Location-based hybrid urban environment for intangible community heritage protection

Yang Bai

December 2022

Abstract

Making invisible elements that contribute to the construction of a community's memory and identity accessible, even to the community members themselves, presents a challenge to heritage conservation efforts[1]. Digital and mixed settings have the potential to assist in combining the tangible and intangible features of historic structures and objects, according to recent work in the field of digital heritage[2]. This article examines how intangible characteristics of a location, such as historically and culturally significant events, may be made visible and put in dialogue with a physical space, as well as with human activities, in a augmented reality environment. The research site is located in the Lower Hill District around the Freedom Corner in Pittsburgh, Pennsylvania, which is a monument and symbol of community discussion, unity, and civic engagement in the city[3]. I describe the creation of a location-based augmented reality application that overlays historical and cultural background information at Pittsburgh's Freedom Corner and its surrounding historical area, taking a broad view on community heritage as a spectrum of perspectives and activities generated and operated by communities themselves[4][5]. It provides a real-world illustration of how interactive augmented reality might assist the public in building understanding through experiences that interactively overlay heritage information within a physical landscape. It describes the interplay between historical research and advancement towards the environment's technical implementation.

Keywords

Intangible Heritage, Community Heritage, Location-based Augmented Reality, Oral History, Freedom Corner, the Lower Hill District

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1 Introduction

According to a Post-Gazette research, 299 out of 1889 historically significant locations in Pittsburgh were lost, or about 16 percent of the individual structures, and that many more were expected to be destroyed in the near future[23]. The loss of structures that are on the register is only a small portion of the overall loss of the city's historical environment. This research indicates that in Pittsburgh, the use of urban space resources has increased in intensity with the growth of urban settings and the commercial regeneration of cities and more and more register-listed buildings are being demolished to make room for potential future expansion as a result of the construction of commercial structures and public services. The loss of historic assets and communities has been hastened by the lack of an efficient program for the preservation of historic buildings and investment in upkeep. Intangible heritages including traditions, memories, and the distinctive qualities of the neighborhoods have also vanished in addition to the actual buildings and structures. Urban development ought to be a dynamic, ongoing process with many overlapping layers, including those of historical significance. There is an urgent need to analyze and resolve the issue of how to protect intangible culture and its carriers during the urban regeneration process.

The heritage itself is more than simply an object on the site since it is both a monument and a component of the living fabric. It also includes immaterial elements like local cultural practices, traditions, and recollections. Scholar of Roman architecture and urban history Gustavo Giovannoni, who is credited with coining the phrase "urban heritage," emphasized the value of protecting historical sites while also recognizing the value of urban growth[24]. Based on the notion of contemplating heritage protection on a broad and inclusive scale, a landscaping approach to urban heritage management developed at the turn of the twenty-first century, which supported a strategy for thoroughly mapping and gathering the city's natural, cultural, and human resources as well as including the public and stakeholders in dialogue. A comprehensive contextual view of urban heritage that incorporates the idea of landscape resulted from the expansion of the concept of cultural heritage to include associative values and varied viewpoints from many participants instead of a focus on tangible assets.[25] In order to safeguard historical assets, the public "should be called on for recommendations and aid," according to the United Nations Educational, Scientific, and Cultural Organization (UNESCO)[26]. The historic urban landscape (HUL) is a tool for managing cultural heritage that is based on the idea that "when an urban settlement is properly managed, initiatives, opportunities, and development can contribute to both quality of life and conservation of cultural heritage, while ensuring a social diversity and justness"[27]. It suggests that it is important to put emphasis on the recognition and protection of heritage, which represents the intangible component, and public involvement in urban developing process. However, in light of the grave concern over the clash between demands for urban growth and historic preservation[28], it is ur-

gently necessary to develop tools using new technologies and media in order to portray heritage and foster a more equitable dialogue among many stakeholders.

Intangible heritage values, such as oral traditions, traditional arts, community engagements, celebratory events, can be seen as a collection of "traditions and living expressions inherited from our ancestors and passed on to our descendants" as Jigyasu points out in his research[29]. The transmission of these beliefs from one generation to the next is crucial for the long-term growth of our culture and society. In addition, a deeper knowledge of intangible values influences how people see the utilization of urban resources beyond economic considerations, which offers the potential to address urban development concerns in a more deliberate and thorough manner.

It has been a number of decades since museums, historic sites, and other relevant organizations used digital technology for legacy conservation, demonstrating the possibility of merging tangible and intangible components of historical structures and items through digitization. Digitization specifically offers chances for reviving previously suppressed narratives at the location[30][31]. More specifically, in order to advance social justice, it is crucial to pay attention to marginalized groups and their archives, according to a probable forgotten narrative in the process of urban development. To reflect certain distinctive or unique viewpoints that are easily neglected in a more broad historical documentation, these archives might be constructed based on historical resources like oral history recordings from tiny communities or groups. As an illustration, consider this oral history project by Densho, a nonprofit organization founded in 1996, which details the Japanese American experience from immigration to reparations with a special emphasis on the mass imprisonment during World War II.[32]

Augmented reality creates an interactive environment by modifying the physical world based on computer-generated perceptual data. The user's perspective of the real environment is merged with the digital world, which improves the integration of the two settings. In addition, augmented reality frees designers and producers from the institutional processes that are typical of traditional exhibit mediums for cultural assets[33]. Historical items can be found and positioned on the actual location inside metropolitan areas. This portrayal is more vivid and comprehensive due to the spatial continuity of history. Additionally, augmented reality makes it simple to offer individualized and personalized presentations of content. If they so want, anybody can create their own *personal* exhibits. Moreover, neither the general public nor community members can have an intuitive or immersive experience when learning about the intangible cultural heritage because the bulk of the aforementioned materials are cut off from the real place and physical space of the legacy. Because of this, augmented reality may be utilized to present local populations' memories on historical locations, illuminating the local history of community.

1.1 Research Question

This study investigates how augmented reality might produce a location-based hybrid urban environment at the intersection of urban heritage and community assets. More specifically,

a) How might location based augmented reality help people see the intangible aspects of urban heritage?

b) How might hybrid experiences improve understanding of local intangible heritage?

I offer "Hybrid View of Lost Heritage in Lower Hill District", an augmented reality tour at Pittsburgh's historical monument Freedom Corner and its neighborhood, to address the concerns raised above. This augmented reality tour told tales of how urban renewal in the 1950s influenced the present and future of this historic district and the growth and collapse of nearby communities. The semi-virtual contents immerse individuals in historical events using oral history data gathered and historical visual materials from public repositories. People may study the historical legacy and have a greater grasp of the mutual mapping of history and reality through the time series focused and location based experience. By utilizing this overlay knowledge, the intangible aspect of regional tradition is once more made concrete.

1.2 Contribution

By drawing from the previous works about digital heritage, this work adds to the field in the following ways:

a) Create a location-based augmented reality walk to explore, learn about, and comprehend the social, cultural, and historical facets of intangible heritage or destroyed tangible heritage. Investigate and comprehend how participants interacted with the walk's auditory and visual components based on how they responded to it.

b) Showcase the design process for a location-based augmented reality application for heritage exhibition. Collection of historical assets, system development, and experience design are all covered. Researchers with little expertise may create a location-based heritage walk more easily based on this procedure, which examines the presentation techniques of various aspects of local history.

c) Use the Lower Hill District and the neighborhood near Pittsburgh's Freedom Corner as an example to study how the augmented reality project contributes to the understanding of local history and heritage.

d) Provide a review of recent literature in the research field about digital heritage

1.3 Thesis Structure

In the thesis, I first present the research review about heritage definition and its protect. Then I go through the field of work about using extended reality for heritage study and protection. Also I offer a case study of Pittsburgh's Lower Hill neighborhood and some specific historical spots covered in the research.(chapter two) After that, I provide a hypothesis for the heritage preservation based on location-based augmented reality technique and its contributions.(chapter three) After that, I will describe the workflow of content gathering, system development, and experience design for the design development of "Hybrid View of Lost Heritage in Lower Hill District" (chapter four). The analysis of participant responses from the user test will be used to deliver the experience assessment result in chapter five. The conclusion (chapter six) and future work (chapter seven) will be covered in the last sections.

2 Background Research

2.1 Intangible Cultural Heritage

2.1.1 Definition and Value Evaluation of Intangible Heritage

Heritage is what we have preserved from the past, a record of the present, and a valuable asset to hand down to the next generation. It may take on a variety of forms, including tangible ones like places, structures, and landscapes as well as intangible ones such as oral histories, performance arts, social customs, religious observances, holiday celebrations, skills and customs relating to environment and the cosmos, as well as awareness and understanding relating to traditional handicrafts. Even though intangible heritage is more vulnerable and invisible compared to physical heritage, it's still an essential aspect in preserving cultural variety[34]. Based on the evaluation of Su, Li and Kang's study, the value of intangible cultural heritage can be divided into four aspects: historical value, scientific value, aesthetic value and economic value[35].

Historical value refers to how well intangible cultural heritage captures the experiences of locals during a particular era. In the study of Foster and Gilman in 2015, the word "local" puts the focus on particular locations which contrasts it with the word "global' 'via the gathering, comprehension, and analysis of resources and materials from the community[36]. Intangible cultural heritage therefore encourages a more accurate, thorough, and impartial view of history and can be seen as a flaw in official historical documentation. Secondly, intangible cultural heritage also contains scientific values which means local knowledge, ideas, and techniques may be gathered and established in this approach[37]. Thirdly, the aesthetic value of intangible cultural heritage supports the idea that plays, performances, tales, and other intangible arts may enhance people's spirituality[38]. Finally according to economic values, the intangible cultural heritage might be used as a resource to meet the needs of the local population by promoting tourism or the rest of the economy. In this condition, heritage sites are more valuable when there are more human activities on the site, and conservation that encourages retrofitting of assets is more valuable than inactive safeguarding[39].

Consider the Chinese practice of "Feng Shui"[40]. As a practical art that is deeply ingrained in human life, it depicts people's social and cultural activities over the course of several historical eras[41]. For both domestic space design and cosmopolitan planning and design, "Feng Shui" has been used as a guide. It is also regarded as a philosophical theory on how people and nature interact. By utilizing the idea in the areas of communication, design, and tourism, it also adds economic value. For instance, when building classical Chinese gardens such as the Summer Palace in Beijing, Feng Shui was used as an important consideration in determining building orientation and vegetation design.[42] It is hard to completely comprehend or examine the design of the Summer Palace

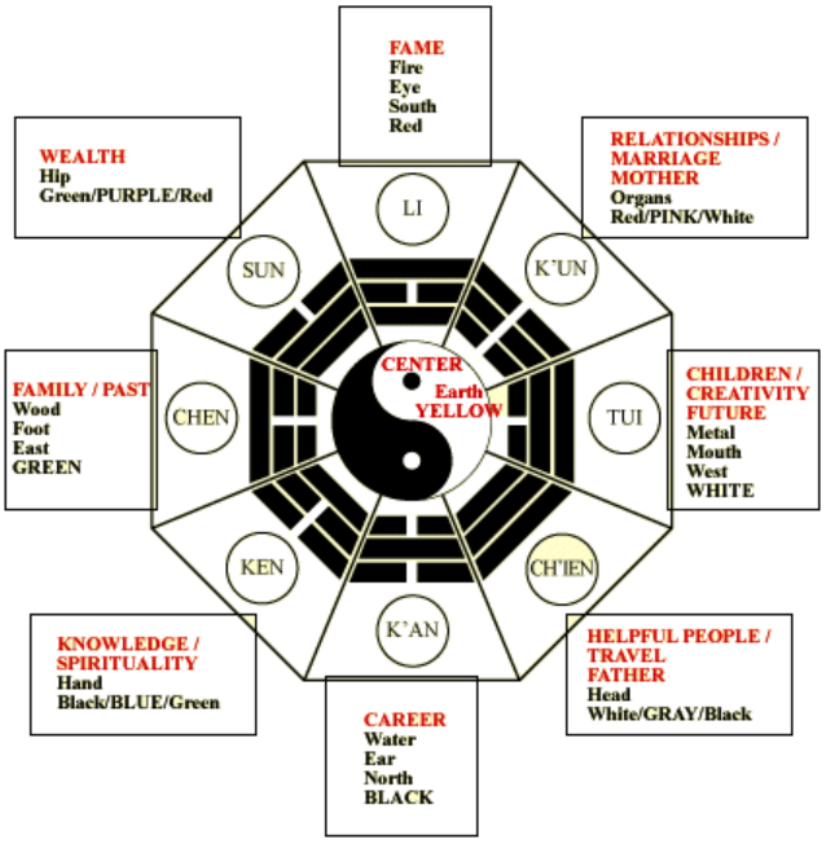


Figure 1: Feng Shui Theory based on Pa-Kua Image, photo on fenshuiart.com[6]

without knowledge of this intangible legacy.

Oral transmission of intangible heritage is possible within a community. Even if there are some distinctions between oral history and intangible cultural heritage: oral history aims to gather and preserve historical data from individuals and organizations whereas intangible cultural heritage strives to maintain cultural heritage with community members by safeguarding the mechanisms that allow traditions and common knowledge to be transmitted, oral narratives could be a valuable tool for comprehending historical occurrences or studying cultural heritage.[43] Take the project called "Memories of Occupation in Greece"[7] as an example. Multimedia testimonials about the German occupation of Greece from 1940 to 1944 were gathered and archived as part of the project. Throughout all, 93 interviews with survivors of the time were undertaken in Greece including different kinds of victims of this historical event

like individuals who were held in detention camps or those who saw reprisals. Generally, the research prompts thoughts on the function of cultural heritage in evoking memories and the possibilities of taking oral history as a source for study. Therefore, it can be claimed that compiling and analyzing these life experiences may be considered as a way to strengthen and protect a group's identity.



Figure 2: Rosina Asser-Pardo who used to hidden during the occupation was being interviewed for project "Memories of Occupation in Greece", photo by Dimitris Polidoropoulos in 2016[7]

2.1.2 Intangible Heritage protection

Heritage draws attention to values and objectives within the community by assisting in the formation of local identity. Both directly and indirectly, heritage has an impact on culture and society. The cultural legacy, which preserves evidence of historical, social, economic, and civic elements of community assets, is eliminated from urban space owing to accidents, natural disasters, or unrealistic urban development plans. For instance, in the research about the reconstruction after a earthquake in Irpinia, Moscaritolo claimed that the work progress shouldn't just focus on the repair of tangible "objects" like infrastructures or houses, but should also consider about the rebuilding as a " complex social process" that takes cultural contexts, expectations, and thoughts about the next generation into consideration.[44] This exposed the importance of intangible cultural heritage protection for the local community and the whole cultural background.

Many scholars have previously concentrated on the digital reconstruction of

historically significant sites in the field of cultural heritage preservation methods. A previous approach for heritage revival in the digital age has been created to address the issue of missing data and is based on crowd-sourcing and SfM algorithms.[45][46] Buildings and even massive structures are rapidly becoming part of the restoration scope. Although this strategy has numerous advantages for preserving and rebuilding cultural legacy, heritage is more faithfully restored as an item or physical asset. The physical form of the legacy is not combined together with other, more intangible elements, such as local culture, public activities, economic developments, etc. This research, on the other hand, offers a strategy for re-creating intangible heritage through an engaging story that is delivered in context.

Intangible cultural heritage also changes over time. Actually, it constantly innovates and changes because it is firmly established in specific areas and neighborhoods and is updated as those communities grow. Therefore, in order to preserve it as "a source of invention and innovation," the preservation strategy for intangible cultural assets should also take durability and renew-ability into account.[47] Many earlier academics have cited community involvement as a key strategy for protecting intangible cultural resources. In a 2013 study by Bakar, the authors discussed a conservation strategy based on the statistical correlations between social and demographic variables and the degree of community engagement in intangible cultural resources. It found that community issues like "acculturation and deculturation, preference of popular culture, weak family institution" affects the involvement of local intangible cultural heritage protection.[48]

Previous studies indicate a high level of community involvement is essential for heritage protection and community identification.[49] But the conventional recording of heritages shown as historical markers, texts, videos, or photographic archives lacks audience participation and interaction, which makes it tougher to pique the public's attention. Additionally, because the majority of the aforementioned resources are disconnected from the actual location and physical space of the legacy, neither the general public nor community members can have an intuitive or immersive experience while learning about the intangible cultural heritage.

2.2 Extended Reality for Intangible Heritage Protection

Virtual reality and augmented reality have already been used by a lot of scholars and artists to depict or portray both tangible and intangible heritages, such as historical structures, social events, local living situations, etc.[50][51][52] These media give a chance to dynamically and interactively convey assets of urban history by more accurately displaying site information and simulating the setting through visual and auditory components. By transporting users back in time and making them "eyewitnesses" to the historic figure, many virtual real-

ity projects that generate immersive experiences concerning local heritage are successful in fostering an intimate attachment between people and the past. For instance, independent virtual reality developer Derek Ham's project called "I'm a man" brings audiences back to the memory about the death of Martin Luther King Jr.[8] However, the entirely virtual experience is disconnected from the physical locations since viewers are more likely to be confused by the spatial ambiguity and lose track of the understanding of history and cultural heritage based on a specific site. Furthermore, since a virtual reality experience requires both touch devices and headgear equipment, the usage settings for this technology tend to be interior and static. When researchers attempt to integrate digital assets with physical surroundings, both historical and contemporary, it introduces additional limits.



