" I hereby declare that I have read through this report entitle "Portable Physiotherapy Limbs Rehabilitation Robot – User Interface and Data manipulation" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering"

        Signature   : ....

        Supervisor's Name   : ....

        Date   : ....

PORTABLE PHYSIOTHERAPY LIMBS REHABILITATION ROBOT

USER INTERFACE and DATA MANIPULATION

TENG JIN CHUNG

**A report submitted in partial fulfilment of the requirements for the degree of
Bachelor of Mechatronic Engineering**

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2013

I declare that this report entitle "Portable Physiotherapy Limbs Rehabilitation Robot – User Interface and Data manipulation" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature   : ....

Name   : ....

Date   : ....

ACKNOWLEDGEMENT

In completing this project, I was help by a lot of great people including my supervisors and fellow postgraduate students. They have paid attention to my project and guide me throughout the whole project in completing the project and also report writing. My formal supervisor, Madam Nurdiana Binti Nordin @ Musa, who had went for further study, had been guiding me from the beginning of the project and proposal writing. I would like to express my sincere appreciation to her. I am also very thankful to my current supervisor, Dr. Ahmad Zaki Bin Shukor, who had given me a lot of advices and guidance in report writing. Without their guidance, this project may not be done.

My faculty, FKE, UTeM, deserve special thanks for providing me the fund for completing this project. Without their funding, I will not be able to done this project.

Last but not least, I would like say thank you to two of my fellow friends, Chang Ling Kwai and Tan Boon Chuan, who are completing the hardware part of PPLRR. Their idea for this project is appreciated and it was a pleasure working together with them.

ABSTRACT

This project focuses on the design of a User Interface for Portable Physiotherapy Limbs Rehabilitation Robot (PPLRR) which is a smart robot which provides full range of rehabilitation exercise (Active range of motion, Active-Passive range of motion and Passive range of motion) for disable people such as stroke patients. The existing rehabilitation robots are commonly designed for one mode of the rehabilitation exercise and do not offer proper display and record of exercise results. The objectives of the project is to design to design a user interface that can choose the exercise mode, start and stop the exercise, chose exercise difficulty, and exercise duration, to design a user interface that can show the quantitative result of the exercise, to analyse the result and show qualitative result of the exercise, and to record the patient's rehabilitation progress and make it accessible to patients and doctors. The user interface is built using Microsoft Visual Studio. The user interface proposed is a touch screen based interface for resolution 1024 x 768 pixels, which has a clean design and big buttons for the disable people and ageing people ease of use. The user interface will have easy way to navigate between different exercise mode and also a demo video play back to guide the user throughout the exercise. During the exercise, the interface will show the percentage of force reading of the user during the exercise for both left and right limbs. At the end of the exercise, the program will record all the force reading and drawn a graph to show the exercise progress to the user. A conclusion will be made from the graph about the exercise for the user to see their performance in the exercise. A smart file naming system will be included to record the result file in Excel format with filename include the exercise time and user name.

ABSTRAK

Projek ini memberi tumpuan kepada reka bentuk antara muka pengguna untuk "Portable Physiotherapy Limbs Rehabilitation Robot" (PPLRR) yang merupakan robot pintar yang menyediakan pelbagai latihan pemulihan (latihan Aktif, Latihan Aktif-Pasif, dan Latihan Pasif)bagi orang kurang upaya (OKU) seperti pesakit angin ahmar. Robot pemulihan yang sedia ada biasanya direka untuk satu jenis latihan pemulihan sahaja dan tidak memaparkan dan merekodkan keputusan latihan. Objektif projek ini adalah mereka bentuk antara muka pengguna yang boleh memilih mode latihan, memulakan dan menghentikan latihan, memilih kesukaran latihan, dan tempoh senaman, reka bentuk antara muka pengguna yang boleh menunjukkan keputusan kuantitatif latihan, untuk menganalisis keputusan dan menunjukkan keputusan kualitatif latihan, dan merekodkan kemajuan pemulihan pesakit dan membuat ia boleh diakses kepada pesakit dan doktor. Microsoft Visual Studio digunakan untuk membina antara muka pengguna untuk PPLRR. Antara muka pengguna yang dicadangkan adalah berasaskan skrin sentuh yang beresolusi 1024 x 768 piksel, dan juga mempunyai reka bentuk yang bersih dan butang besar untuk kemudahan penggunaan warga kurang upaya dan orang tua. Antara muka pengguna akan mempunyai cara yang mudah untuk mengemudi antara jenis latihan yang berbeza dan juga video demo akan dimainkan sebagai panduan bagi pengguna sepanjang latihan itu. Semasa latihan dijalankan, antara muka pengguna akan memaparkan peratusan kuasa pengguna semasa latihan bagi kedua-dua anggota kiri dan kanan. Pada akhir latihan, program ini akan merekodkan semua bacaan kuasa dan graf akan diplotkan untuk menunjukkan kemajuan latihan pengguna. Kesimpulan latihan akan dibuat dari graf untuk pengguna melihat prestasi mereka dalam latihan. Sistem penamaan fail akan merekodkan fail latihan dalam format Excel dengan masa latihan dan nama pengguna sebagai nama fail.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

