The Use of Immersive Virtual Reality in Stroke Rehabilitation by Using Microsoft Kinect™

By

Hafif Halmi Bin Hapsami

Universiti Teknologi PETRONAS,
Bandar Seri Iskandar,
31750 Tronoh,
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

The Use of Immersive Virtual Reality in Stroke Rehabilitation by Using Microsoft Kinect™

By

Hafif Halmi Bin Hapsami

A project dissertation submitted to the
Technology Programme
Universiti Teknologi PETRONAS
in partial fulfillment of the requirement for the
BACHELOR OF COMPUTER INFORMATION SCIENCES (Hons)
(INFORMATION & COMMUNICATION TECHNOLOGY)

Approved by,

_____

(AP Dr. Dayang Rohaya Awang Rambli)

Project Supervisor

DAYANG ROHAYA AWANG RAMBLI
Associate Professor
Computer and Information Sciences
Universiti Teknologi PETRONAS
31750 Tronoh
Perak Darul Ridzuan, MALAYSIA

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

December 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

HAFIF HALMI BIN HAPSAMI

ABSTRACT

This report is a preliminary step onto developing a new way of rehabilitation technique for stroke patient using Microsoft Kinect as the input device. Currently, many typical virtual reality based stroke rehab has been practices to treat these patient such as treadmill, pointing device, hands glove, body suit and many more whereby they have been identified as costly, bulky and also not feasible for distance patients to have their regular set of rehab exercises. With such problems in place, it is crucial to have a better solution which could help the medical industry to stay innovative, creative and effective. Moreover, this project aims to produce a low cost home-based physical VR therapy application intended for hand stroke patients. The project will involves several phases which follow the incremental model whereby firstly the construction of the basic game environment followed by the analysis and design of the system or rehab activities requirements, the implementation of the prototype which enhanced with the usability testing result, further testing and finally the increment routines to complete the milestones.

ACKNOWLEDGEMENT

First of all, I would like praise to ALLAH S.W.T, the most gracious and most merciful for giving me the opportunity and strength in completing this progress report without extreme difficulties. In this opportunity, I would express my hearties gratitude to my supportive supervisor, AP Dr Dayang Rohaya Awang Rambli for her assisting and giving the guidelines, comments and ideas in developing this project.

I would also like to grant with thankfulness to my colleges in UTP for their useful feedback helps in the process of developing this brilliant project. For me they would be the best ever persons to turns out this project into reality.

Last but not least, I like to convey my most truthful thanks to those who are directly or indirectly supporting and contribute until the completion of the project soon.

TABLE OF CONTENTS

LIST OF PICTURES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Project Background

Currently in healthcare practices, we still having a traditional way of therapy for rehabilitation or using the standard input devices or tools in virtual reality in treating the patient at the very best. There are so many researches in developing this kind of virtual reality application in term of medicine, to be more precise, there could be lots of approaches like wrap-around display screens, actual rooms augmented with wearable computers, and haptic devices that let you feel the display images. These kinds of approaches used to enhance the rehabilitation technique and also to proven its effectiveness in healthcare application so many years back ago.

1.2 Problem Statement

Rehabilitation is a process of restoration of skills by a person who has had an illness or past injury. In order to treat patient of rehabilitation, they need to undergo a specific physical care called physical therapy. The physical therapists are primary healthcare professionals who diagnose and treat individuals of all ages, from newborns to the very oldest who have medical problems or other health-related conditions, illnesses, or injuries that limit their abilities to move and perform functional activities as well as they would like in their daily lives [1].

This kind of rehab has come so many year before and people seen it as the conventional way of healing people by using a free weight, elliptical machines, treadmills and many more, to be more advance there were some current technology in virtual reality that have been proved to be the best method of healing stroke patient despite being expensive and bulky such as pointing devices, treadmills, data gloves or head-mounted display which obviously not accessible to individuals for home-based use.

1

Other than that, this processes has its weaknesses as some patients has troubles such living in a remote control area which distance away from the therapist therefore not feasible for them to have a frequent visits, besides that, an expensive treatment also contributes to the factors of demotivation especially for unfortunate family who really need this kind of rehabilitation therapy. This factor actually has led to the increment of patient's rate day by day.

The announcing of Microsoft Kinect in game industry nowadays has made a total change to the world as this input device could altered people perception on healthcare application especially in physical therapy equipment whereby enhancement of virtual reality devices does improved clinical performance [2]. Kinect is a controller-free device whereby it tracks human movement and displayed to the screen, through this technology, it can be implemented to the physical therapy patient who has suffered from hard hand stroke to enable them to have an exercise just at home and being monitored by the therapist form a distance. Furthermore, this device is totally inexpensive compared to others VR equipment, easy to install and easy to handle. Instead of having convention ways to restore patient in good health it can turn out to be fun and interactive way of treatment.

Thus, through this project, hopefully it will be a new approach of rehabilitation technique which can encourage people to have a great reason to complete their rehabilitation session.

1.3 Project Objectives

- To develop a low-cost home based VR physical therapy application for stroke patients.
- To explore the use of Microsoft Kinect as a gesture-based interface device for VR physical therapy application
- To conduct a usability study on the developed application.

2

1.4 Project Scope

The scope for this project is mainly on the usefulness of Microsoft Kinect component such as RGB (red, green and blue) and Depth cameras as the input device in developing the virtual reality rehabilitation treatment technique. I could see the usefulness of Microsoft Kinect really can change the people perception in treating these patient as this input device accept people motion and gesture and transform it into the screen, this research would help many young or even very oldest patient a chance to feel a new way of physical therapy. Therefore it can lead to a betterment of healthcare application. Perhaps, the use of newest technology known as Microsoft Kinect can create another level of healing technique instead of using traditional way which expectantly can reduce the time and cost of treatment.

Other than that, the main target audience is the hand stroke patience itself, whereby they will performs a modules inside the project specifically designed for hand stroke treatment. The therapy also will be specified into one type of activities which focuses on arm type only and also will use a game environment to motivate patient with fun and interactive module so that they will inspire to complete the module provided.

CHAPTER 2

LITERATURE REVIEW

2.1 Virtual Reality

Virtual reality is an artificial environment whereby created with certain software and presented to the user in a way of the user belief and accepts it as a real environment [3]. On a computer, virtual reality is primarily experienced through two elements of senses which are sight and sound [4]. In the most forms of creature, a participant need to wears a headset that incorporates high-resolution video display and audio speakers that would immersing the participant in a computer generated experiences. The participant also wears a special glove or body suit studded with sensors that monitor all the movements. Data from the participant's movements are then fed into a computer, which modifies the simulation accordingly. Virtual reality systems allow a participant to experience, navigate through, and manipulate a proposed area filled with imaginary structures and objects. This area is often denoted to as "cyberspace," a term first used by author William Gibson in his 1984 novel, *Neuromancer*. By the end of the twentieth century, virtual reality not only condensed to a specific technology, but also signaled a broader set of inquiries about the place of this technology in modern life [5].

2.1.1 Technology in Virtual Reality

When talking about virtual reality technologies, our scientist nowadays were working on developing the most realistic 3D stimulated worlds as they can. Normally, the requirements for such a simulated environment need the computer and its peripherals to be able project a 3D world which looks at real as possible to the user. Other than that, the user can feels completely immersed in the virtual environment through telepresence technology. This technology is an advancement measurer that can give the user a sense that he is no longer in his own world, and will have to cooperate and interact with his new environment. Next, the use of haptic systems, it is the event where as a user can

reach out and touch a virtual object and receive computerized feedback that actually makes the user feels a corresponding sensation. This is the newest element of development in the virtual reality technology world. As the time moving on, the peripherals used in virtual reality technology become an important factor in giving the user the ability to interact with his 3D world. Such peripherals, like data gloves and Omni-directional treadmills, body suits, wands, headsets and joysticks are but a few of the devices in common use today as part of the experience [6].

Picture 3: Head-mounted display

Picture 2: Wands

Picture 1: Data gloves

Other than having common virtual reality technologies above, one of the newest most immersive virtual environments is the CAVE (CAVE Automatic Virtual Environment). Stepping into this darkened cubicle is like hiking into your computer screen. There will be no longer observing the data through portals or just a flat screen hence, the display enables you to experience the sensation of being "inside" the data [7, 8].

Picture 4: CAVE Environment

2.1.2 Type of Virtual Reality

There are three main categories and can be ordered by the sense of engagement or degree of presence it provides [9].

- Non-Immersive (Desktop) Systems
  - The virtual atmosphere is observed through a portal by exploiting a standard high-resolution monitor.
- Semi Immersive Projection Systems
  - Most progressive flight, ship and vehicle simulators are semi-immersive. The cockpit, bridge, or driving seat is a physical model, whereas the sight of the world outside is computer-generated (projected).
- Immersive
  - 3D atmosphere perceived through a head-mounted display (HMD). In a completely immersive system that the user able to feels part of the environment (experiences a feeling of 'presence'). The user has no visual interaction with the physical world.

2.1.3 Application

Lots of applications created by VR, most of them are entertainment industry which really interested in games application and theatre experiences. Other than that, car companies have used VR technology to construct virtual prototypes of new vehicles thus the development process becomes more efficient and less expensive. Moreover, virtual environments are used in training programs for the military, the space program and even for medical students. Meanwhile in medicine, staff can use virtual environments to train in everything from surgical procedures to diagnosing a patient.

