CM50175 Research Project Preparation

Designing Interactions Between Cognitive Rehabilitation Therapists And Brain Acquired Injury Patients Using Multiple Errands Task In A Virtual Environment

Research Project Proposal

Prepared by:
Kimberley Ling Zhen Chong
(klzc20)

Supervised by:
Dr. Leon Watts

Department of Computer Science
University of Bath

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Summary

This research project describes an interactive interface for use by cognitive rehabilitation therapists in a virtual environment. It expands on an existing virtual environment that is being tested and used for therapy in patients with brain acquired injuries. The research will introduce an interface for the virtual environment such that it can ease convenience and use for therapists to gain control over the environment through dialogue aspects in the environment. This will provide therapists a way to communicate with patients in the virtual world more efficiently. The research project involves the development of an interface with a semi-autonomous dialogue model and data visualization to aid therapists in assessing and evaluating the progress of recovery in injuries of the patients. A qualitative research will be conducted to evaluate the usability of the environment and further review from clinical experts to validate the environment.

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1 Problem Description

Acquired brain injury (ABI) is known as one of the most common causes of death and disability in children and adults (Dores et al., 2012). It is defined by an injury to the brain that occurs after birth. As such, disorders and disabilities from birth are not considered and progressive conditions such as dementia are excluded. The most two common causes are traumatic brain injuries and stroke (Markovic, 2017). This type of injury severely hinders a person's cognitive, emotional, physical, psychosocial, neurological and behavioural functions (Gilboa et al., 2017). In the United Kingdom, there is a gradual increase in patients with acquired brain injury over the years and statistics indicates that there is at least one person admitted to hospital for an acquired brain injury every ninety seconds (Headway, 2015). Therefore, there is a need for an enhancement to therapy due to the increase in number of patients to cope with severe long term effects that reduce their quality of life such as poor social integrations (Gilboa et al., 2017) and poor memory (Yip and Man, 2009).

Current recovery strategies of ABI involve cognitive rehabilitation that specifies systematic interventions and methods to improve information processing, cognitive functions and the patient's mental health (Markovic, 2017). With current cognitive rehabilitation methods, clinicians face a problem with bringing ABI patients into the real world for practice therapy due to the neuropsychological effects caused by the injury. This leads to patients requiring constant supervision as they might pose threats and risks to themselves and people around them. Besides that, there is a lack of VR programs targeted at cognitive rehabilitation (Larkin, 2017) which gives a room for research in the area and to give an insight of future guidelines for this kind of programme.

The proposed project is to primarily develop an interface for clinicians to communicate with the patient in the virtual world. Using an existing virtual environment, it is possible for clinicians to manipulate a virtual environment that imitates real-world settings and limited adjustment to the difficulty level based on the level of injury faced by the patient. However, the current environment lacks a way of communication from the therapist to the user and the user has to be disrupted to return to the real world for therapists to prompt or hint them. This can be done in a few different methods as proposed by this research.

Furthermore, data can be recorded and analysed in a systematic way with a computer such that clinicians can judge the progress of rehabilitation. These data can also be used to communicate with the patients involved or other parties such as families of the patients. However, the environment is still being developed and requires further study to benefit treatment in improving functionalities for commercial use.

1.1 Related Concepts

1.1.1 Cognitive Rehabilitation

Patients with acquired brain injury frequently suffers from cognitive impairments involving language, reading, memory, executive functioning, and attention (Wilson, 2002). To help compensate for the impact of the difficulties faced by these patients, cognitive rehabilitation is used by clinical psychologists to help improve their performance () In cognitive rehabilitation, the general structure of a provisional model is described as a series of assessment, recovery strategies, evaluation, and re-assessment (King and Dean, 2009). Generally, there are two different approaches for recovery which are the remedial approach and compensatory approach (Wilson, 2002). These approaches differ in how they drive the brain of the patients in learning new skills (Markovic, 2017). In a remedial approach, individuals go through repetitive exercises as a means of training to relearn a functionality they lost. In the compensatory approach, individuals adapt to their current situation, without recovering the performance they once had.