Figure 3: A screenshot from "I'M A MAN" demo, reproduced by the author from Derek Ham's virtual reality project[8]

As a result, several academics concentrated on augmented reality's uses in the field of heritage protection. Nowadays, businesses and organizations are using augmented reality applications for heritage conservation, tour services, and public records due to technological improvements and the widespread use of mobile devices. As a virtual overlay over a real location, augmented reality might potentially enhance exhibiting approaches as well as the user experience. This is in contrast to other types of extended reality techniques like virtual reality and mixed reality. For instance, Sauter presented an location-based historical photo querying application called "GoFind!" in 2018. This project allows users to view multimedia collections based on searching for specific site, which makes the heritage assets more accessible and understandable.[53]



Figure 4: A screenshot from "GoFind!" demo, reproduced by the author from Loris Sauter's augmented reality project[**?**]

The two types of augmented reality are marker-based and location-based. Mark-based augmented reality, sometimes referred to as image recognition augmented reality, needs a marker to start the interaction, typically a trigger picture or QR code. Because it's simple to create and easy to use, this type of program is appropriate for advertising and entertainment usage to boost engagement.[54] For instance, in Natta's project in 2022, a marker-based augmented reality application was introduced to make a reconstruction of a parliament in Turin as shown in Figure 5.[9] However, the flaw is more blatant: marker-based augmented reality is less location-agnostic because it only functions when the camera is close to the marker. In large metropolitan areas that need user mobility and visual alteration like urban environment, marker-based augmented reality is not adaptive enough.

The technology behind location-based augmented reality, in contrast to marker-based augmented reality, doesn't need any actual markers or labels to function. Recent studies look at ways to make historical audiovisual collections available on mobile devices, allowing for the layering of historical information with present-day views via location-based augmented reality. For example, Boboc presented a project which uses location-based augmented reality to place the visual elements of an architecture on the according historical spot.[1] Programs like this are able to browse the back end for all results and save their locations. Users may move around the city environment, and when they arrive at a spot with historical background, they will receive a signal. Users are allowed to engage with concrete elements of urban heritage in a more approachable and engaging way thanks to the combination of digital and physical situations. The display of dispersed and static goods, however, also has drawbacks. Although it may be possible to represent physical heritage through static objects, there

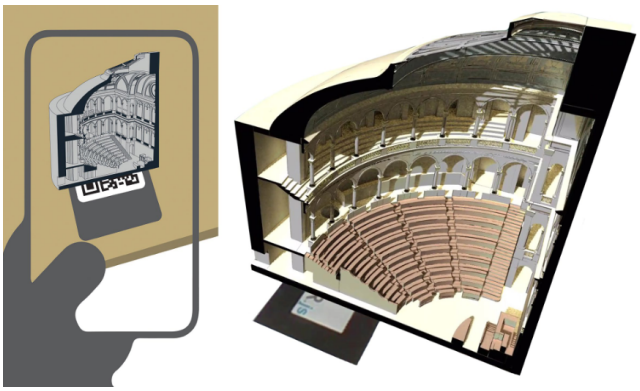


Figure 5: "reconstructive digital modeling and AR application on the chamber of the First Italian Parliament located in the courtyard of Palazzo Carignano in Turin", photo reproduced by the author from Fabrizio Natta and Michele Ambrosio's augmented reality project[9]

are yet no workable display or narrative options for intangible heritage like human activities or historical events. On the other hand, through a multimedia narrative experience in urban areas, this article truly offers a way to showcase intangible heritage via location-based augmented reality.



Figure 6: The display of a church based on location-based augmented reality, reproduced by the author from R˘azvan Gabriel Boboc's augmented reality work[1]

3 Hypothesis

Based on the aforementioned analysis and research, I predict that location-based augmented reality could offer a possibility to display intangible cultural heritage in a way that is more immersive and intuitive. Building a location-based augmented reality project to combine multimedia materials and map them with actual places is easier compared to traditional documentary approaches like photograph gathering, oral history collection, or documentary film. The augmented reality walk's blend of visual, audio, and interactive components will also provide a more engaging experience and aid users in developing a greater knowledge of the region's intangible cultural heritage.

4 Method Statement

In this chapter I discuss the development of "Hybrid View of Lost Heritage in Lower Hill District", the location-based augmented reality walk, from the following aspects: content collecting, system building and experience design.

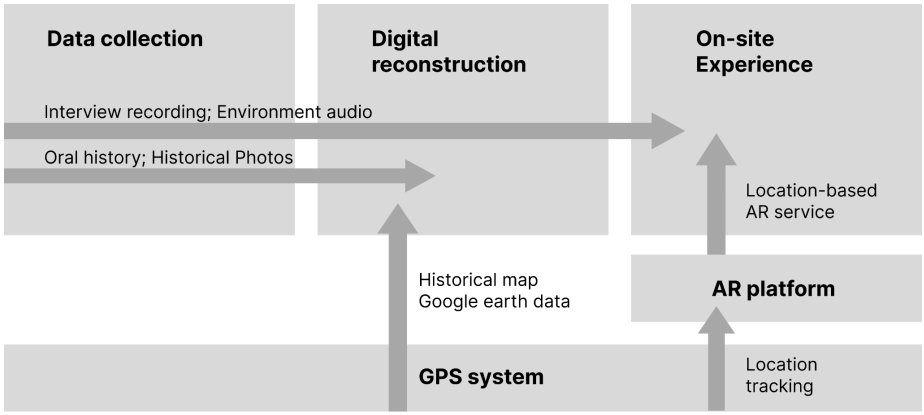


Figure 7: The method structure (Made by the author)

4.1 Case Study: Lower Hill District

4.1.1 History and Community Assets of the Hill District

One of Pittsburgh's original communities, the Hill District, was established in the early 1800s. The Lower Hill, the Middle Hill, and the Upper Hill, collectively known as the "Sugartop", are three communities that are situated on the mountains above downtown Pittsburgh. The Lower Hill District neighborhood was situated between Centre and Bedford Avenues. There used to be a vibrant

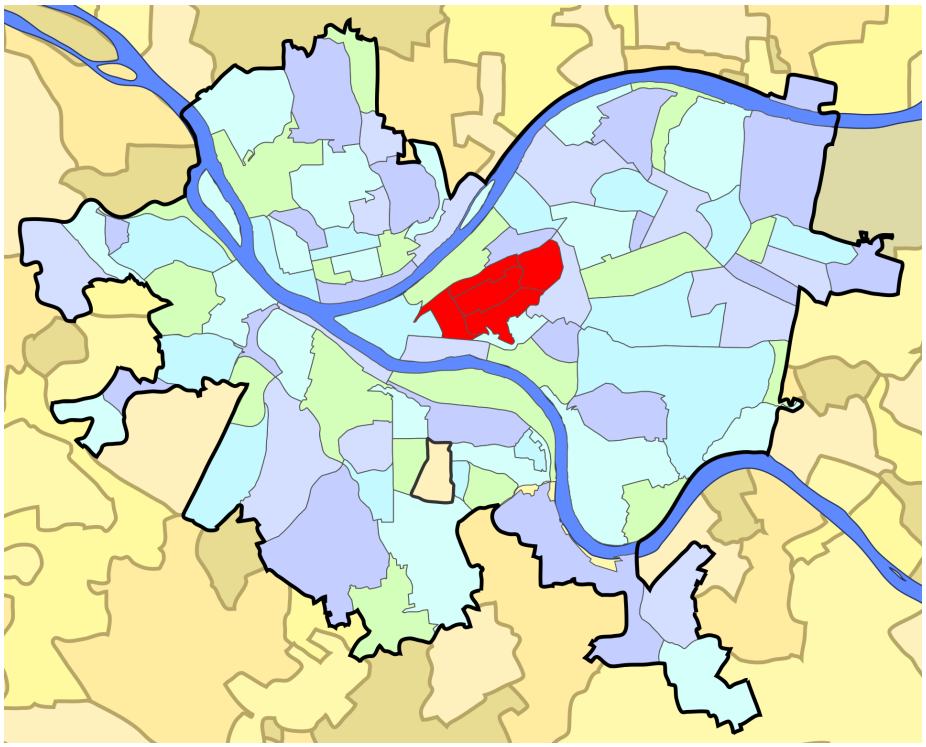


Figure 8: Location of the Hill District neighborhoods within the City of Pittsburgh, photo from Wikipedia "Hill District"[10]

living area with diners, barbershops, cinemas, grocery stores, schools, churches, community centers, and bars here. It's described as "a city within a city" as well as "Crossroads of the World".[55] This neighborhood intrigues me not only because of its extensive and rich history, but also because the Lower Hill locals were forced to leave the area and the entire living neighborhood was torn down during the urban development process. All of the bearers of intangible heritage also vanished. It's difficult to trace the history of a location when all that remains are the physical assets there, and a parking lot currently occupies the historical site. I concluded that it may be a great case study for figuring out how to rebuild the intangible heritage on the site using a hybrid representation made using augmented reality.

Hill District used to be a center of the abolitionist movement in Pittsburgh. 150 liberated slaves from Virginia arrived in Pittsburgh during the American Revolution. They were among the first people to settle in Hill, establishing enterprises and the Bethel A.M.E. church in 1818.[56] The Hill served as a hub for the underground activities and the abolitionist movement before the American Civil War under the direction of Martin Delany, Reverend Lewis Woodson, and

John Vashon.[57]

The Hill District contained 25 different races, according to the 1940 Census.[58] Many people from different racial groups like Jews, Italians, Greeks, and African Americans were involved in local business, regional activities and amusement establishments which gave the Hill's residents a thriving community life.

During this time, the local community's cultural, social, and economic components were lively and vibrant. The Monticello-Delaney Rifles basketball team, which won the Colored Basketball World Championship in 1913, was one of the successful African American basketball and baseball teams in the Hill District.[59] August Wilson, a Pulitzer Prize and Tony Award winning writer who was born and raised in the Hill District, wrote 10 plays on lives in the African-American community.[60] From the early 1920s until the 1960s, jazz developed and flourished in the bars, nightclubs, and playhouses of the Hill District. In the past, one of Pittsburgh's original jazz clubs was housed in the structure at 1213 Wyle Avenue called Local's 471 Musician's Club. For thirty years, this club featured outstanding jazz performances by both local and foreign performers and it also became an important place to offer all the musicians brotherhoods and support. At the club, they chatted, rehearsed, enjoyed music and also, delivered jazz performances.[61] The Bambola Social Club, which became a venue for performances by singers, shake dancers and bands, was one of Pittsburgh's Hill District's most well-known clubs during the 1940s.[62]

4.1.2 Urban Renewal Project in the Lower Hill

Urban Renewal, a movement for urban regeneration, existed from 1955 until 1963. With this project, Pittsburgh's "slum" that was near to the city center would be eliminated. It viewed the Hill District, which was largely made up of African Americans, as a "blighted barrier" to the development of the city. As a result, Mayor Lawrence and his administration opted to build the Civic Arena in the Lower Hill District in order to uplift this "slum" neighborhood. 1,239 black households were evicted as a result of the Urban Redevelopment Authority's destruction.[63] From 17,334 people in 1950 to 2,459 people in 1990, the Lower Hill lost lots of population during this period. People who were compelled to leave the region typically settled in areas that were racially homogeneous, which made the city's segregation issue worse. Pittsburgh was one of the most segregated American major cities by 1960.[64] Additionally, some historically significant buildings were removed, including the Bethel A.M.E. Church, whose members are still suing for damages currently.[15] Following the demolition of the Lower Hill District, public structures like the Civic Arena were constructed. However, in 2012, the Civic Arena was also taken down from the location.[65]

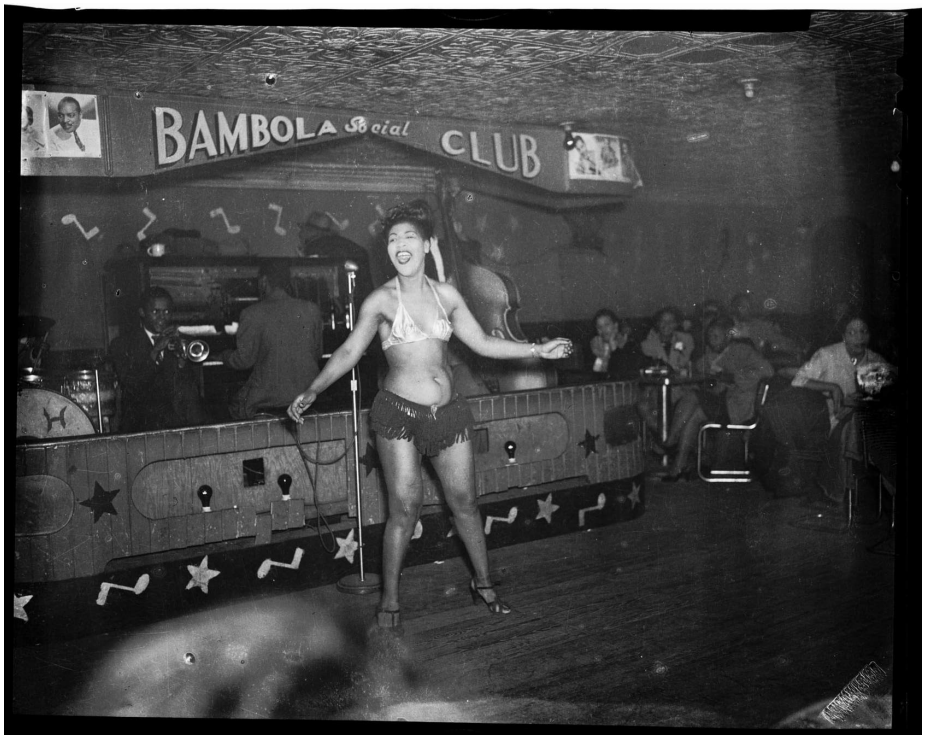


Figure 9: "Shake dancer, possibly "Gypsy Rose Lee" performing with band, including Tommy Turrentine on trumpet, at Bambola Social Club", photo by Charles "Teenie" Harris, c. 1938-1946[11]

4.1.3 Civic Right Activities around Freedom Corner

This landmark commemorates a pivotal moment in Pittsburgh's vast Civil Rights history and is situated at the junction of Centre Avenue and Crawford Street in the city's historic Hill District. Numerous longtime residents were evicted due to the Lower Hill District's Urban Renewal initiative. A billboard erected at Crawford Street and Centre Avenue following the URA's removal of 8,000 people, 413 companies, and 1,300 structures from the Hill. It said, "Attention: City Hall and the URA. NO Redevelopment Beyond This Point." From then, a succession of nonviolent demonstrations took place at this location, which later came to be known as Freedom Corner. An important turning point occurred in 1963 when more than 2,000 Pittsburghers left Freedom Corner to see D. Martin Luther King Jr. delivered his renowned "I Have A Dream" address in Washington, DC.[66] Local communities can congregate at Freedom Corner to express their demands for the protection of their own rights.

4.1.4 Heritage Site Selection and Evaluation

This section will discuss the site conditions at Freedom Corner and the Lower Hill District. To create a site-specific hybrid experience in a long-gone neighborhood, it is essential to have a firm understanding of the physicality and spatiality of the place both in the past and in the present. Before the 1960s, sites including Goode's Pharmacy, Local 471's hall and Musician's Club, Rhumba Theater, and Bethel African Methodist Episcopal Church served as significant economic, social, or cultural centers. The development of Civic Arena, was made possible by the demolition of all the aforementioned sites during the urban renewal. Locals conducted demonstrations to oppose more construction in the Hill District and to demand affordable housing, establishing the Freedom Corner as a forum for Pittsburghers to voice their opinions and needs.

Site 1: Goode's Pharmacy (1303 Wylie Avenue)
1303 Wylie Avenue used to be the address of Goode's Pharmacy. The "cultural and commercial heartbeat" of the Hill District was where Fullerton Street and Wylie Avenue intersect. In 1949, William Goode launched his second pharmacy shop, which became well-known in the neighborhood as an example of a local black-owned company. The Goode's Pharmacy had a fantastic soda fountain, which made it the ideal location for young people to congregate and mingle. In order to serve the neighborhood, it was open 24/7 and provided free delivery.[67]

Young African American pharmacists were unable to receive training at pharmacies managed by white people at the time due to racism; as a result, Goode's Pharmacy was viewed as a safe haven for them to grow in their profession. According to William Goode's daughter, her father believed that "it was the community that had given him his livelihood" and "helping these young men and women to achieve their goals was his way of giving back".[68] Mr. Goode's family and friends established the scholarship in honor of his lifelong

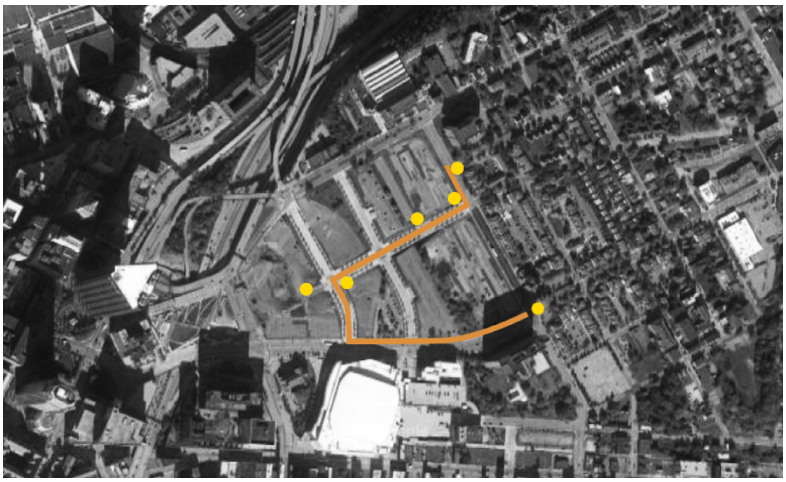


Figure 10: Selected historical sites in this research, made by the author

commitment to assisting worthy African-American students in achieving their goals.