2.1.4 Medicine

Another medical use of VR technology in rehabilitation is psychological therapy by Dr. Barbara Rothbaum of Emory University and Dr. Larry Hodges of the Georgia Institute of Technology pioneered the use of virtual environments in treating people with phobias and other psychological conditions [10, 11].

2.2 Rehabilitation

Rehabilitation is a process used to give a healing sense to the patients who are suffering from physical and mental disorders, or drug addiction. Rehabilitation program could help the patient to get back to his/her normal life and earn a normal livelihood. Rehabilitation plays an important role in the lives of addicts and persons who have suffered from diseases or accidents. Other than that, rehabilitation plays a key role in the lives of people who have suffered from a trauma. This program was given to patients based on their needs. Every person's requirements vary so the program is subjective. Personal attention is given to each patient and his or her development is monitored on regular basis by the therapist [12].

According to the needs, the rehabilitation programs are divided in various types. Rehabilitation types are as follows:

- **Occupational Rehabilitation:** This therapy is given to patients who have lost basic skills after a major accident or a stroke. These skills are needed to perform daily routine activities like cooking, reading, writing, calculating. This happens in majority of cases where there is some injury to brain. Co-ordination becomes a problem for these patients and they need to visit an occupational therapist. The therapist gives treatment in form of medication, exercises to strengthen the muscles. The patients can take help from a psychologist and counselor.

- **Physical Rehabilitation:** This sort of rehabilitation is used for patients who have suffered from bone and muscle injuries. The physiotherapist helps a lot in giving the right exercise module to strengthen the muscles of back neck, shoulder and etc. This injury can happen due to accidents, sports or others. A lot of treatment

and technology is available in physical rehabilitation. The recovery time differs from person to person and so does the type of injury. The patients have to follow thoroughly the given exercise patterns.

- **Aquatic Rehabilitation**: This is a new trend in rehabilitation yet it is a successful in treating problems in joints. The therapists treat the patients by giving various water exercises like swimming, water aerobics, etc. This helps in giving strength, flexibility and mobility to the muscles of legs. Many patients with arthritis, joint pain, and stroke are treated with help of this rehabilitation. The program is customized according to an individual's needs and he or she is treated to recover from the injury so that he or she could have a normal life.

- **Cognitive Rehabilitation**: This type of rehabilitation is given to patients who have suffered from brain injury. To help them to get back to routine activities, they are treated with the help of neuropsychological approach. In this program, the patients are given counseling and mental exercises. This program looks at cognitive, social, moral and emotional aspects of the brain injury that has made the patient reliant on. This rehabilitation helps to support a patient to get back to his normal life prior to injury. The person can go back to his or her studies or job after recovering fully.

2.2.1 Physical Rehabilitation

Physical rehabilitation is a medical treatment that restores, improves, and maintains movement and function of areas of the body that have been injured or impaired. Disease and injury can cause disorder on the body, limiting mobility and causing pain in joints and limbs. Physical therapy is prescribed by doctors to aid patients recovering from some such condition so that they can retain the quality of life they were familiar to before an accident or illness. Many people of all ages engage in physical rehabilitation, including children, adults, and the elderly.

There are different types of physical rehabilitation, one of them is orthopedic physical therapy which commonly performs post-surgery rehabilitation of patients who

would want to heal with better functions of their body most especially with joint mobilizations, strength and agility and stabilizing their bones, ligaments and tendons. Other than that is neurological physical therapy, which for the Alzheimer's disease, brain damage, Cerebral Palsy, Parkinson's disease, and other injuries from the nervous system, The therapy itself will help the patient to improve or restore the dysfunctional part of the body, recovering the patient from having to lose functional independence, poor balance and inability to ambulate, Next is cardiovascular physical therapy, pediatric physical therapy and many more, but the end goal is always an improvement to some area of body movement.

Traditional or conventional physical therapy rehabilitation often takes place in a physical therapy rehabilitation center. These centers look very much like gyms and have similar exercise equipment such as stationary exercise bikes, free weights, weight machines, elliptical machines, rowing machines, treadmills, and stair climbers. Rehabilitation centers may also have whirlpool baths and private treatment rooms where the therapist makes assessments on range of motion improvements and stretches out tight muscles and joints. Physical therapy may also be administered in homes, hospitals, outpatient treatment centers, extended care facilities, schools, and fitness centers [13].

The main issues when conducting this kind of rehabilitation is the fee conducting this session is costly for an average person, this session have to attend several times until the therapist release the patient and if the other way around they need to stay even longer, it may cost a lot and sometimes people are not affordable to have a complete whole session and as the result, the patient did not get into fully recover. Other than that, the commitments from the parents or responsible person also become a big issue as they claim to carry other important things to be done outside office hour. When this situation going to happen, the patient becoming less focus and intent to do something out of therapist expectation. Last but not least is the distance issue, some patient may live in remote area which far from the hospital, it's difficult for them to make an appointment regularly with the doctor in completing their therapy program. As the result, the program did not go well because the patient itself can't attend regular session.

As for the stroke therapy rehabilitation, typical treatment was always being done back at the hospital or homed-based programs with or without the supervision of the therapist. The main objective of the rehab is to gaining as much of the function lost after a stroke as possible. The patient will be doing several sets of activities or regimens sets by the expert which involving arms or legs. By this mean, stroke survivors can slightly have better chances of recovery to become a normal person back. But then, many obstacles have been found for the patient to not keep adherence with the exercises which has been identified in the problem statement.

Picture 5: Hand rehabilitation exercise

Picture 6: Hand rehabilitation exercise

10

Picture 7: Leg rehabilitation exercise

Researches has shown that, only 10 percent of the stroke survivors can recover at almost completely from four(4) million Americans [14], the rest were not successfully recovered with impairment and even worse. This referring to the conclusion that stroke is among the most leading cause of death in the world nowadays.
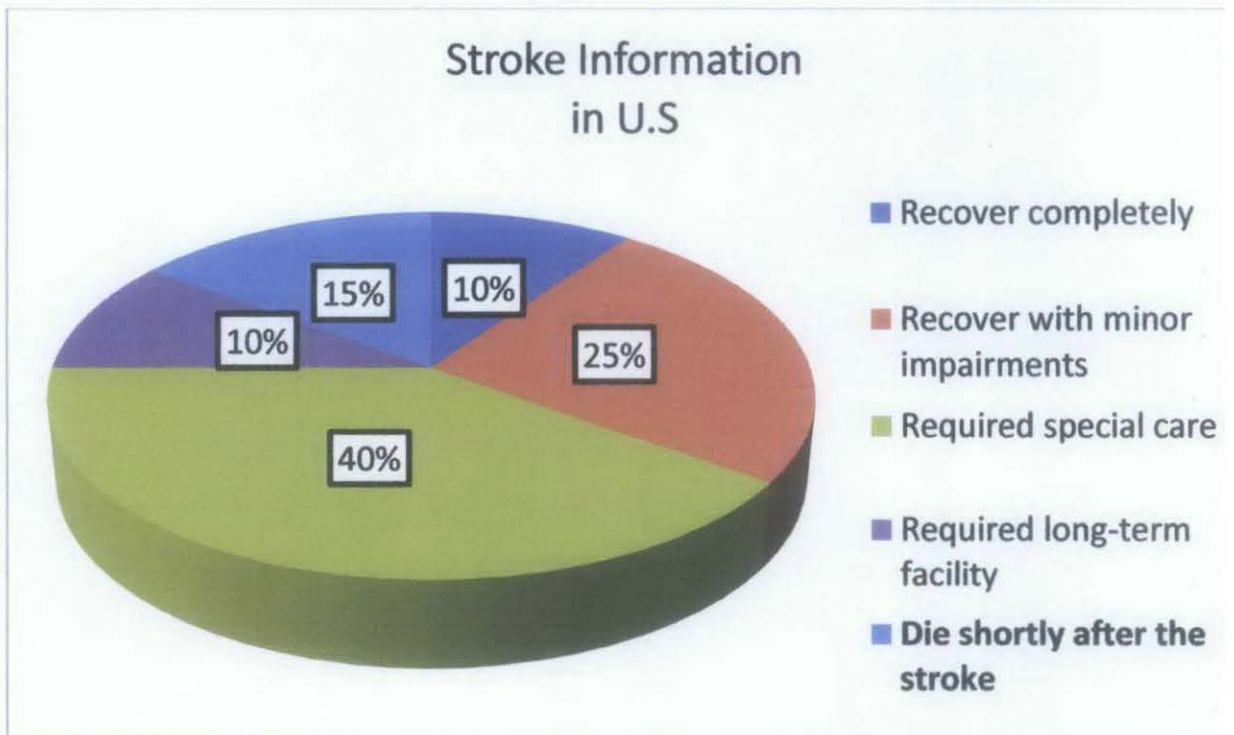

Stroke Information in U.S

- ■ Recover completely
- ■ Recover with minor impairments
- ■ Required special care
- ■ Required long-term facility
- ■ **Die shortly after the stroke**

10% 15% 10% 25% 40%

Figure 1: Stroke information in U.S

2.2.2 Virtual Reality in Physical Therapy (Stroke Rehabilitation)

Nowadays, some of virtual reality tools have been produced specifically in games architecture which has been discussed as the mechanism by which can be the effective tool for exposure therapy [12][13], one of them is called Virtual Reality Treatment (ViRT) system[16]. Viet uses Chromo key technology and Gesture Control software to "place" a patient into a virtual game environment allowing them to have fun exercising. The patient is inspired to have exercise for longer periods and more often while the system keep tracks the progress of the patient. This technology has bring up physiotherapy treatment further one level which applies the technologies from the entertainment and broadcast industries for the betterment of human kind.

