CARNEGIE MELLON UNIVERSITY

School of Architecture
College of Fine Arts

Thesis
Submitted in Partial Fulfillment of the requirements for the degree of

Master of Science in Computational Design

TITLE:

Evoking the Post-industrial Landscape Memories
through Mixed Reality Soundscape

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Evoking the Post-industrial Landscape Memories through Mixed Reality Soundscape

“Any landscape is a condition of the spirit” - Hendri Frederic Amiel

Abstract

Located at the intersections between the landscape, spectral memory, sound, and contemporary media technology, this thesis explores how spatialized soundscapes may serve as media to evoke the spectral memories of physical landscape? An audio walk “Inner Memory of the Post-Industry” was prepared to engage Carrie Furnace - a Pittsburgh historical landmark - as a proof of concept to understand the design of spatialized soundscape. Through the development of mixed reality audio walk, the experience design challenges the linear narrative structure that is commonly found in traditional audio walks (constrained, guided) and proposes a space- driven auditory wandering (open-ended, unguided). Mobile mixed reality is utilized to support sound localization and spatialization and this offers a more flexible and immersive way of exploring the landscape. The spectral memories of the landscape are realized through a virtual soundscape combing environment sound effects with oral history recordings. Taking advantage of the post-industrial landscape’s distinctive aesthetics and it’s spatial complexity as the stage for soundscape design, this thesis explores the juxtaposition between a multi-sensory visual and sonic experience and how it allows people to empathize with historical events to reinterpret the landscape identity. Building upon the proposed technical infrastructure for audio-based mixed reality, this thesis also introduces a workflow of visualizing and designing spatialized soundscapes.

KEYWORDS: Landscape, Audio walk, Soundscape, Audio-based Mixed Reality, Memory, Post-industrial landscape, Mobile Mixed Reality, Spectrality, Carrie Furnace

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Introduction

When studying landscape architecture, the post-industrial landscape is one of my favorite subjects for exploring and designing. Post-industrial landscape usually refers to unoperated and deserted industrial sites. They are often regarded as physical, environmental, and social hindrances, however, as witnesses of our society's industrial past, post-industrial landscapes carry numerous memories which are historically, culturally, and socially significant. The distinctive aesthetics and spatial complexity of the remnant structures on the post-industrial landscape provide great visual and bodily immersion for the visitors. While recognizing the importance of the physical presence for understanding the landscape, I also consider the great value of what is absent and unseen.

Concerned about the prioritization of being, French philosopher Jacques Derrida introduced the concept "spectrality".[1] Derived from Derrida's deconstructive method which describes the temporal and ontological disjunction in presence, spectrality raised a growing interest in cultural and historical geography for exploring the spatiotemporal relationship between the landscape and the spectral. Here, the value of landscape extends from what can be perceived temporarily to a haunted status where the past and future co-exist and interact. Thus, revealing what is known as haunting can provide people a more comprehensive way of understanding the landscape. Sound as a physically unconstrained form makes it the perfect medium for presenting such spectral memory.

As a medium, sound weaves together the multi-sensory sonic and visual experience in the historically and culturally unique spaces like post-industrial landscape. Peter Latz, chief designer of the Landschaftspark duisburg-nord, emphasizes the importance of keeping the existing structure while adding the new materiality to the site to catalyze the metamorphosis of the post-industrial landscape.[2] For Latz, such metamorphic design forms a dialogue between time and space which parallel with the relationship between sound and visual. Though Latz's design concept focuses on the importance of the physicality of the site, from the experiential perspective I regard site-specific sound design as a new materiality added to the landscape.

Curating site-specific soundtracks as a way of experience certain spaces is known as an audio walk. The practice of audio walk (tour) has a long history in the museum and cultural heritage for the purpose of education and exhibition enhancement. Ever since the Stedelijk Museum in Amsterdam started the first museum audio tour in the 50s, now almost all the museums around the world provide audio visiting experience in a shared

[1] Davis, Colin. "Hauntology, Spectres and Phantoms." French Studies 59, no. 3 (July 1, 2005): 373–79. https://doi.org/10.1093/fs/kni143.
[2] Braae, Ellen. Beauty Redeemed : Recycling Post-Industrial Landscapes Risskov: IKAROS Press, 2015.

nature.[3] Through story-telling, the audio tour is considered to give the visitors a deeper appreciation of the artwork with historical context and other educational information. Aside from being explored in the educational setting, the audio walk has also been experimented as a form of art. Janet Cardiff started her art practice in the form of audio walk from 1991. Working with her husband George Miller they conducted over 20 different audio walks in various settings like the forest and urban featuring the binaural recording, sound effects and Janet's voice. Christina Kubisch creates what she called as Electrical Walks in 2004. This public audio walk presents a special exploring and hearing experience of the aboveground and underground electromagnetic fields. There are also experimental theatre groups like Rimini Protokll and European Theatre Lab who create performances in the form of urban-scale audio tours.

From the examples above we can see that usually the audio walk provides two ways of experience and accessing information, one is user-centered and the other is narrative-centered. Neither of these well align with my ideal setting for experiencing landscape - a space-driven auditory wandering. Frauke Behrendt coined the taxonomy "place sound" as a way to describe the work of artists or designers curating the distribution of sounds in space by using GPS.[4] Such setting allows each audience to visit various locations and trigger different sounds into their own version of narratives. In Behrendt's model placing sound is discussed from a systemic level, but the individual presence of each sound element within the soundscape is still lack of exploration. In order to present the identity of spectral memory, the sounds is required to possess their individual data of location, form and size. In order to design a soundscape which also supports all these data I draw on mobile mixed reality.

Mixed reality (MR) allows the virtual and physical world to be blended together in real-time experience. Mobile mixed reality refers to the system of running MR applications on mobile devices like smartphone and tablet. Not only does this have the advantage of mobility, with the recent development of both hardware and software, mobile mixed reality also provides a more accessible platform for designers to develop their own MR experience.

[3] Fidel, Alexander. "Art Gets Unmasked in the Palm of Your Hand." The New York Times, December 1, 2010, sec. Arts. https://www.nytimes.com/2010/12/02/arts/02iht-rartsmart.html.
[4] Behrendt, Frauke. "Locative Media as Sonic Interaction Design: Walking through Placed Sounds". Accessed April 22, 2020. http://wi.mobilities.ca/category/2015-vol-9-no-2-locus-sonus/.

1.1 Research Question

Located at the interface between post-industrial landscape, spectral memory, sound and contemporary media technology, this research asks how can audio-based mixed reality enrich the landscape walking experience? More specifically,

a) how can a spatialized soundscape serve as a medium to evoke the spectral memories of the landscape;
b) how can virtual auditory elements and physical visual elements interplay when it comes to design an immersive landscape walking; and
c) how can audio-based mixed reality (open-ended, unguided) be integrated into the landscape walking experience to break the linear narrative structure (constrained, guided) that are commonly found in traditional audio?

To discuss the questions above I present “Inner Memory of the Post-Industry”, an audio-based mixed reality walk at Pittsburgh’s historical landmark - Carrie Furnace. This audio walk tells the stories about former worker’s life in the booming iron industry and artist’s creation in abundant ruins through the boom and bust cycles of Carrie Furnace by unfolding the memories of this deserted landscape. With oral history data collected from local NGO achieve and industrial sound effects from various online archives, the audio contents immerse people in the historical events. As an unguided experience, people can explore the landscape and encounter various stories as flexible and engaging as possible with the mobile mixed reality. Taking the advantage of such flexibility and spontaneity, the unique visual and spatial complexity of the post-industrial landscape can be fully appreciated.

1.2 Contribution

The contribution of this thesis includes:

- Conducting a spatiotemporal multi-sensory walk as a way to experience and learn the historical, cultural and social significance of the post-industrial landscapes. By evaluating this walk, the dimensions (content, context, experience) that resonate with audiences can be understood. Based on participants’ reaction to the walk, their understanding of the relationship between time-space can also be understood.
- Creating spatialized soundscape with the environment sound effects and human story-telling voice to evoke the spectral memories of landscape. By challenging the common way of presenting sound in audio walk, spatialized soundscape keeps the virtual presence of each sound and stimulates a new way of auditory

immersion for the audience. In other words, all the sounds not only contain the aural content they also feature the position (location, orientation) and form (shape, size) information for the audience to react with.

- Presenting the workflow of designing site-specific auditory experience on visual-based design platforms. This workflow visualized the identity of each individual sound and allows designers who have little experience working with audio editing platforms to create spatialized auditory experience.
- Working with the local NGO - Rivers of Steel to promote local public activities. Carrie furnace as one of the most important tourist hotspot and historical landmarks in Pittsburgh always seeks for different public activity ideas. This thesis provides an intriguing perspective for experiencing Carrie Furnace. Also, during the process of content collecting I help to digitize some analog archive materials for future storing and editing.

1.3 Thesis Structure

In this thesis, I first develop the theoretical background and framing for my research questions (chapter 2). This explores on the post-industrial landscape, the notion of spectral memory of landscapes, audio walks and mobile mixed reality. For the designing process of “Inner Memory of the Post-Industry” (chapter 3) I will introduce the pilot project of exploring audio-based experience, audio content collecting, technical system building, experience design, interaction design and finally the evaluation methods (on-site focus group discussion and take-home survey) for on-site experience. The result of experience evaluation (chapter 4) will be presented through the analysis of participants’ responses in focus group discussion and survey. Finally, the reflections (chapter 5) and future works (chapter 6) will be discussed.

Background

In this chapter I will introduce the theoretical and technical framework for this thesis from six sections, including the spectral memory of landscape, the post-industrial landscape, history of Carrie Furnace, various examples of audio walk, soundscape and mixed reality technology.

2.1 Spectral Memory of Landscape

Spectrality was first introduced by French philosopher Jacques Derrida in his book "Specters of Marx" in 1993. This concept is derived from Derrida's deconstructionism theory which he questions the certainty of being, and is used to describe the temporal and ontological disjunction in presence. Unlike the mundane word "ghostliness", "spectrality" has a scholarly attribute on it that elicits the etymological connection to visibility, and suggests its value in exploring the illuminating phenomenon rather than a simple returning of the deceased.[5] Derrida's publication of spectrality and hauntology is considered as the catalyst for the "spectral turn" in many academic fields.

Under the influence of spectral turn, there is a growing interest in cultural and historical geography for exploring the spatiotemporal relationship between the landscape and spectral. British cultural geographer John Wylie regards the place being shaped through haunting rather than dwelling.[6] Wylie sees the value of spectral in not only displacing the place and self through the medium of ghostly memories, but also displacing the present form itself.[7] What Wylie suggests is a space-time under the haunted setting which past, present and future co-exist, and interact. With spectral memories, we are able to experience the disjointed temporality of the place which also hints an unconventional perspective to understanding landscape.

Landscape is a ubiquitous word that it contains different meanings in various research and practice fields. Under the concept of spectrality, I regard landscape as a "cultural construct in which our sense of place and memories inhere".[8] Every landscape contains embedded stories happened there, and each of them tie the landscape(space) and time (history) together. More specifically, stories as ways to present the memories reflect the

[5] Blanco, María del Pilar, and Esther Peeren, eds. The Spectralities Reader: Ghosts and Haunting in Contemporary Cultural Theory. New York: Bloomsbury Academic, 2013.
[6] Wylie, John. "The Spectral Geographies of W.G. Sebald." Cultural Geographies 14, no. 2 (2007): 171-88. Accessed April 23, 2020. www.jstor.org/stable/44251139.
[7] Ibid.
[8] Ken Taylor, Cultural Landscapes and Asia: Reconciling International and Southeast Asian Regional Values, Landscape Research, 34:1, 7-31, DOI: 10.1080/01426390802387513

value and cultural codes in various political and social arrangements to the society, and reconstruct the meaning of landscape.[9]

2.2 Post-Industrial landscape

The interweaving concepts of landscape and memory forms a great discussion of the landscape identity which has great conceptual value for the design. As a spatiotemporal artifact which holds memories and unique identity, one of the most representative landscapes type is post-industrial landscape.

Figure 1. Bethlehem SteelStacks Arts + Cultural Campus

Post-industrial landscape usually refers to unoperated and deserted industrial sites. With successful design cases like the Landschaftspark duisburg-nord, Gas Works Park and the SteelStacks, there is a trend of transforming abandoned industrial site into the accessible public space with new functionality recently. Many scholars argue that this widespread phenomenon is not only a trend, it also suggests the greater value of the post-industrial landscape itself. British Landscape architect Wolfram Hoefer describes post-industrial landscape as an idealized nature and idealized industry under the changes of our society

[9] BODENHAMER, DAVID J., JOHN CORRIGAN, and TREVOR M. HARRIS, eds. Deep Maps and Spatial Narratives. Bloomington; Indianapolis: Indiana University Press, 2015.

towards a post-industrial situation.[10] Based on the transformation from the industrial situation to the post-industrial situation, Hoefer claims that the endangered condition of regional identity of the post-industrial landscape opens up the discussion of landscape as a unity of land and people.[11]

While Hoefer discusses the identity of post-industrial landscape through its transformation, there are other scholars provides different aspects. British Landscape architect Ellen Braae views the emergence of the post-industrial landscape as a new way of engaging the ongoing dialogue between the past, present and future of the landscape.[12] Canadian landscape architect Michael Hough states that the remnants of the site which inheriting the sense of industrial landscape can provide great evidence to their history.[13] The physical existence of the post-industrial landscape in a certain way provides great resources for us to understand the industrial past. British archeologist Andy Jones also suggests that through the physical endurance of the materiality, the landscape embodies the retentions from the past that speak to future actions and events.[14] American artist and architect Marc Treib points out that the ruins of industrial landscape not only provided the formal interest but also function as a vehicle to consider the passage of time and the entropy of nature.[15] As the blend of the relics of industrialism and the recovering nature, post-industrial landscape catalysts the conversation between space and time and provides an ideal stage for us to explore representation of the spectral memories.

2.3 Carrie Furnace

Most of the post-industrial landscapes around the world are removed and cleared as they often regarded as brownfields which cause physical, environmental and social hindrances. However, as great resource for us to understand the society's industrial past there are very few historically significant ones being preserved, and one of these sites is Carrie Furnace in Pittsburgh.

Pittsburgh was once known as "The Steel City". Back in times the steel industry in Pittsburgh produced more than 60% of the total production in the US. Carrie Blast Furnace was built in 1881 and it produced iron for the Homestead Steel Works from 1907 to 1978.[16] Carrie Furnaces 6 and 7 and their associated structures are located on a portion

[10] Hoefer, Wolfram. "Post-Industrial Landscape," 671–75, 1998. https://doi.org/10.1007/978-3-642-88583-9_131.
[11] Ibid.
[12] Braae, Ellen. 2015. Beauty Redeemed, Recycling Post-Industrial Landscapes. Berlin, Basel: Birkhäuser. https://www.degruyter.com/view/product/449757.
[13] Hough, Michael. Foreword, Manufactured Sites: Rethinking the Post-Industrial Landscape. London ; Spon Press.
[14] Jones, Andrew. Memory and Material Culture. Topics in Contemporary Archaeology. Cambridge: Cambridge University Press, 2007. doi:10.1017/CBO9780511619229. p 31.
[15] Marc Treib. Rust Red: The Landscape Park Duisburg-Nord Peter Latz, n.d. Accessed October 17, 2019. https://www.amazon.com/Rust-Red-Landscape-Park-Duisburg-Nord/dp/3777424277.
[16] "CARRIE FURNACE." Western Pennsylvania Brownfields Center, Accessed October 17, 2019. www.cmu.edu/steinbrenner/brownfields/Case%20Studies/pdf/Carrie%20Furnace%20Case%20Study.pdf.

of a 35-acre site along the north bank of the Monongahela River in Swissvale and Rankin boroughs. Carrie Furnaces 6 and 7 were built in 1906-1907 in order to expand the capacity of the existing Carrie Furnace Plant. During its peak production in the 1950s and 1960s, seven blast furnaces at the Carrie furnace each produced 1000 to 1250 tons of iron a day. [17] During the 71 years of operation, though changes were made to the blast furnaces, but they remained virtually unchanged after the modernization of structure in 1936. This outdated technology was one of the chief reasons that furnaces 6 and 7 were the first ones shut down when the complex began to shut down. It was also the reason that these were the furnaces chosen for preservation. In 2006, Carrie Furnaces 6 and 7 became a National Historic Landmark as part of the Rivers of Steel National Heritage Area and is now managed by the local NGO Rivers of Steel, name after the national heritage area.

Concerning the destruction of the shuttered mills will cause the loss of an important part of the local regional culture, Rivers of Steel was established in 1992 with a mission to tell the stories of the steel related industries and stories of men and women who worked there. Their mission is to "strengthens the economic and cultural fabric of western Pennsylvania by fostering dynamic initiatives and transformative experiences", so through out the years they have dedicated in promoting public programs which celebrates the history of steel industry.[18] For example, they established the oral history archive and gradually extended to the Rivers of Steel's archival, cultural conservation and exhibition programs.

Figure 2. Carrie Furnace

[17] Ibid.
[18] "Our Story." Rivers of Steel, https://riversofsteel.com/about/our-story/. Accessed April 20, 2020.

They also host various art and educational programs to help people explore the heritage through the lens of art and science. Last year, Rivers of Steel Arts presented a multimedia installation "Breaking Ground" by American documentary artist Valery Lyman. Photographs and audios from Lyman's documentary of the oil industry in Bakken region of North Dakota and the major American migration that went along with it are projected directly on the raw industrial surface and machinery.[19] Taking the advantage of the sharing nature of post-industrial landscape, this installation that have been showcased on various different places. Through the bold multimedia presentation, Lyman wants to unveil the rapid expansion and abandonment phenomenon in the industry boom and bust cycles in American history. [20] Thanks to the support of Rivers of Steel for all kinds of experimental art projects I'm able to explore a lot of precious materials in their archive collection and really maximum the potentials of various aspects in the thesis.

Figure 3. Projection Mapping on Industrial Structures from "Breaking Ground"

2.4 Audio Walks

While the landscape architecture approaches towards exploring the space-time in post-industrial landscape and celebrating the landscape memories are often through the physical intervention in re-designing the spatial functionality. Design elements that fulfill the present public activities are added to the landscape in order to bring people to the

[19] "BREAKING GROUND." Rivers of Steel, https://riversofsteel.com/experiences/exhibitions/breaking-ground/.
[20] "Breaking Ground Exhibit Home: North Dakota: Valery Lyman." Breakingground, www.breakinggroundexhibit.com/.

energize the space. However, in such approach people's experience and understanding of post-industrial landscape stays on aesthetic and visual layer, which left the true rich historical information layer hidden.

In order to reveal this layer and present it in a way of experiencing the spectral memory of the landscape I explore the sound and audio walk. Sound as a physically unconstrained and invisible medium, is perfect for presenting such spectral presence in a form of absence. Curating site-specific sound tracks as a way of experience certain spaces is known as audio walk. The practice of audio walk (tour) has a long history in the museum and historical heritage for the purpose of education and exhibition enhancement. Ever since the Stedelijk Museum in Amsterdam started the first museum audio guide in the 50s, now almost all the museums around the world provide audio visiting experience in a shared nature.[21] Usually in the audio walk/tour the visitor will be provided with a handheld device through which a series of pre-recorded soundtracks introducing the background, context, and information for certain things being viewed will be played. Through story-telling, the audio tour is considered to give the visitors a deeper appreciation of the viewed things through a more enriched historical and educational information.

One of the most famous audio tour experiences designed in the historical heritage is at Alcatraz Island Prison. In 1987 artist Chris Hardman from the local non-profit theater company Antenna Theater created an immersive walking tour of the Alcatraz Cellhouse. It was made entirely by interviewing former inmates of the prison, along with guards who patrolled of the island and kids who grew up in the shadow of America's most infamous prison.[22] Visitors will hear the stories of prisons telling their prison life and evocative ambient sounds while they walk through different cells of the prison. The Alcatraz tour greatly enhances the visitor's physical and sensory engagement with the island space and make it one most popular tourist attractions in san Francisco.

Other than being practiced in educational and entertainment setting, Audio walk is also experimented as a form of art. One of the most famous artists who practice audio walk is Janet Cardiff. Starting from 1991, Janet and her husband George Miller conducted over 20 different audio walks in various settings like the forest and urban featuring the binaural recording, sound effects and Janet's voice. The binaural recording creates a three-dimensional picture, so when listener listening with headphones, it is a three-dimensional experience. She thinks the walk as an act of contemplation that when walking with the 3D auditory experience the listener started adding their whole memory back to the actual piece.

[21] Fidel, Alexander. "Art Gets Unmasked in the Palm of Your Hand." The New York Times, December 1, 2010, sec. Arts. https://www.nytimes.com/2010/12/02/arts/02iht-rartsmart.html.
[22] "Alcatraz Tours." Antenna Theater, www.antenna-theater.org/alcatraz-tours.html.

Jena Walk (Memory Field 2004) is the last audio walk Janet and George did. In this walk the visitors were taken to a pastrol landscape and auditorily experience a battle between the Prussians and Napolean which took place 200 years ago.[23] The script for this walk comes from excerpts of Louise Seidler (German Painter)'s diary and the background environment is filled with battle scene sound effects like cannons, muskets and horse galloping by.[24] By mixing sound elements from various time period and events, the listeners will notice the time slips as they walk, and as they aware that the landscape they step on is the same space that others have walked in the past they also weave themselves into the story for the future.

Figure 4 Janet Cardiff Audio Walk

Janet describes the way of how she designs the audio walk as creating foley sound which means creating the environmental sound for a film and the most important thing is to put sound exactly on the spot. That's to say listening the sound in the proper location, the listener will have the experience syncing up and this moment is when a new world is created through the combination of the recorded space and the physical space. The possibility of stimulating such new world is what Janet most interest about. Texture (materiality) is another thing Janet thinks important in creating the audio walk because it will largely influence people's bodily experience in the space, so when designing the walks, the spatial feeling and the texture of the space was vital.

[23] "Jena Walk (Memory Field)." 2006, www.cardiffmiller.com/artworks/walks/jena.html.
[24] Ibid.

Janet also views technology as a great inspiration for her works. Working as a visual artist invisibly, she says she has to writes the script and plan out all the sounds cues on paper and mix sound through reel-to-reel at first, then gradually the digital platform enables her to combine more sound tracks into the walk.[25] The development of technology not only influence how she creates her work but also release the limitation in her previous work and stimulate her to explore other things.

2.5 "Place Sound" and Soundscape

From the examples of audio walk we can see that they two ways of experience and accessing information, one is user-centered (like in the museum) and the other is narrative-centered (like in scripted performance). In the user-centered experience the visitors have the control over the content they listen to, while in the narrative-centered experience the narrative content has the control over the visitors' movement. User-center audio walk requires too much effort from the audience to control the device for content selection which largely distract them from the continuity of the experience, and narrative-centered audio walk limits the flexibility of the audience to explore. Neither of these well align with my ideal setting for experiencing landscape - a space-driven auditory wandering.

In order to design such audio-based landscape wandering experience to enliven the spectral memory, there are challenges from the content design, experience design and technical implementation aspects. The first challenge comes to break the common structure of the narrative content in audio walk. Guided audio walks usually have a linear narrative structure, but true experience of memories is scattered and fragmented. Also, the narrator of the audio walk generally is not someone who has the direct connection to the landscape. Oral history collection provides an ideal way of collecting and presenting the stories with unique vocal quality, and fulfills the need for a more connected content design. The second challenge is to create a system that allows a spatialized way of hearing the sound.

The traditional method of creating audio walk focus more on the content design which leave the form of experience stay unchanged. Even though artists like Janet Cardiff who continuously explores the new form of audio walk experience, however the experience is still constrained in a linear form due to the technical limits back then and not even mention to design a more complex multi-pointed experience in the larger scale. Thus, to create a system which allows a situated way of locating, designing and experiencing the

[25] Cardiff, Janet, "An Overview of Installations and Walks". Harvard GSD Open House Lecture. Accessed January 10, 2020. https://www.youtube.com/watch?v=MW_NOKFwywM

sound is still challenging. With the recent development in locative media, creators are empowered to apply digital media to the real places and triggers the real interactions with mobile device. British digital media researcher Frauke Behrendt coined the taxonomy "place sound" as the way to describe the work of artists or designers curating the distribution of sounds in space by using GPS or Networks.[26] Under this setting, interactive sounds will be placed at particular geographical locations for people to explore. She explained that the key part of "place sound" is the physical presence of audience as the sound will only be triggered in the specific geo-location. Such setting allows each audience to create their own remix of a "place sound" experience by walking through different trajectories.

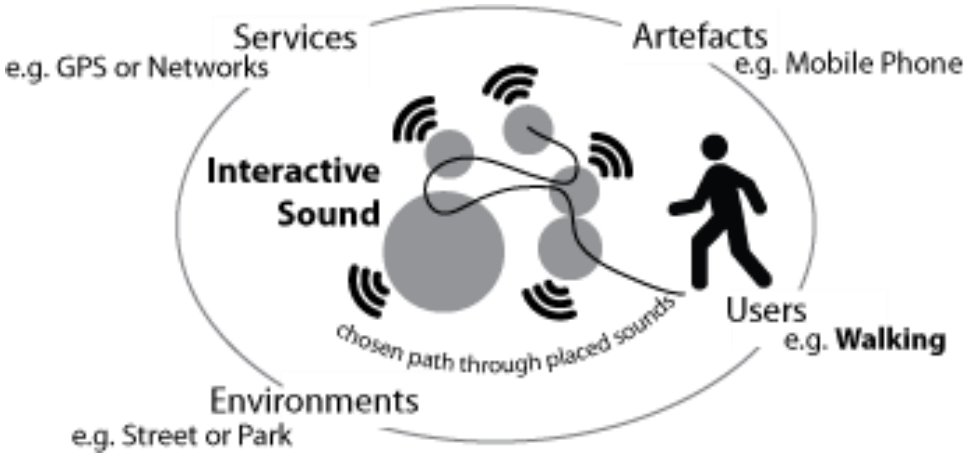


Figure 5. Frauke Behrendt "Place Sound"

Although Behrendt's model discusses linking sound with specific geo-location from a systemic level, I am also interested in the individual presence of each sound element as it is important for claiming the identity to spectral memory. In another words, rather than allow audiences to remix various sounds by visiting the marked locations, I want to create a spatialized soundscape which is parallel to the landscape, for the audience to enter and wander inside. According to Canadian composer and environmentalist Maury Shaffer, soundscape offers a way of describing the relationship between sound and place. The studies of soundscape concern the relationship between man/woman and the sounds of his/her environment and what happens when those sounds change.[27] As an alluring

[26] Behrendt, Frauke. "Locative Media as Sonic Interaction Design: Walking through Placed Sounds". Accessed April 22, 2020. http://wi.mobilities.ca/frauke-behrendt-locative-media-as-sonic-interaction-design-walking-through-placed-sounds/.
[27] Schafer, R. Murray. "The soundscape: our sonic environment and the tuning of the world."

landscape, soundscape evokes the sonic counterpart of a landscape.[28] Each sound element inside the soundscape has its own identity and form just like the physical objects we can find in the landscape. Thus, to design a site-specific soundscape that holds presence for each spectral memory it is vital for all sounds to possess their individual data of location, form and size which helps align them with the physical landscape. In order to allow me design such a soundscape to supports all these data in the audio walk I draw on mobile mixed reality.

