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Master's Thesis
Academic Year 2022

KOKU: Simulate Memorable Scene in Virtual Reality To Improve Reminiscence Experience

Keio University
Graduate School of Media Design

Qiyao Zhang

A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

Qiyao Zhang

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Abstract of Master's Thesis of Academic Year 2022

KOKU: Simulate Memorable Scene in Virtual Reality To Improve Reminiscence Experience

Category: Design

Summary

KOKU is a reminiscence experience design that reconstructs memorable scenes in virtual reality. With the development of the metaverse and VR, people would expect a more realistic reminiscence experience to relive the memory. The core value of the design lies in the immersive reminiscence experience and the conceptual design of idealized memories, which allows people to idealized reconstruct and relive memorable memories in VR. The prototype of this study used 3D scanning technology to reconstruct memorable scenes. By helping six volunteers reconstruct memorable scenes and conducting interviews, found that visiting the 3D reconstructed memorable scenes in VR enabled people to recall more details and relive emotions thus improving their reminiscence experience.

Keywords:

virtual reality, 3D reconstruction, reminiscence, immersive experience

Keio University Graduate School of Media Design

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Another person I would like to thank is my boyfriend, who helped me with all his efforts to complete this research, giving me moral support and material assistance. He accompanied me patiently throughout the research process, actively discussed the details of the conceptual design with me, and provided me with experimental equipment and assisted me with the experiments. Without his support, I cannot imagine how much difficulty I would have encountered in this research. I would also like to thank my family for giving me the freedom and money to do what I like throughout my master's degree, helping me with my experiments during the research process, and following my progress step by step.

During this research journey, I have learned many profound truths that have made me more patient and action-oriented. In particular, the course in Media Design taught me how dreams can fall into reality gradually, and that everyone can sketch out their ideal future through thinking and doing. It also taught me

to look at the world with a future-oriented vision, where every thing and every action, through technology and art, may have a more interesting development in the future. It has given me a pair of eyes that can look at the present and generate insight into the future, which will bring a significant impact in my life and work.

Chapter 1
Introduction

As a reminiscence experience design, KOKU enables people to step into the memorable scene through VR and immerse themselves in the vibe of the time. The project considers the current trend of VR, the digital twin, and the metaverse concept, providing innovative thinking about people's reminiscence experiences in the future. KOKU hopes to enrich the method of the reminiscence and improve the experience.

1.1. Background

Reminiscence is a process of thinking or talking about past experiences that make up who we are now. Revisiting and reflecting on the past allows us to harvest our self-identity and helps us relive the old time [1].

People enriched the reminiscence methods with the development of technology and lifestyle habits. In order to remember, people record what happened in reality or collect items of memorable significance. For a long time, people used pictures and words to record content. In modern times, people invented cameras, which allows people to record more realistic and rich content by taking photos and videos. In addition, historical items and significant objects, like a toy, antiques, or clothing, can also bring back the old time.

All of the above ways of evoking memories are designed to make us recreate scenes of the past in our minds. However, these ways are only abstract pictures, symbols, or sounds and do not reconstruct the scene, making our reminiscence experience incomplete.

1.1.1 Challenges in reminiscence

Most of the time, people record memorable scenes in photos and videos to relive the feelings of the time in the future. However, photos and videos, including 360-degree panoramic images, are ultimately flat and illusory. There are many challenges when using photos and videos to recall the past.

3D details cannot be recorded in photos and videos. When a camera is used for recording, only one angle of the image can be captured, but reality and memory are three-dimensional, the photos and videos lead to the loss of many details and makes the reminiscence experience incomplete. If complete details of the target need to be recorded, it is necessary to replicate the object from a three-dimensional perspective.

Reminiscence through photos and videos are difficult to relive the vibe.The experience of many memorable scenes is made up of complex information, not just visual or auditory, but also the weather and the events taking place. The combination of this information together can influence our emotions. This influence is the vibe, and it is the core value of the experience. When recalling memorable scenes through photos and videos, only a small amount of visual and auditory information can be recalled from the scene, which is not enough to reconstruct the vibe of the time. If the vibe of the time can be reconstructed as much as possible and immersive to the experience, it can enhance the memory experience.

Photos and videos have difficulty presenting the ideal scene.Capturing the ideal image needs professional learning. For most ordinary people, the photos taken often do not reflect the actual situation of the environment at the time, making it impossible to revisit the image well when you see these photos later and want to recall the environment at the time.

In addition, photos and videos are often based on personal preferences in post-production software to adjust the color and output. This behavior shows that people have a personalized demand for recorded content. People are more interested in the idealized scenes in their minds than the real ones. On the other hand, when people recall a scene, the key information they can remember may not happen at the same time and in the same direction, such as the door of a bar and a bottle of wine deep in the bar, then it is difficult to record the two memory points in photos and videos, which is a pity for the reminiscence experience.

1.1.2 Technological innovations that inspired the reminiscence experience

As the metaverse concept gradually develops, people commonly use virtual reality in more life scenarios. Pictures, videos, and other recording methods will not be enough to satisfy people who pursue immersion and interactive experiences. The most prominent advantage of the metaverse is the "sense of presence", which means the immersive experience of being there.

Digital twin technology is an essential support for building metaverse space. Replicating the city or the whole physical environment will become possible.

These development trends will also reshape the recording and reminiscence experience. For example, it is possible to reconstruct scenes from memories in virtual space, and by entering them through VR, you can relive the past.

1.2. Proposal

In conclusion, from the challenges of current reminiscence methods and technological development trends, this study provides innovative thinking and design for future reminiscence experiences and names this experience design as KOKU, which means moment in Japanese.

Concerning the challenges of the current reminiscence method, KOKU will try to solve them in the following ways.

Challenge 1: 3D details cannot be recorded in photos and videos

KOKU will use 3D modeling technology to reconstruct the primary physical environment of the scene in 3D in virtual space, presenting a three-dimensional reminiscence scene.

Challenge 2: Reminiscence through photos and videos are difficult to relive the vibe

KOKU will design an immersive VR experience in the virtual space. In addition to the scene modeling mentioned above, the spatial sound effects of the scene will be added to make the experience more realistic from the location of the sound and volume changes.

Challenge 3 : Photos and videos have difficulty presenting the ideal

scene

Since 3D modeling is an editable process, the experience created by KOKU can also be adjusted according to personal preferences. In the process of scene reconstruction, you can edit the scene according to the ideal memory, such as highlighting key objects, amplifying sound effects, and so on, thus creating a three-dimensional scene worth revisiting.

KOKU reconstructs a memorable scene. A memorable scene here is a representative scene made up of the impressive content of an experience. This representative scene can be the most wonderful scene of an experience, such as leaping into the air while skiing; it can also be a scene that combines several impressive moments, such as recalling the scene of snow in your hometown when you were a child, you can put snowmen, snowflakes, and your father who was shoveling snow in the same scene, even though these did not happen at the same time, they make up your memories.

Based on the above proposal, the following four research questions can be summarized.

1) How to record 3D information of memorable scenes?

2) How to do 3D reconstruction in virtual space?

3) How to idealize the scene?

4) How to design the perspective and interaction of the VR experience?

