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Faculty of Electronic and Computer Engineering

SLEEP MONITORING SYSTEM

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UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : SLEEP MONITORING SYSTEM
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Supervisor's Name : DR WIRA HIDAYAT BIN MOHD SAAD

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ABSTRACT

Sleep monitoring system is a device that able to monitor sleeping quality of the user by using several biological sensors. The development in sensor technology in term of size and accuracy have made the wearable monitoring system which is available for ordinary users. The relationship of movement during sleeping with sleep quality is investigated and discussed in the thesis. The processing unit is needed to process and display the data received from the sleep monitoring system. Therefore, the main objective for this project is to design a sleep monitoring system using Bluno with temperature sensor, heart rate sensor and accelerometer. The graphical user interface (GUI) is designed on the Windows Applications Platform using Visual Studio. The functionality of the sleep monitoring system is verified by experiment involving five subjects. Overall, the sleep monitoring system able to measure body, temperature, accelerometer and video recording. Next, the system will send data to Window Apps through Bluetooth 4.0 and record the data using CoolTerm.

ABSTRAK

Sistem pemantauan tidur merupakan alat yang dapat memantau kualiti tidur pengguna dengan menggunakan beberapa jenis sensor biologi. Perkembangan dalam teknologi sensor dari segi saiz dan ketepatan telah membuat sistem pemantauan boleh dipakai semasa tidur dan system ini terbuka kepada pengguna biasa. Kaitan tentang pergerakan semasa tidur dengan kualiti tidur disiasat dan dibincangkan dalam tesis. Unit pemprosesan diperlukan untuk memproses dan memaparkan data yang diterima daripada sistem pemantauan tidur. Oleh itu, objektif utama projek ini adalah untuk mereka bentuk sistem pemantauan tidur menggunakan Bluno dengan sensor suhu, sensor kadar jantung dan pecutan. Antara muka pengguna grafik (GUI) direka pada Aplikasi Platform Windows menggunakan Visual Studio. Fungsi sistem pemantauan tidur disahkan oleh eksperimen yang melibatkan lima subjek eksperimen. Secara keseluruhan, sistem pemantauan tidur dapat memantau suhu badan, kadar jantung, pecutan dan rakaman video. Seterusnya, sistem akan menghantar data kepada Window Apps melalui Bluetooth 4.0 dan merekodkan data menggunakan CoolTerm.

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PSG	**-**	**Polysomnography**
OSA	**-**	**Obstructive Sleep Apnea**
PAF	**-**	**Population Attribute Fractions**
WISP	**-**	**Wireless Identification and Sensing Platform**
RFID	**-**	**Radio Frequency Identification**
BLE	**-**	**Bluetooth Low Energy**
REM	**-**	**Rapid Eye Movement**
NREM	**-**	**Non Rapid Eye Movement**
EEG	**-**	**Electroencephalogram**
EMG	**-**	**Electromyography**
IMU	**-**	**Inertia Measurement Unit**

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.0 Overview

This chapter consists of overall information of the project. The first section of this chapter is background which explain about the general field involved in this project. This chapter also includes problem statement, objectives, scope of work and chapter review.

1.1 Background

A person spent 28 years of their lifetime sleeping assuming their expected live is around 80 years old. [2] Persistent sleep deficiency can affect the alertness in a day time that can create an unstable mental state which can lead to the cardiovascular diseases and depression. According to Australian Population Survey, it appears that 13% - 33% of adults have difficulties in having a decent sleep. Therefore, ways to improve the sleeping habits and treat the sleep disorder is crucial in maintaining our health. [2]

A recent study shows that sleeping behaviour of human beings has a great impact toward the health condition of the person. Therefore, Polysomnography (PSG) can be used to determine the parameters such as heart rate, brain waves, eye movements, muscle tension and body temperature throughout the sleeping process of the subjects accurately. However, such system need a complex wearable sensors installations attached to the subject's body and thus only limited to clinical usage for now.

Domestic sleep monitoring system such as Fitbit utilizes accelerometer sensor to determine the sleeping stages of the users. However, such device doesn't provide accurate

and fine results due to the influences of the external disturbance such as low level noise with low frequency response. [9]

1.2 Problem Statement

The disadvantage of PSG and Fitbits create questionable results for further investigation. Therefore, combining several parameters in a monitoring system without affecting the sleeping habits of the subject is optimum in getting the accurate data. In this project, the observation of the sleeping behaviour is executed through heart rate sensor, temperature sensor, camera and microphone which attached to the subject's body. [9] Personal health care has grabbed a lot of attention, such as electronic device like a smart phone provide a platform for the user to monitor their health condition constantly. Additional features such as temperature sensor and motion capture using webcam will be added into the project to make the monitoring system more versatile. The profile of heart rate and temperature are collected and can be retrieved from the database as well.

1.3 Objectives

The aim of this project is to record and monitor the sleeping activity of the subject.

1. To build a sleep monitoring system using Bluno that is connected to the computer through Bluetooth 4.0.
2. To extend the design with available camera and microphone in the computer
3. To collect data and analyses it to determine the quality of sleep.