2.6 Mobile Mixed Reality

Mixed reality (MR) aims to blend the real and virtual environment and let them coexist and interact in real-time experience.[29] Rather than an alternative to augmented reality (AR) or virtual reality (VR), MR offers a distinctive perspective that emphasizes the enrichment of human's perception on both real and virtual environments. Flexibility, immersion, interaction, coexistence and enhancement are the key aspects of a MR experience. [30]

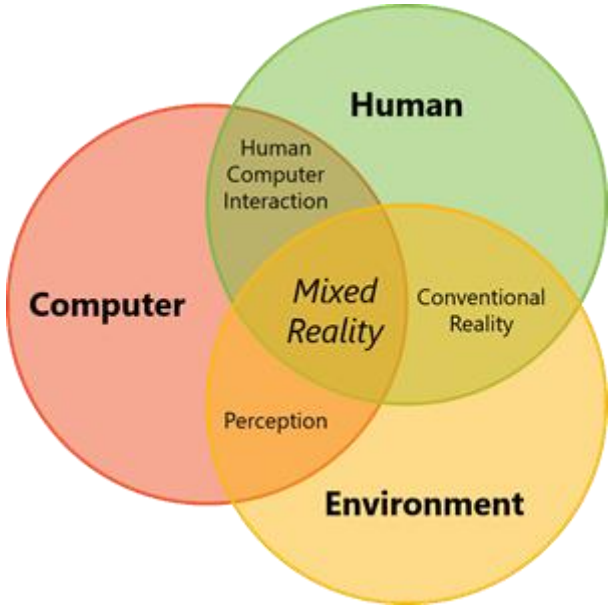


Figure 6 Mixed Reality Diagram Microsoft

[28] Kelman, Ari. (2010). Rethinking the Soundscape: A Critical Genealogy of a Key Term in Sound Studies. The Senses and Society. 5. 212-234. 10.2752/174589210X12668381452845.
[29] Bekele, Mafkereseb Kassahun, Roberto Pierdicca, Emanuele Frontoni, Eva Savina Malinverni and James Gain. "A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage." JOCCH 11 (2018): 7:1-7:36.
[30] Ibid.

The diagram shows the three essential components of this technology. We can thus see that the association between the man/machine interactions, the computer perception of the environment and the so-called "conventional" reality together form the mixed reality. [31] Under this paradigm, user environment must be processed and interpreted in real time, and user must be able to interact with both virtual and physical environment as natural as possible without any mediate, the virtual object also need to be registered in space and time and can be placed according to the user position, the environment, or any other objects.[32] With the recent development of both hardware and software, MR experience can be run on mobile device like smartphone and tablets. This technology not only has the advantage of mobility but also provides an accessible platform for designers and artists to develop their own MR experience.

To set up a mixed reality system the essential parts are[33]:

- Tracking and registration
- Virtual environment modeling
- Computers, display, and devices for input and tracking
- Interaction interfaces

From the MR related technology and projects nowadays, we can see a strong visual-oriented tendency as the majority of them are designed to be screen-based experience. Spectral Memory and soundscape are what people experience passively and invisibly, but most of the MR experience relies heavily on the visual-based interaction and registration process to actively triggers the experience. Already we see the contrast in here, so in this thesis I propose to reduce the self-determined process by limiting the virtual component on screen and use non-visual-based registration process to trigger interaction.

[31] Parveau, Marc, and Mehdi Adda. "3iVClass: A New Classification Method for Virtual, Augmented and Mixed Realities." In Procedia Computer Science, Vol. 141, 2018. https://doi.org/10.1016/j.procs.2018.10.180.
[32] Ibid.
[33] Bekele, Mafkereseb Kassahun, Roberto Pierdicca, Emanuele Frontoni, Eva Savina Malinverni and James Gain. "A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage." JOCCH 11 (2018): 7:1-7:36.

Methods

In this chapter I discuss the development of “Inner Memory of Post Industry”, the spatiotemporal mixed reality walk, from four aspects: Site Condition, Content Collecting, System Building, and Experience design. In order to place this in context, I first introduce a pilot project that sugguests some shared commons with it in terms of the exploration of spatialization setting of sounds in virtual environment and auditory modality for presenting the spectral memory.

3.1 Pilot Project: “But All the Liveliness Belongs to Them, I Have Nothing” [34]

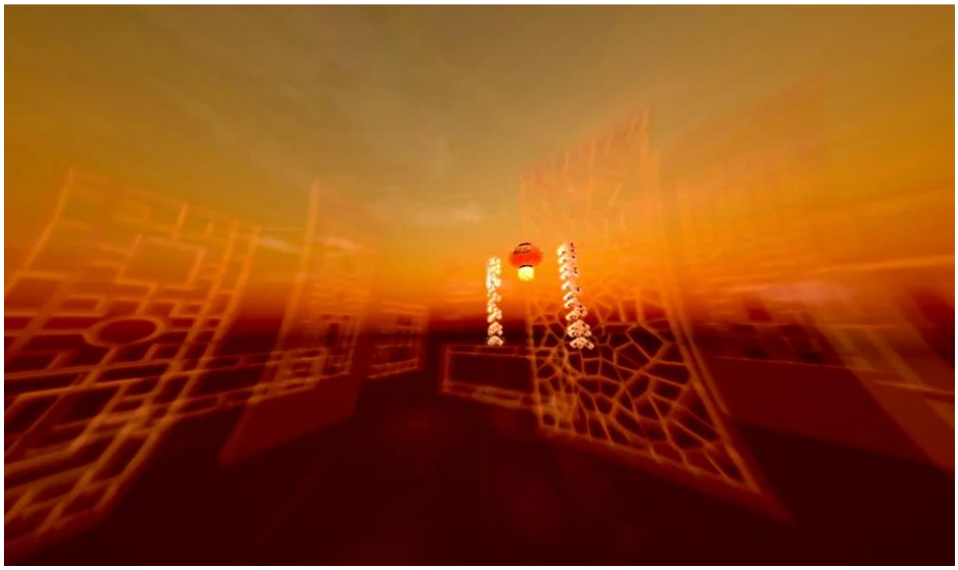


Figure 7 Game Scene: But All the Liveliness Belongs to Them, I Have Nothing

This audio-based immersive experience explores the juxtaposition of nostalgia and melancholy by exploring the vagueness of one’s past memories. Usually, if we try to access deeply rooted memories in the past, we might not be able to recall the entire story but only fragments of it. When chasing the invisible memory, we often get lost in the feeling of emptiness. When entering this virtual space, the participant will be able to vaguely hear the fragment of the sounds related to the Spring Festival. All the sound clips are invisible but moving, thus the participant needs to find the way to follow the movement of the sound in order to hear the entire clip. By encountering and following different audio clips, the participants automatically create their own unique experience in the memory space of Spring Festival. As the participant approaches the middle of the set where the lantern and firecrackers are located, the loud boom noise and extreme visual

[34] Video documentation of the project can be found here: https://www.yixiao-fu.com/i-have-nothing

effect will flush out the other environment, metaphoring the experience when one tries too hard to recall something, the details often oddly get lost.

This project served an initial experiment towards the final platform. It allowed me to test the audio-oriented experience design and the auditory representation of memory. Before this project I have explored the visual-based immersive experience for a long time, but this project opened up my curiosity to explore the sonic experience as sound has so much potential. The unconstrained form of sound releasing it from the physical form which provides great opportunity to experiment on creating a new relationship between the virtual soundscape and the physical landscape.

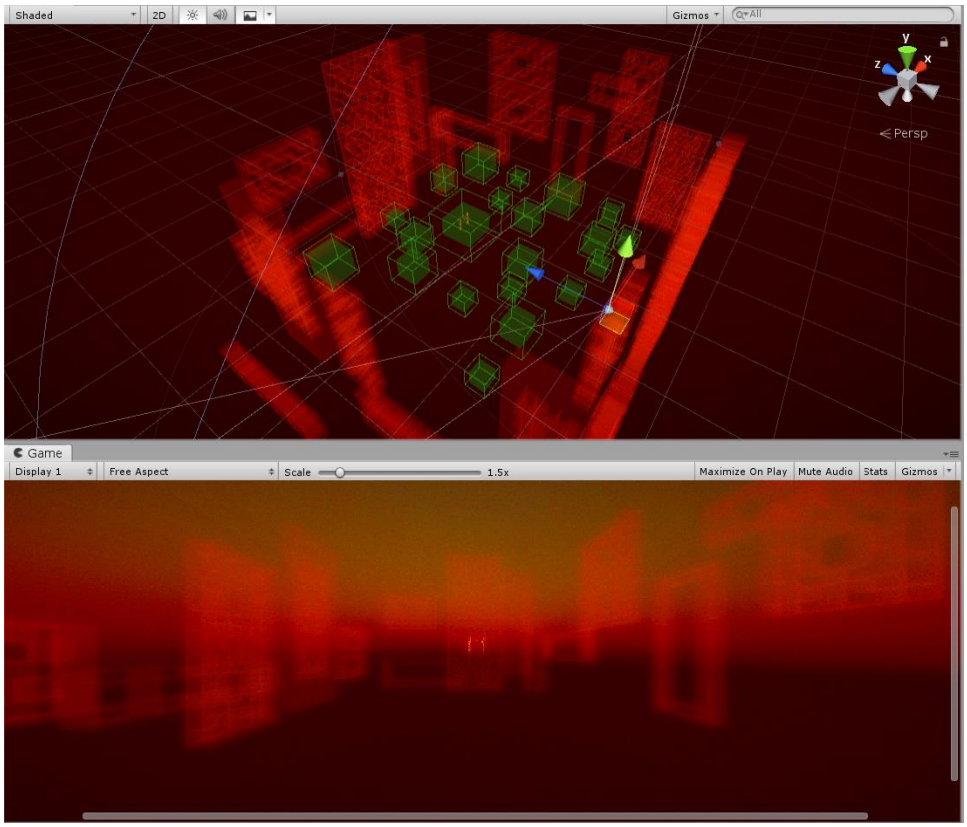


Figure 8 Unity Development: But All the Liveliness Belongs to Them, I Have Nothing

In this project I experiment various types of sound object's agency (movement, interaction, performance) and their relation with the player's virtual avatar. The environment design for this project was in a highly abstract while dreamy way that emphasizes the atmosphere of vague memory. All the sound clips used in this project are closely targeted into specific activities that happened during the spring festival. With unique content, each sound clip becomes the representation of the cultural memory. Thus, by encountering various sound objects and recognizing the sound pattern in each clip the

player's personal memory will be evoked while at the same time building up a personal and emotional connection with the narrative chained by all sound objects. However, as this project has a very specific theme, the legibility of all the sound patterns heavily depends on the player's cultural background and personal experience with the spring festival. Thus, in this thesis I choose a more generalized way to approach the soundscape design. Instead of using sound to evoke personal memory, in this thesis the sounds represent the memory itself. More specifically each individual sound object holds its identity as part of somebody's memory.

3.2 Carrie Furnace Site Condition

Figure 9. Carrie Furnace Structure Map

In this section I will discuss the basic site condition of Carrie Furnace. To design and curate a site-specific experience requires great understatement of materiality, physicality and most importantly the spatiality of the site. The area of the site that I utilized to design the audio walk experience is around 11 acre which will take around 15 min -30 min for a pure walking experience depending on the walking speed. From the image below we can see that the site is at the bottom of the valley. It is isolated from the adjacent community by the railroad on the north side and the river on the south side.

There are fifteen major structure/areas of the Carrie Furnace (see Figure 8), and the main audio walk experience will take place near area 1 to 11 which are "Entrance Plaza", "Stationary Car Dumper", "Ore Yard", "Ore Bridge", "Stocking Trestle, Stocking House", "Carrie No.6 Hoist House", "Carrie Furnace No.6", "Carrie Furnace No.7", "Hot

Blast Plant Draft Stack", and "Gas Washing System". Other than the major industrial structures, there are also art works like Carrie Deer and graffiti walls, which will be introduced detailly in section 3.2.3.

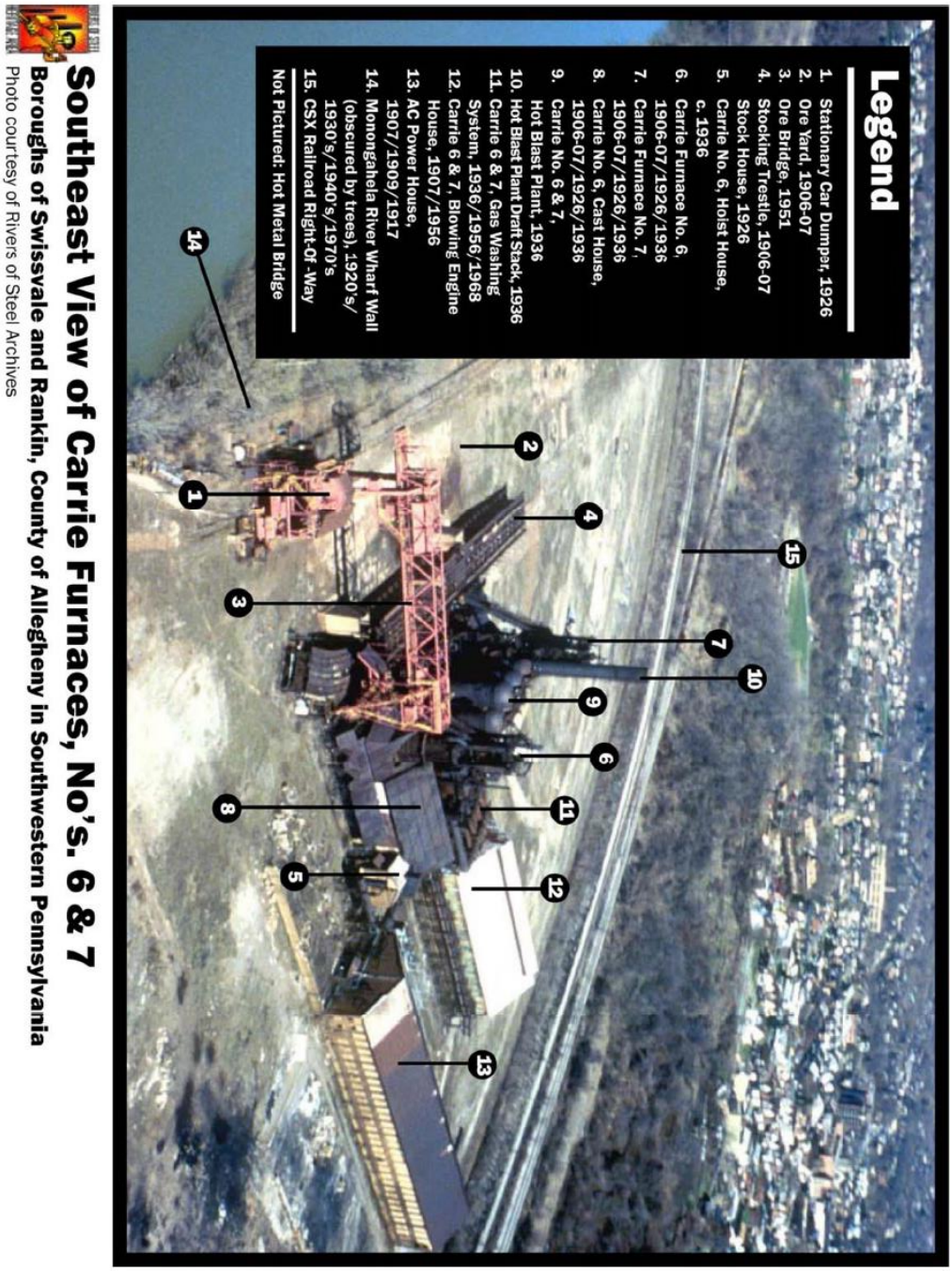


Figure 10. Carrie Furnace Structure Map

Entrance Plaza

The entrance plaza is located between the blowing engine house and AC powerhouse of Carrie Furnace. There is no special function claimed for this area when the furnace was operating, however as the main plaza it is utilized for various events at Carrie Furnace nowadays. For example, the Festival of Combustion and iron casting workshops. On entering from this plaza, visitors can choose various paths to explore the site.

Figure 11. Entrance Plaza View Towards Iron Cast House

Stationary Car Dumper

This stationary car dumper was installed during the modernization in 1925-1926 (see Figure 12,13). Located at the southeastern edge of the ore yard, this large steel-frame structure is approximately 50 feet wide, 60 feet long, and 60 feet high. Stationary car dumper serves to overturn the incoming railcars and transport their content (ore and limestone) into the receiving bin which equipped with an automatic discharge chute. This car dumper may be the oldest still exist in the United States. Other than the main steel structure, this area also features a 1940s-era electric trolley transfer car which is located on the south side of the dumper trestle adjacent to the end of the remaining railroad, and an ore transport cat which is located on the ground near the lower trestle of the stationary car dumper. Since Carrie Furnace was preserved as a historical landmark, this is one of the few remaining structures accessible for visitors to ascend.

Figure 13. Stationary Car Dumper

Figure 12. Ore transfer Car and rail car

Figure 14. Ore Yard view from southeastern end

Figure 15. Ore Yard Graffiti Wall

Ore Yard [35]

The ore yard is a large rectangular pit between the river and the furnaces (see Figure 14, 15). It extends along the northwest-southeastern axis of the whole site and is approximately 135 feet wide, 580 feet long and 25 feet deep. The south wall of the ore

[35] Panoramic view: https://www.google.com/maps/@40.4141248,-79.8886201,3a,75y,133.55h,106.29t/data=!3m8!1e1!3m6!1sAF1QipO1NZzB9lI-Z-9x7Ass1pe4nxcFiNmdxeT569s-!2e10!3e11!6shttps:%2F%2Flh5.googleusercontent.com%2Fp%2FAF1QipO1NZzB9lI-Z-9x7Ass1pe4nxcFiNmdxeT569s-%3Dw203-h100-k-no-pi-20-ya74.000015-ro-0-fo100!7i9728!8i4864

yard near the river was covered by graffiti created by various artists during the abandoned period. This area served as the Storage area for the ore and limestone received from the transfer cars before moved to the blast furnace. With its large capacity, this ore yard was able to stock all the raw materials used at Carrie 6 and 7 blast furnaces during the winter when shipping closed. This yard is the only remaining feature from the original construction (1906-1907) of the furnace.

Figure 16. Ore Bridge

Ore Bridge

This crane (see Figure 16) is a 186 feet long truss, spans 100 feet above the ore yard between the stationary car dumper and the stocking house. It was built in 1951 to replace the two smaller ore bridges from the original construction. The ore bridge functions to load and unload ore at the stockpiles. The operation of the ore bridge was critical to iron production as it served as the link to transfer materials and would directly influence the overall efficiency of the blast furnace.

Stocking house

This tunnel-like structure was originally built in 1906 and modernized in 1925-1926. It is 38 feet wide and 550 feet long (see Figure 18). Both the northern and southern walls are concrete. The eastern and western ends are open to facilitate the movement of scale cars inside the stock house. There is a system of suspended raw material bins on the top of the stock house and they can hold enough materials to support the running of furnace 6 and 7

in case the breakdown from the flow of ore bridge. Underneath the suspended bins was a line of scale cars on the rail which no longer there today. Scale cars continuously loaded the raw materials mixture and transfer them into the skip car which will then take everything up to the blast furnace for burning. Due to the nature of loading material by hand and the semi-hermetic environment, the stock house was considered to be one of the worse working station. Now the visitors can only access half of the stock house till the first skip pit of blast furnace No.7.

Figure 18. Inside Stocking house

Figure 17. Carrie No.7 (left most), Carrie No.6 (right most), Hot Blast Plant (middle)

Carrie Furnace No.6 and 7

Parallel to the ore yard, Carrie No.6 and 7 are positioned on a northwest-southeast axis and are 257 feet apart from each other (see Figure 17). They are cupola-style blast furnaces build in 1936 and are 92 feet high with 23 feet diameter hearths. Near the raised working platform for the blast furnace, there are seventeen tuyers (nozzle through which the air is blow into the hearth of the blast furnace) equally space around the circumference of the hearth. Inside the iron cast house of each furnace, there is a raised working platform adjacent to blast furnace with two slag notches where the melted iron was coming out. Each of them produced roughly 1000 tons of iron a day. The areas near the blast furnace are extremely hot so workers in the cast house need special protection while working there.

Figure 19. Carrie No.6 Iron Cast House

Carrie Furnace No.6 Cast house [36]

The cast house of Carrie No. 6 is preserved and can be viewed from the entrance place (see Figure 19). It is 60 feet tall, 175 feet long and 60 feet wide. The concrete floor of the cast house is one floor above the ground to where near the outside circumference of the blast furnace hearth. The system of iron and slag runner was built into the concrete floor for iron and slag to flow out from the furnace. Visitors can access the space and walk closely to see the detailed structure of the blast furnace and the iron casting station.

Hot Blast Plant

Built in 1936 the hot blast plant of Carrie No.6 and 7 consists of eight stoves arranged in two rows between the two furnaces. Each of them is 104 feet high and 24 feet wide. The gas and air were burnt at the bottom of the stove and then rose through the combustion chamber to become heat stored in the checker brick. The stoves were able to generate blast temperature of 1100 degrees Fahrenheit. The heat then passed to the blast furnace through the blowing engine into the pipe which surrounds the outside circumference of the blast furnace hearth. Visitors can enter the hot blast plant through the platform between Carrie No.6 and 7. This platform also connects to the workers' locker room and engine control room.

Figure 20. Inside Hot Blast Plant

[36] Panoramic view: https://www.google.com/maps/@40.4130766,-79.8894793,3a,75y,100t/data=!3m8!1e1!3m6!1sAF1QipMvE7OVjdU2OkhvqolE7CE1Tjq8bKoiLfow6Lbq!2e10!3e11!6shttps:%2F%2Flh5.googleusercontent.com%2Fp%2FAF1QipMvE7OVjdU2OkhvqolE7CE1Tjq8bKoiLfow6Lbq%3Dw203-h100-k-no-pi-10-ya149-ro-0-fo100!7i8704!8i4352

Carrie Deer [37]

Carrie Deer, one of the largest sculpture artworks at Carrie Furnace, is stands against gas washing system which near Carrie No.7. It was created by a group of young artists known as the Industrial Arts Cooperative in 1997. Made completely from the abandoned materials on site, this 40’ high sculpture took around 12 months for the artists to finish. Now it the serves not only as the visiting hotspot but also the industrial salvage artwork that marks and witness the whole post-industrial period of the landscape it stands.

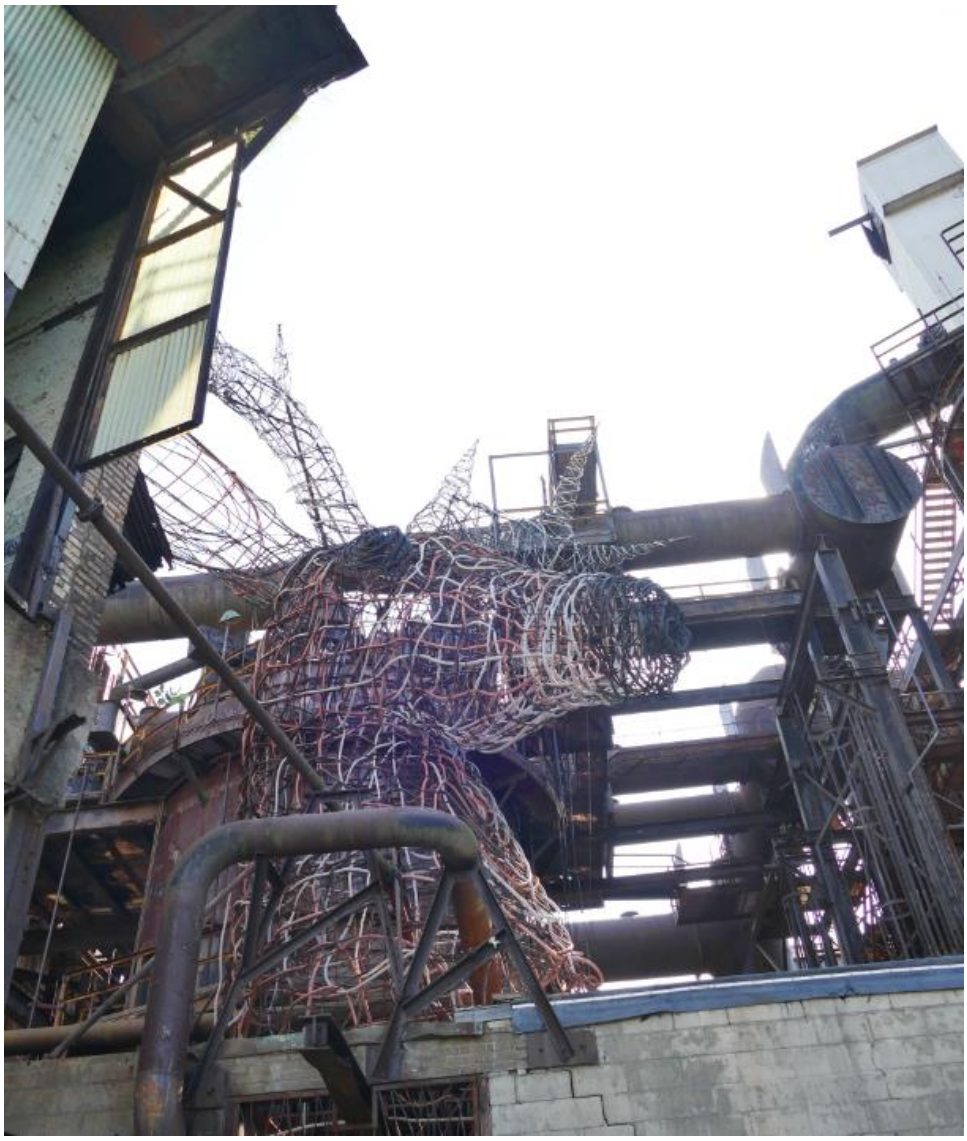


Figure 21 Carrie Deer

[37] Panoramic view: https://www.google.com/maps/@40.4136416,-79.8902552,3a,75y,30.26h,121.83t/data=!3m8!1e1!3m6!1sAF1QipNXkEMHYYyYiZkPQZ5Mowu1xedcrQmC9fOSsy2k!2e10!3e11!6shttps:%2F%2Flh5.googleusercontent.com%2Fp%2FAF1QipNXkEMHYYyYiZkPQZ5Mowu1xedcrQmC9fOSsy2k%3Dw203-h100-k-no-pi-0-ya355.4133-ro-0-fo100!7i8704!8i4352

3.3 Audio Content Collecting

In order to prepare this site-specific work, audio content about the history and impact of Carrie Furnace was prepared. Raw audio materials of the environmental sound and oral history (interview) are collected from various resources including the BBC sound effects, United State Steel Corporation steel making sound collection, Rivers of Steel oral history archive, open-source documentary from the Internet Archive (https://archive.org/) and Creative Commons Licensed sounds from Freesound (https://freesound.org/).

