CARNEGIE MELLON UNIVERSITY

School of Architecture
College of Fine Arts

Thesis

Submitted in Partial Fulfillment of the requirements for the degree of

Master of Science in Computational Design

TITLE:

Collaging the Landscape Histories and Constructing Memories Through Augmented Reality

AUTHOR:

Chengyu Chen

ACCEPTED BY ADVISORY COMMITTEE:

[redacted] May 10th 2022

Daragh Byrne Principal Advisor DATE

[redacted] May 10, 2022

Daniel Cardoso Llach Advisor DATE

Abstract

Located at the intersection between collage, multimedia narratives, and contemporary media technology, this thesis explores how an augmented reality (AR) environment may help people to explore a landscape's history. This work develops a digital walk with historic elements in AR deployed at Allegheny Commons West Park, a historic site in Pittsburgh, Pennsylvania. Traditionally digital cultural heritage experiences tend to be organized in a linear narrative structure and static content. The experience design of this project challenges this convention and uses a non-linear collage based approach. Audiences are guided to positions that offer a viewpoint where virtual content collages assemble into a complete scenario. Viewed from this point audiences can then perceive the historical elements such as people, buildings and environment. In addition, audiences find and form their own trajectories through the designed scenarios, and develop an understanding of the history of the landscape through open-ended exploration of the AR collages. By detailing the technical structure of the system, the thesis also introduces a preliminary workflow for the design of digital cultural heritage experiences with non-linear collage-based narratives.

KEYWORDS: Mobile Augmented Reality, Augmented Heritage, Multimedia Narratives, Landscape Narratives, Collage Art, Cubism, Storytelling, Memory, Allegheny Commons West

Contents

1 Abstract **2**

2 Introduction **6**

2.1 Research Question 8

2.2 Hypothesis 8

2.3 Approach 8

2.4 Contributions 9

2.5 Thesis Structure 9

3 Background **11**

3.1 Collage Art 11

3.2 Multimedia and Narratives 14

3.3 Landscape Narratives 18

3.4 Collage and Memory landscapes 19

3.5 Mobile Augmented Heritage 20

4 Methods **27**

4.1 Preparatory Experiments 27

4.2 Allegheny Commons Park Site Condition 29

4.3 Collage Content Collecting 31

4.4 System Building 37

4.4.1 Virtual Environment Modeling 37
4.4.2 Devices 38
4.4.3 Application Development 38
4.4.4 Limitations 39
4.5 Experience Design 40
4.5.1 Storytelling 40
4.5.2 Collage Scenarios 42

5 Evaluation and Results **49**

5.1 Test Process 49
5.1.1 Think Aloud Protocol 51
5.1.2 Interview 53
5.2 Results 53
5.2.1 Data Collected 53
5.2.2 Field Notes 57
5.3 Discussion 58

6 Future Work **60**

6.1 Technical limitations and future improvement 60
6.2 Design limitations and future improvement 61

7 Conclusions **62**

A Appendix **68**

A.1 Full Think Aloud Protocol Transcripts 68

A.2 Full Interview Transcripts 72

Introduction

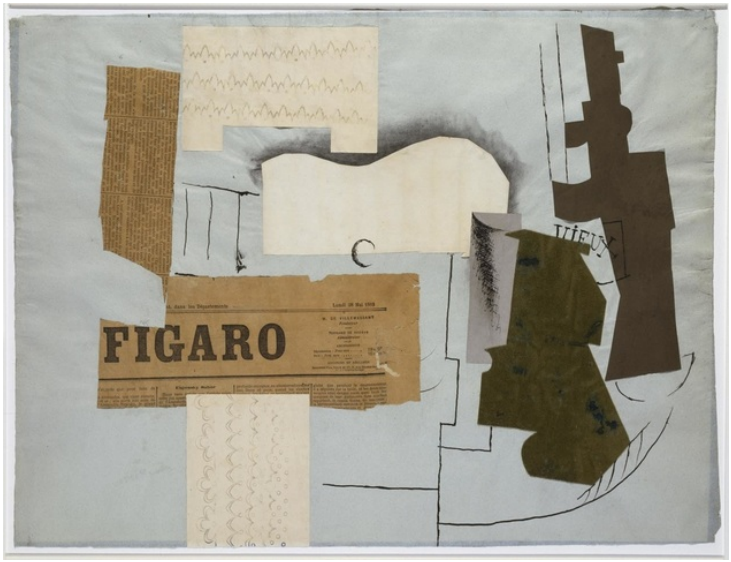


Figure 2.1: Pablo Picasso, Bottle of Vieux Marc, Glass, Guitar, and Newspaper. *1913*.[35]

When studying the history of western modern art, I became fascinated by the ground-breaking ideas introduced during the last 150 years. In the early 19th century, artists like Pablo Picasso and George Braque started experimenting with the combination of elements on a 2D plane, which is known as Synthetic Cubism[19]. As a method of artistic creation in the Cubism Period, collage has established parallels between different art forms and blending illusion and reality. By rearranging and constructing different types of elements, designers may obtain a new wholly image and a overall message. Collage art has been implemented in many kinds of art works, including films, paintings, and literature. This thesis extends this exploration and explores the value of using collage in augmented reality and to present a landscape's history.

Collage art is not always like the Bottle of Vieux Marc, Glass, Guitar, and Newspaper(Figure 2.1), made from sheets of paper on a 2D canvas. Synthetic Cubism was extended when Picasso started collage in 3D by producing sculptures in the project named violin. 3D collage makes familiar 3D geometric objects flow, overlap, and more importantly, interplay[19]. As people perceive the objects, the impression of one object tends to affect their comprehension of other objects. With the concept of collage, elements combined as one sculpture leave different memory on audiences' mind.

3D collage intertwines well with landscape narratives: landscape narratives tell the story of the landscape history that is embedded in the site. While building the elements onto the environment, it is believed to be effective in terms of constructing memory of the site. Frances A. Yates, an English historian, mentions that a person who wants to memorize things must select places, form mental images of the things they wish to remember and store those images in the places[43]. On the site of a landscape, it is common to have monuments, statues, or buildings embedded to evoke the memory of a place. Beyond the static and physical memory carriers, I consider that showing images and placing virtual historic elements onto the site may work as indications of memory on a landscape. With the concept of collage art, I consider that by changing the order of viewing the historic elements, we may create different perception of the stories for audiences.

More broadly, the memory of landscape has been an important topic for designers to consider. "Research on place has mostly adopted a cognitivist orientation and focused on the interior world of the individual and what representations of place are contained there." stated by Timothy Auburn and Rebecca Barnes[2]. Cultural heritage expresses the landscape history and memory, it's helping the audiences with building their interpretation of the site. Since media technology has witnessed a huge development, "Cultural Heritage has been extended to immersive technologies—a collective term for augmented-, virtual-, and mixed-reality technologies, which provide sensory experiences through various combinations of real and digital content...On the whole, cultural heritage sites and artefacts gain significant added value from enrichment through digital media[3]."

From approaches available to virtual cultural heritage, my project focuses on Augmented Reality(AR). AR overlays virtual content onto the real environment and provides the opportunity of interacting with the virtual content to the users. Mobile Augmented Reality (MAR) is a version of AR that operates on mobile devices (e.g. smartphones and tablets). Obviously, the mobility of MAR enables the AR experience to be available everywhere. The tools for developing Mobile Augmented Reality are accessible for designers from all fields to create their own AR experiences.

2.1 Research Question

Located at the intersection between collage, multimedia narratives, and contemporary media technology, this thesis explores how 3D collage Augmented Reality environments may help people recognize and form a memory of the landscape history. More specifically, I ask:

a) How can we incorporate the traditional concept of 2D collage into 3D digital environments, such as mobile AR, to support cultural heritage applications?

b) How can a digital non-linear narrative present the history of a cultural landscape and inform audiences' memory?

c) How does designing 3D collage in mobile AR contribute to creating a multi-sensory digital walk experience for audiences?

2.2 Hypothesis

Based on my understanding of the concept of Collage Art, AR technology, and multi-media narratives, the following hypotheses underly this work:

a) A mobile AR app that uses collage and non-linear narrative techniques will work well to reveal a landscape's history to the audiences.

b) The implementation of the visual AR imitates the characters of Collage, thus creates a new type of multi-media narrative in the medium of AR.

c) The 3D collage content in mobile AR visually will encourage audiences to walk through and form personalized trajectories within the landscape. With the combination of visual and auditory content, the audiences have an relatively immersive walking experience.

2.3 Approach

To explore the research questions and examine the hypotheses, I focus on case study in Allegheny Commons (see description of the site in Section 4.2 and bring out the approach of developing an app with a site specific and collage based AR experience. The mobile app runs

on devices that audiences can hold in hands. With the GPS location service, the app tracks audiences' real-time position, displays the virtual contents at preset locations, and blends the virtual content with the physical world.

2.4 Contributions

The contribution of this thesis includes:

a) Providing a case study of constructing an AR collaged environment that contains a historical virtual scene and current physical scene. Exploring implementing the concept of collage into Augmented Reality platform. The AR environment enables participants compare the now and past, recognize the changes during the century and learn the history the park has gone through.

b) A multi narrative digital visual walk that reveals the history of Allegheny Commons West Park and informs audiences' memory. Audiences gain exposure of the history through experiencing, recognizing and understanding the historic scenarios while going through their personalized trajectories. After implementing Think-Aloud Protocol on the walk experience, the participants' sensorial perception of the landscape history can be understood and a method that inform audience's memory can be concluded.

c) Presenting a workflow for designing an immersive experience on mobile augmented reality platform. The workflow visualizes the people, demolished buildings, and disappeared activities which directs the designers with no experience of creating AR experience.

d) Exploring AR collage as method of presenting a landscape's history and evoking citizens' memories of the landscape. This thesis provides a compelling perspective for experiencing Allegheny Commons West through digital media. During the process, I contribute to revealing histories and engaging people with the histories in creative ways.

2.5 Thesis Structure

In this thesis, I first develop the theoretical background and framing for my research questions (see Chapter 2). This chapter explores on the notion of Collage in Synthetic Cubism, 3D collage, memory, virtual cultural Heritage, Allegheny Commons, and mobile Augmented Reality.

For the designing process of "Memory Collage of the Allegheny Commons" (see Chapter 3), I will introduce the collage design, technical system building, experience design, and finally the evaluation methods (on-site interviews and discussion and take-home survey) for evaluation methods. The result of experience evaluation (see Chapter 4) will be presented. Finally, the reflections (see Chapter 5) and future work, (see Chapter 6) will be discussed.

Background

In this chapter, I will introduce the theoretical and technical framework for the thesis from six sections, including the Collage art, multimedia and narratives, landscape narratives, collage and memory landscapes, and mobile augmented heritage.

3.1 Collage Art



Figure 3.1: Pablo Picasso, Still Life with Chair Caning. *1912*.[34]

To classify the revolutionary experiments made in cubism by Georges Braque, Pablo Picasso and Juan Gris, historians tend to divide cubism into two stages, analytical and synthetic. Collage indicates the beginning of Synthetic cubism and was artistically exploited by other artists such as Futurists, Dadaists, and others[33]. Influenced by Cézanne to explore the further potential in analyzing the structure within painting and vision, Pablo Picasso and Georges Braque began making works which would eventually be understood as Cubist[36]. They added textures and patterns to their paintings and experimented with collage using newspaper print and patterned paper on 2D canvas. In May 1912, Picasso made the earliest known collage art piece named

Still-Life With Chair Caning Figure 3.1 by gluing a sheet of painting onto the surface chair caning. "This device allowed him to complicate notions of the real and the illusionistic, for the chair caning was simultaneously real—a piece of real imitation chair caning—and illusionistic, a picture of chair caning[19]." Collage is a ground-breaking idea as it "changed the way in which Braque and Picasso made their images. Instead of breaking down or abstracting an object into essential forms, the artists now synthetically constructed it by building it up or arranging it out of cut pieces of paper, hence the name Synthetic Cubism. they could introduce into Cubism a variety of textures and colors.[19]."

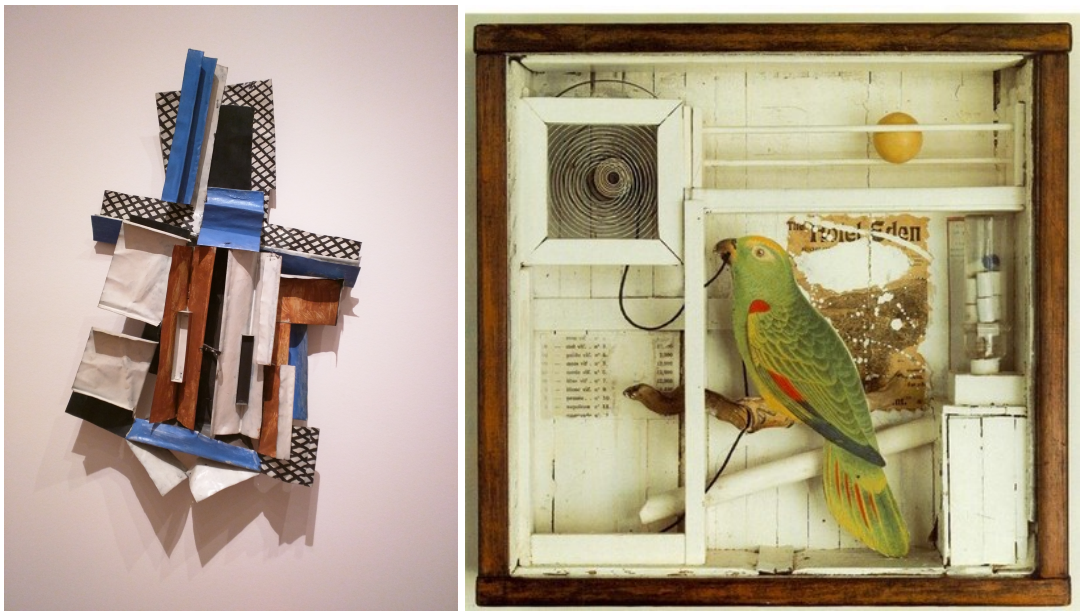


Figure 3.2: *Left:* Pablo Picasso, Violin. *1915*.[21] *Right:*Joseph Cornell, Hotel Eden. *1945*.[27]

"The logical peak of Cubism occurred when Picasso extended Synthetic Cubism to sculpture and created the first construction, a three-dimensional assemblage of materials[19]" called *Violin*. The construction firstly introduced 3D objects into collage art in 1915. Instead of using sheets of papers, Picasso assembled painted and different forms of metal into the project. Just as Collage art redefined painting, "he now redefined sculpture[19]". "Instead of being carved, chiseled, or molded, his sculpture was assembled, and, unlike most sculpture since the Renaissance, it was painted[19]." Similarly in the *Hotel Eden* collage, Joseph Cornell "uses three-dimensional objects that are glued, nailed, stapled, or sewn to a flat base such as a board[27]" to create a confined physical space with stories. The juxtaposition of different elements is fundamental to the objectives of collage art works, which is "to emphasize concepts and processes over the end product", "transforming diverse and distonant elements into a meaningful message[33]."

