Development of Embedded System for Centralized Insomnia System

Novi Azman
Faculty Engineering and Science
Universitas Nasional
(UNAS)
Jakarta, Indonesia
Novi.azman@civitas.unas.ac.id

Muhammad Haikal Satria
Faculty of Engineering
Universiti Teknologi Malaysia
(UTM)
Johor Bahru, Malaysia
haikalsatria@biomedical.utm.my

Muhammad Zillullah Mukaram
Faculty of Science
Universiti Teknologi Malaysia
(UTM)
Johor Bahru, Malaysia
azil.utmskudai@gmail.com

Mohd Khanapi Abd Ghani
Universiti Teknikal Malaysia Melaka
Melaka, Malaysia
khanapi@utem.edu.my

Abstract**—** Insomnia is a common health problem in medical field as well as in psychiatry. The measurement of those factors could be collected by using polysomnography as one of the current standards. However, due to the routine of clinical assessment, the polysomnography is impractical and limited to be used in certain place. The rapid progress of electronic sensors to support IoT in health telemonitoring should provide the real time diagnosis of patient at home too. In this research, the development of centralized insomnia system for recording and analysis of patient with chronic-insomnia data is proposed. The system is composed from multi body sensors that connected to main IOT server. The test has been done for 5 patients and the result has been successfully retrieved in real time.

Keywords— Insomnia, Telemonitoring, Portable ECG

I. Introduction

Insomnia is a common health problem in medical field as well as in psychiatry. Insomnia is characterized by a dissatisfaction of the quantity or quality of sleep with a difficulty of falling asleep, difficulty to keep sleeping, and waking up in the morning [1]. Its health impact has always been underestimated and trivialized. Moreover, insomnia could cause a decreased in daytime function [2] and a significant mental and physical disorders for the patients. A research from [5] shows a staggering increase of insomniac patients in developing countries. 16.6% of respondent from Ghana, Tanzania, India, Bangladesh, Vietnam and Indonesia suffered insomnia and other sleeping disorders.

The prevalence of people with chronic insomnia has increase significantly in urban area. The urban life style, requirements and others socio-economy demands are some of the cause for this increment. [3,4,5] This has indirect effect to the socio-economy factors in a country, where about 60% of people in developing countries living in urban area.

As an individual, a patient with chronic insomnia could affect their quality of life and other health comorbidities. [6,7] Several researches have shown that patient with chronic insomnia will increase their hypertension risk by approximately 350% when compare to people with no sleep disorder. Insomnia is also one of the risk factors for diabetes, anxiety and depression. Further, the patient of chronic insomnia will affect their work performance and social life.

Diagnosis and treatment of patients with chronic insomnia is done individually and respectively. This is due to their individual pattern of sleep and their respective vital signs, such as blood pressure and heart rate, which needs to be monitored continuously. The treatment of each patients will be done based on their insomnia's classification which is based on individual factors, symptoms, frequencies and severity of the insomnia.

The measurement of those factors could be collected by using polysomnography as one of the current standards. However, due to the routine of clinical assessment, the polysomnography is impractical and limited to be used in certain places [8]**.** A proposed Actigraphy could be used to increase accuracy and mobility from polysomnography for sleep pattern measurement. Unfortunately, the limitation of this device and complexity in its installation along with polysomnography are become their restriction [8]. There is a need of practical device that can overcome these problems.

The classification of insomnia to determine type of the suitable treatment should also be done rapidly. This could be achieved by the continuous monitoring of patient in and out of healthcare facilities or lab. The classification also requires a non-medical input, which is subjective and based on patient qualification, their life style and stress level. The device should support and provide this classification along with taking the patient non-medical record in progressive and structured.

The rapid progress of electronic sensors to support IoT in health telemonitoring should provide above requirements. The implementation of anytime and anywhere concept could give the freedom and manifestation of clinical and non-clinical data continuously for patient with chronic insomnia.

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The aim of this research is to provide a reliable telemonitoring system for chronic insomnia with the continuous monitoring of patient's health record as well as the determination of individual insomnia classification to assist medical practitioner for the suitable therapy. The development of a system model of telemonitoring by utilizing IoT technology as the main monitoring devices is need to be done to achieve above objective.

II. Prototype Development

The design of detection devices with vital monitoring based on wireless systems is shown in figure 1. The proposed prototype of this insomnia telemonitoring device should fulfill the specifications of Polysomnography level 2.

Polysomnography level 2 have similar specifications to Polysomnography level 1, with all the required devices and electrodes connected with polysomnography device. The difference on level 2 is the device portability and the absence of environmental conditioning [12]. The selection rationale of level 2 polysomnography is the patient location. The data gather is conducted and installed outside the hospital sleep lab premises and have the convenience of following the patients to their own sleeping premises.