3.3.1 Environment Sound Effects Sources

I collected two primary sources of environmental sound effects:

BBC sound effects

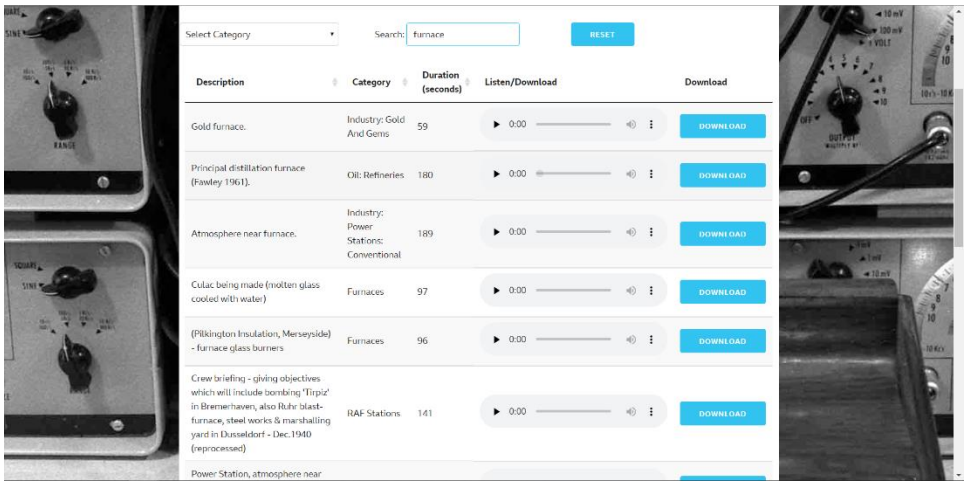


Figure 22 BBC sound effects web database

Starting from 2018, sixteen thousand of BBC Sound Effects are open sourced by the BBC in WAV format online for downloading under the terms of the RemArc Licence (used for personal, educational or research purposes). The database is created in great detail so that all the sound effects can be searched in specific categories and descriptions. Sound effects I gathered from this database include the atmosphere sound near furnace

United States Steel Corporation: The Sounds of Steelmaking collection [38]

The sources file of this collection of the sound effects are provided by the Rivers of Steel. Sound effects in this collection include the recording of blast furnace, forging press, hot saw, plate mill, scrap dumped into a furnace and others. These sound effects provide great detailed sound of specific steel making processes.

3.3.2 Oral history sources

I also included first person testimony to supplement environmental sounds. There are two main oral history collections that I leveraged in this project. The first, the Rivers of Steel historical archives, consists of the interviews with different ironworkers who used to work at the Carrie Furnace and Homestead. The second, the Carrie Deer Documentary, consists of the interview with the artists who created the graffiti and sculpture on site during the post-industrial period.

Rivers of Steel Archives:

The first collection is part of a Rivers of Steel project which was initiated in 2003 with a PHMC grant - Collection and Archiving of Steelworkers Oral Histories.[39] The

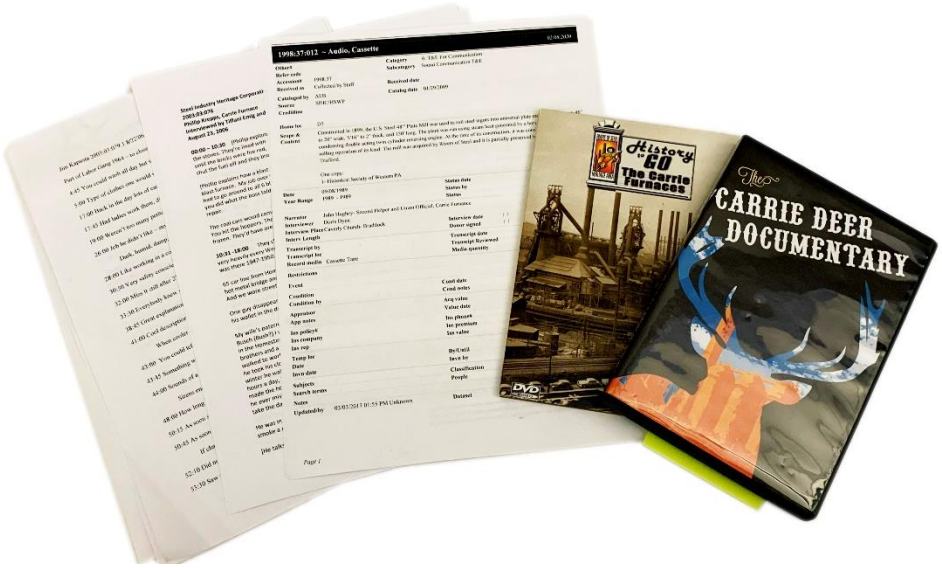


Figure 23 Documentaries and Oral History Archive Data

[38] This collection of steelmaking sounds was provided by the Rivers of Stele in the MP3 format. According to the information online, this collection was published by the United States Steel Corporation. https://www.discogs.com/Unknown-Artist-One-Billion-Dollars-In-Progress/release/6816921

[39] Information provided by Mr. Ron Baraff, Rivers of Steel Director of Historic Resources & Facilities, in the inquiry email.

interviewees ranged from across all facets of the industry within the Heritage Area. Rivers of Steel Cooperation (RSHC) is a designated Regional Folklife Center which is dedicated to conserving the cultural traditions as part of the industrial history of the steel heritage area .[40] Currently, the collection of oral histories in the archive have been published in written and electronic forms including podcasts.

Figure 24 Digitizing Oral History Archive

As the length of each interview in the oral history is around 1 hour, it is very hard for me to listen through all the interviews and digitize them for later editing. Thus, after reading through the profile of interviewees I chose three of them for further research and editing. The 2003 interview collection is all recorded on the mini disc and the 1998 collection is recorded on tape. Thus, transforming them into the digital form is one vital step for including all the content in the digital experience design. Image showed the trans-recording process of Johan Hughey's interview on the tape from 1992.

Jim Kapusta 2003:03:079, Carrie 1964 – closing [41]

[40] Myers, Mary Anne, Abiola Ogunbiyi, Karen Fortuna, Johanna Dubsky, and Andrea Solarz. "Rivers of Steel National Heritage Area Evaluation Findings," n.d., 188.
[41] Minidisc recording of Interview regarding James Kapusta's work at the Carrie Furnaces from 1964-close, James Kapusta - Carrie Furnaces, 08/22/2006 , 2003:03:079.1, Steelworker Oral History Project, Rivers of Steel, Pittsburgh.

Jim Kapusta worked on the Carrie Furnace Labor Gang from 1964 to its close. He has worked on the Blast Furnaces as first or second helper prepping and cleaning runners as well as changing the cooler. He has also worked with the Maintenance department on the Ore-Bridge change the cables and wheels on Larry cars. Rather than focusing on the chronological history of Carrie Furnace, Kapusta's interview gives more social aspects towards Carrie and his personal working life. In the interview he talks about his experience of working at various positions, safety related rules, working with women in the furnace, bidding for jobs, closing of the furnace, unemployment and life after the mill closed. In the interview, Kapusta said that working at the Labor Gang gave him the opportunity to move around and do a lot of different jobs, and among all the jobs he enjoyed being a crane man that most and larry man the least. In addition to all kinds of different jobs he worked, he also made a lot of friends. Kapusta thinks that what is most special while working at Carrie Furnace is people as he could go anywhere in town to visit people he knew.

Jim Kapusta Clip Examples:

"... In the Furnace, you have your green suit, usually with black long johns even when it is summer time. And your hoods and helmets while there was casting. And, that was a unique job. I mean ... not many people saw molten iron and sinders coming out. And working around it, you have to be very careful where you walk. And, we had to wear protective clothing for that. You have to wear your pants and your jacket. You didn't have to wear long johns if you didn't want to but if you're smart you would. It helps to insulate you from the heat and keep you ... um ... really like it kept you a little cooler I would say, but it mainly kept the heat out of you. The jacket and hoods and gloves, when you went to work..."

"... It was just a challenging job to ... you ... you couldn't make a mistake. You have to be on alert all the time. If you bump the leaver, hit a wrong lever or wasn't watching your signal somebody could get injured. Ok, then they had a ground man that would give you signals of up down left and right. You just sat there and watched them ... um ... and you didn't make a move until he told you to move. And, you know left and right you just pointed there and down we would went like that, and that's about it. You just followed the signals. Usually went slow, uh , sometime they just tell you do like this if you really want to go really slow. Different people have different signals, you just had to interpret it, hahaha, with what they want, hahaha. It was a job that when you got to work you knew what you were gonna do for the rest of the day ..."

"... That was a bided job when I worked on the trestle that's why I sat there work for a while. The jobs they had openings on them, like the furnace department we had first, second, third helper called blastman keeper. When the opening came, a man had the opportunity if he had the time to bid on that opening. If he wanted the job for the first helper and he bid it on, he had the time for it, he got it. That was his permanent job then. I'm gonna say at least ten years to get a

decent, good job. There are some jobs that people, they weren't even interested in so they didn't worry about it. But, they had bids for almost every every openings there was in the mill …"

John Hughey 1998:37 Second Helper and Union Official, Carrie Furnace[42]

John Hughey was born in Rankin, PA and started working at Carrie Furnace in 1947. As an African American, he was first worked as the second helper and later became a grievance man fighting for seniority rights for African Americans. Working as both worker and officer in Carrie Furnace, Hughey provides multiple perspectives in the interview. He talks about his own working experience, ethnic background and ethnic composition of Carrie Furnace, the problems African Americans had with the union, the lack of representation in the union for minorities, and also how women worked in the field.

John Hughey Clip Examples:

"… the particular place there at the particular time and I'm … um … the maintenance department was 99 percent pure Caucasian. The furnace department work hard, dirty work was, 99 percent African American or Black, depending on which term you want to use to describe African American. And, um at that particular time Black were not allowed to the maintenance or in the department if you want the good, self-paying jobs and treats and crafts and engineers and all others. They are not allowed to learn, they were not in the office, not in the maintenance, not in the department of fuel division or the ladle house, the lighter job which paid more money…"

"… Oh… if there is any young couple that have young kids, everybody wants the best. The family wants the best school, best churches, best this … this … this … The best opportunities for the American welfare. But then when you find out that is not just like it's told that you see in the movies and hear in the radio and hear in the songs, that… that you say you can't go but so far. In such industries, you just ain't go far. For instance, if you try go to [indecipherable], as wages in the 40 and 50s … [not sure] I'm talking about the [not sure] to go to the trainman, and I'm talking about the [not sure] in the mills, I'm talking about the engineers, the firemen, the brakemen, the conductors. They had their own unions. In their constitution, it was all dependent that you have to be a member of the Caucasian union to just to join that union, so now you can readily understand why you would never see no blacks or minorities running no trains. So they would never learn to train in trains, ride trains, airplanes, whatever things that they do, they weren't allowed to do that. Not because the ability wasn't there. And I think ability means able to learn, because you don't have to know how to do something. That's [indecipherable] … You don't

[42] Cassette recording of Interview with John Hughey-Second Helper and Union Official Carrie Furnace, 09/08/1998 ,1998:37, Homestead Steel Works 48" Mill Oral History, Rivers of Steel, Pittsburgh.

have to be able to know how to do it when you get there, but the ability is able to learn in any steps to progress and learn the job. But that was never happened …"

Philip Krepps 2003:03:076 Carrie Furnace[43]

Philip Krepps worked in the Carrie Furnace power house as a test engineer from 1947 to 1950. He got into the mill through his wife. Having such a deep family connection with Carrie Furnace, Krepps tells some unbelievable stories about his wife's grandfather and great grandfather working at the mill. Her great grandfather was killed in a furnace explosion and her grandfathers were both in strike. As an engineer, he discussed more technical aspects about the blower engines and stoves of Carrie Furnace in great detail. He also shared a lot of his family stories that related to Carrie Furnace

Philip Krepps Clip Examples:

"…When the gas is out at the top of the furnace, it is really hot and a lot of it is dust, and in that dust is a lot of very fine iron, pig iron. As it gets up towards the top it starts to cool down and solidify. And, this could down into the dust catchers which were sort of ... things separated the dust, very hot dust, from the gas stream. And it was collected in these dust catchers, and when they unloaded these dusts you must never allow air into those things. If you did you have a big explosion because these irons are so finely divided, it's sporadic, in other words if you expose it oxygen and it's hot, it burns and you will get a big explosion. But they have steam connected to these things, if they ever had a loss of air … and one thing you can not lie down the blast furnace is to lose the air, so they have redundancy on redundancy to provide this air. But there were times when something happened, the first thing is to open the steam of the dust catcher so no air can sit. Then when the steam gets full, they had what they called the pug mill which is sort of a thing that brings the ore out from the controlled flow and mixes it with the water and it becomes slurry mud. That goes to the sinter plants, and the sinter plants mixed it with the coke breeze and burn it so that it became the [not sure] and then break it up and put right back to the blast furnace. It was much richer than the original iron ore…"

3.3.3 Carrie Deer Artists

Carrie Deer was created the Industrial Arts Cooperative in 1997. This artists group is formed by seven members which are George Davis, Liz Hammond, Tim Kaulen, John Latell, Joe Small, Tim Yohman, and Bob Ziller. During the abandon period of Carrie

[43] Minidisc recording of Interview regarding Phillip Krepp's work at the Carrie Furnaces from 1947 - 1950, Phillip Krepps - Carrie Furnaces, 08/22/2006 , 2003:03:076.1, Steelworker Oral History Project, Rivers of Steel, Pittsburgh.

Furnace, these artists risked their personal safety, fought the nature and even dodged the police to come to the site and build the piece. Thought the original intension is not to stayed as a permeant sculpture, the Carrie Deer already become a symbol of rebirth and renewal of the Carrie Furnace. It is also a part of the new vision of the community, art and historical landmark.[44] In order to celebrate the story behind this unique sculpture, a documentary about the Carrie Deer and the Industrial Arts Cooperative was made with the fund by the Rivers of Steel National Heritage Area, Glyph Inc., and a grant from the Sprout Fund.

With the permission by the Rivers of Steel I collected the audio track from the Carrie Deer documentary and edited it into a forty minutes long artists' discussion. The major editing work focus on extracting the artists' voice by removing the original background music and sound effects from the documentary sound track. All the raw footages of the artist interview were unfortunately not kept in the archive system, so the editing needed to be done in order to remove the background music and other sound effects before excerpting all the interview clips. After cleaning the original documentary sound track and simple reverb adjustment the raw material is ready for reorganizing the content. In order to create a fully spatialized artists talk experience, the single track need to be divided into seven tracks, one for each artist. In this way each artist's sound track is independent and allows a more flexible location placement and behavior design later in the game engine. All the clips are rearranged into a clear structure which mimics the conversational atmosphere between seven artists.

Artists Talk Clip Examples:

"... I had just moved to Pittsburgh from Michigan, there's always been a sculptural element and performance elements to what I do. Performing solo, performing with people, little puppets shows, character shows. I had worked with some other girls that I have met, we have made sort of guerrilla sculpture garbage of Eden. Basically we created the garden of Eden out of garbage ..."

"... Beautiful, I wouldn't call it beautiful. I would call it pretty interesting landscapes that have been transformed from one thing to another and almost flopping back to what they originally were ..."

"... I doubt any place like this would ever exist and to see it the way we did, there was a post-apocalyptic industrial location. All the lockers were filled with people's stuff like the lunch box was still on the desk. It looked like everyone evaporate or vanish ..."

[44] The Carrie Deer Documentary. 2010. DVD. Directed by Sharon Brown, Glyph Inc, Rivers of Steel National Heritage Area. Pittsburgh, PA.

"... I guess it's the combination of realizing the scale of the space and the emptiness. Centers and venues for labor work were missing so much activities because there were just no people there. I think it drew us to want to be active in the space. We kind grew those conditions into our activities. So we would try to make a piece like that was the idea, try to make something leave something behind..."

"... It took more than one length of pipe to make a circle, maybe it took, depending on where we are at the neck, maybe it took three or four and have to overlap with each other. So you have to get that arch. Tim Yohman was like he was Mr. Ring man, cause once he got it he had the magic that he can just feed in. He would just be busted in these rings out and then the next guy will hoist them up and there will be the one up there tie them to the verticals..."

"... We gonna climb that latter that goes up to the top of the blast furnace, and I'm going first and Latell is like keep moving, keep moving, cause I'm just like this whole moment is like, oh my gosh what am I doing. And you get up there and the view is amazing, seeing down the valley. That space, something about that space, is just ... um ... makes you feel with all, you know, and makes you feel small and big and part of something big at the same time..."

"... Like look at these things you can do and like there aren't just being this or just being that, like following some conventional path. There are people that willing to do these things with you. Working on that deer was probably one of the most favorite things I have ever done, everywhere I went from there, parts that deer found me the spirit of collaboration. You being able to ... put out a lot of energy make something and then let it go ..."

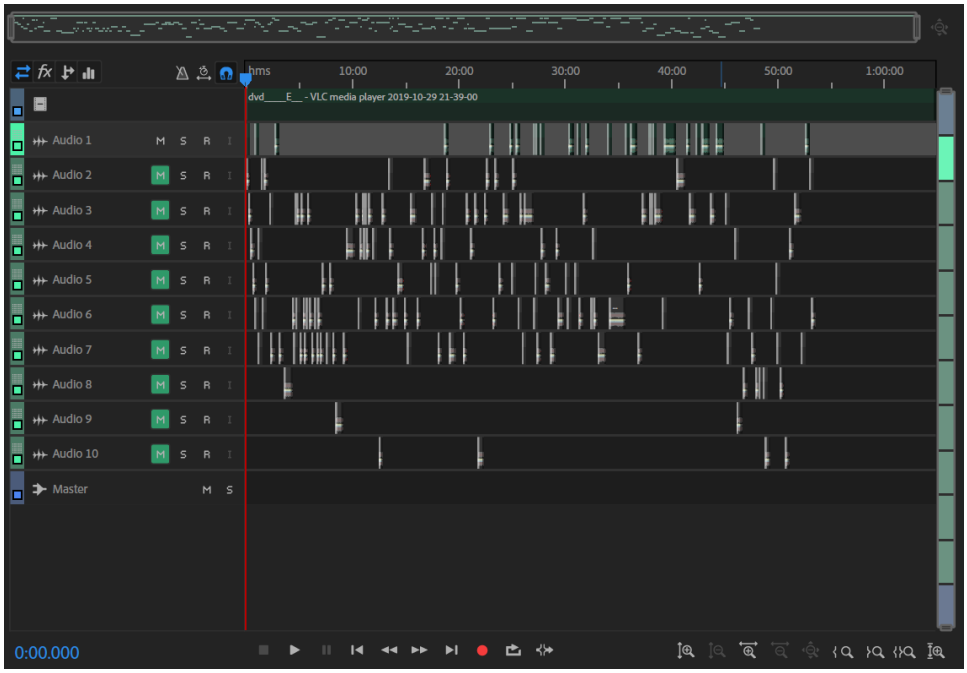


Figure 25 Reorganizing seven artists speak and audio processing

3.4 System building

In this section I will focus on the technical part of this thesis and detailly discuss how I create the system prototype as a support for further development in experience design. I will cover most of the essential parts for setting the designing environment for interactive soundscape in Unity and MR application.

3.4.1 Virtual Environment Modeling

A first, and essential step, for the entire workflow is creating a digital replica of the site. This provides a foundation for the experience design and simulation is essential in the entire workflow. Virtual Environment modelling in a broader sense is the process of simulating real objects and their state in the digital space.[45] The virtual environment provides an accurate reference of the site and empowers the designer to lay out the new added elements to the proper location with proper scale. In this thesis, creating the digital site model provided me a basic scene with all structures of the Carrie Furnace to work on curating the auditory experience inside Unity.

45 Feng Zhou, Henry Been-Lirn Duh, and Mark Billinghurst. 2008. Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR. In Proceedings of the 7th IEEE/ACM International Symposium on Mixed and Augmented Reality. IEEE Computer Society, 193–202.

There are two broader aspects related to the virtual environment modeling, data acquisition and model method. There are a lot of different types of data and modeling methods for example photogrammetry, 3D scanning, or actual measurement. For this project, I choose to build the model manually from the site CAD data. The original CAD data of the Carrie Furnace's plan was provided by the River of Steels as the base for creating the digital models. Large amounts of photos of the site were taken from my first visit there as reference for the adding details. The digital replication of the site is vital for mapping the digital world to the physical as it provides the accurate reference to both the structural and spatial relationships which will largely influence the design and creation of the digital contents.

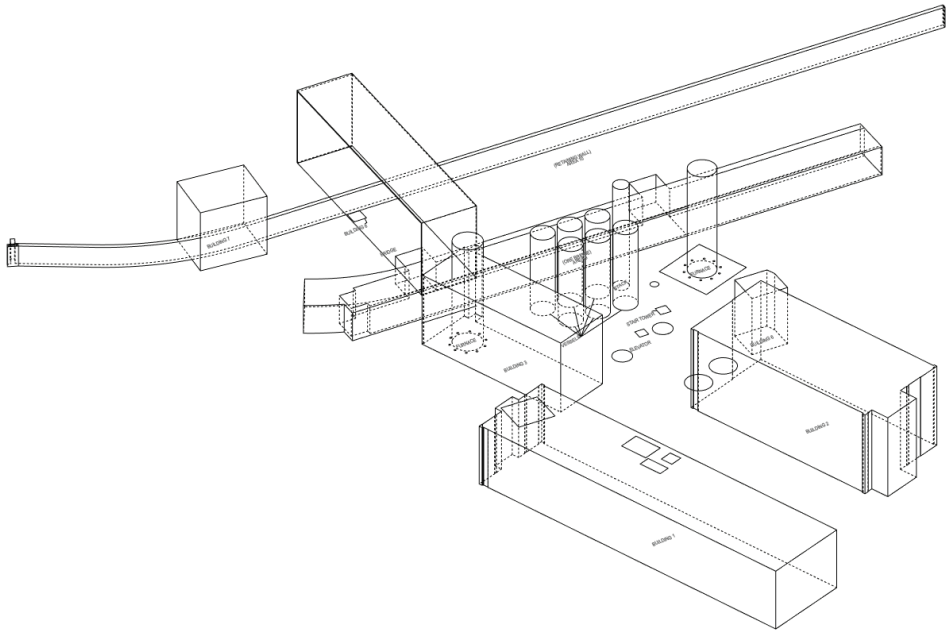


Figure 26 Box Model (Volumetric Model)

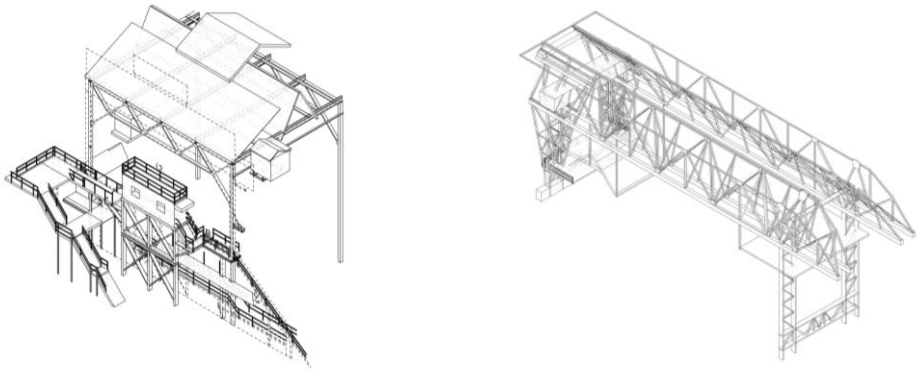


Figure 27. Detailed Structure Model

Figure 28 Virtual Environment Play Mode View

Figure 29. Virtual Environment Developer Mode

Unlike creating 3D models for video game scene which requires high level of details and texture rendering, the key function of creating the site model of the virtual environment is providing the locative and volumetric reference for designer to plan out things on digital platform. Thus, correct measurement and scale are vital for construction a virtual environment as reference for the real physical site. With CAD data of the site, it is very easy to create the box model (volumetric model) of the site at the beginning stage of virtual environment building. If no CAD data can be acquired, we can choose to trace over the map from Google Earth which also provide relatively accurate measurement of the large structures. After the "framework" of the site is settled, various details of each individual components can be added step by step. Carrie Furnace as a post-industrial site has a lot of representative structures like the blast furnace, Crane, Stationary Car Dumper, Ore Bridge, and Carrie Deer. Each individual of these structures holds its own identity on site which will greatly influence the design decision making, thus the detailed models for all of them were created.

3.4.2 Devices

The general devices that required for MR systems are displays, computers, tracking cameras and input devices. However, for building the audio-base MR system, the devices I used is the smart phone which combines the portable display, processing units, tracking sensors, camera and the headphone for the binaural listen.

The smartphone which can be categorized into hand-held device. Such device when used for MR experience, use video-see-through approach to overlay the virtual content onto the real environment view. However, as the goal of this thesis is to jump out from the traditional visual-oriented MR experience and create an immersive audio-based, the display screen on the hand-held device is mainly for showing the debugging interface. Also, as the project is developed in Unity using AR Foundation SDK and other related assets, only the compatible devices can be use to experience the project. Now Unity AR Foundation can support devices with Android 7+ and iOS 11+ system. [46]

Headphones is another key component of the devices for the experience. High performance stereo headphones can provide a lot more details of the audio content for the listeners and provide a much smoother binaural simulation. However, wearing headphones can sometime create a sense of isolation especially with the noise cancelling

[46] AR Foundation allows you to work with augmented reality platforms in a multi-platform way within Unity. This package presents an interface for Unity developers to use, but doesn't implement any AR features itself. To use AR Foundation on a target device, you also need a separate package for that platform (for example, ARKit XR Plugin on iOS or ARCore XR Plugin on Android).

function, which is not ideal for the experience that focus on building the connection with the surrounding environment. To remove such isolated sense the ideal devices are headphones with conversation enhancement function, for instance the Apple Air pod pro under transparency mode.

3.4.3 Tracking and Registration

The tracking system of this project is enabled by GPS, and the built-in magnetometer gyroscopic sensor which are all available in a modern smartphone. Real-time location tracking is vital for mapping the visitor's location on the physical world to the virtual world. Now a days there is a broad range of tracking techniques and most of them can be categorized into two large categories: the camera-based tracking, and the sensor-based tracking.[47] The performance of camera-based tracking relies heavily on good lighting condition and distinguishable geometrical features, thus it may not be usable for the landscape with high-level of spatial complexity and the visual richness. Sensor-based tracking relies on the data from sensor. For this project, three sensors – GPS, electromagnetic sensor, and gyroscope, from the smartphone are utilized to track the position, rotation and motion of the user.

- GPS: Providing real-time location information of the user and the base point for initializing the entire system
- Electromagnetic sensor: Providing the real-time directional reference for the user and setting the location virtual objects
- Gyroscope: Providing the real-world orientation to control the virtual camera and audio listener.

The most widely used registration process for AR and MR projects now is the image target, however the nature of this project requires the registration process to be as seamless as possible. Thus, instead of using image target or marker on the physical site to trigger the events, all the interactive functions are triggered in the virtual end with game object collision.

