MANTECH Publications

Journal of Embedded Systems & Its Applications
Volume 7 Issue 1, January-June 2022

A Study on Embedded System-Based Treatment of Cardiovascular Conditions Using Heartbeat Analysis

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Abstract

In recent years, the majority of individuals have suffered from heart disease. Early identification of heart problems aids in accurate diagnosis. This model is used to screen patients' cardiac features on a regular basis. The heart rate is measured and classed as normal sinus rhythm, tachycardia, bradycardia, or atrial flutter. If any abnormalities are discovered during the study, the patient or cardiologist will be notified. This might be developed into a Point of Care device for use in rural areas and hospitals. The goal of this model is to provide a framework for community healthcare using a heart sound analysis system. This design incorporates several improvements, notably the efficient usage of a heart beat sensor. Medical doctors have also proposed that this sort of equipment might be effective in the early detection of prevalent heart illnesses.

Keywords: *Cardiovascular disease, Embedded System, Heartbeat Analysis, Care device*

INTRODUCTION

Cardiac auscultation is used by clinicians to monitor heart sounds, which aids in the early detection of cardiac problems. However, in real-time applications, this is a time-consuming and inefficient procedure. Cardiovascular disease is a condition that affects the circulatory system. It mostly refers to heart and vascular illness. There are several sorts of cardiac disorders, including heart valve disease, arrhythmia, heart attack, and stroke. Every cardiac disease is discovered using either the heartbeat or an electrocardiogram [1]. The heart beat is a single cycle in which the chambers of the heart relax and contract to pump blood, as well as the opening and shutting of valves. Because ECG records the electrical signal from the human body using an array of electrodes, some preventive measures must be taken, such as healthy eating, exercise, and regular diagnosis of heart conditions.

Stethoscope and electrocardiogram are two primary methods used in the diagnosis of cardiac problems. However, this strategy does not appear to be a system for obtaining correct results [2]. Detecting cardiac illness through heart sounds is a difficult task. Because, while utilising a stethoscope, the doctor not only detects the heartbeat but also hears interference from lung noises, resulting in a noisy system Thus, this way of identifying heart disease is inexact and challenging, resembling a trial-and-error method [3]. Even though the population of developing nations grows every year, the number of cardiologists remains constant. As a result, some gadget has become required for aiding individuals in an emergency and for early identification of heart diseases using a cardiac prescreening device. Stethoscopes like HD Medical HD fono and 3M Sthethos are typically utilised for teaching and educational purposes. In general, there are very few instruments for cardiac prescreening and early diagnosis.

System architecture

The great challenge in healthcare is the cardiology field, which inspired the design of devices with various advantages such as real-time data analysis, low-cost devices, hand-held recording services enabled by portable or mobile devices, classifying the heart beat and sending it to medical professionals in case of emergency with the help of Global System for Mobile Communication [4].

System specification

The gadget is constructed with many technical breakthroughs that have provided a significant additional benefit in cardiology.

1. Heart beat sensor implementation;
2. Medical personnel may monitor the patient's heart function from health care centres using this device;
3. The system offers relevant features that are suitable for non-clinical field application;
4. The heart beat analysis is based on medical domain knowledge and physiological conditions [5]. These

two criteria are used to categorise heartbeats into four distinct situations.

Among the hardware components are:

1. Heart beat sensor, which serves as the cardiac prescreening device's heart. It detects the heartbeat of the human body and generates a digital output for further processing.

2. The 16F877A microcontroller is employed because it provides features such as a high performance RISC CPU, an analogue to digital converter, a UART, and interrupt sources.

3. A Liquid Crystal Display (LCD) is utilised to show the patient's heart rate.

4. Programmable Electrically Erasable Read only Memory (EEPROM) is a non-volatile memory used in this device to save patient data for future examination.

5. Global Mobile System. Communication is included into the cardiac pre-screening equipment allowing communication between the device and medical experts [6].

System Workflow

Depending on the medical domain knowledge, the suggested gadget may differentiate the patient's heart rhythm.

The workflow is well represented in the following:

- The system's core modules include a heart rate sensor [9], a PIC microcontroller, GSM, and an EPROM IC.
- The heart beat sensor is made up of an LED and an LDR. beat sensor
- Through the thumb, the LED light is revealed on the LDR.
- In the case of logic 1- it means no blood flow passage.
- In the case of logic 0-, it denotes blood flow.
- Depending on the degree of LDR, the heartbeat might be classified as normal or abnormal.
- When the signal is transferred to the PIC microcontroller, the heart beat may be categorised based on whether it is lower or greater than the standard level.
- With the support of GSM, the EPROM IC keeps the monthly database of the patient's cardiac parameters and delivers it to physicians during an emergency or at their request.