1.4 Scope of Work

The focus of this project is to add some extra monitoring feature to the underdeveloped existing monitoring system using the existing camera and microphone on the laptop to record the sleeping behavior of the subject. By connecting the Bluno device to the computer using Bluetooth 4.0, the analog data collected will be saved in the computer for further analysis. The interface of the sleeping monitoring will be designed

using Visual Studio to be a user friendly application. The coding used to program the interface in Visual Studio is C#.

1.5 Chapter Review

Chapter 1 presents the overview of the sleep monitoring system by explaining the problem statement and project objectives. This chapter also provides limitation of this project in scope of work and review of the rest of the chapter.

Chapter 2 discusses and critically reviews the previous research and study that related to this project and the concept used in realizing this project.

Chapter 3 describes the methodology of integrating the new features in the existing monitoring system. The procedure of creating the new interface also included.

Chapter 4 describes the functionality of the sleep monitoring system and the results obtained from the system. Chapter 5 concludes the project.

CHAPTER II

LITERATURE REVIEW

2.0 Overview

This chapter contains the research knowledges of the field related to the project title. First, the significance of sleeping quality with human health is investigated. Next, this chapter consists of review of current sleep applications for smart phones. Follows by reviewing previous work on audio, video, Bluetooth 4.0 and lastly accelerometer with sleep monitoring system.

2.1 Sleep Related Diseases

Deep rooted sleep deficiency is pretty common in the Asia community. Sleep deficiency reduces the alertness, average productivity and also affecting the pathophysiological process which may slow down the body metabolism, cardiovascular diseases and even depression. Low concentration due to unsatisfying quality of sleep has a significant consequence on the productivity of workers. [2] Therefore, health care industry had realized the hidden problem and attempt to improve the quality of sleep in mankind. However, according to Mansfield [2] sleep monitoring devices caused sleep loss among adolescents due to the exposure of light emitted from the electronic device's screen.

Sustainability of any system used must include criteria such as achieving goals of care, well-defined outcomes and identifying high risk group. According to an evaluation of the sleeping habits of Australians, Obstructive Sleep Apnea (OSA) affects 25% of adult males and 10% of adult females while 13%-33% of the adult population in Australia has insomnia which is the difficulty of staying asleep. Severe OSA has great impact on

incurring obesity, cardiovascular diseases and diabetes amongst young and middle aged adults. [2] Population attribute fractions (PAF) were used to estimate illness and injuries associated to different types of sleep disorder.

Table 2.1: Illness and Injuries Associated to Different Types of Sleep Disorder.[1]

Attributed injury/ illness	Obstructive Sleep Apnea (OSA)	Insomnia
Stroke	5.3%	-
CHF	1.1%	-
Coronary artery disease	3.6%	-
Depression	6.2%	2.9%
Motor vehicle accidents(MVAs)	4.3%	-
Workplace injuries	0.6%	3.9%

From this report, the total cost of health care for sleep disorder in 2010 was $818 million. According to Mirrakhimov [3], a review of the papers related to OBS in Asian adults is conducted. They found that OSA associated with male, greater neck circumference, smoking, high blood pressure and snoring which leads to cardiovascular diseases. This report only reflected to a developed city such as Japan, Singapore and China. Therefore, the results are questionable.

2.2 Review of Current Sleep Applications for Smartphones

A home diagnostic device would be ideal in reducing the time spent in diagnosis and treatment of OSA patients. Smartphones are closely related in our daily lives. For the purpose of healthcare, it is a tools which capable to compute and communicate with other

devices. Audio and accelerometer embedded in smartphones can be utilized to detect physical motion and audio throughout whole sleeping process. [8]

2.2.1 Actigraphy and Body Position

Actigraphy is not good in deducing the wake sleep pattern of the subject but it can combine with other parameters in producing more accurate results. Body position during sleeping can be recorded along with accelerometer parameters as an indicator of the body movement. However, the movement analysis by the smart phone applications in the market should not be taken seriously since the algorithms used is different from the clinical sleep monitoring system. [7]

2.2.2 Audio

Audio captured throughout the sleeping session will be used to plot qualitative graphs which provide the users of their sleeping quality. Samples of normal breathing and OSA patient's noise are provided for the users to compared with their own recordings and determine their own health state. However, such comparison may be comprehended wrongly since the users are not educated in such area. The recordings are highly dependent on the quality of the internal microphone embedded in the smartphones; all the important details must be recorded to obtain a more precise data for further analysis. The sound card must have flat frequency response towards the band of interest so that the distortion in the signal recorded will be reduced. [7]

2.2.3 Video Analysis

Video analysis is very helpful in diagnosing OSA since video can provide information about the motion and behavior of the subject in the sleep duration. The limitation of video recording is recording in dark atmosphere and the proposed solution is to remove the infrared filter of the camera which may potentially damage the camera. [7]

2.2.4 Heart Rate

The heart rate of the subject can be determined by using applications which required the users to place their finger tip on the camera. The heart rate can be obtained by using infrared emitted by the camera to observe the change in colour. This method is highly questionable and non-applicable to the users.

