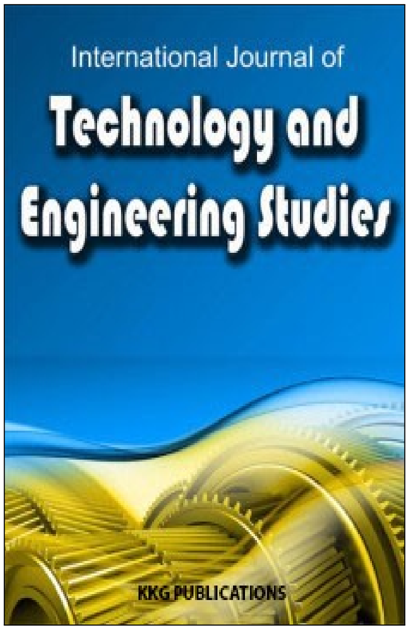

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DESY DWI PURNOMO [1], BASARI [2]

[1, 2] Department of Electrical Engineering, University of Indonesia, Depok, Indonesia

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DESIGN OF PULSE RATE AND BODY TEMPERATURE MONITORING SYSTEM WITH ARDUINO VIA WIFI AND ANDROID-BASED GADGET

DESY DWI PURNOMO [1]*, BASARI [2]

[1, 2] Department of Electrical Engineering, University of Indonesia, Depok, Indonesia

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Abstract. This study intends to design, build and implement a portable monitoring system of pulse rate and body temperature using Arduino microcontroller, equipped with SD Card, LCD screen, a 2.4 GHz Wi-Fi module for transfering data to the server. The author proposed designing a portable pulse rate and human body temperature monitoring system that measures data that can be accessed via the online web and android smartphone. This monitoring system consists of a sender system that combines a pulse sensor (Finger Sensor), temperature sensors, Arduino microcontroller, Mini LCD, SD Memory Card, Wi-Fi (2.4 GHz), and a receiver system. The receiver system consists of a database server using a Hosting server and an android smartphone with Java applications. Validation of this system was done by comparing to OMRON, ECG, Thermometer, and using different SSID when accessing the Wi-Fi network. Compared with OMRON, the error of this tool was 2.3%, 1.39% compared with ECG, 2% compared with Digital Thermometer, and also has a delay time of more than 1 second, so that should be improved in the future in order to be a real-time system.

INTRODUCTION

Health is very important in human life and in the world of health well known as a vital signs that describe the person's health status and consist of [1]: body temperature (BT), blood pressure (BP), heart rate or pulse (HR), and the respiratory rate (RR). Two vital signs which are frequently used in health monitoring are pulse rate and body temperature. The pulse rate shows signs of a person's life and the state of the human body which is experiencing an illness. The Changes of body temperature are also closely linked to the production of excessive heat, excessive heat dissipation, minimal heat production which can affect a person's clinical condition such as fever, heat stroke, hyperthermia and hypothermia. Common tool to measure pulse rate in the medical laboratories is Electro Cardiography (ECG) and one of the commercial measuring tools made by OMRON to measure pulse and Thermometer [2] for measuring body temperature. Generally, a medical practitioner and patient should perform physical communication directly at a certain time and because of the higher daily activities of modern humans, the communication is difficult to do so that the health is neglected and the quality of life declines.

The development of Internet has been able to reduce the distance, place and time and also has become a necessity in human life and easy to obtain because of the cheaper price, wider coverage and faster in speed. The Electronics technology, communication protocols, wireless networks and software can also be a motor to maintain human health. Telehealth is the example of application which doctors and patients use to indirectly interact by utilizing the health sensors that are connected online and there is limitation of time and distance. Technology of Wireless Body Area Network (WBAN) [3] is one of the wireless networks for connecting multiple medical sensors placed inside and outside the human body. The result was from a scan of a patient's body submitted online using Bluetooth, XBee, ZigBee, Wifi to a Database Server.

[4] offered a system concept of wearable sensors consisting of a microcontroller, a Bluetooth module, server and PDA. Data retrieval is controlled by a microcontroller and sent to a smartphone using Bluetooth. In certain emergency situations, the data are sent to the computer as a server and Buzzer provides a certain mark.

[5] described a heart-rate monitor system using a finger sensor with two Arduino Uno. The first Arduino on the sensor system combined with XBee module as the sender to communicate with the second Arduino Uno that was connected to the local PC. The local PC was connected to the database server as a media analysis of health practitioners to monitor patients' health.

