DESIGN AND DEVELOPMENT OF INTERNET OF THINGS (IOT) ENABLED WHEELCHAIR INCLINATION AND GEOLOCATION FOR WHEELER REHABILITATION FITNESS ASSESSMENT

LAI MOON CHIN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF INTERNET OF THINGS (IOT) ENABLED WHEELCHAIR INCLINATION AND GEOLOCATION FOR WHEELER REHABILITATION FITNESS ASSESSMENT

LAI MOON CHIN

This Report Is Submitted in Partial Fulfilment of Requirements for The Bachelor Degree of Electronic Engineering (Telecommunication Electronics) With Honours

Fakulti Kejuruteraan Electronic dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

June 2017

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : DESIGN AND DEVELOPMENT OF IOT ENABLED WHEELCHAIR INCLINATION AND GEOLOCATION FOR WHEELER REHABILITATION FITNESS ASSESSMENT

Sesi Pengajian : 1 6 / 1 7

Saya LAI MOON CHIN

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐	**SULIT***	*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD****	**(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

DR HO YIH HWA
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya

(COP DAN TANDATANGAN PENYELIA)

iii

"I hereby declare that the work in this project is my own except for summaries and quotations which have been duly acknowledge."

Signature : ....

Author : Lai Moon Chin

Date : 2th June 2017

iv

"I acknowledge that I have read this report and in my opinion this report is sufficient in term of scope and quality for the award of Bachelor of Electronic Engineering Electronic Telecommunication with Honour's."

Signature : ....

Supervisor's Name : Dr. Ho Yih Hwa

Date : 2^{th} June 2017

To my beloved family, friends and project supervisor

ACKNOWLEDGEMENT

First of all, I am grateful to be able to undergo my Final Year Project in Universiti Teknikal Malaysia Melaka (UTeM). This project would not be accomplished without the constant support and endless effort of a number of individuals. During this period, I have acquired new knowledge and broaden my vision to the world of electronics. I want to take this opportunity to express my deepest gratitude towards my supervisor, Dr. Ho Yih Hwa on behalf of Faculty of Electronic and Computer Engineering, who concerns and took care of me along the way in completing my project. The motivation and encouragement for the past year are sincerely a thrust to complete this project. In addition, I would like to give my greatest thanks and appreciation to my co-supervisor, Dr. Lim Kim Chuan in giving encouragement when I was facing problem. This project cannot be finished without his advice and cooperation. Also, I would like to thank my family members for their understanding and patience during the development of this project. They are always by my side and being supportive whenever and wherever I need. Their motivational skills are unsurpassed. Their ceaseless mental and moral supports motivate me in accomplishing this project. Last but not least, deepest acknowledgment is given to the master senior, Tan Kien Leong and Mohamed Mahmoud who has been spending their precious time to assist and help me in solving my problems throughout this project. I would like to send my warmest regards for their seamless caring and continuous encouragement which strengthen my confidence to finish my project. I am indebted to those people who gave me their helping hands

ABSTRACT

Rehabilitation is a treatment designed to facilitate the process of recovery from injury, illness, or disease to as normal a condition as possible.[1] Learning how to be mobile and live independently with wheelchair is the main aim of rehabilitation for those who suffered lower limbs impairment from spinal cord injury (SCI). However, currently there is no suitable system that capable to monitor the training condition of wheeler throughout the rehabilitation treatment. This report presents the design and development of a fitness assessment system which allow physiotherapist to monitor the rehabilitation progress of their patients closely. By implementing gyroscope together with accelerometer, the terrain slope can be identified. With this inclination data, physiotherapist able to detect the difficulty level such as an inclined ramp that encountered by wheeler who undergoes rehabilitation training. Depressed patient with cognitive thinking tends to give up and roams around during training session. Geolocation routing is achieved with a GPS module and Google Map API to track down the location of wheeler. A mobile application applying Bluetooth technology is developed for automated data collection from Arduino 101 and Polar H7 heart rate sensor. By using the mature internet of things (IoT) technology, the system is able to perform real-time monitoring of patient and connecting the patient with physiotherapist. Patient's rehabilitation progress will be improved when physiotherapist use their professionalism to provide accurate assessment based on the quantitative and qualitative feedback from the monitoring system.