3.4.4 Interface

[47] Mafkereseb Kassahun Bekele, Roberto Pierdicca, Emanuele Frontoni, Eva Savina Malinverni, and James Gain. 2018. A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage. J. Comput. Cult. Herit. 11, 2, Article 7 (March 2018), 36 pages. DOI:https://doi.org/10.1145/3145534

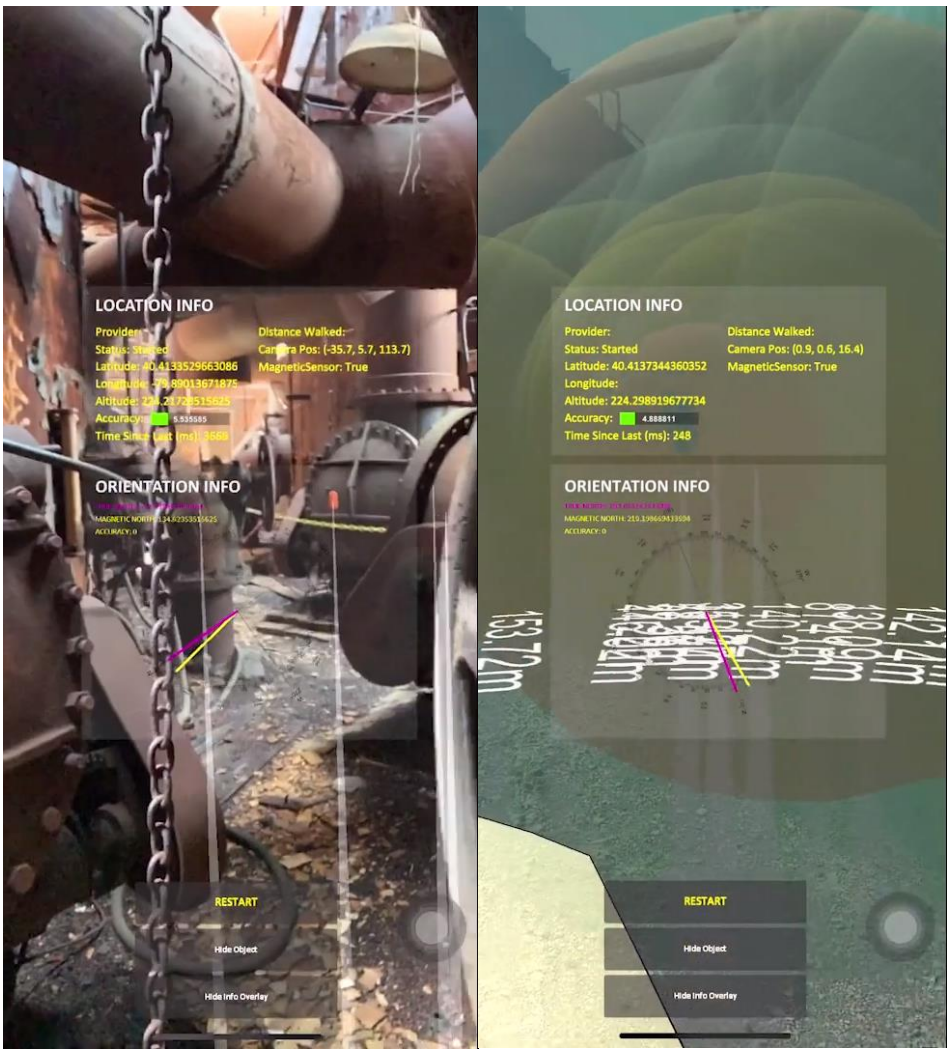


Figure 30. On-site Interface Display

Although the virtual content only contributes to auditory experience, screen-based interface is still implemented for system debugging and monitoring. As the images above show, the interface consists of three parts, tracking information, controlling buttons, and audio visualization. The location information and orientation information come directly from the sensor, and the data reading function used here is part of the template provided by the Unity assets which I will introduce later in the prototype section. Three buttons control the manually restarting function, toggle the display of the tracking information and audio visualization objects. In the area where the accuracy of sensors drops dramatically, the user can have the option to reload the experience manually.

3.4.5 Audio Setting in Unity

Although plugins like Panorama can create spatial movement in audio tracks directly on audio editing platforms, they are usually costly and require certain level of proficiency in sound design. Thus, in this thesis all the spatial blend and related effects are designed and applied directly in Unity. This section will focus on introducing the overall 3D audio setting, audio spatialized and audio compression format in Unity, the detail parameter for each audio clip can be found in the "Cue Sheet" at Appendix XX.

Basic 3D audio

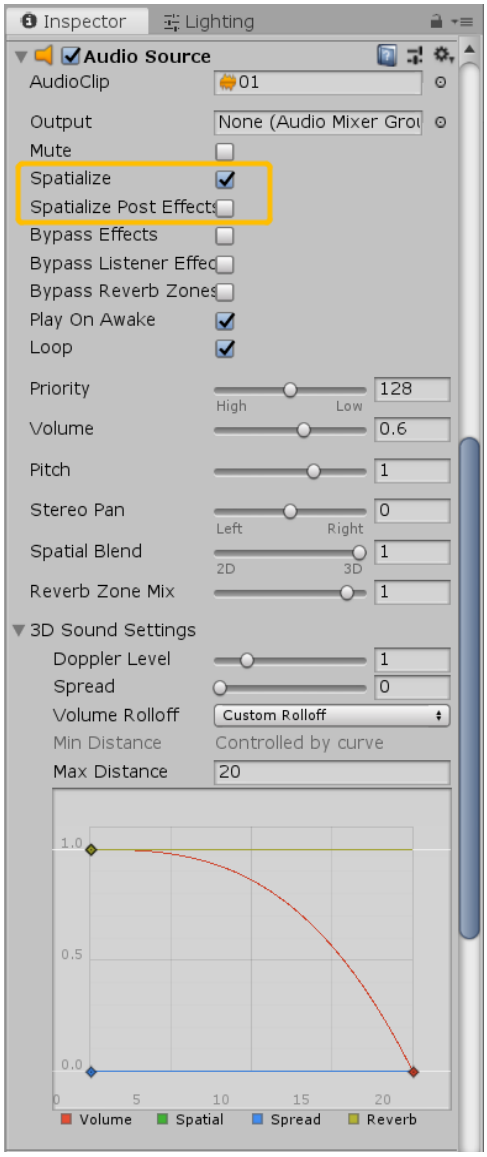


Figure 31 Audio Source Setting in Unity

AudioSource, shown in the image below, in Unity is attached on game object for playing the sound in 3D environment. In Audio source, audio file can be assigned to AudioClip, and in the default mode it will be set to play on awake and looping.

- Volume controls the sound loudness.
- Stereo Pan controls the sound distribution in multi-channel audio, however as 3D sound are automatically forced to mono, so stereo pan can stay as default.
- Spatial Blend value is key to set the AudioSource from 2D to 3D, it needs to be set as 1 for all the 3D sound features to work.
- Spread changes the distribution of a 3D sound between the speakers and takes a value between 0 and 360 degrees.[48] The trick of adjusting the spread value is that by increasing a little it will smooth out the sound transition between left and right channel while at the same time react to the 3D position.
- Volume Rolloff is the curve function that controls the relationship between distance(x) and volume(y). Curve can be customized with control points and create different spatial reaction.
- Min/Max Distance controls the range of distance for the sound to be heard. This range will also be visualized in the game scene as a frame of sphere.

Audio spatialized SDK

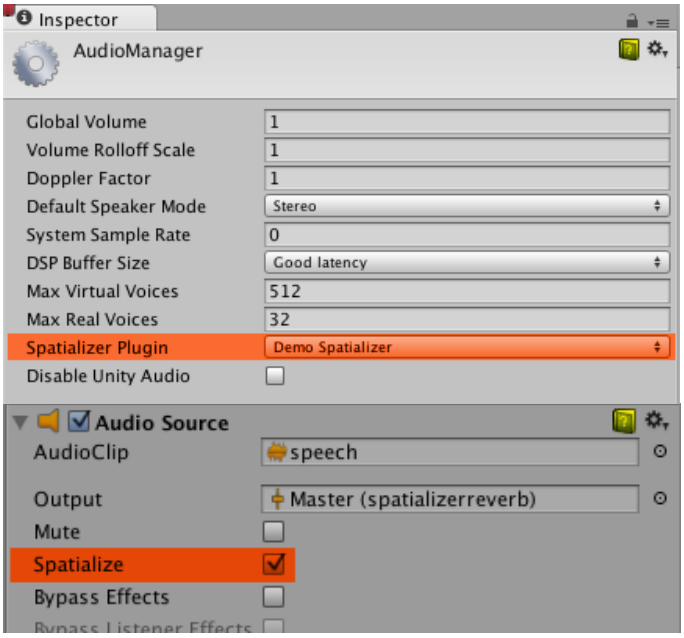


Figure 32. Audio Spatializer setting

[48] Cohen, Yossi, et al. "10 Unity Audio Tips (That You Won't Find in the Tutorials)." Game Dev Beginner, 2 Jan. 2020, gamedevbeginner.com/10-unity-audio-tips-that-you-wont-find-in-the-tutorials/#spread.

The built-in panning of audio sources can be regarded as a simple form of spatialization which takes the audio source and regulates the gains of the left and right ear contributions based on the distance and angle between the AudioListener and the AudioSource. [49] Spatialize setting is an extract function that enhance the spatial performance of 3D sound. It comes from the audio spatialized SDK which is an extension of the Unity 2019 native audio plugin SDK. Adding on top of the build-in panning of audio source, audio spatializer provides the direct HRTF (Head Related Transfer Function). Sound travels through space in all directions as sound wave like a sphere. HRTF mimics the way of how the ear receive sound from a sound source by boosting some frequencies and attenuating others.[50] HRTF filter provided in spatialized SDK is based on KEMAR data set, which measures the left and right ear impulse response to a KEMAR dummy head microphone.[51] In order to use spatialize function, Audio spatialized SDK need to be initialed in the Edit -> Project setting -> AudioManager. Just as image XX shows, Demo Spatializer need to be select for Spatializer Plugin.

Audio format and Import Setting

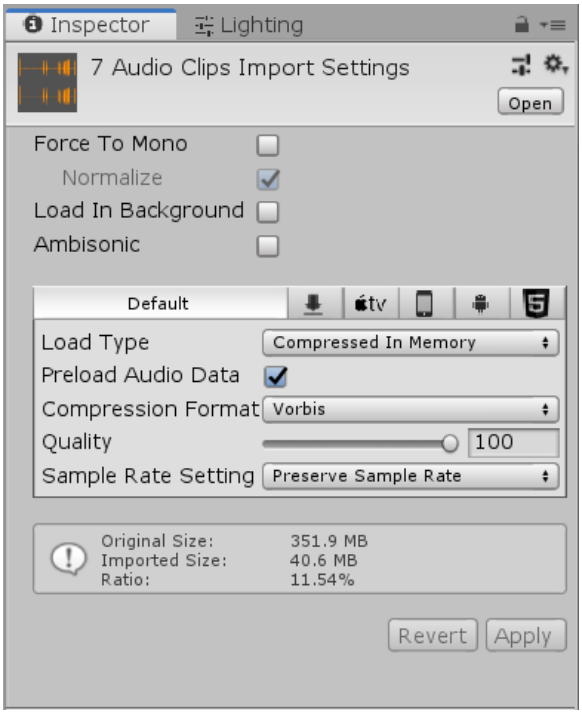


Figure 33. Audio Clip Import, load, compress setting

[49] Technologies, Unity. "Audio Spatializer SDK." Unity, docs.unity3d.com/Manual/AudioSpatializerSDK.html.
[50] "What Is HRTF?" 3Dio, 19 June 2019, 3diosound.com/blogs/learn-about-sound/what-is-hrtf.
[51] HRTF Measurements of a KEMAR Dummy-Head Microphone, sound.media.mit.edu/resources/KEMAR.html.

As the whole auditory experience is designed to run on a mobile platform, it is important to control the size and manage the load type of each audio files. In Unity the default audio import setting keeps the best performance of audio file, however it usually costs certain level of computer power to run especially with 3D effects. For mobile platform which does not have much computer power to support such setting, it is vital for the designer to manage audio file's original size(format), load type and compression format strategically.

The audio file formats that Unity can import are .aif, .wav, .mp3, and .ogg. I use **.wav** and **.mp3** formats for the audio clips in this project. Waveform(.wav) is the standard audio file format for uncompressed audio which keeps all the audio details. As it is the uncompressed format it does not need to be decompressed on load and this makes it possible for playing in the seamless loop. However, the size of wav file can get very large. MP3 is another common format for audio file which uses lossy data-compression to encode audio data and so it can have a much smaller file size compare with wav file. As it is a compress format, there will be a short loading time when play mp3 file every time. The loading time, although very short and sometimes hard to tell when switching from one audio to another, does not allow mp3 time to loop seamlessly. Based on the features of these two audio formats, all the environment sound effect clips (marked as green and yellow) are stored as .wav file and all the human voice clips (marked as orange) are stored as .mp3 file.

There are three audio load types:

- **Decompress on Load**: This loading option works the best for the smaller audio file as in this option the audio file will be stored and run on RAM uncompressed. This option uses the most memory but require the lest CPU power. Using this option for larger file will cause performance overhead.
- **Compressed in Memory:** This option works the best for medium size audio. The audio file will be stored compressed in the RAM and uncompressed when playing, but no additional memory is required.
- **Streaming**: This option works the best for large size file. In this option the audio file will be stored on the disk and stream through disk I/O when playing and so no RAM power is needed for this option.

There are also three compression types for audio file importing which I did not explore much personally. The detail introduction can be found in the manual page. [52] Based on the features of these settings, I set the environment sound effects in "Compressed in

[52] Technologies, Unity. "Audio Clip." Unity, docs.unity3d.com/Manual/class-AudioClip.html.

Memory" and all human voice clips in "Streaming", and all the audio files are compressed in Vorbis format.

3.4.6 Prototype

The first version prototype on-site aims to test the function of mapping the virtual objects to specific geolocation and the spatial performance of sound on the virtual object. In this prototype I created a demo on the mobile device using the Unity assets AR+GPS to position the virtual objects and get the real-time location information of the user.

Figure 34 Location Marker on site

Unity assets and settings

The main function of this unity assets is to place the unity game objects in geographical positions defined by their latitude, longitude and altitude.[53] This assets is developed based on Unity AR foundation, AR core, and AR kit plugin, which provide the essential XR features like device tracking, plane tracking, reference points and etc. Besides the most fundamental function of playing one single game object to certain location, this assets also provides many customizable functions, for instance moving game objects between multiple positions and setting hotspot which activate the target object when the user is near certain area. However, the performance of these modes is not ideal after testing, so I

[53] " Unity AR+GPS Location." Unity AR+GPS Location | Unity AR+GPS Location Docs (v3.0+), docs.unity-ar-gps-location.com/#main-features.

only use the basic function of placing object. Details of setting up the project can be found in the assets' documentation page.[54] Two important components for the project are "AR Session Origin" and "GPS Stage Object".

AR Session Origin places the role of main camera in Unity. To make it a functionable "player", three components need to be added to the camera: Audio listener, Rigidbody and collider.

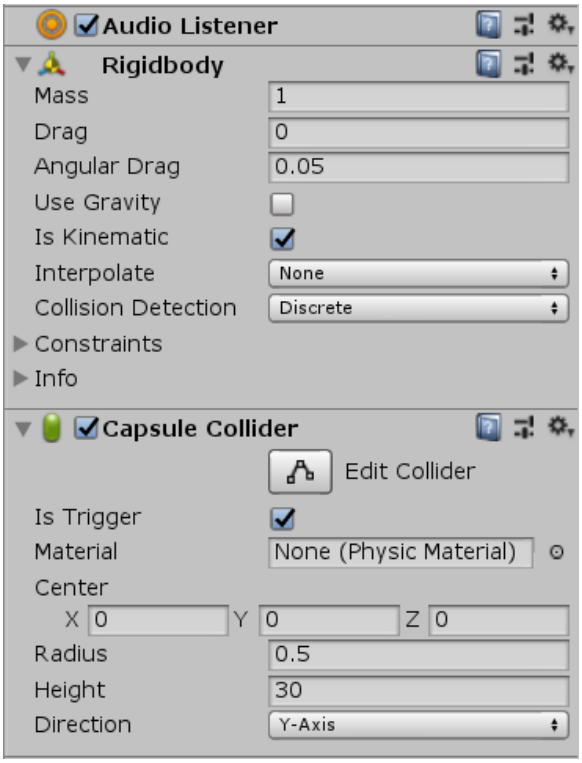


Figure 35. Unity Collider Setting

- Audio listener: receiving input from all the audio sources in the scene and plays the sound through the audio output device. Any audio effects on the audio listener will be applied to all the audio sources in the scene.[55]
- Rigidbody: controls the GameObject through Unity physics engine. This is the essential component for designing any collision-based interaction and events. By enabling "Is Kinematic" the Rigidbody will not influenced by the force. Only one party in the collision needs to have it.[56]

[54] "# Guide." Guide | Unity AR+GPS Location Docs (v3.0+), docs.unity-ar-gps-location.com/guide/#ar-foundation.
[55] Technologies, Unity. "Audio Listener." Unity, docs.unity3d.com/Manual/class-AudioListener.html.
[56] Technologies, Unity. "Rigidbody.isKinematic." Unity, docs.unity3d.com/ScriptReference/Rigidbody-isKinematic.html.

- Collider: defines the shape of GameObject for the physical collision. By enabling "Is Tigger" the collider does not behave as a solid object, rather a trigger for collision-base interaction and events. [57]

GPS Stage Object plays the role of spatialized audio which also carries collider for triggering events and interactions. Audio Source is another important component that needs to be added to the original GPS Stage Object.

- Audio Source: plays the sound in either 2D or 3D environment. It has the audio clip file and various customizable setting for playing the sound. Details of audio settings and audio clip format will be discussed in section 3.4.3.

In this prototype, 12 different capsule-shape location markers are created and set to their GPS locations as where shown on the map. All the location marker carries the water dropping sound with the 15 feet spreading distance. The on-site testing result of this prototype is shown below. The game objects are successfully placed into the site with well performance of the spatialized sound, however, the latitude information of the game object is not reliable. Also, depending on the accuracy of the GPS the location of game object can shift 2 – 6 ft. The observations from this system prototype provide the foundation for the experience design as the game objects need to accommodate the imperfection of the system. On-site testing view is shown in Figure 34.

Figure 36. 2019/12/04 On-site Testing Prototype

[57] Technologies, Unity. "Colliders." Unity, docs.unity3d.com/Manual/CollidersOverview.html.

3.5 Experience Design

Experience design is critical for setting an effective stage for examining the research questions as the structure of walking experience will largely influence the way of how visitors interact with both the soundscape and the landscape. In previous sections 3.3.1 and 3.5.5 I explain how to use Unity to set up the virtual environment for simulating on-site experience and building prototype app on mobile platform for Mixed-Reality walk Digital. In this section I will discuss how I create the detail experience design based on the foundation from previous steps to the final stage of on-site experience testing with the focus on the process of content curation, experience time control, audio spatial composition design, and individual movement and interaction design.

The previous steps of site visiting, raw audio material collecting, and technical system testing provide the designer a fundamental understanding of the site, content materials, and the system limitation. Although the final audio walk will happen in the physical site, the experience design process happens mostly in the virtual platform. Thus, the experience design process requires clear objectives towards the on-site experience, the mechanics of the interaction and the aesthetics of the combining visual and audio elements as a whole.

3.5.1 Content Curation

The broad themes of the content are decided when collecting the raw audio materials, so the goals of content curation is detailing the content selection, audio trimming, content planning and content time controlling. After analysis the raw audio materials, contents are selected and categorized into the following common topics.

Carrie Furnace Worker:

- Self-introduction and working position at Carrie Furnace
- Detail introduction of specific job or furnace structure
- Clothing
- Immigrants workers and ethnical problems
- Safety concern and related issues
- Women worker at Carrie furnace
- Family connection with the steel industry
- Activities other than working in Carrie Furnace
- Unemployment

In order to balance the amount of content to be included, the number of sound object to be encountered by the visitor in one single trip, and the length of the entire audio walk, all Carrie Furnace worker interview clips (long around 1 hour to 1.5 hour) and Carrie Furnace documentary are trimmed into segments with length of 1 min to 4 min. There are in total 44 trimmed clips based on the common topic. [58]

Artists:

- Self-introduction and personal art practice interest
- Shared interest of art practice and the formation of "Industrial Arts Co-op"
- Works by "Industrial Arts Co-op"
- Explore Carrie Furnace
- Inspiration of Carrie Deer from Carrie Furnace
- Building process of Carrie Deer
- Collaboration mode
- Reflection on the Carrie Deer project

As the Carrie Deer plaza is set as a main attraction point for the visitors to enjoying the view and listening to the artist's talk in a relative long time, the artist's interviews are not trimmed into small independent segments, instead a 38 min long looping artists' talk is curated from the seven tracks (see in section 3.2.3). This artist talk is designed to launch from the very beginning when the visitors start their audio walk, thus by entering the Carrie Deer plaza in different time the visitors will listen to various contents. The looping design will ensure the artist' talk keeps playing no matter when the visitors enter this area. As the content of artist's cover all the topic listed above which does not claim a strong linear logic behind, visitors can come in anytime without big understanding issue. In this way, they have the choice to listen to the entire talk or only part of it.

After trimming and editing, all the audio clips are color coded and organized into the "cue sheet" for tracking information like file name, length, format, file size and other design parameters which are added and discussed in the next few sections. The complete spreadsheet of cue sheet can be found in section Appendix.

- Orange: represents individual human voice clip
- Yellow: represents individual sound effects for specific structure and area
- Green: represents the looping background sound effects for overall atmosphere

[58] In this section I will use sound object to represent the unity game object which holds the audio source, instead of directly using audio source.

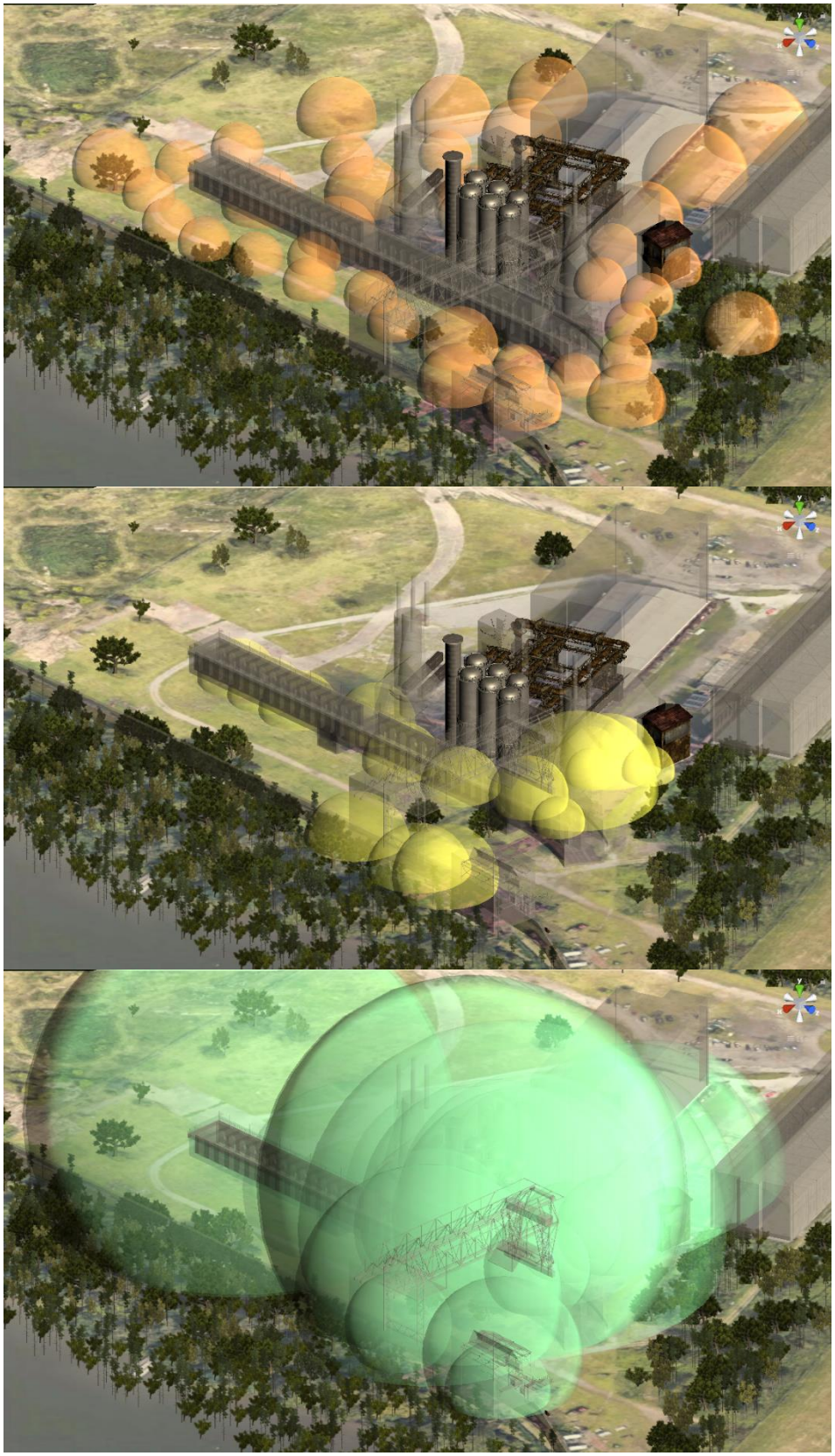


Figure 37. Audio types

3.5.2 Audio Spatial Composition Design

Editing the raw audio materials and compose them together to form an ideal audio composition can be very challenging for people without training in sound design or related fields. Thus, the strategy I take here is to compose all the audio clips spatially in the Unity and using their spatial relationship to form the final soundscape. The structure of the audio composition takes iteration to be designed and decided. The whole process involves several rounds of adjustment to the content, spatial composition, volume, spatial blend, special effect for each audio.

The key for designing a convincing spatial composition for the audios is exploring the relationship between the content narrative of the audio and spatial narrative of the space. Their mutual influence formed a special amalgam which emphasizes the strong connection between physical and virtual experience. It was discussed in "Narrative Landscape" that in the landscape the assumptions towards objects' causal relations are usually made based on the spatial proximity. Which also suggest that narratives in landscape do not necessary involve either the conscious ordering or a defined causal relation. [59] Narrative sequences in the medium of the landscape differ from those in other mediums because the participant moves through the medium itself at his chosen speed while potentially engaging in various activities.[60]

The spatial composition and sequence of audio clips as a foundation for designing the soundscape will largely decide the experience structure. Based on the points above, I demonstrate two parts of designing the audio spatial composition. The first is mapping all the environment sound effects to their relevant structures. By building such spatial relationships, the environment sound effects will replicate the sonic atmosphere of the past when the blast furnace was still operating. The second part is assigning a specific position for the human voice clips under certain design strategies. There are seven design strategies I summarized for placing sound objects, the first four are applied for the environmental sound effects and the rest three are applied for human voice clips.

