# Department of Computer Science The University of Hong Kong



# Final Year Project VR/MR Simulation Interim Report

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# Abstract

Memory Palace, also commonly known as mind palace or the method of loci, is a memory system based on utilizing spatial memory. It has been proven to be an effective way for having quicker and stronger memory. However, the lack of ways to actualize the imagined scene results in a couple of difficulties in using this technique.

The intention of this project is to develop a Virtual Reality (VR) application to let users build their memory palace. The application will be run on Android phone and used together with a head-mounted display (HMD) such as Google Cardboard. Also uSens Fingo will be used for tracking hand motions. The VR application was developed with Unity 3D with a couple of external SDK.

This application can allow users to actualize their imaginary memory palace. People no longer have to rely purely on imagination ability but be able to see and interact with it. It is hoped that the application can help solving some of the major problems of Memory Palace System, as well as enhancing its effectiveness.

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# Section I – Introduction

# 1.1 Background

## 1.1.1 Memory Palace

Memory Palace, also known as the method of loci, journey method or mind palace, is a memory system based on utilizing spatial memory. When using the system, people will visualize things they want to memorize, and mentally place the imagined objects into a place. It is found that humans are much better in memorizing spatial and graphical information than texts or concepts because our spatial memory is very powerful [1] but it is not utilized in remembering texts. Memory Palace aims to enhance memory by the utilization of spatial memory.

Memory Palace has been proven to be an effective memory enhancement technique. It is found that 90% of superior memorizers have used memory palace to aid in their memorization. [2]

Here is the detail of how the system is used:

- 1. Create a list of things to be memorized, e.g. a phone number, a list of names, etc.
- 2. Choose a familiar place (e.g. a street, home)
- 3. Pick locations in the place or on the route, each location for one items on the list

4. Find a symbol for each of the item on the list. The symbol is an object that has connection with the thing to memorize.

Here is an example for memorizing the phone number of HKU CS department:

- 2 a tool like a hammer
- 8 octopus card
- 5 fire
- 9 line
- 2 tool
- 1 won, represented by a trophy
- 8 octopus card
- 0 egg

5. Use imagination to visualize the symbols on the selected locations. For example, a hammer (2 - tool) on the bed, an octopus card on the desk (8 - octopus), etc.

To retrieve the information, go through the memory palace again, and recall the items one by one.

Although Memory Palace has proven to be effective, plenty of people have found difficulties in using the techniques, which has affected its effectiveness:

#### 1. Pure imagination is not enough for visualization

The effectiveness of Memory Palace hugely relies on imagination ability of individuals. Whether the information memorized can become long-term memory depends on the strength of the sensory memory – touch, sight, smell, hearing and taste. [3] This implies that it is necessary to visualize the virtual scene as real as possible so as to deceive the brain that they are real. This is difficult, especially for people who have poor imaginary ability.

#### 2. The memory palace is difficult to record

Although spatial memory is powerful, people can still forget the memory palace that have created. It would be better to record it down for future revisions. Drawings or texts can be used. However not everybody is able to draw and the visualization would be lost if using texts.

#### 3. Running out of space to build memory palace

After using the system for a period of time, people might found that they have used up all of the places that they are familiar with. Some olds places would have to be reused which can confuse old memory. Some people have to go out and find a new place for building memory palace, which is inconvenient and time-consuming.

## 1.1.2 Virtual Reality

Virtual Reality (VR) is the technology to allow users to immerse themselves into a 3D digital world. Users can explore the digital world from a first person perspective similar to how they look at things in reality. The digital world is delivered through a headset. Common headset device includes Oculus Rift, Microsoft Hololens. Google Cardboard is also used together with mobile phone to act as a headset. Users may even be able to have interaction with things inside the digital world with the help of the controller of headsets or hand motion tracking device like Leap Motion and uSens Fingo.

VR is still a young technology that needs to be improved. Currently it has some limitations which have obstructed its prevalence. [4] For example, users might have the feeling of nausea and eye strain when using VR application. The major reason is the algorithm for head motion tracking is not ideal yet.

At this stage, VR is applied mostly to video games. Its use on other aspects such as business and data analytics have been discussed, yet most of them are still at experimental stage and not widely adopted on market.

