COMP4801 Final Year Project

VR-Based Training Solution for Elderly with Spatial Orientation Decline

Phase 1: Proposal

Fung Tsz Ching  UID: 3035182998
Au Yeung Chi Kit    UID: 3035177577
Contents

1. Project Background
   1.1 Background Information
   1.2 Current Challenges
   1.3 Project Motivation

2. Project Objective
   2.1 Vision and Scope
   2.2 Deliverables
   2.3 Limitations and Exclusions

3. Project Methodology
   3.1 Method and Justification
   3.2 Risk and Challenges

4. Project Schedule and Milestones

5. Conclusion

6. References
1. Project Background

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) [1]. 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.

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. 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 proposal introduces a solution that aims to provide a technology-aided solution which can be used in elderly services. As spatial orientation decline is one of the most common cognitive function declines in elderlies, 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 memory and spatial orientation.

1.1 Background Information

The following section of the proposal presents background information on elderly services in Hong Kong and spatial orientation decline in elderly. The section also introduces some proven methods to levitating spatial orientation decline.

1.1.1 Elderly Service in Hong Kong

As stated by Elderly Commission (2017) in Elderly Services Programme Plan [2], elderly services in Hong Kong are mainly categorized in 5 aspects, including active
aging, community support, community care, residential care and end-of-life care. Diagram 1 illustrates the domain of each aspect in elderly services delivery model. Considering the scope of the project, only the Community Support aspect is explained in details.

Diagram 1 Elderly Service Delivery Model in Hong Kong. According to the diagram, elderly service delivered has an increasing care need from Active Aging (Left) to End-of-Life care (Right).

Community Support stage of elderly services in Hong Kong intends to provide community-based services to elderlies. According to Elderly Commission (2017), the major goal of this stage is to achieve “aging-in-place”, which ensures elderlies are able to stay in the community as long as possible and avoid unnecessary institutionalization [2]. At this stage service provider are mainly Community Care Services (CCS) at local community centers and their target audience are elderly with impairment but do not need institutionalization. Elderly Commission believes it is important to prevent health deterioration at this stage.
1.1.2  Spatial Orientation Decline in Elderly

Wang et al. (2002), as cited by Riva (2011), define spatial orientation as a high-level cognitive function that navigates a person in a familiar or unfamiliar environment, with the integration of attentional, mnemonic and perceptual processes [3]. Such ability is common to decline with age due to cognitive function degeneration. Glisky (2007) suggests complex tasks such as space navigation require divided attention and attention switching, which deficit with age due to declining processing resources [4]. As a result of spatial orientation decline, elderly risk getting lost to travel alone, and requires accompanies during traveling, regardless of their familiarity with the environment.

Spatial orientation decline in elderly creates extra social and financial burden to the society. In a social perspective, more manpower is needed to accompany elderlies with spatial orientation decline. This creates caregiving pressure to the elderlies’ family and the professional caregivers (such as community centers).

Similarly, in a financial perspective, the cost for elderly service increases due to the manpower needed. As Elderly Commission (2017) stated, without enough caregivers in the community, elderlies maybe sent to elderly institutions unnecessarily[2]. This leads to financial burden in government subsidized elderly institutions. With consideration of the aging population problem, it is foreseen that the burden will further increase in the next few decades.

1.1.3  Methods to Reduce Spatial Orientation Decline

As suggested by Williams et al. (2010), 4 interventions are developed to levitate cognitive aging problem, including spatial orientation decline [5]. The 4 interventions are namely cognitive interventions, physical activity interventions, social interventions and nutritional interventions. Considering the scope of the project, only cognitive interventions are covered in detail below.
Cognitive interventions mainly refer to memory training interventions. McDougall (2000) suggests it typically includes mnemonic strategies, self-monitoring, and problem-solving etc., as cited by Williams et al. [5]. These methods are proven to have a positive impact on cognitive functions of elderlies, and thus improve the spatial orientation of elderlies.

An example of cognitive intervention for spatial orientation declining elderly involves mental rotation training. Mental rotation, as defined by Shepard et al. (1971), refers to the ability to rotate mental representation of a physical object within the human mind [6]. Mental rotation training, on the other hand, involves practicing questions sets with model line drawings and require patients to identify their rotation virtually. Seattle Longitudinal Study (Schaie et al., 1986) provided 5 hours of mental rotation training for elderlies with spatial orientation decline and discovered that ⅔ of the participant shown improvement after the training [7]. Among the participants, 40% attained the same level of cognitive functionality they had 14 years ago. More surprisingly, the effect of the training continued up to 7 years.

Above findings show that memory training, rotation exercises are proven effective in reducing spatial orientation decline in elderlies.

1.2 Current Challenges
This section presents current challenges faced by the elderly service model in Hong Kong, with an emphasis on elderlies with spatial orientation decline.