1.3. Objective

This study aims to improve people's reminiscence experience in the future by reconstructing scenes and immersive experiences. The purpose of the study is to overcome the current challenges of reminiscence experience, on the one hand, giving more value to the reminiscence experience through innovative thinking.

In response to the challenges of reminiscence experience mentioned in the previous section, the objectives are set as the evaluation criteria for the solutions below.

Goal 1: Recall more details of memorable scenes

The richer details of the reconstructed scene, the complete one's recollection experience will be, and enhancing the completeness of recollection can increase the value of the reminiscence experience. KOKU reconstructs memorable scenes in 3D, which means that the same one thing can be observed more details in KOKU, allowing the user to relive the past scenes from more perspectives than photos and videos.

Goal 2: Relive the emotions in memorable scenes

Revisiting emotions is an important value in reminiscence experiences. By simulating the vibe of an unforgettable scene, KOKU hopes to stimulate similar emotions in the participants. This goal is to evaluate the effect of KOKU on the reconstruction of the scene.

Goal 3: Reconstruct the ideal memorable scene

An ideal memorable scene enables the user to have a reminiscence experience that is more in line with personal preferences and memories. Helping experiencers design ideal memory scenes is the process of visualizing people's ideal scenes. Compared with reality, such idealized scenes are designed memories, and the collection value is worth exploring.

1.4. Contribution

Using VR to reconstruct memorable scenes for reminiscence experiences is a unique idea that has not yet been tried and applied. The study has high research value and potential for development. The main contribution of this study will be applying a "sense of presence" and "idealized memory" to reminiscence experiences.

The sense of presence refers to the feeling of immersion, which is achieved by simulating the physical environment and the vibe of the actual space and using VR presentations so that people can walk in the scene of memories.

The idealized memory is further optimizing the real situation as a personal wish. There are always deficiencies in the real experience, such as too much noise or too dim lighting. Since the reconstructed scene is a re-editing of the memorable scene, much information can be adjusted, and these problems can be remedied in order to simulate an idealized scene. Sometimes our recollection of a scene

is several impressive details that may not have happened at the same time, and it is necessary to put these details together according to our own memory when reconstructing.

In addition, KOKU's innovation can also derive many new values, mainly in terms of new experiences and scene sharing. The new experience is when people create new memories in the virtual scenes of KOKU. For example, discovering details in a virtual scene that you didn't notice in reality before. Scene sharing refers to sharing virtual scenes with others, allowing friends to enter your memory scenes. Compared to the past, when we could only learn about our friends' past through stories or photos, KOKU allows us to share scenes from our own memories with our friends, which has value for social activities.

1.5. Thesis structure

This thesis will contain six chapters, which are as follows:

- Chapter 1: This chapter introduces the background of this research, including the challenges and opportunities, and also presents the proposal, contribution, and purpose of the research

- Chapter 2: This chapter presents the literature review and related works relevant to the research project, including technologies and applications.

- Chapter 3: It introduces the design concept and prototypes of the research object, including the design ideas, methods, and design process, then describes the prototype for this study, including the design process and evaluation of the prototype design.

- Chapter 4: This chapter is about the proof of concept, introducing the experimental method, observation and interview findings, limitations, and results.

- Chapter 5: This chapter is the concluding section of the study, which describes the future work of the study.

Chapter 2
Related Work

Simulating realistic scenarios to improve the reminiscence experience involves several related fields. Including the study of human memory, 3D reconstruction technology, cases of VR games.

The first part is mainly related to memory research. Especially highlight the accuracy of memory and the altered memory-related research. Then, in order to make the KOKU prototype, I explored an appropriate technical approach to simulate the real scene. This step involves photogrammetry and the 3D scan. In addition, the analysis and comparison with similar cases at last help to find unresolved problems as a breakthrough point.

2.1. Memorable scene

2.1.1 Flashbulb memory

Flashbulb memory means a vivid, enduring memory associated with a personally significant and emotional event, often including details such as where the individual was or what he or she was doing at the time of the event.

People often believe that such memories have the quality of a photograph taken at the moment they experienced the event, and they believe with high confidence that these memories are accurate. However, recent research has shown that although flashbulb memories are more likely to be retained than the memory of an everyday event, they are not always accurate. Flashbulb memory represents memorable moments of people so the definition of it can provide a reference for this study [2].

2.1.2 Purposeful exaggerating or forgetting

Research has shown that the brain can intentionally alter real experiences, such as exaggerating facts to improve memory efficiency or forgetting irrelevant content to reduce the amount of information [3]. Thus, exaggeration and purposeful forgetting are strategies that the human brain uses to store, retain and recall information. When people relive good moments spent with friends in the past, it is like adding a filter to the real situation. In your memory scene, everyone was smiling, and the sky was clear when it was not so beautiful in the real world. However, this false memory allows us to have a more comfortable reminiscence experience.

2.2. Reminiscence service

2.2.1 Using VR to reunite people with their departed loved ones

Meeting You is a documentary that helps participants reunite and interact with their deceased loved ones through VR technology. It produced by one of South Korea ' s largest broadcasters, Munhwa Broadcasting Corp, which worked with six different studios to create the VR experience.

In the programme, a mother called Jang Ji-sung lost her daughter to blood cancer in 2016, welcome an opportunity to see her daughter again in VR.

Technicians created a realistic 3D model based on a photo video of her daughter, according to the family's suggestion to create a birthday VR scene. In the experience, the mother Jang was surrounded by a green screen, wearing VR equipment into the scene. In the virtual scene, the daughter Nayeon ran towards Jang and shouted "Mom, am I cute?"

At one point, VR Nayeon has her mother touch her hand, and they float into the sky to a twilight-toned afterlife. There is a flying unicorn and the backdrop is purple. Jang and VR Nayeon sit at a table set with a birthday cake and foods that Nayeon loved, we are told—birthday seaweed soup and a plate of honey rice cakes. This brief act ends with VR Nayeon falling asleep after telling her mother that she ' s no longer in pain. "I love you, Mom, " she says. The purple sky gives way,

and we were back in the studio as an emotive song plays in the background [4].

This VR project helps people meet their past family member in an immersive scene, recreates new memory and brings a reminiscence value.

(Source:Using VR to reunite people with their departed loved ones [4])

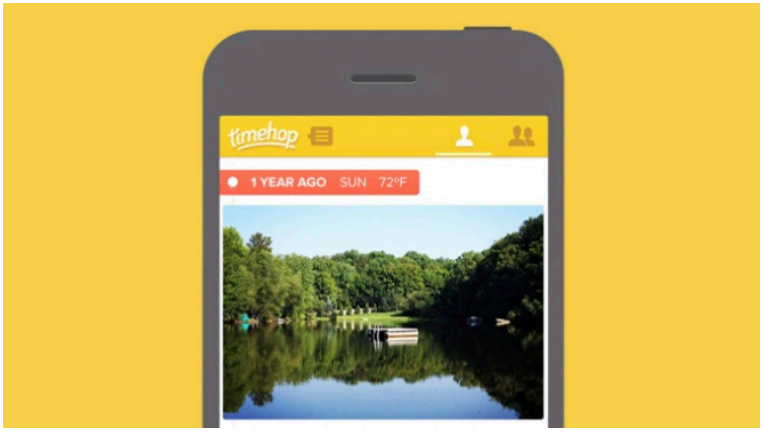
Figure 2.1 Reunited a grieving mother with her dead daughter in VR

2.2.2 Celebrate old memory everyday

Timehop is an application for smartphones that collects old photos, videos and posts from Facebook, Instagram, Twitter, Apple Photos, Google Photos and Dropbox photos and distributes the past everyday. You can see the exact day in history everytime you open the APP, you can generate a share photo of past and present with your friends [5].