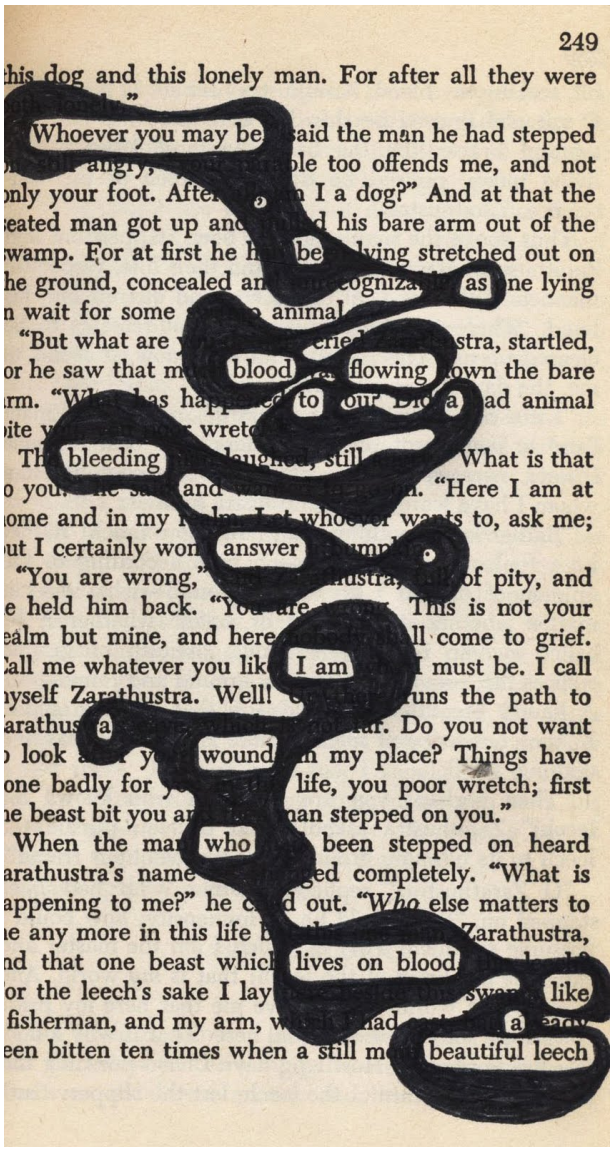


Figure 3.3: Carrie Arizona, Beautiful Leech. *2011*. [15]

The concept of collage has been applied in many fields of art, and transformed into the concept of Montage in literature, film, photography, music and painting. In literature, multi narratives[40] challenge conventional narratives that have a linear structure, a single arc of story, and a single point of view. The concept of multi narrative is similar to collage, in that multiple characters tell different stories and together they form a unified story, which enhances the theme, creates a stronger story arc, or deepens the character development. "A collage in literary terms may refer to layering of ideas or images"[33], found poem (Figure 3.3) "is a type of poetry created by taking words, phrases, and sometimes whole passages from other sources and reframing them by making changes in spacing and lines, or by adding or deleting text, thus imparting new meaning."[8] Interestingly, found poem is seen as a literary equivalent of a collage with a shared feature of combining basic elements into a whole. The filtration, rephrasing and rearrangement of existed words in the poem conveys an improved theme and poetic style. In music, sound montage usually means the playful usage of contrasting musical material of different periods and styles and combining fragments of music by different composers for creating a new piece. Conclusively, through juxtaposing a series of elements, collage creates a meaningful composition beyond the elements themselves.

Digital collage represents the renovation of traditional collage concept under today's technical background. By using computational tools, it encourages new combinations and transformations in creating collage through multi-media. It's a common thing to see 2D digital collage made from Photoshop and Illustrator, similar to a traditional collage art work on 2D canvas. As such, digital collage is expected to be extended in 3D virtual and augmented reality environment.

3.2 Multimedia and Narratives

"Narrative is a medium-independent phenomenon, and, though no medium is better suited than language to make explicit the logical structure of narrative, it is possible to study narrative in its nonverbal manifestations without applying the communicative model of verbal narration."

—-Marie-Laure Ryan

Narratives is the description of a series of related events or experiences. "Through narrative we also explore alternate realities and expand our mental horizon beyond the physical, actual world-towards the worlds of dreams, phantasms, fantasy, possibilities, and counterfactuality"[32], stated by Ryan. Narrative can be conveyed through a sequence of written or spoken

words, still or moving images, music or videos, or a combination of different medium. A story conveyed through different mediums leave different impressions on readers' memory. As a result, we've seen the continuous progress in which narrators explore different mediums towards a new narration.

As multimedia has been developing rapidly since the popularity of computer rose up, narratives are not confined within the range of traditional mediums. Ryan describes two modalities of narrative as "being a narrative" and "possessing narrativity"[32]. "The property of being a narrative can be predicted on any semiotic object produced with the intent of evoking a narrative script in the mind of the audience. Having narrativity means being able to evoke such a script. In addition to life itself, pictures, musics, or dance can have narrativity without being narratives in a literal sense[32]." It can be concluded that there are narratives that don't require texts and words, but objects that possess narrativity.

Narrative is fundamental to cognition, since constructing memory of objects, stories or events perceptually is our way to notice them. "If we define narrative in cognitive terms, it is not a linguistic object but a mental image[32]." states Marie Laure Ryan, readers always create mental images when they are reading narratives, "their mind is notoriously capable of emergent behavior–of creating new connections and of forming new patterns of ideas in response to certain stimuli." New technologies in multi media, by improving the interactivity, multi-sensory perception, or networking capabilities, create unprecedented user experiences when conveying narratives. Janet Murray regards digital media as a new stage on which old narratives will be replayed in new dimension[24].

Multimedia narrative has become a popular storytelling method in museums and galleries. Designers are focusing on implementing creative interactive technologies such as Augmented Reality, mobile display, and tangible devices for new experience. Luigina Ciolfi designed smart replica objects for *The Hague and the Atlantic Wall at Museon*[9]. Replicas of each object could be picked up by visitors to explore the exhibition and trigger virtual content representing different points of view. Eva Hornecker created *The Jurascope* installation in museums to guide audiences to look through a dinosaur, using combinations of photos and animations in Augmented Reality[18]. Multimedia designer Steve Benford designed a visiting experience guiding the audiences to access the physical resources of the sculptures. With the narration and background music, audiences can perceive the sculpture story through along the multi-sensory tra-

jectories.[13] Day of the Figurines is a narrative-driven text messaging game for mobile phones. As the media that carries stories, the game contains the built-in timeline for players to encounter and experience.[5] Benford also presented *Flypad* to explore the design of large-scale interactive experiences for galleries, museums, and other architectural settings[11]. To make sense of the context that don't explain itself, narrative through multimedia always gives a better solution in terms of user experience, managing visitor flow, linking real and virtual, and improving accessibility[11].

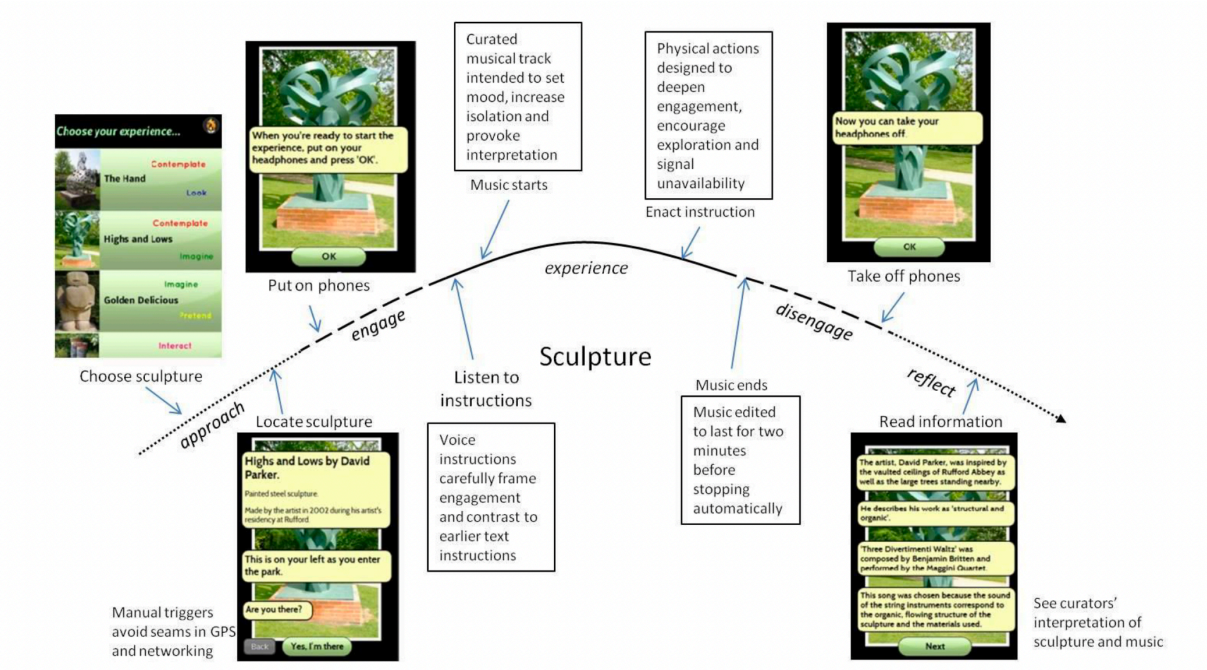


Figure 3.4: Design of the local trajectory through each sculpture by Steve Benford. *2013*.[13]

As Ryan suggests in her book Narrative Across Media, a medium is imitating the techniques of another: cinematic or musical techniques in novels, literary collage, voice-over narration in movies, for example when making a narrative application[32]. It is possible to renovate a medium with the characteristics of other kinds of mediums. Augmented Reality and Collage have many features in common: they're all conveying an idea by constructing abstract or virtual elements. Collage depicts a story in a non-linear structure, in the mean time, AR provides the chance to experience the elements interactively. Therefore, I'm considering imitating the storytelling methods of collage while creating virtual scenarios in AR specifically at the landscape scale.

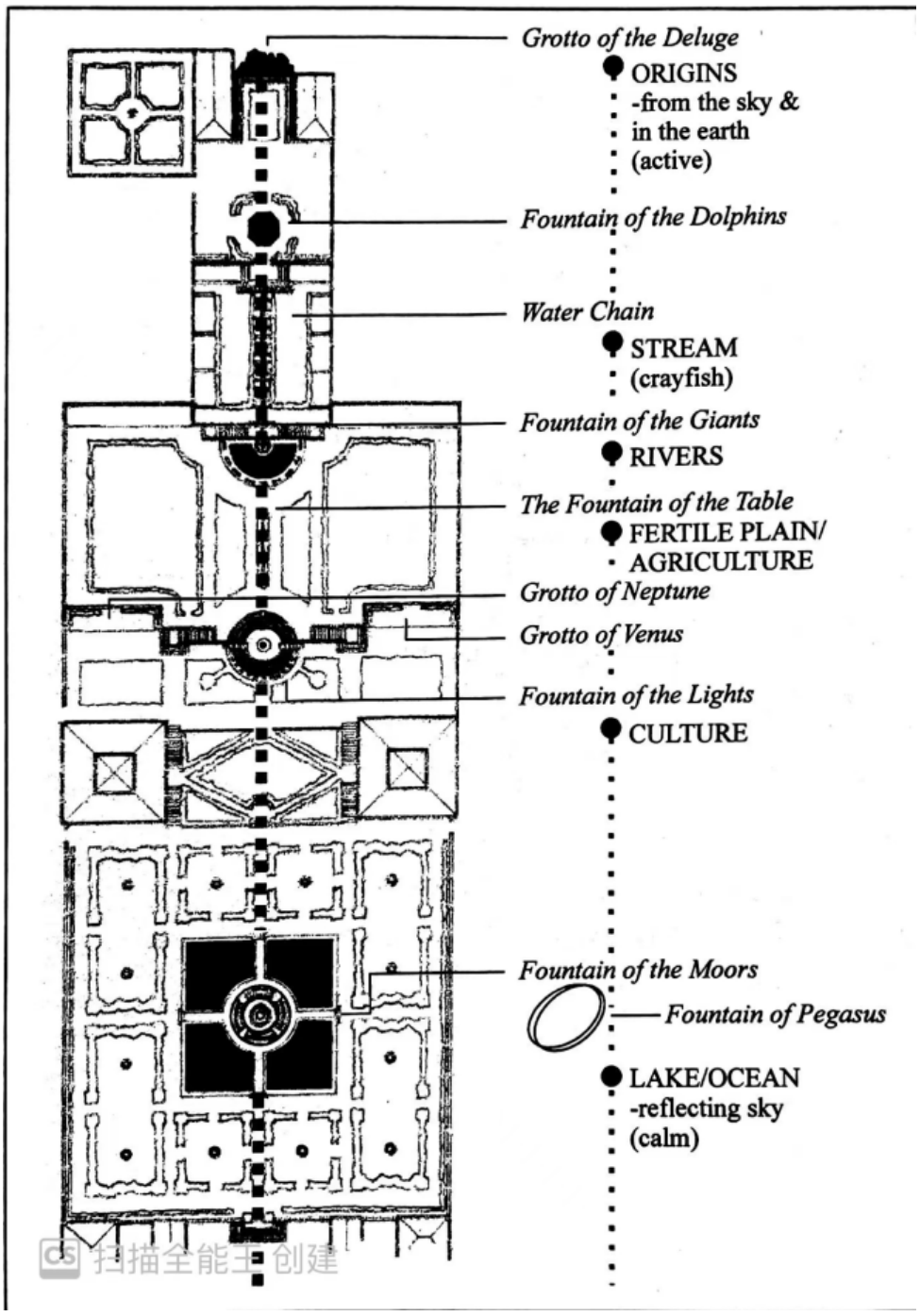


Figure 3.5: Plan of Villa Lante[29]

May 10, 2022

3.3 Landscape Narratives

Multimedia innovates narration in many different contexts, especially narratives that are happening on physical sites, such as landscapes. Landscape narrative presents stories by intersecting with the site, organizing the sequences, and revealing layers of history[29]. Stories link the sense of time, event, experience, memory and other intangibles to the more tangible aspects of place. Since stories conveys intentions when creating an experience, narrative provides a method of presenting the landscape history not in traditional documentation, mapping, and even some forms of design[29]. Landscape serves as background for stories to take place and as the medium that contains histories. It's a better approach to describe the history by depicting a series of historic events that related to the topic rather than by a series straight chronicle of events[29].