# 1.2 Motivation

When the research for choosing the subject of the VR application in this project is being conducted, it is found that VR technology is advanced and has gained a lot of hype from the public, but there are opinions that VR is just for fanciness without being able to solve existing problem and improving working efficiency. The situation that VR's usage is mainly limited to game do provide a strong argument for those criticisms.

In this project, it is hoped that the VR application can have actual impact and solve some existing problems. It is noted that memory palace is a subject that really can use the help of VR to make significant improvement. VR presents itself as a possible tool to enhance its effectiveness by providing a realization of a virtual scene. The detail of how VR can solve the above mentioned problems is discussed below:

#### 1. Pure imagination is not enough for visualization

Everything can be visualized in the digital world. With the help of VR, memory palace users no longer need to rely on imagination to visualize a virtual scene. VR allows them to actually see the things and even interact with it. This can greatly strengthen memory through sensory.

#### 2. The memory palace is difficult to record

The virtual scene is actualized inside VR. The virtual scenes created can be stored, retrieved and modified easily.

## 3. Running out of place to build memory palace

VR can provide affluent virtual places to be used for building memory palace. Those virtual places can be those exist in real world or created. It avoids the troubles to travel around physically to find new places.

# 1.3 Objectives

The objective of this project is to build a VR application for building memory palace. The intention of the application is to provide users an easy way to build and view the virtual scene created for using Memory Palace system. Moreover, the application can provide a way to allow users to actually see the memory palace that have built so as to strengthen users' memory. Currently, some people abandoned Memory Palace because they find it too hard or too time consuming to use and doubt its effectiveness. Hopefully, this application can help removes those current limitation. Moreover, this project is also meant to demonstrate a practical use of VR technology in the aspect other than games.

# 1.4 Scope

When using the application, users can choose a place as the location for building memory palace. Then users can manipulate the virtual place by placing the objects they want to visualize. The application will provide a library of 3D objects for users to choose. The user will be able to interact with the objects by grabbing the object and place it onto the virtual location. After the creation, user can save the created memory palace. They can view or change them later easily.

## 1.5. Previous Works in the field

There is a project called Macunx VR which is labelled as 'a platform for building memory palaces in 3D and Virtual Reality'. The platform is still under development so the exact feature is unknown yet. It can be anticipated that it would provide similar functionality as the application.

# 1.6. Report Outline

The remainder of this report will provide details of the project. Firstly, the features of the VR application will be mentioned. Then the methodology of implementation including hardware and development details will be given. Next, the current progress including completed works and future works will be discussed. After that the working schedule of the project will be outlined. This report will be closed with a summary.

# Section II – Application Features

This section will describe the feature provided by this application and the steps on how the user will interact with it to build their own memory palace.

## 1. Select place as the location for the building of memory palace.

The application start with a non-VR mode. User can select the location from the map (Figure 1) that they are familiar with as the environment for building memory palace.



Figure 1 - Map for Selecting Location

#### 2. Put the phone into head mount display

The application prompt the user to put the phone into head mount display (Figure 2) to start VR mode in building memory palace.



Figure 2 - Prompt for VR Mode

## 3. Build Memory Palace by Adding 3D Objects

The chosen place will be rendered as 360 panorama view in VR mode. User can select the object they need for their memory palace from a 3D model library. Hand motion interaction is supported for users to navigate the 3D model library and drag the objects to the scene and freely place them onto any location in the place (Figure 3).



Figure 3 - VR Environment for Building Memory Palace

## 4. Label the objects with the data they want to memorize

Users can add labels to the 3D objects to indicate what is the data that is linked by that specific object that they want to memorize (Figure 4).



Figure 4 - Labelling the Objects in Memory Palace

# Section III – Methodology

## 2.1 Overview

The application run on Android platform and is used together with head mounted display and uSens Fingo. It is implemented in 3-tier architecture. The main platform of development is Unity 3D. A couple of external software development kit (SDK) is used in the development as well. This section will discuss the methodology of implementation in details.

## 2.2 Hardware

Figure 5 shows the complete hardware setup for the VR application.