[6] also described the application of human body temperature monitoring system using several temperature sensors,

*Corresponding author: Desy Dwi Purnomo
†Email: desy.dwi@ui.ac.id

Arduino Lilypad, Bluetooth Module, LCD screen, Micro SD memory to store data as the result. If the temperature is lower or higher than the normal standard of temperature parameters, the system will command the buzzer to give a warning as a sign and measured results are stored in external memory.

[7] also described the monitoring system of temperature and heart rate using pulse rate and body temperature sensors which merged into one system, connected to the Arduino micro-controller then sent the result data to the android gadget using Bluetooth wireless technology. Android gadget will provide real-time view of the patient's condition through an installed application in android gadget. The [8], [9], [10], [11], [12], [13], [14] also described the portable monitoring system that was used to obtain data of vital signs of the human body, especially the heart rate and body temperature that indicated a person's health condition and can be remotely accessed.

In this paper, the author intends to design, build and implement a portable monitoring system of pulse rate and body temperature using Arduino microcontroller, equipped with SD Card, LCD screen, a 2.4 GHz Wi-Fi module for transfering data to the server. Hosting server has been used as a data processing from the sender, completed with the specific domain addresses which can be accessed from the Internet using a PC or android gadget.

SYSTEM DESIGN CONSIDERATION

Health Monitoring System Architecture

The block diagram of overall health monitoring system is shown in Fig. 1 which is divided into two blocks i.e. Sender system consisting of two sensors controlled by a microcontroller Arduino Mega, equipped with SD Card module, LCD screen, ESP8266 module and receiver system that consists of database server and smartphones based on Android. Data of measuring results are sent to the server using wireless network (Wi-Fi) that operates at a frequency of 2.4 GHz. Data processing starts from sensors that are controlled by the microcontroller which then is sent to the Receiver system and displayed to the LCD screen and saved to the SD Card in the form of a text file that can be opened using Notepad ++ applications.

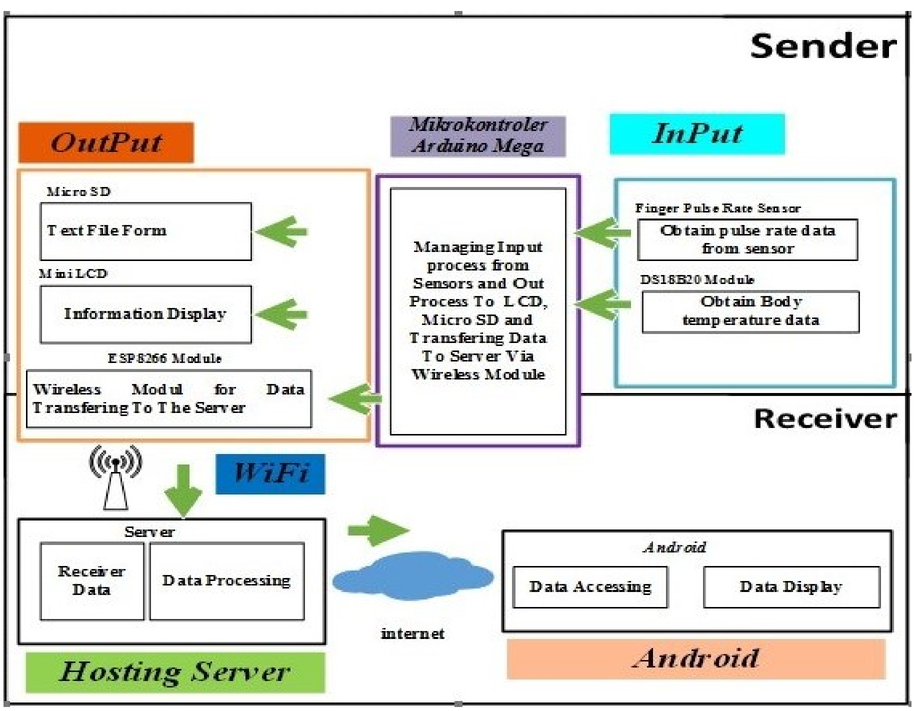

Fig. 1 . Proposed block of health monitoring system

Pulse Rate Measuring Instrument

This system uses a Pulse Rate Finger Sensor using photoplethysmograph technique to detect a pulse. This sensor detects the pulse rate signal using light as a pulse detector of blood volume changes in the network that is synchronized with the heartbeat.

In other words, the pulse sensor is used to measure subtle changes in light of the expansion of capillaries to feel the heartbeat. This sensor is placed on the fingertip to measure pulse rate as in Figure 2.

Fig. 2 . Proposed block of health monitoring system

Body Temperature Measuring Instrument

DS18B20 is a temperature sensor that is used in this project. Its nature of waterproof is suitable for the measurement of human body temperature and has a higher accuracy.

