Faculty of Electrical and Electronic Engineering Technology

THE DESIGN OF SLEEP MONITORING SYSTEM USING ARDUINO

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Bachelor of Electronics Engineering Technology with Honours

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THE DESIGN OF SLEEP MONITORING SYSTEM USING ARDUINO

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A project report submitted
in partial fulfillment of the requirements for the degree of
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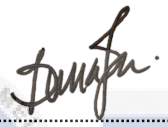
Signature	:	
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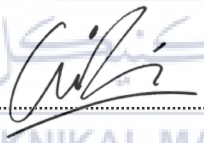
Signature	:	
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DEDICATION

Specially dedicated to
my beloved parents, family and friends who never fail to give help, support and encouragement to me.
Thankyou to my supervisor, Dr. Suraya Binti Zainuddin,
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ABSTRACT

Sleep plays a significant role in balancing an overall health of people. Therefore, any ongoing episode of sleep disruption may lead to many serious health problems such as heart failure, insomnia, depression and obstructive sleep apnea (OSA). People with a pack and busy schedule often seen as the people who would be at high risk of developing such disease since they will not be able to reserve their time for a medical checkup. Due to this issue, a new invention of the sleep monitoring system by using a wearable instrument has been a game changing towards this matter. An easy and portable device of sleep monitoring system that is non-invasive will be able to provide comfort towards the user to practice it in daily life. This project aim to design a simple and convenient sleep monitoring system where it monitors sleep quality by observing environmental parameter and body parameter of the user. The sensor for environmental parameter will be used to monitor temperature, humidity and light intensity where the user sleeps. While sensor in body parameter will be tracking heart rate, level of oxygen in the blood and the temperature of body.The microcontroller that was connected to the sensor and sent data using WiFi connection to the Blynk Apps for display and analyses purpose.

ABSTRAK

Tidur memainkan peranan penting dalam menyeimbangkan kesihatan seseorang secara keseluruhan. Oleh itu, sebarang episod gangguan tidur yang berterusan boleh menyebabkan banyak masalah kesihatan yang serius seperti kegagalan jantung, insomnia, kemurungan dan penyakit gangguan tidur, Obstructive Sleep Apnea (OSA). Orang yang mempunyai jadual yang padat dan sibuk sering dilihat sebagai orang yang berisiko tinggi menghidap penyakit seperti itu, kerana mereka tidak akan dapat meluangkan masa untuk pemeriksaan perubatan. Oleh kerana masalah ini, penemuan baru sistem pemantauan tidur dengan menggunakan alat yang boleh dipakai menjadi cara penyelesaian baharu terhadap perkara ini. Peranti sistem pemantauan tidur yang ringkas dan mudah alih yang tidak invasif akan dapat memberikan keselesaan kepada pengguna untuk mempraktikkannya dalam kehidupan seharian. Projek ini bertujuan untuk merancang sistem pemantauan tidur yang ringkas dan selesa di mana ia memantau kualiti tidur dengan memerhatikan parameter persekitaran dan parameter badan pengguna. Sensor untuk parameter persekitaran akan digunakan untuk memantau suhu, kelembapan dan intensiti cahaya ketika pengguna tidur. Sementara parameter sensor dalam badan akan mengesan denyut jantung, tahap oksigen dalam darah dan suhu. Mikropengawal yang disambungkan ke penderia akan menghantar data menggunakan sambungan WiFi ke Aplikasi Blynk untuk tujuan paparan dan analisa.