The greatest value of Timehop is the collection of content from entire albums and social platforms, reminders and amplification of past memories.

At the same time, some of the more well-known social software is also helping users remember or recall their past. Facebook, for example, helps users revisit posts and images from a year ago or even five years ago with its recap feature; Snapchat's recap feature helps users revisit snaps posted a year ago; Instagram sometimes pushes notifications to users such as "View posts from 4 years ago



(Source:Works As A Digital Time Capsule [5])

Figure 2.2 Today in history

today". The "Today" feature on QQ reminds users to check what they have said and share their memories.

In a data-intensive society, in addition to social media, intelligent devices have become substantial, symbolic and functional tools for storing and reproducing memories. Examples include notifications such as "You have a new memory" or "Best memories of the past three weeks" on Apple phones. These features are embedded in the phone's "Photos" application, which blends algorithms with memories to organize and present photos and videos recorded by the user.

2.2.3 Digital media influence on memory

The technology development brings a lot influence in reminiscence experience.

This kind of reminder feature in smart phone makes the memory more realistic. With algorithmic technology, anniversaries encapsulate an increasing number of social experiences and daily activities, and these events are incorporated into a spatio-temporal cycle measured in one-year anniversaries, resulting in a memory that is celebrated and shared. Such algorithmic memory techniques maximize the user reminiscence experience at a certain time. The circular logic of the year as a unit enables people to feel memories in a sharper and more realistic way, and the perception of memories becomes more concrete and immediate when faced with

the same season, climate, and date.

The intelligent organization of memory by algorithms makes memories clear and organized. Just as machine learning and recognition technologies have been extensively involved in social media memory storage, technologies are helping humans recreate the "past" in an automated and organized way. They can analyze the content of each photo and identify its visual characteristics, whether it is a building, an animal, an object or a human face. By intelligently analyzing and automatically organizing the content of images that represent human memories, intelligent organization of the "past" is possible.

Memory sharing and reminders bring the past to life. Algorithmic memory technology in social media has a logic of engagement that seizes the present moment and keeps sharing it with others.

According to some scholars, memory is a secondary revision of existence, which means that the past, present and future are a dynamic process of constant change. The interactive and sharing nature of social media allows algorithmic memories to be continuously disseminated and exchanged in the medium, resulting in dynamic changes.

In the process of memory sharing, communities that share the same memories are naturally integrated into each other's memory narratives. With this integration, new forms of communication can be formed, and the same memories connect past friendships, so that the "past" is always present in reality.

Algorithmic memory sharing also affects the way people build their personal self-perceptions and identities. According to Aram Sinnreich, a professor at Rutgers University, memory recording software such as Timehop influences people's self-perceptions by allowing us to see our roles not only from the inside, but also from an external perspective.

In the process of sharing and being shared, our perception of our own image can be redefined. For sharing allows us to see our own image in the memory of others, as well as to witness and acknowledge the past. It is a way of seeing ourselves anew and remembering ourselves, and the memory of the "past" will live again in the "present".

As technology helps us remember the past, does the human capacity for active remember get compressed? In his new book, Digital Memory Research, Profes-

sor Andrew Hoskins of the University of Glasgow explores how users' reliance on smartphones, search engines and social media in the digital age has affected everyone's memory in a variety of ways [6].

He argues that the age of digital technology has the potential to change the way humans remember forever. Our brains no longer need to be active to remember and recall, because in the age of algorithms we can recall everything simply by uploading and retrieving. However, when the masses no longer rely on their brains to remember, will the pattern of human evolution change in the future?

Furthermore, as documenting our lives in social media becomes a necessity, our sense of experience of the memory will change. Memory becomes a sharing-oriented behavior rather than a process-oriented experience.

Therefore, in the technology-driven era, while we enjoy the novel experiences brought to us by technology, perhaps it is more important to consider whether our memory and perception are gradually becoming fragile under the transformation of technology [7].

2.3. Reconstruct reality with 3D modeling

2.3.1 Structure-from-Motion photogrammetry

SfM(Structure-from-Motion) is the process of reconstructing 3D structure from its projections into a series of images taken from different viewpoints [8]. To describe it in more common language: taking lots of photos of the object from all possible directions, and then using those photos as input to a specialized software. The software will look for features that are visible in multiple photos and try to guess from which point the photo was taken. Knowing the location and orientation of the camera, it will create a 3D point that corresponds to a 2D feature on the photo. Ideally, there will be a finished 3D mesh as output [9].

Photogrammetry has been in operation since the mid-19th century and plays an essential role in several fields. For example, archaeologists use photogrammetry to quickly map large and complex architectural sites. It also provides extensive support in the areas of architecture, engineering, manufacturing, geological surveys, and so on. Because photogrammetry often involves very sophisticated and

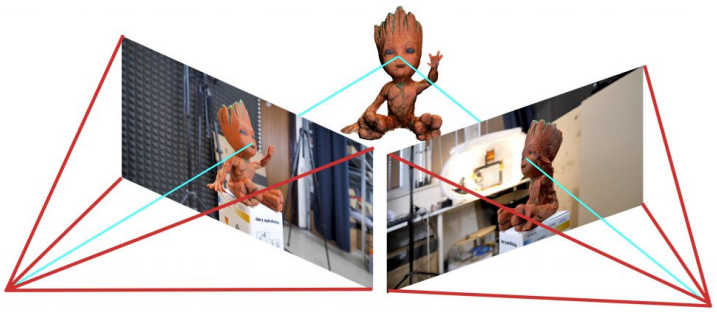
specialized fields of study, the software available for this technology is extensive but expensive. There are few free photogrammetry programs open to the general public, and they are limited in functionality.

Here are some examples of reconstructing with free photogrammetry software, which is popular among general users because they are easy to use, does not require much expertise, and can be used by ordinary people directly for photogrammetry of small objects. Colmap can help us reconstruct geometry from photos, while Meshlab can help us repair and improve the base model output from Colmap.

The following will describe the process of taking pictures for photogrammetry and exporting the model through Colmap and Meshlab, with information from Josef Prusa's Prusa 3D youtube video [10].

Step1: Taking pictures for photogrammetry

First, we need a camera or a smartphone to take 50-80 pictures around the object in a circular motion without changing its position and surroundings.



(Source:Photogrammetry – 3D scanning with just your phone/camera [9])

Figure 2.3 Taking pictures for photogrammetry

Step2 Reconstructing objects from photos in Colmap

Put all the photos taken into a folder, turn on Colmap's auto-reconstruction function, and import the folder. There will be a reconstructed view of the scene and the estimated position of the camera.

