Intelligent Patient Monitoring System for Heartbeat and Temperature with Wireless Emergency Alarm

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Abstract- ***The advancement of technology has helped the world at large in various sectors. The application and improvement of technology in the health sector is very essential to provide timely and accurate health services. This is a project that adds great value to the healthcare sector and reduces the high mortality rates from cardiovascular related diseases. This project emerged due to the high death rates in hospitals owing to lack of constant monitoring of critical patients. The intelligent monitoring system was achieved using fingertip sensors to detect the temperature and heartbeat of patients, the signals are sent to the microcontroller that processes them and outputs the readings on the liquid crystal display (LCD). When the normal value range is exceeded, signals are sent wirelessly to the receiver unit to notify healthcare workers for immediate patient care. This medical system is cost effective and can be used in clinics and hospitals. This project could be further improved to have more vital signs such as blood pressure, respiratory rate and the detected data could be sent to a mobile phone via a GSM module for further analysis.***

Indexed Terms- ***Cardiovascular disease (CVD), healthcare, Heartbeat, Monitoring, Microcontroller, Temperature, Liquid crystal display (LCD),***

I. INTRODUCTION

Congestive Cardiac failure (CCF) has become a major public health problem worldwide and imposes an increasing burden on the health care system. However, cardiovascular diseases (CVD) are the leading cause of death worldwide. More people die annually from CVD than from any other cause. According to the World Health Organization (WHO) registry in 2016, about 17.9 million people died of CVD representing 31% of all global deaths. 85% are due to heart attack and stroke (World Health Organization [1]. One of the main reasons for the large number of deaths is the absence of timely and qualified assistance, monitoring the vital signs of medical care can save up to 60% of human lives through timely detection to prevent heart attacks. Vital signs are measures of the most basic functions of the body. Vital signs are routinely monitored by medical professionals and health care providers and it include body temperature and pulse rate. They are useful for detecting or controlling medical problems. A person's normal body temperature varies based on gender, recent activity, food and fluid intake, time of day, and, in women, the stage of the menstrual cycle. Normal body temperature can range from 36.1°C (equivalent to 97.8 ° F) to 37.2°C (98.6 ° F) for a healthy adult. For critical body temperature which ranges from 44ºC or more, it is certain that death will occur or serious brain damage, continuous convulsion and shock. A person's body temperature can be taken in any of the following ways: by mouth (through the mouth), axillary (under the arm with a glass or digital thermometer) by the ear (through the eardrum), and by the skin (on the forehead). Body temperature may be abnormal due to fever (high temperature) or hypothermia (low temperature). Fever is indicated when the body temperature rises approximately one degree or more above the normal temperature of 37.2°C. Hypothermia is defined as a drop in body temperature below 36.1 ° C. Pulse rate is a measure of heartbeat, or the number of times the heart beats per minute. As the heart pushes the blood through the arteries, the arteries expand and contract with the flow of blood. The heartbeat may vary according to the physical needs of the body, including the need to absorb oxygen and excrete carbon dioxide. The normal pulse for healthy adults ranges from 60 to 100 beats per minute. Pulse rate can fluctuate and increase with exercise, illness, injuries and emotions. Women 12 years of age or older, in general, tend to have faster heartbeats than men. Athletes, such as runners, who do a lot of cardiovascular conditioning, can have heartbeats close to 40 beats per minute and not experience problems.

Tachycardia is a rapid heartbeat, defined as greater than 100 bpm at rest. Bradycardia is a slow heartbeat, defined as less than 60 bpm at rest. During sleep, a slow heartbeat with frequencies of around 40–50 bpm is common and is considered normal. When the heart does not beat regularly, this is known as arrhythmia. Heartbeat abnormalities sometimes indicate illness.

The project design consists of the control unit that makes use of the Arduino ATmega 328, the sensors, the liquid crystal display, the power supply, the transmitter and the push buttons. Fingertip sensors, which are thermistor and heartbeat sensor, are used in the device as the transducer converts the physical PPG signal into an electrical signal. The electrical signal is applied to the microcontroller, which is the main brain of the monitoring system. The microcontroller, according to the algorithm stored in it, processes the signal, measures its frequency and outputs the results to the LCD screen and then commands the RF receiver to sound an alarm when the set range of standard readings of the vital signs is exceeded.