- Attaching to relevant structure
- Duplicating
- Combination of multiple versions
- Atmospheric contrast
- Grouping similar topic
- Adding interest to open filed

[59] Potteiger, Matthew., and Jamie. Purinton. Landscape Narratives : Design Practices for Telling Stories New York: J. Wiley, 1998. p 110
[60] Ibid. p 115

- Scattered Arrangement

Attaching to relevant structure: By attaching the audio clips to the structure which the contents relate to, the causal relations formed spontaneously. One major feature of this audio walk experience is the juxtaposition between audio and visual element. Placing individual sound effect and human voice audio clips to the area near their relevant structures will dramatize such juxtaposition. For example, the crane sound effect and the clip of Jim Kapusta talking about the trussle works and ground signal man are placed near the Ore Bridge area where the crane and tussles are located; the material dropping sound and the history of larry man are place inside the stocking house.

Duplicating: The operating blast furnace has very crowded working environment. Usually each working station will have hundreds of sounds from the repetitive work, so duplicating sound objects to create the crowded and repetitive sound pattern is effective for mimicking the past. What worth mentioning here is that duplicating a single sound does not mean to keep all the settings of the sound object the same. The play time, volume and other related settings still need to be adjusted for each different sound object to avoid the plain sound overlap.

Combination of multiple version: As mentioned in section 3.4.3, all the environment sound effects are stored as .wav file. The file size limits the length and detail of each audio clip. To create a more enriching environment soundscape, I create different version for each environment sound effect with various reverberation performance. By combining multiple versions together even the simple sound effect can form a rich sonic pattern and spatial relation. In this strategy the audio clip itself was edited with different reverberation which differs it from the previous strategy duplicating.

Atmospheric contrast: Large-scale ambient sounds are placed at the core area of the site where dominant by all the heavy structures to form an overwhelming atmosphere with swarming industrial noise. On the contrary, gentle natural sound are placed at the open file and garden to create comfort atmosphere for people to understand the content in human voice clips. There are also place that no sound objects are place, in these areas the silent environment allow people to enjoy the unique emptiness of post-industrial landscape. The atmospheric contrast of sound suggests the mixing stage of different time period and thus greatly enhance spatiotemporal experience. From the image below we can see the density of sound which illustrate the atmospheric contrast on site.

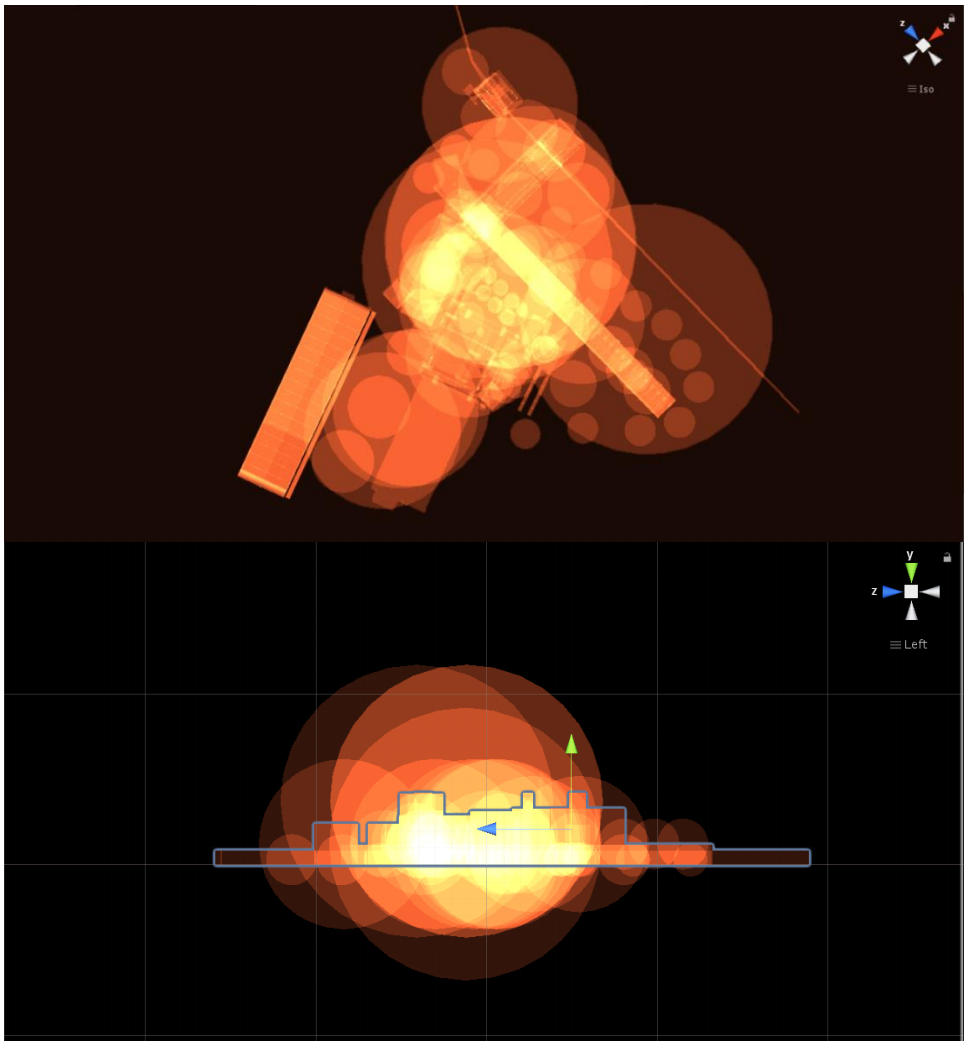


Figure 38. Audio Density Plan and Section view

Grouping similar topic: As I mentioned before, the spatial proximity of objects in landscape suggest their relationship. Grouping human voice clips with similar topic will help to create internal connection between audio clips within certain area. Such group also categorizes space with narratives and naturally create a spatial relationship between the content topics to the physical space.

Adding interest to open field: There is a large area of open field (ore yard) with great side view towards the main structure of blast furnace, however people will usually walk straight pass this area to the next destination. Thus, more Human voice clips are placed in this area to add more aha moments and slow down people for them to enjoy the surrounding views. The openness and emptiness of this area will also form a more ideal environment for people to focus on the serious topics like the immigrants and ethnic problems, safety concern and related issues and women worker.

Scattered Arrangement: Instead of aligning the human voice clips on the cleared pathway in the site, I choose to arrange them in a more scattered composition to destroyed the common sense of the suggested circulation. In this way, the visitors are encouraged to step in to the grass, to feel and explore the landscape, and to walk as freely as possible (within the safe area).

After the location and size (audible area) are decided for all the sound object in Unity, the detail location map can be produced for converting the measurement and information into real-world information. Then the GPS coordinate and size of all sound objects are updated into the "cue sheet".

3.5.3 Movement and Interaction design

Unlike in the traditional audio walk experience where the sound stays relative static in the audience's headphone, the spatialized soundscape creates a 3D relationship between the listener, sound, and their situated environment. Without the physical limitation like the fixed position speakers, the spatialized soundscape in headphone can also support independent movement for each sound object which allows a much dynamic auditory experience. The gentle moving sound can emphasize more on the individual presence of sound while at the same time help to promote the dynamic of activity. Visitors will subconsciously follow the moving sound if they want to hear more content, in this way not only can they concentrating on the audio content more actively, the walking rhythm will also not be breaking by standing still.

As the environmental sound effects are placed to their relevant structures, the movement and interaction design only applies to the human voice audio object. There are three keys points for sound movement and interaction design:

- Path &. Randomness
- Speed
- Interaction

Path & Randomness: These are two different way of setting the movement for sound. Fixed path provides a controllable way of designing movement for the sound. There are many ways to create a movement path can be implemented in Unity, for example creating time-based moving animation, moving sound object along Bezier curve with C# or using path creator assets. The fixed moving path can be implemented at specific cueing moment to lead people walk towards certain area. (see section 3.5.4 scenario 6) The design of a fixed path can take long especially for a lossy structured experience; all the possible interaction scenarios need to be analyzed to decide the form and length of the

path. For the sound objects with no special movement cue, their movements only need to suggest the moving status and maintain the active rhythm of the walking experience so it is more effective and efficient to provide them random movement in a settled range. There are also various ways for creating random movement, for example using the wondering AI with Unity's path finder function or a patrol AI which add more interaction between the sound object and the listener.

Speed: Other than the moving path, speed is another key element that controls the movement of sound. Too fast of the speed will not only cause the pitch shift of the sound but also cause difficulty for people to follow. Thus, setting proper speed will largely contribute to how people interact with moving sound. People's normal walking speed is around 4.5 feet/s, in order to match the slow walking speed during the audio walk I choose to set the speed range of the sound object from 0.5 – 1.5 feet/s. A random moving speed will be generated for each sound object when triggered by visitor's appearance.

Interaction: The interaction between sound object and visitor consists of two parts, the trigger of playing and the speed change. Each sound objects have its collision area (see section 3.4.6). When visitor encounter the sound object and enter its collision area the audio clip will be triggered for playing. The collision area is set to equal with 2/3 of the sound object's audible area because even if the sound is triggered it is very hard for visitors to perceive it at the edge of the audible area. (see section 3.5.4 scenario 5) When visitor is inside the collision area, the speed of sound will also change from its initial value to 0.3 feet/s to slow it down for visitor to follow. It is also worth noticing that each sound source can only be triggered once, in this way even when visitors wander in the same area, they will not hear the same content twice. Some sound objects also function as trigger for the other sound object, which means these sound object function as the "lock". (see section 3.5.4 scenario 3)

Same as the location and size information for all sound objects, after all the movements and interactions are designed the information are also updated in the "cue sheet".

3.5.4 Soundscape Design Scenarios

Scenario 1 Entrance Plaza
Soundscape composition: 1,2,3 + 1,2,3 [61]
As this is the starting point for the entire walking experience the human voice clips placed around this area focus on providing an overall introduction to the history of Carrie Furnace and its significance of representing the iron industry of Pittsburgh. Background

[61] Sound objects are labeled with numbers, their detail name please refers to figure 30 -32.

sounds are place with various reverberation performance and gradient volume change in order to create a smooth atmospheric transition to the core heavy structure areas. The three human voice clips here marked the “entrance” to the virtual soundscape and they also function as the trigger for the artist talk at the Carrie Deer plaza.

Scenario 2 Iron Cast House

Soundscape composition: 4,5,6 + 1,2,3,4,5 + 10,11,12,13

Iron cast house is located right against Carrie No.7. With melting iron flow out from the iron notch, the worker will transfer them into the ladle car. It is the hottest and one of the noisiest areas in the site, so various blast furnace, iron casting and ladle car related background sounds are stacked over here to build the atmosphere. The three human voice clips placed here are also about the working nature and clothing standard of iron casting. The volume of these clips is all turned to the top so they will not be flushed by the aggressive background sound. Noticeably, as the iron casting floor is one story above the ground the sound objects here are placed at a slightly different elevation. People who choose to enter iron cast house will most likely go to the hot blast plant and exit the core structure area from the northwest end where the Carrie Deer plaza is located.

Scenario 3 Sidewalk at the east side of Iron Cast House

Soundscape composition: 7,8,9,10 + 4,5,6

This sidewalk provides a direct view towards the stationary car dumper and a close side view towards the ore bridge. As a fast transition zone more human voice clips are placed here to slow people down. The audio clips placed in this area focus on various job descriptions and the job biding system. This is sidewalk is relative narrow compare with the other areas in the site, thus with high density of human voice clips people will encounter several sound objects continuously and get familiar with how to interact with them. People who choose this sidewalk will most likely to visit the site in a clockwise order. As people need to pass through here to get to the final meeting place, so there is a second layer of audio content which can only triggered by the other sound objects around the site towards the end of the experience.

Scenario 4 Stationary Car Dumper

Soundscape composition: 11,12,13 + 9,10,11 + 14,15

The stationary car dumper has many unique features like the rail car and stock transfer car, so most of the sound effects, like train moving sound and ore loading sounds, are directly attached to them.

Scenario 5 Ore Yard

Soundscape composition: 14,15,16,17,18,19,20,21,22 + 12,13,16,17,22,23

At the edge of core structure area, although the ore yard is covered by the rich background sounds they stayed at low volume level, and so provide a much clear environment for listening to human voice content. The wide span of ore yard also provides an ideal stage for experiencing the spatialization of sound (gradient change of volume, orientation change, spread change) and encountering various memories. The large open field in this area does not have much visual attraction so a large amount of human voice sound objects is placed here to fill the space. The first half (southeastern) of ore yard overlap with the ore bridge area so the audio content here focus on crane man work and ground work in ore yard. At the second half (northwestern) the audio content extended to broader topic like safety concern during working, ethnical issue relates to different works and unions, and gender issues. The less distractive setting of ore yard allow visitor to concentrate more on these serious topics relates to Carrie Furnace and iron making industry. As all the sound objects are moving, so there could be moment when the visitor hearing two sounds from various area at the same time. Under such moment the spectatorship of the visitor is emphasized.

Scenario 6 Stockhouse

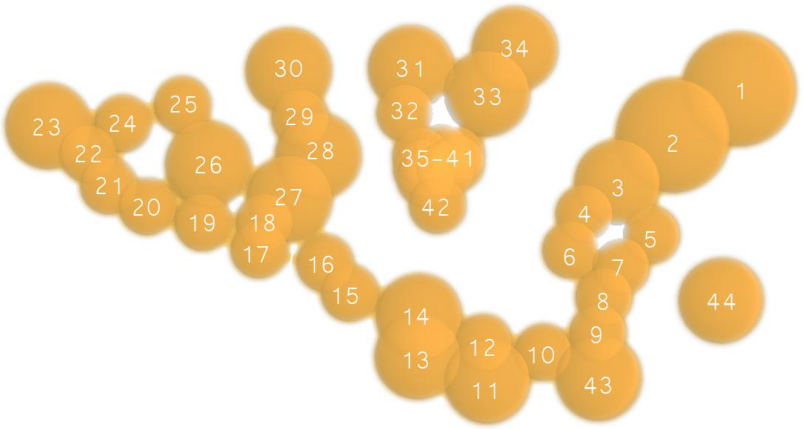
Soundscape composition: 24,26,27 + 14,15,16,17 + 22,23

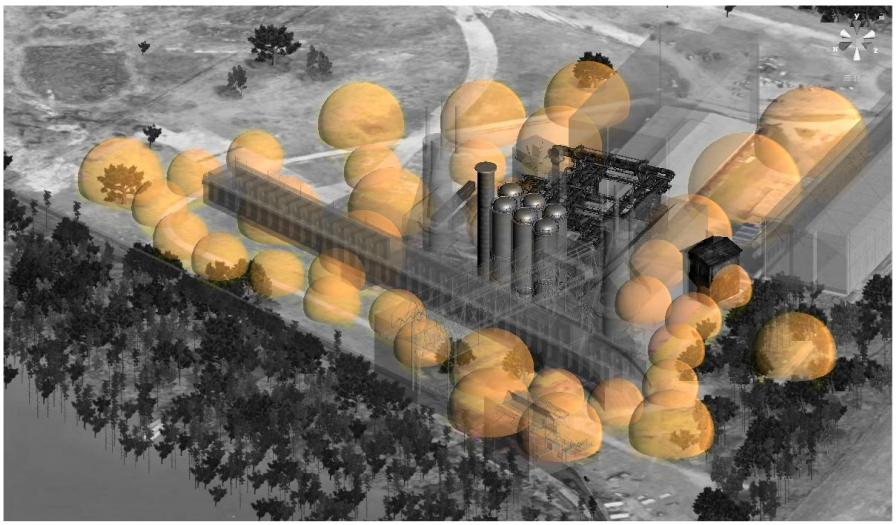
As one of the severest working environments in the past and the eeriest space on site now, the sonic and visual experience inside stockhouse is drastically different than the other place. Sounds of material dropping and car moving on the rail are duplicated and placed along the stockhouse so when people walk inside, they will hear a chain of sound effects which align with the system of suspended material bins and the scale car. Various reverberation versions are also provided here to emphasize the echoing environment inside this tunnel like structure. Due to the gloomy vibe of this area, many visitors will reluctant to go inside. In order to invite them to explore inside, sound object 24 is set with a moving path that will lead visitors to go inside.

Scenario 7 Carrie Deer

Soundscape composition: 4,5,6 + 9,10,11 + 14,15

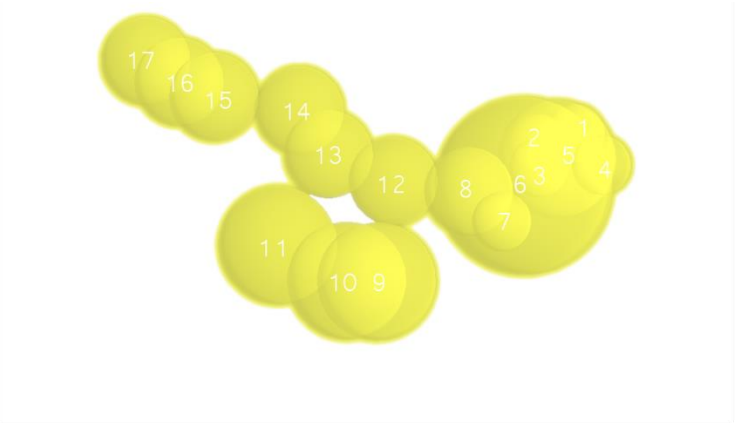
Carrie Deer is embedded and hidden behind the gas washing system. Framed by all the heavy structures, there is secrete open file in front of Carrie Deer for people to stop and enjoy the sculpture and surrounding environment. This area features barren vegetation, odd vintage furniture and other post-industrial elements. The spatiality of this area hints for a longer and single point auditory experience, thus the artists talk is designed here. As one of the highlight moments where the complexity of landscape is catalyzed, visitors can fully immerse them into the heavy structure, odd sculpture and spatialized sounds.

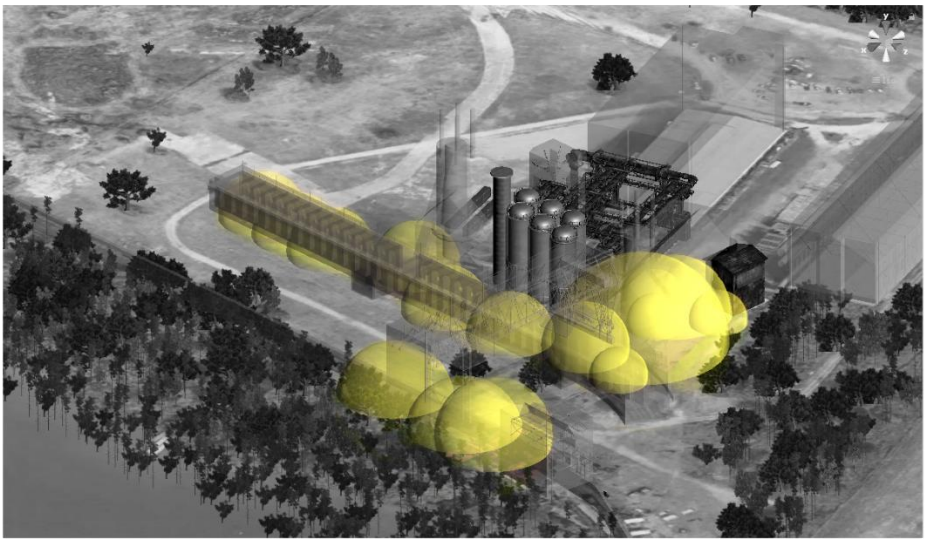




1. Intro 01
2. Intro 02
3. Intro 03
4. Submarine Laddle
5. Dust Catcher
6. Casting Runner
7. Jim Kapusta_01(Labor gang job)
8. John Hughey(self introduction and first work as second helper)
9. Jim Kapusta (wearing gear during case)
10. Jim Kapusta_03(trussel work and ground signal man
11. Intro 05
12. Ron Gault_Material Handler (Put near the Crane area)
13. Intro 04
14. African American labor
15. Jim Kapusta_05(working experience)
16. African American Labor Gang worker (Put near blast furnace)
17. John Hughey(how worker fought for safety equipment)
18. Philip Krepps (His wife's grandfather in the strike)
19. History about Eastern European worker
20. Women in the industry
21. John Hughey(women worker)
22. Jim Kapusta_04(touches on the job losses and women worker)
23. Philip Krepps (get into the mill through his wife)
24. Jim Kapusta_06(describe how he hates larry man's work)
25. John Hughey(Ethic in Carrie and his duties as grievance man)
26. Larry man (Inside the bridge)
27. Philip Krepps (story about one missing man in Carrie)
28. Intro 06
29. John Hughey(Problems African Americans had with the union)
30. Ending 01
31. Ending 02
32. Jim Kapusta_02(Dressing inside furnace)
33. Ending 05
34. Ending 03
35. 1 Liz Hammond
36. 2 John Latell
37. 3 Tim Yohman
38. 4 Joe Small
39. 5 Bob Ziller
40. 6 George Davis
41. 7 Tim Kaulen
42. worker near the blast furnace
43. Philip Krepps (burning dust)
44. Ending 04

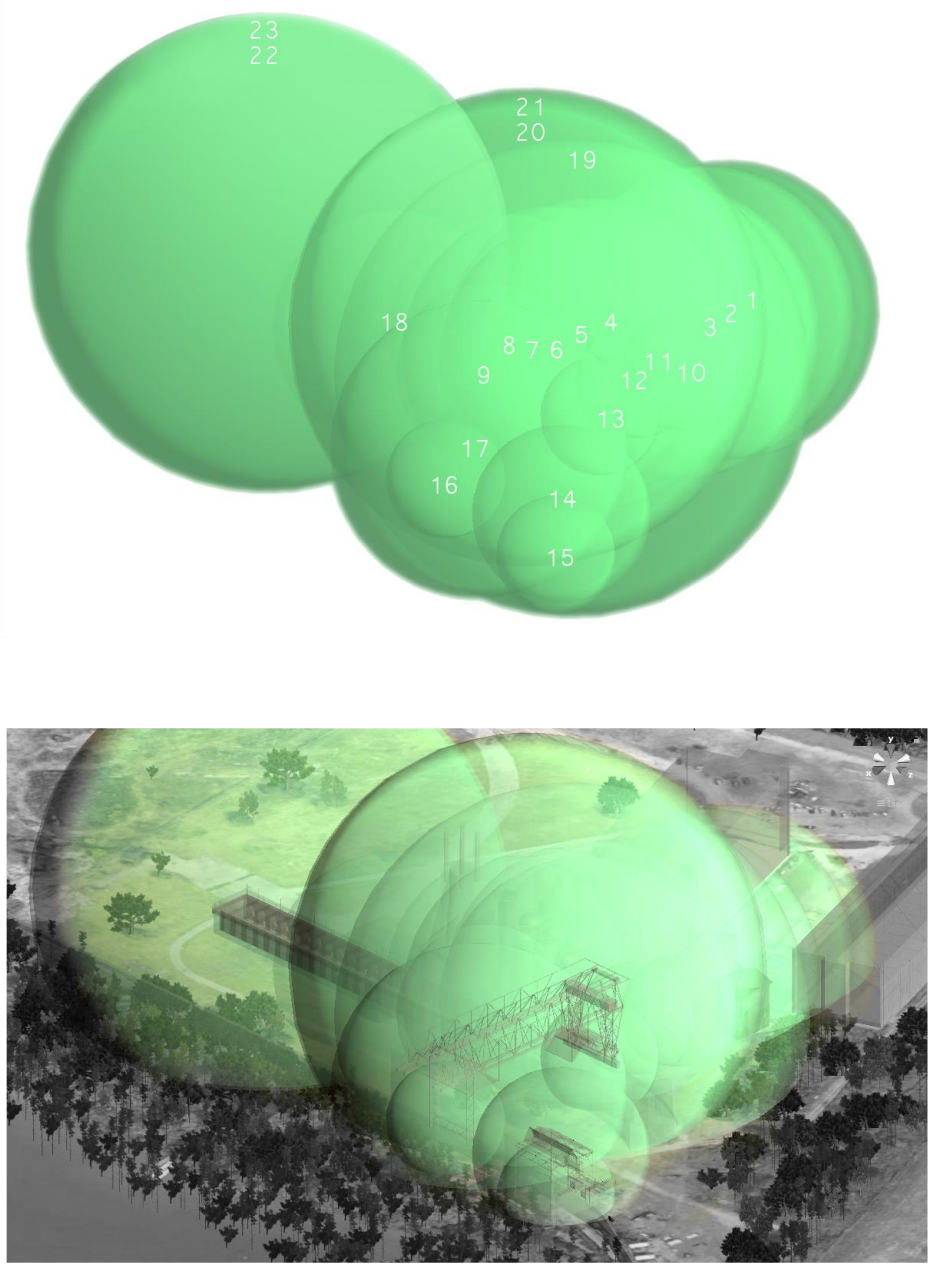
Figure 39. Human Voice Clips





1. Lathe switched on, turns steel, slows down, stops.
2. Ladle pouring molten iron into convector (2)
3. Ladle pouring molten iron into convector
4. Ladle pouring molten iron into convector (1)
5. TheSoundsofSteelmaking - plate mill
6. scrap dumped into a furnace
7. climbing ladder
8. Shutting side of steel truck in steam railway goods yard. (1)
9. Loading coke
10. Loading coke (2)
11. Loading coke (1)
12. Scrap lifted and dropped into steel-making vessel (2)
13. Scrap lifted and dropped into steel-making vessel (1)
14. Shutting side of steel truck in steam railway goods yard.
15. Scrap lifted and dropped into steel-making vessel
16. Scrap lifted and dropped into steel-making vessel (4)
17. Scrap lifted and dropped into steel-making vessel (3)

Figure 40. Individual Sound effects



1. Blast Furnace_far (1)
2. Background_3
3. Background_3 (1)
4. Background_2 (1)
5. Blast Furnace_far (2)
6. Blast Furnace_far
7. Hot Strip Mill_far
8. Blast Furnace
9. nail machine
10. Forging Press
11. hot saw
12. Steel cooling
13. Cranes (1)
14. Loading coke
15. loading
16. Cranes
17. Cranes_far
18. nail machine_far
19. scrap dumped into a furnace
20. Background_1
21. Background_2
22. Background_1 (1)
23. Background_2 (2)

Figure 41. Background Sound Effects

3.5.5 MR Soundscape

The “cue sheet”(see appendix A.2) will serve as the database for the soundscape and the guideline for inputting all necessary information for sound objects in the technical system for building MR app on devices. The information includes, audio clip, import and compression setting, geo-location, size, audio spatialize curve, movement, interaction and trigger sound object (if applicable). The two images below show the system developing view of the final soundscape in Unity and the on-site view of soundscape through MR app on smartphone.

From these two images we can see that the “soundscape” is the combination of numerous sound objects with their individual presences and behavior. It is because all the sound objects are spatially designed and stored geo-location information with them, thus even their spatial relationship (as in Figure 33) changes in virtual developing platform, their relation to the final soundscape stay the same as in original design (as in figure 34).

