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A MULTI-SIGNAL ACQUISITION SYSTEM FOR PREVENTIVE CARDIOLOGY WITH CUFF-LESS BP MEASUREMENT CAPABILITY

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ABSTRACT

Remarkable technological developments in recent years have opened up new possibilities of improving public health care system. Developments in computing, signal processing and communication technologies have resulted in new diagnostic instruments with better precision and connectivity with computing machines, communication gadgets and databases. However, many of these technical marvels are young by age and not yet available to all potential users at affordable cost. Among the various vital biomedical signals that can be collected noninvasively, ECG, PPG, SpO2 and PCG collected simultaneously, can help in examining electrical (ECG) and mechanical (PCG) functioning of heart, efficiency of lungs (SpO2) and condition of arteries (PPG). This promises to give a composite overview of the whole cardiovascular system non-invasively. We propose to develop a portable multi-parameter, non-invasive biomedical signal acquisition system (which can monitor, store and communicate the above mentioned four biomedical signals) for regular tele monitoring of patients especially with cardiovascular complaints. The device will be easy to use and can be operated by a paramedical staff with minimal training. It will be low-cost, so that a large population can be covered using multiple portable units. The gathered physiological data can be sent to the monitoring station and depending on the condition of the patient, further instructions can be issued from there. We also propose to analyse the different signals gathered and find correlation present in them which can lead to a better understanding of the whole cardiovascular system and assist doctors in early diagnosis of crucial symptoms. As an initial step towards that, Blood pressure (BP) and Heart rate (HR) is monitored using the gathered ECG and PPG signals from the device. The reliability of the device for BP and HR monitoring is estimated by comparing it with a clinically proven professional automatic digital BP monitor.

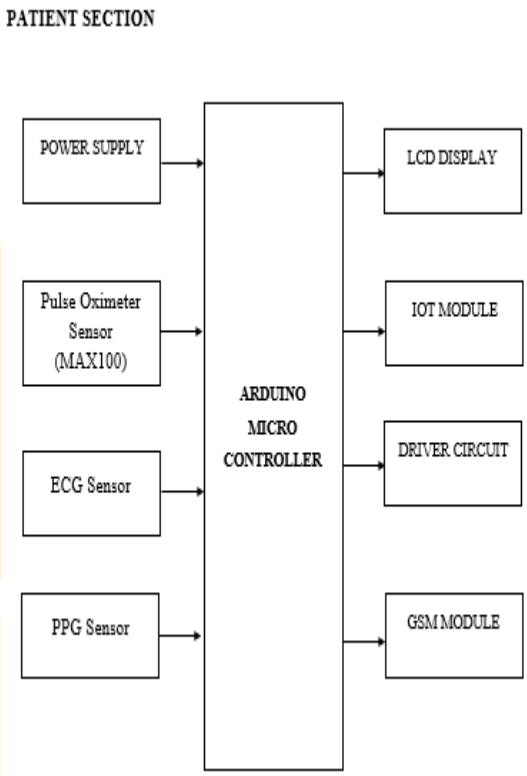
Keywords: Photo plethysmograph, Blood pressure, Heart rate and Preventive cardiology.

1. INTRODUCTION

Cardiovascular diseases (CVDs) are emerging as the leading cause of death worldwide. In developing nations (like India), rapidly changing socioeconomic condition of the masses is resulting in changed habits and lifestyle. This makes people prone to CVDs. To address this problem, preventive cardiology appears to be the most promising approach. For an effective preventive cardiology, prolonged collection, monitoring and maintenance of health data of the target population is important. With higher per capita income, the rural people are adopting new lifestyle, food habits and addictions thus inviting a possible endemic of the so-called life-style diseases. Very little attention has been paid to adult deaths caused

directly or indirectly by these and other related factors. A major attention now needs to get focused on these so-called modern diseases those are fast emerging in our rural society. The particular health problem we have tried to focus in this work is the emerging global pandemic of coronary artery Diseases. Fortunately, indications of CVDs can be obtained by several non-invasive low cost techniques, since the pumping of the heart causes several periodic predictable electromechanical changes in various observable parts of the human body which can be measured externally using appropriate sensors. Once these signals are acquired, processing essentially involves comparison of predefined feature-sets in these signals with the expected behaviour in case of a healthy person

2. BLOCK DIAGRAM



3. WORKING PRINCIPAL

This system is mainly used to monitor the health condition automatically. In this system, we use the Pulse Oximeter (SpO2), Photo plethysmograph (PPG), Phonocardiogram (PCG), Electrocardiograph (ECG), for monitoring the patient health. Any one Condition Abnormal sending Message through GSM to Personal Doctor. All the information is sent to internet through IOT.

4. HARDWARE REQUIREMENTS

Power Supply
Arduino Microcontroller
Pulse Oximeter sensor
ECG Sensor
PPG sensor
IOT
GSM
LCD Display

5. SOFTWARE REQUIREMENTS

Embedded C
Arduino IDE
Proteus testing tool

6. HARDWARE DESCRIPTION

6.1 POWER SUPPLY

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op–amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.

6.2 PULSE SENSOR

The Pulse Sensor is a plug-and-play heart-rate sensor for Arduino. It can be used by students, artists, athletes, makers, and game & mobile developers who want to easily incorporate live heart-rate data into their projects. Essence it is an integrated optical amplifying circuit and noise eliminating circuit sensor.