Step3 Colmap output and creating mesh from point cloud data

The Colmap export will get two files: fused.ply. and meshed.ply. Meshed.ply is already a mesh model, but it is usually not fine enough, so it needs to refine

(Source:https://www.youtube.com/watch?v=ye-C-OOFsX8)

Figure 2.4 Reconstructing objects from photos in Colmap

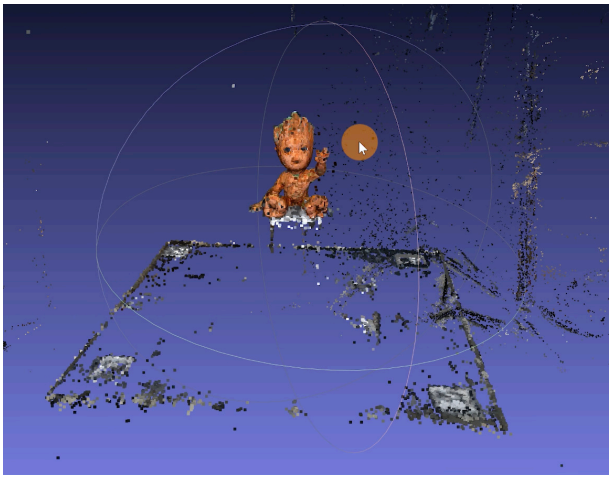
in meshlab. The fused.ply file contains a so-called point cloud. The mesh model will build based on the point cloud in meshlab.

Step4 Improve the reconstructed model.

After a complete mesh is achieved, it can be refined, such as smoothing, deformation, etc. The ultimate result is a reconstructed model.

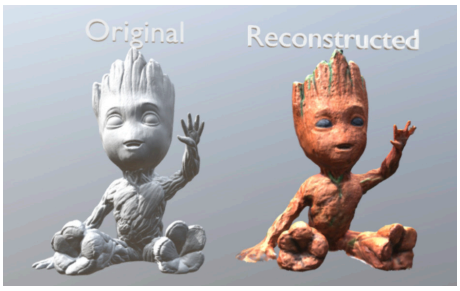
Although photogrammetry can accurately perform 3D reconstruction, it is time-consuming and labor-intensive to apply. Except for some professional application scenarios, it is not suitable for ordinary people. This study hopes to present an immediate scene record, which requires a more simple operation method, the project does not pursue the fine level of scene as well, so the photogrammetry is not suitable for this research application.

There are various approaches to 3d construction. Apart from the highly professional photogrammetry, there is a more convenient method called 3D scanning. By downloading the 3D scanning app into the smartphone, scan the physical environment through the camera, and the app will automatically generate a 3D model of the scene or object.



(Source:https://www.youtube.com/watch?v=ye-C-OOFsX8)

Figure 2.5 Creating mesh from point cloud data



(Source:https://www.youtube.com/watch?v=ye-C-OOFsX8)

Figure 2.6 Reconstructed model

2.3.2 3D scan

There are many kinds of popular 3d scan apps available in the application market, but their effect is pretty mixed. This study has reviewed these apps to find the most suitable 3d reconstruction tool. The following is a demonstration of the best-performing 3D scan app, Polycam.

Polycam consists of three main functions, capturing the physical environment, editing the 3d model, and sharing. 3d reconstruction has two ways, radar mode, and photo mode. Radar mode is suitable for capturing the scene. It uses depth data provided by the lidar sensor to generate a reconstruction directly on the device. Photo mode is suitable for the reconstruction of a single object, and the way to take a photo is the same as photogrammetry, which requires a wrap-around shot of the object from different angles. When scanning an object, it is better in a broad place so that the camera can capture the details from all perspectives.

Figure 2.7 3D scanning

Figure 2.8 3D scanned model

After practically using polycam, the reconstruction accuracy of individual objects is the best performance in the same category of apps. In contrast, in the scene reconstruction, the reconstruction effect is not so good for the environment with complex texture, rich details, or more dynamics, and the distant scene and the sky cannot be effectively reconstructed when shooting outdoors.

The 3d model generated by this 3d scan software applied to the mobile phone

lacks reconstruction accuracy, but the operation is simple, and the scene generation is fast, which is suitable for reconstructing realistic scenes in this study.

2.4. Reconstruction in virtual reality

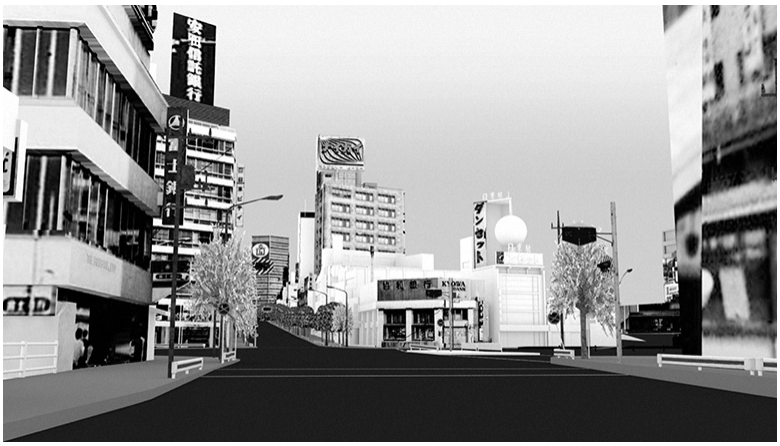
Panoramic photography technology and VR technology allow people to experience realistic scenes in a more immersive virtual space. This feature led many fields to experiment, such as tourism, architecture, art, and other industries. In the application of tourism, many cases of VR tourism have emerged in recent years, such as the 3d reconstruction of museums so that people can visit in virtual space or the use of panoramic cameras to photograph the landscape so that people can see 360-degree views. In the construction industry, people get more accurate spatial information through 3d view, and in the art industry, people experience artworks through VR immersion. KOKU hopes to enhance the reminiscing experience by enabling people to step into memorable moments through VR technology.

2.4.1 1964 Tokyo VR

1964 Tokyo VR is a project that collects photos and images of Tokyo around 1964 from companies and individuals to recreate the past landscape through virtual reality technology. The project uses the latest 3D technology to restore Tokyo around 1964 in virtual reality. People can experience the streets and environment of the time and feel the changes between the past and the present. The project gives highly nostalgic value to some older people.

The project used photogrammetry to generate a 3-dimensional topographic map of the city from aerial photographs of Shibuya taken in the 1960s. This method analyzed the parallax information, shadows, and contrast of the photographs to create a 3-D physical entity. Through this method, the height relationship of each building can be used as a guide for detailed model creation [11].

However, since the scenes are reconstructed through old photos, there is a lack of accuracy, and the scenes are oriented to the general public, not from personal memories and a specific moment.



(Source : https://1964tokyo-vr.org/)

Figure 2.9 1964 Tokyo VR

2.4.2 Versailles VR

Among various VR applications, it is a common way to restore famous museums or historical buildings to the virtual world for people to enjoy. This kind of content containing a cultural and artistic value is digitally presented to preserve these precious cultural heritages forever, and on the other hand, people who cannot visit these places can feel the value of these places through VR immersion.

Versailles VR — the Palace is yours is a VR game that reconstructs Versailles in a virtual reality setting, allowing players to wander through the halls and rooms alone and enjoy the great works up close. In addition, when the controller points to some key content, the related introduction will show up so that players can explore all corners of the palace in depth. The game can also switch the scene to the night tour mode and feel the night Versaille's different scenes. The tour will be accompanied by the sound of the guide's explanation and background music so that the whole game experience is not boring and dull.