Figure 11: "Pharmacist William Goode, standing outside of Goode Pharmacy with advertisement for Nucoferrin in window, Wylie and Fullerton Avenues, Hill District", photo by Charles "Teenie" Harris, c. 1950-1965[12]

Site 2: Local 471's hall and Musician's Club (1213 Wylie Avenue)
The Hill District's Musician's Club of Musicians Union Local 471 was situated at 1213 Wylie Avenue. It functioned as a hub for black and white Pittsburgh artists to interact, converse, and play jazz music. A trumpet player who is a member of Local 471 named Charles Austin said the club's openness allows musicians to perform, create bands, and even exchange advice.[69]



Figure 12: "Interior of Musician's Club, Local 471, with striped awning over bar, television in corner, and round bar stools", photo by Charles "Teenie" Harris, c. 1955-1975[13]

Site 3: Rhumba Theater (53 Fullerton Street)
Red Hot Theater Located in the Hill District of Pittsburgh, on Fullerton Street just off Wylie Avenue. There were at least four names for the theater. In 1926, it adopted the name Burke's Theater. It had taken on the name Golden Theater by 1934. It was changed on September 25, 1935, into Javo's Jungle, a nightclub that operated until February 1937. It was renamed Rhumba Theater in April 1937. Jacob Solz oversaw the theater, which catered to the African-American neighborhood. In 1957, it was still in use. In 1958, it was taken apart to make place for the Civic Arena.

Site 4: Bethel African Methodist Episcopal Church
After a large fire completely destroyed the former Bethel Church in Pittsburgh's central business district, the Bethel A.M.E. Church at Wylie Avenue and Elm



Figure 13: "Exterior of Rhumba Theatre seen from across street, Fullerton Street, Hill District", photo by Charles "Teenie" Harris in 1962[14]

Street was constructed in 1906. The first "colored" religious organization in Pittsburgh was Bethel A.M.E., which was established on Front Street in 1808 as the "African Church."[56] As a crucial center for intellectual development and independence-related activities in the 19Th century, Bethel A.M.E. acted as a buffer for African Americans' social standing.[70] The Urban Renewal Project led to the demolition of the chapel in 1957. Actually, it was the final piece of architecture around Wylie Street to be taken down. The 2010-built PPG Paints Arena for the Penguins uses the site of Bethel A.M.E. as a parking lot.[71]

Site 5: Civic Arena

Between Pittsburgh's Lower Hill neighborhood and downtown, Civic Arena was constructed in 1961 as a result of the Urban Renewal Project within the 1950s. It was initially built to house the Civic Light Opera, and it has since held a variety of family events as well as performances by musical greats including Frank Sinatra, The Rolling Stones, Garth Brooks, and The Grateful Dead. It was the first sizable sports arena of its sort in the world and included a 170,000 square foot retractable roof.[72] Civic Arena, however, was shut down in 2010 and destroyed in 2012 because City Planning and City Council were unwilling to accept the proposal for this building's historic status.[73]

Site 6: Freedom Corner



Figure 14: "Demolition of the Bethel A.M.E Church began in 1957" © Rev. Dr. Dale Snyder[15]

In order to defend their own rights, locals frequently stage demonstrations at Freedom Corner. A billboard arose near Crawford Street and Centre Avenue to protest the government's intention to relocate urban redevelopment from the Lower Hill District to the Middle and Upper Hill. After that, this location is used for public events or demonstrations. In Pittsburgh, it benefits all the neighborhoods, not just the African American ones.



Figure 15: "The construction of the Civic Arena in the Lower Hill district. Parts of Wylie Avenue, Crawford Street, Fullerton Avenue and Webster Avenue were demolished to make room for the large silver dome. These streets were significant business and cultural centers of the Hill District prior to their demolition. Construction of the arena began in 1958", photo by Charles "Teenie" Harris in 1958[16]

4.2 Content Collecting

4.2.1 Historical Images

The image contents are collected from two primary sources:

a)Pittsburgh City Photographer (PCP) Collection

The Pittsburgh City Photographer (PCP), a unit of the Pittsburgh Public Works Department, was created in 1906 and was assigned with snapping photographs of the city's infrastructure. Public spaces like parks, streets, buildings might require photography due to the requirement of government agencies. PCP photographers also kept track of the locations of the images. This research selected on 716 photos in the Pittsburgh City Photographer Collection on "Historical-Pittsburgh" website about the Hill District.[17]

b)Teenie Harris Photography Collection

Photos in this collection were taken by Pittsburgh photographer Charles Teenie Harris who depict black lives in Pittsburgh between 1920s and 1970s. Different



Figure 16: Freedom Corner in Pittsburgh (Photo by the author)

aspects of human daily activities like Marriage, deaths, portraits, religious services and other events happening within urban landscapes were displayed with photos. This research chose 83 photographs in the collection about the Hill District.[18]

All photos from above two resources are manually tagged and categorized according to time and theme as shown in Figure 16. Each square in Figure represents 10 photos. Examples of photo collections are shown in Figure 17.

4.2.2 Online Oral History Collection

Oral history documentation is also an important resource in this research to provide evidence for digital modeling and scenario construction. There are three main resources I leveraged in this project. The first is TheHistoryMakers oral history archive which consists of interviews with previous local residents in the Lower Hill District.[74] The second one is African American Jazz Preservation Society of Pittsburgh Oral History Project which contains the memory about Jazz bands and Local 471 musician club history.[75]

The third resource is documentaries about the Hill District including 3 spe-



Figure 17: All photo collections are manually tagged and categorized based on time and theme. Each square in Figure represents 10 photos (Made by the author)

cific videos. The first one is a YouTube video provided by Pittsburgh HillDistrict named The Renewal of Pittsburgh's Hill District created by Soleil Nagoda and Laurel Cooper which contains several interviews with local residents and their experience about the Urban Renewal project.[76] The second video is a documentary called Civic Arena Engineering and Innovated in Pittsburgh made by Rick Sebak and WQED which is about the construction of Civic Arena in Pittsburgh. Several interviews with engineers and designers are included in this video.[77] The third one is Pittsburgh People and Places Tour: Stop 4 which introduces the history of the Freedom Corner in Pittsburgh.[78]

4.2.2.1 "TheHistoryMakers" Oral History Collection

By collecting and documenting oral history from "TheHistoryMakers" which is the largest African American video oral history public archive. Based on how well they related to the topic of memories of living in the Hill District, I mainly chose two interviews from the collection (Sala Udin and Bev Smith). The database of "TheHistoryMakers" contains transcripts of every interview, making it simple to look for the necessary information. The appendix contains a list of all the audios utilized in this study. Some examples are displayed as follows.



Figure 18: Images from Pittsburgh City Photographer (PCP) Collection and Teenie Harris Photography Collection about Hill District[17][18], organized by the author

a)Sala Udin's Interview

Sala Udin was a city administrator and civil rights activist. He was born on February 20, 1943 in Pittsburgh. He helped to establish Black Horizons Theatre in 1967, a company that produced plays by black authors to embrace Black Power. Additionally, he held the position of Sixth District Councilman. Udin talked about his early years in the Lower Hill District in this interview, including his memories of Goode's Pharmacy, the Rhumba Theatre, his mother's sandwich store, etc. He also brought up the process of Pittsburgh's Urban Renewal and how many buildings, including the Bethel A.M.E. Church, were demolished.[79]

Sala Udin's Interview Clip Examples:

"...Fullerton and Wylie was the heartbeat–both the cultural and commercial, there were stores, newsstands, cigar stores, grocery stores, drug stores. The Goode family owned the drug store. Everybody knew Goode's Drug Store [Goode's

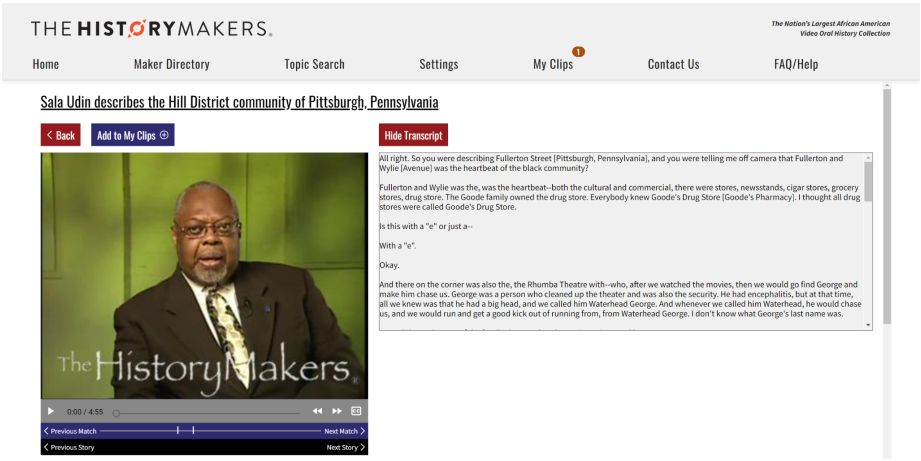


Figure 19: Sala Udin's interview about the Hill District community of Pittsburgh, reproduced by the author from "TheHistoryMakers" Oral History Collection website[19]

Pharmacy]. I thought all drug stores were called Goode's Drug Store... There were a lot of Jews there because the Jews tended to dominate the merchant group that owned stores and bars and places in the Hill District, and some of them lived there. But it also included a lot of Italians, Syrians, and Lebanese. Those are the groups that I remember, and a lot of blacks...I would say that 30, 40, maybe 50 percent of the businesses were black-owned. The doctors and dentists had their offices in the community. The–several of the bars were owned by blacks. Pat's Place was a newsstand and cigar shop that was black. Goode's Drug Store was black. A lot of sandwich shops were black. My mother [Mary Ella Howze] and her sister opened a little sandwich shop next door to the Rhumba Theatre for a time. And they sold hot sausage sandwiches and fish, fried fish sandwiches, to people going into and coming out of the Rhumba Theatre... And there on the corner was also the, the Rhumba Theatre with–who, after we watched the movies, then we would go find George and make him chase us. George was a person who cleaned up the theater and was also the security..."

b)Bev Smith's Interview

The radio show host Bev Smith was born in Pittsburgh on March 4, 1943. She was a radio host for the stations KDKA in Pittsburgh, WGBS in Miami (now WNMS), and WKIS in Orlando. Smith also served as the thirteen-year host of the BET conversation show Our Voices. For her services to radio and television, Smith has won close to 300 honors and awards, including the coveted Max Robinson Award and the Radio Air Crystal Award. In the conversation, she spoke about her memories of living in the Hill District and her feelings

towards its renovation.[80]

Bev Smith's Interview Clip Examples:

"...I was on the radio at that time. And I was asking–because I had a talk show called, "In the Public Eye", and I begged people not to sell their homes in the Hill District [Pittsburgh, Pennsylvania], which is where I live now. This was all black, black and Jewish, black and German. And this was where the community was considered the lower Hill. This was the part of the Hill where you had to throw your hat in, where I'm living right now. You would throw your hat in. It was the lower Hill, and you didn't go to the lower Hill. Although you did go, because they had the best jazz clubs, and stuff like that. And then, yes, the city–the organizers, the fathers, the developers–started to push and push. And they started to push blacks out of the Hill District, because they had moved whites to the suburbs. And the suburbs had high taxes, very little, if any, transportation. And black people–white people wanted to move back into the city that they fled. And so, gentrification began, and continues even to this day..."

4.2.2.2 African American Jazz Preservation Society of Pittsburgh Oral History Project

There are no transcripts available for this oral history resource and all the documentary resources mentioned in this section. As a result, all of the video segments are manually translated into texts by myself.

Boswell Rober's Interview

Boswell Robert used to be a bassist who used to rehearse with Billie Holiday in Pittsburgh. He talked about how he joined Local 471 and his early musical experiences in this interview. His memories of the other artists in this musical society were also brought to mind. He described it as the setting where they could interact with each other and "got really connected".[81]

Boswell Robert Interview Clip Examples:

"...Well I will say yes. Because we used to go to sessions down the union. Everybody could sit in there. There was a room where you could play. We were all going in and out and played the sessions there because how else could everybody know what you could do? And that's how I really got connected..."

Hughes John's Interview

Hughes John was a teacher as well as a pianist who had performed in Pittsburgh in the past. He discussed his involvement with Local 471 and his relationships with other musicians throughout the conversation. He highlighted how wonderfully the union's (Local 471) musicians were taken care of. They had "food,

brotherhood" and "business they wanted to conduct". The union (Local 471) also provided legal services for the musicians. The musicians received legal assistance from the union (Local 471) as well. The club evolved into a location where individuals could find support outside of their musical endeavors.[82]

Hughes John Interview Clip Examples:

"... It serves the musicians who actually come into Local 471. For the Food, for the brotherhood, for the business they wanted to conduct... You can come and get some legal help. You can come in and get some musical help, some good food, and brotherhood. And also you can meet other musicians... It was great... Yeah they have a kitchen there. If you travel there and you live in the hotel downtown. You can hook up at night there... They have chicken sandwiches. got some food, socialize you know. They have already got a good kitchen..... it's like a club...there are plays, practices and talks to find out what's going on with the musician who came in"

4.2.2.3 Documentary: The Renewal of Pittsburgh's Hill District

Prof. Laurence Glasco Interview

Prof. Laurence Glasco was Associate Professor of History at the University of Pittsburgh. He was born in Xenia, Ohio, in 1940. Since joining the University of Pittsburgh's history department in 1969, he has concentrated on local and worldwide African American history. He discussed his views on the urban renewal project here and the growth of the Hill District throughout the conversation.[83]

Prof. Laurence Glasco Interview Clip Examples:

"...Blacks got jobs. They won't get people to reserve a labor shortage... And the same thing happened to women. So you got women moving into the labor market. Blacks and women really got benefits economically... It was very good. It was very bad. It was something for everything... The fall and down of the Hill is the success of the people. They moved up. They wanted new houses. So they became increasingly impoverished... 'Look out! This is all new.' You know that Americans always have this idea that something new is gonna be better. So this is a new idea, the new apartment, new Civic Arena, a new image and the other. So this just fits in with the American idea that new will always be better... Really the rights on the top of urban redevelopment is what made the Hill District a vibrant neighborhood..."

4.2.2.4 Documentary: Civic Arena Engineering and Innovated in Pittsburgh

The clips in the documentary contains some discussion and interviews among Rob Hoffman (an architect and an advocate for saving the arena), John Minetti (a structural engineer) and Fill Hundley (Principal in the architectural firm DRS) who all have admired the Civic Arena.

Interview and Discussion Clip Examples in "Civic Arena Engineering and Innovated in Pittsburgh":

"...The dome design, the cantilever trust that's supporting the whole thing, I think probably most engineers, most people who have never heard of it probably wouldn't believe that it opened like it did..." (John Minetti)

"...The concept was to have a dome that opened... Well how do you get this dome to open? It's more than architecture. It's engineering..." (Fill Hundley)

"...We got people there who were true visionaries here you know and pushed the envelope on the use of structure and the use of materials and originally the structure was not even intended for hockey. It was just gonna be the Civic Light Opera in concerts, sort of like the Hollywood Bowl..." (Rob Hoffman)

"...I went one night to the Civic Light Opera with Mr. Dieter and we went in there and they opened the dome and it just blew me away. I said thank God I'm with this firm because this is so great. I'm part of this. I'm part of this excitement of architecture..." (Fill Hundley)

"...I was there once for a concert also and I don't know if you had the same impression but it was silent. I really didn't hear like all this machinery I mean it just was moving..." (John Minetti)

"... In many ways this is the right project for Pittsburgh. The steel, the innovation... It's gonna cost 1520 million dollars to demolish the building. It's a lot of money number 1. Number 2 you are losing something you will never get back. It's truly a Pittsburgh landmark..." (John Minetti)

4.2.2.5 Documentary: Pittsburgh People and Places Tour

Clip Examples of Prof. Laurence Glasco's Introduction about the Freedom Corner

"...Actually it had been called Freedom Corner for some time because it started in the mid of 1960s when people used to gather right on this spot to start marches towards downtown to protest of all sorts of things. Particularly they protested jobs. They protested for housing. They protested against police brutality. They

protested against the war in Vietnam. It became a rallying place because of its location right towards downtown... This was the place that the community, the hill district community, came together to protest what was the greatest probably tragedy that ever to befall the Hill and that is what was called Urban Renewal. That is the redevelopment of the Hill which involved tearing down a huge expanse of the commercial center of the Hill for the direction of the Civic Arena. The idea was that this was to be a benefit to the city and the community. But it turned out not to be so... This area really represents a continuing sense of protest and search for racial, social, economic, gender justice. It's not just Blacks protest from this area. But women protested for women's rights. Gay protested for their rights. All sorts of groups who feel that the city, the state, the nation needs to address their needs have used this area as a symbolic gathering place to move forward..."

4.2.3 Other audio resources

4.2.3.1 BBC Sound Effects

Beginning in 2018, BBC has made 16,000 BBC Sound Effects available for download in WAV format online in accordance with the RemArc Licence (used for personal, educational or research purposes). All sound effects could be searched in designated groups and attributes thanks to the meticulous database creation. I acquired sound effects from this database, such as the sound of building construction and protester's' voices.[20]

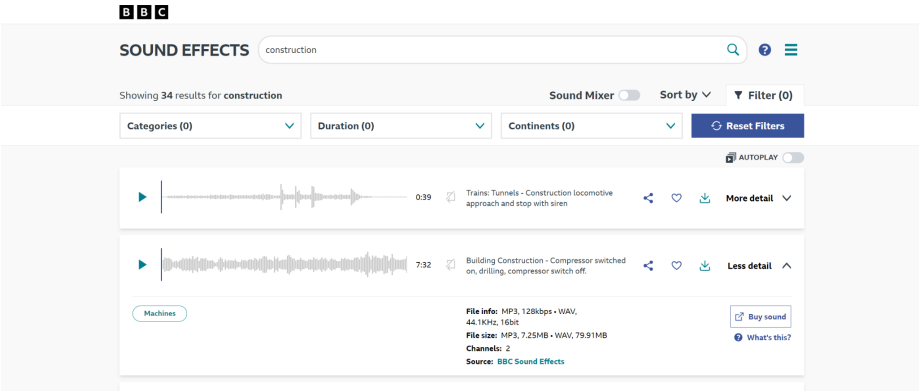


Figure 20: The BBC Sound Effect data set, reproduced by the author from "BBC Sound Effects" website[20]

4.2.3.2 "La Space": Album of Stanley William Turrentine

Tenor saxophonist Stanley William Turrentine played jazz in America. Turrentine was born into a musical family in Pittsburgh's Hill District, in the United States. Mr. Turrentine never lost touch with his origins in Pittsburgh. His record from the middle of the 1980s, "La Place," was named after a street in the Hill District and the honors listed the names of a number of dozen individuals, some of them were artists he knew growing up.[84] The audio clips are taken from Stanley Turrentine's album "La Place".[21]

Track Listing

Sample		Title/Composer	Performer	Time	Stream
	1	Terrible T Bobby Lyle	Stanley Turrentine	06:28	
	2	Cruisin' Bobby Lyle	Stanley Turrentine	05:57	
	3	Night Breeze Bobby Lyle	Stanley Turrentine	05:00	
	4	Take 4 Gerald Albright	Stanley Turrentine	05:03	
	5	Touching Bobby Lyle	Stanley Turrentine	06:08	
	6	La Place Street Bobby Lyle	Stanley Turrentine	06:23	
	7	Sparkle Bobby Lyle	Stanley Turrentine	06:20	

Figure 21: the playlist of "La Place", reproduced by the author from AllMusic website[21]

4.3 System Building

4.3.1 Pretest demo

To test the virtual assets displacement in the physical place, I designed a pretest project based on 2D historical images and oral history audio clips. Adobe Aero, which offers a simple method to create, watch, and share immersive narrative experiences in mobile augmented reality, was used to create this project. With Adobe Aero, it's simple to quickly create an augmented reality scenario with multimedia content and interactivity. Additionally, designers have the option to perform rapid iterations with the asset placement and experience design processes on the site using the program. Figure 21 depicts the Adobe Aero user interface.

