COMP4801 Final Year Project

VR Street Navigation for Elderly with Spatial Orientation Decline

Phase 2 – Interim Report

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1. Project Background

This section introduces the background information of the project. With regard to the existing works in the market, the section argues the motivation and desirability of the project.

1.1 Background Information

Over the past decade, aging population problem in Hong Kong surfaced and it is predicted that percentage of the population aged 65 or above will increase sharply from 15% in 2014 to 31% in 2044 (Census and Statistics Department, HKSAR, 2015). As elderlies commonly experience cognitive, memory and physical ability decline, they will require long-term assistance from their relatives and professional caregivers. It is foreseen that the problem will increase the society’s dependence on elderly services and leads to high social and financial cost.

 Currently, most of the elderly services solely rely on manpower, and would not able to cope with the increasing number of elderly in the next few decades. This project introduces a solution that aims to provide a VR solution which can be used in elderly services. Spatial orientation decline is one of the most common cognitive function declines in elderlies, so the solution aims at levitating its negative impact on training. With VR technologies, the project intends to deliver personalized training for elderly to improve their spatial orientation.

1.2 Existing Works

VR training system is common in skill training of different aspects like military and medical. It provides learners with a virtual environment where they can develop their skills without the real-world consequences of failing. Despite precipitous growth in VR research and development over the decade, there are few applications that available for the elderly. Research in 1999 on VR simulator has already proved that use of VR with the elderly is feasible and the symptoms of simulator sickness are not related to age.
In 2010, there is a study in South Korea that suggested Virtual Reality technology can be used for the way-finding study for the elderly people. In the study, it focused on the design inside healthcare facilities as it is a challenging task for elderly who have limited cognitive abilities. The results demonstrated significant impact of age on perceived difficulties of way-finding. However, in reality, many guides are provided inside the facilities, which decrease the difficulties of way-finding. The more challenging part to the elderly is to locate themselves in a local community and it is much harder to patients with spatial orientation decline or even dementia.

In 2017, an mobile application targeting elderly with Major Cognitive Disorder won the silver award in Hong Kong ICT Awards. It provides training of tasks in daily life included way-finding. In the way-finding game, Elderly is trained to memorise the path to various locations by choosing the correct image of street view of corresponding direction, while occupational therapist can collect data from the user include the reaction time and adjust the difficulty of the game. It is alternative way to provide training of wayfinding but more data can be collected in VR environment as the user (elderly) can be distracted by other objects and their behaviours and performance will be affected in reality.

In current market, there are softwares in computer/ mobile applications that provide training to elderly but there are no VR product that provide training to elderly with spatial orientation decline. Therefore, It will be a breakthrough in elderly training systems and VR development.
1.3 Project Motivation

1.3.1 Provide sustainable alternative for elderly services

According to the Social Welfare Department, over 7 thousands million dollars will be spent on elderly services in 2017-2018. The expenditure in elderly services will increase because of worsen of aging population. Under this circumstance, it is important for the society to discover a sustainable form of elderly service to minimize the risk brought by the aging population.

1.3.2 Provide Spatial Orientation Training for Elderly

Current Community Care Services primarily focus on serving elderly with a moderate level of impairment. Support services to elderly with low to mild-level of impairment in early stage can efficiently slow down the decline of health. Also, currently financial support from community is limited. The project targeted this group of elderly so that their spatial disorientation can be slow down.

1.3.3 Collect Related Training Data for Analysis

Currently, limited data related to VR-based training for elderly is available for research. It is foreseen that more technology-aided service to elderly will be developed because of the evolution of technology and cost control. Therefore, this project suggests the use of Virtual Reality (VR) technologies to create elderly services, which can provide data collection channel for research purposes.
2. Project Objective

The project aims to develop a VR Street Navigation Software which allows senior users to train cognitive functions.

To achieve the above objective, features of the final deliverable of the project are identified:
FE-1: Simulate local community with VR technologies, which allow users to navigate inside the virtual world;
FE-2: Provide training tasks for users to train cognitive functions;
FE-3: Provide utility software for advanced users (such as caregivers) to create customized VR environment with a user-friendly interface.
3. Methodology

3.1 Literature Review

Analysis on research of VR software/testing on elderly and product of elderly services in current market has been made to support the objective of the project and modify the design and feature of the deliverable. It is supported that the use of VR with the elderly is feasible and wayfinding help train and improve elderly's spatial orientation. Products in current market help inspire idea and provide suggestions in data collection and technology used.

3.2 VR Street Navigation Software

We want to simulate a virtual world so that user can navigate inside the world. Normal camera can only provide limited visible angle which affect the degree of simulation. Therefore, a 360 degree camera is used to capture the street view. Video is displayed to the user through VR headset to create the virtual environment. Oculus Rift, a tendered headset under computer platform is used instead of using cardboard (mobile platform) as it required processing of multiple videos and computer can provide a better performance. User can be able to travel inside the virtual world by displaying and rewinding the video of corresponding street.
3.3 Training Task Implementation

Unity is used as the development software of the training system as it contains native support for Oculus Rift. The 360 videos are imported as movie texture in Unity. By creating the skybox that contain the movie texture, the virtual world is created. Google Map API is used to create a local map after collected the videos. By pinpoint the location inside the Google Map at corresponding time of the videos, all the routes in the videos then can form a map. It will stored in a map database for the user (service provider) to set up the training (e.g. starting point and destination). Redundant object in the video will be removed and virtual object like guides and passerby will be put inside the virtual environment to provide a better simulated environment
4. Work Accomplished

In phase 2 of the project (October 2017 - December 2017), two main features are developed, including VR street view creation and virtual object registration. The section introduces the work accomplished in the Phase 2 of the project.