1.1.2 Virtual Reality

There are three main types of virtual reality (VR) which are immersive, semi-immersive, and non-immersive (Larkin, 2017). In an immersive VR environment, the user is equipped with a headset and replaces their physical space with the perception of a virtual environment. These environments usually invoke self-reports of simulator sickness which is a disparity between the visual aspects of peripheral vision and kinaesthesia (Parsons, 2015). Semi-immersive VR involves just the projection of a virtual environment without hindering the sight of the real world. In an non-immersive VR, the user interacts with the virtual environment passively and does not need physical movement to navigate in the environment but relies on an interaction device such as a keyboard or trackball.

Primarily for this research, an immersive VR is used to give a sense of real world situations. Although there are no reports of existing complications with the use of the existing environment, the vulnerability of the patients should not be neglected. Despite that, the use of such technology on the population would contribute to the research area on where the simulator sickness may come from as the population suffers from varied levels of injuries and in different areas of the brain. Furthermore, the use of immersive VR can simulate realistic situations that allows ecological validity as well as dynamic assessment and training (Parsons, 2015).

1.2 Cognitive Rehabilitation used in Virtual Reality

Virtual reality is mostly known for its characteristics of providing presence, involvement, immersion, and immediate feedback. As such, it is a desirable environment to develop rehabilitation in. Many researches conducted emphasise on the assessments of memory, attention deficits, and executive functioning impairments. There is a common limitation of cost and availability of creating the virtual environment (Parsons, 2015). Moreover, it is unknown what kind of side effects that could be imposed on the patients. However, it is a safer environment in which the complexity can be customised to the patient (Larkin, 2017). In addition, there has been reports of significant improvements in patients (Yip and Man, 2009; Parsons, 2015) being projected in real world after rehabilitation strategies have taken place in virtual reality.

2 Objectives

The following objectives outline the direction in which the proposed research would take.

2.1 Design

Scenario cases can be used to design high fidelity prototypes of the interface for therapists to generate dialogues or to communicate with their patients. The class architecture can be designed with LucidCharts after looking at Unity's documentation on its interfaces and plugins available. As the system requires evaluation after development, the approach is to design it first such that the key functionalities can be prioritised during development.

2.2 Development and Testing

Although communication with the therapist is not done throughout the entire session when the patient is completing the Multiple Errands Task, it is essential for the therapist to be able to communicate to the patient when needed. These communication methods would also allow the therapist to communicate with the patients not as a bystander, but as a bystander in the simulated world. Furthermore, real-time visualization of data can help both the therapists and patients to figure out what they need to work on more as well as assessing improvement of recovery. These will be done with Unity C# and may need some plugins from Unity depending on availability and functionality.

2.2.1 Text-based communication

With a virtual device in hand, the patient can look at a virtual mobile phone for the tasks and receive communication through messages sent to the virtual device. This is a natural way for communication even held in reality. For the bystanders, the therapists would have a series of options to choose from and choosing an option would immediately be projected to the patient as a text box.

2.2.2 Audio-based communication

Another way a therapist can talk to a patient in the virtual environment is through audio. Since the patient is already being put in an immersive environment, the therapist can use a second headset or just a microphone itself so that it projects into the patient's headset and having. By selecting an avatar from a series of other avatars available in the environment, the therapist can choose to pretend to be the avatar the patient is looking at and a voice changer is applied by software for the patient to get a real world experience of different voices. The option of the therapist itself is also included so that they can communicate to the patient as themselves.

2.2.3 Virtual Avatar

This method requires sensors to be placed around the room so that the therapist can be projected into the virtual environment. It mainly emphasizes on the projection of the therapist in the environment together with the patient and would not have an option for the therapist to act as other characters in the environment. It would take visual input from the physical space as well as audio input so that the therapist can communicate to the patient naturally and control the other avatars through a semi-autonomous dialogue model.

2.2.4 Data Visualization

Currently, the system collects data from the environment and is exported as a large comma-separated values (CSV) file. Using the existing foundation of the data visualization, it may be possible to have the data visualized in a video form to see the pathways the patients have taken and to observe pattern.

2.2.5 Evaluation

A qualitative research in the form of natural testing will take place after a briefing to the therapists and patients are given and having consent to run the study.

Notes will be taken from observation as well as interviews with the therapists and patients separately and also jointly to get different insights on the effectiveness of the system.