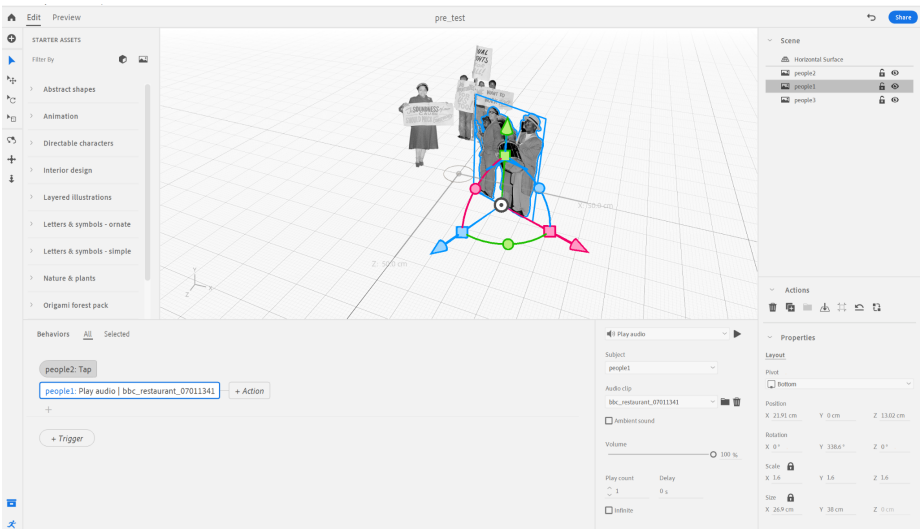


Figure 22: Adobe Aero interface (Made by the author)

I created a prototype using Adobe Aero that features three scenarios to show neighborhood civic engagement, urban regeneration initiatives, and local economic activity. Materials are gathered from the audio recordings from section 4.1.3 and the historical photos referenced in section 4.1.1. By projecting visual components on specific sites where the events took place in the past, this pretest prototype *replicates* a location related augmented reality experience. Additionally, I tested the audio play that is linked to the picture and is activated when the user taps the image. Figure 23 displays the screenshots from the pretest demo.

I went through multiple iterations regarding site selection and material displacement based on this pretest, which really aids in the scenario design. Addi-

tionally, it offers the opportunity to swiftly alter the contact process. In section 4.3, these improvements will be covered in more depth. Even though Adobe Aero provides a perfect tool for fast prototyping, it's hard to build a location-based augmented reality project since geometry data can't be attached to a specific location according to location tracking sensors without image anchors. Therefore, for the following prototyping and testing process, I will switch to Unity engine which will be introduced in detail in sections from 4.2.3 to 4.2.9.



Figure 23: Pretest demo screenshots to display local economic activities, the urban renewal program and civic activities around the Freedom Corner (Made by the author), with materials from historical photo collections[17][18]

4.3.2 Modeling and digital site building

4.3.2.1 Constructions

Previous constructions as an important part of the heritage scene provides a basic background for human activity scenarios and audio play. Based on the analysis in section 2.3.4, six sites are selected as follows: Goode's Pharmacy, Local 471's hall and Musician's Club, Rhumba Theater and a nearby sandwich shop, Bethel A.M.E Church, Civic Arena and the Freedom Corner. All photos of constructions are shown in Figure 24.



Figure 24: All constructions within the project (Made by the author)

Historical maps and photographs serve as the foundation for architectural modeling. Consider the Rhumba Theater as an illustration. I investigated the historical map of the Lower Hill District in 1923[22] to set the model scales as seen in Figure 25, in accordance with its recorded address (53 Fullerton Street). Additional modeling information is gathered from old photographs taken from various viewpoints (Figure 26). The model's textures are chosen from the Blender texture collection.[85] Historical images are sometimes utilized as textures for displays and signs (Figure 27). To ensure that the texture will be properly shown for the subsequent processes, each architecture is exported from Blender to Unity independently with a texture folder.

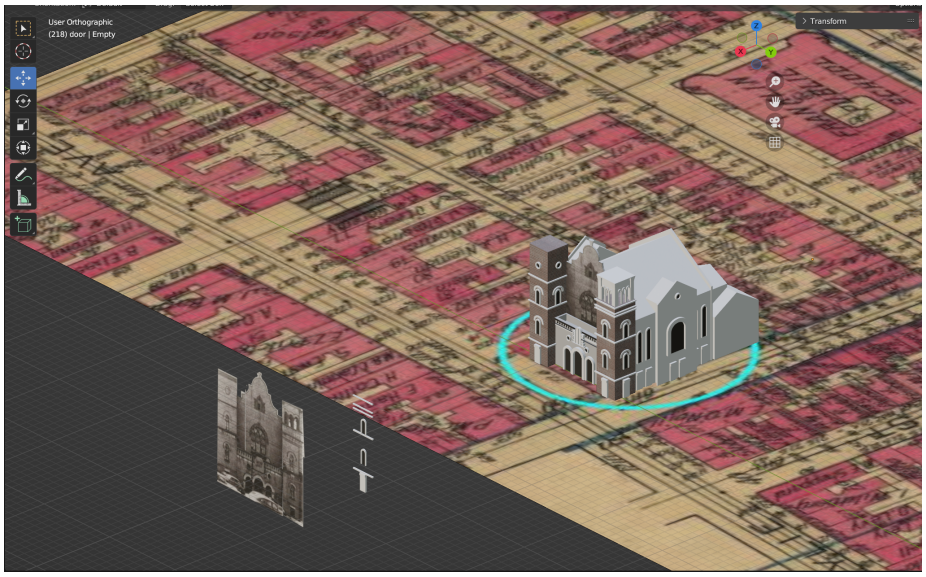


Figure 25: Model building based on historical map (Made by the author), the map which is used as a reference is a historical map of Pittsburgh in 1923[22]

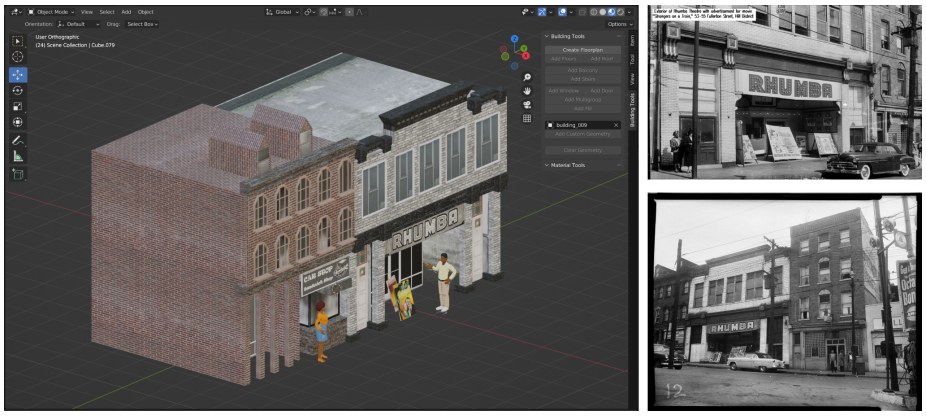


Figure 26: Model building based on historical photos (Made by the author), the historical photos used as references (right) are from historical photo collections, photo by Charles "Teenie" Harris[17][18]

4.3.2.2 Human Activity

Human activities is another layer to be built in this application. At first I chose to build 3D models based on pre-designed low-poly human assets from Unity Asset Store[86] as the method to represent local human activities. The modeling and editing of human activity assets are based on historical photos. It

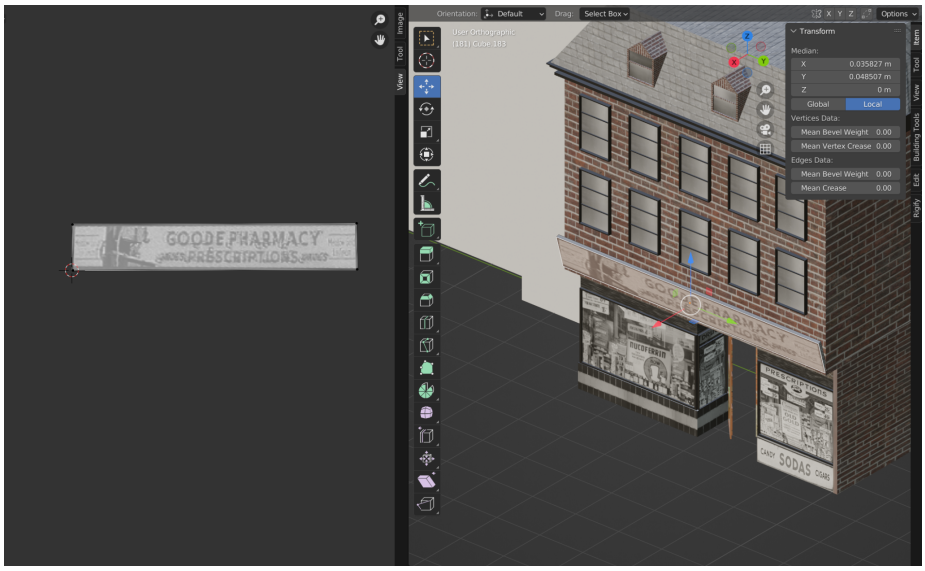


Figure 27: Texturing process with textures from historical photo (Made by the author)

takes into account the inhabitants' physical characteristics and attire from the photographs. Figure 28 displays a comparison between historical images and model assets. The production process of 3D human assets contains three steps: model editing, armature attachment and pose editing.

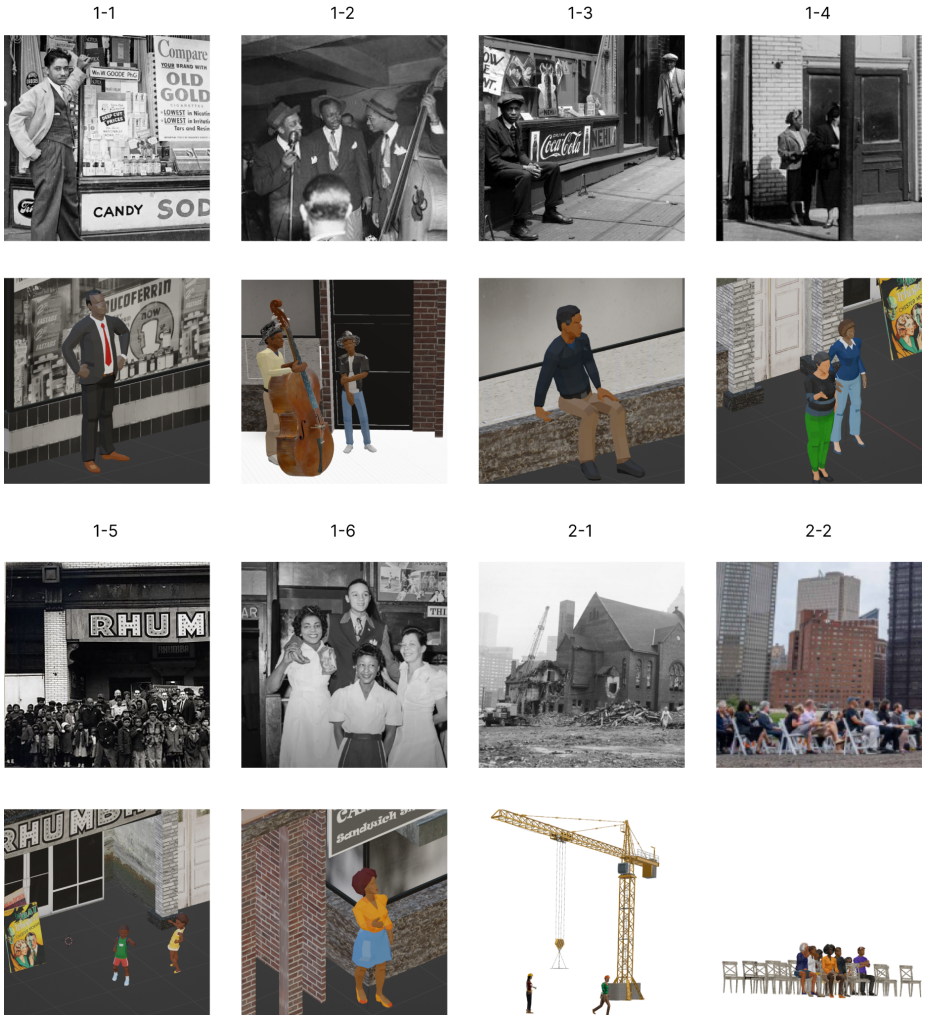


Figure 28: Comparison between historical images and model assets (Made by the author)

However, I found that these low-poly models were not realistic enough to reflect previous community members and their activities. Therefore, 2D photographs are also modified and added to the environment using Adobe Photoshop. Figure 30 illustrates how the background of the photographs are removed to allow for a more seamless integration between 2D human figures and 3D architectural settings.

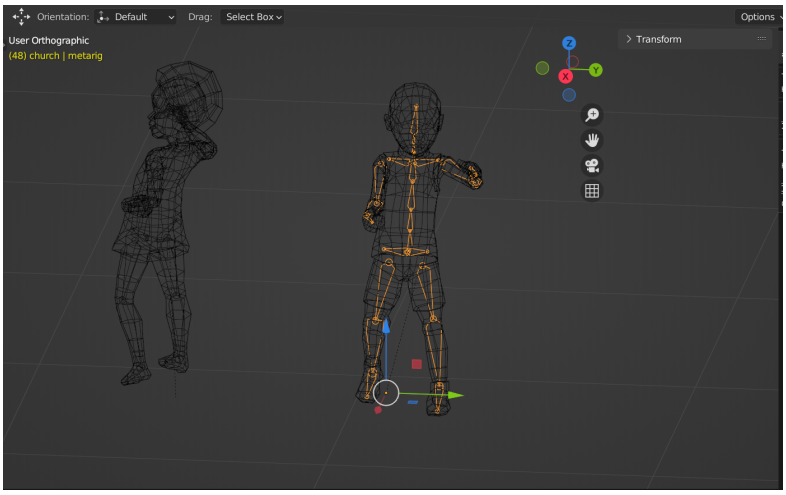


Figure 29: The Armature Attachment process of human assets (Made by the author)

4.3.2.3 Other Assets in the scenario

In addition to buildings and people, the augmented reality application also uses certain additional model assets. These models are relocated in the scenarios to improve the narration, such as the cranes within the scene of the Civic Arena. The models presented in the section were all obtained from Sketchfab[87] and are all listed in the appendix.



Figure 30: 2D assets used in the augmented reality scene (Edited by the author), with materials from historical photo collections[17][18]

4.3.3 Devices

The equipment needed for this augmented reality application is a mobile phone, which includes computing power, positioning sensors, portable screen, a camera. Headphones are also required for audio listening. Since this program was created in Unity utilizing the AR Foundation SDK for the Android platform, it is strongly advised that the user select a mobile device running the same operating system in order to install the application. Regarding the headphones, high-quality binaural headphones might offer a better presentation of all ambient audios throughout all situations. However, users should be cautious while using headphones with a significant noise-canceling feature for this project since they might miss all of the outside ambient voices from the physical world when they take the location-based augmented reality walk.

4.3.4 Tracking and Registration

This project uses sensor-based tracking as its tracking technique. Sensor-based tracking is more suited for situations with high levels of spatial and visual complexity, such as most metropolitan environments, as opposed to camera-based tracking, which depends on the right lighting conditions and easily-recognized physical features. Three different types of sensors, including a global positioning system which provides the user's current location information and serving as the system's starting point, a magnetometer which supplies the user with a real-time orientation guide and determining the placement of virtual items, and a gyroscope which gives the virtual camera and sound receiver adjustable real-world direction, are employed specifically for this project to detect the location, rotation, and motion of the user in the real environment.[88] Smartphones used for this project should contain all three kinds of sensors mentioned above.

In terms of registration, location-based initiatives need a more adaptable and portable engagement procedure than conventional marker-based solutions. As a result, all operations in this project are completed based on game object interaction in Unity platform.

4.3.5 Location-based Asset Display

The AR Foundation SDK and the AR+GPS plugin[89] in the Unity engine were used to create the project's whole location-based functionality. After importing the plugin package, an object called "GPS Stage Object" can be appended in the scene and a script named "Place at Location" is automatically attached. Then, as illustrated in Figure 32, it is simple to obtain a set of latitude and longitude data by choosing a specific location site on the Google Map. When materials are added to the "GPS Stage Object" as child objects, all assets, including the visual and audio ones, will be put on the specific address. The "Altitude Mode" parameter should be changed to "Ground Relative" to ensure that the assets are positioned at the proper altitude. To conceal the entire initial distance tracking interface for the visual assets, "Debug Mode" should be

disabled after the testing process.