1.2.1 Increasing Expenditure in Elderly Services
According to the Social Welfare Department, it is estimated that 7,651 million Hong Kong dollars will be spent on elderly services in 2017-2018, which is a 7.3% increase from the expenditure in 2016-2017. It is foreseen that with the aging population
problem worsening, the expenditure in elderly services will definitely increase. It is urgent for the society to find a sustainable plan for elderly service, which is capable of handling the increasing number of elderly.

1.2.2 Reducing number of carers and increasing number of elderlies

The aging population problem also leads to a shrinking workforce. According to Census and Statistics Department, HKSAR (2015), working-age population (age 15-64) is estimated to sharply drops from 74% of the population in 2014 to 54.6% in 2064 [1]. As a result, the elderly per working-age person ratio will drastically increase from 1:5 in 2014 to 1:1.8 in 2064. As a result, the number of professional and family carers will decrease while the number of elderly increases. The society needs to find a solution that capable of providing caregiving services for a large number of elderly with a few caregivers.

1.2.3 Lack of community service for elderlies with mild-level of impairment

According to Elderly Commission (2017), current Community Care Services (CCS) primarily focus on serving elderly with a moderate or severe level of impairment. The Working Group believes that support services to an elderly person an with low to mild-level of impairment should be strengthened to slow down further health degeneration. CCS should discover new types of services specifically for elderly with low to mild-level of impairment (eg. mild spatial orientation decline) to lengthen their possible time of stay in their community, without being sent to institutions.

1.2.4 Current community support system lacks carer support

Currently, most of the community services available are solely depending on manpower and require a large number of family and professional caregivers. For example, in order to accompany an elderly with spatial orientation decline, family caregivers need to be with the elderly whenever they travel to any place. Professional caregivers need to accompany elderlies one by one to prevent them
getting lost, even in the community center. This creates a tremendous pressure on caregivers and it is important to find a caregiver-friendly solution for them to take care elderly with spatial orientation decline in a more effective way.

1.3 Project Motivation

This section discusses the motivation of this project and how it can solve the challenges presented in Section 1.2.

1.3.1 To Provide a Low Cost Alternative for Elderly Services

Consider the rising expenditure in elderly services as illustrated in 1.2.1 and the huge pressure on caregivers as illustrated in 1.2.4, it is important to find a low-cost alternative to cope with the aging population. One possible solution is using technology to reduce financial and manpower cost in elderly service.

Therefore, this proposal suggests the use of Virtual Reality (VR) technologies to create elderly services. With the aid of technology, it is believed that personalized and effective services can be provided with a lower manpower and financial cost in long-term.

1.3.2 To Provide Spatial Orientation Training for Elderly with Low to Mild-Level Impairment

As discussed in 1.2.3, there is currently limited community support for elderly with low to mild-level of impairment. Most of the support and services available are small-scaled and solely depending on manpower. A possible solution to this problem is a technology-aided, automated elderly service that targeted elderly with low to mild impairment as users.
The proposal targeted elderly with spatial orientation decline, as this is a typical cognitive function decline among elderly with low to mild-level impairment. As this special group of elderly still have the ability to perform physical activities as a normal adult (e.g., walking around in the community), it is believed that a spatial orientation training will able to slow down their memory degeneration, and thus improve their living standard by achieving “Aging-in-place”.

1.3.3 To Collect Related Training Data for Analysis

Currently, limited data related to VR-based training for elderly is available for research. It is aimed that the proposed solution can provide data collection channel for personalized training and research purposes.
2. **Project Objective**

The following section illustrates the objectives of the proposed project, including vision and scope, main deliverable, and limitation and exclusions.

2.1 **Vision and Scope**

By Using VR devices, user can experience training in virtual environment inside a close and safe area. The training system can will be able to slow down the recession of users’ brain and maintain user’s spatial orientation ability. After the training, user can able to finish path on their own in real life. Data will be recorded during the training so medical staff can also adjust the treatment to the patient base on the training record.

The project aims on providing a training system for elderly. To let the user experience real environment during the training, user should be able to control the movement (stop/moving to different directions) inside the virtual world. Guiding should be provided during the early stage to help user recognise the map and the difficulties of the training can be adjust by control the number of guiding.

For data recording, analyst should be able to reach different data, e.g. the time of finishing and special event(s) happened during the training of each user. Analyst compare data of different users or different training of same users to estimate the ability of user and further improve or adjust the training. We can also collect the data to discuss the further use from medical use or even extend to other aspect.

2.2 **Deliverable of the project**

2.2.1 **Main Feature**

The proposed deliverable of the project is a VR software with following features:

**FE-1:** Simulate local community with VR technologies, which allow users to navigate inside the virtual world
FE-2: Provide training target/challenges for users to train their spatial orientation ability.

FE-3: Record training progress and performance for further analysis.