One of the technologies in US that have been developing nowadays is IREX (Interactive Rehabilitation and Exercise System). This system uses immersive video gesture control technology to place patient into virtual sports or gaming environment where they are guided through clinician prescribed therapeutic exercise regimes, patients are immersed in a full-body virtual world where they can interact with on-screen images and objects, designed to enhance the sense of "presence" for the patient. Real-time auditory and visual feedback further stimulates the patient, resulting in improved motivation and effort in rehabilitation exercises.

A medical research towards virtual therapy has confirm its benefits for patients with cognitive and physical incapacities, including those with cerebral palsy, autism, Alzheimer's and dementia, as well as those getting better from stroke and traumatic brain injury. As with all GestureTek systems, IREX is totally gesture-controlled and does not need patients to wear, hold or touch anything special, or use any peripheral device. With the system being touch-free, there's no risk of cross-contamination [17]. All activities are low impact activities and can be made more challenging as patient movement improves. However, this system would be expensive because it comes with a set of LCD ceiling-mounted projector, a flat-screen television monitor and a green mat plus all other required equipment.
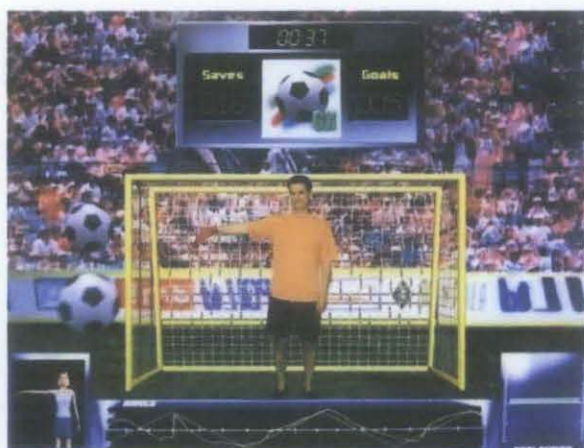
Picture 9: [16] IREX Sports environment   Picture 8: [16] IREX Exercise environment

Other than that, virtual physiotherapy device created by PhD student of University of Portsmouth called Wendy uses a modified treadmill and a C3 visual display around the stroke patient to project the virtual environment [18]. The idea was using moving images to trick the patient's brain into thinking that they are walking slowly than they are which encourage them to walk faster. This system also uses variety of different images from urban landscape to forest and mountain scenes which inspire the patients to pick up objects and collect points.

Over the time, this can be used to recover a patient's pace, almost without the patient recognizing it. As well as handgrips on either side of the treadmill are perfect for those who are fearful of falling over which the system offer a comfort zone, while the immersive display projects them into walking down a street.

Nevertheless, this system need the patient to do the exercise at fixed place set by the therapist and time consuming to complete the session alone and might be costly to have a consistent meeting for an unfortunate person.

13

Picture 10: [17] With the stroke victim

Picture 11: [17] The VR device

Apart from that, there was a researches made in 2010 whereby video games did have advantages over traditional treatment tools, a small pilot study made by some of researchers found that the stroke patients who played Nintendo's Wii Sports for a few weeks could perform tasks faster than patients who played typical hand cards games [19].The researchers also conclude that it's at least safe for the stroke patients to play video games including those virtual reality programs the requiring movement while improving their body movement.

Additionally, there is a project called Oovit PT [20] whereby aims to create a virtual rehabilitation system which adherence to home exercise. A typical physical therapy regimen is said to be poor by the patient itself since it is being done at home without any supervision by the expert. Through sensor-enable gaming interface, the project able to support patient with sufficient data being fed back to the therapist so that they comply with the home exercise through shared decisions between physical therapist and the patient itself about appropriate regimens and goals they should have. After both of the party agreed towards some point, the system can be adjusted properly to fit the regimens needed.

Picture 13: Oovit PT 3rd person view
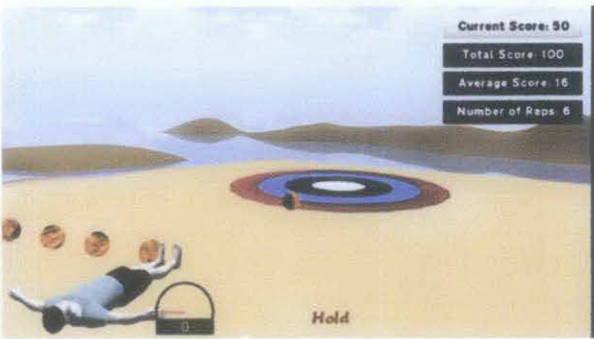
Picture 15: Oovit PT Game view

Picture 14: Oovit PT Patient lifting the leg

Picture 12: Oovit PT Game's analysis

15

2.3 Microsoft Kinect

Kinect was designed for a style add-on peripheral for Microsoft Xbox 360 console game platform, it is a controller-free gaming and entertainment experience, it consist of single sensor bar that contains two depth sensors and a standard RGB camera. The main feature for Kinect is the depth which is the cameras can tract both of our movement from side to side, front to front and as well as up and down. Kinect also has a built in microphone that allows voice activated commands when applicable but in this term of research, I would concentrate more on the usage of its sensors. As the Kinect connected to the common pc, the virtual environment will be projected into the screen and allow body movement to interact with the system through the motion sensors. As previously mentioned, among the problem face during the rehabilitation period was the cost of the treatment itself, having this device would reduce the cost of expenditures as the price for this equipment is cheaper compared to other VR devices.

Picture 16: Microsoft Kinect

Moreover, the patient can have fun while exercising because it use the concept of games, by implementing this device into a virtual reality system, it would be a magnificent work as it offers a full range of motion tracking and feature like video chat, by using this feature patient can communicate directly to the therapist without having a same place to meet, a patient who have to undergoing a physical therapy rehabilitation can have the treatment even at home because it easy to install and also easy to monitored by the therapist even from a distance.

2.3.1 Kinect in Medical Games

One of the game developers based in Belgium, named Fishing Cactus has come out with the project's name R.O.G.E.R which stands for Realistic Observation (in) Game and Experiences (in) Rehabilitation [21]. It is a serious game which is used to help patients who suffer from a lack of logic and organizational skills (typically post-stroke patient's patient).

With the provision and guides of four therapist and also from Microsoft Innovation Center, they created a photo-realist environment running on Xbox 360 whereby the therapist can assign patient to do his luggage for a specific destination (the mountains, the sea, a city-trip and etc.) and can observe how the patient reacts to the environment and the type of objects he gathers in his luggage.

It helps the therapists to analyze and observe if patients are disorganized and see where they have lost their common sense and focus on those points in therapy. In order to make it more real, they create several challenges elements to make them lose focus such as phone ringing, radio and so on.

Other than that, serious games developer named Red Hill Studios recently has created a specifically Kinect-based physical therapy games which clinically can helps to slow the progression of the neurodegenerative disease or Parkinson's [22]. The games were developed with partnership with the UCSF School of Nursing to ensure the maximum effectiveness towards the patient and ultimately can lead to the major success in virtual reality's technology especially in medical dictionary

17

2.3.2 Motivation of Work

The idea comes when the Kinect system allows the player of Xbox 360 using voice commands and hand gestures to control the games without to touch a game controller, Technique such as voice recognition and facial recognition are used for identifying user's movement. In addition, Kinect system is still very fresh in this games industry and we had few people are trying to explore its capabilities to the maximum outcomes nowadays. Moreover the cost for obtaining this system is inexpensive or low cost compared to the others virtual reality mechanism such as CAVE system, data gloves or body suits, means typical person or family could afford to have one at home. It is worth to implement seems this system could assist lots of people out there which can bring various beneficial to others especially in healthcare applications.

CHAPTER 3

METHODOLOGY

3.1 Incremental Lifecycle Model

A methodology is a formalized approach to implementing the System Development Life Cycle (SDLC), [23]. It is a process used by the developer to develop an information system. There are numerous different methodologies in SDLC which being used to build a system good depending on the different factors of the system itself. However for this project, the most suitable methodology to be implemented is the Incremental Model whereby only focusing on limited project scopes and expanding or improving products by multiple iterations which are far the most suitable approach onto developing the Kinect –the healthcare application system.

The reasons this model been selected because is the fact that it's generates working software faster and early during the software lifecycle so that we can respond to each build, in addition it also easier to test and debug during a smaller iteration thus it could reduce the potential of getting complicated bugs on final product later on. Moreover, this method uses divides and conquer breakdown of task causes easier to manage risk because risky pieces are identified and handle during the iteration process. Other than that, this model provides lower initial delivery cost because its only develops major function at the first place so that we can get important functionality early. As the result, the risk of changing requirement is reduced due to the good planning and design at the early stages.

