DESIGN AND DEVELOPMENT OF SMART PATIENT HEALTH MONITORING SYSTEM USING ECG

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ABSTRACT
This paper presents the design and implementation of a compact microcontroller-based portable system used for measurement of temperature and heart pulse on real time. A long-term study of (ECG) signal during everyday activity is required to obtain a broad spectrum of heart disease categories based on heart rate changing. The typical (ECG) signal uses basic logical decisions or more complicated algorithms to process the heart disease. A patient monitoring system takes the heartbeat and body temperature by using embedded technology. This system is embedded with temperature and heart pulse sensor to monitor the health of patients. The system consists of software and hardware Bluetooth module, DSB18B20 temperature sensor and a heart pulse sensor which are directly linked to a microcontroller (ATMEGA-328PU) unit. The microcontroller, DSB18B20 and the heart pulse sensor utilized a 5V power supply, provided by a regulator called LM7805.A. 5V power supply unit activates the heart pulse sensor and the DSB18B20 connected to the microcontroller. Whenever the heart pulse and temperature is sensed by the heart pulse sensor and DSB18B20, signal is sent to the microcontroller, the microcontroller decodes and sends an instruction to the Bluetooth module which transmit data to the smart phone with the aid of a smart phone application. The response time is fast. The value of the heart pulse rate and temperature measured can also be seen on the LCD. The mobile health monitoring system was able to detect different pulse rate and body temperature of different people Back and front mobile application can be included in the design so that medical personnel can interact with the patient whenever they find it difficult to go the hospital.

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Keywords: *Microcontroller, ElectroCardioGraphy, Temperature Sensor, Mobile Application, heart pulse sensor, temperature sensor*.

INTRODUCTION
Microcontroller Based Wireless Temperature and Heart Beat rate is suitable for operation in a small office or residential areas. The system is easy to operate by using mobile phone. The result will be displayed through Liquid Crystal Display (LCD). Early diagnosis for heart disease is typically based on tape recording of Electro CardioGram (ECG) signal which is then studied and analysed using a microcomputer. This paper however, presents the design and implementation of a compact microcontroller-based portable system used for measurement of temperature and heart pulse on real time. Diagnosis of heart disease using ElectroCardioGram (ECG) signals, may be achieved by either comparing the pattern of the ElectroCardioGram (ECG) signal with a typical diseased signal. The typical (ECG) signal uses basic logical decisions (Leffler, 1994), or more complicated algorithms to process the heart disease (Arif, 2012). The first approach requires complicated mathematical analysis to obtain the expected result, while the second one involves using machine algorithm (programming language) which is used in most cases. A long-term study of (ECG) signal during everyday activity is required to obtain a broad spectrum of heart disease categories based on heart rate changing. Different methods were used, e.g. minicomputer in an area where patient

needs special attention and care or microprocessor-based card in a small movable system (Stefan *et al.*, 2017). In this case, the advantage is the restriction of patient movement. A wire-free system connected to a hospital computer system allows patient mobility within restricted area in the hospital. Tape systems for storing (ECG) signals are large, heavy and fragile. Also, this system needs large batteries. Therefore, to reduce the size and power consumption of the system, a single micro controller Reduced Instruction Set Computer (RISC) architecture microcontroller was chosen. So that, it can prevent the patient from moving around (Mohamed *et al*, 2008). A data transmission instruction using messages is implemented in the system Microcontroller Based Wireless Temperature. A Heart Beat Rate which can be displayed through LCD.

This research work is useful in medical applications and offers less cost and size than Photoplethysmography (PPG). In the case of emergency, for people who are suffering from heart diseases, continuous monitoring of the patients is required which is sometimes not possible in the hospital or the patient's location is far away from the hospital. In such case this system is useful to measure the heart rate and the information is transmitted to the medical advisory for the necessary actions so that patient can be under control, prevented from adverse situation before getting to the hospital. Heart pulse rate means the number of heartbeats per unit time, usually expressed as beats per minute (bpm). The human heart pounds to pump oxygen rich blood to the muscles and carry cell waste products away from the tissues. Heartbeat rate can vary according to the demand of the muscles to absorb oxygen(O_2) and excrete carbon (IV) oxide (CO_2) changes such as during exercise or relaxation. It also varies significantly between individuals based on age, fitness and genetics. This means that the heart must beat faster to deliver more oxygen rich blood. During exercise, the heartbeat rate gives a strong indication of how effective the exercise is to the body.

