we added more models to the environment, making it look more like people used it in the past. Also, with the IRB's certification and approval, we could playtest our virtual museum at Alphafest and write about the feedback that we got in this paper. Because of this, we could get the feedback necessary for us to improve our virtual museum while making sure that we maintained the participants' well-being.

Because of the things that went wrong, there are a number of things that we would do differently. One main thing that should have been different is our team chemistry. We never took the chance to get to know each other and talk about each other's skill sets. We think that because of this, we never built the team chemistry that could have been necessary for us to feel comfortable communicating with each other and working on this project together instead of separately. One of us had direct access to the virtual museum while the other uploaded art assets to Google Drive. We think that as a result, there was an imbalance of work on the direct elements in the virtual museum that were separate from the 3D models. This made one of us uncomfortable reaching out for help or working in front of the other because it felt unfair compared to the workload that the other had to go through. This also led one of us to panic, trying to upload as many 3D models as possible, skipping steps that would have clarified whether the models looked like they were supposed to in Unreal Engine. We always felt like we had to overcompensate for the imbalance, which actually slowed down our processes further instead of speeding them up. Because we never took the time to build our chemistry as a team, we never resolved the work imbalance and communication issues until very late into the project. Because of this, we would take the time to build our team chemistry if we were to do anything differently for this project.

Conclusion

Our goal was to create a virtual environment for the Jazz History Database. Although there were mistakes in implementation and hesitations in writing this paper, the virtual museum was a success. We accomplished most of the goals that we set out to do. We imported artistic assets and music recordings and coded the

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