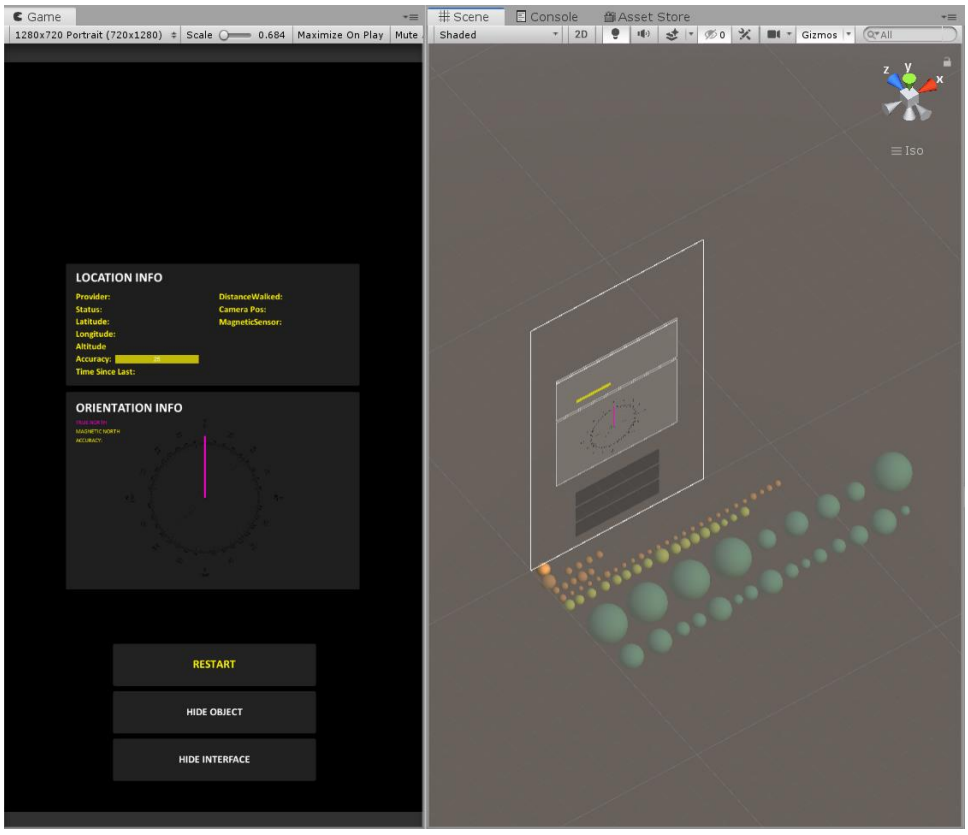


Figure 42 System Development view of Soundscape

Evaluation and Results

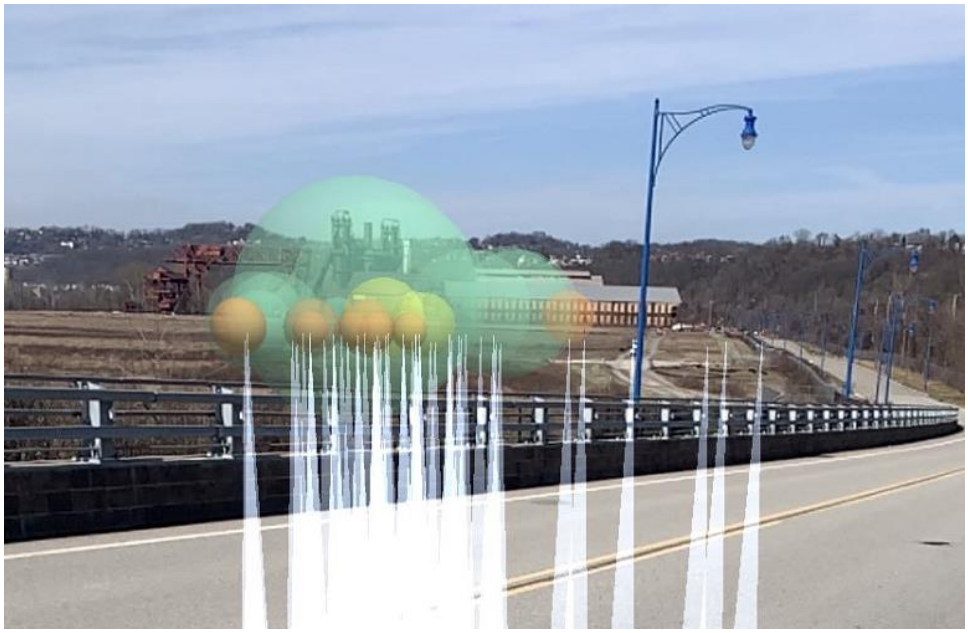


Figure 43. On-site view of Soundscape

To evaluate the experience design, I arranged three activities in the beta test which includes on-site audio walk, on-site focus group discussion and take-home survey. I have in total 11 participants attend the beta test before everything was lockdown, unfortunately as I originally plan to 20 participants. The whole audio walk last around 1 and half hours and after that everyone was gathered together for a 30 minutes group discussion. At last a take home survey was given to each participant in print and digital version. I collected qualitative data form both the focus group and the survey, and some quantitative data from the survey also. While focus group discussion let the participants to reflect their walking experience relatively free, the short answer questions in the survey focus more on specific aspects of the experience.

4.1 Beta Test

There are three activities for the beta test, the on-site audio walk, on-site focus group discussion after the walk, and the take home survey. The purposes of these activities are to

a) observe visitors' movement, behavior and their way of exploring the site during audio walk;
b) observe how they are influenced by the spatialized soundscape in the site and how they react to it during the walk;

c) analyze how they perceive the individual presence of the spectral memories in the spatialized soundscape
d) analyze how the juxtaposition between sonic and visual experience influences the visitor's perception to the site.
e) analyze how the audio content influence their understand to the cultural, social and historical significance of the site.

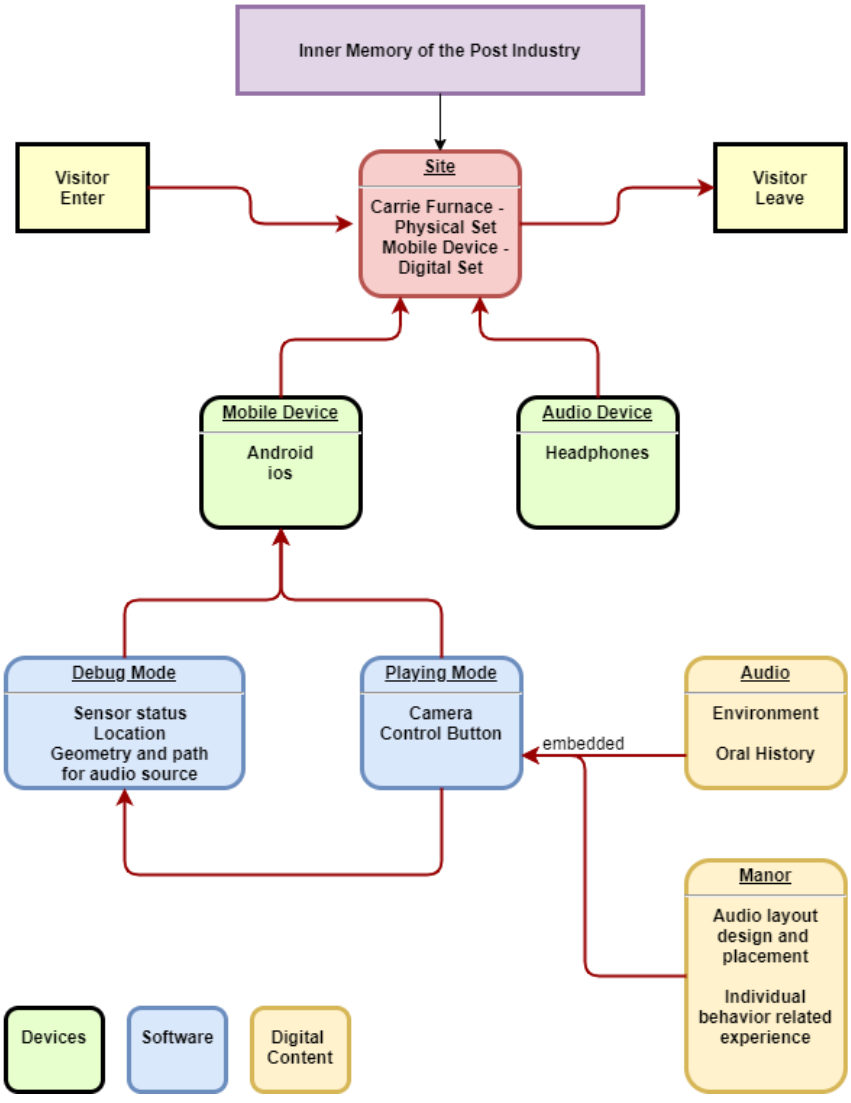


Figure 44 Experience Design Content Map

4.1.1 Overall Process

Participants will be invited to the Carrie Furnace to attend the activity, and the potential participants include the staff of Rivers of Steel, former workers at the Carrie Furnace, CMU professors (from architecture, drama, art departments), CMU students (from architecture, drama, art departments). The survey question data and focus group discussion data will be collected after each sit-visiting session for encoding the observations. The target number of participants are 20 (10 for each session, two sessions). Each participant will be asked to bring their own Bluetooth headphones and mobile device with gyroscope (360 Video on Youtube can be used to easily test whether the mobile device has gyroscope or not). If the participants have any concern about using their own devices, I have limited number of devices for access, however they are first come first serve. With the participant's consent I will install the MR app on their smartphone. An optional screen recording consent form will be provided to the participants for those who are willing to keep the record of their site-visiting experience and share it with me.

Before starting the audio walk, I will briefly introduce the project and the way of using the MR app. Due to the nature of the site with a lot of inaccessible areas and structures, the participants will also be introduced with safety rules and be asked to sign the consent form to participate and the waiver of liability and hold harmless agreement. The whole experience is under the permission of Rivers of Steel, the NGO that runs and maintains the Carrie Furnace Historical Landmark. (https://riversofsteel.com/about/) A map with location marker will also be provided to the participant to facilitate their walk in the site. After all the introduction information, all the participants will enter the Carrie Furnace to explore this post-industrial site with the new auditory experience.

The whole audio walk will take around 1 h 15 min to 1h 30 min. After finishing the walk, the focus group discussion session will also be held on-site for all the participants to share more ideas about their experience. It will take around 30 min. The discussion session will be audio recorded for transcribing. After the focus group discussion I will give each participant a take-home survey (printed or digital version provided).

4.1.2 Focus Group Discussion

The focus group was held in the iron garden which is located at the southeastern edge of Carrie furnace which provides a semi-private setting in the woods for the discussion. With a side view towards some of the most dominant structure of the blasts furnace, the tranquil environment of iron garden extracts out the participant from the previous walking experience and prepare them for the discussion while at the same time leaving some visual hint for them to reflect on.

The focus group discussion ranged from extremely structured to unstructured. As I want to get answer for specific aspect of the experience so I lead the first half of discussion with structured questions. For the second half I kept discussion open to get more individual suggestions and reflections on the experience. Focus group discussion script can be found in appendix.

The topic of the focus group mainly focused on the following aspects:

- Immersion level of the overall sonic experience and its connection with the physical structure and visual experience.
- Sense of the spatialized soundscape and the presence of spectral memories
- Narrativity of the environmental sounds and the oral history content.
- Reflections of the experience
- Performance of the system
- Others

4.1.3 Survey

The take-home survey is provided to participants after all the on-site activities. I choose to provide the survey for people after the focus group discussion because: a) participants will have a more comprehensive and structural understanding for various aspects of experience from the discussion based on other people's points, b) save more time for participants on-site. The survey question consists of two parts:

Quantitative question

- Rating the following aspects of the experience: **Immersion, Realism, Narrativity, Engagement, Cultural Richness, Social Richness, Historical Richness**

Qualitative questions

- How much time did you feel like to spend for the experience?
- Did you feel like you were influenced by other people's movements on the site?
- What was your strategy moving inside the site?
- To what extent did you react to moving memories?
- How far in advance could you predict the location and movement of the audio sources?
- To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

- Did anything hold you back during the experience?
- Describe the most memorable moment during the experience.
- How do you feel when looking at an existing structure and listening to the sounds accordingly?
- Other Personal comments

Quantitative questions allow me to evaluate the performance of different aspects of the experience with a clearer and more objective standard. Qualitative questions, in another hands, provides open-ended environment and allows more unique ideas from the participants.

4.1.4 Data Encoding process

Before starting coding all the data, I will transcript everything and sort all the documents in the order of the participant's assigned tester number. Then I will check the validity of the data by picking a random sample of the completed surveys and transcription.

For the quantitative data collected from the survey, I will firstly convert the raw data into the digital chart for later analysis. As each keyword will be given a number value according to its relevance of the experience, the mean of each keyword is calculated for encoding the data.

Qualitative data are collected from both focus group discussion the short answer questions in the survey (Question 2 to 12). I will start by reading through the data several times to get familiar with it and then I will start analyze through looking for basic pattern and common topics in the transcarips. After analyzing the basic pattern I will come up with the board concepts and its relevance to the research objectives.

4.2 Results

In this section I will analyze the qualitative and quantitative data I got form 10 participants and encode them into key insights. The analysis result will help to evaluate the performance of experience and system design and will also provide me with more sophisticated perspectives in the later discussion of the research questions.

4.2.1 Qualitative Data

Figure 45. Participants gathering in front of Stationary Car Dumper

One focus group discussion session was held after all the visitors experienced the project on March 9th 2020. Nine visitors attend the focus group discussion. The whole session was audio recorded for transcription under the consent by all the visitors. The complete transcript can be found in the appendix. A.3.

Time slip and Immersion:

" I feel like… going through the site and um hearing the sounds of the machines and operations while you are in the machines and looking at the stop and hearing the people who were operating those things and saying what they did and … you kind of like … It's almost like an informational tour but is so much more than that."

During the discussion, there are a lot of people expressed their astonishment of how immersive the entire experience is. Participant 3 said that when he was inside the machines he stopped and look around hearing the all sound of the machine and people who were operating those things and saying what they did he feels like an informational tour but so much more than that. Active sound elements bring the participant into a living scene though the landscape even though the structures stays static.

Connection between audio and visual element:

"Hearing about like all the technology they added which you know the stationary cars and the different cooling things and also hoarding the train going in the background, just naturally like oh yap this is still … we are still living in this infrastructure. Uhm, for that I think it also made it feels very real, which is nice."

Soundscape enhances the immersion when visitor starts to build the connection between the sonic and visual elements. Adding the situated sound can help to form a more immersive experience when it comes to the situation that the participant can find the connection between the audio and visual elements. Participant 3 mentioned that when he walked to the stationary car hearing people introduce all the technology and the hoarding train going in the background, he naturally felt that we were still living in this infrastructure and everything was so real like they were back to live again. Thus, when the participants capture the matching details from both the digital audio and physical structure, they will automatically create an immersive scene in their mind where the presence of each element is enhanced.

Bodily immersion:

Figure 46. Inside Stocking house (Tunnel)

"I like the tunnel because it's creepy and the sound there is … I think it is something dropping, right? I felt something might drop in the real world so … I found it was interesting."

"Yeah, very impressive and the most impressive moment is the deer. And some artist are talking about their experiences and there are also some background sounds like the bird chirping and the train passing by so it's very immersive. like all kinds of feelings, experience and the sounds, the

sunlight shines into the factory it's like very … yeah… you got me. So it's very impressive and immersive."

Not only can soundscape enhance people's empathy towards the historic events and structure it also helps to enhance the full bodily immersion in the physical environment. Participant 9 brought up her experienced inside the tunnel (stocking house as what she refers to). The environment was really creepy and when she heard the sound of material dropping, she felt that something might really drop in the physical world. Participant 6 mentioned the deer and the artist talk as his most impressive moment. He said that when he accidently went into the deer the physical environment, the sounds and the sunlight were perfectly matched together. Suddenly all kinds of feeling emerged. In both cases, the soundscape stimulates the full body experience which goes beyond the multi-sensory sonic and visual experience I imaged before.

Atmospheric contrast of Soundscape:

"I think it is … it's immersive. It's definitely… I mean now that I look back at it, you know and it's so peaceful and quiet, and I hear birds chirping, but when I was in the heart of the Blast furnace when it … gets really dark and you heard all the sounds, it's really reminiscent of … um … what might have happened in the past."

Other than discussed his direct experience in the soundscape, Participant 5 spoke about how the atmospheric contrast created by soundscape and how such contrast made him reminiscent and curious about what may have happened in the past. We were sitting in a very quiet and sunny garden environment for the discussion, and he said that when looking back to the core area of the Carrie Furnace very thing feels so peaceful and quiet, but when he was in the heart of all the structures it was very dark and noisy. The atmospheric contrast between various areas in the landscape and soundscape hints the changing of time which again greatly dramatizes the mixing status of the past and the present.

Presence of spectral memory:

"Uh-huh. And, also you told me that the sound will move and I will have to follow the sound and after that I kept following the sounds and the experience started to turn into a game. That's when I suddenly start to focus more on the sound rather than the site."

"I really enjoyed how I was the one trying to look for people's recordings rather than like … like the users experience was nice in the sense that I was visiting the place rather than the person trying to tell me what their experience is, cause I feel that's how the museum's tend to be oriented and it can feel a little bit like the people that are telling their stories don't really have the autonomy over their narratives, but because I was like dropping in the middle of a person speaking I almost feel like I was really like being placed into their life story rather than them

trying to tell me a story. So I don't know, it was really nice. And I really loved how ambient sound was changing as we go through the site, especially in the tunnel when like, as people have mentioned that the trains that don't see right now I can feel it passing because of the sounds. It just like really enhance this, I don't know, the sensory experience."

When discussing the moving human voice sound, participant 9 mentioned that after she found out she needed to follow the movement of human voice sound the whole experience started to turn into a game. By following the sound, she suddenly found herself focusing more on the content. Participant 10 also mentioned that by encountering different human voice sounds she had the feeling that he was actually visiting the place and was dropping in the middle of a person speaking. Under such a setting, she felt that she was placed into their life stories rather than them trying to tell her a story. From their experience, we can see that the unique presence of each individual spectral memories was perceived by listeners through sound, and by adding movement to the sound not only was the presence emphasized but the engagement level of experience was also enhanced.

Interface and technical issue:

"also some suggestions about the user experience, because I'm kind of confused. You provide a video recording like right?on the screen right ? so sometimes I'm confused do I have to face my phone to the structures to hear the sound by the way it's not very helpful because most of the time I only need to see the things with my eyes and not looking them through the phone screen. So it is a little weird sometimes. I think I would preferred the interface to be something as simple as the Google map, and you just provide the markers of the current location and the audio sources. I think that's enough for me. But overall it's pretty good."

Other than the positive feedbacks on the soundscape and content design, people also express their critics on interface. Participant 8 said that although he knew he suppose not to stare at the screen but the camera view makes him feel confused and distracted sometimes so he suggested to simplify the interface. Besides the comments on interface, participant 7 also said that she realized the unstable accuracy of GPS at some areas and this cause the location shift of soundscape. Although this is a system bug it was very surprising for me as participant 7 said that she found the dislocation of sound a very interesting experience.

While focus group discussion let the participants to reflect their walking experience relatively free, the short answer questions in the survey focus more on specific aspects of the experience. For example, the participants' moving strategies, reaction to the spectral memories, and the influence of other people during the walk, A lot of the points that mentioned in the focus group discussion are emphasized again in some survey questions so I will leave them and discuss the new insights.

Figure 47. Inside Hot Blast Plant

Collective walking experience:

"I wanted to experience the site mostly by myself. I occasionally ran into people and stopped for a quick chat, but I generally avoided walking with a group."

"Yes, when I see someone standing in one place for a while, I would be thinking that there must be something interesting there. And for places that people just pass by and don't stop, I will pay less attention."

Other than the influence by the sounds, as a collective walking experience, the participants' movement are commonly influence by the other people at certain level, and such influence shows on various types of participants on different ways. The participants who want to have more interaction with the others or want to know more about what the others' are listening to tend to be influenced in an active way that they will actively approach the other people or go to the place where the others have been to. While the participants who enjoy exploring the landscape alone or want more surprise from the sounds show the passive influence by the others that they tend to stay away from the other people and avoid being part of the group. In both ways, the participants movements are influences by the presence of the others in the landscape.

Moving strategies:

"I do not have a strategy. I'm partly guided by the spatiality of the site and partly guided by the sounds. Sometimes when the app glitches, or when I don't hear any sounds, I tend to use the 3D bubble markers on the screen to reorient myself."

"Follow my intuition, but if something interesting happen, for example: workers' story I will follow the voice."

"Mainly three strategies:

a. *Following others at first*
b. *Combine the judgement from the image and the sound and move to the target*
c. *Look at map and decide where to go next."*

As the participants all choose their individual trajectory for exploring the landscape and soundscape, it is very important to know their moving strategies. Some common strategies of moving in the site from the answer:

- Randomly wondering
- Moving towards interesting structures
- Following the others path
- Following the location marker on the map

These strategies of walking the landscape are highly similar to the natural way of landscape walk. While the mixed reality technology adds an auditory level of experience it did not break the nature of landscape walk. This result exemplifies the success of integrating the new media technology into landscape walking in a relatively seamless way.

Passive interaction:

"I enjoyed the serendipity of the audio interactions"

"I think it makes more sense to don't control it but I walk around to discover it."

"Sometimes when the voice fade out or they speak too fast I would want to hear it again"

Around half of the participants like the way of having no control over their listening content. They enjoy the serendipity of encountering and interacting with the sounds, and at the same time they think having control over the sounds means they need to put effort on operating the device will distract them from the immersive experience. Another half of the participants wants have certain level of control over the sounds. Most of them expressed their disappointment of losing the stories they wanted to hear and want a more structured understanding of the site through the controllable content selection.

Interaction with spectral memory:

"I followed the audio if I was curious to hear more of the story. I liked how the memories flowed in/out and how some were just brief glimpses into what it was like at that time in history."

"I generally allowed memories to move in and out of focus without trying to chase them. However, I would try to face the audio sources to enhance the sound"

"They were spooky sometimes, depending on the location. To me they've added a layer of information that enriches the environmental sound effects."

Most of participants will follow the spoken clips and try to get to the center of each audio source as close as possible. Others who enjoy the "spookiness" of the invisible spoken clips let the them flow in/out naturally without chasing them. For the environmental sounds, the participants tend to view them as part of the structure that will hint them to move towards various location. From here we can see the participants' understanding and the reaction to the spatialized audio resources. Different than the 2D sound which only convey the acoustic information, the 3D sounds provide the sense of space which allow the listener to react and interact with them spatially. The spatialization of the audio sources also emphasize their independent presences in space and form a stronger connection with the physical landscape. The unique environmental sounds are expected to happen at specific structure of the landscape. For the spoken clips, most of the participants cannot predict their location nor movement. They just assume them to happen all over the site.

Spectatorship:

"I like the "automatic" way, so that I won't be distracted by operating the device."

Some of the participants feel their movements are directly controlled or influenced by the audio clips that they will either slow down to listen to the content or follow the clips and move toward different directions. Some feel it depends on their interests of the audio content that they can autonomously walk away. There are two participants who specifically think there isn't any notion of controlling in the experience. They situate themselves as the pure spectator and all the audios as part of the environment that he simply appreciates rather than directly engage or interact with.

Most memorable moments:

When discussing the most memorable moment during the experience everyone provides very detailed description of specific scene and the audio content they listened. All these moments are so vivid and attracting. Just like the unique vocal quality in each

oral history clip, the text by each participant carries their power. Through these texts all the participants memories are also weaves into the collective memory of this project.

Figure 48. Carrie Deer Plaza

Participant 1*: "My favorite memories were the artist's ones (the owl!), but I also liked the different ambient/industrial sounds and how they moved with you."*

Participant 2*: "While hearing about jobs there and looking up at the blast furnace, I realized how scary and intense it would have been to work there. I am used to desk jobs."*

Participant 3*: "I really enjoyed being in the furnace area and hearing the sounds of the furnace operating. It made me think much more about the history of the space, rather than just focusing on aesthetics. Also, hearing trains going by in the background tied the whole experience to the present and the ways in which the history has shaped the city in which we live now."*

Participant 4*: "The object dropping sound in the tunnel, really make it immersive."*

Participant 5*: "Standing underneath the six stoves, which are disproportionately tall, peculiar looking and alienating. Enveloped by the roaring engine sounds, these industrial machines felt alive again. I felt a slight disturbance, fear, yet sublime sensation all at the same time."*

Participant 6*: "I love the entrance square where there was a deer sculpture. I was alone, listening to artists talking about this place, the sunlight shed through the factory, abandoned factory and art, train passing away in the background, old chairs & table. The nostalgic feeling was hard to express in language."*

***Participant 7**: "I really like the moment when I entered the tunnel. The environment was pretty quiet so that the sound dominated your feeling."*

***Participant 8**: "When I was walking down the road at the edge of the park, the strong sounds of machines and people came in and I feel that the past and the present are mixed. I think it would be better if we can have more sounds of machines or people outside and they can be just noise and don't necessarily need to tell some stories."*

***Participant 9**: "TUNNEL. The past voice will influence my feeling in the tunnel and I start act differently. I want to cover my head to avoid iron drop off."*

***Participant 10**: "After I went through the site and walked around the furnace, I felt a little bored about those steel structures. At that time, the short talk happened to start to play, which is about the meaning of keeping this landmark is to remind people of their lives in the old days. It is like a short conclusion which encourages you to explore more about this site."*

What worth noticing is that in order to "record" their memory of the landscape a lot of participants express their desire of taking photo while experience the audio walk. However, as the MR application occupies the camera and can not be run in the background they fight about whether to pause the audio and switch to camera for photo taking. While utilizing personal mobile device allows a more accessible way for people to enjoy this experience, the user experience issue of the application is also expose and leaves space for future improvement.

Overall, participants have a high-level satisfaction of the experience. Most of the participants feel a strong connection between the visual and auditory experience, the sounds provide a time-traveling like experience which brings them back to the old activities in the place and bring the structures back to live again. However, the juxtaposition between the vividness of soundscape and the emptiness of the rotting industrial structure reveals the layer of spectrality in the experience. Everyone feels the power of the mixed reality and thinks that combining virtual and physical elements in real-time interaction really enhances the experience as a whole and helps them to walk and explore the landscape in a more engaging way.

4.2.2 Quantitative Data

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	Mean
Immersion	5	4	5	5	4	5	5	4	2	4	4.3
Realism	3	3	5	4	3.5	4	4	5	2	4	3.75
Narrativity	3	3	4	3	5	5	4	5	4	4	4
Engagement	4	4	5	3	4	5	5	5	4	5	4.4
Cultural Richness	5	4	5	4	4	5	4	5	3	5	4.4
Social Richness	2	1	4	3	3	4	5	4	3	4	3.3
Historical Richness	5	5	5	4	4	4	5	5	5	4	4.6

Figure 49 Result of Survey Question 1

The form above shows the result of how the participants rate certain aspect of their site walking experience from 0 to 5. The first four keywords target the various sensorial experience aspects, and the later three keywords target different contextual contents. From the mean of each keyword we can see that 5 out of 7 get the score equal and above 4 (80%) in the range of 0 to 5, which represent a high level of satisfaction of the experience and the content. Historical richness gets the highest score 4.6 (92%), and the social richness gets the lowest 3.3(66%) among all keywords.

