GAME FOR ANKLE REHABILITATION

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I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature	:	……
Supervisor Name	:	DR KHAIRUDDIN BIN OSMAN
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DEDICATION

Dedicated to my beloved father and mother Hassan Shafii and Khadijah Hj Abd Rani.

ABSTRACT

An ankle injury can happen to almost everybody especially to active people who are vulnerable to ankle sprain injuries. The ankle rehabilitation is to regain full function without limitations and strength of ankle joint under therapist exercise. The purpose is to develop of this project is to develop an ankle rehabilitation system and design an interactive games and their connectivity. This system is a user-friendly device where it can move using the user's free will, thus giving the patient comfort to do the rehabilitation process. As the analysis in this system, gyro meter was put on the platform to measure the point angle of patient's feedback can achieve to analyze the performance of the patient that investigated the conditions of patient's ankle on ankle rehabilitation process. The results show the angle of the patient's ankle by playing the games using the platform that used Arduino IDE and Unity software while the data are collected using Microsoft Excel. This thesis presents an ankle rehabilitation system that are connected to an interactive game to replace the ankle rehabilitation system that connected via IoT with an Android devices from previous project. This thesis proposes different approach of ankle rehabilitation system that linked to interactive game to help the patients in ankle rehabilitation therapy.

ABSTRAK

Cedera pergelangan kaki boleh berlaku kepada hampir semua orang terutama kepada orang aktif yang terdedah kepada kecederaan luka pergelangan kaki. Pemulihan pergelangan kaki adalah untuk mendapatkan kembali fungsi penuh tanpa batasan dan kekuatan pergelangan kaki di bawah latihan terapi. Tujuan projek ini adalah untuk membangunkan sistem pemulihan pergelangan kaki dan reka bentuk permainan interaktif dan penyambungan mereka. Sistem ini adalah peranti mesra pengguna di mana ia boleh bergerak menggunakan kehendak bebas pengguna, dengan itu memberikan keselesaan pesakit dalam melakukan proses pemulihan. Sebagai analisis dalam sistem ini, meter gyro diletakkan di atas platform untuk mengukur sudut titik maklum balas pesakit boleh dicapai untuk menganalisis prestasi pesakit yang menyiasat keadaan pergelangan kaki pesakit pada proses pemulihan pergelangan kaki. Hasilnya menunjukkan sudut pergelangan kaki pesakit dengan bermain permainan menggunakan platform yang menggunakan perisian Arduino IDE dan Unity sementara data dikumpulkan menggunakan Microsoft Excel. Tesis ini membentangkan sistem pemulihan pergelangan kaki yang disambungkan ke permainan interaktif untuk menggantikan sistem pemulihan pergelangan kaki yang disambungkan melalui IoT dengan peranti Android dari projek terdahulu. Tesis ini mencadangkan pendekatan pemulihan pergelangan kaki yang berbeza yang dikaitkan dengan permainan interaktif untuk membantu pesakit dalam terapi pemulihan pergelangan kaki.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

DOF	:	Degree of Freedom
IoT	:	Internet of Things
2D	:	Two-dimensional
3D	:	Three-dimensional
API	:	Applications Programming Interface
VR	:	Virtual Reality
PCB	:	Printed Circuit Board
ROM	:	Range of Movement
ARES	:	Advance Routing and Editing Software

CHAPTER 1

INTRODUCTION

This chapter will be briefly explained the introduction, problem statement, objective, scope and also the thesis outline.

1.1 Introduction

Ankle rehabilitation is the treatment for patients who suffer from neurologic ankle injuries or musculoskeletal that effects muscles, ligaments, tendon or bones that caused by sprains, accidents or dislocations [1]. This injury happened when the ankle bends more than normal and affects or damages the ligament or worst it stretches or tear [2]. Normally the ligament needs six weeks to heal but depend on ankle sprain level [3]. In those six weeks, the patients need to do rehabilitation exercises such as inversion, eversion, abduction, adduction, dorsiflexion, and plantar flexion. As we are in the midst of significant transformation or known as Industry 4.0, the rehabilitation

using interactive games offer more successful therapy to patient. It is convenient to promote physical exercise for therapeutic uses for rehabilitation, balance and management of illness [4]. Traditionally, the therapist used physiotherapy treatment for patient, but it is insufficient and can be more effective if assist by technology [5]. Using games for ankle rehabilitation focus on solution for patients to supply them with sustainable progress throughout the treatment. It is design and develop to know the ability of patient for therapeutic purpose. Figure 1.1 shows the ankle structure.

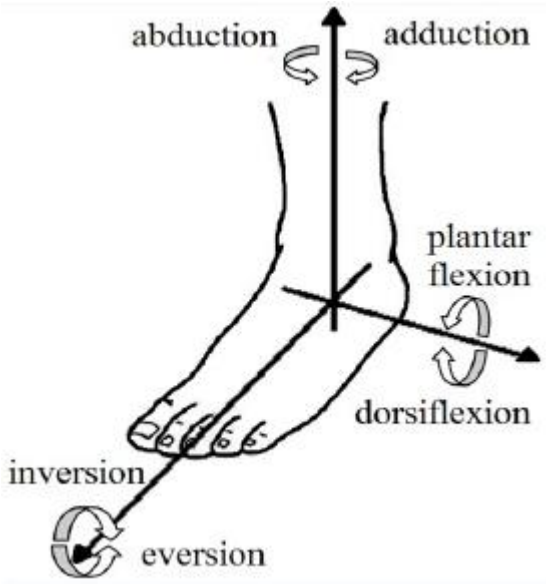

Figure 1.1 Ankle structure

1.2 Problem Statement

Since we are living in this technology century, the technology involves robotic assist and gaming have been developed rapidly throughout the year but most of ankle rehabilitation system does not connect to interactive game. Presently, mouse and keyboard is used by the robot users input instructions to the control system. Researches had identified the new alternative to replace existing therapy as it is inconvenient.