As landscapes are rarely understood in terms of one single moment, the narrative of landscape are always organized around a series of specific events, concepts, or themes. Designers use similar methods in both traditional Chinese landscapes and western landscapes to guide the audience and experience the landscape through the best route. "Seeing and being seen" is an important rule in traditional Chinese landscape design: designers arrange the objects like walls, pavilions, pools and even windows to imply a best view of the landscape for audiences. Many elements align with each other and create a combined scene only in a specific point of view. From a larger scale, designers also arrange the spaces with different sizes, themes or features along the route. Audience is able to experience a specially designed space sequence while walking in the designed route.

As a representative of traditional Chinese garden, Liuyuan is famous for its space sequence design. The garden designer considered every views audience may see in the garden. Spaces vary along the audiences' trajectories and affect the walking experience. Watching at specific nodes in the sequence, audiences can see a well combined scene of buildings, water, and trees. The scenes are often confined by windows, beams, and corridors[25]. In terms of designing experiences along physical trajectories, Steve Benford created virtual content instead of real one. Benford designed a visiting experience guiding the audiences to access the physical resources of the sculptures. With the narration and background music, audiences can perceive the sculpture story through along the multi-sensory trajectories[13]. Landscape trajectory design gives me a hint in creating digital walk experience, it makes me consider how to guide audiences through

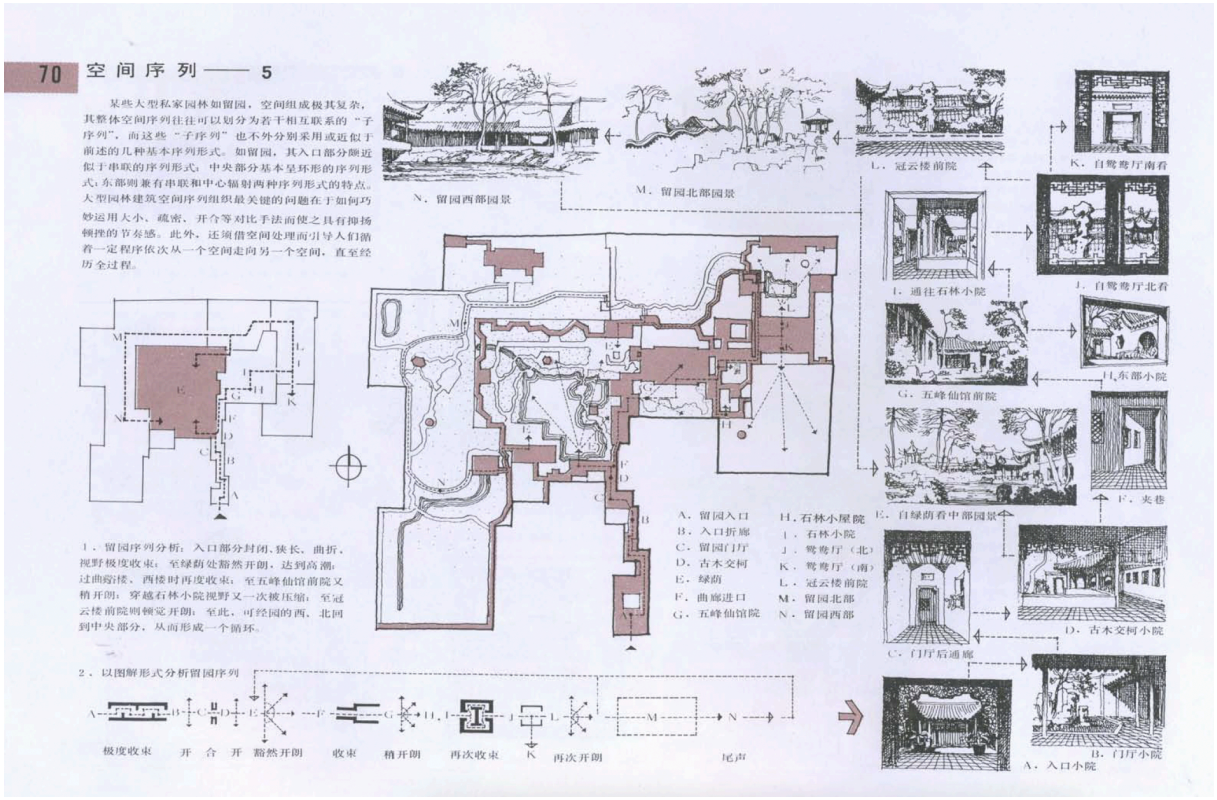


Figure 3.6: Analysis of the design of Liuyuan Garden[25]

the preset route and watch the content from specific points of view.

3.4 Collage and Memory landscapes

“I don’t consider myself a storyteller. But if I reach into my coat pockets, I’m likely to find scraps of notes, a ticket stub from a concert, ATM statements, bibliographic references for this book, phone numbers, a map of Boston from a spring field trip, a frayed napkin – each piece an unlikely memento recalling a time, an event, or a place. The contents of coats worn less frequently seem to span longer time frames. From this partial anthology, edited as much by chance as by intention, I can begin to reconstruct the various narratives that cohere around this life[29].”

—-M. Potteiger

In the narrative by Potteiger, his character forms vividly when he describes the elements in his coat pockets, but not a detailed story of himself. Similar to other kinds of narratives, readers are not expecting a detailed story, as they fill meanings in their cognitive blueprint of the story. Narrative is thus a mental representation of causally connected states and events that captures a

segment in the history of a world and of its members[32]. As a narrative, collage tells the central idea by displaying images with different contexts at the same time.

Collage in painting has witnessed a continuous development since it emerged in the early 19th century. “Here” (Figure 3.7Figure 3.8) is an artist book disguised as a graphic novel about one location over time by American illustrator Richard McGuire. It collages people, activities, and scenes from different period of time but the same site, forming a sense of visual multi narrative. Elements with different historic background extends the audience’s perception of the site, gives an additional dimension of expression to the 2D painting. Through the perspective of Richard McGuire, I see the potential of collaging virtual content from different times to describe the history context[16].

With a similar idea to Richard McGuire’s Here, Building Stories is a graphic novel containing 14 comics by American cartoonist Chris Ware describing the story in a three-floor Chicago apartment building. Interestingly, the order in which readers read the stories builds different reading experiences and perspectives of the whole book. All the different story units contribute to the memory construction in readers’ mind, they overlay, interconnect, and fill in the blanks created by other units. Building Stories demonstrates that stories should be told through a web of interconnected stories rather than in a strict linear order. With a similar concept of reading collage art work, it returns the right of interpretation to the readers who need to be active in creating a timeline and make sense the whole story.[23]

Theoretically, memory can be constructed by perceiving specifically designed scenario. Yates mentioned that the trained memory was of vital importance back in ancient times when there was no paper for note-taking and tools for typing letters.[43] Memory can be constructed, strengthened or confirmed by training: when seeing the places and the images overlie on the places, audiences form a overall sense and memory of the site rather than perceiving a continuous story. With this idea, the formation of landscape memory when audiences perceive the elements embedded on the site and form a comprehension of the overall environment.

3.5 Mobile Augmented Heritage

Augmented Reality(AR) aims at enhancing audiences’ perception and understanding of the real world by superimposing computer generated content such as images, 3D models, multimedia



Figure 3.7: Richard McGuire, Dancers of Here, 2014[16]



Figure 3.8: Richard McGuire, Fall of Here, 2014[16]

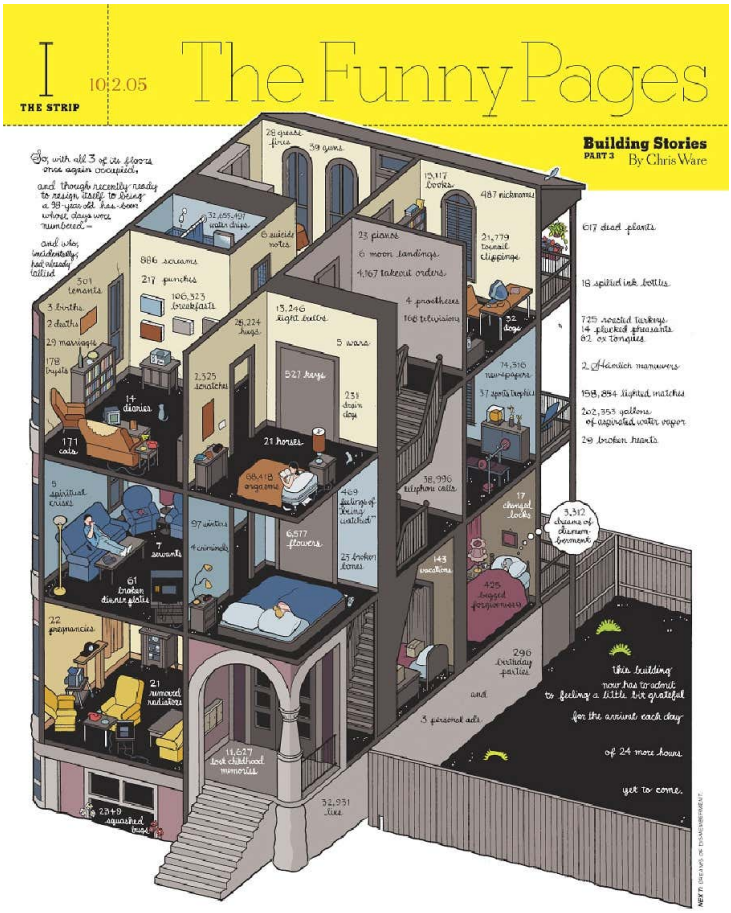


Figure 3.9: Chris Ware. Building Stories. 2017

onto the real world. Augmented Reality provides the freedom of synthesizing virtual elements that were not possible to exist. AR is a well-developed method of making 3D digital collage with an immersive user experience, benefiting from it's display, geolocation and data transfer methods. "In mixed reality performance, cultural, physical, and digital data can be juxtaposed or intertwined to generate a complex hybrid compositions of fictional, physical, and virtual worlds."[4]

While interacting with traditional AR, users always complain about the discomfort of wearing the heavy interaction devices, comparing to which, Mobile Augmented Reality (MAR) is held on a cellphone or other mobile devices with a significant advantage of mobility, light weight, and a personal gadget for social interaction. In trade-off, AR interfaces have small keypads, small screens, limited computational resources and less immersion.[10] Mobility is the feature that MAR is suitable for designing a semi-immersive landscape walk, as audiences are able to carry the device around, find their own paths through the site, and construct a unique understanding of the story.

In recent years, mobile phones and tablets had a great technological development. Focusing on showing the creativity and innovation, multimedia application makes the cultural heritage digitally available and perceivable to the audience, improving the availability especially when physically constrained. With the help of mobile augmented reality, cultural heritage tour can become a more appealing and accessible experience.

Laurajane Smith[39] points that the heritage is about negotiation – about using the past, and collective or individual memories, to negotiate new ways of being and expressing identity. She says that in this process objects, sites, places or institutions like museums become cultural tools or props to facilitate this process.

Heritage Interpretation[38] is an activity that should forge emotional and intellectual connections instead of simply communicates factual information.[6] Interpreter Freeman Tilden[38] proposed six principles for interpretation, which are: "

1) Any interpretation that does not somehow relate what is being displayed or described to something within the personality or experience of the visitor will be sterile.

2) Information, as such, is not Interpretation. Interpretation is revelation based upon in-

formation. But they are entirely different things. However all interpretation includes information.

3) Interpretation is an art, which combines many arts, whether the materials presented are scientific, historical or architectural. Any art is in some degree teachable.

4) The chief aim of Interpretation is not instruction, but provocation.

5) Interpretation should aim to present a whole rather than a part, and must address itself to the whole man rather than any phase.

6) Interpretation addressed to children (say up to the age of twelve) should not be a dilution of the presentation to adults, but should follow a fundamentally different approach. To be at its best it will require a separate program.[6]

”

With the features such that Reality View, Location Based Tracking, Registration and Tracking, the embedding of Virtual object and so on, Heritage Management specialists recognize augmented Reality Applications as powerful Heritage Interpretation tools following other forms of communication adopted[6]. Giovanna Casimiro brought up an app *Look Again* (Figure 3.10) which allows a time travel through 5 different decades of one of the oldest houses in Boston. With the creation of the 3D images, the textures, the dynamic and functionalities of the app, the team managed to create a digital historical experience[7]. In TARX application(Figure 3.11) a map functionality allows one to selectively choose augmented points of interest (POI). The app overlays historical pictures on the scenarios along the audience's journey, as a method of helping with recognizing and labeling the important sites[30].