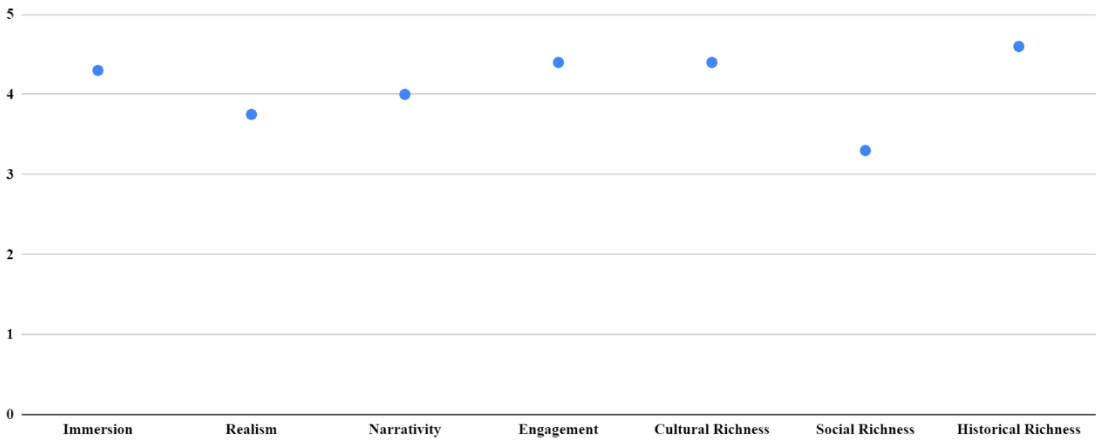


Figure 50. Mean value of scores

As the goal of this project is to create an immersive post-industrial landscape walk that celebrate the memory and narrativity of the landscape, the score above shows a pretty successful result of the experience. Most of the participants give fairly high score for the “immersion” and “narrativity”. The engagement level is also high which suggests the

participants' good acceptance of integrating the digital media technology in the walking experience and the harmonious balance of mixing the virtual and physical elements. Content wise the result also shows the well-developed cultural and historical richness of the project, however there is still space remains for the social aspect of the content to be developed and enriched.

What's worth noticing is that participant #1 and #2 gives "social richness" score 2 and 1, and participant #9 gives "Immersion" and "Realism" score both 2. When discussing the things that hold them back during the experience, participant #1 and #2 wrote the disconnection with the others and the vulnerability with wearing the noise-cancelling headphones. Due to the uniqueness of the site, as it was maintained in the original abandoned condition there are certain areas

Question 2 of the survey asks the participants to give an estimate length of time they feel like to spend for the experience. The longest time from the answer is by #8 who would like to spend 2 – 3 hours for the whole experience, and the shortest time comes from #2 and #9 who would like to spend around 45 min (0.75 h). For all 10 participants, the average time they feel like to spend is 1.225 hour. As I discussed in the section 3.4.4 the entire audio walk is designed to be around 1 to 1.5 hour long, and the data here shows a closely matching result to the intended experience time. While the result shows the high-engagement of all participants in the walking experience, it also hints the influence of audio sources to the participants' movement as the pure landscape walk at Carrie Furnace only takes around 15 to 30 minutes.

4.3 Discussion

Auditory Presence and Soundscape site-specificity:

One of the major focus of this thesis is the use of sound as medium to present the spectral presence of memory in an absent form. More specifically, how to construct the presence of the invisible element. Presence, the perceptual illusion of non-mediation, happens when listener fails to perceptually recognize the systems pf mediation between him/her and a virtual world or a virtual object.[62] The invisible and abstract form of sound reduce the greatly reduce the existence of such system. So, an auditory system with ability of providing us with spatial cues from the entire surrounding space is believed to be crucial for inducing high-presence experiences. [63] Such auditory system in this thesis is the

[62] Loomis, Jack M. "Auditory distance perception in real, virtual, and mixed environments." Mixed reality: Merging real and virtual worlds (2001): 201-214.
[63] Larsson, Pontus, Aleksander Väljamäe, Daniel Västfjäll, Ana Tajadura-Jiménez, and Mendel Kleiner. "Auditory-induced presence in mixed reality environments and related technology." In The Engineering of Mixed Reality Systems, pp. 143-163. Springer, London, 2010.

virtual soundscape. Spatial cues suggest the site-specificity and spatial property and individual agency of the sound. Just as what Janet Cardiff mentioned as “right on the spot” in her creation process, the perfect matching point of sound and view is vital.

For the single person immersive experience, presence does not only come from the environment but also come from the appearance of the participant to “being there” and this sensation in this thesis is formed with the participant’s spectatorship in the experience. The passive interaction with soundscape enhances the participant’s spectatorship during the experience and is evaluated to better convey the presence of spectral memory (sound) than the active interaction.

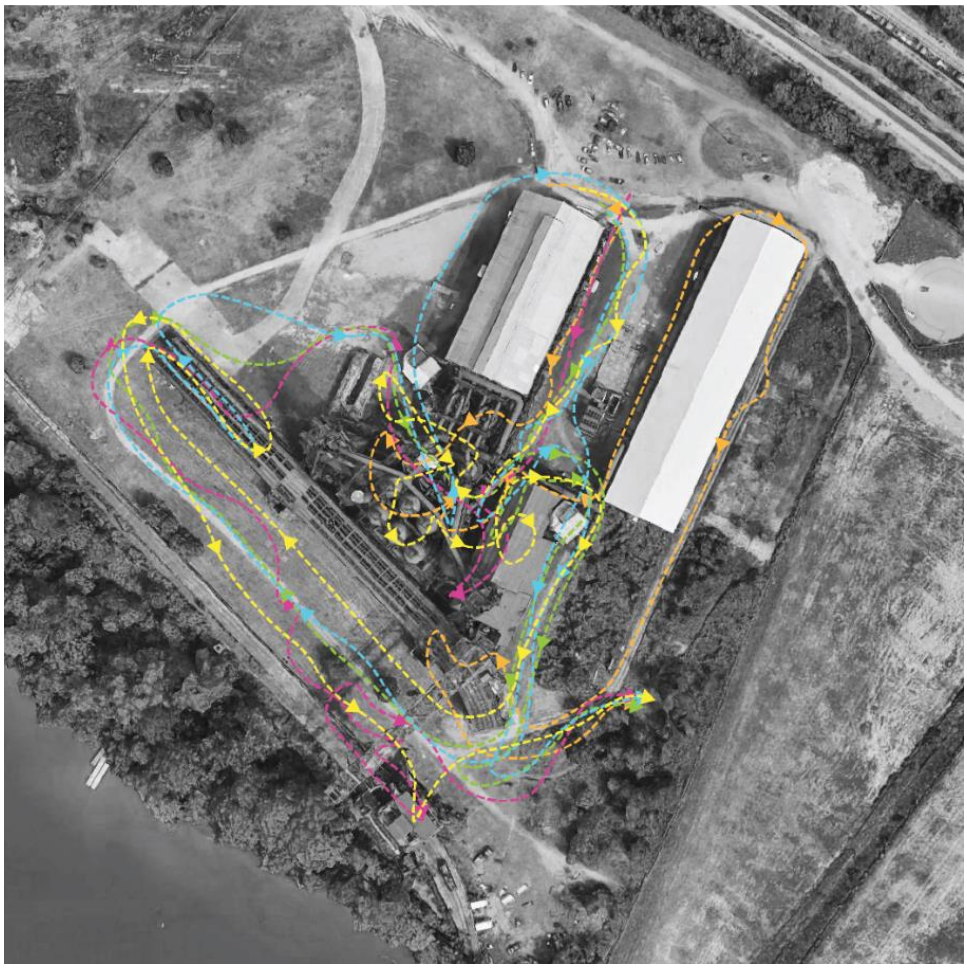


Figure 51. Participants' circulation

Open-ended and unguided narratives for space-driven wandering:

The map above shows the different trajectories participants took during the experience. (Individual trajectory please refers Appendix. A.1) Starting from the entrance plaza, everyone took their own path based on spatial interests. Some people take a clockwise path, from hoist house to stationary car dumper then travel through the stocking house to Carrie deer than to the iron casting house, and some people take a counterclockwise path which they start ‘form the heart of the blast furnace to Carrie deer than the other area. There also some people just wandering inside the space with any determined path. Either way they will experience all the key structures and all history content. However, it is the order of experience rather than the physical composition gives meaning to the narrative sequence.[64] The clockwise experience provides a storyline that corresponds to the manufacturing process of the iron from the raw ore to the final pig iron. The counterclockwise path provides a more time-slip experience as the participant will go straight to the industrial period with all the machines operating and then swiftly change to the post-industrial period where everything was abandoned and the artists took over the site with their creations. Each trajectory provides a different time and narrative experience and leave all the possibility of exploration open ended. Every participant has a deep, rich and meaningful experience while taking unique path through the audio contents. In this way, an idealized condition of non-linear spatiotemporal site-specific wandering experience is created.

Design Implications:

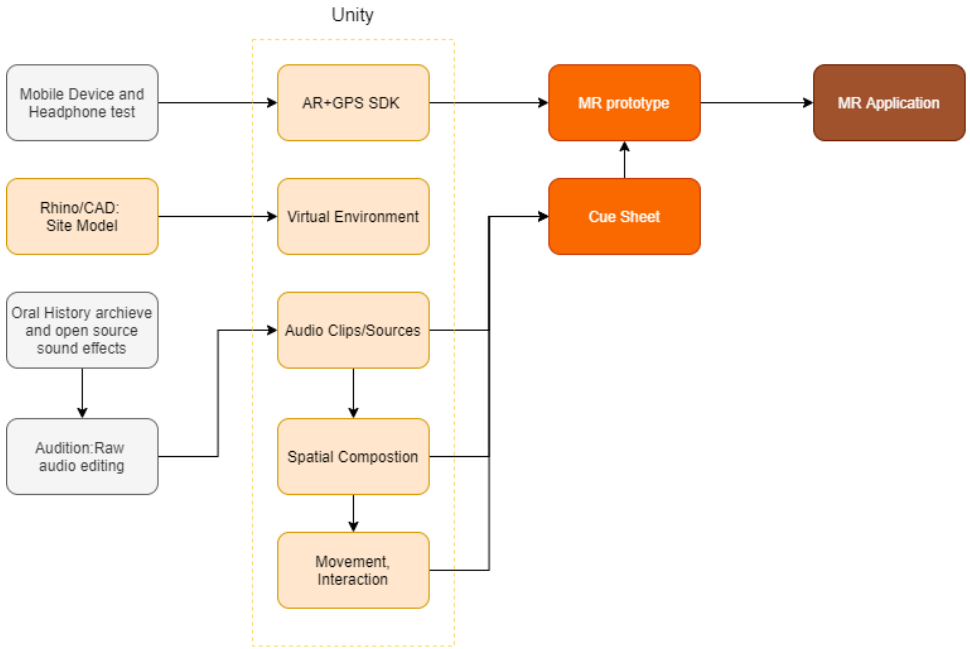


Figure 52. Design Workflow

[64] Potteiger, Matthew., and Jamie. Purinton. Landscape Narratives : Design Practices for Telling Stories New York: J. Wiley, 1998. p 112

There are mainly four stages in this design workflow: Preparation, Virtual experience building, Database translation, Application building. The preparation processes of content research and collecting are vital for the entire experience design as the level of amount and depth of the content will directly influence the designer's understanding of the site and impact the richness of the experience design. Building connections with local authority organizations can be a very effective way to gather valuable content materials for the specific site. For example, the local library, media press, or authority organization who run the site usually has its own collection of archive materials which usually cannot be found online. Also, consulting the archivist with specific topic interests will be very helpful to avoid losing in the ocean of archives. Parallel with content collecting, I also start to create the virtual environment of Carrie furnace in Unity for later virtual experience simulation. The hardware and software for mixed-reality are also built and tested in an on-site prototype with simple location markers and sound examples with various spatialization settings. This prototype than become the technical reference of the experience and interaction design. As the site is not easily accessible so having the technical reference and visual-based experience design platform is vital for creating a comprehensive on-site experience.

The virtual experience building in Unity is also key for this workflow as it not only provides a visualization platform for designing the sound spatialization and interaction mechanisms, it also provides a full simulation of the on-site experience. Being about to visualize the invisible element is vital for design site-specific activities as the spatial cue and visual cue of the virtual environment will provide a situated reference for the designer especially when the site is not easy for access.

Not only can it support the designer from experience simulation aspect, the nature of game engine also allows the designer to design and build the application on one single platform which great reduced the difficulty of technical works.

Future

5.1 Current limitations

Technical limitation

- The performance of the system now heavily depends on the accuracy of the GPS, however for landscape with a high level of spatial complexity this system will become very unstable.
- Due to the problem of system overload, now the experience cannot support very complicated environment sound effects.
- Now the system uses gyroscope and electromagnetic sensor to get the data of the user's position information, however the mechanism of these sensor limits the user's gesture for using the application.
- The system does not support data collecting function. Being able to collect more precise data (the exact sound the user encounter and their trajectory) is important for understand the collective experience with more users.

Design limitation

- This is the first time I explore the sound as a medium so I only have very limited knowledge with sound design.
- The original design intention was to reduce the screen-based interface as much as possible, however the value of interface was under estimated.

5.2 Future works

Technical Improvement

- In the future I would like to experiment with more tracking method for MR like combining Bluetooth beacon on certain areas for assisting the position recalibration when the GPS accuracy drop dramatically.
- I would like to explore the various audio editing method (audio mixer, other third-party plugin) in Unity to create more enriching and dynamic sound pattern in real time rendering with limited numbers of audio files.
- I would also like to include the data streaming function to the current system so more data about each individual experience can be collected for analysis.

Design Improvement

- The interface design for audio-based mixed reality on mobile devices need to accommodate other possible functions that the user might use during the landscape walk. For example, photo shooting or screen recording. The screen recording (real-time experience recording) allow the recorded moment (personal memory) to be shared with the others. During the lockdown time, I send the tested screen recording of on-site walk experience with a lot of my friends so they can all experience this project even if they are in home. By watching the first perspective video and listen to what the experiencer was experiencing, they feel they are entering another people's memory.
- Sound design can also be improved through implementing ambisonics sound and more accurate spatial wave file synthesis data.

Other opportunities

- Growing archive and memorial of oral memories for landscape: The possible future of extending the project into a growing archive and memorial of the people who have personal connections to certain landscapes. This this only creates a prototype of auditory representation for memory in the oral history. However, the system has greater potential to be developed into a forever growing digital archive of personal memory for any landscape. Potentially everyone can add their own stories in oral form and place it into the landscape. Just like the comments section in music application. Nowadays, people leave comments not only for critiquing the song itself, more often people write down their own story related to the song and gradually all these stories and memories themself form a unique atmosphere and a new world.

- Authoring tool: Follow the workflow the presented in this thesis, in the future there is potential for me to build the connection between each platforms I used and create an automatic pipelines with easy access interface so more designers who has limited technical experience can use the system to create their project and put their efforts more on content and experience design.

Conclusion

In conclusion, this thesis successfully created a spatiotemporal multi-sensory audio walk with mobile mixed reality technology. By evaluating the mixed reality audio walk, this thesis provides valuable insights for understanding the virtual presence of soundscape and its relationship to the physical landscape. More importantly, by exploring the design opportunities within such a relationship this thesis exemplifies how to use sound as medium to evoke the spectral memories of the post-industrial landscape. Taking the advantage of mobile mixed reality, this work has examined the structure of an open-ended and unguided audio walk. This system architecture provides greater flexibility for people to explore the landscape in an open-ended interaction with the content, and develop personalized narratives and their own storylines. Lastly, a suggested workflow for visual artists and designers to adapting these strategies to other similar site-specific contexts and audio walks is presented.

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Appendix

A.1 Selected Participants trajectory map

A.2 Sound Cue Sheet

Object Name	File Name	Length	Format	File Size	Digital Radius	Real Radius (m)	Volume	GPS Coordinate	Play on awake	Loop	Play Once	Activate Target	Wander AI	Hide Objects	Play Delay
Background_1	Background_1 - dimmed	2:34	WAV	56.4 MB	800	71.92	0.5	40.41288665579205 -79.89020168781282		x				x	x
Background_2	Background_2	2:01	WAV	44.6 MB	800	71.92	0.2	40.41288665579205 -79.89020168781282		x				x	x
Background_1 (1)	Background_1_01	2:34	WAV	56.4 MB	800	71.92	0.5	40.41343886808244 -79.89124453064507		x				x	x
Background_2 (1)	Background_2	2:01	WAV	44.6 MB	400	35.96	0.2	40.4135172880818 -79.89009869092116		x				x	x
Background_3	Background_1_01	2:34	WAV	56.4 MB	500	44.95	0.1	40.4135597655692 -79.88960516478984	x	x				x	
Background_3 (1)	Background_2_01_short	2:01	WAV	44.6 MB	500	44.95	0.05	40.4134061926714 -79.8897553688221	x	x				x	
Blast Furnace	Blast Furnace	0:37	WAV	9.15 MB	400	35.96	0.5	40.41336044736846 -79.89054501122156		x				x	x
Blast Furnace_far	Blast Furnace_far	0:39	WAV	14.3 MB	800	71.92	0.3	40.413115382983065 -79.8902446038119		x				x	x
Blast Furnace_far (1)	Blast Furnace_far	0:39	WAV	14.3 MB	500	44.95	0.02	40.41363165088969 -79.8895879992415		x				x	x
Blast Furnace_far (2)	Blast Furnace_far	0:39	WAV	14.3 MB	500	44.95	0.2	40.4131938036087 -79.8902059799366		x				x	x
Cranes	Cranes	2:22	WAV	34.6 MB	300	26.97	0.5	40.4126064634405 -79.890502631697		x				x	x
Cranes (1)	Cranes_far	2:22	WAV	34.6 MB	300	26.97	0.5	40.4127535032909 -79.8902301193266		x				x	x
Cranes_far	Cranes_far_01	2:23	WAV	52.7 MB	500	44.95	0.3	40.41271020785837 -79.8904505975952		x				x	x
Forging Press	Forging Press	0:39	WAV	9.59 MB	200	17.98	0.2	40.413118650464185 -79.88985836571375		x				x	x
hot saw	hot saw	0:29	WAV	10.7 MB	300	26.97	0.1	40.4131480580367 -79.88990128105799		x				x	x
Hot Strip Mill_far	Hot Strip Mill_far	2:58	WAV	65.5 MB	500	44.95	0.3	40.41327875896522 -79.8902059799366		x				x	x
Loading coke	Loading coke	2:30	WAV	25.3 MB	300	26.97	0.1	40.41235812879131 -79.89019578708394		x				x	x
loading	loading	1:00	WAV	14.7 MB	200	17.98	0.3	40.41225928399324 -79.890236020874		x				x	x
loading_far	loading_far	1:00	WAV	14.7 MB	300	26.97	0.3	40.412359762550295 -79.89027303450713		x				x	x
nail machine	nail machine	1:39	WAV	36.3 MB	300	26.97	0.5	40.41309904495169 -79.89042055665777		x				x	x
nail machine_far	nail machine_far	1:39	WAV	36.3 MB	400	35.96	0.3	40.41333430673621 -79.89074242173957		x				x	x
scrap dumped into a furnace	scrap dumped into a furnace	0:43	WAV	10.5 MB	500	44.95	0.6	40.41325915387329 -79.89036047511037		x				x	x
Steel cooling	Steel cooling	1:27	WAV	31.9 MB	200	17.98	0.2	40.41306310214123 -79.88996565374693		x				x	x
climbing ladder	climbing ladder	1:15	WAV	27.4 MB	100	8.99	1	40.4127788259656 -79.89006435884222		x				x	x
Ladle pouring molten iron into convector	Ladle pouring molten iron into convector	1:06	WAV	12.9 MB	100	8.99	0.6	40.41311211500315 -79.88990128073057		x				x	x
Ladle pouring molten iron into convector (1)	Ladle pouring molten iron into convector	1:06	WAV	12.9 MB	100	8.99	0.6	40.413069637357744 -79.88964808013408		x				x	x
Ladle pouring molten iron into convector (2)	Ladle pouring molten iron into convector_01				100	8.99	0.6	40.41325261917376 -79.88987982273103		x				x	x
Lathe switched on, turns steel, slows down, stops.	Lathe switched on, turns steel, slows down, stops.	2:41	WAV	27.1 MB	100	8.99	0.5	40.41328529441007 -79.8898068667768		x				x	x
Loading coke	Loading coke	2:30	WAV	25.3 MB	200	17.98	0.2	40.412572154120795 -79.8903712034553		x				x	x
Loading coke (1)	Loading coke_01				200	17.98	0.2	-79.8907037975369 -79.89062172184276		x				x	x
Loading coke (2)	Loading coke_02				200	17.98	0.2	40.41247902853147 -79.890317559275		x				x	x
scrap dumped into a furnace	scrap dumped into a furnace	0:43	WAV	10.5 MB	300	26.97	0.3	40.41293240104316 -79.88989698893421		x				x	x
Scrap lifted and dropped into steel-making vessel	Scrap lifted and dropped into steel-making vessel_01	0:30	WAV	5.16 MB	150	13.485	0.3	40.41351402086931 -79.89093983160274		x				x	x

Scrap lifted and dropped into steel-making vessel (1)	Scrap lifted and dropped into steel-making vessel_01	0:30	WAV	5.16 MB	150	13.485	0.3	40.413180733947044 -79.89054071877037		X				X	X
Scrap lifted and dropped into steel-making vessel (2)	Scrap lifted and dropped into steel-making vessel	0:30	WAV	5.16 MB	150	13.485	0.3	40.41307290546437 -79.89041197273765		X				X	X
Scrap lifted and dropped into steel-making vessel (3)	Scrap lifted and dropped into steel-making vessel_01	0:30	WAV	5.16 MB	150	13.485	0.3	40.41369373402386 -79.89119303187184		X				X	X
Scrap lifted and dropped into steel-making vessel (4)	Scrap lifted and dropped into steel-making vessel	0:30	WAV	5.16 MB	150	13.485	0.3	40.413615313731 54 -79.89106428551167		X				X	X
Shutting side of steel truck in steam railway goods yard.	Shutting side of steel truck in steam railway goods yard.	0:07	WAV	1.29 MB	150	13.485	1	40.41336044774239 -79.8907123798199		X				X	X
Shutting side of steel truck in steam railway goods yard. (1)	Shutting side of steel truck in steam railway goods yard.	0:07	WAV	1.29 MB	150	13.485	1	40.412932401541745 -79.89012873120375		X				X	X
TheSoundsofSteelmaking - plate mill	TheSoundsofSteelmaking - plate mill	0:45	WAV	7.67 MB	200	17.98	0.3	40.41319707195857 -79.88983261526302		X				X	X
Artist Center								40.4135932580818 -79.89031219469327								
1 Liz Hammond	1 Liz Hammond	0:38:57	MP3	53.5 MB	150	13.485	1	(5.4,0)	X	X			X (-1,1,-10,10)	X	
2 John Latell	2 John Latell	0:20:35	MP3	28.2 MB	150	13.485	1	(0,5.1)	X	X			X (-1,1,-10,10)	X	
3 Tim Yohman	3 Tim Yohman	0:35:40	MP3	49 MB	150	13.485	1	(-8.9,0)	X	X			X (-1,1,-10,10)	X	
4 Joe Small	4 Joe Small	0:39:28	MP3	54.2 MB	150	13.485	1	(0, -6.5)	X	X			X (-1,1,-10,10)	X	
5 Bob Ziller	5 Bob Ziller	0:40:16	MP3	55.3 MB	150	13.485	1	(-5.1,4.1)	X	X			X (-1,1,-10,10)	X	
6 George Davis	6 George Davis	0:41:12	MP3	56.6 MB	150	13.485	1	(-6.7,-4.5)	X	X			X (-1,1,-10,10)	X	
7 Tim Kaulen	7 Tim Kaulen	0:39.59	MP3	54.9 MB	150	13.485	1	(8.7,5.5)	X	X			X (-1,1,-10,10)	X	
Intro 01	Introduction 01	0:00:54	MP3	1.25 MB	300	26.97	1	40.41383832066461 -79.88930797573632			X	Ending 01	X (-1,1,-10,10)	X	
Intro 02	Introduction 02	0:00:28	MP3	681 KB	200	17.98	1	40.413798294313 -79.88941204508593			X	Ending 02	X (-1,1,-10,10)	X	
Intro 03	Introduction 03 (pittsburgh canal and rail)	0:00:25	MP3	604 KB	150	13.485	1	40.41349768355796 -79.88961374740029			X	Ending 03	X (-1,1,-10,10)	X	
Intro 04	Introduction Car dumper	0:00:37	MP3	888 KB	150	13.485	1	40.41252599990562 -79.89041894674303			X	Ending 04	X (-1,1,-10,10)	X	
Intro 05	Introduction of Rail (put near the train)	0:01:24	MP3	1.93 MB	150	13.485	1	40.41212531442789 -79.89003431757739			X	Ending 05	X (-1,1,-10,10)	X	
Intro 06	Introduction (near the blast furnace)	0:01:43	MP3	2.37 MB	150	13.485	1	40.41369046657064 -79.89071667161626			X	Place Holder	X (-1,1,-10,10)	X	
Ending 01 *	Ending 01	0:00:21	MP3	519 KB	150	13.485	1	40.414176097326354 -79.89084810018541			X	Place Holder	X (-1,1,-10,10)	X	
Ending 02 *	Ending 02	0:00:34	MP3	830 KB	150	13.485	1	40.41415567557584 -79.89044040441514			X	Place Holder	X (-1,1,-10,10)	X	
Ending 03 *	Ending 03	0:00:27	MP3	650 KB	150	13.485	1	40.41325915462118 -79.88890886306764			X	Place Holder	X (-1,1,-10,10)	X	
Ending 04 *	Ending 04	0:01:47	MP3	2.47 MB	150	13.485	1	40.41293240141709 -79.88913416862489			X	Place Holder	X (-1,1,-10,10)	X	
Ending 05 *	Ending 05	0:01:23	MP3	1.92 MB	150	13.485	1	40.41266691327049 -79.8892790079117			X	Place Holder	X (-1,1,-10,10)	X	
African American labor	African American labor	0:01:10	MP3	1.6 MB	150	13.485	1	40.41272327811003 -79.89039909800341			X	Place Holder	X (-1,1,-10,10)	X	
African American Labor Gang worker (Put near blast furnac	African American Labor Gang worker (Put near blast furnace)	0:01:37	MP3	2.23 MB	100	8.99	1	40.41293893577379 -79.89071667161626			X	Place Holder	X (-1,1,-10,10)	X	
Casting Runner	Casting Runner	0:00:32	MP3	773 KB	100	8.99	1	40.413134987867565 -79.88987123946573			X	Place Holder	X (-1,1,-10,10)	X	
Dust Catcher	Dust Catcher	0:01:12	MP3	1.67 MB	100	8.99	1	40.41317746547173 -79.89003431757739			X	Place Holder	X (-1,1,-10,10)	X	
History about Eastern European worker	History about Eastern European worker	0:01:21	MP3	1.87 MB	100	8.99	1	40.41310231230898 -79.89086687532108			X	Place Holder	X (-1,1,-10,10)	X	

Larry man (Inside the bridge)	Larry man (Inside the bridge)	0:00:37	MP3	898 KB	150	13.485	1	40.41366432544338 -79.89111149265227			X	Place Holder	X (0,0,0,0)	X	
Ron Gault_Material Handler (Put near the Crane area)	Ron Gault_Material Handler (Put near the Crane area)	0:01:26	MP3	1.97 MB	100	8.99	1	40.41256970267985 -79.89020597895433			X	Place Holder	X (-1,1,-10,10)	X	
Sumarine Laddle	Sumarine Laddle	0:00:30	MP3	723 KB	100	8.99	1	40.413279576612574 -79.8897585868508			X	Place Holder	X (-1,1,-10,10)	X	
Women in the industry	Women in the industry	0:00:54	MP3	1.24 MB	100	8.99	1	40.41343886733458 -79.89142906642884			X	Place Holder	X (-1,1,-10,10)	X	

A.3 Complete Focus Group Discussion Transcript

People start walking to gather to the final gathering place, they firstly misunderstand the final meeting point.