The phases of the project will be divided into:
1. Analysis
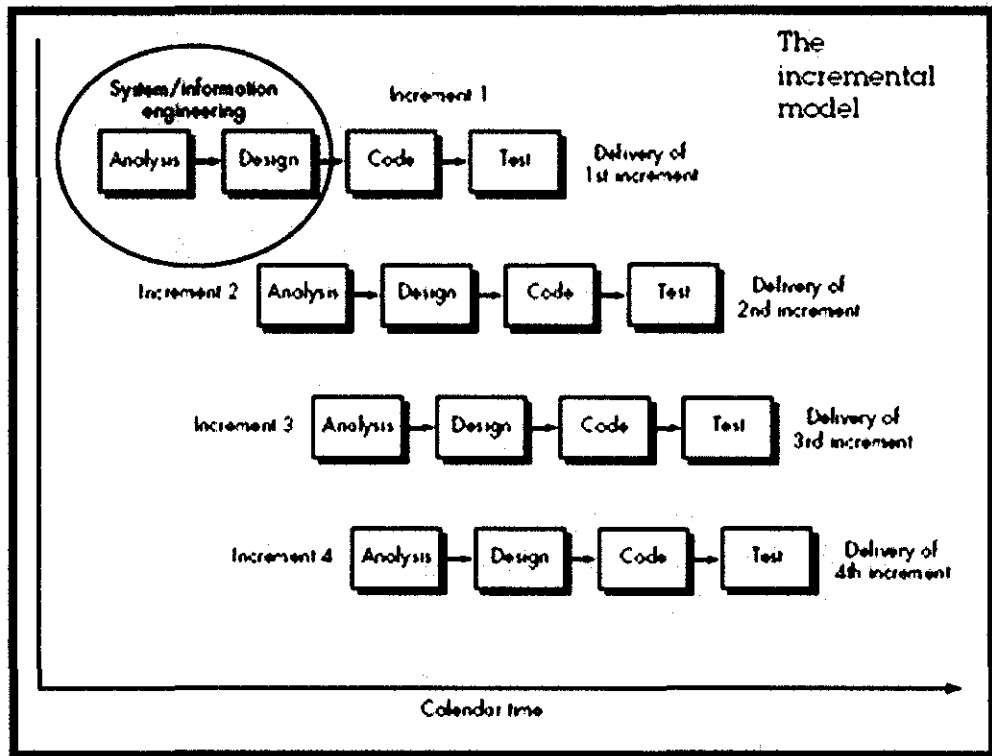2. Design
3. Implementation
4. Test

Figure 2: Project Methodology

3.2 Project Phases

3.2.1 System Analysis

At the first stage of analysis process, all required information being collected in order to assess the project scope for developing such as healthcare application especially in VR perspective, the risk of having this project also being identified and discussed as well as the problem statement whereby the explanation of having this new way of treatment instead of conventional method can ease lots of patient out there. Aside from that, the requirement software for developing process such as (PhotoshopCS5, OpenNi, Activate 3D, NITE XML Toolkit and Unity3Dand devices(Microsoft Kinect and Personal Computer) also being discussed and identified including functional and less functional part of the project.

During this phase, the project scope will be narrowed down to meet more detailed purpose which to threat leg and hand stroke patient due to the time constraint and cost containment. Hopefully, the research will be continued to fit others part of physical therapy as well. Hence, to describe the system into more meaningful works, the use of use-case diagram and activity diagram are sufficient to explain the functionalities and the important actors of the system.

All the data including pictures and figures being gathered through the reading of journals, visiting the websites, participating in forums and etc. This part was important in order to capture the crucial reasons to have an improvisation to an old conventional method of treatment in physical therapy rehabilitation. Once the basic and important parts of the system have been identified, an analysis is done to let the process of design important functions and modules which are to be developed afterward.
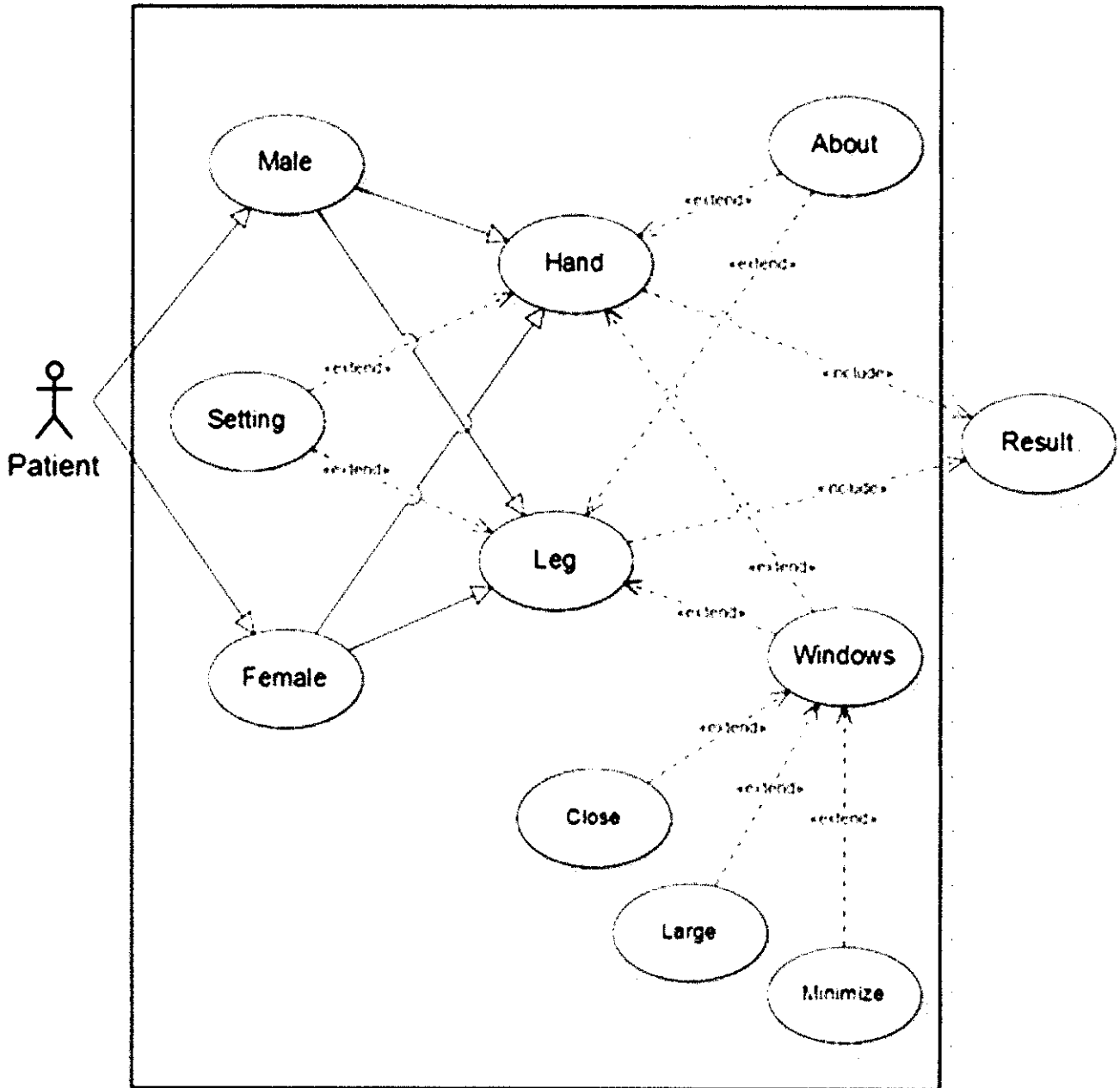
KINECT Physical Therapy System

