# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# DEVELOPMENT OF WIRELESS MONITORING DEVICE FOR PATIENTS UNDERGOING LIMB JOINTS PHYSIO REHABILITATION via IoT SYSTEM

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

by

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FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING

TECHNOLOGY

2018

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TAJUK: **DEVELOPMENT OF WIRELESS MONITORING DEVICE for PATIENTS undergoing LIMB JOINTS PHYSIO REHABILITATION via IoT SYSTEM**

SESI PENGAJIAN: **2018/19 Semester 1**

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# APPROVAL

This report is submitted to the Faculty of Electrical & Electronic Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Telecommunications) with Honours. The member of the supervisory is as follow:

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PUAN RAHAINI BINTI MOHD SAID

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# ABSTRACT

Our country has been battling a critical issue at which the lack of physiotherapist alongside growing number of physiological patients is often highlighted. Hence, one of the proposed solutions was developing an affordable yet effective physio self-rehabilitation device that can be utilized in private residence. This concept would greatly benefit those patients who are currently experiencing difficulties such as long waiting list, outdated equipment, transportations issue to rehabilitation center and high consultation cost. Hence, an idea was born to develop a wireless monitoring device that emulates the physio rehabilitation via IoT system. This allows patient to self-rehabilitate and be monitored in real time at the comfort of their home without the physical presence of a physiotherapist. This project is based on the planning, build and testing of an experimental prototype system with the aim of studying the feasibility and potential benefits to the patients. Literature is reviewed in the fields of physiology, modernized rehabilitation and IoT in medical applications in existing systems and future technology. The prototype system also aims to replicate an interactive method of communication between patients and physiotherapist which is done remotely using a smartphone app. This app would also present an illustration of relevant information to patients of their rehabilitation progress in graphical form while also recording their personal feedback. Lastly, a controlled test involving patients alongside fit and healthy correspondents will be conducted to investigate the efficiency of the device and obtain the necessary input and feedback on this concept. The outcome of the study was illustrated in graphical representation in the form of performance index and EMG data which can then be analyzed by the physiotherapist.

**Keywords- self-rehabilitation; IoT; remote monitoring; Bluetooth; EMG.**



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# ABSTRAK

Negara kita kerap menghadapi isu kritikal berkenaan kekurangan ahli fisioterapi tambahan pula dengan peningkatan jumlah pesakit fisiologi sering menjadi tumpuan masyarakat. Oleh itu, salah satu jalan penyelesaian dicadangkan adalah membangunkan sebuah alat pemulihan diri physio yang efektif yang boleh digunakan di kediaman sendiri. Konsep ini amat memberi manfaat kepada pesakit yang sering mengalami masalah seperti senarai menunggu lama, peralatan uzur, masalah pengangkutan ke pusat pemulihan dan kos konsultasi yang tinggi. Oleh itu, satu idea dicetuskan untuk membangunkan peranti pengawasan tanpa wayar untuk pemulihan fisio melalui sistem IoT. Ini membolehkan pesakit untuk memulihkan diri dan dipantau di kediaman mereka tanpa kehadiran pakar fisio. Projek ini adalah berdasarkan perancangan, membina dan menguji sistem prototaip dengan tujuan untuk mengkaji sumbangan manfaat kepada pesakit. Pengajian kesusasteraan dikaji teliti dalam bidang fisiologi, pemulihan moden dan pengunaan IoT dalam aplikasi perubatan dalam sistem sedia ada dan teknologi masa depan. Sistem prototaip ini juga bertujuan untuk menghasilkan kaedah komunikasi interaktif antara pesakit dan ahli fisioterapi yang dilakukan menggunakan aplikasi telefon pintar. Aplikasi ini juga akan membentangkan ilustrasi maklumat yang relevan seperti kemajuan pemulihan mereka dalam bentuk grafik dan merakam maklum balas peribadi mereka. Akhir sekali, ujian terkawal yang melibatkan pesakit dengan individu yang sihat dan cergas akan dijalankan untuk menyiasat kecekapan sistem dan mendapatkan input dan maklum balas yang diperlukan mengenai konsep ini. Hasil kajian dipaparkan secara terperinci dalam bentuk graf iaitu indeks prestasi and data EMG untuk dibuat penyelidikan selanjutnya oleh pakar fisioterapi.

**Kata kunci- self-rehabilitation; pemulihan diri; IoT; Bluetooth; EMG.**



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# DEDICATION

This Bachelor Degree Project is dedicated to all the physiological patients who have long been waiting for a low cost in-home physio self-rehabilitation device which would significantly eases their burden of receiving rehabilitation. This much needed solution was proposed and materialized with the hopes of assisting them have always been in my thoughts throughout this journey. I genuinely believe every patient deserves an equal and affordable medical treatment regardless their financial capabilities and background. Hence, I strong believe nobody deserves to be suffering from the lack of treatments accessibilities and options.