ABSTRAK

Rehabilitasi merupakan rawatan yang khas direka untuk memudahkan proses pemulihan daripada kecederaan atau penyakit untuk mencapai keadaan sembuh yang semungkin.[1] Kemampuan untuk menjadi mudah alih dan hidup berdikari dengan kerusi roda merupakan matlamat utama rehabilitasi bagi mereka yang kehilangan upaya untuk berjalan akibat kemerosotan daripada kecederaan saraf tunjang (SCI). Walau bagaimanapun, pada masa kini, tidak ada sistem yang sesuai dan mampu memantau keadaan latihan pesakit sepanjang tempoh rawatan rehabilitasi. Laporan ini membentangkan reka bentuk dan pembangunan sistem penilaian yang membolehkan ahli fisioterapi untuk memantau kemajuan pemulihan pesakit dengan mudah. Dengan pelaksanaan sensor giroskop bersama dengan sensor pecutan, kecerunan rupa bumi boleh dikenal pasti. Sejerusnya, ahli fisioterapi boleh mengesan tahap kesukaran yang dihadapi oleh pesakit yang menjalani latihan rehabilitasi. Pesakit yang mengalami pemikiran cognitif merayau semasa rawatan rehabilitasi. Perhubungan Geolokasi antara pesakit dan fisioterapi dicapai dengan penggunaan modul GPS dan pelaksanaan Google Map API. Oleh itu, lokasi pesakit boleh dijejaki. Satu aplikasi telefon mudah alih yang merealisasikan teknologi Bluetooth dicipta untuk proses pengumpulan data secara automatik daripada Arduino 101 dan Polar H7, satu sensor yang mengesan kadar jantung. Dengan menggunakan teknologi IoT, sistem yang dibangunkan mampu melaksanakan pemantauan rawatan rehabilitasi serta-merta. Platform yang dicipta mampu menghubungkan pesakit dengan ahli fisioterapi. Proses pemulihan pesakit akan bertambah baik apabila fisioterapi mampu memberi penilaian rawatan yang tepat dengan maklum balas kuantitatif dan kualitatif yang didapati melalui sistem pemantauan yang telah dicipta.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADC	Analogue to Digital Converter
API	Application Program Interface
ATT	Attribute Profile
BLE	Bluetooth Low Energy
CSS	Cascading Style Sheet
DOF	Degree of Freedom
EXIF	Exchangeable Image File Format
FKEKK	Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
GATT	Generic Attribute Profile
GLONASS	Globalnaya Navigazionnaya Sputnikovaya Sistema
GPS	Global Positioning System
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
I2C	Inter-Integrated Circuit
IAB	Internet Architecture Board
IDE	Integrated Development Environment
IIoT	Industrial Internet of Things
IMU	Initial Measurement Unit
IoT	Internet of Things
IP	Internet Protocol
JSON	JavaScript Object Notation
MAC	media access control
MCS	master control station
PCL	Point Cloud Library
PNT	positioning, navigation, and timing
RF	radio frequency
RFID	Radio Frequency Identification
RGB-D	Red Green Blue - Depth
ROS	Robot Operating Systems
SCI	Spinal Cord Injury
SIG	Special Interest Group
SPI	Serial Peripheral Interface
TS	Typescipt
TTFF	Time to First Fix
UART	Universal Asynchronous Receiver/Transmitter
UAV	Unmanned Aerial Vehicle
UI	User Interface

US	United State
UTeM	Univeriti Teknikal Malaysia Melaka
UUID	Universally Unique Identifier
WHO	World Health Organization

CHAPTER I

INTRODUCTION

This chapter introduce the overall concept of the project. The objectives and problem statement will be discussed. This chapter also included the scope of work for this project. Moreover, a brief discussion on methodology will be included. The overall structure of this report will be explained in this chapter.

1.1 Project Introduction

According Wealth Health Organization (WHO), rehabilitation of people with disabilities is a process aimed at enabling them to reach and maintain their optimal physical, sensory, intellectual, psychological and social functional levels. The purpose of rehabilitation is to optimise patient's sensory, physical, and mental capabilities that were lost because of severe injuries, illnesses, or diseases to attain independence and self-determination. Besides, rehabilitation integrate patient back into the lifestyle activities that they have chosen, whether it is at home, work or leisure. Training for patient to compensate for deficits that cannot be reversed medically also included in the rehabilitation treatment. Treatment should start as soon as possible to speed up recovery. It is prescribed after many types of injury, illness, or disease, including amputations, neurological problems, brain injuries, stroke, and spinal cord injuries.[2]