As Benford stated, environments paths are designed along which real and virtual environments may be viewed and/or experienced in their relationship to each other and details from one made to have an impact on the other[4]. Historic trajectories allow for the possibility of replaying and regenerating the perspectival view of the intersection between trajectories over time. While interpreting the virtual heritage, participants are mapping in the sense that they are feeling their way through an unknown environment precisely in order to know it, “constantly renegotiating the real and virtual elements that form it, learning to move between them, affording one through the other[4].” As such, designing the display and interaction of past, present,



Figure 3.10: Giovanna Casimiro, Ethan Vogt: Look Again. *2019*[7]

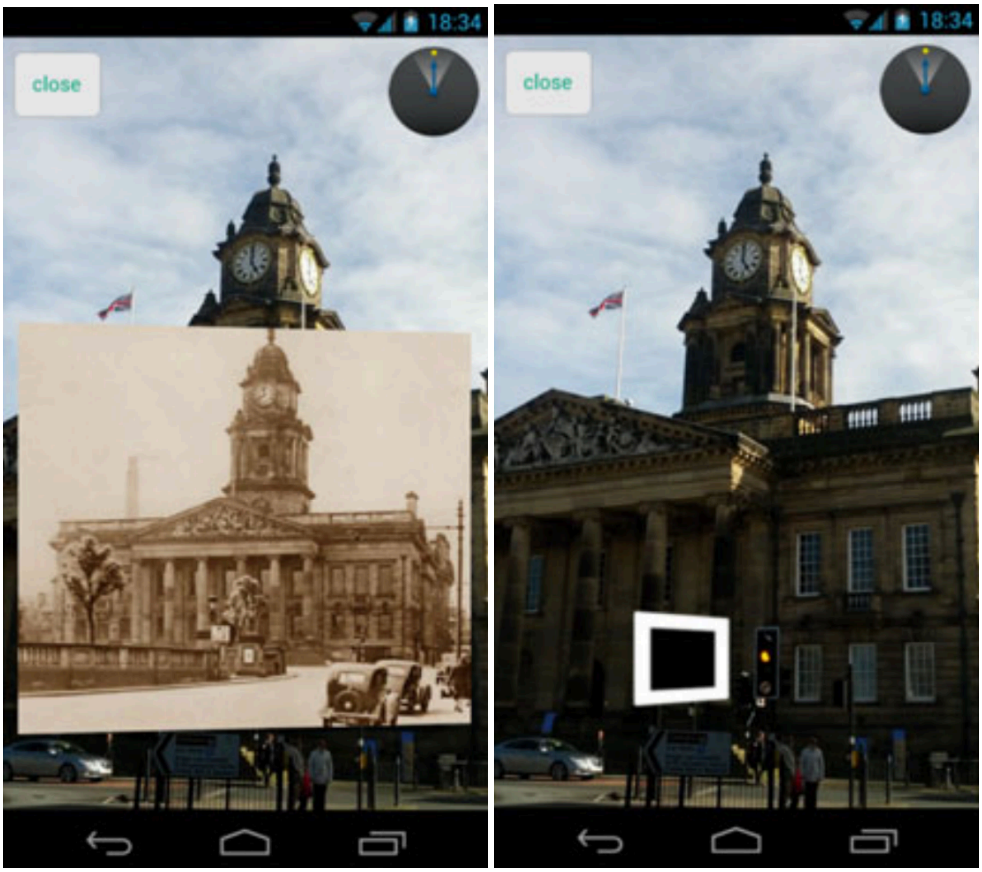


Figure 3.11: TARX application: map, AR and warp view. *2011*[30]

and future living along the trajectories is the most important part of a mixed reality in heritage interpretation.

In the thesis, I build the cultural content and information by adding historical images into augmented reality. Augmented Reality adds a spacial dimension to traditional collage art, and create an immersive walking experience.

Methods

In this chapter I discuss the development of "Memory Collage of Landscape", the collaged augmented reality walk, from four aspects: Site Condition, Content Collecting, System Building, and Experience Design. In order to place this in context, I first introduce some pilot projects that help to develop proof-of-concepts for my AR collage approach. They suggest shared commons with the collage augmented reality walk in narrative building and digital collage.

4.1 Preparatory Experiments

In the two following projects, I reproduced the collage art pieces within Mobile Augmented Reality. In the rebuild (see Figure 4.2) of Picasso's *Bottle of Vieux Marc, Glass, Guitar, and Newspaper*, I managed to separate every piece of the original collage and put them in the AR space. With a similar concept to found poems, the existing elements were separated and rearranged individually. Every piece of the original collage was able to rotate towards the camera but stayed at a fixed location. As the audience turns the camera, the pieces were holding the position but rotating and reconstructing a collage with a different manner. Although collage is known as a non-linear narrative, with Augmented Reality, the Picasso's collage was being detached from the original relationship, and rearranged into a random framework. It was interesting to discover that AR rebuilds 2D collage works into a dynamic, random and subjective style. Audiences were still able to recognize the object as a whole while perceiving the collage in different orders and forms. This project suggested the potential of constructing people's memory of a scenario out of different pieces of collage.

To build the virtual environment, I used AR Foundation SDK and AR Kit SDK in Unity. After extracting elements of collage, I made materials and use the images as transparent texture. Then the images become materials that can be applied to 3D planes and become objects. To build the set up of AR Foundation, I created an AR session origin as the initial geolocated point. Then import all the collage contents in front of the AR camera. After deploying it onto cellphone, the AR scenarios can be viewed by moving cellphone around.

I next rebuilt *Here*(see Figure 4.4) by Richard McGuire, time frames extracted from the

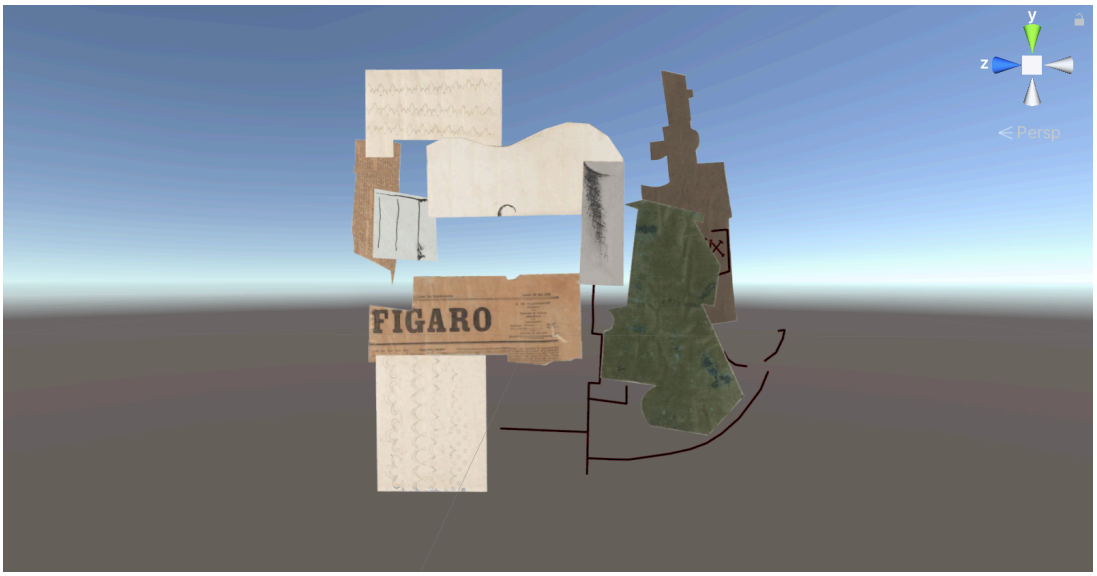


Figure 4.1: Rebuild Picasso art piece in Unity



Figure 4.2: Rebuild Picasso art piece in mobile AR

comic scenario are floating upon the background scene. While experimenting to reconstruct this comic book in AR, I noticed the feature of alignment between different collage pieces. Describing the historical scenes at specific geolocated points, the frames only make sense when they are aligning well to the background. I consider this feature as a way to guide audiences to a certain place and watch the collage from a certain point of view. Simultaneously, AR is also good at presenting the frames of different timelines from the original comic scene.

The projects served as initial experiments towards the final platform. They allowed me to test the vision-oriented experience design and digital collage in Augmented Reality. As a non-linear narrative already, collage is becoming more unconstrained within the digital technology, which provided a great opportunity to experiment on creating new forms of narrative by displaying images with various contexts and stories in a virtual layer on physical environment.

Next, I conducted experiments with collecting the historical contents and collaging them on a specific landscape site. Based on these projects, collage is believed to become a way that helps evoke and construct memory in audiences' mind. Every piece of collage is holding its own historical background and contributing to the whole scenario. By conducting the narrative through image collage, it's possible to convey the landscape history in a flexible order and return the freedom of experiencing to the audience.

4.2 Allegheny Commons Park Site Condition

The Allegheny Commons were officially established and designated for common pasture in a plan for the Town of Allegheny in 1784. It was officially dedicated for park purposes by Allegheny City in 1867. Designed by John Ormsbee Simonds and Mitchell Grant (see Figure 4.5), Allegheny Commons is the oldest park in Pittsburgh. Known for its mature canopy trees, wide promenade, and lake Elizabeth, Allegheny Commons is the front yard for the Northside's neighborhoods. The park was designed by the firm of Mitchell and Grant in 1867 utilizing a combination of formal, classical planning and picturesque landscape design which was ideally suited to its unique site.The park possesses a 150-years history with monuments, memorials, and infrastructures that have witnessed the modern history of Pittsburgh, especially around the Lake Elizabeth. For example, the *George Washington Memorial*, and the *Civil War Soldiers Monument*.

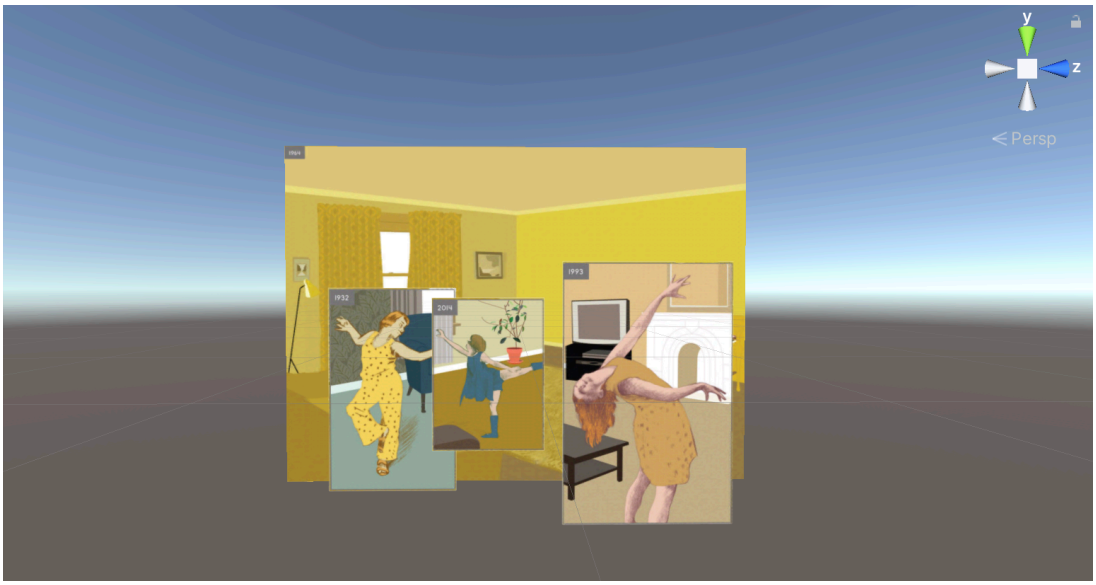


Figure 4.3: Rebuild Here by Richard McGuire in Unity



Figure 4.4: Here by Richard McGuire in mobile AR

"The iron industry was booming, spurred alike by the transitory demands of the Civil War and the growing needs[22]". Known as a "City of Steel", Pittsburgh in the early 20th century had a large amount of steel companies and factories. As the World War II started, Pittsburgh was the main city that contributed to the steel supply of the United States. "The war in Europe brought full employment and prosperity to Pittsburgh. Factories were humming, plants were operating around the clock. At day the pall of smoke blackened the sun; at night the glow from the mills painted the skies red. Pittsburgh worked as never before to produce the tools that were to bring victory[22]." As a result, the huge growth of the steel industry polluted the air, water, and green land. Pittsburgh has become a "City of Smoke"[28] in 1950s.

As Allegheny Commons' historic landscape has undergone numerous alterations over 150 years, this makes maintaining its integrity a paramount concern. Today, efforts are underway to restore the park to its former glory. City of Pittsburgh, Parks Conservancy, and North Side community are making plans on preservation, restoration, and reconstruction of the park to more closely resemble its original intent[1].

Located at the most central location in the city and the biggest local population, Allegheny Commons was the place that people went to escape the city's excessive smog. People came to the park for family gatherings, wandering, boating, and skating. As the central feature of the park, Lake Elizabeth is named for Elizabeth Kirschler the daughter of Charles F. Kirschler, the final Mayor of Allegheny City. Surrounded by a beautiful scene, the lake was a popular space for swimming, boating, and skating. Lake Elizabeth came to its current form in the 1960's. As part of the Allegheny Center conversion by the Urban Redevelopment Authority, it was redesigned as a concrete water feature with pedestrian bridges.

Conclusively, Allegheny Commons has a natural open space around the Lake Elizabeth and residents in the neighborhood of West Allegheny. It also possesses the rich history that could be revealed to nowadays people.

4.3 Collage Content Collecting

I collected original old photos of Allegheny Commons and Pittsburgh from 1900s to 1960s as resources for the collage content [1][17]. The pictures are mostly from Pittsburgh or Allegheny archives. The pictures are mostly in black and white, with an unrealistic style and different from

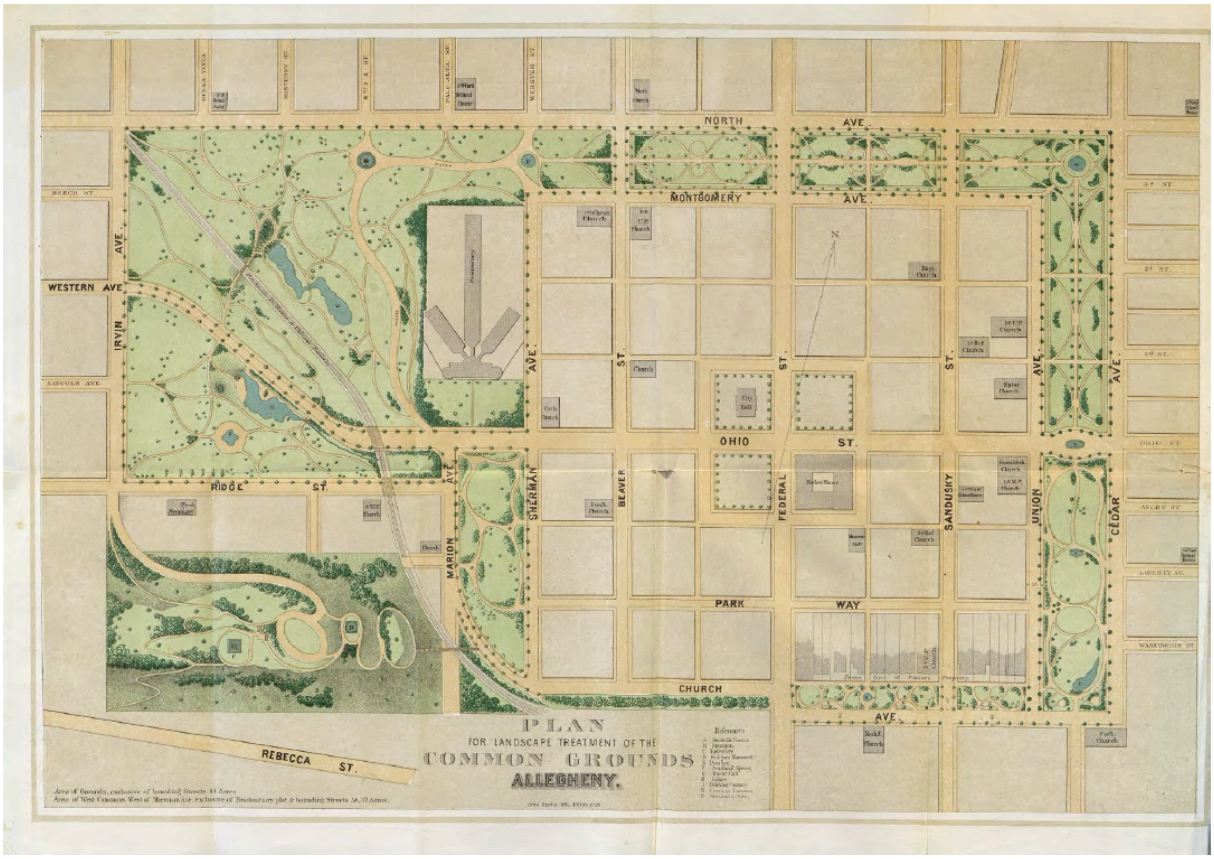


Figure 4.5: 1867 Allegheny Commons Park plan by Mitchell and Grant[1]

the physical world. Since Allegheny Commons West is famous for its rich historic background and tolerant public spaces for human activities, I chose the main activities happening in the early 20th century as the main content to reveal.