Through VR Versailles can get beyond the actual experience. The production team took 132,000 photos to reconstruct a 3D model of Versailles through photogrammetry. In the virtual Versailles, every detail is accurately replicated, which allows players to observe the palace's painted ceiling and other artworks closely. In the game, there is an immersion mode, a model of a piece of an artwork independently displayed in space for players to observe. In addition, some of the

areas do not open to the public in reality, they can also be visited in the virtual palace [12].

(Source : https://store.steampowered.com/app/1098190/VersaillesVR/)

Figure 2.10 Versailles VR

The virtual experience integrates the guided tour of the real tour experience into the game, allowing players to gain an in-depth understanding of the story behind the palace.

2.5. Relive in the memory

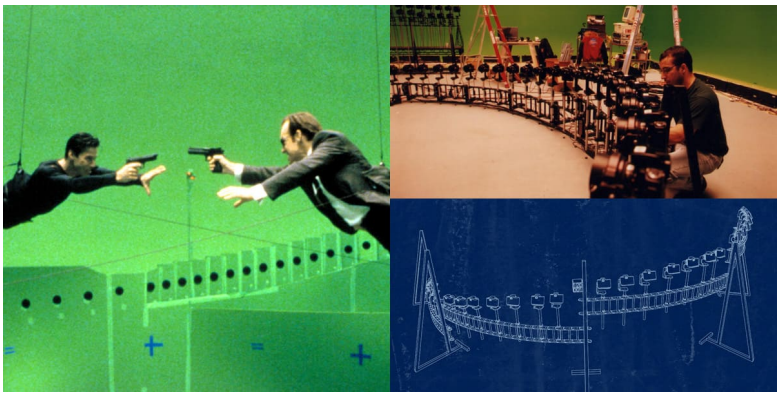
People have been pursuing to keep memorable moments forever, such as taking photos and videos. In some science fiction movies, people are no longer satisfied with the flat memory brought by photos and videos and reminiscing through time travel and time pause. These movie clips are somewhat similar to the concept expressed by KOKU, and there is much to learn from the way they are presented.

2.5.1 Live photo

Apple Live Photos is a camera feature introduced on the iPhone that captures sound and movement a second and a half before and after a photo is taken to create a video-like effect. Made up of audio and still photos, Live Photos are not video files, but more like animated GIFs. To make a Live Photo move, users simply tap on the picture. They can also set a Live Photo as the background on their iPhone ' s home or lock screens [13].

2.5.2 Bullet time

Bullet time is a kind of variable-speed visual effect applied to films, broadcast advertisements, and real-time graphics within video games and other special media, which can achieve the effect of enhanced slow-motion and time standing still. Such visual effects techniques can present images that cannot be seen in real life, producing some extreme visual effects in time and space. For example, wrap-around motion perspective slow-motion shots of a fast-moving object. The most famous use case of bullet time is the movie The Matrix [14].



(Source : https://beforesandafters.com/2021/07/15/vfx-artifacts-the-bullet-time-rig-from-the-matrix/)

Figure 2.11 The Bullet Time rig from ‘ The Matrix ’

Bullet time is suitable for application in a high-speed motion scene, which enables us to observe the full view of a moving object and will give us the illusion of time standing still.

2.6. Conclusion

According to the analysis of the cases related to this study, the current cases for experiencing simulated realistic scenes by VR are not consistent with this study in terms of project purpose and presentation. KOKU mainly focuses on recording and simulating personal subjective memory scenes, so this study is a breakthrough in this area. However, these cases also provide support for the design of KOKU in terms of theory, technology, and methodology.

Chapter 3
Concept Design

3.1. Ideation

KOKU is a VR experience that can reconstruct people's memorable scenes in 3D virtual space. A memorable scene means a time that people feel impressed and want to relive in the future. The digital twin technology allows both the world and humans to have a digital double in the virtual world, and such a technological trend supports the application of KOKU.

KOKU can record the visual and auditory information of the current scene and generate a 3D model where the person can adjust the model according to their wish of the scene and eventually enter the scene through VR to interact and relive the past in an immersive experience. KOKU can be a dynamic scene recorded over a period of time or a static scene, all depending on the requirements for the scene.

3.2. Design process

This chapter focuses on the presentation and experience process design of KOKU. In the beginning, an analysis of people's recollection experience is conducted to discuss the scenarios of using KOKU. Since KOKU is a conceptual design proposed for an idealized experience, the design mentioned in the four processes may not be applicable to the current technological approaches.

3.2.1 Scenario

At the beginning of the design of KOKU, firstly analyzed the current way of reminiscence and sorted out the demand for reminiscence experience. Then sum-

marized the advantages and scenarios of KOKU.

At present, people mainly record and recall memorable moments by taking photos and videos. A photo is a flat still image record. People choose the composition, add filters, take poses, and other ways to leave the best moment for memory. It can be printed and saved on the phone to view at any time. Video is a dynamic recording with audio. People can edit the video through montage and other ways to recall visual and auditory information. In addition, there is a camera that can record panoramic images, which can help people record visual and auditory information in 360 degrees.

The above methods of recording and recalling are applicable to different scenarios and bring people the experience from different angles. For example, putting the family group photo in the wallet or uploading a video with friends on Instagram. The biggest feature of KOKU compared to photos and videos is that it can be immersed in a 3D scene for interaction. Therefore, KOKU is more suitable for scenes with reliving value and sense of atmosphere.

3.2.2 Solution

The KOKU process is divided into four steps, recording, reconstruction, idealization, and VR experience. Recording means recording the memorable moments, including visual and auditory information in the scene. The second step, reconstruction, is to 3D reconstruct the scene information in a 3D virtual space.

Idealization means adjusting the 3d model as we expect in our memory. Finally, VR experience means designing the perspective and interaction of the VR simulation experience according to our memory. After that, it is possible to relive the scene from memory through VR. The design ideas for each step will be described in detail below.

Recording

Recording in KOKU is recording the real-time 3D visual and auditory information and the events of the scene in the memorable moment. For an example, to record a concert, the visual means recording the physical environment in 3D, like the stage, singer. The auditory means recording the space sound of the environment, like the song, voice, and applause. The event is a memorable detail. It would be record independently to simulate the experience and interaction of mem-

ories through VR, like the event is the best part of the song, when you interact with the singer you can hear the best clip.

Reconstruction

Reconstruction is the process of integrating the recorded information into the virtual space. Firstly, building a 3D model of the scene, then simulating the environment and atmosphere, like weather, light, sound. At last, adding the interactive event, like the movement, activities

Idealization

Idealization means adjusting or exaggerating memorable scene as the idealized memory scene. Because Reality experiences often have some flaws and redundant distractions, such as noise, which we would ignore when recalling. And Memories are not always accurate, and we selectively exaggerate or modify facts as we wish to get a more intense reminiscence experience, also some important details in memories, which did not occur at the same moment and place, but appear at the same time in memories, can be integrated in KOKU. Idealization methods are fixing defects, removing distractions, amplifying features, and integrating key points.

VR experience

This step is to design the content of the VR experience from the perspective of the KOKU experience, including both perspective design and interaction design.

People usually have a first-person perspective when they remember the past, but it is helpful to see ourselves from a third perspective because you can recognize your state at the moment. Therefore, in KOKU's VR experience, there are two perspectives to choose from. One is from the first-person perspective, which allows you to see the scene in an immersive way, and the other is from the third-person perspective, which allows you to see yourself as you were at the time.