The patient monitoring systems is one of the major improvements in the world health care program because of the improved technology. A patient monitoring system takes the heartbeat and body temperature by using embedded technology. This development in technology is highly needed because many sick patients at the hospitals die because of high fever and heart attacks. The recent change of cardiovascular disease has shown that heart beat rate plays a key role in determining the possibility of a heart attack, while the rise in the body temperature can cause fever on a patient. Heart diseases such as heart attack, coronary heart disease, congestive heart failure, and congenital heart disease are the leading causes of death for men and women in many countries. Most of the time, the aged people of the society are more prone to heart disease problems than the younger ones. For people who live alone with no one to monitor their health condition, this device offers an opportunity to them for a continuous monitoring of their health status. The device is efficient to give a patient's health status. Jenthamilaras *et al.*, (2018) proposed using the important parameters as temperature, ElectroEncephalography (EEG) and heart beat reading were monitored using Arduino Uno. These sensors signals are sent to Arduno Uno through amplifier circuit and signal conditioning unit. Patients body temperature, EEG and heart rate are measured using respective sensors.

Shaad Mahmud *et al.* (2017) developed an integrated system using analog circuit and wireless microprocessor on a smart phone. The analog circuit commence with the use of a buffer amplifier to make high input impedance, then passes through different stages of low-pass filter, high-pass filter (HPF), notch filter and high gain amplifier. The ECG signals send to smart phone in real time with graphical interface on the screen, including heart rate, respiration suggestions based on the current health condition.

Rotariu *et al*. (2011) developed integrated system for wireless monitoring of chronic patients (especially for the elderly people). The system is suitable for a long time monitoring. Although, medical personnel can assist if the condition is serious. Personal Digital Assistant (PDA) which has a monitoring application received signal from monitoring devices. The signals will activate the alarm, when the monitor parameters

like temperature exceed the preset limits. The status of the patient's condition is communicated periodically to the central server which is connected with the global system for mobile communication (GSM) or General Packet Radio Service (GPRS) connection. However, this type of system was useful for application that requires high band width. Internet has made it possible for many machines and devices that we make use of everyday to be controlled through the internet of things technology (Tastan, 2018). The application of smart health to detect the health status of different people is very important nowadays.

The signal level of the circuit of the health monitoring system is low which was later amplified using an amplifier circuit to boost the signal before transmission to Arduino uno (Senthamilarasi, *et al.*, 2018). The patient monitoring system is connected to a cloud network database system to enable continuous monitoring of the patient health status by the medical personnel. If there is any abnormality this can be detected by the medical personnel. The design, construction and simulation of a wireless patient monitoring system with a mobile alert technology was carried out by (Chukwunazo *et al.*, 2015). The measurement of the patient health system is done by constantly observing the temperature, pulse rate and maintaining a record of these parameters. A wireless monitoring system that can be monitored through signs such as the temperature pulse rate of the patient in real time and give results in form of notification.

Monitoring system is characterized as the system applied for testing and observing physiological signs that incorporate the results like ECG (Shola *et al*., 2017). The high use of mobile smart device in the health sector has enhanced the work of the health personnel such as doctors. This device will transmit the readings from the sensors to the cloud. The doctors and others can get the results from here. This result will be accessible for analysis progressively.

PROBLEM STATEMENTS

There is high rate of untimely death due to inadequate or no mobile and proper health care system, which could be used to monitor patients' health status. Increasing rate of blood pressure is becoming a serious concern because there are no efficient facilities in the country to monitor high blood or too low blood pressure. The available ones are very expensive. Most people living in rural areas find it very difficult to receive medical personnel attention, this type of system can be used because it is economical and easy to operate. The aim of this project is to design and develop a smart patient health monitoring system using ECG.

METHODOLOGY

In order to achieve the objectives of this research of microcontroller based heart rate monitoring system, several hardware components and software tools were employed and used. Most of this components can be seen in fig1below.