II. REVIEW OF RELATED WORK

Recently, various attempts have been made to improve the characteristic of the conventional thermometer and stethoscope. The newest method of measuring temperature and heartbeat is by using sensors for pulse and body temperature, it combines the two most vital signs and provides more concise and accurate readings without stress, unlike frequent checking of the pulse and the patient's temperature. The sensors are used to detect the heartbeat and body temperature, the readings in BPM (beats per minute) are displayed on the connected LCD (liquid crystal display) and the body temperature will be displayed on the serial monitor along with the BPM readings [2]. The advantage of this innovation is that it saves continuous measurement time and provides accurate values unlike manual measurement way. But it lacks the emergency notification capability.

A further improvement led to the design of a GSM-based heartbeat and temperature monitoring system using a fingertip sensor, which is a microcontroller-based project. It frequently provides the doctor with the heart pulse rate and the human body temperature via sms, which means it has GSM module integration. Thus, it has the advantage of console notification for the clinician to take immediate action when[3]. However, the limitation of this project is that the notification could fail in the event of a network failure. This project "Smart Microcontroller-Based Patient Monitoring System for Measuring Heartbeat and Temperature with Integrated Alarm" measures body temperature and heartbeat using a thermistor as a temperature sensor and a pulse sensor for heartbeat. The sensors are placed on the fingertip, the values or readings of beats per minute and the body temperature are displayed on the liquid crystal display (LCD), when the readings are above or below the normal range, then the system will activate an alarm to notify health workers that there is an emergency in the ward. In conclusion, this technological advance is highly recommended due to the increase in the mortality rate related to cardiovascular disease. It is almost impossible for doctors and nurses to stay near a patient's bed all day to monitor their health, but with this project, temperature and heartbeat can be monitored without frequently checking patients. Thus, it saves time, provides accurate readings, and is easy to access and understand. It also helps detect heart attacks and high fever to prevent the high death rate, especially in the ICU.

III. METHODOLOGY

The microcontroller-based intelligent patient monitoring system is designed and built using some specific components according to its specifications and functions. There are different sections that make up this system. They are power unit, control unit, display unit and alarm unit.

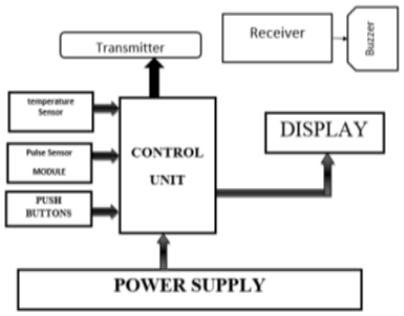

FIG 1: Shows the complete block diagram showing all necessary sections.

IV. MODE OF OPERATION

This project consists of the design and construction of a heartbeat counter and a temperature sensor using a microcontroller thermistor and a pulse sensor based on the principle of photoplethysmography (PPG), which is a non-invasive method to measure the variation in tissues using a light source and a detector. Since the volume of blood inside the fingertip increases as the heart expands and decreases as the heart contracts, the resultant pulsing of blood volume in the fingertip is directly proportional to the heartbeat. We would have successfully and accurately obtained the heartbeat count if we could count the number of pulses in a minute (which we can). In this project, we are trying to put together a means by which the heartbeat and temperature of a patient can be measured using sensor upon which the fingertip is placed, and the result is displayed on a text-based LCD. The control unit is connected to an AC power source, while the energy is stored in the battery bank, so that when the AC power source is turned off, the power source is now switched to a DC power source that will last a maximum of seven (7) hours. When the control unit is powered, the push buttons is used to set the minimum and maximum range of each vital signs (heartbeat and temperature), the middle push buttons serve as menu to choose the vital signs to be set, then the left button sets the minimum range while the right push button sets the maximum range. When the ranges are set, the receiver which has the buzzer beeps when the range is exceeded. The receiver which is connected to the control unit wirelessly is kept ten (10) meters to twenty (20) meters away from the control unit, which can be at the healthcare (doctors or nurses) offices or passage of the ward. It sounds an alarm when there is an emergency (when the set range is exceeded). The receiver makes use of 9V battery as DC power supply.

