IoT-BASED PORTABLE HEALTH MONITORING DEVICE

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

This thesis is also dedicated to my supervisor Prof. Madya Ts. Dr. Eileen Su Lee Ming, my friends and everyone who encouraged and supported me throughout making this thesis.

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ABSTRACT

Almost all the people in the world have various kinds of health problems. These health issues and ilnesses mostly require immediate and continuous monitoring of patient data by measuring body temperature, pulse rate, blood oxygen saturation, and skin conductance. Previous works on this matter have used many methods for each of the mentioned measurements separately. In this study, single IoT-based portable health monitoring device will be introduced. Sensors measuring body temperature, pulse rate, blood oxygen saturation and skin conductivity will be jointly implemented in this project. A webpage for showing the measurement data has been created and patient data is stored in private cloud accounts that patients possess. Through this study, a combined IoT-based portable health monitoring device, while maintaining the idea of not hurting patients has been made available for making immediate and continuous monitoring of patient data available for everyone with different kinds of health issues.

ABSTRAK

Hampir semua orang di dunia mempunyai pelbagai jenis masalah kesihatan. Isu kesihatan dan penyakit ini kebanyakannya memerlukan pemantauan segera dan berterusan terhadap data pesakit dengan mengukur suhu badan, kadar nadi, ketepuan oksigen darah dan konduktans kulit. Kerja-kerja terdahulu mengenai perkara ini telah menggunakan banyak kaedah untuk setiap ukuran yang disebutkan secara berasingan. Dalam kajian ini, peranti pemantauan kesihatan mudah alih berasaskan IoT tunggal akan diperkenalkan. Penderia yang mengukur suhu badan, kadar nadi, ketepuan oksigen darah dan kekonduksian kulit akan dilaksanakan secara bersama dalam projek ini. Halaman web untuk menunjukkan data pengukuran telah dibuat dan data pesakit disimpan dalam akaun awan peribadi yang dimiliki oleh pesakit. Melalui kajian ini, gabungan peranti pemantauan kesihatan mudah alih berasaskan IoT, sambil mengekalkan idea untuk tidak mencederakan pesakit telah disediakan untuk menyediakan pemantauan segera dan berterusan terhadap data pesakit untuk semua orang yang mempunyai pelbagai jenis isu kesihatan.

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LIST OF ABBREVIATIONS

UTM	-	Universiti Teknologi Malaysia
IoT	-	Internet of Things
I2C	-	Inter-Integrated Circuit
SPI	-	Serial Peripheral Interface
UART	-	Universal Asynchronous Receiver Transmitter
SDA	-	Serial Data
SCL	-	Serial Clock
FYP	-	Final Year Project

LIST OF SYMBOLS

R	-	Resistor
C	-	Capacitor
D	-	Diode
IC	-	Integrated Circuit
GND	-	Ground

CHAPTER 1

INTRODUCTION

1.1 Problem Background

Almost all the people in the world have various kinds of diseases and in most cases, these health problems require close monitoring of the patient's health records. Therefore, doctors and patients individually need health monitoring devices, more specifically electronic devices that can monitor vital health-related parameters. These devices help anyone dealing with any disease come to a conclusion regarding their current state of health along with helping them find out the effectiveness of the medications they use. Health monitoring devices are also useful when it comes to maintaining the healthy state of the individual by taking preventive measures based on the observation of any abnormal changes in the individual's health [1].

Having said the advantages, currently available health monitoring devices have some drawbacks as well. Some of these include ease of access, privacy, portability, and price. Today, patients and personal doctors cannot access health monitoring devices all-in-one in a single user interface and cannot carry them anywhere easily. In terms of privacy, patients do not have a chance to either consent or not to consent to share their personal health information with the healthcare facilities that they are examined at or with their personal doctors. Furthermore, these health monitoring devices separately can cost more compared to a single all-in-one device. This is due to their non-integrated structure, for example, for five electronic health monitoring devices user needs to buy five of them separately, which use five separate microcontrollers, voltage regulators and other common components [2].

To tackle some of the mentioned inconveniences and issues, wearable devices are often preferred due to their size and light weight for portability, sporty look, and compatibility with smartphones to have instant statistics available along with personal

record accounts of the users [3]. There are many wearable electronic devices available around in the market that possess the features of monitoring pulse rate, heartbeat, blood oxygen saturation, electromyography, electrocardiography to assess the health of patients. Although some of them give accurate results, the direct and instant accessibility to the monitoring system by the patient as well as being an all-in-one portable device have not been successfully handled yet.