2.2.6 Ethical Considerations

As the project deals with a vulnerable population, ethical considerations over their mental wellbeing is crucial. An ethical review of the system imposed on the users as well as the data being collected would be taken into consideration.

3 Project Plan

The preliminary timeline for the research project generally starts from Task 2 of the research proposal process to the main research project submission date. The main tasks for the project is broken down into Design, Development, Testing, Evaluation, Data Analysis, and Documentation. Although the timeline comprises of activities that occur prior to the start of the main research project such as the research proposal and the learning curve in preparation for the main research project, they will not be discussed below as they are not the main concerns for the dissertation. The full Gantt Chart can be referred to in Appendix A.

3.1 Weekly Meetings

For the project, weekly meetings are conducted for an hour with the project supervisor. Joint meetings with the developer, Zack Lyons and another student (Liam Rundell) with a similar project would occur occasionally during these meetings to invoke more productive thoughts on the system.

3.2 Design Stage

The design stage involves the design of technical aspects in the environment within a week. This time frame is sufficient as it would be a phase to produce artefacts in software development. It comprises the prototyping of an interface in terms of its visual appearance in low fidelity. The class architecture for Unity will also be created with the specified requirements. Evaluation methods will also be planned and designed.

3.3 Development Stage

The development stage of the interfaces within the environment would take the longest time and is estimated to take place from May to the end of July to leave some time for testing and debugging the system environment. The implementation of different features of communication can take place in parallel to finish development on time.

3.4 Testing Stage

The testing stage is scheduled to be finished by early August so that the environment is ready to be deployed and evaluated. In this phase, it would mostly be the researcher and research personnel involved in the testing.

3.5 Evaluation Stage

The evaluation stage is when participants including both therapists and patients with brain acquired injuries would test the system environment. The evaluation would be aimed at effectiveness . As recruiting participants might take some time, the time estimated is to be about a month long to recruit and carry out evaluation tasks that can be comprised of one-to-one interviews and joint interviews with both the patients and therapists.

3.6 Data Analysis

The data analysis stage takes a week long to analyse the collected data from the evaluation stage by mid-September for the write-up of the dissertation.

3.7 Documentation

The documentation stage would initially start in parallel with the development stage after the research proposal with literature and technology review is done. This would save time for the later stages such that only the results and discussion sections can be filled in. Ideally, the dissertation would be reviewed by the project supervisor two weeks before submission so that it can be re-edited and be peer-reviewed several times before submission.

4 Resources Required

4.1 Software

For the design part, tools such as InVision and LucidCharts can be used to create the prototype and class diagrams. These tools are readily available and are free to use on the web.For the development part, an existing environment created by Zack Lyons will be required for adapting the system environment to run and test. It is developed in Unity 3D and the code would be written in the C# language. A code repository on Github would be created for accessibility for the supervisor as reference. Further considerations for the development is to use the free Nvidia VRWorks plugin for Unity.

4.2 Hardware

For the VR component, the HTC Vive headset and a pair of headset for both visual and auditory perception is required for deployment. A computer with the capability to develop, run and deploy the system is also needed. With the amount of storage and processing required to run the program, home devices may not be capable to run the program. There is a set-up currently available at 1 West 2.58 which can be used for development and testing. Microsoft Kinect may also be required for scanning input of therapist for projection in the virtual environment. It is also possible to apply for a Graphic Processing Unit (GPU) Grant for free from Nvidia to conduct current and future research under the supervisor's application.

4.3 Participants

Participants with a brain acquired injury and clinical experts need to be recruited for the evaluation of the study. With the existing relationship of the supervisor with the Brain Injury Rehabilitation Trust, it is possible to recruit both volunteers and therapists from the organisation. An alternative to the evaluation of the system is to recruit healthy participants from the university as a control group to test the system. Clinical psychologists from the Department of Psychology can then be asked to spare some time to evaluate the system.