This sensor was developed by Maxim Integrated, has an accuracy of $\pm$ 0.5°C from -10 C to + 85°C at room temperature, works at a variety of temperatures (-55°C to + 125°C) or (-67 °F to + 257°F). DS18B20 has a 64-bit serial code that is unique, allowing multiple DS18B20 functioning on same 1-Wire bus. It also has a query time lesser than 750ms and can be used at 3.0V.

Microcontroller Arduino

A Arduino Mega Microcontroller was selected as one of the main components of this system. Arduino Mega 2560 is using ATmega2560 chip, has a number of I/O pins i.e. 54 pieces of I/O digital pin (15 pins of which are PWM), 16 analog input pins, 4 pins UART. Arduino Mega 2560 is equipped with a 16 MHz oscillator. The hardware is as shown in Figure 3.

Fig. 3 . Arduino mega [13]

LCD Screen

The display module is lightweight, low power, small and easy to use via I2C. It can operate in the 3.3 to 5.0 V power supply. It has a screen resolution of 128 x 64 pixels, I2C interface, dimensions 0.96 x 0.75. It is shown in Fig. 4 below.

Fig. 4 . LCD screen

ESP8266 Module

ESP8266 is a WiFi-based wireless module that is inexpensive, works at a frequency of 2.4 GHz, running at 3.3 volts and will be at risk of damage when given power of 5V. ESP8266 has the strong capability of processing and storage on-board and could be integrated with sensors and other applications specialized devices through GPIOs with simple development and minimal loading time.

Schematic

Schematic is a interconnection illustration of circuit between electronic components with Arduino Microcontroller pins. The Components connected to the Arduino are two sensors, module SD Card, LCD and Wireless Modules as shown in Figure 5.

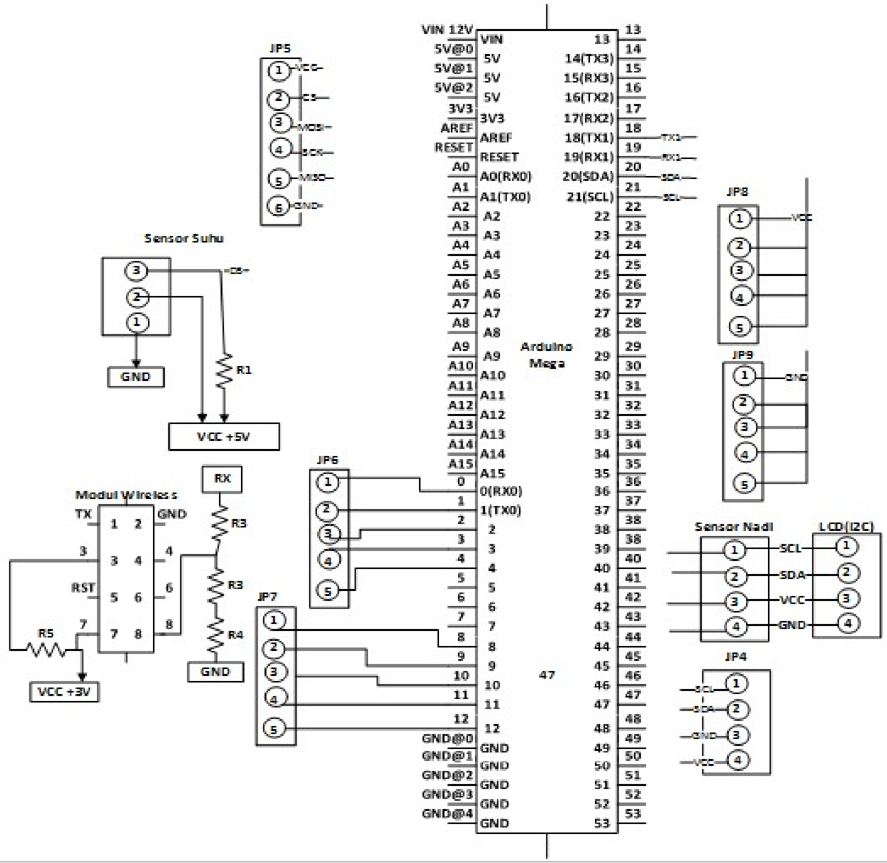

Fig. 5 . Schematic of sender system

SYSTEM IMPLEMENTATION

Validation had been done to ensure that the designed system can be realized and implemented. The Box of sender system that includes two sensors, LCD, wireless module and SD Card as seen in Figure 6 below.