Ankle rehabilitation manually is not efficient to use. The development had changed to fulfil the requirement of Industry 4.0 but the system before does not interactive and user friendly so it might lose user's interest. Hence, this project aims at making advanced technology that use a hardware and games for ankle rehabilitation. The purpose of using this new technology is to provide comprehensive analysis on the effectiveness of ankle rehabilitation [6]. This led to different approaches of technology-assisted therapy.

1.3 Objective

The objectives of this project are as follows:

i. To develop a hardware for ankle rehabilitation system.

ii. To design an interactive game and the connectivity between ankle rehabilitation system.

iii. To analyze the performance of the patient that investigated the conditions of patient's ankle on ankle rehabilitation process.

1.4 Scope of Work

The scope of work of this project are as follows:

i. Need to design a controller system using servo motor and Arduino platform with gyrometer.

ii. The prototype can use 3-Degree of Freedom (DOF) to move ankle to the 3 step angles which can execute ankle inversion/eversion rotation (x-axis),

dorsiflexion/plantar flexion rotation (y-axis) and abduction/adduction rotation (z-axis).

iii. Need to develop an interactive game and the connectivity between ankle rehabilitation systems.

iv. Include games movement via 2D development with features and functionality based on prototype.

1.5 Thesis Outline

The structure of this thesis is classified into five primary chapters that are an introduction, literature review, methodology, result and analysis, discussion and conclusion and future work.

Chapter 1 briefly describes the introduction and overview of the conducted project. This part also covers about the problem statement, objectives and scope of the project.

Chapter 2 comprise the literature review which is the most crucial part that interrelated to the project. This chapter begins with the ankle rehabilitation system background studies.

Chapter 3 discussed the methodology part. This chapter focuses on the procedure that takes place to complete this project including general project progress and project flow chart is conferred. This part will also explain the specific flowchart of the procedure taken to recognize any specific steps for the project.

Chapter 4 involve the results and discussion of the whole project. This chapter discussed step by step of the design of the system and detailed part modelling. All the findings with diagram, table, and graph will be presented in this chapter.

Chapter 5 is about conclusion that consists of the project summary that conclude the overall project accomplished from objective. After the projects are completed, recommendations for future work are made for an advance project product or enhancement that might be done in the future.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

The ankle sprain is very common to occur and takes time to heal and the patients also need to do rehabilitation exercises that require them to work with the therapists [7]. Intensive rehabilitation is applied nowadays in this technology world that used interactive games as one of the rehabilitation tools in physical therapy. The current treatment strategy is to ensure safe and rapid recovery. It combines interactive games with advanced technology to motivate patients throughout different stages of the therapy program [8]. It offers interactive exercise to see patient's progress and performances on single session that specify on movement of ankle. Basically, we will design the prototype and develop the games based on the step angle for x-axis, y-axis and z-axis. Mostly two Degrees of Freedom (2-DoF) is used in the previous technology of ankle rehabilitation system which the user can only tilt their feet using the platform to the x-axis and y-axis [9][10]. The positions or angle of the ankle about

three orthogonal anatomical planes or 3 degrees of freedom (3-DoF) will be designing to combine all three movements of plantar flexion/dorsiflexion rotation, abduction/adduction rotation and inversion/eversion rotation [11]. The games is developed by gaming software that is Unity and we will analyze the performance of the patient that investigated the conditions of patient's ankle on ankle rehabilitation process. It is a combination of motivational games with advance sensor technology that let us know the ability of patients by using this system. All the data are collected and analyze so that we can see the progress of the patients who suffered from ankle strains.

2.2 Degree of Freedom

Mostly in the previous technology of ankle rehabilitation system are two Degrees of Freedom (2-DoF) which the user can only tilt their feet using the platform to the x-axis and y-axis or any other combination of two axes (2-DoF) only [12][13][14]. This is the most simple and less number of actuator is used to move the platform and less footwork exercise will be given to patients.

In this design, the positions or angle of the ankle about three orthogonal anatomical planes or 3 degrees of freedom (3-DoF) will be design to combine all three movements of plantar flexion and dorsiflexion rotation, inversion and eversion rotation and abduction and adduction rotation. The angle range must accurate to make sure the ankle in a good position and successful in order to heal ankle sprain [15]. This 3 degree of freedom is enough to cover all the footwork as the actual movement in human life.

Six Degree of Freedom (6-DoF) has more footwork compare to three Degrees of Freedom (3-DoF) but will be too complex and need a lot of actuators to control. It also will increase the price but based on six degrees of freedom analysis shows better