According to World Health Organisation (WHO), there are around 650 million people live with disabilities of various types. The number is still increasing due to the rise of chronic diseases, injuries, car crashes, falls, violence and other causes such as ageing[1]. The increase of disable people led to the increase the need of physiotherapy treatment and rehabilitation facilities. This is the reason Portable Physiotherapy Limbs Rehabilitation Robot (PPLRR) is introduced. PPLRR is a smart robot which provides a full range of rehabilitation exercise (Active range of motion, Active-Passive range of motion and Passive range of motion) for disable people such as stroke patients. PPLRR provides cycle motion exercise which is simulating the walking motion and a cycle motion can exercise all of the muscles in the limbs. PPLRR has a special feature which can detect the force that the user is exerting on the handle of PPLRR. PPLRR will extract or retract the handle to prevent overstretching the user base on the force reading.

This project will only focus on the designing of the user interface and data manipulation. The hardware of PPLRR is done by other students. The user interface that is design is touch screen based and the resolution is limited to 1024 x 768 pixels.

1.1 Motivation

On 24th April 2007, a news report entitle "Killer stroke: Six Malaysian hit every hour" in The Star, it stated that six new cases of stroke occur every hour in Malaysia. Datuk Seri Dr. Chua Soi Lek, who is the formal Health Minister, also tell the news reporter that about 52,000 Malaysians suffered strokes annually when it is the most preventable of all life-threatening health problems[2]. Based on a study from National Stroke Association of Malaysia, it shows that of all those illness which require physiotherapy, stroke is the third largest cause of death in Malaysia after heart disease and cancer. Every year, estimated 40 thousand people in Malaysia suffer from stroke, which is the most common cause of severe disability[3].

It was clearly shown that physiotherapy is a need for those unlucky ones to rebuild their limbs strength in order to obtain a better quality of life. Disabled people would gain better chances of rehabilitation if they do physiotherapy more frequently. Referring to National Institute of Neurological Disorders and Stroke in USA, physical therapy may also be used to prevent contractures (permanent muscular contractions) and deformities of the bones, joints, and muscles that would limit recovery for those who emerge from coma, stroke or spinal injury[4].

1.2 Problem Statement

For disabled people, they need some rehabilitation equipment that can help them undergo rehabilitation. Most of the rehabilitation robot's user interfaces that already exist usually were designed for one kind of patient. So for an example, a stroke patient needs to undergo three stages of rehabilitation which is Passive state, Active-Passive state and Active state, so the patient need to use different tool during each state of rehabilitation stage. Besides that, these equipment need to be designed in a way that it will be easy to use especially for those who have difficulty in moving their arms. There are some products in the market which have a small touch display which is used to operate the machine. It was

not that convenient for some disable people to navigate around the user interface in a small screen which contain a lot of small buttons. One more thing that is not focused in most of the rehabilitation machine is the rehabilitation progress of the patient. Most machines will not display any result of the rehabilitation exercise and didn't analyse the result of the rehabilitation exercise. Patients and specialists are unable to trace back the rehabilitation progress of the patients. So a User Interface should be designed that will include all those features to solve the problem.

1.3   Objective

1. To design a user interface that can choose the exercise mode, start and stop the exercise, chose exercise difficulty, and exercise duration.
2. To design a user interface that can show the quantitative result of the exercise.
3. To analyse the result and show qualitative result of the exercise.
4. To record the patient's rehabilitation progress and make it accessible to patients and doctors.