2.2.2 Functionalities

To support the above main features, several functionalities are going to be implemented:

FU-1: Location Registration: the system can able to identify the location of user the virtual world. (Related Feature: FE-1, FE-2)

FU-2: Image editing: the system can able to (i) erase the redundant object and (ii) create virtual object inside the virtual world to facilitate the training

FU-3: Database for recording the user, time and special event happened during the training (Related Feature: FE-2, FE-3)

2.3 Limitations and Exclusions

The system simulate real environment by using VR software but there are limitation. It required high processing power to simulate a large open world so the community size of the virtual world is limited. In real life, people always need to travel to another place by using public transportation like bus or mini bus. With decrease of spatial orientation ability, elderly may face difficulties during taking the transportation. However, the transportation time often take over 15 to 60 minutes, which will lengthen the time of training and decrease its efficiency. Second, It required scanning of the environment outside the vehicle which made the map extremely large. Therefore, the training of taking transportation will not be included in the project.
3. **Project Methodology**

3.1 **Pre-required Hardware**

A VR headset (e.g. HTC Vive, Oculus Rift) will be required for running the deliverable product. A 360 degree camera will be needed for capture the street and road in real life for image processing.

3.2 **Software development Cycle**

![Software development Cycle](image)

*Figure 1: model of repeated iterative cycles*

This project will use the repeated iterative cycles. Each module will be test separately before we move to the next one so we could discover bugs at early stage and prevent downward flow of defects to later stage. We will follow the iterative cycle for each function. After each iteration, a deliverable with partial functions will be available.

3.3 **Image processing and indexing**

After collecting the images taken by the camera, the images are processed before display to the user. There are two ways to erase redundant object like passer-by/car for the image, include cloning people out manually and blending multiple photos to calculate the final pixel of an image. Second, we will index each image by using 3D coordinate system to identify the corresponding location, which allow us to create an open world by using the images.

3.4 **Testing**

Since the target of the project is elderly, especially those with with Spatial Orientation Decline, beside testing inside the lab, there will be a connection with the Homes for the elderly. Elderly will participate the testing in the final stage so that we can collect more targeted suggestion and feedback.
4. **Project Schedule and Milestones**

The table below illustrates the schedule and major milestones in various phases of this project:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Date</th>
<th>Task</th>
<th>Major Milestones</th>
</tr>
</thead>
</table>
| Phase 1 (Inception) | Sep 1 - Oct 1  | - Problem Identification  
- Identify major objectives of the project  
- Background research | - Project Proposal  
- Project Website |
| Phase 2 (Elaboration) | Oct 2 - Nov 15 | FE-1:  
- Create prototype with 360 video running on VR headsets  
- Video controllable through user controls  
- Create an open environment for users to navigate  
FE-2:  
- Create simple training challenge for prototyping | - Early vertical prototype with simple training functionality and base environment |
|                | Nov 16 - Jan 7  | FE-1 (FU-1):  
- Create and Register virtual objects in the environment | - Prototype with virtual objects to make it real  
- Interim Report |
|                | Jan 8 - Jan 12  | - First Presentation | |
| Phase 3 (Construction) | Jan 12 - Mar 1 | FE-1 (FU-2):  
- Remove redundant objects from the environment | - Product with realistic environment for training purpose |
|                | Mar 2 - Apr 15  | FE-2:  
- Implement training challenges  
FE-3:  
- Implement training record analysis functionality | - Final product with realistic environment, personalized training challenges, and training record analysis functionalities  
- Final Report |
## VR-Based Training Solution for Elderly with Spatial Orientation Decline

### Phase 1: Proposal

<table>
<thead>
<tr>
<th>Dates</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr 16-20</td>
<td>Final Presentation</td>
</tr>
<tr>
<td>Apr 21 - May 1</td>
<td>Exhibition Preparation</td>
</tr>
<tr>
<td>May 2</td>
<td>Project Exhibition</td>
</tr>
</tbody>
</table>
5. Conclusion

With the aging population problem worsening in the next few decades, it is foreseen that the society will have an increasing dependency on elderly services. Currently, elderly services are expensive, manpower-based, and lack support for elderlies with low to mild-level impairment. Therefore, this proposal would like to introduce an elderly service solution which is cheaper, technology-aided, and targets elderly with low to mild-level of impairment and spatial orientation decline.

This proposal suggests a Virtual Reality (VR) based training solution for elderly with spatial orientation decline. Using VR technologies, a local community is simulated with the usage of VR headsets, which allow users to navigate the virtual world. Training challenges are provided for users for improving their spatial orientation. Training records are stored and analyzed for future reference of the caregivers. It is believed such solution will able to provide cheaper, more personalized training method for elderly with spatial orientation decline.

The project intends to use an iterative method in software development. With the aid of iterative cycles, critical risks can be identified and migrated at the early stage of development.
6. References