Me: Thanks for taking the time to join me to talk about your site-visiting experience in the Carrie Furnace. My name is Yixiao Fu and I'm now a second-year master student at Carnegie Mellon University. I'm the designer of the Inner Memory of the Past Industry project. As you have all just experienced, this is an unconventional audio walk experience, and be more specific I would like to call it a spatiotemporal audio walk. I want to know what you like, what you don't like, and how this experience might be improved. There are no wrong answers but rather different points of view. Please feel free to share your point of view even if it differs from what others have said. Keep in mind that we're just as interested in negative comments as positive comments, and at times the negative comments are the most helpful. You've probably noticed the microphone. I'm audio recording the session because I don't want to miss any of your comments. People often say very helpful things in these discussions and I can't write fast enough to get them all down. I will be on a first-name basis tonight, and I won't use any names in the reports. You may be assured of complete confidentiality. Well, let's begin.

Me: Do you guys like the experience?

#3: Ya, I feel like… going through the site and um hearing the sounds of the machines and operations while you are in the machines and looking at the stop and hearing the people who were operating those things and saying what they did and … You kind of like … It's almost like an informational tour but is so much more than that. Hhhh… Ya, it was it was …. I just really enjoy it and I thought it was good.

#5: Oh, ya … I think it is … it's immersive. It's definitely… I mean now that I look back at it, you know and it's so peaceful and quiet, and I hear birds chirping, but when I was in the heart of the Blast furnace when it … gets really dark and you heard all the sounds, it's really reminiscent of … um … what might have happened in the past.

The location is … the GPS kept moving so I had to restart over and over again and also when I was at the Blast furnace I heard a lot of artists comment which I found was wired because I thought it was closer to the dear that I suppose to hear all the artists, but somehow I heard them at the hear of the mill with all the stoves and Bakst furnace. Um and ya… that's my criticisms.

#3: One thing I will add … I thought it was really neat over by the train. Hearing about like all the technology they added which you know the stationary cars and the different cooling things and also hoarding the train going in the background, just naturally like oh ya this is still … we are still living in this infrastructure. Uhh, for that I think it also made it feels very real, which is nice.

Me: Anyone else from this side?

#9: I like the tunnel because it's creepy and the sound there is … I think it is something dropping, right? I felt something might drop in the real world so … I found it was interesting.

Me: That's where they would load all the raw materials. Everything will drop into that … like … that wedge shape structure and then the larry worker will load the material to the skip car and then all the way to the top of the blast furnace.

#9: Uh-huh. And, also you told me that the sound will move and I will have to follow the sound and after that I kept following the sounds and the experience started to turn into a game. That's when I suddenly start to focus more on the sound rather then the site.

#4: There is one moment that I can heard four voices and I don't know where to go. Yeah, just this one place. It's more like, ok,I hear this one and I heard this one and I hear another one, and they are all over the place. And I don't know where to go next. So I just decide OK this way it's easier. Yeah that's my comments. Everything else works pretty fine.

#8: also some suggestions about the user experience, because I'm kind of confused. You provide a video recording like right?on the screen right ? so sometimes I'm confused do I have to face my phone to the structures to hear the sound by the way it's not very helpful because most of the time I only need to see the things with my eyes and not looking them through the phone screen. So it is a little weird sometimes. I think I would preferred the interface to be something as simple as the Google map, and you just provide the markers of the current location and the audio sources. I think that's enough for me. But overall it's pretty good.

#6: Yeah, very impressive and the most impressive moment is the deer. And some artist are talking about their experiences and there are also some background sounds like the bird chirping and the train passing by so it's very immersive. like all kinds of feelings, experience and the sounds, the sunlight shines into the factory it's like very … yeah… you got me. So it's very impressive and immersive. I also Agree with #8 that the user interface needs to be improved.

#5: I personally use it to debug, like I mean when I feel that something is off, like supposedly the furnace is there, not supposed to hear the sound here, then I will use the phone to look at where those bubbles are being placed. But what I was going to say is that there were six big stoves, those big structures and I stared underneath among them. I feel like hearing the sound makes them, so much more, I don't know… like you feel almost sublime in a way. Because it's like you know, it's giant, it's weird looking, and it's… it's at an industrial scale. You are filling your scale compared to it it's just so out of proportion, and to some extent it's like you know it's kind of fearful in a way. I thought that having all those sounds involving you somehow enhanced that feeling.

#11: I really enjoyed how I was the one trying to look for people's recordings rather than like … like the users experience was nice in the sense that I was visiting the place rather than the person trying to tell me what their experience is, cause I feel that's how the museum's tend to be oriented and it can feel a little bit like the people that are telling their stories don't really have the autonomy over their narratives, but because I was like dropping in the middle of a person speaking I almost feel like I was really like being placed into their life story rather than them trying to tell me a story. So I don't know, it was really nice. And I really loved how ambient sound was changing as we go through the site, especially in the tunnel when like, as people have mentioned that the trains that don't see right now I can feel it passing because of the sounds. It just like really enhance this, I don't know, the sensory experience.

Me: I don't know if anybody called deep into the tunnel, because there is a story about a missing man…

#11: yeah, yeah I got that one.

Me: Do you wan to share that story you heard with the other people?

#11: I don't remember I think he says he is an engineer and …. Was that the one with the carbon monoxide poisoning or? Or that's the different one?

Me: the story is about a missing man fall into the pit of the skip car. Like, there is a water pit in the tunnel. He disappeared and the other people only found his wallet so they guess he might fall into the pit and missing. I don't know if anybody catch that one, but there are a lot of small stories that I put in the site here and there.

#7: I really like this, so the spatial experience along with this like audio experience which creates some like… A little problem is that sometime the location is moving when I also move which makes me a little bit confused when I experience the space. And actually the location of the sound is moving towards another place, and this is a little bit confusing for me. but overall the experience is very nice.

Me: so like when the sound clips started moving it is after you restart the app, all the sound sources will smoothly move from the origin to their GPS location. I didn't put them into the sense in the way that they will show up at certain location suddenly.

#7: But it also create an very interesting experience that everyone is listening to different set of sources, so that different people can have different experience which is an interesting output.

#6: I think one more point is that the whole site is so big, so I think maybe for some people you can add some directions for the circulations like how people can move from point to point. Because it seems that everyone has visited the tunnel but I don't know where that is.

Everyone laughing

#6: Yeah, I haven't been to the tunnel, so … Maybe you can provide the map for some people like me who want to explore the site thoroughly, a more detailed map to explore every spot.

#3: I feel like one of the nice thing was the act of discovery. You don't know what's gonna be where and kind just figuring out as you go. I feel like if you knew where things were it …

#6: Yeah, that's what I mean by some people. So maybe you can design a hidden button that …

#3: I feel like if you see some part of the site and you are like I haven't been there yet, so you just go there and …

Me: Did you go to the back area over there?

#6: Not so far. I don't know which area I can enter or not …

#10: I really like the way how the sound introduces you to the site from the entrance to the center of the structures. From the droplets to the bigger background sound and … but I found that after I going into the … like go through this way and along this way , I found the background sound has less difference. Like the change of the background sound is not that much, so … it's a little bit repetitive.

Me: Did you hear any clips with people talking over that part?

#10: I only hear the background sound.

Me: It is like that there are over ten clips of human voice, so the background sound was designed to have less details in that area. The repetitive pattern is kind like a design choice I made. Because here is away from the main structure so I want people to focus more on the content of the oral history. Sad you miss the oral history part over there.

#10: And I also went into this hall (main building 1), but because there is no sound inside so I don't quite sure what's going on inside there.

Me: Did you like the interior structure?

#10: I thought that was a workshop area?

Me: Ture, so there is actually intended to be the meetup space for the beginning and there is no specific audio clips inside. Everyone laugh

#10: ok, now I got it, cause I was confused as it seems like a place for the employees here to do something...

Me: Thanks everyone for coming today. Um...I think everybody already mentioned about all the questions I want ask here, so thank you again for coming to experience this project, although I know it's not perfect in terms of the performance. I hope your guys like it.

#9: And also the weather helps a lot.

Me: Yeah, the weather really helps. There was one time that I came here in the snowy day, it's just freezing to death outside so I only stayed for around 15 minutes and I just give up. Because the wind is so strong the snow just kind of flying towards me vertically.

#9: But this place is supposed to be hot during the winter, right?

Me: Not really, so there are actually some clips over by the crane area talking about their working experience during the wintertime. I don't know if everyone encountered those clips …

Walking out the Carrie Furnace

A.4 Complete Bets Test Survey

Date:03/04/2020
Place:
# of testers: 1
Age: 30

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion Realism Narrativity Engagement
___5____ ___3___ ____3___ ____4____

Cultural Richness Social Richness Historical Richness
_____5_____ _____2_____ _____5_____

2. How much time did you feel like to spend for the experience?

1 Hour

3. Did you feel like you were influenced by other people's movements on the site?

Yes, I thought following them would lead me to more audio clips

4. What was your strategy moving inside the site?

I moved towards interesting structures and also followed the sound as it got louder.

5. Do you wish to have more control over the listening content?

No, I liked the way it was

6. To what extent did you react to moving memories?

I followed the audio if I was curious to hear more of the story. I liked how the memories flowed in/out and how some were just brief glimpses into what it was like at that time in history.

7. How far in advance could you predict the location and movement of the audio sources?

I don't think I could predict the audio clips - I just moved with them.

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

I felt a little of both, I was drawn to the audio clips, but also had the power to walk away if I wanted to hear a different one.

9. Did anything hold you back during the experience?

I felt a little disconnected since you don't interact with other people, and are on the phone with headphones.

10. Describe the most memorable moment during the experience.

My favorite memories were the artist's ones (the owl!), but I also liked the different ambient/industrial sounds and how they moved with you.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

I liked hearing about the stories related to different areas and I thought it was more powerful hearing it from the people who were there rather than a tour guide.

12. Other Personal comments

I loved it! Very interesting way to interact with a place and hear stories from the people who worked there. I liked how clops moved in/out and didn't necessarily finish. I would just improve some of the technical bugs and maybe make some suggestions at the beginning regarding what type of headphones to use or a general path to take,

Date: 3/04/20
Place:
# of testers: 2
Age:

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion Realism Narrativity Engagement
____4___ ___3___ ___3____ ___4_____

Cultural Richness Social Richness Historical Richness
_____4_____ _____1_____ _____5_____

2. How much time did you feel like to spend for the experience?

45 min

3. Did you feel like you were influenced by other people's movements on the site?

Yes, I thought they might have found interesting sound clips. I also didn't want to get separated.

4. What was your strategy moving inside the site?

I wondered. Towards points of interest. When I heard a clip I tried to move towards it. Sometimes I thought I had to stand still to hear stories, other times I thought I had to move.

5. Do you wish to have more control over the listening content?

Yes, I kept losing stories I wanted to hear.

6. To what extent did you react to moving memories?

I always moved towards the spoken clips

7. How far in advance could you predict the location and movement of the audio sources?

Not at all, I had trouble finding and following

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

I always moved towards audio, but when there were no stories I wandered freely towards what interested me.

9. Did anything hold you back during the experience?

The noise-cancelling headphones made me feel vulnerable to the danger of the site.

10. Describe the most memorable moment during the experience.

While hearing about jobs there and looking up at the blast furnace, I realized how scary and intense it would have been to work there. I am used to desk jobs.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

I felt more connected to the old activity of the place, but I felt less connected to the present experience of it.

12. Other Personal comments

As an art project it was interesting to better connect with the grittiness of the place. I gained more understanding of the experiences of past workers and activities there. The ambient noise was suggestive and the real voices of past inhabitants was haunting.

In comparison to a guided tour, I felt disconnected and isolated by my headphones. The ambient noise also began to wear on my ears and cause stress/discomfort. I had some trouble funding audio clips at times and when I did, I felt compelled to listen to the whole thing. I would have preferred a dense field of short clips, so I could freely move from one to the next with little concern, and less ambient noise, short + soft suggestive clips might be enough to give people a sense of it.

Date: 3-9-2020
Place: Carrie Furnace
# of testers: 3
Age: 23

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion	Realism	Narrativity	Engagement
5	5	4	5

Cultural Richness	Social Richness	Historical Richness
5	4	5

2. How much time did you feel like to spend for the experience?

1.5 hours

3. Did you feel like you were influenced by other people's movements on the site?

I wanted to experience the site mostly by myself. I occasionally ran into people and stopped for a quick chat, but I generally avoided walking with a group.

4. What was your strategy moving inside the site?

I mostly tried to keep moving toward things which I hadn't seen / heard before.

5. Do you wish to have more control over the listening content?

No, I enjoyed the serendipity of the audio interactions

6. To what extent did you react to moving memories?

I generally allowed memories to move in and out of focus without trying to chase them. However, I would try to face the audio sources to enhance the sound

7. How far in advance could you predict the location and movement of the audio sources?

I found that there was audio wherever I went and didn't feel the need to chase after any particular source.

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

I didn’t feel like there was any notion of control. I felt like the audio was part of the spatial experience, not something that I needed to engage with, just something to appreciate.

9. Did anything hold you back during the experience?

I kept switching to the camera app so that I could take photos, which stopped the audio I was listening to and would sometimes cause the app to restart when I switched back to it.

10. Describe the most memorable moment during the experience.

I really enjoyed being in the furnace area and hearing the sounds of the furnace operating. It made me think much more about the history of the space, rather than just focusing on aesthetics.

Also, hearing trains going by in the background tied the whole experience to the present and the ways in which the history has shaped the city in which we live now.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

It definitely added to the experience, made me understand how the various parts of the furnace were used, and allowed me to imagine the history of the furnace.

12. Other Personal comments

I enjoyed it. Thank you!

Date: 3/9/2020
Place: Carrie Furnace
# of testers: 4
Age: 25

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion Realism Narrativity Engagement
___5_____ __4_____ ___3_____ ____3_____

Cultural Richness Social Richness Historical Richness
_____4_____ _____3____ _____4_____

2. How much time did you feel like to spend for the experience?

One and a half hours.

3. Did you feel like you were influenced by other people's movements on the site?

No.

4. What was your strategy moving inside the site?

Following the nearest sound effect's guidance.

5. Do you wish to have more control over the listening content?

No.

6. To what extent did you react to moving memories?

Try to get closer to the center of the ambient sound and feel the atmosphere in that specific surrounding environment.

7. How far in advance could you predict the location and movement of the audio sources?

In some circumstances, for instance, the deer, I can guess the sound effect is about that object and I will move closer to that.

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

Feel like being controlled by the audio.

9. Did anything hold you back during the experience?

In some places, there’re more than one sound and audio sources which are equally attractive, making me confused to decide where to go next.

10. Describe the most memorable moment during the experience.

The object dropping sound in the tunnel, really make it immersive.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

Feel like a time-traveling experience.

12. Other Personal comments

A better UI maybe?

Date: 03/09/2019
Place: Carrie Blast Furnace
# of testers: 5
Age: 28

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion	Realism	Narrativity	Engagement
4	3.5	5	4

Cultural Richness	Social Richness	Historical Richness
4	3	4

2. How much time did you feel like to spend for the experience?

An hour to an hour and half.

3. Did you feel like you were influenced by other people's movements on the site?

Not significantly, but other participants' movements do suggest places to explore.

4. What was your strategy moving inside the site?

I do not have a strategy. I'm partly guided by the spatiality of the site and partly guided by the sounds. Sometimes when the app glitches, or when I don't hear any sounds, I tend to use the 3D bubble markers on the screen to reorient myself.

5. Do you wish to have more control over the listening content?

Yes. I'd like to hear more about the history of the site and get a more coherent understanding.

6. To what extent did you react to moving memories?

They were spooky sometimes, depending on the location. To me they've added a layer of information that enriches the environmental sound effects.

7. How far in advance could you predict the location and movement of the audio sources?

I don't have a strong experience of the movement of the narration. To me they seemed static. But in general if I see a blast furnace or a stove I would expect loud noises coming from that direction.

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

I felt that I have no control over the audio. To a small extent my movement is affected by the environmental sound effects.

9. Did anything hold you back during the experience?

Some locations get a bit too dark and eerie, but otherwise I haven't felt impeded.

10. Describe the most memorable moment during the experience.

Standing underneath the six stoves, which are disproportionately tall, peculiar looking and alienating. Enveloped by the roaring engine sounds, these industrial machines felt alive again. I felt a slight disturbance, fear, yet sublime sensation all at the same time.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

The sound really brought the structure back to life again. It added a layer of nostalgic yet eerie sensation against the emptiness of the abandoned site.

12. Other Personal comments

The site had offered quite a variety of spatiality, from dark and compressed spaces to the bright and open fields. Moreover the industrial landscape is strangely alienating because the forms and materials were all servicing an industrial process as opposed to the familiar and everyday spaces. I think these fine spatial granularities offer opportunities to explore one's movements, orientation and body positions in a particular space in relation to the added environmental sound effects.

Date: **3.9.2020**
Place: **Carrie Furnace**
# of testers: **6**
Age: **25**

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion	Realism	Narrativity	Engagement
5	4	5	5

Cultural Richness	Social Richness	Historical Richness
5	4	4

2. How much time did you feel like to spend for the experience?
1 hour

3. Did you feel like you were influenced by other people's movements on the site?

Yes, I tried to avoid people since I prefer accidental engagement. Seeing others listening to their phones is kind of a spoiler of experience.

4. What was your strategy moving inside the site?

Almost random. I prefer to explore those interesting places in the site.

5. Do you wish to have more control over the listening content?

No.

6. To what extent did you react to moving memories?

Just normal.

7. How far in advance could you predict the location and movement of the audio sources?

Depends on the place itself. Some places are quite iconic.

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

Neither, it was well balanced. I like the feeling like I was joining an audio story and if I was not interested, I can just leave.

9. Did anything hold you back during the experience?

1. The site was complicated. I could not know which places are supposed to be entered, some places were not seemingly safe even though there was no yellow chain.
2. GPS precision, weak signal, inconsistent listening experience.
3. User experience of the app. Background running ability is a must. I just wanted to play a little BGM while listening to the memories. Too much irrelevant info displayed on screen. Volume was too low.

10. Describe the most memorable moment during the experience.

I love the entrance square where there was a deer sculpture. I was alone, listening to artists talking about this place, the sunlight shed through the factory, abandoned factory and art, train passing away in the background, old chairs & table. The nostalgic feeling was hard to express in language.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

The scenes were like rising before my eyes.

12. Other Personal comments

This site itself was a nostalgic place and with your audio, it becomes more fascinating. It reminds me of one of my favorite games: Nier Automata. It also has scenes in an abandoned factory, visual atmosphere and BGM matches what I have seen today, I was moved in another way.

Date: 3/10/2020
Place: Carrie Furnace
# of testers: 7
Age: 25

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion Realism Narrativity Engagement
____5____ ___4___ ___4____ ____5____

Cultural Richness Social Richness Historical Richness
_____4_____ _____5_____ _____5_____

2. How much time did you feel like to spend for the experience?

1 hour

3. Did you feel like you were influenced by other people's movements on the site?

Yes. Actually, I am curious if others stop at some spots.

4. What was your strategy moving inside the site?

Mainly three strategies:

- Following others at first
- Combine the judgement from the image and the sound and move to the target
- Look at map and decide where to go next

5. Do you wish to have more control over the listening content?

Yes for some of the contents. If there could be a theme or a short description of each content, it will help understanding the topic and intention. Besides, for the clips I would prefer to have the choice to listen from the beginning when I arrive the position.

6. To what extent did you react to moving memories?

Captured fragments from the contents. Missed some details actually.

7. How far in advance could you predict the location and movement of the audio sources?

Not determined. 3-10m. Sometimes when I arrive it still feels like I need to move forward.

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

I feel more like I am controlled by the audio sources.

9. Did anything hold you back during the experience?

The movement of the sound source (after restart) makes me confused at some point.

10. Describe the most memorable moment during the experience.

I really like the moment when I entered the tunnel. The environment was pretty quiet so that the sound dominated your feeling.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

It is informative when you look at an artwork and at the same time someone is telling you why and how it is coming up with. Also it feels that you can imagine a vision of this space in the past when you hear the ambient sound related to former activities and scenes.

12. Other Personal comments

It was a really impressive experience. A small suggestion is that for now most of the contents are speech-based which makes me feel similar during the whole experience. I found it very interesting that different spaces could influence the feeling a lot. Maybe some unique experience could be designed and amplified accordingly. (I feel there are some, but maybe could be more)

Date: 3/09
Place:
# of testers: 8
Age: 25

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion Realism Narrativity Engagement
____4____ ___5____ ____5____ ____5_____

Cultural Richness Social Richness Historical Richness
_____5_____ _____4_____ _____5_____

2. How much time did you feel like to spend for the experience?

2-3 hours

3. Did you feel like you were influenced by other people's movements on the site?

Yes, when I see someone standing in one place for a while, I would be thinking that there must be something interesting there. And for places that people just pass by and don't stop, I will pay less attention.

4. What was your strategy moving inside the site?

Watching the map that I was given and try to go to the spots labeled on the map or represented as spheres in the app.

5. Do you wish to have more control over the listening content?

No, I don't. I think it makes more sense to don't control it but I walk around to discover it.

6. To what extent did you react to moving memories?

It relates the structures to what happened in the past and gives me better experience when exploring the site. Very impressive.

7. How far in advance could you predict the location and movement of the audio sources?

I was just referring to the map or other people's behavior for important spots.

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

I thinks the sounds controlled my movement. Sometimes I just walk around aimless and a sound that came to me will stop me.

9. Did anything hold you back during the experience?

It would be better if the app can give me more hints. By now the spheres represented in the app are not very easy to read.

10. Describe the most memorable moment during the experience.

When I was walking down the road at the edge of the park, the strong sounds of machines and people came in and I feel that the past and the present are mixed. I think it would be better if we can have more sounds of machines or people outside and they can be just noise and don't necessarily need to tell some stories.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

Combining visual experience with stories is pretty cool and enhanced my experience as a whole. Without sounds, what I would be doing is just walking around, taking a few photos, and leaving without that much memory about this place.

12. Other Personal comments

I think the fading effect can be improved because previously Yixiao showed me that the sound can attract people from some distance and will become louder when people get closer. But I didn't feel this effect worked significantly at the site.

Date: 03/09/20
Place:
# of testers: 9
Age: 28

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion Realism Narrativity Engagement
____2___ ___2___ ___4____ ____4____

Cultural Richness Social Richness Historical Richness
_____3_____ ______3_____ _____5_____

2. How much time did you feel like to spend for the experience?

45 minutes

3. Did you feel like you were influenced by other people's movements on the site?

Yes, if I saw my friend walked by I will approach there and ask: What are you listening right now? Did you see the tunnel? (for example)

4. What was your strategy moving inside the site?

Follow my intuition, but if something interesting happen, for example: workers' story I will follow the voice.

5. Do you wish to have more control over the listening content?

Yes, Sometimes when the voice fade out or they speak too fast I would want to hear it again

6. To what extent did you react to moving memories?

I will try to follow, but I quit quickly if I can not find it.

7. How far in advance could you predict the location and movement of the audio sources?

I can not predict… I can image there will be many sound related to the blast furnace

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

I fell I was controlled by audio sources, the sound also push me to explore the place I won't go, for example, normally I will avoid the muddy road or dark place but I will go

there for sound in the experience. Also, sometimes the sound will influence my perception of direction. When I stay in a certain area without hearing anything I will have the wrong impression that I walk into a new area while in fact I just return to the same point.

9. Did anything hold you back during the experience?

Climbing up to the second floor I guess. I'm not quite sure where I can't pass

10. Describe the most memorable moment during the experience.

TUNNEL. The past voice will influence my feeling in the tunnel and I start act differently. I want to cover my head to avoid iron drop off.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

Not really related actually, because I also didn't know what they were supposed to sound like. However, when I standing on the open grass field and listening to the sound I will image the working condition for the former workers.

12. Other Personal comments

For the interface, since I know the issue with GPS I always keep my eyes on the accuracy bar and I like the ball because I can know where I can found audio sources. I am afraid I missed any audio source which will cause the experience to be incomplete. I also want to know what others heard about. Sometimes when I found that I did not hear the part that others hear I felt very disappointed.

Date: 3/9/2020
Place:
# of testers: 10
Age: 25

1. How do you rate the following (0-5) according to your site-visiting experience?

Immersion Realism Narrativity Engagement
____4___ __4____ ____4___ ____5____

Cultural Richness Social Richness Historical Richness
_____5_____ _____4_____ _____4_____

2. How much time did you feel like to spend for the experience?

1 hour

3. Did you feel like you were influenced by other people's movements on the site?

Yes

4. What was your strategy moving inside the site?

Follow the instruction point on the printed map, and also follow people's movement

5. Do you wish to have more control over the listening content?

No. I like the "automatic" way, so that I won't be distracted by operating the device.

6. To what extent did you react to moving memories?

None.

7. How far in advance could you predict the location and movement of the audio sources?

I didn't have prediction on the talk part, but I did predict the background steam sound.

8. To what extent did you feel like you were in control of the audio sources or you were controlled by audio sources?

I think I was not in control of the audio. The audio was like part of the environment.

9. Did anything hold you back during the experience?

When I was at the entrance, I was listening to the small droplet sound. Than as I went into the center of the furnace, the louder steam sound starts and the surrounding became very quiet.

10. Describe the most memorable moment during the experience.

After I went through the site and walked around the furnace, I felt a little bored about those steel structures. At that time, the short talk happened to start to play, which is about the meaning of keeping this landmark is to remind people of their lives in the old days. It is like a short conclusion which encourages you to explore more about this site.

11. How do you feel when looking at an existing structure and listening to the sounds accordingly?

Amazing. My favorite part.

12. Other Personal comments

None