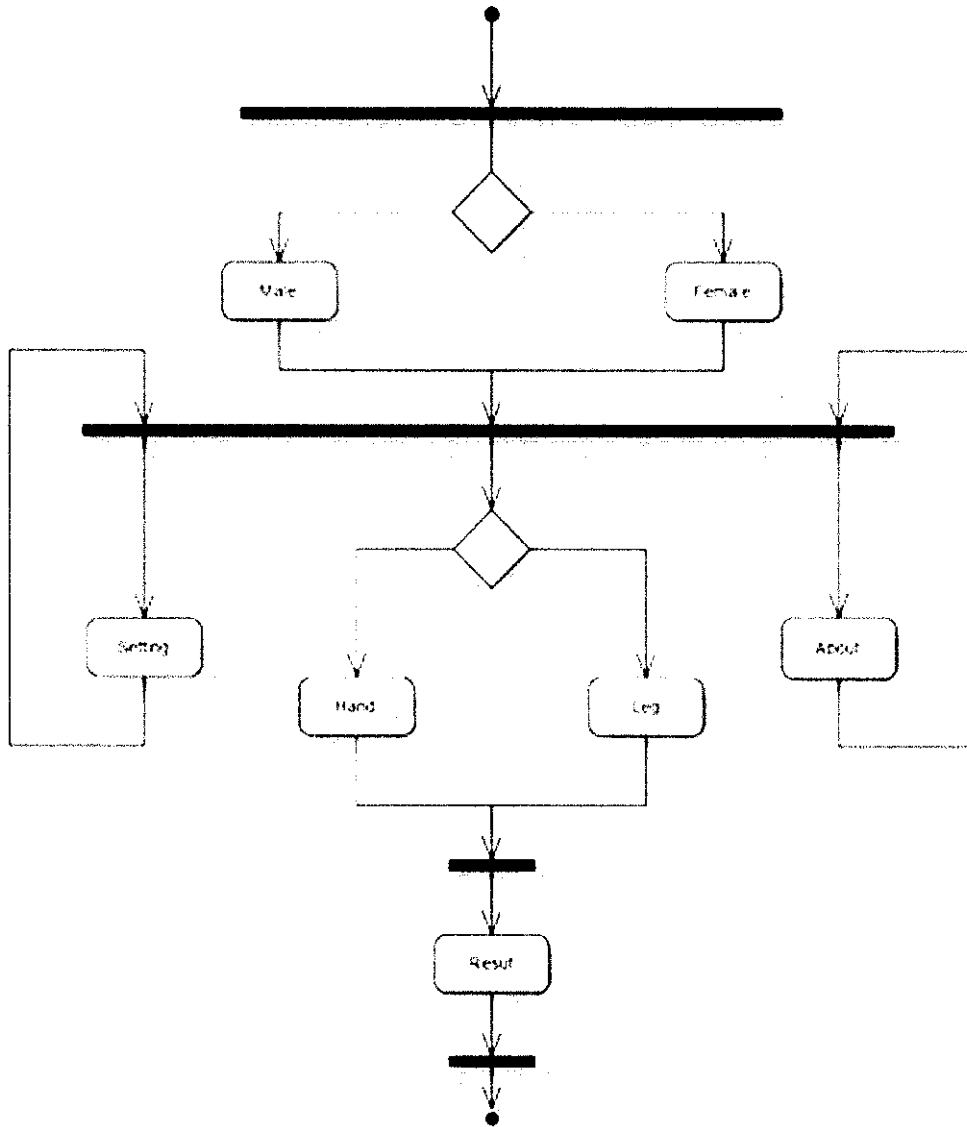Figure 3 : Early use-case diagram

Kinect Physical Therapy System

Figure 4: Early activity diagram

Male or Female: To choose patient's gender to load the model in the system

Hand or Leg: To let the patient choose particular body they want to exercise

About: To describe about the system

Setting: To adjust activity's countdown timer and activity's goal.

Result: To display result after each activity

3.2.2 System Design

After thorough analysis were done in the previous phase, the project can proceed to the design phase whereby the most important starting part in the developing the system to determine the successfulness of the project whether it meets given time and around budget. The purpose of the analysis phase is to figure out the requirement of the project meanwhile the purpose of the design phase is to decide which requirement is to be implemented and how to execute it. Inside the phase as well, all the information and requirements gathered during the analysis phase were organized and presented in the form of **key milestone** and **Gantt chart diagram** in index section later on. Moreover, a simple prototype has been work out to demonstrate the basic idea of using Kinect for initial incentive.

For the first step, couple of designs for the interface and the system itself has been design out to have a rough idea on what will the system contains. The system divided into two parts which is hand and leg to enable the patient chooses their own desire related to their needs. Every part has their activities and objectives. But the end goal is always the same which is to improve some body movement.
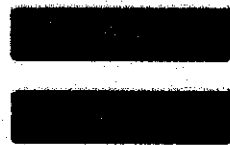
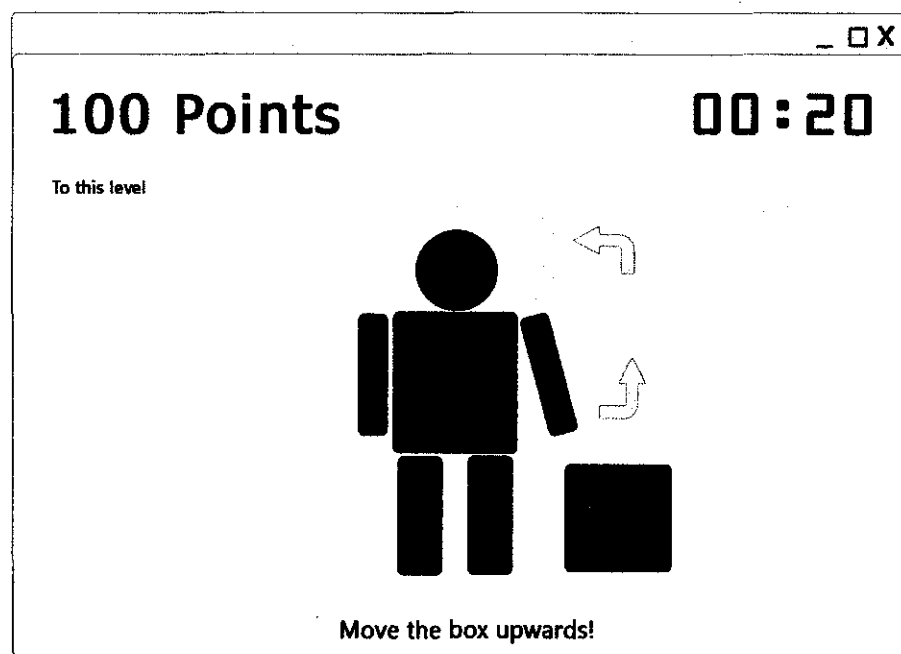Figure 5: System Interface (Draft)

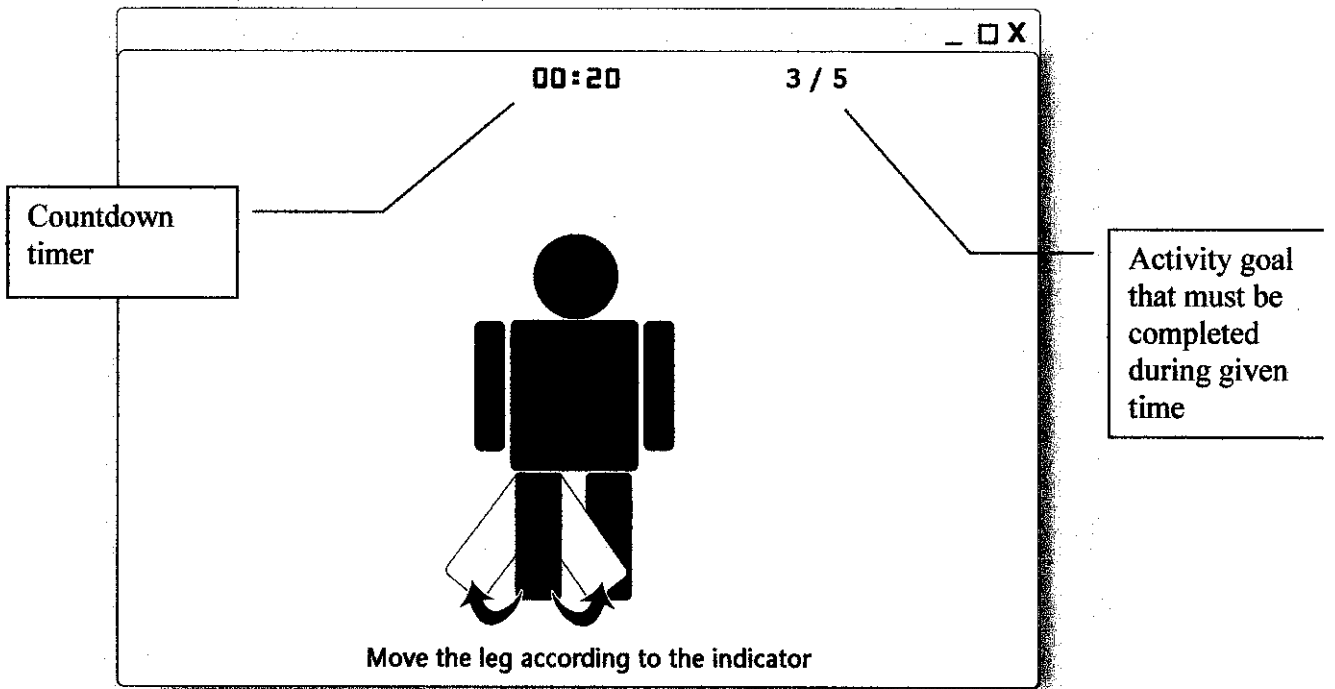Figure 6: Hand's module activity (Draft)

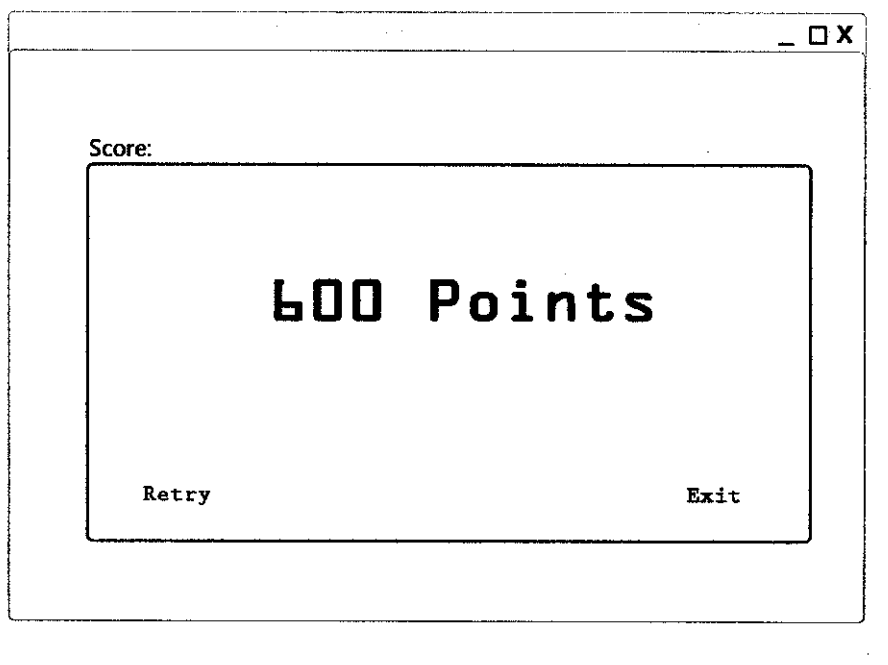Figure 7: Leg's module activity (optional) (Draft)

Figure 8 : System Result (Draft)

3.2.3 System Code/Implementation

In this implementation phase, a mini prototype is developed based on the design and analysis phase. This phase involve the building of the actual natural user interface system itself using an Integrated Development Environment (IDE) or known as Microsoft Visual Studio 2010 using the C# programming language. Besides that, a substance for background environment were injected using an open source software called Activate3D [24] and Unity3D [25], this software was developed to create 3D environment and translating player motion into virtual world and generates accurate real-time animation that could retains the unique characteristics of the player's movements, it provides free platform for beginners to create their own virtual scene with motion responses character. However, different software are needed to set up the Kinect to the personal computer and to allow modification procedure, they were called openNI and NITE XML, openNI provides application programming interface (API) for writing applications which utilizing natural interaction [26]. Meanwhile NITE XML is the toolkits that contain libraries for developer and some end user tools that will be used to manipulate the prototype later on [27]. These open source software are like middleware to enable manipulation on the Kinect's RGB and depth cameras.