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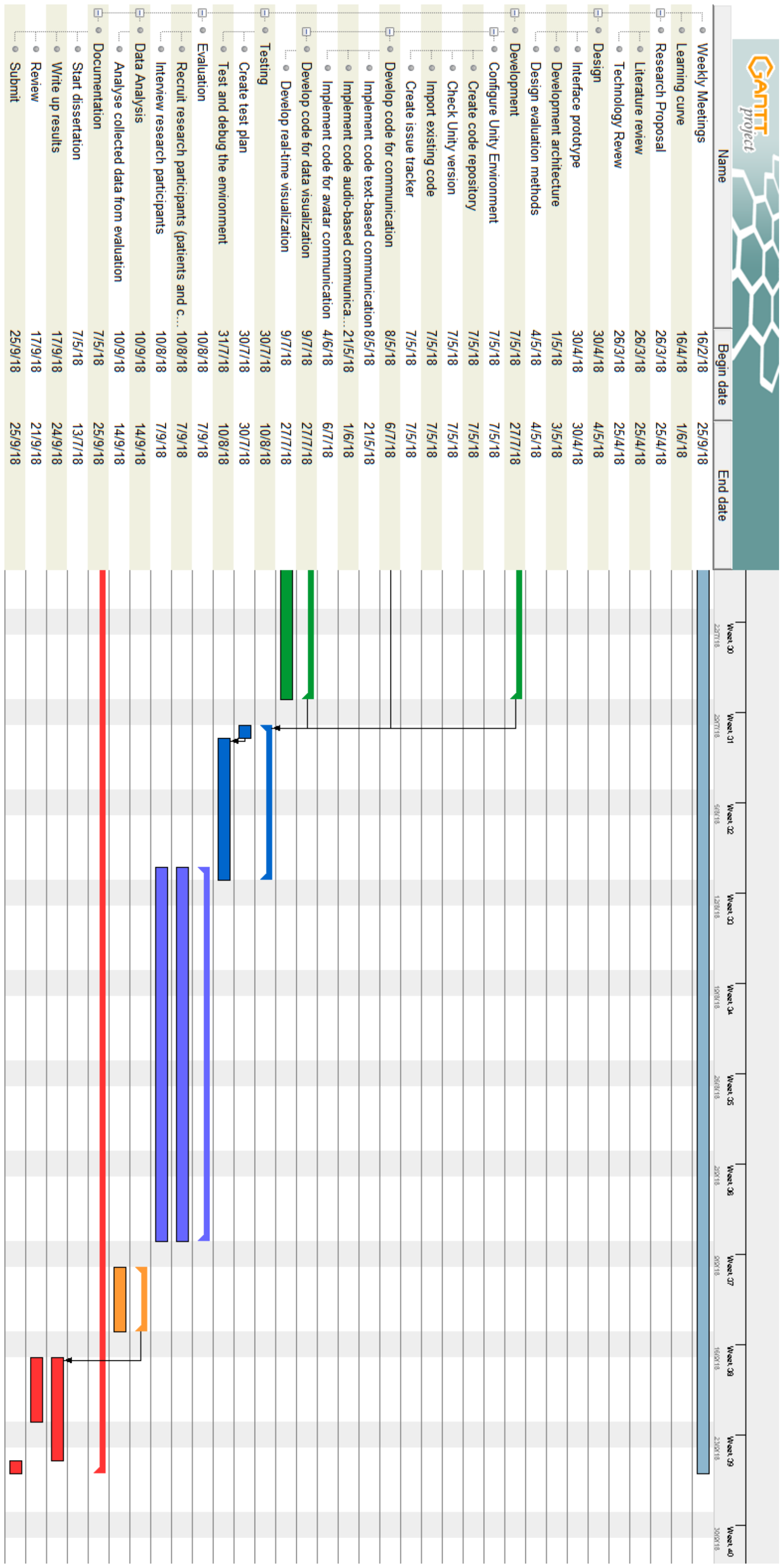
Appendix A