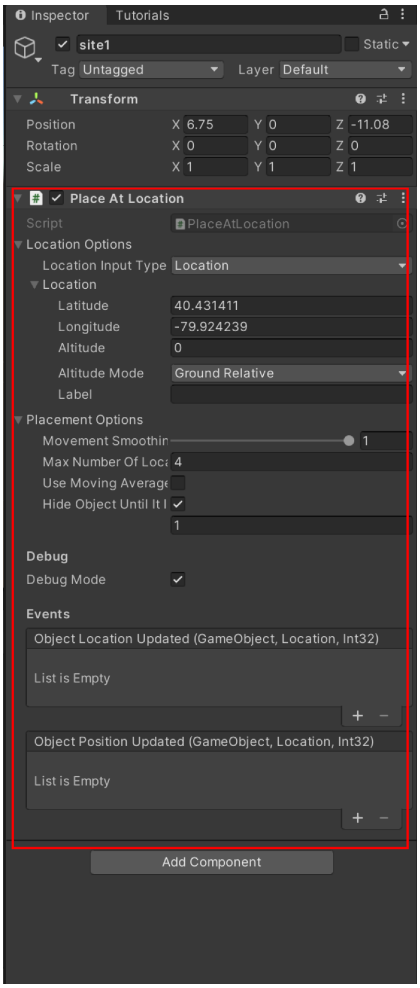


Figure 31: The inspector setting screenshots for location setting in Unity (Made by the author)

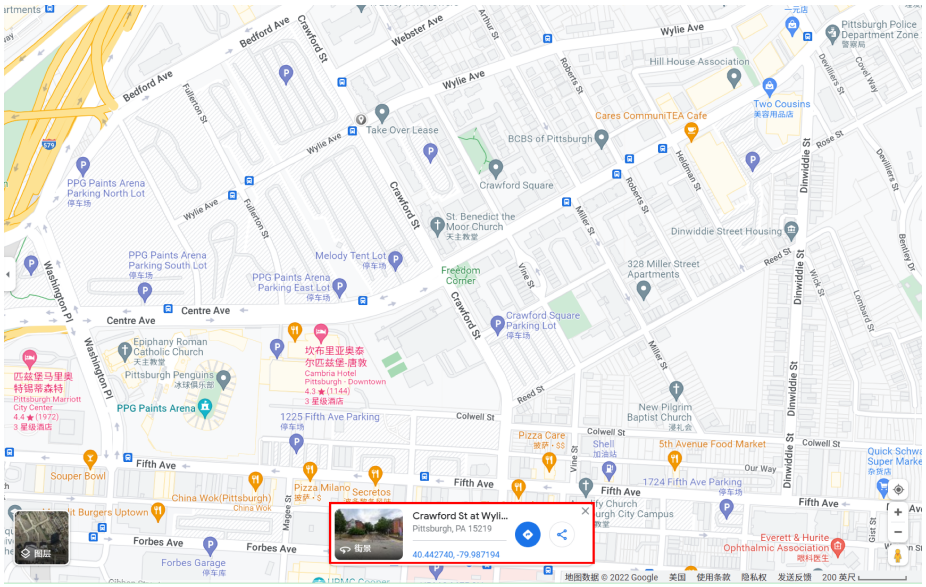


Figure 32: Getting latitude and longitude data of geography location from Google Map (Made by the author)

4.3.6 Audio Elements Settings

4.3.6.1 Audio Clips Importing

Maintaining a balance between file size and quality is crucial to provide a fluid experience on mobile devices. As a result, it's crucial to regulate the importing procedure for audio assets, particularly the parameter of format and loading technique. The audio file forms that Unity can accept are*.aif*,*.wav*,*.mp3*, and*.ogg*, according to the Unity audio importing guide.[90] Since the *.mp3* file employs "lossy compression" to encode audio data and has a considerably smaller file size than any other kind, I decided to use it for all audio parts in my project. Also the *.mp3* files will load faster when played because of their compression format.

The Unity engine supports three distinct audio loading modes, including "Compressed In Memory," "Streaming," and "Decompress On Load," as well as three different compression types, including "PCM," "Vorbis," and "ADPCM." According to Korzuszek's blog post regarding the audio import settings in Unity, it is preferable to use "Compressed In Memory" as the load format for seldom played and brief audio clips, "ADPCM" for oral history documents and "Vorbis" for environment audio clips as compression format.[91] This is due to the fact that the duration of the environment audio clips in this project ranges from 3 to 5 minutes while the duration of the oral history audio clips is between 60 and 90 seconds. In comparison to raw "PCM," "ADPCM" is around 3.5

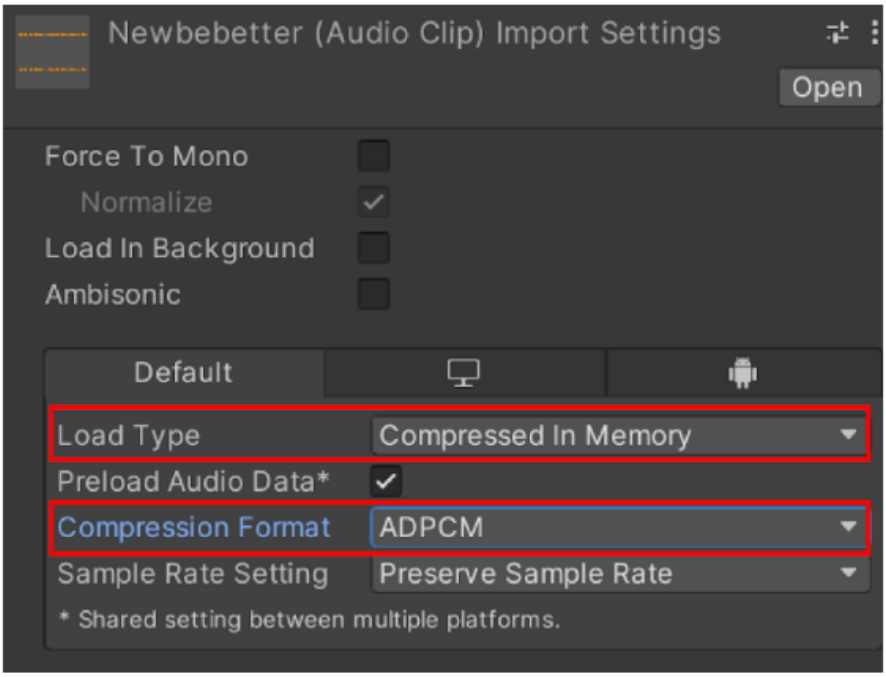


Figure 33: The audio clips import settings in Unity (Made by the author)

times smaller, and the decompression process uses less CPU power than "Vorbis". Nevertheless, lengthier audio snippets can be too lengthy to apply the "ADPCM" approach.

4.3.6.2 Audio Spatializer Settings

Unity offers spatializer effects that can include the two-eared "head-related transfer function (HRTF)" to support the audience better perceive the orientation of the audio through the noise removal of the head and the small delays between the ears.[92] This enhances the rationality of sound extension. Customs can click the "Audio" section inside the "Project Setting" panel as illustrated in Figure 34 to add this extra customized spatialization effect. Then select "MS HRTF Spatializer" from the drop-down option to install the "Spatializer Plugin". After the plugin has been installed successfully, customs may turn on this feature by checking the "Spatialize" box on the "AudioSource" panel.

4.3.6.3 Audio Play Settings

In order to play sound in a physical domain, game objects in the Unity engine are associated with a "AudioSource" attribute. While an audio file is added to the "AudioClip" category in the "AudioSource" panel, it automatically plays

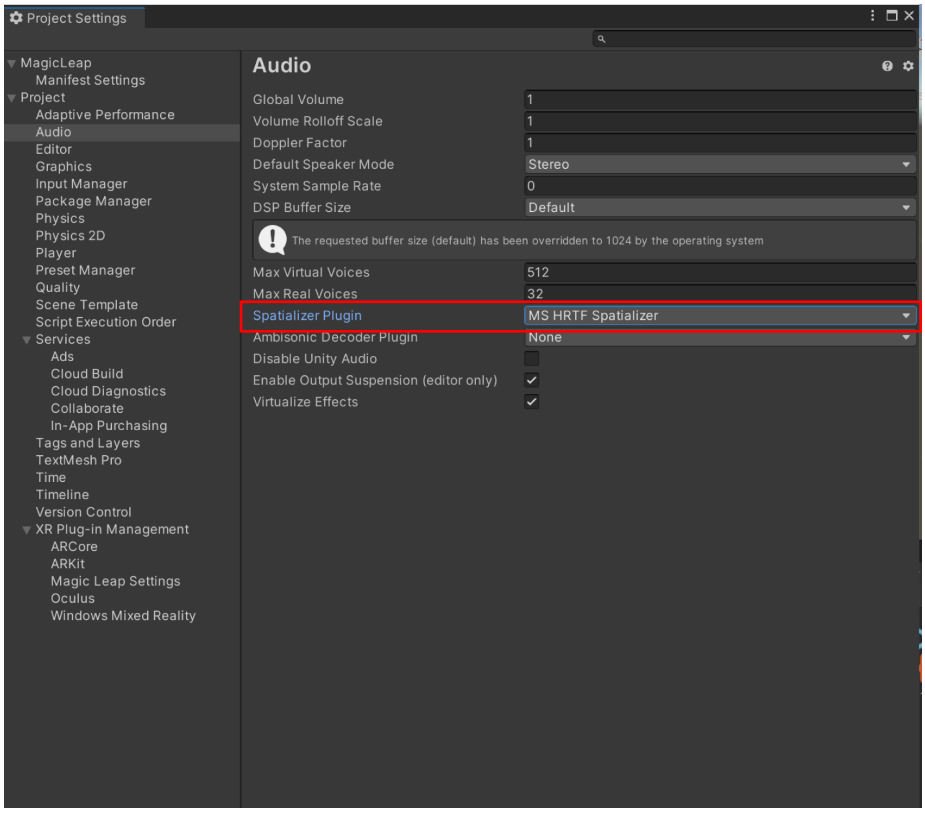


Figure 34: The spatializer plugin install process (Made by the author)

with “Play On Awake” and “Loop” checking on. So the ”Loop” selection needs to be turned off initially since it will triggered only after the user tap on the start button in the scene. Also the “Spatial Blend” needs to be set as 1 to turn on the 3D sound effect. Besides, the “Min/Max Distance” section can be changed to adjust the audio’s audible hearing distance[93].

Final setting in for “AudioSource” of this project is shown in Figure 35.

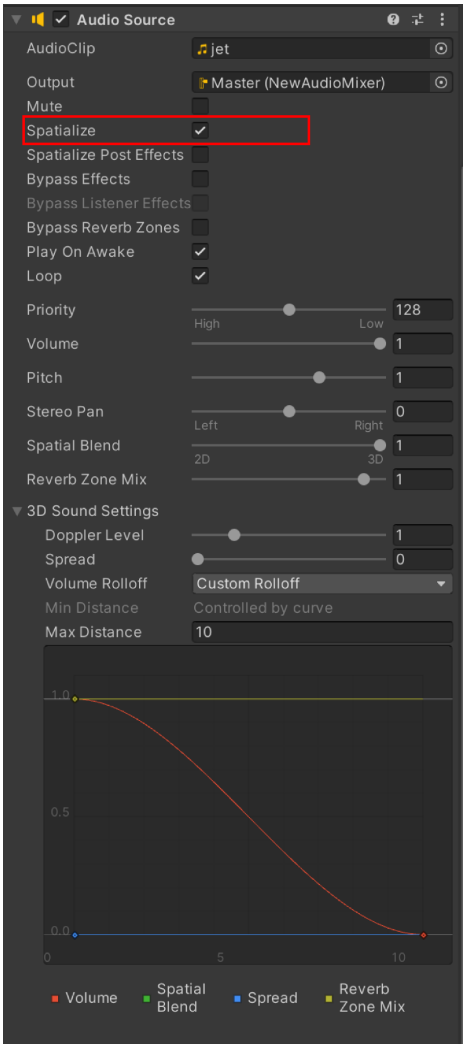


Figure 35: Parameter settings of “AudioSource” in Unity (Made by the author)

4.3.7 Interaction Settings

There are two interaction design targets in this project. One is to let the user tap one specific object in the AR scene. The other is have a clickable icon on the interface for the mini-map. Therefore the interactive settings in Unity will also be divided into two sections in the following discussion: interaction in the augmented reality scenes and interaction on the user interface.

Interaction in the Augmented Reality Scenes

The essential design problem of this section is to figure out a way to detect the tabbing screen activities from the user. If the clicking point is on the game object, then the relatives events will be triggered. I set a *"RaycastHit"* variable as "Hit" and the position value called *"Camera.main.ScreenPointToRay (Input.GetTouch[0].position)"* as "ray". Based on Unity documentations about the function called *"Physics.Raycast"*[94], I chose to use *"Physics.Raycast (ray,out Hit))"* as a test value to verify if there is a hit from screen. Once a hit is received, the function will then check the *"Hit.transform.name"* to see if it's equal to "button", which is the object category name I set for the interactive button in all the scenes. By doing this, once the user click on the button on the mobile screen, the interaction will be automatically triggered.

There are two following events after the button clicking has been checked as true. The first one is toggle the visibility of human activity images and the interactive button. After the clicking, the images of human activities will be shown in the scene and the button will be hidden. I made this happened by changing the value of the interior function in Unity called *"GetComponent¡Renderer¿().enabled"*.[95] The second one is the audio clips of environment sounds which are attached to this scene will be played. The method of playing specific audio in the background is using *"Getcomponent¡audiosource¿().clip"*[96] to set the audio to be played and using *"Getcomponent¡audiosource¿().play()"*[97] to play the specific clip.

Interaction on the User Interface

As for the interface interaction part, I chose to set the mini-map as a "Button" object which has been pre-designed in Unity.[98] I set all the click events based on the properties of the "Button" control. Based on the *"Button.onClick"* function, the click event can be detected and responded through tracking the *"TaskOnClick"* status. The final interaction about the mini-map is the user can click the button to open and close the mini-map. The yellow spots on the map illustrate the locations of all sites in the project.



Figure 36: Screenshots of the interface with the mini-map included (Made by the author)

4.4 Experience Design

The experience design process is essential to this study's attempt to address the research topic of how location-based augmented reality may be developed as an on-site preservation strategy to influence users' awareness of intangible assets. In order to improve the authenticity and deliver-ability of the story, the main focus of this section will be on how to physically depict digital architecture, human activities, and auditory features. The following factors were taken into account when I developed this technique: content presentation, scenario design, and user flow design.

4.4.1 Content Presentation

As stated in section 4.1, the project's materials are split into three groups: constructions, human activities, and audios (environment sounds and oral history).

When I tried to map every object in the physical world, "location-based" was the crucial notion. Digital representations of buildings are positioned on their historical addresses in accordance with the historical evidence from old photographs and other public sources. In order to better illustrate the social and cultural activities in the community, which can be considered as an important part of the intangible cultural heritage, 2D and 3D assets of human activities are placed around buildings or structures based on the explanations in related oral history materials. Thirdly, to further enhance the immersive nature of the project, audio excerpts featuring interviews and environmental voices are also played. More information about historical occurrences and everyday life in communities can be found in oral history recordings. The following graphs depict the spatial organization of all the contents, and the appendix has a complete list of all the digital materials.

Physical environment, digital structures, displays of human activity, and ambient audios are intimately integrated to strengthen the story of scenes. Consider the Rhumba Theater scenario as an illustration. The construction of Rhumba Theater and next-door sandwich shop are placed on their previous location on the site. According to some public historical archives like Sala Udin's oral history, *"...And there on the corner was also the, the Rhumba Theatre with–who, after we watched the movies, then we would go find George and make him chase us... My mother [Mary Ella Howze] and her sister opened a little sandwich shop next door to the Rhumba Theatre for a time. And they sold hot sausage sandwiches and fish, fried fish sandwiches, to people going into and coming out of the Rhumba Theatre..."*, photos of staff and local artists who used to work or perform here are included into the setting based on the description. Additionally, a busy business scene ambient sound from BBC Sound Effects is used to provide a more vivid picture of earlier cultural and economic facets of community life. To provide users a deeper understanding of what occurred here in the past, Sala Udin's oral history interview are also played in the background.

4.4.2 Design Scenarios

From the perspective of narrative, the six sites can be divided into three groups based on their historical following the sequence of historical periods. These three scenarios address several facets of intangible heritage in the Lower Hill District's local community, including the thriving economic and cultural lives in the neighborhood, the impacts of urban renewal projects, and civic rights activities around Freedom Corner.

Here are some further descriptions of each scenario.

list.png

Figure 37: Asset Distribution (Made by the author)



Figure 38: On-site augmented reality scene of Rhumba Theater (Made by the author)

Scenario 1 (site 1-3):

This scenario depicts the neighborhood's appearance in the 1940s. Both the artistic and economic life of Pittsburgh's Lower Hill District was centered around Fullerton and Wylie. William Goode, a pharmacist, was standing outside of Goode Pharmacy. The neighborhood was well known for local businesses like Goode's Drug Store. Selling hot sausage sandwiches and fish sandwiches to those entering and exiting the Rhumba Theater, the sandwich shop beside the door was booming. The American Federation of Musicians' Local 471 office was housed in a bar at 1213 Wylie Avenue. Jazz musicians practiced and performed here.

Scenario 2 (site 4-5):

The second scenario displays the changes that happened in the neighborhood during the Urban Renewal project from the 1950s to 1960s. Bethel A.M.E Church was removed from the district for the construction of Civic Arena. On the same location, the Civic Arena was built for public activities including musical performances and sport competitions. Engineers, works and constructing tools are shown in this scenario.