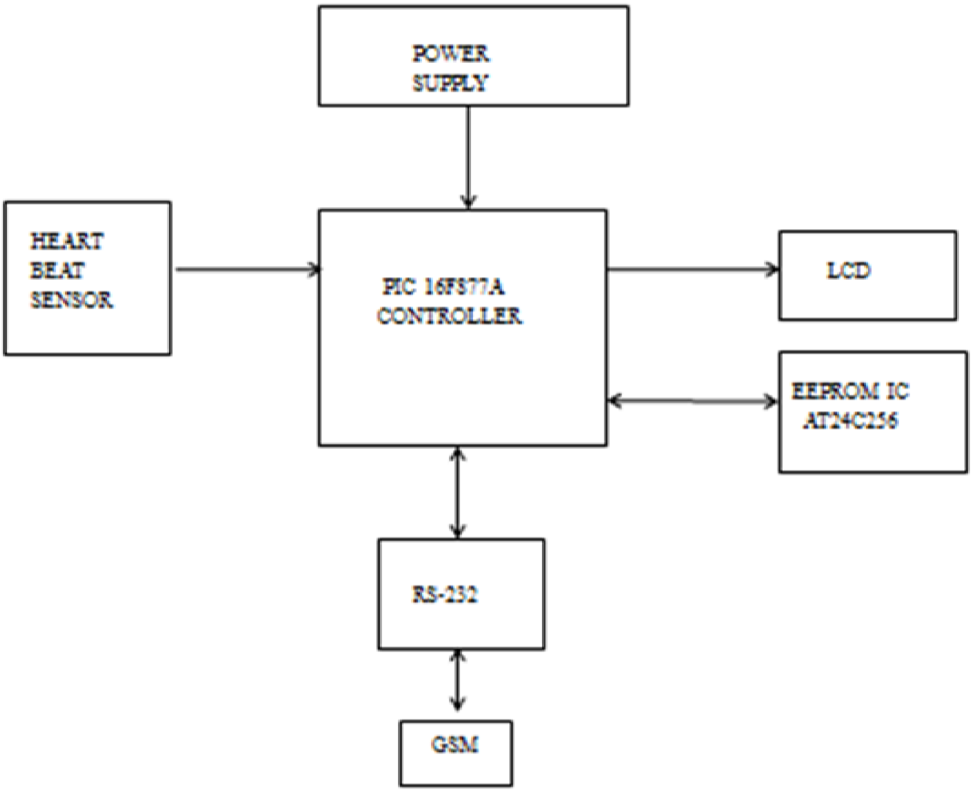

Fig.1. Block diagram of system

Hardware Implementation

Heart beat sensor

When a finger is placed on a heartbeat sensor, the heartbeat is digitally output. It combines LED and LDR technology. The beat LED illuminates with each heartbeat when the heart beat detector is turned on [7]. To measure Beats per Minute, the digital output from the heartbeat sensor may be directly linked to the microcontroller (BPM). Heart Beat Sensor provides a clear picture of the heart's operation. The sensor can detect blood flow through the ear lobe, where the quantity of blood fluctuates over time [8]. The signal is then boosted, reversed, and filtered.

The following are the characteristics:

- The heartbeat may be indicated with the aid of LED.
- Small and portable size
- The working voltage is 5 volts DC.
- Digital signal output is instantaneous, allowing direct connection to a microcontroller.
- 100 mA Operating Current
- Output Data Level: 5 Volts TTL
- 660nm Super Red LED light source

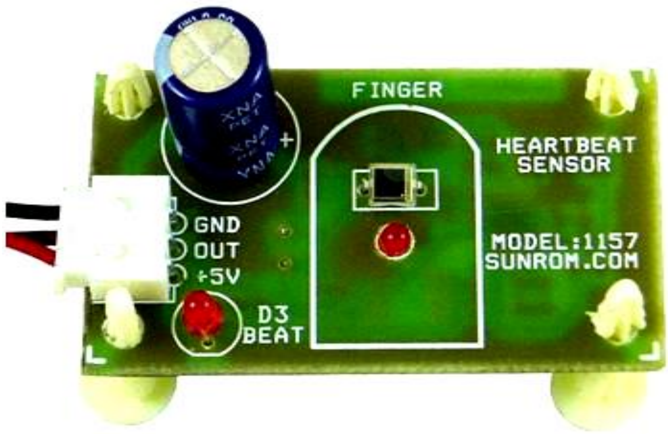

Fig.2. Heart Beat Sensor

PIC 16F877A Controller

The signals collected from the heart beat sensor are processed by the Peripheral interface controller. The PIC controller has a high-performance RISC CPU and an 8-channel Analog-to-Digital converter with 10 bits per channel. It has an SSP with SPI (Master/Slave) and I2C, as well as a USART with 9-bit detection. Interrupts, Memory organization