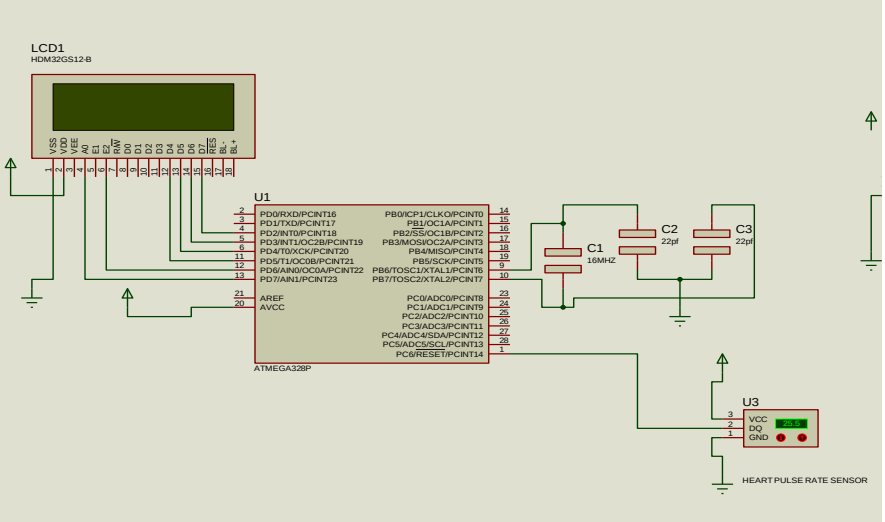

Figure 1: Circuit diagram of the system

THE PRINCIPLE OF OPERATION OF SMART PATIENT HEALTH MONITORING SYSTEM

Bluetooth module, DSB18B20 temperature sensor and a heart pulse sensor which are directly linked to a microcontroller (ATMEGA-328PU) unit were used. The microcontroller, DSB18B20 and the heart pulse sensor utilized a 5V power supply, provided by a regulator called LM7805. A 5V power supply unit activates the heart pulse sensor and the DSB18B20 connected to the microcontroller as shown in fig. 1 above Whenever the heart pulse and temperature are sensed by the heart pulse sensor and DSB18B20, signal is sent to the microcontroller, the microcontroller decodes and sends an instruction to the Bluetooth module which transmit data to the smart phone with the aid of a smart phone application. The response time is fast. The value of the heart pulse rate and temperature measured can also be seen on the LCD.

VISUAL REPRESENTATION OF ELECTROCARDIOGRAM (ECG) SIGNAL

An electrocardiogram (ECG), also called an EKG, is a graphic tracing of the voltage generated by the cardiac or heart muscle during a heartbeat. This is shown in fig. 2 below. It provides very accurate evaluation of the performance of the heart (Sowmyasudhan, *et al.*, 2011). The heart generates an electrochemical impulse that spreads out in the heart in such a fashion as to cause the cells to contract and relax in a timely order and, thus, give the heart a pumping characteristic. An actual voltage potential of approximately 1mV develops between various body points (Sowmyasudhan, *et al.*, 2011).

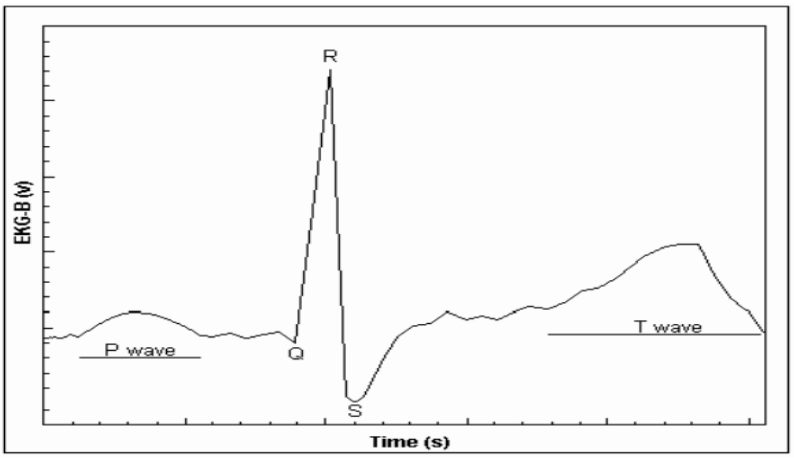

Figure 2. The ECG signal waveforms.