First, Lake Elizabeth provided a great space for people swimming in summer and skating in winter. A boat house is believed to be on the side of the lake, providing services of renting and docking boats[20]. As shown on a postcard[41], people used to gathering around the boat house, swimming and playing. As main activity in the lake, swimming was an important way to relax for people in 20th century.



Figure 4.6: Bathing at Lake Elizabeth. North Side. *1905*[41]

Second, Allegheny Commons provided a inclusive public space for people off work and students after school to relax. In the early 20th century, citizens took the park as an important place for many activities, such as socializing, chatting, and relaxing.

Third, as the development of steel industries and people cared less about the environment, Allegheny Commons was effected by pollution and waste. To reveal this, I collected the pictures of Pittsburgh's sky and streets when Pittsburgh are under the name of "City of Smoke", also the ones that show the trash people threw into the lake and rivers in Pittsburgh.



Figure 4.7: Lake Elizabeth West. *1911*[1]



Figure 4.8: Swimming in Lake Elizabeth in West Park. *1913*[37]



Figure 4.9: New Boathouse of Lake Elizabeth. *1915*[1]



Figure 4.10: Historical Photos of Allegheny Commons. [1]



Figure 4.11: The smoke in Pittsburgh's sky. *1920* [31] [42]



Figure 4.12: Trashes in Pittsburgh's river. *1920* [44]

4.4 System Building

In this section, I will focus on the technical part of this thesis and discuss how I created the system prototype as a support for further experience design development in detail. I will cover most of the essential parts for setting the designing environment for interactive collage augmented heritage in Unity and AR, and how I deployed them into compatible mobile devices for experiencing.

4.4.1 Virtual Environment Modeling

A first, and essential step, for the entire workflow is creating a digital replica of the site. As an essential part in the entire workflow, this provides a foundation for the experience design and simulation.



Figure 4.13: Virtual Environment Play Mode View

Since the main purpose of creating the model is for design reference, there is no need to create a precise model. The model should describe the main path that audiences may go through and spaces that are compatible to place virtual scenarios. As a result, I created this by building the landscape in Rhino based on Google Maps. After building the basic digital site scene, the virtual contents can be added one by one onto the prototype through the method stated in the section “Application Development”.

4.4.2 Devices

AR overlays virtual elements on a physical environment using a video-see-through approach. As the goal of the thesis is to create a visual walking experience for displaying historical elements to the audience, a large display screen improves the visual experience as users may view the virtual content clearly and discover details easily. The devices that required for mobile GPS AR application are computers, tracking camera, and displays. For building the collage AR system, I'm using an iPad Pro as a combination of the required devices, including: portable display, location services, and camera. If pursuing a better experience of real-time tracking and location updating, an iPad of WiFi and cellular version which has a GPS modular is recommended.

Also, as the project is developed in Unity of version 2020.3.14f1 using AR Foundation SDK, AR Kit SDK and Unity AR+GPS assets, it's important to use devices that are compatible with these assets. In the project, I'm using AR Foundation and AR Kit for iOS devices. AR Foundation supports devices with Android 7+ and iOS 11+ system.

4.4.3 Application Development

To map the virtual objects onto specific geolocation and test the performance of the system, I made the system using Unity. The system is using the AR+GPS asset and collage assets, it's deployed in the mobile device. The main function of Unity AR+GPS asset is to place the game objects at a preset location in Unity. I used the Web GPS Editor provided by Unity to mark the location, get the longitude and latitude. After testing on the site, I also managed to set the elevation of all the objects. With an error with in 2 meters, the prototype works well on positioning objects onto specific locations and update user's real-time location into the system.

Before setting up the AR environment, I managed to place images as objects into the scene. First, after importing the images into the Assets folder, I created several materials that take the images as sources correspondingly. Second, all the materials are set as "Unlit/Transparent" ones to be applied as containers of PNG images. Third, create 3D planes as objects that hold the materials as texture. The next step is to develop the AR app with the content I have.

There are several technical settings to make the prototype work in an AR environment: first, the planes should be imported as a child object of a GPS Stage Object. By inputting the latitude,

longitude and altitude into the GPS Stage Object, the objects will be placed onto the right location. Second, to make objects moving along a certain path, I have to add a script called "Move Along Path" and input a preset path to the "Location Path". Third, the objects are also set to turn automatically towards the camera by changing the scripts (see Figure 4.14). Two important components for the project are "AR Session Origin" and "GPS Stage Object", as they are the AR and GPS containers with special settings. Details of setting up the project can be found in the assets' documentation page.

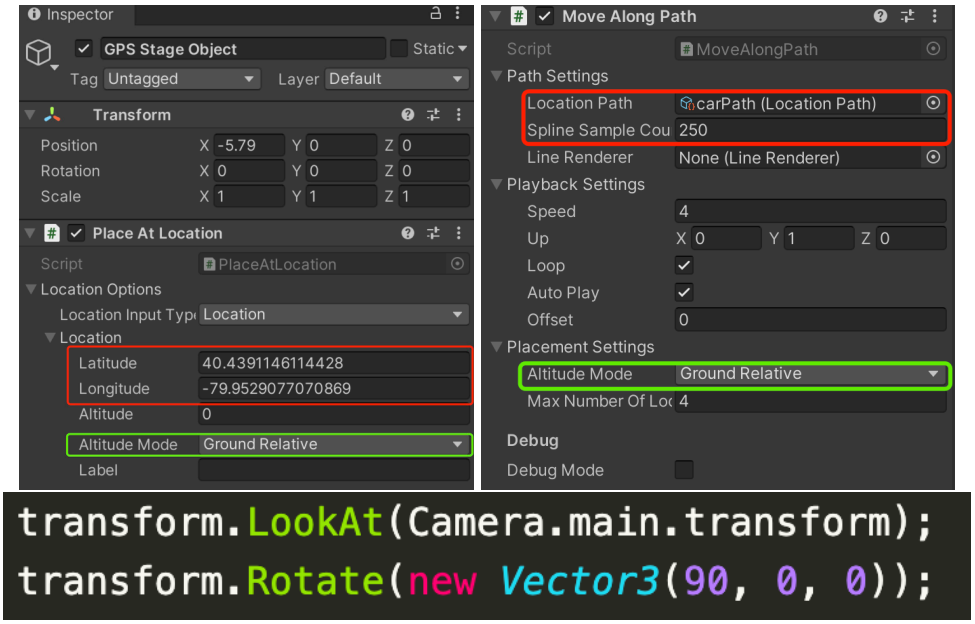


Figure 4.14: Unity AR Location settings.

To place the images onto right positions in the collage, I spent much time on testing and refining the scenarios back and forth. And finally, I added a background sound as an "Audio Source" onto an object. By turning on the "play on awake" and "loop", the sound will be played in loop when the system is activated.

4.4.4 Limitations

After several on-site tests, I noticed the limitations of the system as below: first, the accuracy of the GPS location service is not always in a high level. As the most important factor in the project, the GPS location worked not well sometimes and causing the system to be unusable. Second, the iPad screen size is still limited to see the details of the content. Third, Web Map Editor only supports getting the longitude and latitude of points by selecting on the map virtually. It is hard to construct the collage scenarios precisely. As a result, many on-site tests are needed

to construct the scenarios on the right positions.

4.5 Experience Design

4.5.1 Storytelling

As a central attraction of Allegheny Commons West, many historical events and activities happened around Lake Elizabeth. Many monuments, public art works and utilities remain around the lake. When designing the route for the digital walk, I chose the path around or across the Lake Elizabeth with a famous attraction *Civil War Soldiers Monument*. I managed to place scenarios along the path, not necessary to be in a linear time, but randomly scattered in different places. Audiences are welcomed to explore their own route by walking around the lake and viewing virtual scenarios in the mobile AR device. At the end, it is anticipated they would form a meaningful story in their mind.

With the collage content I collected, it is possible to tell the story in a historic background. Allegheny Commons West used to be a playful and beautiful place for citizens, providing picturesque swimming, skating, and walking trails, along with various other attractions. It provides the public places that helped change the city's image from industrial to environmental, and it literally cleaned the air from the smog created by the Steel Mills. However, because of the rise of steel industries and chaos during the *World War II*, "Pittsburgh was not a beautiful place to look at. Its buildings spread out without planning, its streets were congested, its rivers polluted. Smoke and smog, the curse since earliest time, blackened the skies, the curtains and everything white." Pittsburghers also cared little about protecting the environment: "People felt that a town of steel mills and factories had to be dirty and its skies had to be dark. 'A smoky Pittsburgh is a healthy Pittsburgh,' went the saying. As long as the stacks emitted smoke, things were fine. 'We didn't mind the smoke so much,' says an old Pittsburgher recalling those days, 'for it indicated production and it indicated prosperity.' While they grumbled about the bad housing conditions and complained about the poor transportation and about the eternal smoke and smog, they did little to remedy the abuses[22]."

Although the smoke made residents' living condition worse, there are economic reasons why smoke in Pittsburgh was hard to eliminate: "No one in the city denied that smoke was one of the chief obstacles to Pittsburgh's progress. Young people needed by industries would not

want come there, large corporations were ready to leave. Yet for generations very little was done to eliminate the smoke. The reason for this was simple: Pittsburgh was a coal-producing center and a great number of people made their living by digging coal; large coal corporations had fortunes invested in their companies. Thus the interest of many was not to eliminate but rather to make smoke. Smoke was the symbol of property, of moneymaking, of employment. It took courage and determination to tackle the problem[22].” As a result, a park like Allegheny Commons that represented natural beauty became a container of trash and polluted water under polluted air.

“*The Pittsburgh Renaissance* was the title self-awarded to the city’s enormous gathering of energy and leadership in the years that followed the Second World War and to the changes that came to the city.[22]” When the*World War II* was over, the City of Pittsburgh started its process of “Renaissance”. The city government was a “constructive force for the general welfare”, it pushed the urbanization forward by city planning and building managing. More importantly, Pittsburgh got rid of the name “The Smoky City”. Since before *The Pittsburgh Renaissance*, “Three man in Pittsburgh had decided that the time for action against smoke had arrived. This was the first battle for smoke control, fought and won before the beginning of the *The Pittsburgh Renaissance*”. They are an editor named Edward T. Leech, a physician named I. Hope Alexander, and a city councilman named Abraham L. Wolk. Starting from that time, the mayor appointed a citizens’ commission to recommend an effective smoke-control law. With a joint effort by many stakeholders, Pittsburgh won the war against smoke. “Pittsburgh’s victory over air pollution was its great community triumph...There were many smoky cities in the United States still, but Pittsburgh was not one of them[22].”

I made a narrative of the history using collage to demonstrate the environmental changing process the park has been through. The collage I’ve constructed in the AR only makes sense when being viewed from a specific position. To indicate the best position of watching, I labeled the position of watching as a round dot on the ground. From view of the dots, the collage of pieces forms a meaningful scenario as a whole. Audiences can also use the dots as references to plan their individualized digital walk. As a result, people can have different walking experiences based on different watching sequences.

As the basic content, collage element play an important role in designing walk experience and revealing the history. I used Photoshop to extract elements from the collage contents that

I've collected, scale them into a reasonable size, and to blur their boundaries to fit within the environment better.

Based on the virtual model, it's necessary to create a collage prototype of the site as a basic content organizing tool. Designers may use this as a reference during story designing and route planning. Figma is a handy platform for prototyping, I used this tool to place collage contents on the screenshots from Google Maps and plan the story sequences.

4.5.2 Collage Scenarios

Scenario 1 Park Entrance

At the entrance of the path, I intended to describe the street and transportation scenes in the past. In the 1910s, Pittsburgh was a busy city with many vehicles on the main roads[22]. For example, people are driving in the early ancient American automobiles and bicycles.

Scenario 2 Swimming Crowd

Back in the summer of early 20th century, people used to swimming in the Lake Elizabeth wearing the old style swimming suits.

Scenario 3 Around Boathouse

Boathouse besides the lake served as a place for renting and keeping the boats, but also provided spaces for citizens to relax, socialize and chat. As the most active place in the park, there were many kinds of activities happening around the boathouse. The boathouse was the center of memory that people had about Allegheny Commons and the Lake Elizabeth.

Scenario 4 Kids Playing

Because the north of the park is near to the residential area, there were many installations for kids. There were always kids chasing, jumping, and playing with each other.

Scenario 5 Boating In The Lake

Boating in the lake is another main activity besides swimming. People rent boats from the boathouse and went boating in the lake.



Figure 4.15: The mock up of AR scenarios



Figure 4.16: Park Entrance.