Spinal cord injury (SCI) is damage to the spinal cord that results in a loss of function, mobility, and/or feeling. According to National Spinal Cord Injury Statistical Centre, in the year 2016, people in the U.S. who have SCI are estimated to be approximately 282,000. The average age of injury is around 42 years old. Male has accounted approximately 80% of the SCI cases. The healthcare cost and living expenses of a SCI person vary greatly based on education, neurological impairment, and pre-injury employment history. It is estimated an average cost of $72,047 dollars will be spent by a SCI person per year in 2015. Currently, vehicle crashes are the leading cause of injury, followed by falls, acts of violence and sport injury.[3]

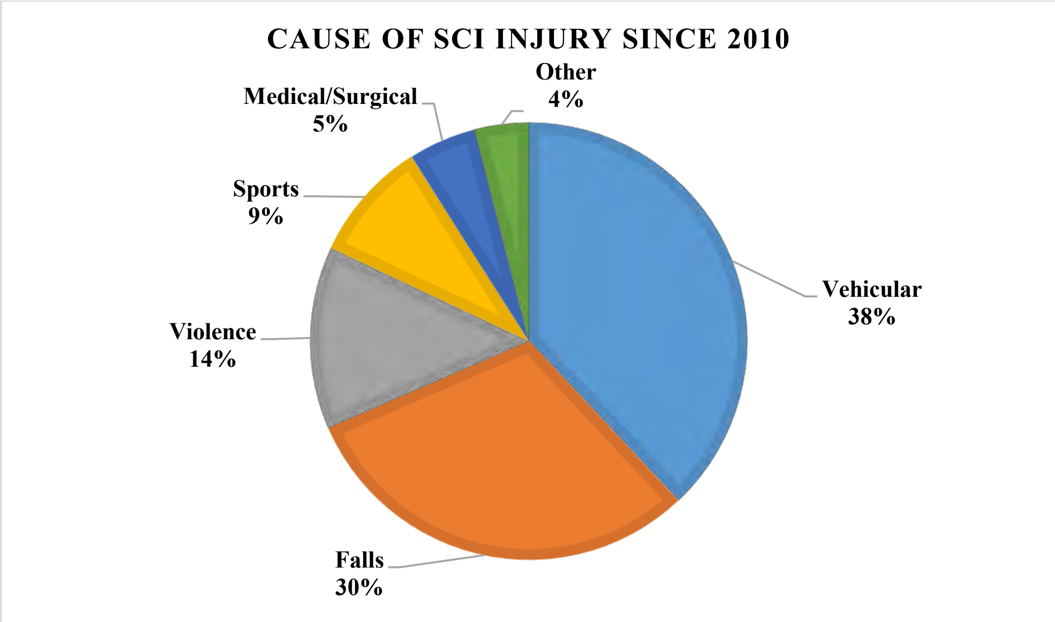

Figure 1: Causes of SPI since the year of 2010

To date, there is still no cure for SCI.[2] Hence, a wheelchair became the most important method of locomotion for the SCI patients. Rehabilitation program prepares wheeler to be mobile in daily life with wheelchair and train their mentality so that they are ready to go back home, returning to the community, and ready for the workplace. However, depression and cognitive thinking of patient after their injuries has hindered the rehabilitation progress. Patients are demotivated in their training and will roam around the training area. Moreover, the patients may face difficulties such as inclined track, declined track, or rough roads during their training. By monitoring the terrain slope that the patient undergoing in real time, physiotherapist able to identify such difficulties. The location tracking of the patient is also important for physiotherapist to track back patient with cognitive thinking that has roamed around training area. Automatic collection of relevant data in real-time can be achieved with the Internet of Things (IoT) enabled technologies and platforms. With such system, physiotherapist can deliver qualitative and quantitative advice to the patient and suggest the most suitable rehabilitation course for the patient. Besides, the management team will be able to allocate the limited resources wisely through the monitoring system. Therefore, seamlessly connecting the wheeler and the physiotherapist help to streamline the healthcare process.

1.2 Problem Statement

The first problem of this study is that physiotherapist unable to determine the difficulty level that faced by wheeler when moving around training track. Propelling a wheelchair over a flat or inclined terrain will give different impact on the patients' muscle training. When ascending ramps with manual wheelchairs, shoulder forces and moments more than double. Without knowing whether the patient capable of propelling over the inclined terrain results the physiotherapist misjudgement on patient performance which in return a poor medical plan will be delivered.