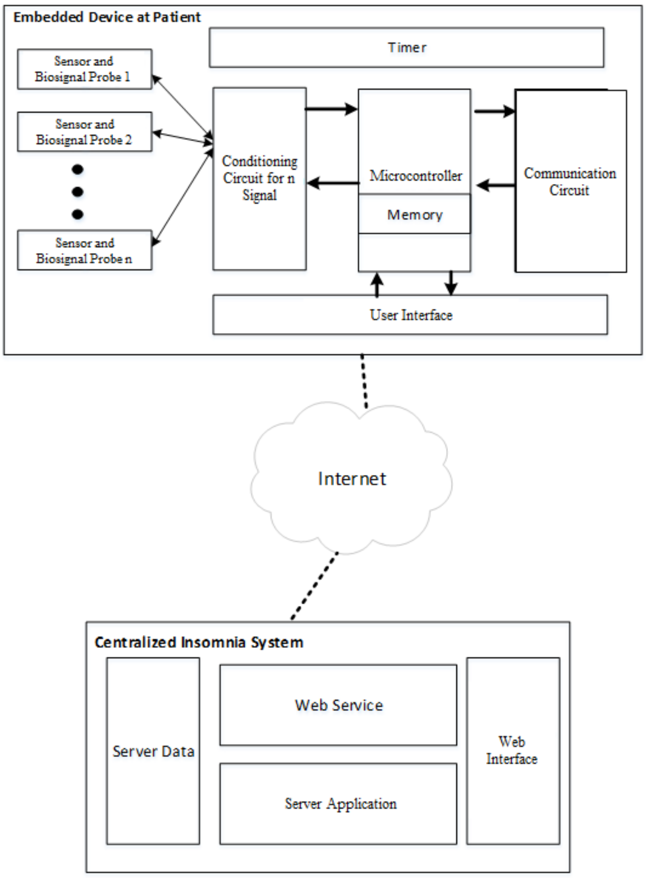

Figure 1. Infrastructure diagram of Embedded system development for centralized Insomnia System

Other specifications are the smaller size and lighter weight of device. The purpose of the embedded device is to gather the data and sent to the centralized server by using IoT principles. The stored data is then prepared and analyze by researcher at anytime and anywhere.

The centralized insomnia system should provide lightweight data delivery and reception, where multi-sensory devices are connected continuously. The server also needs to provide data processing and automatic analysis of insomnia level where all healthcare and research personnel accessed it. This configuration could minimize the device setup and installation at patient's side.

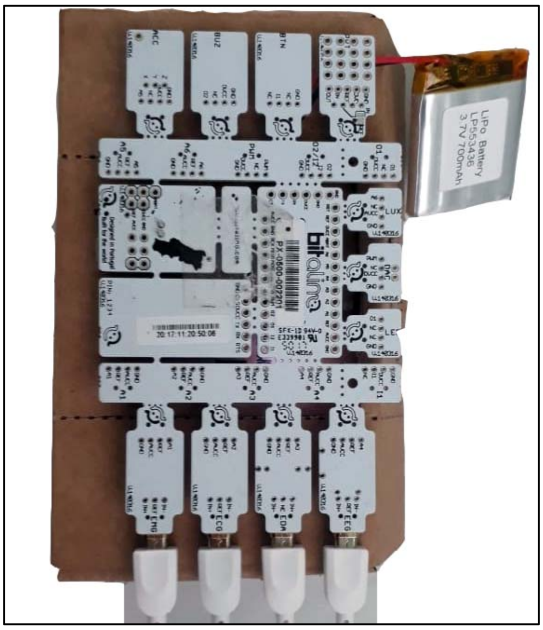

Figure 2. Embedded Device configuration and connection

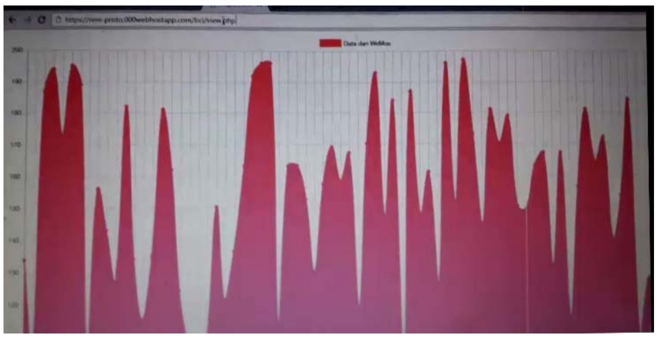

Figure 3. Load measurement of data sending in the centralized insomnia server.

In this preliminary development, the embedded system is using BITalino solution for physiological computing from Instituto Superior de Engenharia de Lisboa, Portugal [13]. The selection justification of this device is its low-cost and modular biosignal acquisition hardware platform that could provide basic configuration of data acquisition of patient with chronic insomnia disease. It is also has been tested with the standard reference device for ACC, ECG, EEG and EDA data with high correlation of the raw waveforms [14]. Figure 2 shows the BITalino platform used in this research and its configuration. ECG and EEG are connected to each 4 sensors port in BITalino.

data amount per time sending from the device to the servers. Currently the load balancing mechanism is not being implemented while there are only two connected device.