The interactive experience is an interactive way to relive what we were doing at the time. For some experiences that require operations, such as setting off fireworks or opening a door. In addition, the VR experience design will limit the walkable range, birthplace.

3.3. The first prototype

Due to the current technical limitations, KOKU is difficult to achieve completely through the prototype, so I will find a way to create a prototype that could show the core concept of KOKU as much as possible. In order to present an immersive experience, I tried to use a 360-degree panoramic camera and 3d scanning software and iterated two versions of the prototype. Here is the specific prototyping process.

The first prototype created a memorable scene through the panoramic video, the impressive details, and interactive content called "exploration points" set in the scene. One of the reasons for using panoramic video is that the content captured on video is more realistic and more operational than building a 3d model.

3.3.1 Design process

The process of Prototype is divided into four main steps: experience, record, and reconstruction. I will use my own memorable scene of walking on the seaside for the prototype design.

Experience

The purpose of the first step is to find memorable scenes in the experience that are worth recording. Since the memorable scene is a word that contains subjective opinions, memorable scenes are different for different people. While experiencing a walk on the seaside, I found some details that made me feel happy, such as the sound of the sea lapping on the shore, seagulls flying in the sky, and children flying kites on the shore. The string of these critical details made the whole time memorable. Therefore I chose the panoramic video containing these details as the prototype's content.

Recording

The second step is to record the experience process of the previous step. I wore the 360 camera on my body and recorded the whole process of walking on the beach, and took close shots of the memorable details: the sound of the sea, seagulls flying in the sky, and children flying kites on the shore.

Reconstruct

In the third step, I reconstruct the scene of memorable scenes and add im-

pressive details to them. This step involves designing an interactive panoramic image. It is divided into a base scene and a detailed scene. The base scene is the panoramic image of the scene, and the detail scene is the specific shot of the details. Cut out the panoramic image of walking on the beach as the base scene, then set exploration points on it to mark the location of the impressive details, and then place the captured detail content at the location one level after the exploration points. In the VR experience, you will first enter the panoramic image, and by clicking on the exploration point, you can see the corresponding detailed scene.

Figure 3.1 First prototype

3.3.2 Evaluation

Seven days after the prototype was finished, I evaluated it using a VR headset. The reason for the seven-day interval is the accuracy of the evaluation. Because memory has a process of forgetting, the content recalled after seven days is truly memorable.

The purpose of the evaluation was to assess whether the memorable scene reconstructed by KOKU is accurate and whether the recall experience through KOKU is better than the ordinary recall experience.

The whole evaluation process is divided into two parts, recall, and experience. Recall means describing the memorable scene before using KOKU, then experi-

encing it through the VR headset, and analyzing the effect after the experience. The following is a record of the specific evaluation process.

Recall

Before the KOKU experience, I wrote down my memories of the memorable scene on a piece of paper. Memories are recalled from a sensory perspective, including visual, auditory, and behavioral, the following is what I wrote down.

Visual

The most impressive scene was sitting and resting on the lawn of a seaside park, with an endless sea, few clouds in the blue sky, a blinding sun, and many children flying kites on the lawn.

Hearing

The sound of waves hitting the shore, the sound of children laughing, and the occasional sound of seagulls.

Behavior

Sitting on the grass, watching the kite flyers.

Experience

Through the VR headset, I entered the basic scene and looked around, then looked at three detailed points in turn. In this process, I noticed some details that I had not noticed in my real-life experience, such as people riding bicycles on the grass. I stayed longer in the basic scenes and got more feelings and discoveries. While staying in the detail scenes for a shorter time, I found that although these detail scenes impressed me at that time, viewing them individually did not make me recall anything.

3.3.3 Considerations

The choice for the memorable scene scene is true, but there are many problems in the reconstruction and experience of the scene.

Hard to catch the memorable moment

Many unforgettable moments are only realized when recalling the scene after it has happened. When experiencing it, it may be too late or inconvenient to record.

Lack of immersion

The panoramic camera is recorded from the perspective of the time, which makes the KOKU experience has certain limitations, such as the inability to

switch perspectives or move freely in the scene. In addition, the presentation of some detailed scenes is separated from the base scenes, making it impossible to experience the scene entirety.

Unable to identify oneself

Since the panoramic camera records from the first-person perspective, it is impossible to identify what you are doing at that time in the KOKU experience, which is not conducive to recalling the feelings at that time.

Unable to edit the scene

In the concept design of KOKU, an important part is idealization, which requires editing of the scene. And it is difficult to edit the panoramic video.

3.4. The second prototype

After learning from the last experience, I decided to make the prototype through 3D reconstruction for the second time. Because the 3D reconstruction is more consistent with the concept of KOKU compared to the panoramic camera shot, presenting the scene from a three-dimensional perspective and being able to walk in it through VR, the 3D reconstruction also has some disadvantages, such higher technical requirements in modeling as well as time costs, and at present it is not possible to achieve dynamic 3D scanning reconstruction. Therefore the quality of this prototype design is still rough, and it is a static scene. In order to compensate for the concept that cannot be shown in the prototype design, the next step will shoot a concept video of the second prototype for a complete explanation. Here is the specific design process.

3.4.1 Design process

The second prototype will be a real-time 3D reconstruction of the memorable scene through 3D scanning software, including the environment and people, for the sky and distant scenes will be generated through the panoramic camera background. In addition to this, the spatial sound effects of the scenes will be recorded, and finally a web page that can be experienced in VR will be created.

Design tools

First of all, in order to carry out the prototyping smoothly, it is necessary to investigate and try out the current 3D reconstruction software as well as modeling software and VR experience software.

In the second chapter of this paper, we have explored the utilization of current 3D reconstruction software and selected PolyCam as the software for 3D scanning. This software performs well in generating 3D models of scenes in real time, satisfying the conditions needed for making prototypes in terms of rendering efficiency, accuracy and output method, and it can be quickly started for people who are not professional modelers.

For the VR experience, Mozilla hubs is the software of choice, it is a private space sharing site that allows you to import or design 3D scenes and create your own virtual space and enter it through a VR headset, or invite others to enter it, where each person has their own avatar and supports the ability to walk freely in the space, interact, speak and type conversations. also has an associated 3D modeling site, Spoke, that allows users to design virtual spaces. Therefore, Spoke will be used as the modeling software in this study.

Scenario

The prototype was still selected and reconstructed by myself as the experiencer. Since the 3D scanning software requires a surround shot of the subject, it needs to be scanned in an open and flat space, in addition to bright light and an environment that is not too complex. I chose my favorite event park camping as a memorable scene, because the scene is easier to shoot, the ambient sound of the park as well as the beautiful environment and rich details are very suitable as a prototype scene to highlight the design concept of KOKU.

Experience

The purpose of this step is to find memorable scenes as well as memorable details of the experience. On a sunny weekend, I went camping on the lawn of a park. I laid out picnic mats on the grass in a wooded area in the center of the park and sat on them to enjoy the fresh air of the woods. After an hour or so of camping, I recorded the details that left a lasting impression during my camping trip.

Memorable details: sunlight through the leaves, yellow wildflowers on the grass, cicadas sounds, birds chirping, children laughing.