Moreover, physiotherapist is unable to locate the wheeler accurately when wheeler undergoes rehabilitation on the track away from the centre. Depression comes when the functionality of one who was fully abled was compromised by diseases or accidents. Consequently, cognitive thinking will lead patient to give up their training and roaming around the centre. Such condition brings inconvenience to physiotherapist when training was undergoing.

Seamless data transmission must be implemented to allow upload of information to the physiotherapist in the centre for real-time monitoring. With this implementation, physiotherapist is able to have close monitor on the condition and performance of the patient without interviewing the patient which always return inaccurately feedback regarding their treatment.

1.3 Objectives

This project aims to achieve the following objectives:

1 To design and develop a wheelchair fitness assessment system that physiotherapist able to monitor the rehabilitation progress of their patients.
2 To design a platform whereby doctors and patients always stay connected.
3 To increase the involvement of patients in rehabilitation process.

1.4 Scope of Work

The following describes the scope of the work that will be completed in order to develop a wheelchair fitness assessment system. The scope is organised into 4 tasks.

In task 1, the integration of Arduino 101 with NEO6M GPS module will be carried out to generate inclination data (degree) and geolocation data (latitude and longitude). The integrated hardware will then attach to the wheelchair. Furthermore, these data will be sent out to a mobile application via Bluetooth connectivity that embedded on the Arduino 101.

In task 2, a mobile application that aggregate multiple connections via Bluetooth connectivity will be built using Ionic 2 platform. These connections will receive data including inclination degree, geolocation data, heart rate bio-signal, mileage and self-propelling detection. All the received data will be displayed on the mobile application user interface. A Google map is included to show the location of the patient. All these data is then sent to a server created on Azure via web-socket.

In task 3, feature that will be able to locate the physiotherapists' location and route them to the location of patient which received from the mobile application will be implemented on a server.

In task 4, a web user interface that displays the routing of physiotherapist location to patient location will be built.

In this project, there are few tasks that will not be included. The first excluded task is the creation of server that will be deployed on Azure. This scope of work is completed by the collaborator in this project. Second excluded task is the display of inclination degree, heart rate bio-signal, and mileage of the patient on webpage. This scope of work is done by the previous mentioned collaborator. In addition, the detection of wheeler propelling condition and calculation of mileage is accomplished by another collaborator.

1.5 Report Structure

The main structure of this technical report is divided into 5 main chapters1. In Chapter I of this technical report, introduction about the project is reviewed. Moreover, the objectives and problem statement of the project are discussed. Then the scope of work and this report's structure is briefly explained.

Chapter II focused on the literature review of the project. Topic and concept that are related to the project are briefly explained. In addition, related field of work are discussed from different point of view.

Chapter III explained the methodology implemented to solve the problems in this project. It discussed about the method used to collect, process and analyse data. A flow chart is included to act as a guideline for the progress of the project.

In Chapter IV, all the findings of the project are shown and explained. The outcomes are discussed from the perspective of objective and problem statement.

Chapter V, the concluding chapter is about summarising the results of the project and suggestions are made for future research. The conclusion of the data that has been collected is reviewed with the objectives and methodology of the project.

CHAPTER II

LITERATURE REVIEW

The previous chapter has deliberated the problem statements and objectives of this project. This chapter will review about the applied technology in this project. Related work from other researches has been studied and examined.

2.1 Geolocation

The wireless detection of the physical location of remote devices is known as geolocation. Geolocation also refers to the physical location itself or the process of detecting a location.

Geolocation data is generally used for three reasons:

- Geo-Positioning: Find an object or a person on a map based on the physical location of that object or person.
- Geo-Coding: Used to search the available types of objects and services based on the list provided relative to the physical location
- Geo-Tagging: Geographic data is embedded into an object's metadata as reference for others

Generally, geolocation is used to locate human or object. It is used in a variety of applications that implement such function. Geolocation mostly work with Global Positioning System (GPS) in a device. Besides GPS, geolocation also may work through an Internet Protocol (IP) address, media access control (MAC) address, radio frequency (RF) systems, Exchangeable Image File Format (EXIF) data and other wireless positioning systems. The existing and planned systems are:[4]