MEASURING THE HEART RATE

Heart rate is measured in beats per minute (bpm). In measuring heart rate, there are various ways to measure such as using pulse oximeter, heart rate monitor, electrocardiograph and ECG strap. The beats per minute varies according to people's age, physical body condition and environmental factor. There is a center in the brain responsible for controlling the heart beat rate (Postula, 2008). This center works based on the information received from the body muscles and sensors (i.e. this determines the rate at which the heart works either fast or slow). Measuring this manually requires the person to stop the activity he/she is doing in order to count the number of heart beats over a period of time. Measuring the heart rate using an electrical circuit can be done much quicker and more accurately.

Heart rate measurement is one of the very important parameters of the human cardiovascular system. The heart rate of a healthy adult at rest is around 72 beats per minute (bpm). Athletes normally have lower heart rates than less active people. Babies have a much higher heart rate at around 120 bpm, while older children have heart rates at around 90 bpm. The heart rate rises gradually during exercises and returns slowly to the rest value after exercise. The rate when the pulse returns to normal is an indication of the fitness of the person. Lower than normal heart rates are usually an indication of a condition known as bradycardia, while higher than normal heart rates are known as tachycardia.

Highly active people, particularly endurance athletes, often have very low resting heart rates than others (below 60 beats per minute). Heart rate can be measured by measuring one's pulse. Pulse measurement can be achieved by using specialized medical devices, or by merely pressing one's fingers against an artery (typically on the wrist or the neck). It is generally accepted that listening to heartbeats using a stethoscope, a process known as auscultation, is a more accurate method to measure the heart rate.

MICROCONTROLLER (ATMEGA328PU)

The Atmel 8-bit AVR RISC-based microcontroller combines 32 kB ISP flash memory with read-while-write capabilities, 1 kB EEPROM, 2 kBSRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes). The device operates between 1.8-5.5 volts.

LIQUID CRYSTAL DISPLAY (LCD)

The display unit consists of four seven segment displays, attached to the port or the micro controller. These four-segment display arrangements show the level of the liquid at any particular point in time**.**

The backbone of this system is software program; including the design of circuit, data communication and system interfacing. The data communication and all part must be tested in order to check the connection of the whole system. Furthermore, every parts of the system are tested individually to ensure the functionality before running system at large.
The flow chart for transmitter and receiver module are shown as figure below:

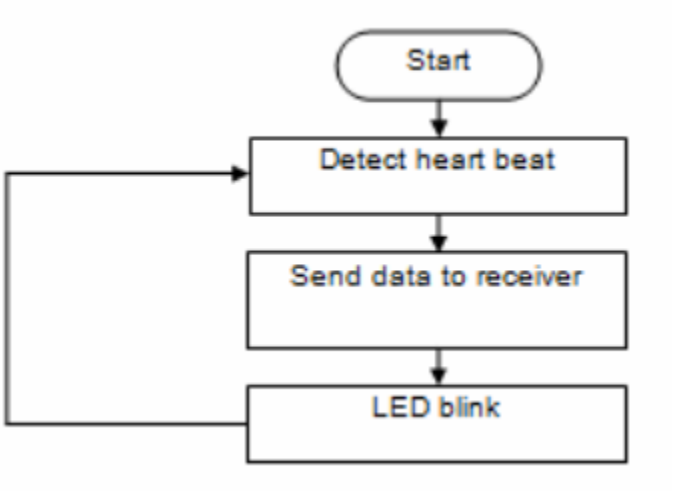

Fig 3(a): Flow chart of transmitter module.

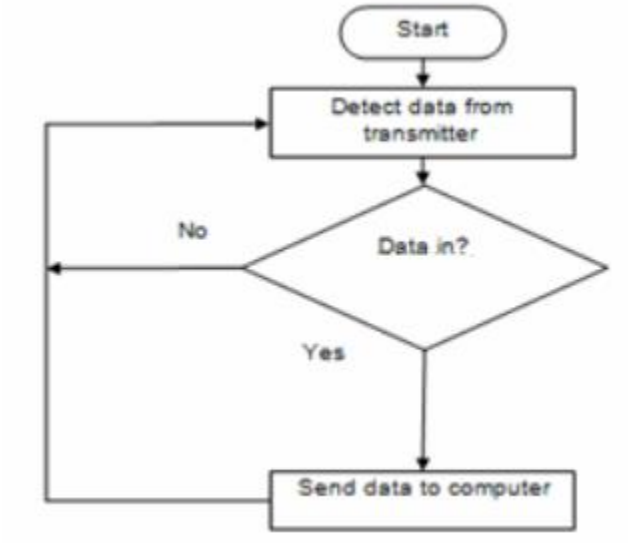

Fig 3(b): Flow chart of receiver module.