Figure 4.17: Swimming Crowd.



Figure 4.18: Around Boathouse.



Figure 4.19: Kids Playing at the North.

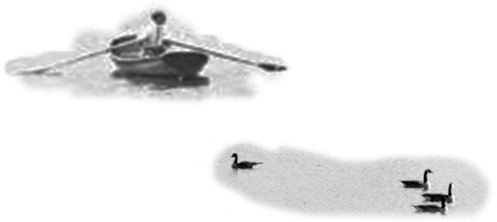


Figure 4.20: Boating in the lake.

Scenario 6 Polluted Environment

Scenario 7 Walking Around The Lake During the 1950s-1960s, the steel industries were contributing to the air pollution in Pittsburgh. As the pollution became severe in the air, citizens no longer came to the lake for swimming and boating. Becoming careless about the environment protection, people started to throw trash into the lake. As recorded, there were plenty of trashes in and at the bottom of the Lake Elizabeth during 1960s.

Scenario 8 Kids Around Fountain



Figure 4.21: Polluted Environment.



Figure 4.22: Walking Around the lake.



Figure 4.23: Kids around the fountain.

Evaluation and Results



Figure 5.1: On-site view of collage based experience

While I have described the design and development process of the digital walking experience, I next consider how an audience will experience it, and how it will shape their experience of the site. To evaluate the experience design, I decided to conduct usability testing. Usability testing is an important process, it allows the designers to receive feedback on designed prototypes [26]. To conduct a usability test of the system, I arranged three activities in the test which include an on-site Think Aloud Protocol, an interview, and field notes. I had 5 participants take part in the test. All five participants were CMU students from architecture department. I collected qualitative data from Think Aloud test, completed a short interview with each person and recorded field notes including trajectory maps, as they walked the site.

5.1 Test Process

I studied the experience design over a period of two weeks. The application was uploaded on two an Apple iPad Pro that was given out to the visitors. Overall, 5 people took part in the study.



Figure 5.2: Participants observing on the site

The purpose of this evaluation was to:

1) observe participants' movement, interaction, and how they explore the landscape during the visual walk by capturing video recording.

2) take field notes about how participants respond to the digital walk and map their trajectories as they explore the site.

3) through the field notes, find out how participants are influenced by the virtual scenarios when they are choosing paths through the landscape and how they react to the AR historical scenarios.

4) complete an analysis of the Think-Aloud Protocol to know how the visual content affects participants' understanding of the landscape history and culture.

5) conduct and analyze an interview to understand what does the collage based scenarios make the participants notice, learn or recall about the site and it's history.

5.1.1 Think Aloud Protocol

The term "think-aloud protocol" refers to a type of lightweight research method used in empirical translation process research. During a Think Aloud Protocol, the subjects are asked to perform a task and to verbalize whatever crossed their mind during the task's performance [14]. The method has the advantage of letting you discover what users really think about the design that they are experiencing while they are experiencing it. Using TA and protocol analysis, investigators can identify the information that a person is focused on during problem solving and how that information is used to facilitate problem resolution[12]. Jakob Nielsen claims the advantages of Think Aloud Protocols includes: "

1) Cheap. No special equipment is needed;

2) Robust. Most people are poor facilitators and don't run the study exactly according to the proper methodology.

3) Flexible. You can use the method at any stage in the development lifecycle.

4) Convincing. You can get the most convincing feedback for your design which is from the users.

5) Easy to learn. It's easy to learn in 2 days.

[1]"

As an important source of qualitative data, the Think Aloud Protocol is a basic method of collecting feedback from participants in this testing process. Participants were invited to the Allegheny Commons West to attend the activity. Once recruited for the test, participants were asked to sign a consent form and given an iPad Pro. Then they were ready for the test. Before



Figure 5.3: On-site testing

the test began, I briefly introduced the history of the site, the mobile augmented reality system and the Think Aloud Protocol. Then participants were asked to complete a task which is to "find their path through the scenarios and make sense the park history during the walk". I used video to record participants' interactions from a distance and kept silent while they were moving and talking to not interfere with the experience. The device held by the participant was also recording the screen to capture their viewing perspective on the scene. Overall, the whole walk experience will take around 10 minutes to 15 minutes.

[1]https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/

5.1.2 Interview

After the Think-Aloud Protocol, I conducted a short interview with the participants. The questions were designed to find out participants' thoughts on the walking experience that they just went through. The questions are below:

Question 1 How did you understand each scenario? How did the content make sense to you?

Question 2 How did you think of the combination of visual and audio experience? How does the combination effect your walking experience?

Question 3 How did you decide your trajectories through different virtual scenarios?

Question 4 How was the experience enhanced comparing to walking in the landscape without holding the mobile augmented reality device?

Question 5 What did this digital walking experience made you think about?

Question 6 How do you think of the whole walking experience?

5.2 Results

Based on the test, I managed to collect two kinds of data: qualitative and quantitative. In this section, I report on the analysis the data I got from 5 participants and try to form insights out of it. The analysis helps to evaluate the performance of the system and overall experience.

5.2.1 Data Collected

Scenario Comprehension

Feedback on Scenario Comprehension provides insights on how do the participants understand the scenarios. Furthermore, it helps to understand how well does collage in AR work as a narrative to tell a story.

P1: "Wow, so many people used to swim here! But there was smoke in the sky when they were swimming. Wow there were really many people here! It seems that it was really crowded in the past."

P2: "I felt that it's a little bit confusing when I saw these scenarios appear in the same time. For example, when I'm watching this scenario, I can also see the car in the last scenario."

P3: "I saw many people swimming in the lake, I think this was be a good place for vacations on weekends and it was really a lively place. I also saw there is a house far away from here, let me get closer and see.

P4: "I felt the scenarios gave me a broad sense of what was happening on the site. When I was approaching them, the images combined together and formed a scenario, I could understand them really well."

P5: "I think each piece of collage in the scenario combine with each other and convey an idea together. They may not make sense when they are alone, but they are depicting a meaningful story while being perceived as a whole. I think it's a really good concept."

The collage content expresses the landscape history interactively. While walking in different scenarios, all of the participants noticed that the collage elements are turning towards their viewpoints. Thus, participants were trying to turn the screen towards different direction and switching their positions to watch the scenarios. 3 out of 5 participants felt that they were led to the specific positions where the collage elements align well together and construct complete scenarios. This demonstrates that the virtual collage works well with guiding participants to specific positions in a landscape.

Multi-sensory Experience

Feedback on Multi-sensory Experience provides insights on how does the walking experience provide multi-sensory experience to the participants.

P2: "The audio is more helpful for me to understand the scenario. The audio makes the story line more complete and easy to understand."

P4: "The combination of visual and auditory content made me feel more immersive in the scenes. I can understand the virtual content in a multi-sensory way. It's adding another layer to the visual content."

P5: "I think the audio provides much extra information to me. The audio was the sound from people who were playing, it made the scenarios much more immersive and attracted me to

concentrate on the scenarios. Maybe dialogues make more sense."

All of the participants felt that the combination of visual and auditory content enriched the historic content. 4 of 5 participants considered the layer of auditory sensory makes the scenario more immersive and easier to emphasize. One of the participants thought that the virtual audio was blocking her perception of the real world sound, and it's a little bit distracting.

Trajectories

Feedback on Trajectories provides insights on how does collage scenarios in AR shape participants' trajectories through the landscape.

P2: "I chose my trajectory in a randomly way. Since I noticed that there is a lake at the center of the site, so I chose to walk around the lake. But the scenarios didn't have an clear order to go through, so I felt it's free to go through different scenarios."

P3: "At the beginning, I was trying to go to all the virtual scenarios that I saw. Sometimes I lost my way on the site and didn't know where to go, I just chose to explore different possible paths to go."

P4: "I would go to see the virtual content that were easy to notice. With the purpose of going towards them, I also considered the path on the landscape."

Although the participants thought they chose their paths randomly, they were affected by the landscape and the positions of the virtual scenarios. The virtual scenarios guided the participants through the landscape in a natural and free way, participants didn't feel any pressure while walking freely and choosing the scenarios to watch at their own pace.

Interaction With The Landscape's Memory

Based on the feedback on Interaction With The Landscape's Memory, I can conclude how well do the participants understand the landscape's history. Furthermore, it's an important feedback in terms of evaluating how well does the collage scenarios in AR express the history.

P1: "I got to know about the site history, such as the pollution the site had gone through, the people who were playing on the site. With the help of visual and audio content, I had a deeper impression of the history just like I was in the old times. After seeing so many people playing on the site, I can feel this place was bustling and lively in the old days. Comparing to what the site

is like now, I got to know that there is no pollution anymore, but less people here."

P1: "What does the monument mean in your app? I thought I might be relevant to the virtual content. The monument makes me feel that the site has a long history."

P3: "Since I came here for the first time, I didn't know anything about the site. With the app, I got to know many about the site history."

The virtual content depicts stories that are invisible on the site. In the meantime, the physical memorials and landscape also possess the memory of the history. While walking with the mobile AR app, participants kept feeling the blend of virtual and physical environment. Both the virtual and physical content are revealing different landscape memory. The memories complement each other and form the participants' whole impression of the landscape.

Most Memorable Scenarios

The feedback on Most Memorable Scenarios helps with understanding how well does collage in AR help people remember and understand the landscape's history.

P2: "I don't know exactly the time of the scenario, but I remember there was a factory here which polluted the environment. The site was a popular place for people gathering and playing. There were many interesting history in the APP, but I don't know the order of them."

P5: "I remembered this place was an important activity center of the citizens. Also I remember the factory that polluted the environment and affected the citizens' living surroundings. After comparing the scenario in both virtual and real environment, I noticed that the site has gone through a big change in appearance."

All 5 participants pointed out that they remembered the story of people swimming in the lake, the kids playing with the slide, and the pollution from the factories that the landscape has gone through. The comparison of the lively human activities happening in a beautiful landscape and the polluted environment seems to have left a deep impression on participants' mind. The site-specific virtual content make sense in participants' mind. While perceiving the scenarios, the participants creatively relate the virtual scenarios to the physical landscape, and form a story line in their mind.

5.2.2 Field Notes

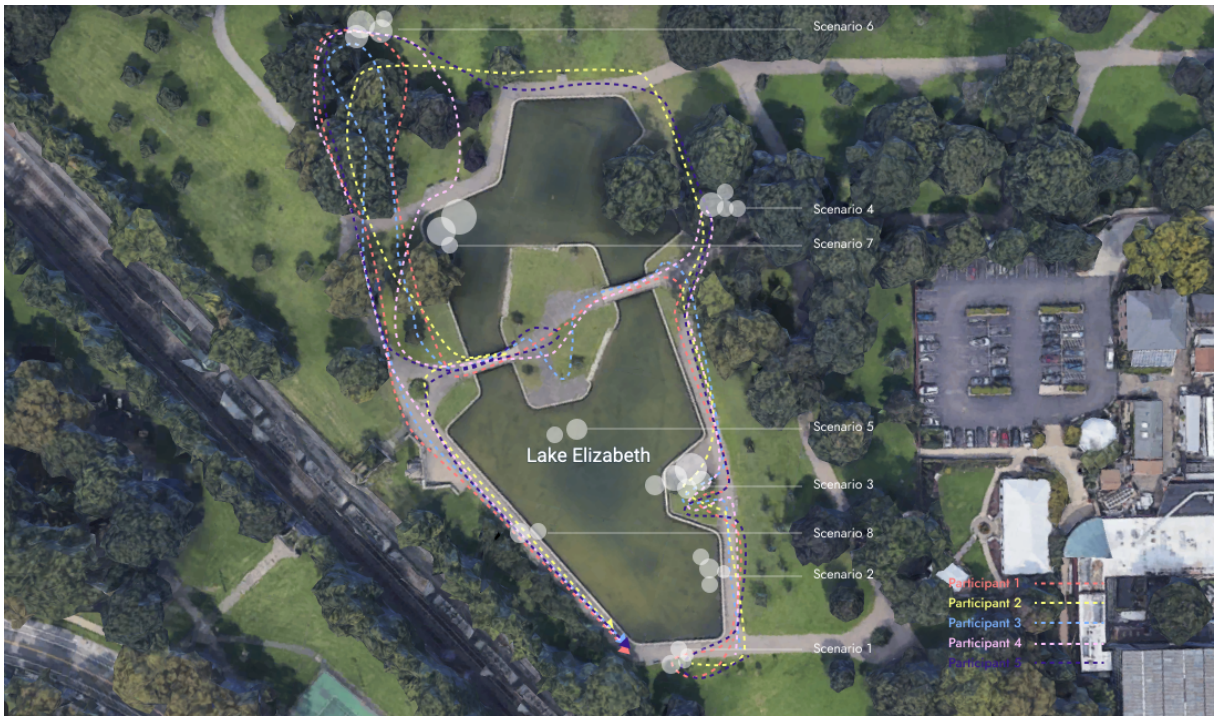


Figure 5.4: Participant trajectories

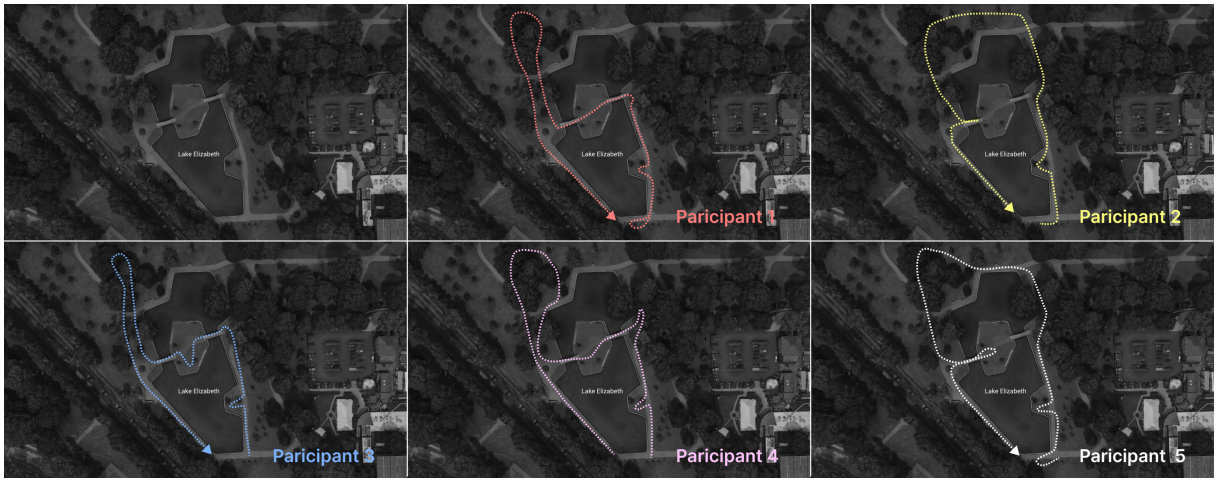


Figure 5.5: Individual trajectories

Based on the notes that I took during the evaluation process, I compiled a participant trajectory mapping. The mapping shows how did the participant arrange their own path through the virtual scenarios on the landscape, and how are the trajectories different from each other.