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LIST OF ABBREVIATIONS

V	-	Voltage
IoT	-	Internet of Thing
OSA	-	Obstructive Sleep Apnea
OSAS	-	Obstructive Sleep Apnea Syndrome
PSG	-	Polysomnography
WHO	-	World Health Organization
CSI	-	Channel State Information
TX	-	Transmitter
RX	-	Receiver
ECG	-	ElectroCardiGram
ADHD	-	Attention Deficit Hyper Disorder
RLS	-	Restless Leg Syndrome
RGB	-	Red Green Blue
IoMT	-	Internet of Medical Things
IMU	-	Inertia Measurement Unit
CLM	-	Complex Leg Movement
LDR	-	Light Dependent Sensor
DHT11	-	Digital Humidity and Temperature 11
VCC	-	Voltage Common Collector
GND	-	Ground
ALC	-	Ambient Light Cancellation
USB	-	Universal Serial Bus
Wi-Fi	-	Wireless Fidelity
IDE	-	Integrated Development Environment
PCB	-	Printed Circuit Board

CHAPTER 1

INTRODUCTION

This chapter will be discussing the background of this project. Problem statement, objective and scope will be explained as well in this section.

1.1 Research Background

Acquiring a good sleep quality is an important factor for human physical and mental health, day-time performance, and safety. The risk of chronic disease and mental depression can also be reduced by getting sufficient sleep. In addition, our brain will be able to work properly in order to improve productivity.

Sleep monitoring can be classified as one of the health monitoring systems that functions as a tracker in order to monitor someone sleep quality. Since health monitoring is interpreted by monitoring a balanced diet & lifestyle, in this case, health monitoring will be explained in terms of monitoring the body's vital signs. The basic function of our body, such as body temperature, blood pressure, heart rate and respiratory rate, which may vary with age, weigth, gender and overall health, can be measured by vital signs. Therefore, in a rapidly developing world, health monitoring has been revolt to the stage that it can be done anywhere and anytime. This situation was definitely a game-changing for people with a busy schedule.

With the help of today's technology, many high-end health monitoring devices have been invented and and marketed. However, these devices will mostly cost hundreds or even thousands of Malaysian ringgits. Therefore, designing a health monitoring system based on IoT that can be used almost anywhere comes up, and this project is carried out to serve that

purpose. The Internet of Things will be the main object in this project. In order to analyze sleep quality, an IoT integrated sleep monitoring system is required. This sleep monitoring system will help track user sleep patterns and estimate how much time has been spent asleep, awake, and restless. This way, it will definitely benefit most people with a busy schedule.

1.2 Problem Statement

In today's world, restless sleep is a major problem in our society affecting productivity, health and quality of life for adults and children's learning ability. The more common sleep problems involve poor sleep habits, various idiosyncratic behaviors disrupting sleep, insomnia, circadian rhythms, undiagnosed restless legs syndrome, low iron status and sleep apneas. Therefore, to relate, people who live with a busy and stressful life such as inconsistent work shift, workload stress and lack of sleep will probably have a low tendency to go for a health checkup. However, this scenario could lead to many health issues in future if there is no action taken.

Thus, many high-end health monitoring devices have been invented in today's technology. Unfortunately, most of these devices would cost thousands of Malaysian ringgits. Therefore, this project proposed designing a cost-effective health monitoring system that still serves an excellent quality. Promising technologies such as the Internet of things (IoT), fog computing, big data and cloud computing have significant potential for the implementation of home-based solutions to monitor and support the health monitoring system.

1.3 Project Objective

The objective of this study had been determined as follows:

a) To design a health monitoring system prototype based on the IoT (Internet of Things) concept

b) To enable a real time sleep monitoring system through mobile application

c) To collect environmental and body condition data to log into database

1.4 Scope of Project

The scope of this project are as follows:

a) Project was divided into 2 parts which are hardware and software part.

b) Investigation of environmental condition and body condition parameters related to quality of sleep achieve by users.

c) Data was obtained by using a sensor connected to a microcontroller and stored in the database.

CHAPTER 2

LITERATURE REVIEW

The literature review topic covered in this chapter pertains to the analysis of various related journals and articles. The discussion of the topic is focused on the theoretical background of the studies. In addition, this part also involves the materials that studied and which is relevant to the study.