Scenario 3 (site 6):

A billboard was placed at the intersection of Crawford and Centre Avenue, which said "Attention City Hall and U.R.A.: No Redevelopment Beyond this Point!/We Demand: Low Income Housing for the Lower Hill". People gathered here to express their feelings about stopping further redevelopment in the district and get lower price housing back. The sound of the protest can be heard in the background.

4.4.3 User Flow Design

As shown in Figure 39, the user flow of the project starts with checking the mini-map and moving towards the site. Once users enters the site within the pre-designed distance, they can view the model of historical constructions and hear the oral history narratives in the background. Next, when the user clicks the start button in the scene, the photos of human activities will be displayed. At the same time, enlivenment audios like jazz music or the sounds of protests can be sensed by users. After they finish the experience of the site, users can double check the mini-map and head for the next site.

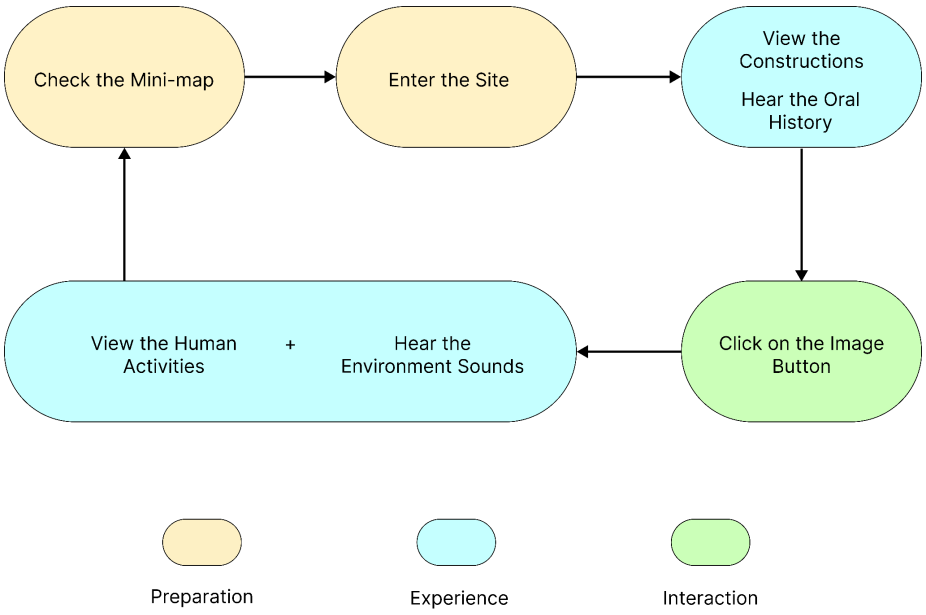


Figure 39: The framework of user flow in the augmented reality walk (Made by the author)

5 Evaluation

To better evaluate how the location-based augmented reality project affect people's feeling and understanding about local heritage, I designed a user test with three parts: site walk, individual interview, take-home survey. I had 10 participants in total who are students with design or urban planning backgrounds or augmented reality developing experience. The test and evaluation focus on their opinion about the design of hybrid walk on the site, multimedia display as well as how this experience changed their perception of local heritage. After having a hybrid site walk with their own mobile phones and headphones on the slide walks around the Freedom Corner in the Lower Hill District, I will have a interview with each participants individually. Then for the last step, a take-home survey in digital version will be given to all the participants to collecting their views about multimedia design and interaction design more specifically. The reflection and evaluation of this test provide valuable references for the future iterations about the hybrid walk experience about intangible heritage based on augmented reality platform from the design perspective.

5.1 User Test

The purposes of all the three activities, site walk, individual interview, take-home survey, within this user test are the followings:

- observe how participants behave/think/feel during the on-site augmented reality walk
- observe how they interact with the digital heritages and how they get affected
- analyze how the visual and audio elements in the augmented reality application affect people's feeling and understanding about local intangible heritage

5.1.1 Overall Process

Participants were invited to the site in the Lower Hill District to experience the location-based augmented reality application with their own mobile devices and headphones. Potential participants include people with extended reality development experiences or have a related design or urban planning background to provide professional perceptions for future iterations and research. The expected number of participants was 10 (divided into 2 sessions, about 5 for each session). The application was installed on the devices before the site walk starts. A test demo was run on their devices to make sure they won't have any technical concerns during the walk. If the participants have any privacy concerns, they can choose to use my own mobile phone to get involved.

Participants went through the experience one by one for around 30 minutes. As participants took the walk, they were asked to think aloud which means they were required to talk about what they were thinking or feeling during the walk. The talking process was documented under their permission.

After the walk, I had a 10-minute interview with each participant. The interview was also documented. Afterwards I gave each participant a take-home survey (digital version).



Figure 40: A participant was viewing the virtual billboard and people in the protests on the historical site(Photoed by the author)

5.1.2 Interview

The interview was held on the sidewalks around the Freedom Corner. After having a view of the intangible heritage of the district digitally, participants accepted the interview within the physical space individually. The reason why I want to avoid making the interview session as a focus group discussion is that individual's personal understanding could be affected by other's thoughts or feelings. It could be harder to collect their initial thoughts and feedback if they have exchange their minds. Therefore, the interviews were held and documented separately immediately after the side walk. The interview transcripts can be found in the appendix.

The topic are covered in the interview:

- Reflection of the experience
- Immersive level of the overall augmented reality walk
- Feeling and understanding about the district after the walk
- Other comments or suggestions

5.1.3 Survey

The take-home survey was provided to participants after they finish all the on-site activities. Based on this survey, participants could provide more comprehensive viewpoints after they had more time to review the whole experience. Besides, this survey focused on some more specific questions like how well the multimedia elements affected their understanding process.

Quantities questions:

- How well do you think the visual elements help with your understanding about the heritage?
- How well do you think the audio elements (environment audios and oral histories) help with your understanding about the heritage?
- How well do you understand the historical time period shown in the application?

Qualitative questions:

- How do you feel about the interaction process of this augmented reality application?
- What do you think about the correlation among heritage sites?



Figure 41: A participant was taking the interview after the augmented reality walk (Photo by the author)

5.2 Data Processing

The data processing progress was divided into two parts: organizing data and understanding data. For the organization part, I started by combining records from different parts of the test of the same participant together and replacing all the identical information like names with the assigned tester number. After that qualitative data and quantitative data are separated for further data familiarization progress.

For the second part, I generated raw data for each participant and data visualizations as pie charts for each question with the Google Form response collection tool. All further data evaluation will be built on those results. As for the quantitative data, I decided to go through all the documented interview scripts first and got familiar with the patterns and commons for each question. Then I tried to map all the answers with research questions mentioned in the previous sections.

5.3 Data Evaluation

In this section I will go through different kind of data I gathered from 10 participants about their thoughts and comments of the whole augmented reality walk in multiple aspects, including immersive experience, visual and auditory experience, and supports for understanding of the local heritage.

5.3.1 Multimedia Assets Display

"...For me I think the visual parts works better. I mean it's hard for you to see the digital views like this. You can go to the museum if you want to know more about this piece of history, but it's very hard to gain an immersive experience like this. The scale of the architecture and people are real. The textures are real. At least it can make you more impressive. As for the audio, I think they are related to the visual elements right now. But I think if you can make it more like a dialog, you know. Like in a game, I can click on a character, and make him talk to me. I think it will definitely make the whole experience more interesting." (Participant 1)

"...The audios worked well. I learned a lot from the narrator in the background. As for the digital models, they are not bad. But I think they looked not that real. They still looked like models...I think it's their textures. You know when we normally render a model, the texture assets really matter. So I just wonder if you can modify this issue by changing the textures or rendering materials you choose..." (Participant 5)

"...As I said, I liked the visual elements since they are nicely built and positioned on the location. However, I have to say I learnt more from the audio. I mean the speaker in the background. Yes the oral history. The oral history provided

more details. Otherwise I couldn't fully understanding what happened here..." (Participant 8)

Generally participants thought all visual and auditory elements are relevant to the heritage and local history. The real scale and historical based position make the experience more realistic. It makes users easier to image how community used to look like previously. Since visual elements are more "intuitive" than aural storytelling, some individuals prefer them. At comparison to traditional media like video records or displays in museums, the portrayal of physical and intangible heritages through augmented reality in real space also provided them with a more immersive experience. When participants approached the digital buildings and saw the physical space at the same time, they will immediately built a connection between the past and present of the community. It's hard to view the heritages which were removed from the site through other approaches.

For another thing, some participants, like participant 5, learned more from the audio components like the oral history. They believed that the audio tales offered a lot more information to aid in their understanding. As Participant 8 mentioned in the interview, it's hard for him to fully understand what happened if he didn't hear the oral history in the background. Participant 10 and others who shared his perspective said that the project's integration of the visual and audio elements greatly enhanced their ability to see and comprehend the historical era and daily lives of the community.

On the other hand, some participants mentioned that the digital scenes on several separated spots make the experience intermittent. As participant 10 said, she believed it would be easier to make the experience for her feel more real and immersive if she could see a street rather than a single building. These viewpoints suggest that the quantity and distribution of digital assets in the physical world will have an impact on people's perceptions of the degree of immersion of the hybrid experience. Additionally, it is anticipated that the portrayal of designs will be improved because, as several participants noted, digital architectures still resemble "models" more than actual architectures. The need to increase the realism of scenes in upcoming research and projects arises from the fact that this is a reflection of the historical context.

5.3.2 Understanding about the district and local heritage

"...Yes I think they helped. Previously I didn't know much about the district. But when I saw the images of people who used to live here, I started to realized here might be a living neighborhood before. I tried to figure out the reason why they disappeared in the following process. It's pretty nice, the exploration based on all the oral history and visual cues..." (Participant 6)

"I don't know much about the relationship among heritage sites. If some visual cues can be offered or there is a correlation among the digital contents of

different sites. In the AR environment, I feel like I just encounter them when walking around and someone introducing the heritage by showing something. I won't pay much attention to understanding the relationship between them. If there are some interactions of feedback, users might have more motivation to try to understand that." (Participant 9)

This section of the evaluation discusses how augmented reality aids in the comprehension of regional heritage and history. The third and fifth survey questions as well as the interview subject concerning personal understanding are all part of the information presented in this section. People felt that the interview and open-ended survey questions contributed to their awareness of the region's history and cultural heritage. Even while some participants complained that it was difficult for them to recall every detail once the tour was over, they still felt that the augmented reality experience at such important historical sites piqued their curiosity about the community's intangible legacy. I assess their comprehension of the connections between all the heritage sites from their descriptions. For this section, half of the participants believed they could sense the association from the standpoint of community development. The others believed it would be better if there were interactive elements to boost their interest for learning more about it. They felt it was somewhat difficult for them to understand the relationships across various sites.

5.4 Interaction

"...I think the interaction process is pretty direct and intuitive. I have really enjoyed it. What was particularly interesting to me is that there was a thing there is several workers involved in the sandwich shop and I think this thing is really good because is there a lifelike and there's this sort of tenderness in it and it feels very relatable. I really like this project..." (Participant 7)
"... I think it's necessary to try to add more interactions. Sometimes I can't help clicking different elements. If I can get some reactions it will definitely be more attractive to me..." (Participant 6)
"...The AR application helps me understand the physical heritage better. It integrates different forms of media, providing a sense of immersion. But I think there can be more interaction mechanics to strengthen the user's participation, like how the users trigger the oral histories. It would be more impressive if the digital content can respond to users' behavior..." (Participant 10)

As for the interaction design, most participants thought that it makes the whole experience more engaging and interactive. The map leads users to move around the site. But some participants like participant 3 thought that the size of the map is too tiny so it's kind of hard for them to read the map. Also many participants mentioned that they were willing to see more different kinds of interactions among digital assets. For instance, participant 10 expected to see clickable architectures to make the scenes look more real and attractive. Other comments also mentioned some methods like adding certain real-time features or

integrate the audio components with the human figure more closely to improve the project's interaction and create a hybrid environment that is more engaging and immersive.

6 Discussion

6.1 Intangible Heritage Representation via Multimedia

One of the major goals of this research is to depict local intangible heritage, which includes local cultural, social, and economic activities, utilizing multimedia, including visual, audio, and interactive aspects. In the past, academics in this sector focused more on the preservation of tangible legacy or the absence of vibration in the exhibition of intangible heritage.[45][46] Heritage, as I have stated, is more than simply an item. To portray local intangible heritage, the historical setting, the physical subject, and the regional customs and practices should all be merged as an integrated whole. Together, they may give the audience a better and more complete understanding of the heritage's origins, historical development, and present-day significance for the neighborhood.

I proposed a "location-based" augmented reality experience as a strategy for representing regional heritage in order to do this. The term "location-based" denotes two levels of information. For starters, the hybrid experience may access the actual location information because the augmented reality tour is taking place on a historical landmark and area. On the other hand, depending on location data, all digital assets, such as models, photos, and audio files, are mapped to the actual physical place. For instance, the model of Goodie's Drug Store, photographs of Mr. Goodie operating the store in the 1940s, and oral histories of the drug store and other local businesses from local residents are all combined and merged as a complete intangible heritage scene and are relocated on their historical grounds.

According to the user test, the integration and connection of all the items supported the participants' comprehension of the regional heritage. When depicting historical settings and human actions, the visual aspects are intuitive. The aural components, such as oral history and background music, provide further information about the historical events. Users can form a vivid and thorough impression in their brains by investigating the link between visual and audio elements.

6.2 Design Implications

The methodology for designing and creating a location-based augmented reality experience for a community's intangible heritage is another contribution of this study. Data gathering, digital construction, experience design, and application development are the four processes that make up the entire design flow. The process of gathering data include collecting various types of historical content from a variety of sources, such as pictures, audio snippets from oral histories, documentaries, etc. Creating relationships with local authority groups like the local library, the government, or related public archive organizers is an efficient way to obtain relevant material for the specific urban space. Another effective

approach to get oral history recordings for the project is to gain access to relative researchers or local community members. Regarding the digital construction, I made the decision to create virtual replicas of physical cultural assets like buildings and structures and to reflect human activity on the site by editing old photographs. All the assets are mapped out as part of the experience design, and the user interface is created so that users can access them. For instance, the user in this project will first observe the architectural structure and hear the introduction to the oral history. They can then press the start button to view the human photos and hear the ambient sound. Participants had the opportunity to gradually increase their comprehension of the site thanks to this interaction design.

In the last segment, which deals with application development, the Unity engine plays a crucial role since it offers an environment for creating augmented reality applications called the AR Foundation as well as plugins that already have GPS-based location-based services built in. In order to make the entire on-site walk more immersive and engaging, I demonstrated how to merge digital assets with actual space as well as how to create the interface and acoustic settings. Generally speaking, it offers a way for designers with less experience to create and construct the application with fewer technological challenges.

7 Future

7.1 Current Limitations

7.1.1 Technological Limitations

- Considering the limitation of the GPS recognition accuracy(5m-10m), the assets are supposed to be placed with a distance to avoid the overlap. Therefore, currently it's hard to design a continuous scene in a larger scope.
- The current application is not able to collect user data during the walk. So the user-test methods are limited to subjective approaches like interview or surveys.

7.1.2 Design Limitations

- Due to the time and research scope limitation, the interaction design is simplified as the toggle of visibility of human activity assets in the scene.
- The guiding interface is currently designed as a mini-map to suggest the user follow the designed walking route. But it's also possible to design a location-based notification system to make the whole experience more immersive and flexible.
- User-test collected opinions from people with relative experience or knowledge now. It's also interesting to explore the feedback from local community members or other stakeholders.

7.2 Future works

7.2.1 Technological Improvements

- In the future, I'd like to explore the methods to refine the accuracy of GPS recognition to enlarge the scope for heritage scene display in the urban space.
- Also, data tracking and collection can be combined with user activities like moving route, dwell time as well as interactive activities. Those data can be used to a more objective evaluation and help with further design interaction.

7.2.2 Design Improvement

- It's possible to exploring the interaction with different kinds of assets like the architecture models and the human activity images to make the whole experience more interesting and immersive.

- Also, the guidance system can be refined based on the location-based technology like triggering an audio when the user approach a specific spot to guide further direction.
- Besides, under the evaluation section, I'd love to hear more opinions from local communities and relative authority organizations which can bring suggestions for project development from different aspects. It's also possible to introduce the voice of local communities in the heritage protection field by letting them investing in histories by using some crowd-sourcing data about local history.

8 Conclusion

Generally the project provides a more immersive and intuitive method for people to interact with local intangible heritage and build a better understanding about it. The multimedia platform worked well to provide a more comprehensive recognition of the heritage and history. People thought the realistic photos and the oral history are more convincing than a simple background narrator. It's hard for people to understand and remember all the materials during the walk. But it's considered to a good way to trigger their interests about local heritage and community. Also it provides a workflow for future researchers and designer to develop a location-based augmented reality application with less technological and design difficulties and challenges.

References

[1] Răzvan Gabriel Boboc, Florin Gîrbacia, Mihai Duguleană, and Aleš Tavčar. A handheld Augmented Reality to revive a demolished Reformed Church from Braşov. In *Proceedings of the Virtual Reality International Conference - Laval Virtual 2017*, VRIC '17, pages 1–4, New York, NY, USA, 2017. Association for Computing Machinery.

[2] Fabrizio Natta and Michele Ambrosio. AR for Demolished Heritage: the First Italian Parliament in Turin.

[3] Derek G. Handley. "The Line Drawn": Freedom Corner and Rhetorics of Place in Pittsburgh, 1960s-2000s. *Rhetoric Review*, 38(2):173–189, April 2019. Publisher: Routledge _eprint: https://doi.org/10.1080/07350198.2019.1582239.

[4] Jiyoung Kang. AR Teleport: Digital Reconstruction of Historical and Cultural-Heritage Sites for Mobile Phones Via Movement-Based Interactions. *Wireless Personal Communications*, 70(4):1443–1462, June 2013.