GANTT project
Name
Begin date
End date
Weekly Meetings 16/2/18 25/9/18
Learning curve 16/4/18 1/6/18
Research Proposal 26/3/18 25/4/18
Literature review 26/3/18 25/4/18
Technology Revew 26/3/18 25/4/18
Design 30/4/18 4/5/18
Interface prototype 30/4/18 30/4/18
Development architecture 1/5/18 3/5/18
Design evaluation methods 4/5/18 4/5/18
Development 7/5/18 27/7/18
Configure Unity Environment 7/5/18 7/5/18
Create code repository 7/5/18 7/5/18
Check Unity version 7/5/18 7/5/18
Import existing code 7/5/18 7/5/18
Create issue tracker 7/5/18 7/5/18
Develop code for communication 8/5/18 6/7/18
Implement code text-based communication 8/5/18 21/5/18
Implement code audio-based communica... 21/5/18 1/6/18
Implement code for avatar communication 4/6/18 6/7/18
Develop code for data visualization 9/7/18 27/7/18
Develop real-time visualization 9/7/18 27/7/18
Testing 30/7/18 10/8/18
Create test plan 30/7/18 30/7/18
Test and debug the environment 31/7/18 10/8/18
Evaluation 10/8/18 7/9/18
Recruit research participants (patients and c... 10/8/18 7/9/18
Interview research participants 10/8/18 7/9/18
Data Analysis 10/9/18 14/9/18
Analyse collected data from evaluation 10/9/18 14/9/18
Documentation 7/5/18 25/9/18
Start dissertation 7/5/18 13/7/18
Write up results 17/9/18 24/9/18
Review 17/9/18 21/9/18
Submit 25/9/18 25/9/18
Week 30
Week 31
Week 32
Week 33
Week 34
Week 35
Week 36
Week 37
Week 38
Week 39
Week 40

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Import existing code	7/5/18	7/5/18
Create issue tracker	7/5/18	7/5/18
Develop code for communication	8/5/18	6/7/18
Implement code text-based communication	8/5/18	21/5/18
Implement code audio-based communica...	21/5/18	1/6/18
Implement code for avatar communication	4/6/18	6/7/18
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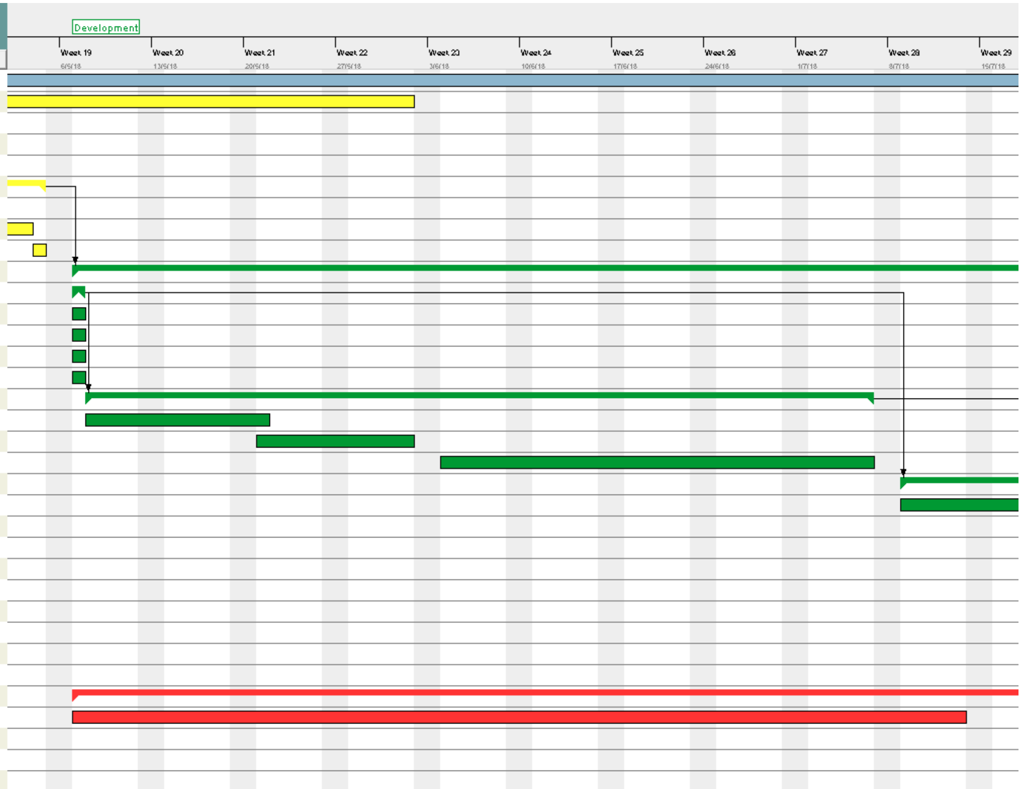

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