3.2.4 System Testing

As soon as the system is built successfully, the system testing phase was used to test out the implementations, This system testing phase also known as the prototype evaluation phase whereby during this phase, the prototype was thoroughly checked and examined the functionalities whether it meets the requirement or the other way around. According to the incremental methodology, if an error or lacking of function was found within the phase, the crucial phases (analysis, design, implementation and test) need to be continuously repeated until it satisfies the entire requirement. This testing phase was also used to identify and fix any bugs that occur during the built system.

27

CHAPTER 4

RESULT & DISCUSSION

Part 1: Result

4.1.1 System Architecture.
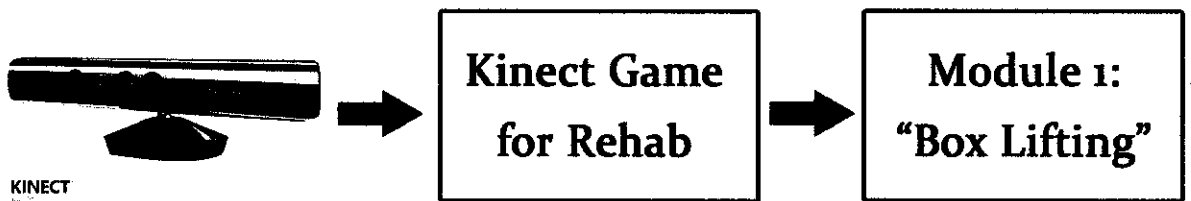
Picture 17: System architecture

Kinect:

Is act as the input device for the system and primarily used to receive body motion using its RGB and Depth sensor cameras to enables users to control and interact with the natural user interface through module given.

Kinect Game for Rehab:

The main graphic interface that provides user an initial window before playing the game using the Kinect device. It has only two options for this time being which is "Play" and "Exit".

Module 1: Box lifting

Current available module resides in this system. Contains an activity specifically designed for hand stroke patient. Users need to race with the time given by lifting a box as much as it can to get the highest marks at the end of the session.

When the user has finish the session, their score will pop out on the screen and they have the choice to go over again the game or easily exit the game. And the process will continue all over again until the users choose to exit the game.

4.1.2 System Flowchart.
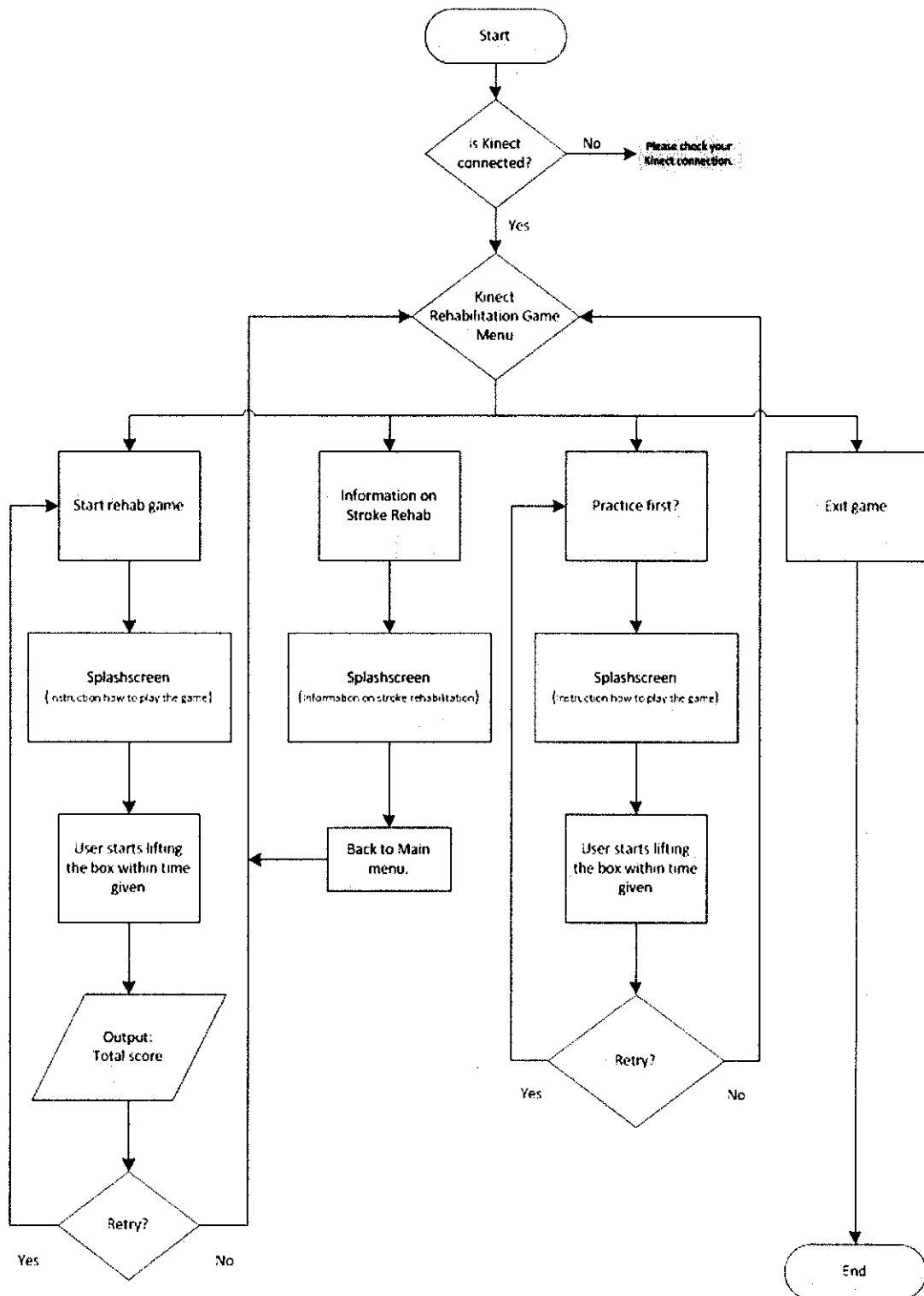
Figure 9: Latest System flowchart

4.1.3 Usability Test.

Usability test is being used to tests the interaction between people and the software. It is important to finds out whether the software successfully meets the user expectations and needs. Therefore the developer can deliver a product that is more intuitive to use. By using usability test, the developer can identify the problems that people are having when navigating the software. To have a very best result, the test should be done on the targeted audience itself in order to gather useful and valid data and also having feedbacks from the user explaining their concerns also might be useful to reinforce the test and to be able to design a successful system. In this case, several audiences from my friends have been chosen to carry out specific task on the prototype.

The questions contains in the test is much more emphasizing on the functional of the software and its interfaces, users are freely leave their comment after gone through the software to enable the developer to do the iteration process all over again until it satisfy the user's requirements.

Sample of questions:

1) The system was easy to use.
2) The interface was attractive and understandable.
3) I need to learn a lot of things before I get started.

Result:

Based on the latest result that being ran on 5 selected persons upon the successful program, the users seems to be more satisfied with the prototype's interface of the software. The result shows that the accumulated number of polls for question 2 (red) is the highest among the rest following the scale of 1 (Disagree) – 5 (Strongly Agree).

The latest result would come together with the feedback gained from all the users after being done the test:

"It was fun and amazing"
"It's a new way of rehab"
"More modules would be interesting!"
"Should be publicized"
"Needs to have a female character"

Part 2: Discussion

4.2 Data Gathering and Analysis

Data gathering is a process of collecting all sort of information on particular subject or topic to enable a person to make the best decision based on the findings. With such valid records, all information can be used to produce a result which slightly can reduce the cost and time consumed of completion. There are many method of data gathering that can be used to retrieve those information such as reviews, reports, documents, surveys or panel of expert, in fact, having several methods of data collection in one particular subject would be the most suitable step as it offers different angle of perception.

As for this project, reviews and observations are selected as the main source of information since Kinect is still very new in the market especially in medical substance, furthermore there is no solid research on performance nor usability testing that could be the source of references. Thus, many experiment and test need to be done in order to get the right approach to accomplish the project objectives. As the result, many videos of physical rehabilitation and also reviews from the therapist experts are taken into consideration into developing the project.

After necessary data has been collected, analysis and interpretation processes are needed to drive out the data. All the project iterations and activities are being observed and recorded to identify its capabilities and weaknesses which enable the developer to discuss with the supervisor and making the best decisions up to this moment.