1.4   Scope

1. This report concerns on the user interface and data manipulation part.
2. This report will not cover the mechanism and the choice of sensors and actuators.
3. There is also limitation which the user interface is design at resolution of 1024 x 768 pixels, other resolution setting may not get the optimized result.
4. For totally unconscious patients or patients who cannot move, they will still need help from other people such as family member or specialists to operate PPLRR user interface.
5. The other part of the project is done by:
   - Chang Ling Kwai   - Structure Design
   - Tan Boon Chuan   - Integration and Control

CHAPTER 2

LITERATURE REVIEW

This literature review will be split into four parts, which is i) study of available products user Interface, ii) designing the User Interface, iii) data Manipulation, and iv) a conclusion for the literature review.

Table 2.1: Overviews of literature review

Portable Limbs Rehabilitation Robot - User Interface and Data Manipulation Literature Review	Study of available products	• MOTOmed viva2 • Carex Pedal Exerciser With Digital Display • Comparison between available products and PPLRR user interface
	Designing the user interface	• Method to navigate between Exercise mode • Muscle force analysing • Method to choose the exercise mode • Exercise duration
	Data Manipulation	• Representation of Quantitative result • Analysing the result to show Qualitative result • Storing the result
	Conclusion for literature review	

2.1   A Study of Available Product

2.1.1   MOTOmed Viva2 User Interface

MOTOmed viva2 was an available limbs rehabilitation machine on the market right now. It aims to maximize therapy success and efficiency with easy operation with a screen and an intelligent user guidance, viewable therapy success (training feedback during the training and training analysis at the end of the training) and added future value. MOTOmed viva2 operating panel with colour display (11.3 x 8.5cm). The large colour display provides easy, clear and logical user guidance. There are only a few large physical buttons which always provide the functions needed, such as speed, direction and easy start of exercise[5].

Figure 2.1: MOTOmed Viva2 and the display[5]**.**

Figure 1.2: The display of MOTOmed viva2 while exercise is on-going[5]**.**

2.1.2 Carex Pedal Exerciser with Digital Display

Carex Pedal Exerciser with digital display is ideal for users with limited mobility and can be used on a table top as an arm exerciser or placed on the floor to exercise the legs. The digital display on the Carex Pedal Exerciser is able to show time, repetitions and calories burned[6].

Figure 2.3: Carex Pedal Exerciser with digital display[6]**.**

The display on the Carex Pedal Exerciser is too small to display too many data and information. It just limit to three kind of information which is the time, repetitions and calories burned[6].

Figure 2.4: The display on Carex Pedal Exerciser[6]**.**

2.1.3 Comparison between Available Products and PPLRR User Interface

Table 2.2: Comparison between available products and PPLRR user interface

	MOTOmed viva2	Carex Pedal Exerciser with digital display	PPLRR
More than one exercise mode	●		●
Display instruction video			●
Voice guidance			●
Display time	●	●	●
Colour display	●		●
Touch screen based user interface			●
Data recording	●		●
Accessible saved file (.xls)			●
Analyse the data	●		●

From Table 2.2, it is clearly shows that PPLRR user interface have more advantages compare to the other two available products in the market. Besides that, the exercise result file for PPLRR is saved in excel format. It can be printed out if the user or doctor wanted to, or it will be just saved in the hard drive of PPLRR and can be opened to view at any time.

2.2 Designing the User Interface

As a study on other existing rehabilitation robot, some are already equipped with a display. Visual information is one of the best ways to put the required knowledge on how to interact with the rehabilitation robot. Especially for elderly people with restricted abilities to memorize and often only slightly distinct computer literacy, this is one very important parameter to allow an effective and satisfying interaction with the rehabilitation robots.

The important features for the acceptance of technical assistance system by the older users are adequate visualization and direct feedback, a more intuitive handling of the functions, which makes the whole interaction process transparent to the user and thus allows a subjective impression of control over the robot activities. So, the design of the robot's user interface plays an important role, as this is perceived by many users as part of the system they can communicate and interact with[7][8].

Another rehabilitation system which uses Wii for balancing rehabilitation has a display to show the stepping activity, and the rehabilitation process. It has three bars, two vertical bars showing the force the patient putting on both left and right side, and another horizontal bar shows the total body weight placed on the rehabilitation apparatus[9]. It was a very good way to show the patient which side of their limbs are exercising and motivate the patient to try to use the less used limb to exercise more.

Besides that, a touch screen based user interface for the rehabilitation robot can offer a more portable size which has the advantages like fast access with different features to input the patient data, can effectively increase operator accuracy, reduces training time, and improves overall operation efficiencies[10].