2.1 IoT based Smart Health Monitoring Systems

The author of "IoT based Smart Healthcare Monitoring Systems"[1] said that research into health requests has been undefeated among the multiple requests of IoT. These requests generally due to the cost-effective, easy interpretation and satisfaction feedback of the patients. IoT has offered as the main platform for awareness monitoring. Various kind of sensor that are linked to devices has been useful in analysing patient details that then can provide the caretaker to be able to guide on health care.

2.2 Sleep Apnea

Sleep apnea is a serious health condition that often causes poor quality of life and high medical care costs. It is usually caused by the accumulation of sleep disruption due to age. Due to this, it has been identified to be a major health issue among the elderly. According to [2] the reason behind this was, over the years, human beings will experience changes in their bodies and lives. One of those changes is sleep disruptions that occur with age, making it difficult to sleep. In other words, Obstructive Sleep Apnea Syndrome (OSAS) is one of the most dangerous and common respiratory disorders that produced during sleep.

Eventho sleep apnea at any age is a major concern, but it is even more problematic in elderly people who are more likely to have issues with breathing at night. On the other hand, a study shows that between 13 and 32% of elderly people (over 65 years old) having sleep apnea. In detail, sleep apnea generates the risk of traffic accidents caused by the excessive daytime somnolence. Hence, a home-based system to monitor and support OSAS patients will help to reduce the health risks associated with OSAS and improve elderly's QoL.

According to [3] obstructive sleep apnea syndrome (OSAS) can be interpreted as a breathing disorder characterized by the partial or total obstruction of the airways during sleep. Due to the non-availability and costly polysomnography (PSG) test required, the estimation of OSAS cases not getting diagnosed and without treatment was estimated up to 75%. The World Health Organization (WHO) has also considered that OSAS to be the most common sleep disorder. OSAS was also known to associate with the increased risk for many severe health effects such as Alzheimer's disease, insulin resistance, strokes, hypertension and coronary disease.

2.3 Sleep Monitoring System

Variety of sleep trackers on the market, some of which are wearable and others that clip to the human body. Features of these devices may vary, but some common capabilities that we can find include such as sleep quality which trackers can detect interrupted sleep, and it notifies the condition of the people while there are asleep. There also devices that analysed based on the environmental factors of user. This device will record environmental factors such as the amount of light or temperature in your bedroom, to be able to guide the user to obtain an optimum good quality of sleep.

A sleep monitoring system called “Wi-Sleep” [4] was introduced as the first sleep monitoring system by leveraging the WIFI signals. The author stated that this system is completely contactless compared to the many existing sleep monitoring system that usually attached to human body. Wi-Sleep will continuously gather the fine-grained wireless channel state information (CSI) around the user. From there, Wi-Sleep will then begin to extract the behaviour of the sleeping positions and patterns of user respiration. Two MicaZ node that function as transmitter (TX) and receiver (RX) was setup 3 meters apart while the person was lying on a bed between them. There’s also an embedded accelerometers on a smartphone being attached to chest of the person to observe the movement of the chest.

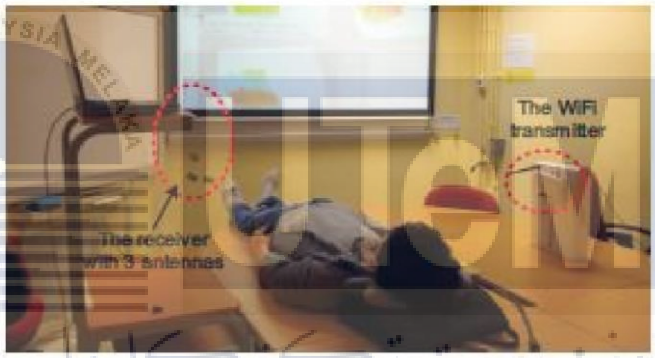

Figure 2. 1 Experiment setup - The TP Link WR740 was used as TX while Dell M2300 as the RX.