4.2.1 Experimentation/Modeling

The following experiments are done based on the key milestones in the Gantt chart shown in appendix:

4.2.1.1 Increment 1: Skeleton tracking developed using Microsoft Studio 2010.

For the first step in developing the program, a user's skeleton was successfully tracked by using Microsoft Studio 2010 in windows presentation format (WPF) written in C# language, this skeleton tracking system is ultimately important as it is being used in all of the developer's foundation in turning the project into reality. Below, the picture showed the sample of the program together with the interpretation from the observation.
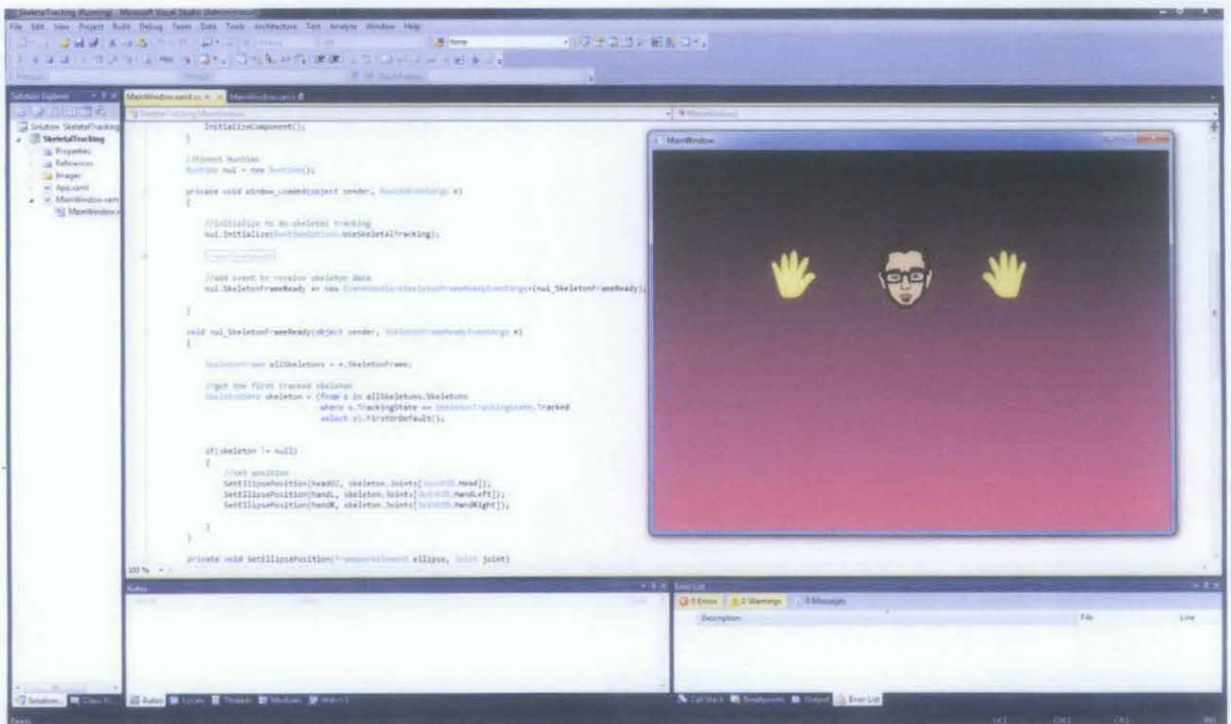
Picture 18: Skeleton tracking developed using Microsoft Studio 2010

33

Interpretation and Analysis

Based on the observation, the skeleton tracking is successfully projected on the screen represented by the hands and head of the cartoon. These objects would response to each of the user movement in real time according to human joints. A delay in movement however has been detected when running this simple program; in fact, the skeleton would act funny when the user is out of Kinect sensor boundaries. This sufficient information has been the strong reason for the developer to try out the Unity3D as the game engine that provides a platform for Kinect to works with.

4.2.1.2 Increment 2: Creating 3D model in Unity3D using Kinect Wrapper.

The second increment is all about to create a 3D model that can serve as the player later on. After completing the design of the model, however a wrapper is needed in order to control the model by the Kinect, this is the moment when the Kinect wrapper comes into the picture. This wrapper is developed by one of the Kinect community member. It is such a big handy whereby the wrapper can fit into the model perfectly.

Picture 19: Creating the game environment using Unity3D.

34

Interpretation and Analysis

Through the observation, the Kinect wrapper has perfectly fit into the model meshes. Each of the movement made by the user successfully mapped into the screen with relatively small delay compared to the one build in Microsoft Studio 2010. However, there is some glitch seen in the sample while it running whereby the model suddenly set into weird position until the user calibrates again with the Kinect, but then after much discussion, that was causes by the Kinect device itself.

4.2.1.3 Increment 3: Creating the game environment using Unity3D.

The third increment is among the most crucial part in developing this project whereby creating the environment for the model to be positioned with. This decision is being made based on the data gathering result to choose the most appropriate environment tool for the rehabilitation to take place. Other than that, the biggest achievement also started here when the model is able to grab and hold the object around him.

Picture 20: Creating the game environment using Unity3D.

Interpretation and Analysis

Based on the observation, user can fully control the model movement in real time while grab and holding the object in this case is a box wherever they want to move to, this can be a great opportunity to the developer as they can proceed with the next milestone. However the model could only to pick up and holding the box up until the sample is restart again. The environment is quiet nice as the tree and grass is moving around according to the wind direction.

4.2.1.4 Increment 4: Creating the Score counter and Remaining time counter.

In this crucial increment, the score count has been created and placed on the top left of the users screen to let the users know their current score whenever the character got destroy the box. Remaining time also has been set up together into the screen to alert the user how much time is left for them to add up their scores. These features actually are the main factors to motivate the users to complete the game.

Picture 22: Score counter and Time remaining features.

Interpretation and Analysis

When the user run through the game, remaining time operates as expected once the game started and score counter increasing starts from zero whenever the box on user's hand got destroy. Once the time remaining close to zero, the scene automatically changes to score board scene whereby users' latest score appeared on the screen.

4.2.1.5 Increment 5: Creating Main menu and Score Board.

For this increment, the essential parts in developing a good game starts in here whereby a game menu is created tailored to the main game, the scene was created using the same engine whereby it being linked between the main scene and also the score board at the end of the game after the users finish the game. During the process of development, many challenges has been brought up since it is still a new type of game, among the challenges, the developer need to figure out on how to make the score board linked between the scenes, it was the toughest for this time being since it needs to be test out in every linked scenes.
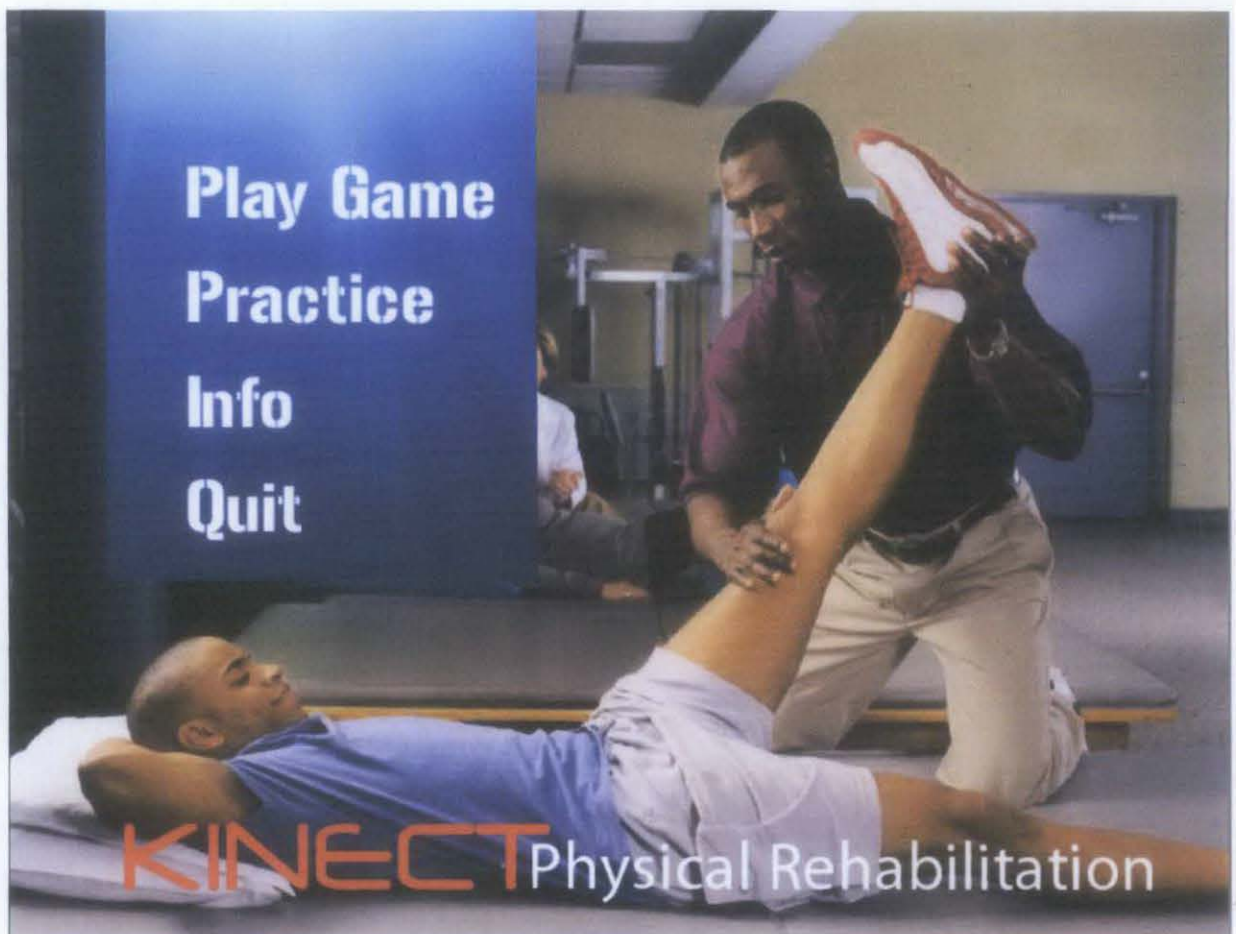
Picture 23: Main menu

Interpretation and Analysis

Through the observation that was being made during this increment, users will go first into the main menu screen to choose out either to play the games or to quit the application. After playing the game until the end of the time, the score board screen will appear afterwards showing the high score that the users got during the game. Then users can choose whether to retry the game by hitting RETRY button or just leaves the game as the score will restore back to 0 by pressing QUIT button.