6.3 ECG SENSOR

The ECG sensor is attached to the patient using disposable electrodes on the left and right side of the chest. The signal obtained from the body is filtered and amplified. The sensor outputs an analog signal which is then converted by the analog-to-digital converter (ADC). The serial-to-Bluetooth module transmits the digital output of the ADC to the cell phone. On the phone the sampled ECG is displayed. An electrocardiogram (ECG or EKG) is a recording of the electrical activity of the heart over time produced by an electrocardiograph, usually in a non-invasive recording via skin electrodes. Electrical impulses in the heart originate in the sinoatrial node and travel through the heart muscle where they impart electrical initiation of systole or contraction of the heart. The electrical waves can be measured at selectively placed electrodes (electrical contacts) on the skin. Electrodes on different sides of the heart measure the activity of different parts of the heart muscle. An EKG displays the voltage between pairs of these electrodes.

6.4 MAX30100 SENSOR

The MAX30100 is an integrated pulse oximetry and heart- rate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. This sensor consists of two Light Emitting Diodes (LEDs), (one emits infrared light and other emits red light) modifiable optics, low noise signal processor which detects heart pulse rate signal. It's operating voltage are from 1.8v to 3.3 v. Our analysis shows the accuracy rate of the Max30100 measurement is 97.11% and 98.84%, for heart rate and oxygen saturation (SpO2), respectively.

6.5 ARDUINO UNO

Arduino Uno is one type of microcontroller board, and it is designed by Arduino.cc. It can be built with a microcontroller like Atmega328. This microcontroller is also used in Arduino UNO. It is a small size board and also flexible with a wide variety of applications. Other Arduino boards mainly include Arduino Mega, Arduino Pro Mini, Arduino UNO, Arduino YUN, Arduino Lilypad, Arduino Leonardo, and Arduino Due. And other development boards are AVR Development Board, PIC Development Board, Raspberry Pi, Intel Edison, MSP430 Launchpad, and ESP32 board

6.6 IOT MODULE

The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.

HOW IT WORK

The RX and TX pins of the ESP8266 Module are connected to RX and TX Pins on the Arduino board. Since the ESP8266 SoC cannot tolerate 5V, the RX Pin of Arduino is connected through a level converter consisting of a 1KΩ and a 2.2KΩ Resistor. Finally, the GPIO2 pin is connected to an LED to test the working of the program

6.7 GSM MODULE

A GSM modem or GSM module is a device that uses GSM mobile telephone technology to provide a wireless data link to a network. GSM modems are used in mobile telephones and other equipment that communicates with mobile telephone networks. They use SIMs to identify their device to the network.

6.8 LCD DISPLAY

LCD 16x2 is a 16-pin device that has 2 rows that can accommodate 16 characters each. LCD 16x2 can be used in 4-bit mode or 8-bit mode. It is also possible to create custom characters. It has 8 data lines and 3 control lines that can be used for control purposes.

6.9 ARDUINO IDE

IDE stands for Integrated Development Environment. It is a text editor that lets you upload code on to arduino. Every program file is called a sketch and contains all the code that you write for your projects. Every file has an extension of. ino which used to be a. pde! Verify Button. The first button is the verify button. The verify button is used for compiling your code and checking for errors. It highlights all the errors that you have in the sketch. If there are no errors, there won't be any highlights and you are good to go. The shortcut key for the verify button is 'cntrl + r'.

6.10 PROTEUS TESTING TOOL

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards

6.11 WHAT IS PROTEUS?

It is a software suite containing schematic, simulation as well as PCB designing. ISIS is the software used to draw schematics and simulate the circuits in real time. The simulation allows human access during run time, thus providing real time simulation

6.12 FEATURES OF PROTEUS

There are 2 main parts of proteus first is used to design and draw different circuits and the second is for designing of PCB layout.

First is ISIS that used to design and simulate circuits. And second is ARES that used for designing of a printed circuit board.

It also provides features related to the three-dimensional view of design in PCB.

7. CONCLUSION

The study proposes a portable, affordable and non-invasive biomedical signal acquisition system. The system is capable of monitoring, storing and communicating multiple physiological signals- ECG, PPG, SpO2 and PCG. Due to their high clinical importance, these signals can be used to obtain an overview of an individual's health. Cheap and easily available electronic components used in developing this device makes it cost-effective. And the easy to use, non-invasive sensors makes it user friendly. Since high BP (hypertension) is the leading cause of ever increasing CVDs, we have shown how this device can be used to pre-screen hypertension by using the ECG and PPG signals of merely 10 second duration; the proposed device reliably extracts the BP-HR form ECG and PPG signals. The device is validated against clinically proven professional automatic digital BP monitor (OMRON HBP1300). A series of validation tests is performed to prove that the device can be safely used as a pre-screening device also without any assistance of trained practitioner. As already discussed, the device is non-invasive, portable and user friendly, it can be easily used for continuous monitoring without hospitalization. Also, the data recorded from such prolonged monitoring can be used to detect arrhythmia and heart rate variability during both, real-time as well as store-and-forward mode. In future, with some minor modifications in the mode of transmission of the acquired physiological signals, the device can be used as reliable telediagnostic and telemonitoring device.

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