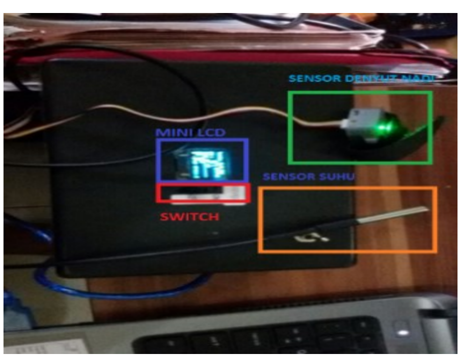

Fig. 6 . Box of sender system

In addition, this tool has been implemented by some volunteers to measure pulse rate and body temperature as shown in Figure 7 and Figure 8.

Fig. 7 . Measuring of body temperature

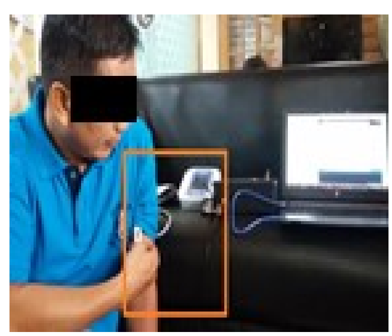

Fig. 8 . Measuring of body temperature

For adaptation to the SSID name of access point, mini application (SSID.exe) has been created and has to be firstly installed to the computer to configure SSID name, ID user to this device using USB serial cable as shown in Figure 9.

Fig. 9 . Setting SSID to the device

A Switch also realized to control data transfering to the server. When the switch is "on", data will be sent to the server and if "off", data will not be sent to the server. It is parallel placed with LCD as shown in Figure 11.

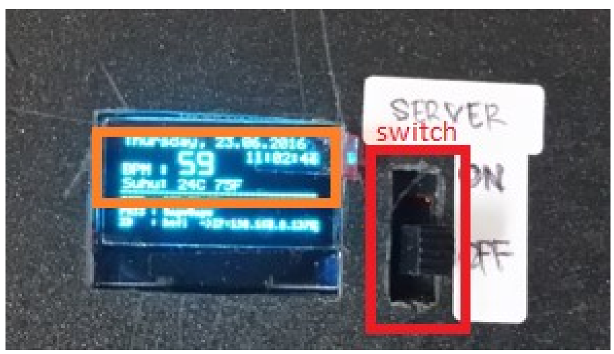

Fig. 10 . Switch and LCD display

Data of Measuring Results are also stored on the SD Card in the text form that can be opened using Notepad ++ as shown in Figure 11. The file name is Datalog.txt.

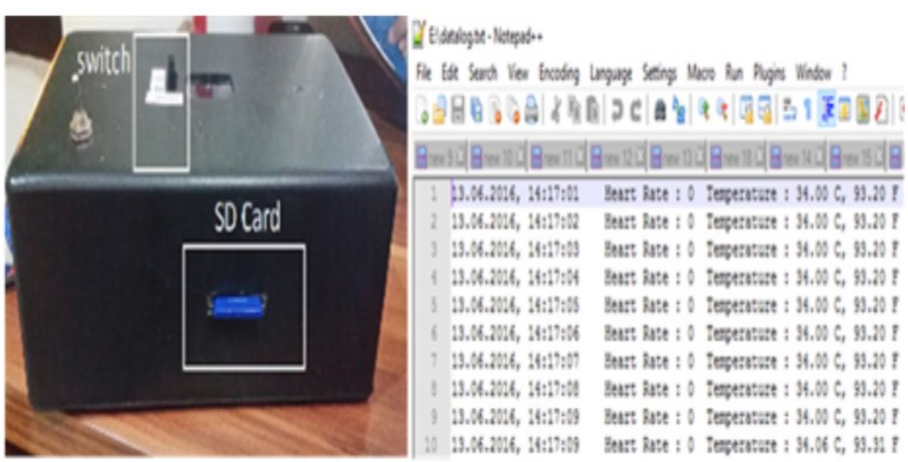

Fig. 11 . SD card

The Web Hosting Domain is http://cpanel.iotredfox.com/ that is Implemented in Admin Server which is shown in Figure 12 and described as server systen that consists of several functional folders such as information on the CPU Usage, I/O Usage, domain names, Files, Databases, Domains, Email, and others. There are several functional PHP files on the server i.e. add_client2.php, add_datau2.php, add_datax.php, add_json.php. Administrator of the system created all clients in the server via Android Gadget.

Fig. 12 . Admin server

In Figure 13 and Figure 14, Client can monitor result data by accesing to the server at http://iotredfox.com/index2.html or via installed application on Android Gadget. The measuring data from sensor will be added with timestamps from the local server. Healthdroid.apk application must be installed first on android devices so that once opened, will appear two options i.e. Admin and Client user. An Administrator is authorized to register, monitor all clients and delete a user client. A Client has authorization to see the results of measuring data , log data as well as in the form of graphs as shown in Figure 15.