CHAPTER 5

CONCLUSION

Project objectives:

- To develop a low-cost home based VR physical therapy application for stroke patients.
- To explore the use of Microsoft Kinect as a gesture-based interface device for VR physical therapy application
- To conduct a usability study on the developed application.

As for the first objective whereby to create low cost home base PT equipment for the stroke patient can be archived, the second and the third objective need to be done to understand the limitation of this device called Microsoft Kinect. Developing the basic foundation to using the Kinect is a must in order to explore each of its usages which can beneficial for medical purposes.

In conclusion, to summarize the result generated from the test conducted towards the targeted audiences, users seems motivated to complete the module as they are very excited to get higher score to compete among their friend. This shows a positive sign of the system currently has achieves its basic objectives which to encourage the users to complete the game.

Following, the user simply recognized this game was hassle-free and interesting to play which actually the main purpose for having Kinect as the input device at the first place. This advantage more likely to be the main attractive factor for the new user to try out this product to replace their current rehab practices to help them boost the recovery process.

For **future recommendation**, more features should be included such as for leg stroke, limb stroke and many more for product expansion so that the system would come into a package that combines all the rehab activities into one single software by using a Kinect only, other than that, a simple network integration could be added into this game, this would enable all users across the world become connected and allowing them to compete each other's to archives highest score, which would make the game more interesting to play. Therefore making another way of creating successful approaches to create an affordable, fun, modern, simple and multipurpose home-based rehabilitee application.

As we are concern now, many of the technology advancement have made a massive enhancement towards our surrounding nowadays. The usage of technology has proven its benefits and also its contributions for the betterment of the human mankind. Therefore, creating such an inspired solution such as Microsoft Kinect as an interactive input device has made significant changes in medicine history and also provides a future idea in VR healthcare application.

REFERENCES

Problem Statement

1   Physical Therapist, Retrieved February 26, 2011 from Bureau of Labor Statisticshttp://www.bls.gov/oco/ocos080.htm

2   K. Wiederhold (2006), "The potential for Virtual Reality to Improve Health Care", page 3-4.

Literature Review

3   Stephen Ellis, 'Nature and origin of virtual environments: a bibliographic essay', Computing Systems in Engineering, 2(4), page 325; Jon Palfreman and Doron Swade, The Dream Machine- Exploring the Computer Age Condon, BBC Books, 19911, pages 95-97.

4   Virtual Reality, Retrieved February 23, 2011 from Mid-market website
http://searchcio-midmarket.techtarget.com/sDefinition/0,,sid183_gci213303,00.html

5   Heim, Michael. The Metaphysics of Virtual Reality. New York: Oxford University Press, 1993.

6   Virtual Reality Technology, Retrieved February 23, 2011 from Ezine articles website
http://ezinearticles.com/?Virtual-Reality-Technology&id=4038501

7   Messner, J.I., Yerrapathruni, S.C.M., Baratta, A.J., & Whisker, V.E. (2003). Using virtual reality to improve construction engineering education.

8   Virtual Reality System, Retrieved February 29, 2011 from NCSA's Multimedia Online Expo website
http://archive.ncsa.illinois.edu/Cyberia/VETopLevels/VR.Systems.html

9   What is Virtual Reality? Retrieved February 23, 2011 from Micheal Louka website
http://www.ia.hiof.no/~michaell/home/vr/vrhiof98/whatisvr/What8.html

10 Rothbaum, B. O., Hodges, L. F., Kooper, R., Opdyke, D., Williford, J. & North, M. M. (1995a). Effectiveness of virtual reality graded exposure in the treatment of acrophobia. American Journal of Psychiatry, 152, 626-628.

11 Hodges, L. F., Rothbaum, B. O., Kooper, R., Opdyke, D., Meyer, T., deGraaff, J. J., Williford, J. S. & North, M. M. (1995). Virtual environments for exposure therapy. IEEE Computer Journal, July, 27-34.

12 Types of Rehabilitation, Retrieved February 27, 2011 from rehabilitation.org website
http://www.rehabilitations.org/types-of-rehabilitation.html

13 What is Physical Therapy Rehabilitation, Retrieved February 26, 2011 from wisegeek website
http://www.wisegeek.com/what-is-physical-therapy-rehabilitation.htm

14 Stroke Rehabilitation Information, Retrieved November 4, 2011 from National Institute of Neurological Disoders and Stroke.
http://www.ninds.nih.gov/disorders/stroke/stroke_rehabilitation.htm

15 Wiederhold, B. K., & Wiederhold, M. D. (2005a). The effect of presence on virtual reality treatment. In: B. K. Wiederhold& M. D. Wiederhold (Eds.), Virtual reality therapy for anxiety disorders: advances in evaluation and treatment (pp. 77–86). American Psychological Association.

16 Physiotherapy patients learn to enjoy boring exercise in virtual game environment, Retrieved February 28, 2011 from Virtual Medical Community website
http://www.hoise.com/vmw/00/articles/vmw/LV-VM-06-00-26.html

17 IREX, Retrieved March 3, 2011 from virtualworldlets.net website
http://www.gesturetekhealth.com/products-rehab-irex.php

18 Virtual Reality Transforming Physiotherapy, Retrieved February 29, 2011 from virtualworldlets.net website
http://www.virtualworldlets.net/Resources/Hosted/Resource.php?NewsMenu=Yes&Name=VRPhysio
1

19 Effectiveness of Virtual Reality Using Wii Gaming Technology in Stroke Rehabilitation, Retrieved April 21, 2011 from Stroke.org
http://stroke.ahajournals.org/cgi/content/short/41/7/1477

20 Oovit PT, Retrieved November 3, 2011 form NewMediaMedicine (MIT Media LAB)http://newmed.media.mit.edu/oovit-pt

21 Fishing Cactus presents R.O.G.E.R, Retrieved April 6, 2011 from fishing cactus blog
http://blog.fishingcactus.com/index.php/2010/10/07/fishing-cactus-presents-r-o-g-e-r-the-first-medical-kinect-serious-game/

22 Xbox Kinect Games to Slow Progression of Parkinson's, Retrieved November 1, 2011 from Industry gamers http://www.industrygamers.com/news/xbox-kinect-games-to-slow-progression-of-parkinsons/

23 Dennis A., Wixom B.H., Tegarden D. (2005), *Systems Analysis and Design with UML Version 2.0.* John Wiley & Sons, Inc.

24 Revolutionary in creating robust in-game character for motion games, Retrieved March 22, 2011 from activate3D website
http://activate3d.com/products/how-icm-works/

25 The ultimate tool for video game development, Retrieved March 23, 2011 from Unity3D website
http://unity3d.com/

26 The openNI Toolkit, Retrieved March 22, 2010 from openNi website
http://www.openni.org/

27 The NITE XML Toolkit, Retrieved March 22, 2011 from sourceforce
http://sourceforge.net/projects/nite/

APPENDIX

Milestone archived: 1, 2, 3, 4 and 5

Increment 1: Skeleton tracking developed using Microsoft Studio 2010.

No.	Activity / Month	January	February	March	April	May
1	**Increment A**					
2	Analysis			■		
3	Design				■	
4	Code				■	■
5	Test (Delivered)					■

Increment 2: Creating 3D model in Unity3D using Kinect Wrapper.

No.	Activity / Month	Sept	Oct	Nov	Dec	Jan
1	**Increment B**					
2	Analysis	■				
3	Design	■				
4	Code		■			
5	Test (Delivered)		■			

Increment 3: Creating the game environment using Unity3D.

No.	Activity / Month	Sept	Oct	Nov	Dec	Jan
1	**Increment C**					
2	Analysis		■			
3	Design		■			
4	Code			■		
5	Test (Delivered)			■		

Increment 4: Creating the score counter and remaining time counter.

No.	Activity / Month	Sept	Oct	Nov	Dec	Jan
1	**Increment D**					
2	Analysis		■			
3	Design		■			
4	Code			■		
5	Test (Delivered)			■		

Increment 5: Creating main menu and Score board.

No.	Activity / Month	Sept	Oct	Nov	Dec	Jan
1	**Increment E**					
2	Analysis			███		
3	Design			███		
4	Code			███		
5	Test (Delivered)			███		