On the other hand, another sleep monitoring systems was introduced, and it was called as “Sensor Pillow System” [5] The system proposed the idea of measuring physiological parameters in sleep where it used a pressure sensor sheet under the pillow and a sensor pillow interface box. The data from pressure sensor will be transmitted to the desktop computer, and the count of respirations and turns in sleep will occur. The method used was contributed to such advantages such as unrestrainedly sensing where the pressure sensor was placed under the pillow, so there is no direct contact happening while the system is monitoring the user’s respiration through head movement. The flexibility of this system is

that the user can use it everywhere and every day since it is not attached to the pillow so that the comfort and cleanliness of the pillows used are maintained. A comparison in data obtained was made between the sensor pillow and medical device at three different positions to be able to determine the accuracy of the system.

Meanwhile, another sleep monitoring system that is simple, affordable and movable for sleep monitoring was introduced by [6]. This paper focuses on monitoring the patients with OSA by only collecting the data of single-channel ElectroCardiGram (ECG) data. The reason behind this proposed system was to bring attention apnea event detection based on the research that has been made in determining the solution for it. This paper consists of two phases where the first phase associated in a patient diagnosis. In this phase, a wearable ECG sensor was handed to the patient with the attachment of mobile device to be worn one night at their home. The data from the sensor will then be monitored through the mobile device which is connected locally via Bluetooth. On the following days, the doctor will analyse the data with reference to the episodes of OSA. As for the second phase, patient was being monitored in real time while wearing the wearable ECG sensor. The data recorded in this phase will be monitor in real-time where if the values of parameters activated one of the rules that describing the occurrence of the episode of OSA, the monitoring system will start to alert that an apnea episode has occurred and immediately push an action of instance waking up the patient or sending a notification to their medical personnel. Another approach that can be seen was the development of classification based on the database given. Each individual will represents a set of rule that makes reference to a class. However, it could be more than one rule if it is necessary in each class, to improve the performance of classification.

2.3.1 Comparison of the three approaches in previous research in terms of the design of sleep monitoring system

Table 2. 1 Comparison from different approaches for design of sleep monitoring system

Author	Title	Approaches
(Liu et al., 2015)	Wi-Sleep: Contactless Sleep Monitoring via WiFi Signals	➢ This approaches focus was to design a sleep monitoring system called "Wi-Sleep" that will collect data with the help of WiFi Signals. ➢ The system use wireless channel state information (CSI) technology to track & collect data information. ➢ CSI express that RF signal will propagate from the TX(s) to the RX(s) to measure person's respiration & sleeping postures. ➢ Method used was contactless from the user
(Harada et al., 2000)	Sensor Pillow System: Monitoring Respiration and Body Movement in Sleep	➢ This paper use physiological parameters to track the sleep quality of user. ➢ A pressure sensors was attached to a piece of sheet before placing it under the user pillow. ➢ Sensor Pillow Interface Box used was consists of ADG406 as analog multiplexer, PIC16F877 as microcomputer and FM transmitter module as a transmitter to send data to host computer. ➢ The count of head turns and respiration rhythm obtained will be compare to medical device to define the effectiveness of the proposed sytem.

(Sannino et al., 2014)	Monitoring Obstructive Sleep Apnea by means of a real-time mobile system based on the automatic extraction of sets of rules through Differential Evolution	➢ This paper proposed to help patient that experiencing Obstructive Sleep Apnea (OSA) to keep track their sleep quality. ➢ The system adopt a single-channel ElectroCardioGram (ECG) technology to record patient data. ➢ There's two phase involve in this system which in phase I patient data is collected by giving the patient a wearable chestband with ECG sensor attach to it and is connected to mobile device via Bluetooth. The data obtained on this one night will be stored in mobile device. ➢ Phase I was designed as a step to develop a classification of OSA or non-OSA event detected. Better understanding of patient can also be achieved using IF…..THEN rules. ➢ While, in phase II a real-time monitoring system will take place. In this phase the same equipment will be use but with different method of processing data obtained. Since the system is in real-time environment, the data will be will be processed along with the set of rules develop earlier to determine if OSA event was taking place or not. If the apnea event was detected to taking place at the moment, the patient will be force to wake up and the care taker will notify immediately.