EEPROM IC

EEPROM (electrically erasable programmable ROM) provides exceptional performance and capabilities. Because high voltage is created internally for programme and erase mode, it only requires one external power source. There are two operations: write and erase, which are performed on a byte-by-byte basis. The EEPROM operates on the UV-EPROM concept. Electrons become caught on the floating gate, altering the cell's properties. It will be saved as a logic "0" or "1". It is really a memory device with relatively few cell design requirements. The floating gate is part of the storage transistor, which traps electrons. It also has an access transistor for operations. Each EEPROM cell is made up of two transistors. When electrons are taken from the floating gate, the EEPROM cells are deleted, and it is also erased when electrons are trapped from the floating gate.

GSM

Time Division Multiplexing (TDMA) and Frequency Division Multiplexing (FDM) are used in the worldwide system for mobile communication (GSM). Both user A and user B are present.

Sharing the channel in terms of both time and frequency this implies that user A is present on channel 890 MHz for two seconds before switching to channel 900 MHz for two seconds before jumping to 910 MHz for two seconds and so versa. Each user utilises a different frequency in separate time periods. This is referred to as Frequency Hopping. GSM frequencies include 900, 1200, 1800, and 2100. The initial version of GSM 900 operates at a megahertz frequency. There are 125 up link channels and 125 down link channels here. The communication channel from mobile to base station is called the uplink channel, while the communication channel from base station to mobile is called the downlink channel. GSM allocates 124 channels for communication and 1 channel for safe guard, each of which requires 100 Hz. It serves as a barrier between the channels. Payload data is the content data that is used to send messages and information.

RS-232 Interfaces

It is defined as data communication equipment that links data terminal equipment (DTE) control signals to data circuit terminating equipment (DCE). This interface is most typically encountered in serial ports on computers. Signal time, electrical qualities, signal meaning, connection pin out, and physical dimensions are all specified in the standard.

Classification of Heart beat

The Cardiac Pre-screening equipment analyses the heartbeat and divides it into numerous categories. It can also classify heartbeats as normal or abnormal [10]. The various categories are as follows:

- Normal sinus rhythm- 60-100 beats per minute heart rate
- Bradycardia - occurs when the heart rate is lower than normal.
- Tachycardia - when the heart rate is faster than normal.
- If your heart rate is less than 60 beats per minute, you have sinus bradycardia.
- If your heart rate is between 100 and 180 beats per minute, you have sinus tachycardia.
- Atrial flutter is characterised by a heart rate of 250-350 beats per minute.

Simulation

The simulation is run using the MPLAB IDE compiler's PIC Simulator

As indicated in Fig. 3, the patient's information will be delivered to the physician's mobile phone through GSM.

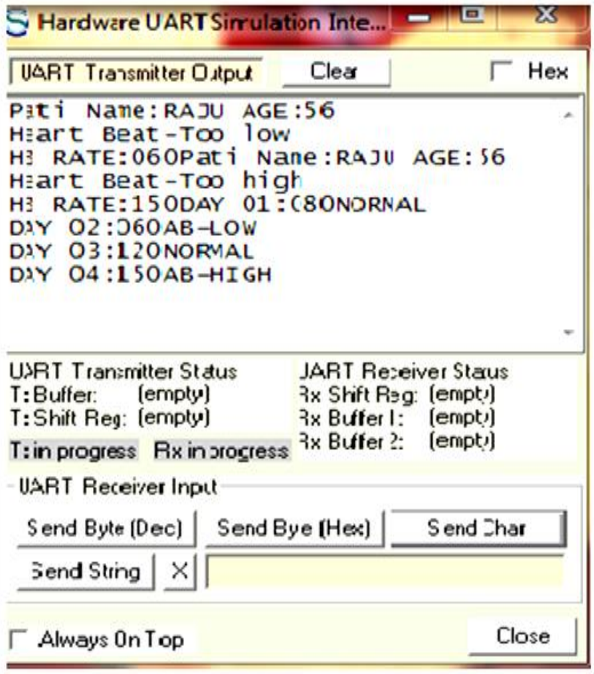

Fig.3. Simulation showing Patient's details

Fig.4. Simulation showing the data stored in EEPROM memory

CONCLUSION

As a result, any anomaly in the heart rate may be detected by this method. The PIC Controller will continually monitor any changes in the heart rate. The anomalies in the patient's heart rate will be communicated to the physician. In real-time systems, this technology is more dependable and portable. This type of device aids in the early diagnosis of abnormalities and gives patients with prompt therapy. The project is practicable and adaptable, so its essential idea and substance may be absorbed and passed along. This gadget is less expensive and more widely available. Its functioning is so easy that it does not require the aid of any skilled technicians.

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