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# ACKNOWLEDGEMENT

Salam Sejahtera,

I would like to express my sincere feeling of being thankful and grateful for the effort and help from my friends, family and study colleagues in order to complete this project entitled "**Development of Wireless Monitoring Device for Patients Undergoing Limb Joints Physio Rehabilitation via IoT System** " which fulfills the requirement of my Bachelor Degree Project. Their involvement directly or indirectly throughout the completion of this report is very much appreciated.

Most importantly, I would like to show my upmost gratitude to Madam Rahaini Binti Mohd Said for playing the part as my project supervisor and providing encouragement and constructive suggestions which have improved the quality of the work. She has been instrumental in guiding me in the right path whenever I seemed to deviate or lose focus in the process of completing this project. This also includes Encik. Fauzan Bin Kadmin who is the co-supervisor as they helped me when I seem to have doubts and also guided me to complete this project precisely. Additionally, I would also like to extend my grateful acknowledgement to other lecturers of Universiti Teknikal Malaysia Melaka who may have been indirectly involved in giving me proper guidance along this journey.

Lastly, special thanks to my friends and family for the abundance of love, support and encouragement as nothing would have been possible without them. Also,



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I would like to thank everyone else for giving me the strength and guidance to go through the entire rough patch I went through during the completion of this project and also my classmates for playing a crucial role in adding the finishing touches to this project. In addition to that, I would also like to also thank Faculty of Engineering Technology (FTK) for presenting me this opportunity to showcase my skills and capabilities in executing the final year project and providing the right platform that allows me to fulfill my desire and ambition in completing this project. Besides that, this experience allowed me to gain valuable vast knowledge and skillset required in order to graduate as a proficient and competent Engineering Technologist graduate.

Thank You.



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# CHAPTER 1

# INTRODUCTION

## 1.0 Background

In this modernization era, one of the community issue that are widely talked about among the general public is the never ending shortage of physio specialists in the physiotherapy field being one of the rising concerns in the past decade. At the moment, Malaysia has an underwhelming doctor to population ratio of 1:633 whereby the government has set a target to achieve a 1:400 ratio by the year 2020 [1]. In regards to that, several attempts have been carried out across the globe in order to present a constructive solution to this matter.

Additionally, failure to seriously pinpointing and solving this issue often leads to patients being severely compromised as this particular group of patient suffers basic disabilities which may affect their process of recovery if not treated accordingly. Consequently, for the conduct of bachelor degree project entitled “Development of Wireless Monitoring Device for Patients Undergoing Limb Joints Physio Rehabilitation via IoT System“, an electronic device was proposed which could emulate the rehabilitation therapy specifically tailored for neurologic patients which is designed in a manner that focuses a significant accentuation on treating and providing supportive care as well as nursing for the well-being of the patient.



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This form of therapy protects the patient against any probable risk of complications and simultaneously preserves tissue strength and function during the recovery period. With the advancement of technology, the development of an effective self-rehabilitation mechanism could able to deliver a more progressive rehabilitation strategy while subsequently reducing the heavy load of therapists. The role of self-rehabilitation programs using IoT technology comes into the frame as it represents a modernized and groundbreaking treatment for neurological patients.

Most likely to rehabilitate upper limb impairments, it emphasizes on improvising current technique of physio exercises and encourage disciplined participation. Furthermore, it allows patients to self- rehabilitate with the latest technological advances by performing simple exercises and self-mobilization aimed to independently perform the feasible and inexpensive method of therapy with the implementation of this project without needing the physical presence of a therapist. It is regarded as a promising approach in the field of rehabilitation (Mohd Nordin *et al.*, 2014), particularly in developing countries like Malaysia where rehabilitation costs are often too expensive alongside long waiting list [2].

In order to further gain additional information regarding the current method of rehabilitation system being utilized these days, I have decided to approach and held constructive interview with several patients who are currently undergoing physio rehabilitation in order to obtain their first-hand experience input and their genuine views regarding the current system offered to them. I will focus and scrutinize on the common problems and limitations faced by the patients when undergoing their treatment and willing to be open to their suggestions which could be realistically be implemented in this project. Through this approach, I could get directly to the actual problem statement and have a clearer picture on ways to improve the rehabilitation for the benefit of both patients and physiotherapists.