[5] Matthew L. Vincent, Mariano Flores Gutierrez, Chance Coughenour, Victor Manuel, Lopez-Menchero Bendicho, Fabio Remondino, and Dieter Fritsch. Crowd-sourcing the 3D digital reconstructions of lost cultural heritage. In *2015 Digital Heritage*, volume 1, pages 171–172, September 2015.

[6] Feng Shui Art.

[7] Ozeni Athanasiadou Droumpouki, Anna Maria. Memories of the Occupation in Greece, May 2016.

[8] Derek Ham. I AM A Man | VR Civil Rights App, January 2018.

[9] Fabrizio Natta and Michele Ambrosio. AR for Demolished Heritage: the First Italian Parliament in Turin. page 121. September 2022.

[10] Hill District (Pittsburgh), November 2022. Page Version ID: 1123403185.

[11] Shake dancer, possibly "Gypsy Rose Lee" performing with band, including Tommy Turrentine on trumpet, at Bambola Social Club | CMOA Collection.

[12] Pharmacist William Goode, standing outside of Goode Pharmacy with advertisement for Nucoferrin in window, Wylie and Fullerton Avenues, Hill District | CMOA Collection.

[13] Interior of Musician's Club, Local 471, with striped awning over bar, television in corner, and round bar stools | CMOA Collection.

[14] Exterior of Rhumba Theatre seen from across street, Fullerton Street, Hill District | CMOA Collection.

[15] Naomi Chris Hedlin Harris, Rich Lord. Oldest Black church in Pittsburgh calls out racism, seeks reparations, April 2021.

[16] Pittsburgh Civic Arena under construction | Historic Pittsburgh.

[17] Pittsburgh City Photographer Collection | Digital Pitt.

[18] CMOA Collection.

[19] Details, Sala Udin describes the Hill District community of Pittsburgh, Pennsylvania.

[20] BBC Sound Effects.

[21] Stanley Turrentine Albums and Discography.

[22] Archives & Special Collections | University of Pittsburgh Library System.

[23] Tearing Down History.

[24] Dennis Rodwell. *Conservation and Sustainability in Historic Cities*. John Wiley & Sons, April 2008.

[25] Shalini Panjabi and Tim Winter. Understanding the tensions in place: Conflict and conservation in Kashmir. *Historic Environment*, 22(1):19–25. Publisher: Australia ICOMOS (International Council on Monuments and Sites).

[26] UNESCO World Heritage Centre. Convention Concerning the Protection of the World Cultural and Natural Heritage.

[27] Loes Veldpaus, Ana R Pereira Roders, and Bernard J F Colenbrander. Urban Heritage: Putting the Past into the Future. *The Historic Environment: Policy & Practice*, 4(1):3–18, April 2013. Publisher: Routledge _eprint: https://doi.org/10.1179/1756750513Z.00000000022.

[28] Rebecca Madgin. Reconceptualising the historic urban environment: conservation and regeneration in Castlefield, Manchester, 1960–2009. *Planning Perspectives*, 25(1):29–48, January 2010. Publisher: Routledge _eprint: https://doi.org/10.1080/02665430903421726.

[29] Rohit Jigyasu. The Intangible Dimension of Urban Heritage. In *Reconnecting the City*, pages 129–159. John Wiley & Sons, Ltd, 2014. Section: 5 _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/9781118383940.ch5.

[30] Liron Efrat. Historical APPistemology: The Mapping of the Expanded Field of Cultural Heritage AR Apps as a Creative Tool. *International Journal for Digital Art History*, (6):3.02–3.15, October 2021. Number: 6.

[31] Guzman Molina, P.C., Pereira Roders, A.R., Colenbrander, B.J.F., and Architectural History and Theory. Bridging the gap between urban development and cultural heritage protection. In *conference; IAIA14*, 2014.

[32] Densho: Japanese American Incarceration and Japanese Internment.

[33] Augmented reality, November 2022. Page Version ID: 1122588432.

[34] https://plus.google.com/+UNESCO. Cultural heritage, November 2020.

[35] A Bibliometric Analysis of Research on Intangible Cultural Heritage Using CiteSpace - Xinwei Su, Xi Li, Yanxin Kang, 2019.

[36] Michael Dylan Foster. *UNESCO on the Ground: Local Perspectives on Intangible Cultural Heritage.* Encounters: Explorations in Folklore and Ethnomusicology Ser. Indiana University Press, Bloomington, 2015.

[37] Pinar Yelmi. Protecting contemporary cultural soundscapes as intangible cultural heritage: sounds of Istanbul. *International Journal of Heritage Studies*, 22(4):302–311, April 2016. Publisher: Routledge _eprint: https://doi.org/10.1080/13527258.2016.1138237.

[38] Vincenzo Lombardo, Antonio Pizzo, and Rossana Damiano. Safeguarding and Accessing Drama as Intangible Cultural Heritage. *Journal on Computing and Cultural Heritage*, 9(1):5:1–5:26, 2016.

[39] William C. C. Wright and Florian V. Eppink. Drivers of heritage value: A meta-analysis of monetary valuation studies of cultural heritage. *Ecological Economics*, 130:277–284, October 2016.

[40] Sun-Kee Hong, In-Ju Song, and Jianguo Wu. Fengshui theory in urban landscape planning. *Urban Ecosystems*, 10(3):221–237, September 2007.

[41] SANG HAE LEE. *Feng-Shui: Its Context and Meaning (china).* Ph.D. ISBN: 9798206250084.

[42] Guo-Ming Chen. The Impact of Feng Shui on Chinese Communication. *Communication Studies Faculty Publications*, January 2007.

[43] Intangible Cultural Heritage | The National Heritage Council of Namibia.

[44] Gabriele Ivo Moscaritolo. Reconstruction as a Long-Term Process. Memory, Experiences and Cultural Heritage in the Irpinia Post-Earthquake (November 23, 1980). *Geosciences*, 10(8):316, August 2020. Number: 8 Publisher: Multidisciplinary Digital Publishing Institute.

[45] E. K. Stathopoulou and F. Remondino. Semantic Photogrammetry - Boosting Image-Based 3d Reconstruction with Semantic Labeling. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 42W9:685–690, January 2019. ADS Bibcode: 2019ISPAr42W9..685S.

[46] Gamze Fahriye Pehlivan. Remains from a Demolished Cultural Heritage: A Historical House in Karaagac. *Art-Sanat Dergisi*, (15):249–285, February 2021. Number: 15.

[47] Francesca Cominelli and Xavier Greffe. Intangible cultural heritage: Safeguarding for creativity. *City, Culture and Society*, 3(4):245–250, December 2012.

[48] Aisyah Abu Bakar, Mariana Mohamed Osman, Syahriah Bachok, and Mansor Ibrahim. Analysis on Community Involvement Level in Intangible Cultural Heritage: Malacca Cultural Community. *Procedia - Social and Behavioral Sciences*, 153:286–297, October 2014.

[49] IJIH - International Journal of Intangible Heritage.

[50] Marcello Atzeni, Giacomo Del Chiappa, and Jessica Mei Pung. Enhancing visit intention in heritage tourism: The role of object-based and existential authenticity in non-immersive virtual reality heritage experiences. *International Journal of Tourism Research*, 24(2):240–255, 2022. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/jtr.2497.

[51] Florent Poux, Quentin Valembois, Christian Mattes, Leif Kobbelt, and Roland Billen. Initial User-Centered Design of a Virtual Reality Heritage System: Applications for Digital Tourism. *Remote Sensing*, 12(16):2583, January 2020. Number: 16 Publisher: Multidisciplinary Digital Publishing Institute.

[52] Mariapina Trunfio, Maria Della Lucia, Salvatore Campana, and Adele Magnelli. Innovating the cultural heritage museum service model through virtual reality and augmented reality: the effects on the overall visitor experience and satisfaction. *Journal of Heritage Tourism*, 17(1):1–19, January 2022. Publisher: Routledge _eprint: https://doi.org/10.1080/1743873X.2020.1850742.

[53] Loris Sauter, Luca Rossetto, and Heiko Schuldt. Exploring Cultural Heritage in Augmented Reality with GoFind! In *2018 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR)*, pages 187–188, December 2018.

[54] Ajaya Kumar Dash, Santosh Kumar Behera, Debi Prosad Dogra, and Partha Pratim Roy. Designing of marker-based augmented reality learning environment for kids using convolutional neural network architecture. *Displays*, 55:46–54, December 2018.

[55] Hill District - Pittsburgh Music History.

[56] Bethel A.M.E. Church Historical Marker.

[57] Martin Delany - Pittsburgh Music History.

[58] Christopher Lemery. Guides: Pittsburgh Census Information @ Pitt: 1940 Census.

[59] Monticello-Delaney Rifles | The Black Fives Foundation, November 2008.

[60] August Wilson, November 2022. Page Version ID: 1124055345.

[61] History of Pgh Musicians L. 471.

[62] Bambola Social Club - Pittsburgh Music History.

[63] Lilian McKibbin Steiner. *"Sugar Top" and the "Cobblestone Jungle": Urban Redevelopment in Pittsburgh's Hill District 1955-1959*. Thesis, 2010. Accepted: 2010-08-11T19:23:32Z.

[64] The Story Of The Pittsburgh Neighborhood That Inspired "Fences" | National Trust for Historic Preservation.

[65] Civic Arena - Pittsburgh Music History.

[66] Freedom Corner | PGH Events.

[67] The Pittsburgh Courier from Pittsburgh, Pennsylvania on August 4, 1951 · Page 13.

[68] Publications | PittPharmacy Publications | Page 13.

[69] Musician's Club of Local 471 - Pittsburgh Music History.

[70] Tony Norman. Tony Norman: The road to reparations at Bethel African Methodist Episcopal Church, October 2022.

[71] From "citadel of hope" to parking lot: Pittsburgh's oldest Black church demands reparations.

[72] Mellon Arena Arena: History.

[73] Civic Arena (Pittsburgh), November 2022. Page Version ID: 1119501981.

[74] The HistoryMakers Digital Archive (March 17, 2022).

[75] Guide to the African American Jazz Preservation Society of Pittsburgh Oral History Project Records and Recordings, 1995-1999 AIS.1998.04 | Digital Pitt.

[76] Pittsburgh HillDistrict. The Renewal of Pittsburgh's Hill District, June 2014.

[77] pitcitywatcher. Civic Arena Engineering & Innovated in Pittsburgh, January 2009.

[78] Renewing Communities. Pittsburgh People & Places Tour: Stop 4 (August Wilson House & Freedom Corner), July 2021.

[79] Sala Udin, 68 Stories.

[80] Bev Smith, 82 Stories.

[81] Boswell, Robert - April 22, 1996 | Digital Pitt.

[82] Hughes, John - April 4, 1996 | Digital Pitt.

[83] Laurence Glasco | Department of History | University of Pittsburgh.

[84] Hill District-born jazz great Turrentine dies.

[85] Blender Institute. Textures.

[86] Low Poly Animated People | 3D | Unity Asset Store.

[87] Newsfeed.

[88] Yixiao Fu. *Evoking the Post-industrial Landscape Memories through Mixed Reality Soundscape.* thesis, Carnegie Mellon University, March 2021.

[89] AR + GPS Location | | Unity Asset Store.

[90] Unity Technologies. Unity - Manual: Audio files.

[91] Wrong Import Settings are Killing Your Unity Game [Part 2] – The Knights of Unity.

[92] Unity Technologies. Unity - Scripting API: AudioSource.spatialize.

[93] Unity Technologies. Unity - Manual: Audio Source.

[94] Unity Technologies. Unity - Scripting API: Physics.Raycast.

[95] Unity Technologies. Unity - Scripting API: Renderer.enabled.

[96] Unity Technologies. Unity - Scripting API: AudioSource.clip.

[97] Unity Technologies. Unity - Scripting API: AudioSource.Play.

[98] Button | Unity UI | 1.0.0.

A Assets List

B User Test Responses

B.1 Interview Transcripts

Participate 1
The participant has an architectural design background, game design and augmented reality development experiences. He also has computational design background.
The author: How do you generally feel about this augmented reality walk?
Participant 1: I found it interesting. I think it's kind of hard to obtain this experience via other approaches. I can see the people in the scene. It feels like a game. I mean the immersive feeling is strong. It made me feel that I'm really viewing that world. Actually I want to ask how to think the location-based augmented reality works better that the marker based augmented reality?
The author: Generally it works better in two ways. For one thing, the marker won't make changes to the physical environment. This is a way to protect the heritage and also the project can be kept on the site for the longer period since it doesn't depend on some physical images or QR codes. Secondly since you don't really need to stop and scan anything, the whole experience will be way more immersive and continuous.
Participant 1: OK I see. I have another question then. The background narrator, do you record this? What are the resources of those audio?
The author: They are oral history from public archives and documentaries.
Participant 1: Oh that works better. That will be definitely more convincing.
The author: As you mentioned that, how well do you think the visual and audio elements works in this project? How well do they support your understanding?
Participant 1: For me I think the visual parts works better. I mean it's hard for you to see the digital views like this. You can go to the museum if you want to know more about this piece of history, but it's very hard to gain an immersive experience like this. The scale of the architecture and people are real. The textures are real. At least it can make you more impressive. As for the audio, I think they are related to the visual elements right now. But I think if you can make it more like a dialog, you know. Like in a game, I can click on a character, and make him talk to me. I think it will definitely make the whole experience more interesting.
The author: Oh thank you for your suggestions. The next question will be how do you think about your current understanding about the district or the local heritage. Does this experience help? If so, how much does it help?
Participant 1: I think it helped me with the understanding. I mean I've been here in Pittsburgh for a while but I really know nothing about the this location previously. At least this application made me more interested about this area.

Participate 2

ID	Category	Name	Resources	Length	Start point	End point	Location	Looping
1	Model	Local 471 club	self-made	/	/	/	(40.442991, -79.987384)	/
2	Model	Goodie's drug store	self-made	/	/	/	(40.442749, -79.987288)	/
3	Model	Rhumba Theater	self-made	/	/	/	(40.442407, -79.987953)	/
4	Model	B.M.E Church	self-made	/	/	/	(40.441597, -79.989773)	/
5	Model	Civic Arena	self-made	/	/	/	(40.441542, -79.990042)	/
6	Model	Bill board	self-made	/	/	/	(40.441015, -79.986071)	/
7	Image	Local 471 club's Musicians	Teenie Harris Photography Collection	/	/	/	(40.442979, -79.987360)	/
8	Image	Local 471 club's singer	Teenie Harris Photography Collection	/	/	/	(40.443031, -79.987404)	/
9	Image	Man sitting in front of Local 471	Pittsburgh City Photographer Collection	/	/	/	(40.443031, -79.987360)	/
10	Image	Sandwich shop workers	Teenie Harris Photography Collection	/	/	/	(40.442413, -79.988067)	/
11	Image	Performer in Rhumba Theater	Teenie Harris Photography Collection	/	/	/	(40.442483, -79.987864)	/
12	Image	Mr. Goodie standing in front of the store	Teenie Harris Photography Collection	/	/	/	(40.442746, -79.987300)	/
13	Image	Mr. Goodie in the store with customers	Teenie Harris Photography Collection	/	/	/	(40.442738, -79.987290)	/
14	Image	Removing B.M.E Church	Pittsburgh City Photographer Collection	/	/	/	(40.441613, -79.989674)	/
15	Image	Building Civic Arena	Teenie Harris Photography Collection	/	/	/	(40.441514, -79.990188)	/
16	Image	People's protest for jobs and houses	Teenie Harris Photography Collection	/	/	/	(40.441063, -79.986164)	/

Figure 42: Form of assets information, visual part

ID	Category	Name	Resources	Length	Start point	End point	Location	Looping
17	Audio	Hughes John Interview	African American Jazz Preservation Society of Pittsburgh Oral History Project	25"	05:05	05:30	(40.442991, -79.987384)	No
18	Audio	"La Space"	Album of Stanley William Turrentine	1'30"	00:30	02:00	(40.442991, -79.987384)	Yes
19	Audio	Sala Udin's Interview	"TheHistoryMakers" Oral History Collection	27"	00:24	00:51	(40.442749, -79.987288)	No
20	Audio	Sounds on the street	BBC Sound Effects	15"	00:00	00:15	(40.442749, -79.987288)	Yes
21	Audio	Sala Udin's Interview	"TheHistoryMakers" Oral History Collection	57"	01:35	02:32	(40.442407, -79.987953)	No
22	Audio	Sounds in the restaurant	BBC Sound Effects	24"	00:00	00:24	(40.442407, -79.987953)	Yes
23	Audio	Bev Smith's Interview	"TheHistoryMakers" Oral History Collection	37"	01:25	02:02	(40.441597, -79.989773)	No
24	Audio	Sounds during construction	BBC Sound Effects	30"	00:00	00:30	(40.441597, -79.989773) (40.441542, -79.990042)	Yes
25	Audio	Prof. Laurence Glasco's Interview	Documentary: The Renewal of Pittsburgh's Hill District	23"	19:45	20:08	(40.441597, -79.989773)	No
26	Audio	Engineers' interviews	Documentary: Civic Arena Engineering and Innovated in Pittsburgh	7"	04:40	04:47	(40.441542, -79.990042)	No
27	Audio	Sounds of protests	BBC Sound Effects	9"	01:42	01:51	(40.441542, -79.990042)	No
28	Audio	Prof. Laurence Glasco's talk	Documentary: Pittsburgh People and Places Tour	15"	00:00	00:15	(40.441015, -79.986071)	Yes
29	Audio	Prof. Laurence Glasco's talk	Documentary: Pittsburgh People and Places Tour	1'45"	10:45	12:30	(40.441015, -79.986071)	No

Figure 43: Form of assets information, auditory part

The participant has a city planning background, no augmented reality development experience.