4.1 VR Street View Creation

A prototype was developed to demonstrate the desired VR Street View of the final deliverable. The VR Street View is generated using 360 panorama videos taken by 360 camera. With the use of these 360 videos, a video-based skybox is created and being attached to the scene.

When the player move forward in the virtual environment, the video plays and gives the player an impression that he is moving forward. Similarly, when the player move backwards, the video rewinds and gives the player an impression that he is moving backwards.

Currently, the player can only walk forward or backward on a predefined path where the 360 panorama video is taken. The player is not allowed to change direction or go for a different path. This is intended to be fixed in the next phase.

4.2 Virtual Object Registration

On top of the prototype built in section 4.1, virtual objects are added to the software through registering in a map. The map stores the locations of the virtual objects in the path recorded by the 360 panorama videos. Virtual objects are added in the environment according to the stored location. When the scene is rendered, virtual objects will be rendered on top of the 360 panorama video, which creates an illusion that the object is registered on a certain position in the video.

Currently, only static virtual objects are added in the scene. It is intended to add moving virtual objects such as pedestrians in the next phase.
5. Problems Encountered

The section would introduces problems encountered during the development process in Phase 2.

5.1 Hardware Capability

In the development process of the project, the development team faced a difficulty in accessing computers capable of running VR software on Oculus Rift. This is due to the high graphics card specification required by Oculus Rift. As a result, the team was not able to test the software frequently on Oculus Rift and this greatly hinders the development process.

To solve this problem, the project team decide to borrow equipment from HKU CS Department in the future for testing purpose.

5.2 Difficulty in Registering virtual objects accurately

As mentioned in section 4.2, virtual objects are added in the environment through a static location data stored in a map. When the scene is rendered, the object is rendered on top of the panorama video, giving an illusion that the object “sticks” to a given position in the video. However, there are multiple problems that leads to the difficulty in “sticking” the object to the video accurately.

Firstly, the moving speed of the camera can be inconsistent with the moving speed of the first-person camera in the environment. Secondly, quality problems of the video, such as hand shaking and out of level greatly affect accuracy in the calculation of object position.

To solve this problem, it is intended to improve the accuracy through programmatically reduce hand shake, auto correction of video level, and dynamic calculation of movement speed in the video.
5.3 Difficulty in Removing Objects from Existing Video

As described in Section 4.1, the virtual environment is built with 360 panorama videos. However, as the videos are taken in real world, unwanted objects are also captured in the videos. The following figure shows 2 examples of the unwanted objects captured.

![Camera stand captured in the video](image1.png) ![Pedestrian captured in the video](image2.png)

Figure 1 examples of unwanted objects captured in 360 videos

In Figure 1(1), the stand of the camera is captured accidentally, occupying one-fifth of the scene. On the other hand, in Figure 3(2), pedestrians are captured in the scene accidentally. The unwanted objects shown in the figures will drastically affect user experience. For example, the camera stand in Figure 3(1) will create a black shade in the bottom of the VR environment, which will distract users and hinders training effectiveness. On the other hand, the pedestrian captured in Figure 3(2) is asynchronous with virtual objects created in Section 4.2. This creates confusion and should be avoided in future deliverables.
6. Future plan

The following section summarizes the work remaining after Phase 2. After Phase 1 and 2, Phase 3 will commence shortly as the final phase of the development process. The following section introduces the scope and timeline in Phase 3.

6.1 Improve VR Street View

As mentioned in section 4.1, in the current version of VR street view, the player can only walk forward or backward on a predefined path where the 360 panorama video is taken. To provide the functionality of changing direction or go for a different path, it is intended to create a map with multiple 360 panorama videos which is capable in handling such functionality.

6.2 Improve Virtual Object Registration

As mentioned in section 5.2, to solve the accuracy problem in virtual object registration, it is intended to discover methods that can programmatically improves 360 panorama video quality in the next phase. On the other hand, while currently there are only static objects added in the environment, it is intended to add moving objects such as pedestrians in the environment in the next phase.

6.3 Utility Software Development for Customized Map

As the target group of the software are elderlies living in local communities, there is a need for customizing the environment based on various local environments. Therefore, it is intended to add a utility software for advanced user such as medical staffs to customize maps in a user-friendly GUI for their end users. Advanced users would only need to take 360 videos in their community and import the videos to the utility program. The utility program will automatically generate a VR training environment based on the input.
6.4 Training Task Implementation

To achieve the training target of the solution, training tasks will be added to the solution to boost training efficiency. According to the background research done in Phase 1 of the project, cognitive exercises are effective interventions for elderly in the early stage of spatial orientation decline. These cognitive exercises may include memory exercises and reasoning exercises. Therefore, it is planned to add these cognitive exercises in the VR solution, such as route memorizing minigame and route-finding exercise in the software to maximize training result.
7. Conclusion

Virtual Reality (VR) based training system is the solution of providing service to the elderly with spatial orientation decline or even dementia in early stage. With VR headset, a small local community is simulated allow users to train their spatial orientation ability in a familiar environment inside a closed and safe area. Data of training are recorded for analysis. It is believed that the deliverable can provide a personalized and low cost training service for elderly with dementia or spatial orientation decline.

After research on literature and products in current market, the pre-requisite was prepared and several main feature has been developed. Problems were encountered when facing the hardware capability and video processing and the solutions are provided.

In the upcoming months, further modification will be made on the features that have been created in the previous stages to enhance the system such as improving virtual street view and object registration. Customized map and training task implementation will be the main focus of the remaining time and an applicable deliverable then can be launched for further testing.