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Hence, in order to combat the current complications faced by the patients in their physio rehabilitation, therefore a wireless monitoring device was planned to be developed to assist the patients experiencing various difficulties while undergoing physio rehabilitation. Using this device, patients could able to perform self-rehabilitation at the comfort of their home without the physical presence of a physiotherapist. Ideally, the patient would simply have to strap to device, turn on and carry out the similar rehabilitation technique as performed routinely from the physio sessions. The device retrieves the relevant data from the conducted session before being transmitted directly to the patient smartphone. A custom made Android app will be installed in the patient's smartphone in order to process the data and would produce graphical interface and statistics of their progress. Simultaneously, these data will also be transmitted to web server whereby the doctor could able to monitor the current progress from their office workstation. Additionally, patient could leave a comment or remark after the exercise for further diagnosis remotely by the physiotherapist.

## 1.1 Problem Statement

One of the rising problems that is gradually becoming the concern of the community is the rising number of patients waiting to seek physiotherapy treatment due to lack of physiotherapist to cater the overwhelming demand. Additionally, the increasingly frustrating long waiting list for the patients waiting for their turn to seek rehabilitation also poses a side effect if not treated in time. According to a recent scientific research, approximately 40% of individuals who experienced conditions such as stroke, physical trauma and paralyze are most likely to develop mild to moderate functional impairments such as joint stiffness or dead limb if treatment was not provided on time.



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Therefore after conducting several extensive studies, many researchers and also professionals from the medical field come into an agreement that a quick treatment conducted on the early stages of continuous rehabilitation will be extremely crucial to enhance the patient recovery progress and reduce the risk of any potential side effects from prolonged and delayed recovery process. From another perspective, one way of solving this problem is producing a wireless device which allows the patients to perform self-rehabilitation without the presence of physiotherapist.

The device will automatically record all relevant data of the current active exercise and generates a graphical illustration for the patient reference before transmitting the data wirelessly to web server to be analyzed by a certified physiotherapist for further analysis. As compared to current existing devices for physio rehabilitation therapy which are huge in size, complex, and not portable, this device will be compact, wireless and equipped with rechargeable battery for remote self-rehabilitation and added portability. It supports wireless communication which eliminates the needs for manual data collection as well as being user friendly and offers ease of use. Although there is various third party rehabilitation mechanisms available in the market, most of the devices are outrageously priced and does not offer the ideal solution that would benefit the patients alike. Hence, this device if materialized as part of PSM project would offer a low cost solution equipped with high functionalities to enhance the desired outcome to cater to the needs of the patients who deserves a proper medical solution for an affordable price.



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## 1.2 Objective

Upon analyzing the problem statements mentioned above, the primary objectives of the conduct of PSM are:

i. To develop a low cost health monitoring prototype that records relevant health data and transmit wirelessly to physiotherapist.
ii. To study the feasibility of utilizing IoT technology in a device that presents the role of emulating an effective self-rehabilitation technique.
iii. To study the effects and outcome of conducting the self-rehabilitation technique as compared to current rehabilitation method.
iv. To remotely analyze the performance and active progress of the patients performing the self-rehabilitation technique using the device.

## 1.3 Scope

In the process of materializing this project, medical-based sensors such as ECG and EMG sensors would be utilized alongside a Bluetooth module and Arduino microcontroller. Essentially, the optimization of these sensors plays an important factor in replicating the desired in-home self-rehabilitation device. Furthermore, while optimizing the technology of Bluetooth is a low-power narrow range communications protocol, it delivers an effective remote monitoring system which presents a wireless platform to transfer data and information among Bluetooth supported devices using the same core.



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Hence, the Bluetooth module plays the role of a primary component in this wireless monitoring device in order to learn the effects and final outcome of executing the self-rehabilitation technique. Additionally, this proposed technology would allow remote monitoring of patient's rehabilitation progress which will be optimized to deliver the rehabilitation data from the sensors onto the smartphone app. Using this app, the patients could able to see basic info, statistics and a graphical interpretation of their rehabilitation progress and these data will be sent to the open source database for further analysis by certified physiotherapist.

## 1.4 Preliminary Result

Once a prototype of the wireless self-rehabilitation device is produced in the foreseeable future, testing could be initiated on selected voluntary patients. The will most likely be held in a medical institution with close supervision from a certified physiotherapist involving 30 test subjects. 15 of them would be healthy individuals meanwhile another 15 would be patients who are still in the various recovery stage of their physio rehabilitation. The state of their health and condition will be analyzed before assigning them accordingly to 3 categories of the **"type of exercises"** which comprises of slow pace 45 ° limb movement, moderate pace 70 ° limb movement and fast pace 90 ° limb movement. To accurately simulate the multiple situations in which the patients may tend to experience, each test subject will be needed to execute the respective rehabilitation exercises several repetitions for a steady data collection. Once the data is gathered, a graphical representation of the end results will be plotted for comparison on the performance of the test subject according stages of recovery from being severely disabled to perfectly healthy. This data will then be made available to physiotherapist and doctors for their further study and analysis on this subject matter. The table shown below would be an expected



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