# 1. Mobile Phone with Android 4.4 or above.

**2. Head mounted display**, Google Cardboard is currently used for development.

**3. uSens Fingo**, a hand motion tracking device to provide user interaction.



Figure 5 - Complete Hardware Setup of Google Cardboard and uSens Fingo

# 2.3 Architecture

This application is implemented with 3-tier architecture (Figure 2) consisting of client application, server and database. The VR application running on Android phone is the client application. Client communicates with server by HTTP protocol. Server is responsible for processing client request. It is connected to a database system and handles the storage and retrieval of user data.



Figure 6 - 3 Tier Architecture

# 2.4 Development

The following tools and technology are used for development:

• Unity 3D

Unity 3D is the development platform. It is a 3D game engine which is popularly used for games and VR applications development. C# is used to write scripts in Unity.

Google VR SDK

Google VR SDK provides a set of API for VR specified features.

## Google Poly SDK

Google Poly is 3D asset library launched on November 2017. Its SDK provides the feature of real-time import of 3D models into the scene of an application.

## Google Street View API

Google Street View API provides images for making the 360 panorama view of different places as the background environment in VR.

#### • UI - Builder

UI - Builder is an SDK purchased on Unity asset Store. It is a customizable UI kit that provide ready-made UI components with good design and style.

## • Fingo SDK

Fingo SDK is for the implementation of uSens Fingo. The image of hands is naturally formed by Fingo and the SDK is used to define how the user can interact with the application with different hand movements and gestures.

• Express JS

Express JS is a node.js framework for building lightweight server. The server for this application has small workload so lightweight is favorable.

## • MongoDB

MongoDB is a NoSQL database. It is more suitable for storing unorganized data than SQL relational database. The user data of this application is stored in JSON format.















Figure 10 - Google Street View



#### Figure 11 - UI Builder



Figure 12 - Fingo SDK







Figure 14 - MongoDB

# Section IV - Current Progress

## 4.1 Overview

In the first semester, a portion of time has been spent on studying and research on finding suitable technology. Half of the necessary works are finished thus far. In the second semester, the rest of the necessary works are expected to be finished. There are also some optional features that may be included depending on time. This section will discuss finished works and the future works in details.

# 4.2 Finished Work

## 4.2.1 Panorama View with Google Street View

The panorama view of the places in VR is accomplished with Google Street View API. Firstly, a sphere is created as the background environment of the scene in VR. Then with the latitude and longitude of a place, the images of the 6 direction: front, back, left, right, up, top (Figure 15) are requested with Google Street View API in run time. After that the images is used to create a cubemap. The cubemap is then used to create a new material. Finally the new material is applied onto the environment sphere (Figure 16).



Figure 15 - Images of 6 directions: front, right, back, left, top, bottom



Figure 16 - Environment Sphere

#### 4.2.2 3D models Library

A 3D models library (Figure 17) is provided for users to select objects to create memory palace. The 3D library is created with Google Poly SDK. The Google Poly is a 3D model library with very rich assets. The asset of the library is requested dynamically at run time. Therefore the application can leverage the growing asset content of Google Poly.

The featured asset are listed by default. The user can also search for the objects they want. Only the thumbnails are shown in the library, after the selection, the 3D objects will be downloaded from Google Poly.

The downloading speed is found to be slow. Some UI improvements (eg. loading circle) will be made to improve the user experience when waiting for download.



Figure 17 - 3D Models Library

# 4.2.3 Hand Motion with uSens Fingo

uSens Fingo is used for user interaction (Figure 18). The hand motion within the application is implemented with Fingo SDK. The user interaction include pressing buttons in the user interface and grabbing, placing and scaling 3D objects. The implementation is achieved with the calculation of the position and angle of bones, fingers and palms of the hand with Fingo SDK.

The sensitivity of the hand motion tracking can be improved in the future.



Figure 18 - Hand Motion with Fingo

## 4.2.4 Keyboard with Fingo interaction

A keyboard with Fingo interaction is implemented to allow user input. It is used for entering keyword for searching in 3D model library and for typing the labels of 3D objects as mentioned in section II.