The RESTApi that being implemented is post mechanism for the data sending from device and get mechanism for the data retrieval at the researcher's computer for analysis.

III. Result and Analysis

After obtaining the required data as a reference to make the prototype device from the field study stage, at this stage the researchers initiated the manufacture of prototypes of the device used to perform chronic insomnia telemonitoring, which in the manufacture of prototypes is divided into 4 sub-stages.

The data obtained are also required to view system performance as well as reconfiguring or re-tuning which is expected to improve the performance of the prototype device that has been created. Patient's device for patient with chronic insomnia that connected with centralized system for medical practitioner.

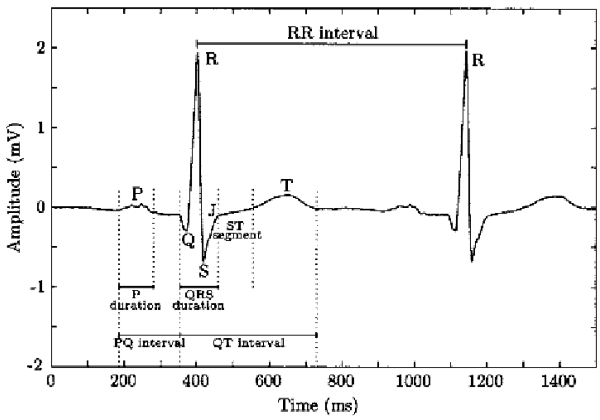

Figure 3. Classic ECG signal characteristics and analysis of its interval [14]

Follow the classic ECG signal characteristics in Figure 4, the analysis of data acquisition results on the server is done. Figure 4 is the snapshot data for 5 second of 3 subjects each subject are recorded for 1 hour.

By observing Figure 4 the RR interval between the 3 subjects differs significantly especially in subject number 2. The same also applied to the P and T wave in all of the subjects. In subject 1 the P and T wave have a miniscule amplitude whereas in the case of subject 3 the amplitude is very significant. The interval of P duration from subject 1 is 0.264. Estimate error compares from ECG refference data is 0.144 for subject 1.

The data is collected through the BITalino sensors and sent to centralized server. The data sending is using RESTApi standard for lightweight communication protocol of continuous connection. Figure 3 shows the screenshot of

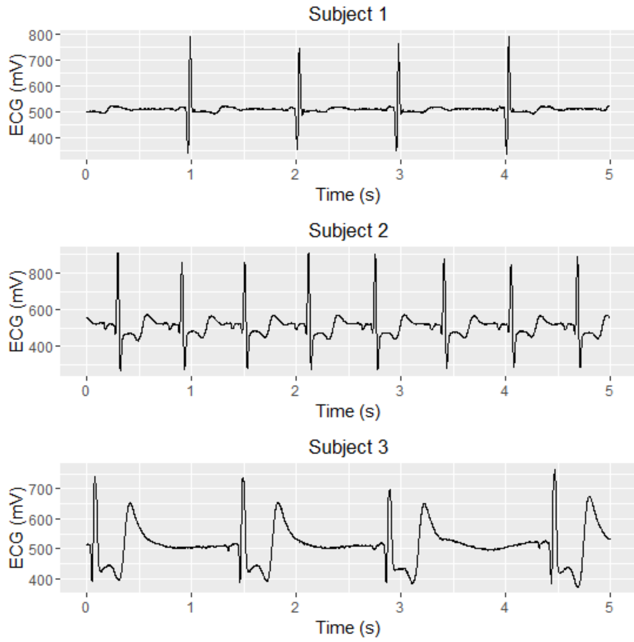

Figure 4. ECG Data Plots

Although the mean and standard deviation of each of the data are almost the same. The data distribution of each subject are difference the kurtosis from each dataset differ by a wide margin and the skewness are also different. T-test and χ^2-test of the data also suggest that the data have a different true mean and variance

Subject	Mean	Sd	Min	Max	kurt	skew
1	512.5	67.25	0	1022	33.48	-0.5
2	511.3	72.70	266	932	12.21	1.75
3	511.4	64.41	340	789	4.72	0.89

Table 1. Descriptive Statistics of the ECG Data

Subject	T-test	χ^2-test
1 and 2	9.625e-05	< 2.2e-16
2 and 3	0.005031	< 2.2e-16
1 and 3	0.8129	< 2.2e-16

Table 2. Statistics Test P-value of the ECG Data

IV. Conclusion

The implementation of embedded device for patient with chronic-insomnia disease has been done. The proposed device is lightweight and could be portably deploy at patient's premises. Current development also successfully implement the centralized insomnia server for data collection and analysis. This server is implemented by using RESTApi for robust and lightweight data sending from the device. Results of ECG data from 3 subjects has been retrieve successfully. The analysis of these data shows that the result is close to the ECG data references. In the next research, full multi-sensory will be implemented to fulfill the polysomnography level 2 requirements. The auto analysis to determine the insomnia chronic level also need to be done

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