V. FUNTIONS AND KEY ELEMENT OF EACH UNIT

a. The Power Supply Unit:

The power supply supplies electrical energy needed by the system to function. Here the power supply has the primary and secondary stage. The primary stage converts 220V AC to 12V DC. The 12V used to charge the battery which forms a power accumulator to the system and is further regulated to 5V DC for the digital devices in the system. When the AC is connected to the system, the power bank is being charged so that when the AC power supply is interrupted the stored power in DC will now supply power to the system. The duration of the charged DC battery is 0 to 7 hours maximum. The receiver makes use of 9V DC battery.

b. The Control Unit:

This system contains the Microcontroller, pull-up and pull-down resistors and the Oscillator. ATMEGA 328 is the microcontroller used in this system. ATMEGA328 was used here because of its vast application and programmability. The microcontroller momentarily sends and receives pulses from the heart beat sensor module and the collected value is then stored in a temporal memory location. According to the arithmetic expression in the firmware the MCU converts the value to ASCII code and displays it on the LCD.

c. The Push Buttons:

These are two active push buttons connected from ground to the microcontroller. The first button is used to send logic zero to the pin 19 of the microcontroller which according to the firmware starts reading information from the sensor when pressed while the second button connected between pin 18 and ground of the circuit is the button used to reset the system after each cycle of the heart beat monitor. In other words, the first button stands for reset button while the second button is used to start the heart beat reading.

d. The Display:

The display is a liquid crystal display. The sensed and calculated values are sent by the microcontroller to the display unit for human interpretation.

e. Pulse Sensor Module:

The pulse sensor LTH1550-01 photo interrupter works based on the principle of photoplethysmography. It is simply an IR diode – photo transistor pair in single package.

f. Transmitter and Receiver:

The transmitter and receiver make use of radio-frequency module (RF module) to transmits radio signals from the transmitter to the receiver wirelessly. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. A RF transmitter receives

serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter.

g. Temperature Sensor:

The thermistor is a temperature dependent resistor. The thermistor changes resistance with respect to the temperature applied to it. In this system, a thermistor is connected in series to a resistor which forms a voltage divider and the output is fed to an ADC (Analogue to Digital Converter) of the microcontroller which converts the analogue signal to a readable output.

VI. SYSTEM DESIGN AND ANALYSIS

The project design consists of the control unit that makes use of the Arduino AT mega 328, the sensors, the liquid crystal display, the power supply, the transmitter and the push buttons. Fingertip sensors, which are thermistor and heartbeat sensor, are used in the device as the transducer converts the physical PPG signal into an electrical signal. The electrical signal is applied to the microcontroller, which is the main brain of the monitoring system. The microcontroller, according to the algorithm stored in it, processes the signal, measures its frequency and outputs the results to the LCD screen and then commands the RF receiver to sound an alarm when the set range of standard readings of the vital signs is exceeded.

All hardware and software design steps are considered here including block diagram, circuit diagrams, algorithm, flowcharts etc

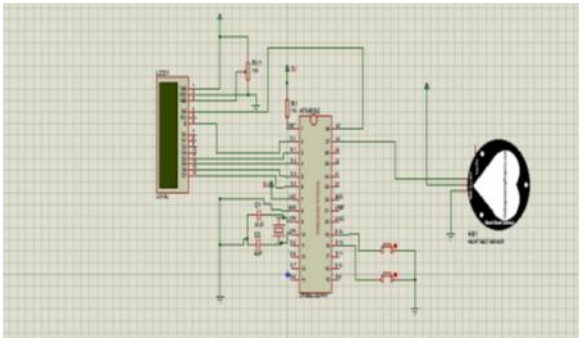

Fig.2 Circuit diagram of the system.

CONCLUSION

The design and implementation of a "Microcontroller-Based Intelligent Patient Monitoring System for Measuring Heartbeat and Temperature with Integrated Alarm" acquires patient's vital parameters such as heartbeat and temperature at important positions. The system displays real-time patient data on the LCD screen and these values could trigger alarm notification wirelessly if it goes above or below the normal range. The normal temperature value is 36.1°C to 37.2°C, while the normal heartbeat is 60 to 100 bpm. If any of these values decrease or increase, an abnormal condition will be detected and the alarm will be activated in the hallway of the ward or at the doctor's office. Under normal conditions, the LCD screen displays the values for on-site. This system is cost effective, user friendly and serves as a great improvement over other conventional measurement system.

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