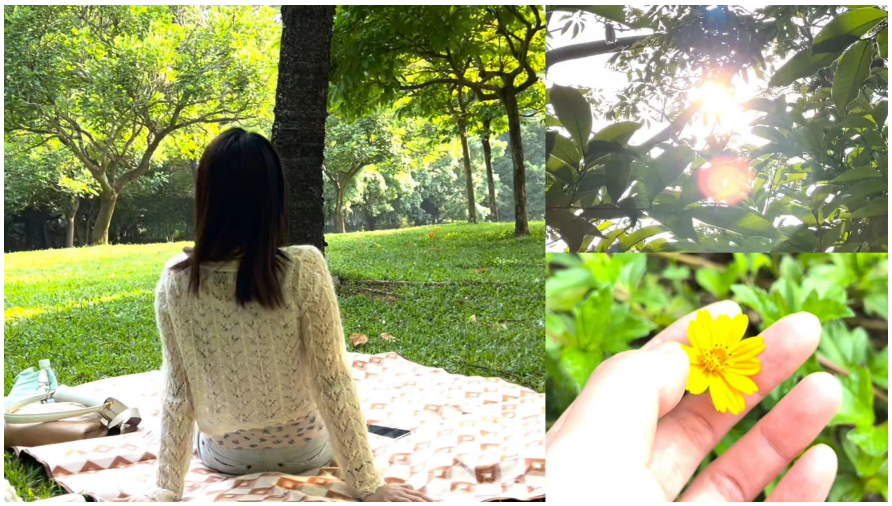


Figure 3.2 Memorable scene and details

Recording

This step will 3D scan the scene, including myself, and record the memorable details summarized above, then take a photo through the panoramic camera as the background of KOKU. I stayed on the picnic mat to enjoy the view and let my partner use PolyCam to scan me in 3D. He needed to use the phone camera to slowly rotate me three times while ensuring that my entire body was captured, and these three circles were used to 3D scan me at three angles: overhead, parallel and elevation. After the scan was completed, the object was selected for rendering and after waiting for 5 minutes, a 3D model was produced.

Next, I continued to photograph each of the memorable details described above through 3D scanning. I photographed the lawn, wild flowers and trees in the park. Some of the details that could not be scanned, such as the leaves and light on the book, will be illustrated through concept video.

The next step is to record the sound effects of the scene. I recorded the ambient sounds of the park, birds chirping, children laughing and cicadas chirping. Finally, using a panoramic camera to take a photo at the place where I camped before.

Reconstruct

In the Spoke web page, I imported the model from the previous step and the sound effects for the reconstruction of the memorable scene. First I imported the panoramic photo taken at the camping trip into Spoke and set it to 360-

equirectangular, so that it could be used as a three-dimensional background for the scene. After that, I imported the photographed lawn as the ground, the people as the subject, and then the trees and wildflowers. Then add bird chirping and cicada sound effects to the trees. Add a lighting effect to the scene to simulate the sunny weather at that time.

Figure 3.3 Reconstruction

VR experience

This step focuses on designing the perspective and interaction during the VR experience. In this prototype, two perspectives will be set up, the first-person perspective and the third-person perspective. The first-person perspective is the perspective when I am experiencing camping, and the third-person perspective is the perspective where I can see the whole scene. When the participant performs the VR experience, you will appear directly at the birth point set in the third-person perspective. The experience will be at the same height as where I was camping, and you will be able to walk freely in the scene.

3.4.2 Concept Video

Due to technical constraints, the prototype could not fully demonstrate the ideal effect of KOKU. In order to clearly demonstrate and illustrate the concept of KOKU, I made a concept video during the second prototype production. In the

Figure 3.4 Second prototype: whole scene

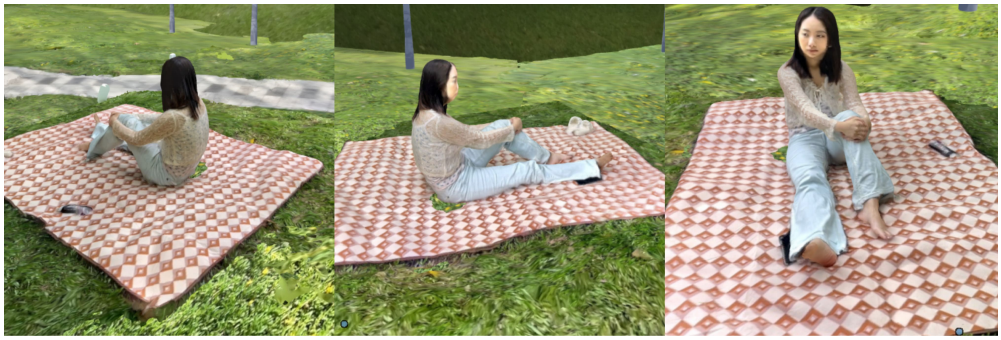


Figure 3.5 Second prototype: difference view points

second prototype, a static basic KOKU scene was shown, but in fact the ideal KOKU should be a dynamic scene with a more detailed 3D reconstruction effect and real interaction.

Therefore, in this video, the ideal KOKU use process was simulated and filmed. The video is shot from a first-person perspective, simulating the perspective of the VR experience in KOKU, recording the entry into KOKU and walking through the memorable scenes, as well as the exploration of the memorable details.

Chapter 4
Proof of concept

KOKU helps people using VR experience 3D reconstructions of ideal memorable scenes, enabling them to recall more details and relive the emotions of the moment, with the aim of overcoming some of the current challenges in the reminiscence experience. In the previous chapters, the prototype for KOKU highlights the design concept. To evaluate the effect of KOKU on the improvement of the reminiscence experience, this study will use the second prototype for experimental evaluation.

4.1. Methodology

Since KOKU is a reconstruction of people's memorable scenes, it is necessary to invite volunteers to perform more scene reconstructions to evaluate the effect.

In this study, a KOKU scene will be created for each volunteer participating in the experiment, and then the participants will be asked to use KOKU for a reminiscence experience. After the experience, an interview will be conducted with each participant. The participant's performance will be observed during the experiment, and the observed information will eventually be analyzed as experimental data along with the interview content.

4.2. Experiment

The purpose of the KOKU study was designed to overcome the challenges of the current reminiscence experience, so this experiment will be evaluated whether KOKU is able to achieve its research purpose. The assessment criteria are as follows.

- Recall more details of memorable scenes
- Relive the emotions in memorable scenes
- Reconstruct the ideal memorable scene

4.2.1 Experiment participants

There were six participants, three males and three females, aged 25-75.

4.2.2 Experiment setup

Interview

Due to the objective of KOKU is to reconstruct memorable scenes, so how to choose and catch the memorable moment is a problem. Before the experiment, I made a interview to every participant to know about their memorable scene. Here are the interview questions.

- Please recall a memorable scene that you want to relive in and desicribe it.
- Why is this scene unforgettable?
- What was your feeling and what you were thinking about when it was happening?
- When did you realize it is a memorable scene?
- What did you do to remember this scene?
- What are the features of your memorable scene?