The author: How do you generally feel about this augmented reality walk?
Participant 2: Generally I think this project is great. It provides a view to see the process of the urban renewal process and the the city's development. And it is shown in the first-person perspective, which is really special. And the views in the application makes me feel it's realistic. However, I think it will be better if there is a brief guidance at the beginning of the whole project. I mean, I was kind of confused about how it works when I got started.
The author: OK. Then how do you feel about the visual and auditory elements in this projects? How well did they work to effect your understanding or feelings?
Participant 2: Actually I think the visual elements worked much better than the auditory aspects. They contributed more because they are more intuitive, and they looked pretty nice through the augmented reality application.
The author: Great. Do you feel immersive when you went through the whole journey?
Participant 2: Yes, yes. To be honest, at some moment it was hard for me to tell the differences between the virtual and physical assets. They looked pretty real. I think all the assets fit into the background better than I thought.
The author: OK,OK. Then I also want to ask how do you think about your current understanding about the district or the local heritage. Does this experience help? If so, how much does it help?
Participant 2: I think it increased my interests in learning about this area. Also I think it really decreased the time and efforts I need to spend if I want to learn. For instance, previously I need to read books or articles to learn about it. Or seeing historical images. And they are black and white mostly(laughing). But this project better connects the history with current location. It increased my interests and also make the history more accessible.
The author: Could you please describe a scene that impressed you most?
Participant 2: That's a good question. Emmm, the first scene jumps to my mind is the church. It looks pretty nice. But for now I think it's just a clearing. The comparison between those two is really impressive.

Participate 3
The participant has backgrounds for architectural design and urban design, no augmented reality development experience.

The author: How do you feel about this walk generally?
Participant 3: Generally I think it's nice. But to be honest, at first it was not very clear to me how the digital assets, I mean those models, I'm not so sure how they connect to the site. I think not until the third one. I just realized that this is something happened here previously. And the map, I think it's kind of hard to read... At least for me...
The author: Could you please tell me more about the map? Why do you think

it's hard to read?
Participant 3: I think it's too tiny. I can hardly tell where I was based on it.
The author: OK, I see. Then what do you think about the auditory and visual elements in this application?
Participant 3: They are pretty cool actually. I found them interesting and they are reflections of previous history. But I think for one scene...the theater? Yes, that one, the audio is too long. I basically finished viewing the scene but I had to stop there for more time to hear the audio. Maybe it will be better if they can fit more with each other.
The author: Thank you for your opinion! Next question is, how well did those elements work to effect your understanding or feelings?
Participant 3: I think generally they are good. But I hope to see more details. If you want to make them more real, you have to provide more details. For now I don't think that's enough.
The author: Sure. Then I also want to ask how do you think about your current understanding about the district or the local heritage. Does this experience help? If so, how much does it help?
Participant 3: To be honest, I didn't remember too many details. I know there is a sandwich shop here, a theater, a church, and a performance? Yeah I'm not so sure if I fully understand all the materials. Sometimes the audio is hard to understand... I'm not a native speaker (laugh). But I can generally figure out that they are related to each other. I think they helped me to build the understanding of this place.
The author: Thank you. Do you have any other comments or suggestions?
Participant 3: Emmm, I think it's better to add more details still. If you can make the image move. Animation, yes. I bet it will be much more interesting if I can see this.

Participate 4
The participant has backgrounds for architectural design and urban planning, no augmented reality development experience.

The author: Hi, my first question is how do you generally feel about this augmented reality walk?
Participant 4: I like it very much! I found that it's a nice way for me to learn more about the history.
The author: Then how do you feel about the visual and auditory elements?
Participant 4: You mean the images? Oh models as well. Emmm...generally I think they were nice to reflect the historical scenes. I think the images are very intuitive. They made me feel more about how people used to work and live here previously. The author: What about the auditory ones? How do you feel about them?
Participant 4: I think it works as a background instruction. I mean it's kind of hard for me to capture all the details but it provided more information for sure. But not as intuitive as visual elements.
The author: OK I see! Next may I ask how do you think about the immersive

level of this experience?
Participant 4: It's pretty nice. I mean you can walk and see what happened previously. It's pretty cool, right? I think the size of the architectures... Yes, the digital ones. I think they are pretty real. They really fit into the environment, which made me really surprised. I think it feels pretty real to walk through all the virtual streets and people. Yes, I think it's pretty immersive for me.
The author: Thank you. I also want to know that how this experience works for your understanding about the district?
Participant 4: It helped, of course. I mean I had little knowledge about this district previously. But I know this used to be an important neighborhood for the locals and it got removed. People were not happy about this and fought against it. It's pretty clear to see through this experience!
The author: Cool. Then do you have any other comments or suggestions?
Participant 4: Emmm, maybe if you can add more scenes in this application, it will be better.

Participate 5
The participant has backgrounds for architectural design and urban planning, no augmented reality development experience.

The author: Thank you for having this interview. My first question is how do you feel about this augmented reality walk generally?
Participant 5: I think it's great to combining different kinds of assets together like images, models and sounds. I really like the scene with some musicians in it... Yes the jazz club. Once the background music started, it made me feel pretty real immediately.
The author: Oh I see. Then how do you feel you about visual and auditory elements specifically in this project? Did they support your understanding of this district?
Participant 5: Emmm, as I said, generally I think they are nice. The audios worked well. I learned a lot from the narrator in the background. As for the digital models, they are not bad. But I think they looked not that real. They still looked like models.
The author: Could you please tell me more about why you felt like this?
Participant 5: I think it's their textures. You know when we normally render a model, the texture assets really matter. So I just wonder if you can modify this issue by changing the textures or rendering materials you choose.
The author: Thank you for this suggestion! Then do you have any other comments or opinions about this project?
Participant 5: Oh one more thing I want to mention, I found the shadow of the architecture is not right... Yeah, the direction. So are they pre-designed or pre-set?
The author: Yes, the light and shadow are pre-designed in the game engine.
Participant 5: Yeah, it makes sense. But it will be more real if the shadow can change based on the real sunlight directions. I guess it's another reason I found the models looked not like real architectures.

Participate 6
The participant has backgrounds an architectural design background and augmented reality development experiences. He also has computational design background.

The author: So generally how do you think about this experience?
Participant 6: I like it. I think it successfully offered a method to experience what happened here previously. I mean in the urban space, it's very creative and interesting. The augmented reality worked pretty stable, which was also nice.
The author: Thank you. How do you feel about the auditory and visual elements in this project then? Do they help with your understanding about this district?
Participant 6: Yes I think they helped. Previously I didn't know much about the district. But when I saw the images of people who used to live here, I started to realized here might be a living neighborhood before. I tried to figure out the reason why they disappeared in the following process. It's pretty nice, the exploration based on all the oral history and visual cues.
The author: Good to hear that. Could you please describe a scene that interested you most or made you impressed?
Participant 6: Emmm. let me see. I think it might be the theater. I saw the sandwich shop nearby and some staffs. And I hear this part, the story also in the audio in the background. It's very interesting to find they are actually related!
The author: Thank you. Then do you have any other comments about this walk?
Participant 6: I think it's necessary to try to add more interactions. Sometimes I can't help clicking different elements. If I can get some reactions it will definitely be more attractive to me.

Participate 7
The participant has backgrounds an architectural design background and computational design background.

The author: Hi, so generally how do you think about this augmented reality walk? Participant 7: It's interesting to see a project like this. Especially you managed to combine models and images together. It's interesting to walk and see different things appear on the screen.
The author: Cool. Then how do you feel about those visual and auditory elements specifically? Like the images, models and the sounds.
Participant 7: Actually I think the 3D model worked well. Real size, real material, you know what I mean. May I ask a question actually? Yeah, why you choose to use images to show human activities? I mean, they didn't fit well from my point of view.
The author: I tried to use human models for this part. But the low-poly models

are not very ideal to represent real residents in this district.
Participant 7: So for the reality. It makes sense. But I'm still willing to see a 3D version (laugh). You can add more animations or interactions based on that.
The author: Thank you for sharing this. Next could you please tell me how does this experience work for building your understanding about this area?
Participant 7: Oh sure. I think it helped a lot. I mean, even though it's hard for me to understand everything, I can still know about the general developing process of this district. It also triggered my interests to explore more about it in the future. I think the interaction process is also pretty direct and intuitive. I have really enjoyed it. What was particularly interesting to me is that there was a thing there is several workers involved in the sandwich shop and I think this thing is really good because is there a lifelike and there's this sort of tenderness in it and it feels very relatable. I really like this project.
The author: Thank you. So do you have any other suggestions or comments about this project?
Participant 7: Emmm, maybe not. I think you did a great job! Oh maybe the 3D human figure display I mentioned. I'm willing to see them in the future.

Participate 8
The participant has an architectural design background, game design and augmented reality development experiences.

The author: Thank you for have the walk and the interview. So my first question is going to be how you feel about this walk generally?
Participant 8: I really like the project! I think you put many real historical materials here, like images and the audios. Did you build the models on your own?
The author: Yes, they were built based on some historical maps. And I also used some textures from real historical photos.
Participants 8: Oh really cool. I think those elements looked really nice.
The author: So how you feel about those auditory and visual elements specifically? Did they help with your understanding about this district?
Participant 8: Yes of course. As I said, I liked the visual elements since they are nicely built and positioned on the location. However, I have to say I learnt more from the audio. I mean the speaker in the background. Yes the oral history. The oral history provided more details. Otherwise I couldn't fully understanding what happened here.
The author: I see. Then could you please describe a scene you felt the most impressive in this walk?
Participant 8: I think it might be the church. It's great and impressive. I felt sorry it was removed from the neighborhood. I can feel that it must mean a lot for the local people.
The author: Thank you for sharing this. So do you have more suggestions or options?
Participant 8: Let me see. I think I really hope to see more interactions. I mean

you have a very good start here. But I think you can add more details in all the scenes to make it more interesting and realistic. Like the window or door can be open. Or I can click something to play a specific human animation. I know augmented reality platform has this potential.

Participate 9
The participant has backgrounds an architectural design background, computational design background.

The author: Hi, thank you for have the walk and the interview. First, I want to hear about how you feel about this walk generally?
Participant 9: I think this is a great project. So all the assets are placed on their previous location in the history right?
The author: Yes, exactly.
Participant 9: That's pretty cool. I think it's kind of magical to see what happened previously and what it looks like now at the same time on the same location. I think it greatly help me understand the history and historical activities in this site. I like the image showing what the protesters do to protect their community. I can't help think if we can also put some architectural design projects on the location in this way. It will be more intuitive than just seeing some images.
The author: That's an interesting idea. May I ask how you feel about the visual and auditory elements? How did they work for your understanding about this district?
Participant 9: I think it helped. I mean previously I might choose to see a documentary if I want to know more about this piece of history. But this project it provided more. Like the multi-media experience, the interaction. I think I'm more focused during this process. But I don't know much about the relationship among heritage sites. If some visual cues can be offered or there is a correlation among the digital contents of different sites. In the AR environment, I feel like I just encounter them when walking around and someone introducing the heritage by showing something. I won't pay much attention to understanding the relationship between them. If there are some interactions of feedback, users might have more motivation to try to understand that.
The author: Thank you. Then could you please describe a scene that interested you the most or make you very impressive?
Participant 9: I think I will choose the last one. Yes, the protest. It's because I think this scene combines the background sounds well with, you know, the visual parts. The voice of people during the protest, really impressive. And I can see the Freedom Corner from this viewpoint. It's very well designed.
The author: Cool. Do you have any more comments or opinion?
Participant 9: Not much except the interaction one. I think it can make the walk more immersive and interesting.

Participate 10
The participant has backgrounds a design background, no augmented reality

development experience.

The author: Hi, thank you for being here. I firstly want to ask how you generally feel about this experience?
Participant 10: I like it and I think it's a very creative way to show people the changes of the urban space during a historical period. It feels like a time travelling experience (laugh). Yeah, I like it.
The author: Thank you for saying this. Then could you tell me more about how you specifically feel about those visual and auditory elements in this project?
Participant 10: Visual and auditory... Emmm, let me see. I think I might prefer visual parts more. Since you can hear the audio from other resources like some documentaries. But the visual elements, especially the models, they are unique in this experience. It's hard to experience the same through other methods. But I also agree that it's essential to combine the visual with auditory ones. The storytelling will be more comprehensive in this way.
The author: I see what you mean. Then how do you think they help with your understanding about this district?
Participant 10: I think it supported the understanding definitely. I didn't know much about this neighborhood before but I think I can rough tell people what happened here by having this walking. It's very impressive.
The author: Thank you for saying this. Finally do you have any comments or instructions?
Participant 10: I think it will be better if we can see more scenes. I think for now they are separated spots. But if we can see a street, you know, instead of just some isolated buildings, it will be more immersive and interesting.

B.2 Take Home Survey Responses

Participate 1
Date: 2022-11-27
1. How well do you think the visual elements help with your understanding about the heritage?
Extremely helpful.
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Extremely helpful
3. How well do you understand the historical time period shown in the application?
Clearly understand(more than 50% but not 100%)
4. How do you feel about the interaction process of this augmented reality application?
It is a new experience for me to know about the history, very interesting and look forward to seeing more interactions.
5. What do you think about the correlation among heritage sites?
What do you think about the correlation among heritage sites?

Participate 2
Date: 2022-11-30
1. How well do you think the visual elements help with your understanding about the heritage?
Extremely helpful
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Extremely helpful
3. How well do you understand the historical time period shown in the application?
Clearly understand(more than 50% but not 100%)
4. How do you feel about the interaction process of this augmented reality application?
Fairly interactive. Suggest adding a real-time location function to make it even more interactive.
5. What do you think about the correlation among heritage sites?
Highly correlated.

Participate 3
Date: 2022-11-30
1. How well do you think the visual elements help with your understanding about the heritage?
Very helpful
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Neutral
3. How well do you understand the historical time period shown in the application?
Clearly understand(more than 50% but not 100%)
4. How do you feel about the interaction process of this augmented reality application?
It would be better with some introduction before the application. I feel confused in the beginning.
5. What do you think about the correlation among heritage sites?
N/A

Participate 4
Date: 2022-12-1
1. How well do you think the visual elements help with your understanding about the heritage?
Very helpful
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Very helpful
3. How well do you understand the historical time period shown in

the application?
Neutral
4. How do you feel about the interaction process of this augmented reality application?
Helpful but somewhat detached from the modern urban context.
5. What do you think about the correlation among heritage sites?
N/A

Participate 5
Date: 2022-12-1
1. How well do you think the visual elements help with your understanding about the heritage?
Very helpful
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Extremely helpful
3. How well do you understand the historical time period shown in the application?
Neutral
4. How do you feel about the interaction process of this augmented reality application?
I think it greatly help me understand the history and historical activities in this site. I like the image showing what the protesters do to protect their community.
5. What do you think about the correlation among heritage sites?
Different activities happened in these sites. And these activities combined with the process of the gentrification in the city. People nowadays can understand what it was before the gentrification and how people reacted to the gentrification.

Participate 6
Date: 2022-12-1
1. How well do you think the visual elements help with your understanding about the heritage?
Very helpful
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Very helpful
3. How well do you understand the historical time period shown in the application?
Totally understand
4. How do you feel about the interaction process of this augmented reality application?
I think the interaction process is pretty direct and intuitive. I have really enjoyed it. What was particularly interesting to me is that there was a thing there is one mom and multiple kids involved and I think this thing is really good because is there a lifelike and there's this sort of tenderness in it and it feels

very relatable. I really like this project.
5. What do you think about the correlation among heritage sites?
I think the correlation is very strong, because these are all about like black community and also multi culture community. And I think it's about different facet of those community. Like there is recreational, use and residential use and also commercial use.

Participate 7
Date: 2022-12-2
1. How well do you think the visual elements help with your understanding about the heritage?
Very helpful
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Very helpful
3. How well do you understand the historical time period shown in the application?
Clearly understand(more than 50% but not 100%)
4. How do you feel about the interaction process of this augmented reality application?
Smooth and interesting.
5. What do you think about the correlation among heritage sites?
I can feel the correlation. But it can be stronger if any maps or historical narrative are provided.

Participate 8
Date: 2022-12-2
1. How well do you think the visual elements help with your understanding about the heritage?
Extremely helpful
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Extremely helpful
3. How well do you understand the historical time period shown in the application?
Clearly understand(more than 50% but not 100%)
4. How do you feel about the interaction process of this augmented reality application?
The whole is pretty good. It can present intuitive pictures and scenes. The sound and explanation can also make people understand the stories that happened before. It can make people understand what they want to show in a short time. The multi-sensory experience can also make people leave a deeper impression.
5. What do you think about the correlation among heritage sites?
If there is a connection between several narrators, or if there is a series of explanations between scenes, before and after scenes, maybe the correlation will

be better?

Participate 9
Date: 2022-12-3
1. How well do you think the visual elements help with your understanding about the heritage?
Very helpful
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Very helpful
3. How well do you understand the historical time period shown in the application?
Clearly understand(more than 50% but not 100%)
4. How do you feel about the interaction process of this augmented reality application?
The AR application helps me understand the physical heritage better. It integrates different forms of media, providing a sense of immersion. But I think there can be more interaction mechanics to strengthen the user's participation, like how the users trigger the oral histories. It would be more impressive if the digital content can respond to users' behavior.
5. What do you think about the correlation among heritage sites?
I don't know much about the relationship among heritage sites. If some visual cues can be offered or there is a correlation among the digital contents of different sites. In the AR environment, I feel like I just encounter them when walking around and someone introducing the heritage by showing something. I won't pay much attention to understanding the relationship between them. If there are some interactions of feedback, users might have more motivation to try to understand that.

Participate 9
Date: 2022-12-3
1. How well do you think the visual elements help with your understanding about the heritage?
Very helpful
2. How well do you think the audio elements(environment audios and oral histories) help with your understanding about the heritage?
Very helpful
3. How well do you understand the historical time period shown in the application?
Clearly understand(more than 50% but not 100%)
4. How do you feel about the interaction process of this augmented reality application?
I think it's interesting and engaging. Hope to see more though.
5. What do you think about the correlation among heritage sites?
I'm not very clear about this. But I know they are all about this community in the past.