Nowadays, the market of healthcare is experiencing a rapid growth and is believed to be dramatically massive due to the upcoming global aging. The medical Internet of things (IoTs) is endowed with expectation to fulfill the rigid demand, which requires all kinds of digital medical devices linked and accessed to the Internet to acquire all the parameters related to the personalized health, such as medical images, biochemical and biophysical parameters. The acquisition and transmission of the tremendous amount of biomedical information required high bandwidth and fast speed [4].

The use of health and well-being monitoring technologies has been steadily increasing and such systems can now be found in smart homes, age-friendly workplaces, public spaces, and elsewhere. These monitoring technologies employ a wide variety of off-the-shelf smart sensors and medical devices to support functional, physiological, and behavioral monitoring and to address social interaction aspects of daily life. These systems focus either on specific health-related conditions or on supporting the more general aims of comfort, well-being, and quality of life [5].

IoT in healthcare services has received growing attention due to the rapid technological advancement of sensor devices, sensor networks, and mobile data transmission. It can collect, store, record, and analyze the data, which can be further streamed with much faster speed. Bio-chemical sensors are analytical devices that convert a biological response into an electrical signal and then monitor the electrolyte concentration and pH in the sweat and are even able to detect specific components. The transducer in bio-chemical sensors is made up of an ISFET (ion-sensitive field-effect transistor) or a chemFET (chemically sensitive field-effect transistor). An enzyme biosensor uses immobilized biocatalysts such as a single or multiple enzymes,

which recognize, bind, and subsequently transform the target analytes (substrates). In enzymatic sensors, both the enzyme inhibition and catalytic conversion of the substrate can be used to monitor the analyte. The miniaturization of sensors helps to reduce the material cost as well as power consumption. It focuses much on the increase in quality care. These provide a better solution for measurement of various body parameters such as ECG (Electrocardiography), temperature, moisture, and heartbeat. The performance of these sensors can be evaluated based on specific vital parameters such as sensitivity, linearity, selectivity, the limit of detection, dynamic range, the precision of the response, reproducibility, response to interferences, portability, ease of use, operational stability, and response time [6].

Starting from a wide array of different physical input devices, the wearable computing research community has explored a range of methods to interact with applications [7]. Some of the recent works on portable health care devices have been compared in Table 1.1. Proposing portable all-in-one device along with secure IoT capability and intuitive user interface will fill all the gaps mentioned above.

Table 1.1 Comparison of recent works on health care devices [8, 9, 10, 11, 12]

Author	Project	Features
Y. -S. Shu et al.	26.1 A 4.5mm2 Multimodal Biosensing SoC for PPG, ECG, BIOZ and GSR Acquisition in Consumer Wearable Devices	PPG, ECG, GSR
P. R. Geovanny and S. Gómez Ernesto	Methodology for the registration of human movement using accelerometers and gyroscopes	Accelerometer, Gyroscope
M. Tamayo, A. Westover and Y. Sun	Microcontroller based pulse oximeter for undergraduate capstone design	Pulse Oximeter
J. L. Flores Vásquez, G. Z. Guillen and L. J. Troncoso	Evaluation and correction of infrared temperature readings inside a neonatal incubator with the MLX90614 sensor	Infrared Temperature Sensor
J. Healey and B. Logan	Wearable wellness monitoring using ECG and accelerometer data	ECG, Accelerometer
Zaur Rustamov	IoT-based portable health monitoring device	Pulse rate, blood oxygen level, non-contact temperature, stress and sleep quality measurements

In addition to filling the gaps of current systems, users will possess private cloud accounts. This allows users to be able to share their personal health information with anyone they want, track their healthiness.

1.2 Problem Statement

Currently, monitoring accurate body temperature without physical contact, blood oxygen, and heart rate measurements cannot be acquired in a single portable medical device in a short time.

1.3 Research Objectives

The objectives of the research are :

(a) To develop a portable IoT-based health monitoring device with integrated sensors.

(b) To develop a webpage with intuitive user interface to display sensor readings.

(c) To develop a database, where users will possess cloud accounts that they can track, send, print their data.

1.4 Research Scopes

Information used for this project are sourced from publicly available databases. Only available sensors are used and may not be medical grade. The prototype will be tested by some volunteers.

1.5 Significance of Research

Medical devices have a vital importance in human lives. Today, many researchers have already worked in this field and done great improvements. However, there are still gaps to be filled especially for making this kind of devices available to everyone in a cost-effective and portable way.

1.6 Report Outline

Chapter 2 summarizes relevant research suggested or presented by other researchers along with discussing the background research for this project. Chapter 3 presents the methodology and approach to the project. Hardware details, circuitry and the process diagram have been included in this chapter. Chapter 4 demonstrates the results and discussion of the projects. Finally, chapter 5 gives the conlusion and recommendations for the future work in this field.

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