TESTING AND RESULTS ANALYSIS

The Patient Health Monitoring System developed is tested using various persons with normal to abnormal health conditions. The various testing and findings producing results with minimal error rate and the observations are listed below.

TEMPERATURE FINDINGS

The NC type thermometer used is programmed to display the value at room temperature with minimal error of + or – 5. The Smart Patient Health Monitoring System was used to test the body temperature of different patients and the results are shown in table 1 below. Also, the results were compared with the clinical readings.

Table 1: Observation of the temperature readings

Patients	Clinical readings (C^0)	Instrument readings (C^0)	Comment
Patient 1	36.7	36.9	Normal
Patient 2	37.8	37.0	Normal
Patient 3	39.0	38.4	Abnormal
Patient 4	37.3	36.9	Normal
Patient 5	38.7	38.0	Abnormal

NOTE: The normal body temperature ranges from 36.1 ^{0}C to 37 ^{o}C

ECG FINDINGS

The IR sensor is used to measure the pulse rate in the error range of + or – 6. The Smart Patient Health Monitoring System was used to test the pulse rate of different patients and the results are shown in table 2 below. Also, the results were compared with the clinical readings.

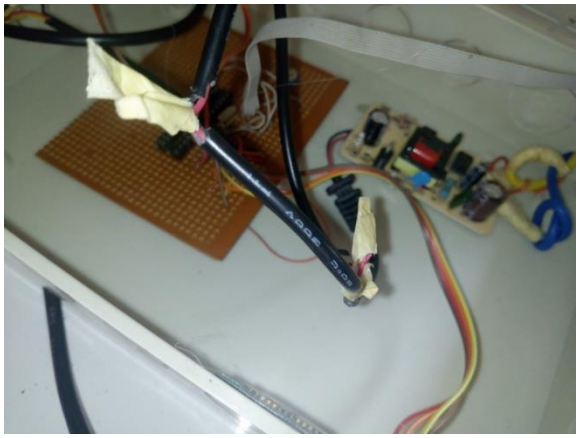

Fig 4: ECG measurement sensor

Table 2: Observations of the Ecg readings.

Patient	Sex	Age	C.R (bpm)	I.R(bpm)	COMMENT
Patient 1	FEMALE	50	67	67	Good
Patient 2	MALE	29	64	64	Good
Patient 3	MALE	32	84	83	Poor
Patient 4	MALE	47	64	64	Good
Patient 5	MALE	35	78	80	Poor

Clinical Readings (C.R) (Rabiat Soaga Memorial Health Centre, MAPOLY)
Instrument Readings (I.R)
NOTE: The normal pulse for healthy adult ranges from 60pbm to100bpm the pulse rate may fluctuate and increase with exercise, illness, injury and emotions. Female ages from 12 and above tends to have fast heart rate than males.

RESET BUTTON

In order to get readings of a patient, the rest button is always activated after each patient is been examined and readings are taken.

CONCLUSIONS

The mobile health monitoring system was able to detect different pulse rate and body temperature of different people. This system comprises of temperature sensor, microcontroller with software, liquid crystal display (LCD) and regulated power unit. There was transmission of signal between the sensors and the body in contact. Increasing rate of blood pressure is becoming a serious concern because there is no efficient facilities in the country and the available ones are very expensive. Most people living in rural areas find it very difficult to receive medical personnel attention, this type of system can be used in the rural areas because it is economical and easy to operate.

RECOMMENDATIONS

The following are recommended for future work;

- Photopletismography can be used to get more parameters like blood pressure, sugar level, pulse rate and body temperature.
- Database can be used to record different patients' pulse rate and body temperature without any mistake.
- Back and front mobile application can be used so that medical personnel can interact with the patient whenever they find it difficult to go the hospital.
- Government should also provide this type of facility for people in the rural areas so that they can measure their oxygen level without the assistance of laboratory scientist.
- Engineers should provide a method of sterilizing the liquid crystal display so that people using the system would not be infected.

ACKNOWLEDGEMENT

Deep and unreserved appreciation goes to Rabiat Soaga Memorial Health Centre for giving us the privilege to test the equipment.

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