2.2.5 Temperature

Skin temperature increases during sleeping and increases when waking up. Therefore, the sleep-wake up session can be determined based on the body temperature.

So far, there aren't any temperature sensors which can utilize in measuring body temperature. However, in some of smartphones, the weather temperature sensor can use to detect body temperature.

This review paper infers that smartphones can be the next generations sleep monitoring system. However, the existing applications doesn't have strong scientific theory based results which may give incorrect data to the users. Furthermore, the results may vary according to the specifications of the phones, body conditions of the users, the locations of the sensors from the users and the constantly varying environment. [7]

2.3 Previous Work of Integrating Audio and Video in Sleeping Monitoring System

According to research by Yanchi [5], hearing the breathing with smartphones to obtain a fine grained sleep monitoring is a simple yet effective methods in recording every details in the signals. The system created by the author can remove background noise and determine the breathing rate based on the frequency of the signals collected. This system can classify different type of situation during sleeping based on the sound retrieved from the recording. This rational behind this research is the existence of the light weighted monitoring system which is designed based on the model of PSG. This product require

the commitment of the users to wear certain sensors during sleeping which may disrupt the sleeping habits of the personnel. Therefore, the results collected maybe inaccurate due to the possibility of discomfort of the users when sleeping. Collecting the breathing sound of the subjects is a very crucial parameter in identifying the sleeping pattern of the subjects. Earphone is suitable for collecting the data since earphone is usually placed very closely to the users and most of the users listen to music using earphone before go to sleep. Besides that, earphone can record higher quality sound that the microphone embedded in the smartphones. [5]

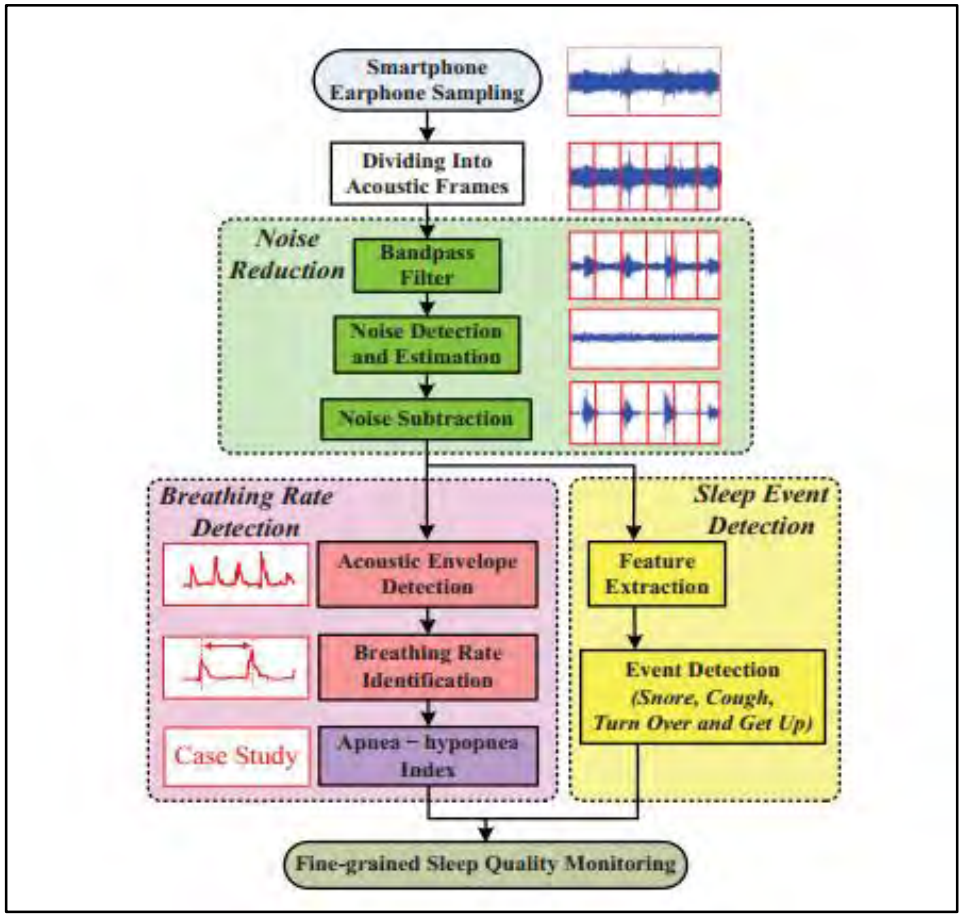

Figure 2.1: Algorithms of Fine-Grained Sleep Monitoring System [5]

This system can differentiate the user with OSA with a periodically lower breathing rate during sleep. This system can further detect snore and turn over based on the sound recorded. The whole research is built on the theory that the amplitude of the sound signal during sleeping is related to the airflow during breathing. [4] Research regarding the body positions and movements monitoring during sleep using Wireless Identification and