Figure 19 - Keyboard with Fingo Interaction

# 4.3 Necessary Future Works

## 4.3.1 Place Selection

The application will allow the user to choose places to build memory palace. The thought at the stage of planning is to provide a google map (Figure 20) for users to select locations at run time. This approach can allow users to have unlimited number of places to work with and solve the problem of running out of place as mentioned in section 1.2.

After some initial implementation, it is found that there is no natural google map support in Unity. The solution is yet to be found. If no solution is found eventually, a different approach will be chosen, which a large number of places will be provided statically (Figure 21).



Figure 20 - Selection with Map



Figure 21 - Selection with Static Places

## 4.3.2 User data Storage

The application allows users to store their created memory palaces and view them later. The user data is stored in JSON format. JSON is used because it is small in size and quick for transmission. A JSON data of an example scene is shown in Figure 22.

The initial plan is to implement a server with Express JS and a database with MongoDB. This allows better data safety compared to local storage on android phone as data can be easily lost on the device. Yet the data storage part is not the primary focus of this project, it is preferred to spend more time onto the main features.

Implementing server and database will require more time than local storage. The evaluation between need and time will be evaluated to choose between the two approaches.

```
"loci_id": 152,
"scene":
   "scene_id": 52,
  "start_coordinate": "(101, 80)",
"end_coordinate": "(785, 12)"
},
"items": [
   {
     "item_id": 1,
     "reference_object_id": 71,
     "coordinate": "(20 ,20)",
"description": "Phone number of Henry"
     "item_id": 2,
    "reference_object_id": 45,
    "coordinate": "(60 ,100)",
"description": "Phone number of Larry"
   3.
  {
"item_id": 3,
     "reference_object_id": 14,
    "coordinate": "(80, 154)",
"description": "Phone number of Jessica"
]
```

Figure 22 - Example JSON Data

## 4.3.3 Complete User Interface

The implementation at this stage are scattered into different parts. A complete user interface logic will be implemented to integrate different parts into a usable application. The appearance and usability of the user interface will also be focused to provide good user experience.

## 4.4 Optional Future Works

The following works are improvement on the main feature. The concrete methods of implementation are not yet explored. Research on feasibility and time is needed to decide whether they will be included in this project.

#### 4.4.1 Voice Input

The input is achieved with a keyboard as mentioned in section 4.2.4. Voice input can possibly be more favorable compared to keyboard input for the user under VR environment.

## 4.4.2 User Define New Places

Currently, the places for selection in the application are limited to outdoor places since Google Street View is used to provide images. There are apps that allow user to take 360 degree panorama images e.g Google Cardboard Camera. It will favorable to let the user to upload their own pictures of places e.g their home.

#### 4.4.3 User Define New Objects

Currently users can only use the objects available in Google Poly to build their memory palace. It is favorable to let users import their own objects into the scene. It is infeasible to require the user to create 3D models so the possibility would be to let user upload images.

Time	Task	Status
September	Research on topics and technology	Completed
	Project plan and website	
October	Study of Unity and other SDKs	
November	Implementation with Fingo	
December	Implementation of panorama view	
	Implementation of 3D models library	
January	Continuation on previous implementation	
	First presentation and intermediate report	
	Implementation of place selection	In Progress
February	Implementation of data selection	Not Started
	Implementation of user interface	
March	Implementation of optional feature	
	Finalize the implementation	
April	Complete testing	
	Final presentation and final report	
Мау	Project Exhibition	

# Section V - Working Schedule

# Section VI - Conclusion

This report has described the background, objective, design and the methodology used in building the VR memory palace application. The application is aimed to help people who use Memory Palace system to actualize their memory palace. VR can solve the problem that Memory Palace system has as well as enhancing its effectiveness. This project is desirable because it demonstrates how VR can be used to solve problems but not just of fun and fanciness.

This application allows user to choose places and 3D objects to build their memory palace. The application is run on android phone and used together with head mount display. uSens Fingo is used for hand motion tracking. The application is developed with Unity as the platform and some external SDKs are also used in development.

The development of the application is under progress. Half of the works are finished, such as 360 degree panorama view, 3D models library and hand motion interaction. Future works include features for place selection, data storage and user interface. There are optional features that may be included depending on time.

With more experience and familiarity with the technology, it is expected that working efficiency and quality will be further improved in the second semester.

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