According to the trajectory map, I concluded important points as below:

a) The virtual scenario positions work as good indications for the participants. Participants

mostly arranged their path and walked towards the scenarios.

b) The paths already exist on the site and the landscape design affect the participants' trajectories significantly. Participants tend to follow the paths on the site most of the time.

c) When it's hard to see the virtual scenarios, or they want to shorten their route, the participants would leave the paths on the site. participants consider the virtual content as more important to watch.

d) Comparing the trajectories with each other, participants were choosing to walk around the site in an anticlockwise direction. Since participants were attracted by the scenarios on the right of the lake, they have similar trajectories on the site.

e) Comparing the trajectories with each other, I found that they vary from one to another. Because participants have a different consideration on the scenario orders, they tended to walk in the order that the storyline makes sense to them.

5.3 Discussion

The evaluation provided insights on the walking experience. These include:

a) By perceiving the combination of collaged elements in AR, participants appeared to form a good understanding of the histories that the elements are conveying. It can be concluded that collage in AR works well as a new kind of spatial and historical multimedia narrative.

b) The collage content offers a means to guide people to specific locations within a landscape. By forming collaged objects based on a person's movement, this helps to suggest how they should walk through the landscape and orient themselves to objects and places of historical interest.

c) Most of the participants developed a good understanding of the landscape's history, even though they encountered the scenarios (and their virtual collages) in different orders. The format allows for storytelling of landscape history through non-linear narratives.

d) In the interviews, all of the participants could recall the key information, scenarios, and history of the site. This site specific and collage-based AR format works seem to work

well to introduce cultural heritage experiences, to reveal a landscape's history, and to build people's knowledge about the site.

Future Work

In this chapter, I will introduce the limitations and suggestions for future improvement of current approach. Both of the limitations and future improvements involve both design and technical aspects. Readers may build on the analysis and information in this chapter to improve the approach in different directions.

6.1 Technical limitations and future improvement

a) The performance of the system relies on a stable GPS tracking system. Since the location-based service are not always continuous and precise, the user experience can be affected to some extent. To solve the GPS tracking problem, an iPad with both WiFi and Cellular capabilities would be better. To have a precise location, it's better to turn on the WiFi, Cellular and all the location services in the iPad settings. The designer may test out the scale of the Unity space, build the AR elements in right sizes, test and revise it back and forth. Without using the AR+GPS asset, the app has to start with a correct initial position and direction to place everything on the right location. I don't recommend using AR+GPS asset when the site scale is small enough to handle the virtual contents location manually. Since the GPS location

b) As a mobile AR device, iPad only provides semi-immersive experience during the digital walk. The display can also be effected by the sunlight. An immersive mobile AR device such as *Microsoft Hololens* may help with improving users' visual experience, since users may get rid of the limitations of screens and notice the details in the virtual space.

c) Due to the limitation of device, only a certain level of interaction is supported on an iPad. While holding an iPad, users' hands are restricted from performing other interactions. Users also have to turn their hands and face direction to view the virtual content from different perspective. An immersive mobile AR device like *Microsoft Hololens* liberates users' hands and body also supports hand gesture interaction. Users may interact with the virtual elements freely and immerse into both physical and virtual space, instead of being an outside viewer.

6.2 Design limitations and future improvement

a) The collage walk in the thesis mainly supports viewing with limited interaction. Audiences may feel less involved while watching. Adding interactions between users and virtual content might help. This could include providing a pointer that embedded in the interface to activate a textual introduction of a scene, or enabling hand gesture in a *Microsoft Hololens* to trigger a movement of GIF animation.

b) Since the thesis was build on a physical landscape, there could be more consideration of the relationship between a person's position and the position of the virtual content. For example, the virtual scenarios may only show up when the user is close to them, the background ambient sound may also vary depending on the distance between the user and the scenarios.

c) As this thesis explored the possibilities of combining collage with landscape virtual heritage, there are also other fields where digital collage can be implemented. For example, collage AR can be used in an indoor museum space to construct the background of exhibits. Collage in VR has more freedom in virtual content construction. It also provides a complete immersive virtual environment for making creative collage.

Conclusions

In conclusion, this thesis successfully created a collage based multi-sensory walk with mobile augmented reality technology. By creating and evaluating the walking experience with 5 paricipants, the thesis explored how to implement the concept of collage in creating visual digital contents for virtual cultural heritage. More importantly, by exploring combining the collage with Augmented Reality, this thesis exemplifies how Augmented Reality can be extended to form a new multi-media non-linear narrative. With mobile Augmented Reality, this thesis is not only collaged cultural content, but also interactively guides audiences to explore the landscape, develop personalized trajectories, and learn about the landscape history. Lastly, the thesis provided a workflow for artists and designers to create site-specific visual augmented reality walk with the introduced strategies.

References

[1] *ALLEGHENY COMMONS PARK | Pittsburgh Parks Conservancy*. URL: https://pittsburghparks.org/1936-2/ (visited on 05/08/2022).

[2] Timothy Auburn and Rebecca Barnes. "Producing place: A neo-Schutzian perspective on the 'psychology of place'". In: *Journal of Environmental Psychology* 26.1 (2006), pp. 38–50. ISSN: 0272-4944. URL: https://www.academia.edu/1414938/Producing_place_A_neo_Schutzian_perspective_on_the_psychology_of_place (visited on 05/10/2022).

[3] Mafkereseb Kassahun Bekele et al. "A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage". In: *Journal on Computing and Cultural Heritage* 11.2 (2018), 7:1–7:36. ISSN: 1556-4673. DOI: 10.1145/3145534. URL: https://doi.org/10.1145/3145534 (visited on 01/25/2022).

[4] Steve Benford and Gabriella Giannachi. *Performing Mixed Reality*. Cambridge, MA, USA: MIT Press, Aug. 5, 2011. 312 pp. ISBN: 978-0-262-01576-9.

[5] Steve Benford and Gabriella Giannachi. "Temporal trajectories in shared interactive narratives". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '08. New York, NY, USA: Association for Computing Machinery, 2008, pp. 73–82. ISBN: 978-1-60558-011-1. DOI: 10.1145/1357054.1357067. URL: http://doi.org/10.1145/1357054.1357067 (visited on 03/25/2022).

[6] Guida Casella and Moises Coelho. "Augmented heritage: situating augmented reality mobile apps in cultural heritage communication". In: *Proceedings of the 2013 International Conference on Information Systems and Design of Communication*. ISDOC '13. New York, NY, USA: Association for Computing Machinery, 2013, pp. 138–140. ISBN: 978-1-4503-2299-7. DOI: 10.1145/2503859.2503883. URL: https://doi.org/10.1145/2503859.2503883 (visited on 02/26/2022).

[7] Giovanna Graziosi Casimiro. "Augmented Heritage: digital tools for historical experience". In: *Proceedings of the 9th International Conference on Digital and Interactive Arts*. 41. New York, NY, USA: Association for Computing Machinery, 2019, pp. 1–5. ISBN: 978-1-4503-7250-3. URL: http://doi.org/10.1145/3359852.3359885 (visited on 02/24/2022).

[8] Chelle. *Found Poetry: Creative Visual Poems in Your Art*. Artjournalist. Sept. 7, 2018. URL: https://artjournalist.com/found-poetry/ (visited on 05/08/2022).

[9] Luigina Ciolfi. "Hybrid interactions in museums: Why materiality still matters". In: *VIRTUAL HERITAGE* (2021), p. 67.

[10] Feng Zhou, HB-L. Duh, and M. Billinghurst. "Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR". In: Book Title: 2008 7th IEEE/ACM International Symposium on Mixed and Augmented Reality. IEEE, 2008, pp. 193–202. ISBN: 978-1-4244-2840-3. DOI: 10.1109/ISMAR.2008.4637362.

[11] Martin Flintham et al. "Flypad: Designing Trajectories in a Large-Scale Permanent Augmented Reality Installation". In: Jan. 1, 2011, pp. 233–252. ISBN: 978-0-85729-912-3. DOI: 10.1007/978-0-85729-913-0_13.

[12] Marsha E. Fonteyn, Benjamin Kuipers, and Susan J. Grobe. "A Description of Think Aloud Method and Protocol Analysis". In: *Qualitative Health Research* 3.4 (Nov. 1, 1993). Publisher: SAGE Publications Inc, pp. 430–441. ISSN: 1049-7323. DOI: 10.1177/104973239300300403. URL: https://doi.org/10.1177/104973239300300403 (visited on 04/27/2022).

[13] Lesley Fosh et al. "see me, feel me, touch me, hear me: trajectories and interpretation in a sculpture garden". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '13. New York, NY, USA: Association for Computing Machinery, 2013, pp. 149–158. ISBN: 978-1-4503-1899-0. DOI: 10.1145/2470654.2470675. URL: https://doi.org/10.1145/2470654.2470675 (visited on 03/23/2022).

[14] Yves Gambier and Luc van Doorslaer. *Handbook of translation studies. Vol. 1*. Handbook of Translation Studies. Amsterdam ; John Benjamins Pub. Co., 2010. 468 pp. ISBN: 978-1-280-49726-1.

[15] Vince Gotera. *Carrie Arizona's Altered-Page Found Poems*. The Man with the Blue Guitar. Apr. 7, 2011. URL: http://vincegotera.blogspot.com/2011/04/carrie-arizonas-altered-page-found.html (visited on 05/08/2022).

[16] *Here*. Richard McGuire. URL: https://www.richard-mcguire.com/new-page-4 (visited on 01/25/2022).

[17] *Home*. Allegheny West. URL: https://alleghenywest.org/ (visited on 04/27/2022).

[18] Eva Hornecker. “The To-and-Fro of Sense Making: Supporting Users’ Active Indexing in Museums”. In: *ACM transactions on computer-human interaction* 23.2 (2016). Publisher: ACM, pp. 1–48. ISSN: 1073-0516. DOI: 10.1145/2882785.

[19] H. W. Janson. *Janson’s basic history of Western art*. In collab. with Penelope J. E. Davies and H. W. Janson. Book Title: Janson’s basic history of Western art. Upper Saddle River, N.J: Pearson Prentice Hall, 2009. xviii+670. ISBN: 978-0-13-603912-9.

[20] *Lake Elizabeth | Historic Pittsburgh*. URL: https://historicpittsburgh.org/islandora/object/pitt%3A715.205801.CP (visited on 04/28/2022).

[21] Ryan Libel. *Picasso Sculpture at the MOMA (Yes,There are Violins)*. Ryan Libel. Sept. 28, 2015. URL: https://ryanlibel.com/2015/09/28/picasso-sculptur-at-the-moma-yesthere-are-violins/ (visited on 05/08/2022).

[22] Stefan Lorant. *Pittsburgh: the story of an American city*. In collab. with Henry Steele Commager. 5th ed., updated and enlarged, Millennium ed. Pittsburgh, Pa: Esselmont Books, 1999. 776 pp. ISBN: 978-0-9674103-0-2.

[23] Kai Mikkonen. *The Narratology of Comic Art*. 1st ed. Vol. 1. Routledge advances in comics studies. Book Title: The Narratology of Comic Art. London: Routledge, 2017. ISBN: 978-1-138-22155-0. DOI: 10.4324/9781315410135.

[24] Janet H. Murray. *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*. Cambridge, MA, USA: MIT Press, July 17, 1998. 336 pp. ISBN: 978-0-262-63187-7.

[25] Yi-gang Peng. *[Analysis of the traditional Chinese garden / Peng Yi-gang]*. Peking: China Architectural Industry, 1986.

[26] S. Camille Peres, Tri Pham, and Ronald Phillips. “Validation of the System Usability Scale (SUS): SUS in the Wild”. In: *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 57.1 (Sept. 1, 2013). Publisher: SAGE Publications Inc, pp. 192–196. ISSN: 2169-5067. DOI: 10.1177/1541931213571043. URL: https://doi.org/10.1177/1541931213571043 (visited on 04/27/2022).

[27] *Picasso and Collage*. Weiner Elementary. URL: https://www.weinerelementary.org/picasso-and-collage.html (visited on 05/07/2022).

[28] *Pittsburgh’s Dark History*. Popular Pittsburgh. Feb. 11, 2015. URL: https://popularpittsburgh.com/darkhistory/ (visited on 04/27/2022).

[29] Matthew Potteiger. *Landscape narratives: design practices for telling stories*. In collab. with Jamie Purinton. Book Title: Landscape narratives : design practices for telling stories. New York: JWiley, 1998. xii+340. ISBN: 978-0-471-12486-3.

[30] Klen Čopič Pucihar and Matjaž Kljun. "Augmented Reality Systems and Their Future in Tourism: Before, During and After the Journey". In: *Augmented Reality in Tourism, Museums and Heritage: A New Technology to Inform and Entertain*. Ed. by Vladimir Geroimenko. Springer Series on Cultural Computing. Cham: Springer International Publishing, 2021, pp. 49–67. ISBN: 978-3-030-70198-7. DOI: 10.1007/978-3-030-70198-7_3. URL: https://doi.org/10.1007/978-3-030-70198-7_3 (visited on 02/27/2022).

[31] *(railroad tracks beneath sky filled with smoke, Pittsburgh, Pennsylvania) | CMOA Collection*. URL: https://collection.cmoa.org/objects/dc3560f8-8d03-47cf-aa0d-8683621dfcf3 (visited on 05/08/2022).

[32] Marie-Laure Ryan. *Narrative across media: the languages of storytelling*. Frontiers of narrative. Lincoln: University of Nebraska Press, 2004. 422 pp. ISBN: 978-0-8032-3944-9.

[33] Livia Stefan. "The art of collage and Augmented Reality 2D/3D Techniques". In: (). URL: https://www.academia.edu/9816559/The_art_of_collage_and_Augmented_Reality_2D_3D_Techniques (visited on 02/09/2022).