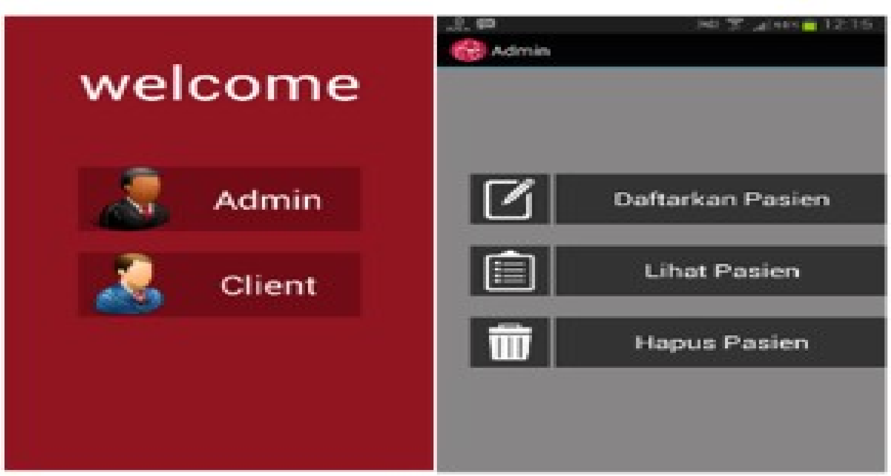

Fig. 13 . Android application

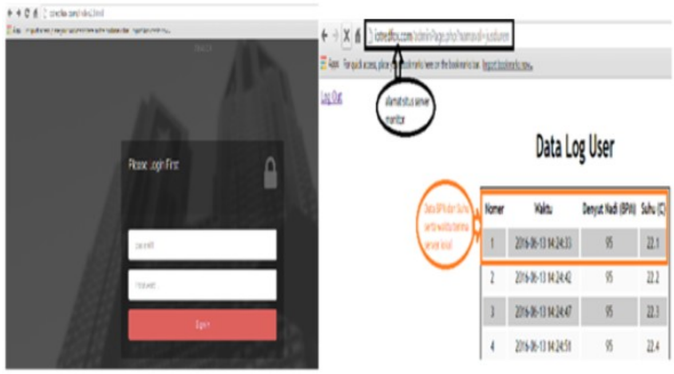

Fig. 14 . Client monitor from server

Fig. 15 . Client monitor from android gadget

RESULTS AND DISCUSSION

The validity of this tool system has to be tested. We have tested to get pulse rate data from 2 volunteers in the clinical laboratory and 5 volunteers using commercial device OMRON. Body Temperature Data were also collected from 5 volunteers using Thermometer. Figure 16 described data obtained in the clinical laboratory and written on the table 1. This device has 1.39% of error compared with ECG.

Fig. 16 . Measuring in clinical laboratory

TABLE 1
COMPARATION OF ECG

No	Results (BPM)		Error %
	ECG	Device	
1	81	81	1.25
2	65	66	1.54
Average		1.39	

OMRON shown in Figure 17 is the device that compares with and we can see the result in table 2. This device has 2.26% of error compared with OMRON.

Fig. 17 . OMRON

TABLE 2
COMPARATION WITH OMRON

No	Results (BPM)		Error %
	OMRON	Device	
1	67	68	1.49
2	55	54	1.82
3	58	59	1.72
4	62	64	3.23
5	66	64	3.03
Average		2.26	

This device also compared with the digital Thermometer to get its validity to make sure that it can be used as measuring instrument. We used 5 volunteers to get body temperature data and written in Table 3 below. This device has 2.03% of error.

TABLE 3
COMPARATION WITH THERMOMETER

No	Results (BPM)		Error %
	Digital Thermometer	Device	
1	35.1	34.06	2.96
2	35.9	35.38	1.45
3	33.4	33.94	1.62
4	35.6	35.19	1.15
5	36.4	35.31	2.99
Average		2.03	

CONCLUSION AND RECOMMENDATIONS

The objective of this project has been successfully achieved. Pulse Rate And Body temperature measurement for remote health monitoring has been designed and developed. The system provides the reliable measurements that are very user friendly. The device and the system can be improved in terms of sizing and integration with more measurement devices. But there was delay time more than 1 second so it can not be called realtime system. In the next time, RTOS can be implemented to improve delay time and volunteers should be added to increase validity value.

Declaration of Conflicting Interests

There are no associated conflicts of interest.

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