There are a lot of ways to design a user interface; the most common way is by using Microsoft Visual Studio. There is option like QT Creator which also can be used to build the user interface. There is actually not much difference between the two software, both also offer C++ as the language to compile the software, but Microsoft Visual Studio offer more options in term of language and functionality. C#, VB.NET, F#, M, Python and Ruby as the programming language are also supported in Microsoft Visual Studio. Besides that, QT creator is still in a developing stage that the software is not that stable compare to Microsoft Visual Studio. So Microsoft Visual Studio will be used to design and build the user interface for PPLRR.

In choosing the language to use in building the user interface for PPLRR, the options are VB.NET, C++, C, C#, F#, Python, and Ruby. The most commonly use languages to program on the .NET Framework are C# and Visual Basic .NET. C# and VB.NET are syntactically different, but there is equivalent command between VB and C# for almost every command. So the language that will be used in this project will be VB.NET[11].

2.2.1 Method to Navigate between Exercise Modes

There are three stages of rehabilitation; Active stage, Active-Passive stage and Passive stage. Active stage is where the patient is conscious and is able to control their limbs but is still not fully functioning. Active-Passive stage is where the patient just got up from the unconscious stage and trying to regain the control of the limbs. Passive stage is where the patient is in coma or unconscious stage and totally unable to move. Different stages will need different kind of rehabilitation exercise[12][13].

Limbs movement dysfunctional mainly caused by injury of nerve centre or conduction system, which may lead to a decrease or disappear of the harmonious function in the muscle group of limbs, and it may affect the limbs to be unable to do the accurate actions. In the recovery process, most patients will experience the stage of antony, spasm, separation movement, partial separation movement and normal movement[12]. To fulfil the patients' different training requirements in different stages, different kind of training process must be designed to suit every patient.

There will be four exercise modes in PPLRR, so the user interface must have a way to navigate between the four exercise modes. The most common way is by using "tabs" or "multi-windows". There will be up to five windows if using the multi-windows method, four will be the exercise mode and one will be the main interface. So each time user want to switch to another exercise mode, user may face problem like the windows is hiding behind other windows. So by using tabs method is much better. To switch to another exercise mode, user will just need to click to the tab that the user wants to.

2.2.2 Muscle Force Analysis

Muscle weakness can be measured per se, or during the performance of a motor behaviour. Voluntary muscle force can be clinically measured by the British Medical Research Council manual muscle test. Quantification by isometric force measurements can be used too. Robotic rehabilitation devices are usually equipped with force transducers or force sensor, can therefore measure muscle force[14].

Motion controls strategies of rehabilitation robot are based on theories of movement function and rehabilitation, as well disease mechanism. The most widely used is force control strategy, which mainly applies force sensor to detect and control the interaction between the robot and the disease sites directly[12][15].

PPLRR is using four force sensors to read the force value when the user Pull and Push during the cycle motion exercise. All the force sensors are connected to a microcontroller which will send the force reading to the Intel Atom processor. To retrieve the force reading, serial communication is needed. The traditional way is by using Max232 IC to connect to the PC serial port. Since serial port had been shifted out from the laptop PC, it had been replace by USB. So USB to UART converter is the new method to allow communication between PC and microcontroller[16].

A total of four force values, left side pull, left side push, right side pull, and right side push, will be send to the Intel Atom processor. Force readings that are sent by the microcontroller are in STRING format, because it is the most effective way for the program to receive all the values in one shot. If it is sent in INTEGER format, there may be loses after some time of sending and receiving. The details of the manipulation of the force value will be show in Section 2.2 Data Manipulation.

2.2.3   Method to Choose the Exercise Difficulty

There are a few ways to create a list of difficulty for the user to choose, such as checked list box, combo box, radio buttons and more. Checked list box is a box which list down all the choices and user will need to select the choice by checking one of it.

Figure 2.5: Checked list box, combo box and radio buttons

Combo box is a box which will only shows one choice, the other choices will be opened by clicking the down arrow. And finally radio button is a list of choices and that will need user to click on the round button to select the choices. Since the user interface is touch screen-based, the radio button is the best choice because user may find difficulty when checking the checked list box and find difficulty when selecting the down arrow.

2.2.4   Exercise Duration

The exercise duration can be system preset or user-defined. For system preset exercise duration, it will not be flexible because user may want to have a longer exercise or very short exercise. By using numeric up down function in Microsoft Visual Studio, the user is allowed to set the duration of exercise freely.

Figure 2.6: Numeric Up Down function for exercise duration