[34] *Still-Life with Chair Caning, 1912 by Pablo Picasso*. URL: https://www.pablopicasso.org/still-life-with-chair-caning.jsp (visited on 04/30/2022).

[35] Tate. *'Bottle of Vieux Marc, Glass, Guitar and Newspaper', Pablo Picasso, 1913*. Tate. Section: Art & artists. URL: https://www.tate.org.uk/art/artworks/picasso-bottle-of-vieux-marc-glass-guitar-and-newspaper-t00414 (visited on 04/28/2022).

[36] *The Birth of Collage and Mixed-Media*. Artsy. Feb. 6, 2014. URL: https://www.artsy.net/article/matthew-the-birth-of-collage-and-mixed-media (visited on 05/07/2022).

[37] *The Odd, Mysterious & Fascinating History of Pittsburgh - Swimming in Lake Elizabeth in West Park - August 8, 1913 | Facebook*. URL: https://www.facebook.com/

OddPittsburgh/photos/a.1951493531761179/1951493548427844/ (visited on 05/08/2022).

[38] Freeman Tilden. *Interpreting Our Heritage*. Google-Books-ID: dDiPX4sDBekC. Univ of North Carolina Press, 1967. 196 pp. ISBN: 978-0-8078-4016-0.

[39] *Uses of Heritage*. Routledge & CRC Press. URL: https://www.routledge.com/Uses-of-Heritage/Smith/p/book/9780415318310 (visited on 03/26/2022).

[40] *What Is a Multiple Narrative?* Education - Seattle PI. URL: https://education.seattlepi.com/multiple-narrative-5829.html (visited on 04/27/2022).

[41] *What's in a name?: Exploring the history of the North Side's Lake Elizabeth | Pittsburgh Post-Gazette*. URL: https://www.post-gazette.com/opinion/Op-Ed/2018/12/16/The-Next-Page-Exploring-history-Pittsburgh-North-Side-Lake-Elizabeth-Patricia-Lowry/stories/201812160077 (visited on 04/27/2022).

[42] *When Coal Smoke Blacked Out The Midday Sun*. HuffPost. Section: Environment. June 5, 2012. URL: https://www.huffpost.com/entry/historic-pittsburgh-smoke-control-photos_n_1569252 (visited on 05/08/2022).

[43] Frances A. Yates. *The Art of Memory*. Google-Books-ID: bHeVn9BkUFwC. Random House, Oct. 31, 2011. 474 pp. ISBN: 978-1-4481-0413-0.

[44] *Zero Waste PA*. URL: https://pennenvironmentcenter.org/feature/pac/zero-waste-pa (visited on 05/08/2022).

Appendix

A.1 Full Think Aloud Protocol Transcripts

Participant 1

"It's a really cool app! I love it!

Wow, so many people used to swim here! But there was smoke in the sky when they were swimming, they must come from different time period. Wow there were really many people here! It seems that it was really crowded in the past.

I heard a lot of kids are screaming in the background.

The collage content blend really well with the lake!

Wow I saw ducks and boats in the lake. It makes me feel that it had a really good environment in the old days.

I saw there is a big house there, and there are some boats besides it. I think the house was used as placing boats in the past.

I expect the virtual scenario aligns perfectly with the physical world. When the virtual content appeared in the wrong places, I would still assume that they are in the right places.

The virtual content emerged from the water...It seems a little strange.

Where does the water of the lake come from?

I saw there are several huge black clouds in the sky, also a factory that is producing the smoke. But I don't understand why the garbage only appears here.

I think it's really hard to find out where are the scenarios at, maybe it's because of the screen is reflecting the sunlight and I can't see clearly. I'm also not sure where should I go.

I feel the collage content is directing me to the right observing spot, but you have to make it

clear at the beginning.

It will be better to have a virtual path to guide me to the right observing spot.

I saw there are many kids playing around the installations.

What does the monument mean in your app? I thought I might be relevant to the virtual content. The monument makes me feel that the site has a long history.

I also saw there are people taking kids to play here."

Participant 2

"I saw there are 3-4 layers of collage content here. They are all old photos.

I felt that it's a little bit confusing when I saw these scenarios appear in the same time. For example, when I'm watching this scenario, I can also see the car in the last scenario.

It seems that they are all statistic.

I saw there is a boathouse and there are many boats around it, it's really interesting. Are they in the same time period?

Is the sound playing all the time? Or is it changing according to the scene?

Where do you get the sound source? What time period is the sound from?

I saw there is a small fountain and many people gathering here. I feel the collage content is moving along with me.

Sometimes I can't notice the virtual content.

Since I thought the default route that I should take is around the lake, I don't know which path should I choose to get to the scenarios that are not around the lake.

Because of the sunlight, I can't see them clearly.

I saw there is a factory here and it's producing smoke. It's seems that the site had a severe

pollution problem in the past.

I saw there are installations for kids to play with.

I think the collage is not strongly guiding me to some observing spots. Since I know the collage is always a free form of art. When there are holes in the pictures, I will consider it to be just an artistic creation.

But why does the factory only have chimneys here? I was expecting it to be a complete scene.

The collage content made me know about the story visually, but I think I want to know the exact time of the historic content."

Participant 3

"I saw there is a car with some people in it, I guess people in the old days would drive to here and play.

I saw many people swimming in the lake, I think this should be a good place for vacations on weekends and it's really a lively place. I also saw there is a house far away from here, let me get closer and see.

I saw there is cloud in the sky, I'm not sure which scene is that in. The blue sign on the ground is hard to notice, I think put the signs in the sky will be better.

I also saw there are some people over there around a small fountain. It seems that kids always played around it.

Are those stones? Oh no it's garbage in the lake.

Is the smoke from a bomb or...Oh it's from the factory! That's really severe pollution.

I also saw people boating in the lake and ducks, but it's floating in the air. It seems that the app is not working well sometimes.

I saw there are so many garbage in the lake, it seems that people were not protecting the environment really well.

These virtual ducks are really similar to the real ones in the lake, I feel it's really fascinating. It seems that the real ducks and virtual ducks are playing together.

I saw there are many installations for children to play, there should be many kids living in the neighborhood.

I saw there are many people gathering by the lake and watching the kids swimming in the lake, it seems that the parents in the old days always took their kids to play here."

Participant 4

"I saw there are so many people swimming here. There are boats around the house.

When did these scenarios take place?

Sometimes I feel it's confusing when the virtual content from different scenarios overlay with each other.

I saw there are so many garbage in the lake, when did the scenario take place?

I think the sunlight makes the screen hard to watch carefully.

I feel the collage is guiding me to the position where the collage align well together and create a complete scenario."

Participant 5

"I see there are sidewalks by the side of the road.

I saw there are people swimming in the lake and there is a big house. But there is smoke in the air far away from here. It seems that the site was polluted in the past.

I think it must be a really important place for people who were living here.

Since I saw there are people boating and swimming in the lake, but the lake is really shallow now. So I think there must have been a huge change on the landscape.

Now I'm in front of the garbage in the lake, and when I think of the smoke and factory scene in the air, I think it had gone through a period of time when the landscape was polluted.

I saw there is a small fountain, but I don't know the exact time of it.

Comparing to the current site, I know the building used to be on the site has disappeared.

Is that a slide for kids? I think there must be a residential area around here since the kids can't go really far from their home to play.

From this angle, the virtual content is aligning well with the real trees. I think it's really fascinating.

It's hard to recognize the virtual content when it's far away from me. I feel the direction that I'm facing to is really important to some scenarios. When I notice them, I'm not in the best position to look at them."

A.2 Full Interview Transcripts

Participant 1

Question 1 How did you understand each scenario? How did the content make sense to you?

"I think each piece of collage in the scenario combine with each other and convey an idea together. They may not make sense when they are alone, but they are depicting a meaningful story while being perceived as a whole. I think it's a really good concept."

Question 2 How did you think of the combination of visual and audio experience? How does the combination affect your walking experience?

"I think it's a really different experience when the visual and audio content blend together very well. The visual and audio content adds a new layer to the space, extending the time and space dimensions of the landscape. I got to know many things that are invisible on the site. However, it's a little bit distracting when I just want to experience the natural landscape."

Question 3 How did you decide your trajectories through different virtual scenarios?

"Since the site is not too big, I just chose to walk around the lake. In the meantime, the virtual scenarios in the virtual space also guided me through the landscape. If there was no virtual scenarios, I wouldn't go there."

Question 4 How was the experience enhanced comparing to walking in the landscape without holding the mobile augmented reality device?

"I can feel a different timeline on a scenario."

Question 5 What did this digital walking experience made you think about?

"I got to know about the site history, such as the pollution the site had gone through, the people who were playing on the site. With the help of visual and audio content, I had a deeper impression of the history just like I was in the old times. After seeing so many people playing on the site, I can feel this place was bustling and lively in the old days. Comparing to what the site is now, I got to know that although there is no pollution anymore, but less people here."

Question 6 How do you think of the whole walking experience?

"I think it has a good concept, but there are technical improvements can be made in the future. Without your explanation, it would be hard for me to know how to use the app. It's also better to have some warning signs to protect the user from stepping into the water, since the users are concentrated on the app while they are walking. I also prefer it has different timelines that users may choose to experience, so that users can have a clear idea about how did the site evolve in a strict timeline."

Participant 2

Question 1 How did you understand each scenario? How did the content make sense to you?

"The scenarios make sense when I was looking at them individually, but it's a little bit confusing when I couldn't differentiate which scenario is at front and which is at back. "

Question 2 How did you think of the combination of visual and audio experience? How does the combination affect your walking experience?

"I think the audio is more helpful for me to understand the scenario. The audio makes the story line more complete and easy to understand."

Question 3 How did you decide your trajectories through different virtual scenarios?

"I chose my trajectory in a randomly way. Since I noticed that there is a lake at the center of the site, so I chose to walk around the lake. But the scenarios didn't have an clear order to go through, so I felt it's free to go through different scenarios."

Question 4 How was the experience enhanced comparing to walking in the landscape without holding the mobile augmented reality device?

"Holding the device in my hands, I couldn't stop staring at the screen. Without the device, I might go on Internet and search for the history. But the screen showed the history in an understandable way, it made me immerse into the history."

Question 5 What did this digital walking experience made you think about?

"I don't know exactly the time of the scenario, but I remember there was a factory here which polluted the environment. The site was a popular place for people gathering and playing. There were many interesting history in the APP, but I don't know the order of them."

Question 6 How do you think of the whole walking experience?

"I really love the walking experience that the APP provided. I always love the site-specific AR which makes me feel the comparison between the real world and virtual world."

Participant 3

Question 1 How did you understand each scenario? How did the content make sense to you?

"The content are forming a clear story to me. I can imagine the scenario out of the images."

Question 2 How did you think of the combination of visual and audio experience? How does the combination affect your walking experience?

"I think the audio combines very well with the virtual content, it made me to imagine and

construct the story that happened on the site. When the sound was muted in some scenarios, I felt the content became thinner. Sometimes I felt the sound volume was too high so that I couldn't notice the real world sound."

Question 3 How did you decide your trajectories through different virtual scenarios?

"At the beginning, I was trying to go to all the virtual scenarios that I saw. Sometimes I lost my way on the site and didn't know where to go, I just chose to explore different possible paths to go."

Question 4 How was the experience enhanced comparing to walking in the landscape without holding the mobile augmented reality device?

"Since I came here for the first time, I didn't know anything about the site. With the app, I got to know many about the site history."

Question 5 What did this digital walking experience made you think about?

"I remembered the environment pollution problems that the site has gone through. I remembered there were many children playing on the site. But I'm curious about the exact time when the story happened. When I was watching the content, I was not sure if they are in the same time period or not."

Question 6 How do you think of the whole walking experience?

"I think the screen held in my hands confined the view that I could have seen. I also hope there could be indicators above the scenarios to tell the audiences where to go clearly."

Participant 4

Question 1 How did you understand each scenario? How did the content make sense to you?

"I felt the scenarios gave me a broad sense of what was happening on the site. When I was approaching them, the images combined together and formed a scenario, I could understand them really well."

Question 2 How did you think of the combination of visual and audio experience? How

does the combination affect your walking experience?

"I think it made me feel more immersive in the scenes. I can understand the virtual content in a multi-sensory way. It's adding another layer to the visual content."

Question 3 How did you decide your trajectories through different virtual scenarios?

"I would go to see the virtual content that were easy to notice. With the purpose of going towards them, I also considered the path on the landscape."

Question 4 How was the experience enhanced comparing to walking in the landscape without holding the mobile augmented reality device?

"The device provided me the chance to know about the history. "

Question 5 What did this digital walking experience made you think about?

"I remembered the factory that polluted the environment, also the people gathering and playing on the site."

Question 6 How do you think of the whole walking experience? *"I think more textual introduction can make me understand the history better. Maybe a small amount of words that can introduce the scenario briefly will be good, such as the time period, or a short title. I think the pictures can be transparent when they are away from me."*

Participant 5

Question 1 How did you understand each scenario? How did the content make sense to you?

"I think each piece of collage in the scenario combine with each other and convey an idea together. They may not make sense when they are alone, but they are depicting a meaningful story while being perceived as a whole. I think it's a really good concept."

Question 2 How did you think of the combination of visual and audio experience? How does the combination affect your walking experience?

"I think the audio provides much extra information to me. The audio was the sound from

people who were playing, it made the scenarios much more immersive and attracted me to concentrate on the scenarios. Maybe dialogues make more sense."

Question 3 How did you decide your trajectories through different virtual scenarios?

I think I decided my trajectories based on the route on the site. When I saw the virtual content in the APP, I would go there to find out for details.

Question 4 How was the experience enhanced comparing to walking in the landscape without holding the mobile augmented reality device?

"I think the device provided me more information about the landscape. Since the buildings and activities have all disappeared, I definitely couldn't know about these things without this app. The pictures and audio reconstructed the historic scenarios vividly."

Question 5 What did this digital walking experience made you think about?

"I remembered this place was an important activity center of the citizens. Also I remember the factory that polluted the environment and affected the citizens' living surroundings. After comparing the scenario in both virtual and real environment, I noticed that the site has gone through a big change in appearance."

Question 6 How do you think of the whole walking experience?

"I think the sense of guidance is not that strong. Sometimes I had a hard time with finding the scenario positions. I hope the black and white images can change to colorful ones when I'm approaching them. Or it could be better to have obvious pinpoints to guide me to go to different places."