Choosing location

Based on the above interviews, I found some features and patterns of memorable scenes. For example, memorable scenes are usually regular things that occur frequently or precious experience hard to come by. Moreover, the reason why memorable scenes are memorable is usually related to a deep emotional experience. Some things can be predicted to be memorable before they happen, such as a

college graduation ceremony. Sometimes, people deliberately create memorable scenes, such as an elaborate birthday party. Therefore, in the experiment, in order to more accurately capture participants' memorable moments, the scenes most likely to produce memorable memories were selected.

Since KOKU needs to record memorable scenes, especially the good scenes worth revisiting, the participants will choose the shooting location by personal preference.The place should be an open environment with prominent subjects, avoiding complicated or poorly lighted environments.

Recording

I will follow the participants to the chosen location for the activity and let them choose their favorite scene as KOKU shooting scene for recording during the activity. The recording includes 3D scanning, environmental sound effects, and panoramic photos. The participants are required to keep the same action or state when recording.

Making KOKU

After the recording, the models, sound effects, and photos in the previous step were imported into spoke to create KOKU scenes.

Experience

Before experiencing in VR, the experiment will first allow the participants to recall the scenes on the day of the KOKU event, so that they can compare with KOKU reminiscence experience. Then the participants will walk in the virtual scene with VR headset and explore freely in the scene. I will observe their reaction.

Interview

After the experience ten questions will be asked of the participants and related discussions will take place. The content of the interview will be used as the most important experimental data for evaluation.

Discussion

After collecting experimental data through interviews and observations, the data were analyzed and discussed, and then summarized the effectiveness of KOKU.

4.3. Test and results

4.3.1 Observation

The observation can be used as experimental data to visualize the participants ' reaction and usage habits. The following will summarize and analyze the observations of the participants.

Focus on self

Through observation, I found that the participants were most concerned about the 3D reconstruction of themselves in the KOKU scene. They would carefully observe themselves around their own models, including whether the reconstruction was realistic, what their expressions and movements were at that time, and so on. Participants often laughed when they saw their reconstructed models, and said KOKU allowed them to observe themselves from God's perspective, which was a refreshing experience. In addition, female participants said they were more concerned about how they looked in the 3D reconstruction model.

Exploration

Participants treated the KOKU scene as an exploration game experience, they were more curious about the VR experience, and it was a very new experience for them, so they would fully explore the features they could use in the scene and explore the angles they would not see in real life. For example, they will try to find out where the boundary of the scene is, they will pay attention to some details in the environment, and they will try to observe themselves from different angles.

4.3.2 Interview finding

After the KOKU experience, participants were required to undergo an interview to understand their feelings about the KOKU experience, and the content of these interviews would serve as an essential criterion for assessing whether KOKU had achieved the purpose of the study. The interviews are based on six main questions, and some relevant discussions will also develop according to the participants' answers. The following are the interview questions and some relevant findings.

Did KOKU help you recall more details?

For all participants, the answer was yes, compared to photos and videos KOKU has a richer perspective and more detailed information. Participants also felt that more details would help enhance the reminiscence experience.

Did KOKU allow you to relive your mood or feelings at that time?

Most participants stated that during the KOKU experience, they felt as if they were back in the scene, which allowed them to relive the emotions. The extent to the emotions they felt at the time depended on their behavior in the scene. One participant who reconstructed the ping pong scene in KOKU said that she was in a tense and focused mood, but she did not feel the tense feeling during the KOKU experience. The fresh experience distracted her attention, but it doesn't mean a negative influence on her reminiscence, on the contrary, noticing some previously overlooked details in the environment allowed her to gain a richer recall experience. Therefore, it can be speculated that some intense and exciting emotions are difficult to relive through KOKU.

Did KOKU reconstruct your ideal scene? What are the shortcomings?

Due to some technical limitations, most participants said that KOKU was not able to reconstruct their ideal scenes, but gave positive feedback on the concept of the ideal scenes. One participant who recreated a scene of her family and dog said it was a pleasant surprise to be able to customize KOKU scenes. There are many precious moments in memory, such as marriage, graduation, meeting with old friends, or memories of loved ones who have passed away. KOKU can make up for many regrets in life and give comfort to the soul.

How do you usually recall the scene in the past?

Almost all participants were accustomed to reminiscence through photos and videos, while some were more sensitive to sound, such as being able to recall the scene when they once heard a song, and some liked to collect old things because it was hard to forget what had happened to them.

Does KOKU improve your memory experience compared to your usual way of recalling? How ?

Most of the participants felt that KOKU enhanced the recall experience in some ways compared to the previous recall method. It is difficult to say that KOKU is a perfect recall experience because different memories apply to different recall meth-

ods. However, according to the participants' responses, KOKU is outstanding in enhancing people's memory experience from the perspective of immersion.

If the technology is mature, how would you use KOKU?

All participants expressed their willingness to record their memorable scenes through KOKU, and one participant thought KOKU is a good experience and she thought there are many ways to apply KOKU that are worth exploring, such as sharing and even trading KOKU. KOKU can be used as a meta-universe social scene, inviting people to catch up in the scene of memories, and can also sell the memories of celebrities, such as the experience of having lunch with Warren Buffett, which will have a high commercial value. In addition, in the education field, students can also learn through KOKU because the immersive experience helps students remember.

4.4. Limitation

As a conceptual design for the future, there are many technical shortcomings, so in the prototyping, it is impossible to achieve the ideal effect of KOKU, and many problems were exposed in the experiment. These problems are mainly reflected in the 3D model is not fine enough, scene deformation, failure to present dynamic scenes, and the inability to reconstruct complex ideal scenes. In addition, it was also found in the experiment that the selection and definition of memorable scenes of the participants were not accurate. Sometimes the memorable scenes could not be recorded in time when they occurred, and it took a long time to record when using the 3D scanning software. Participants needed to keep still during scanning, which affected the experience of memorable scenes.

Chapter 5
Conclusion

5.1. Conclusion

At the beginning of the study, summarized the current challenges of reminiscence experience and formulating the proposal by means of hypotheses, in the second chapter, introduced many works in related fields and found the technical means that can support the research questions, and in the third chapter, discussing the concept of KOKU and the prototype design, after that, the participants went through the KOKU reminiscence experience by means of experiments and the effectiveness of KOKU in improving the reminiscence experience is confirmed in the post-experimental interviews.

5.2. Future work

Reconstructing 3D scenes of memories in virtual space and stepping into the scenes through VR are very innovative experiences for people. In the process of making prototypes and experiments, participants were full of surprise and excitement about KOKU. During the interviews, many participants also proposed some novel ideas that exaggerate the design concept, but due to time constraints, it is difficult to practice them in this study and could be a direction for future research.

One of the participants believed that the problem of difficulty in recording memorable scenes in time is that people have difficulty realizing the reminiscence value of memorable experiences in the future when they experience them, and they cannot afford to distract themselves to record them, he suggested that KOKU can automatically record memorable experiences by monitoring changes in people's physiological data, because people usually have corresponding physiological reactions when they experience memorable experiences, such as increased heart rate,

rapid breathing, KOKU can automatically record the scene when it detects the change of physiological response, so that it may be possible to record the memorable experience in time. Another participant believed that adding smell, touch, and other sensory simulations to the VR experience could increase the immersion of KOKU and further enhance the reminiscence experience. This is because smell and touch can also trigger memories. Many VR experiences are already applying smell and touch simulation technology, and it is necessary to apply the device in KOKU experience to verify it.

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