

Heart Attack Detection Walking Stick with Emergency Help

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Abstract—The Heart Attack Detection Walking Stick with Emergency Help is an equipment that is used daily to indicate heart condition, to detect heart attack and to call for emergency help. It has been designed specially to help senior citizens and patients with heart disease.

Index Terms— heart attack, detection, gsm, message, emergency

I. INTRODUCTION

A heart attack happens to a person when the blood flow and oxygen supply to heart muscle is blocked, and it is mostly caused by the Coronary Artery Disease (CAD). CAD occurs when the arteries that supply blood to the heart muscle (coronary arteries) become hardened and narrowed [3]. It often causes irregular heart beat or rhythm by blocking blood stream.

The symptoms of heart attack can be detected by observing electrocardiogram (ECG) waveform. An ECG is an electrical recording of the heart and is used in the investigation of heart disease. An electrical impulse initiates muscle contraction, which results in heart beating. The spacing between pulses provides a measure of the heart's rhythm, whereas the height of the pulses is an indicator of pumping strength. By observing

the ECG waveform, the heart condition of the patients can be explained by doctors. The senior citizens are more prone to have heart attack than young people. The Walking Stick with Heart Attack Detection is specially designed to help the senior citizens who need walking aids by walking sticks and have the most possibility of heart attack. The walking stick is used as detection unit and as the medium asking for medical help

II. OVERVIEW OF DESIGN

The ECG sensor module unit on the wrist captures abnormal heart beat signal from the patient. The microcontroller on the stick runs a heart attack algorithm. Warning is given out to the person about his heart condition with the help of a buzzer. The GSM module sends messages to the close relatives and calls the hospital for medical help at the moment of heart attack. This project aims to shorten the time between the moment of heart attack and the arrival of medical personal. The warning before the emergency call will give the patient a chance to avoid heart attack.

III. BLOCK DIAGRAM

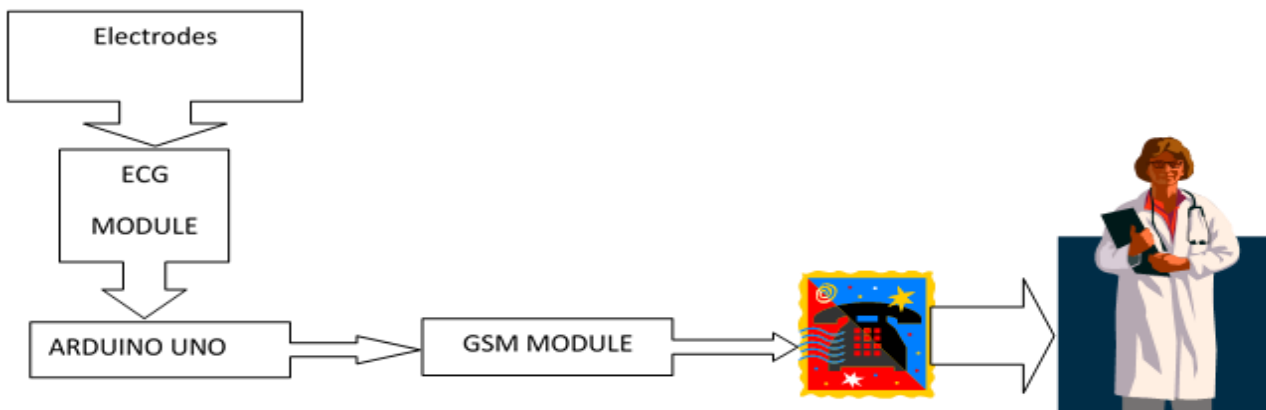


Fig 1. Block diagram representing the setup

IV. WORKING

Two biosensors worn on the user's wrists send the real ECG signal to the ECG sensor module. The amplified and filtered output from the ECG module is given to the analog pin of Arduino UNO. The code for detecting the abnormal heart condition is uploaded in the Arduino board. The input ECG signal is processed with this code to detect the occurrence of heart attack. If any symptom of heart attack is detected, the risk level rises. When the risk level reaches up to the emergency mode, the GSM module is used to send messages to the required persons.

V. PARTS AND DESIGN

A. Biosensors

The Ag-AgCl ECG electrodes were used as the biosensors. The benefits of the electrodes include good electrical contact with human skin, low motion artifacts and strong adhesive quality to skin.

B. Ecg module

The AD8232 SparkFun Single Lead Heart Rate Monitor is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analog reading. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily. The AD8232 is an integrated

signal conditioning block for ECG and other biopotential measurement applications. It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement. The AD8232 Heart Rate Monitor breaks out nine connections from the IC that you can solder pins, wires, or other connectors to. SDN, LO+, LO-, OUTPUT, 3.3V, GND provide essential pins for operating this monitor with an Arduino or other development board. Also provided on this board are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach and use your own custom sensors. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heart beat.

Features:

- Operating Voltage - 3.3V
- Analog Output
- Leads-Off Detection
- Shutdown Pin
- LED Indicator
- 3.5mm Jack for Biomedical Pad Connection

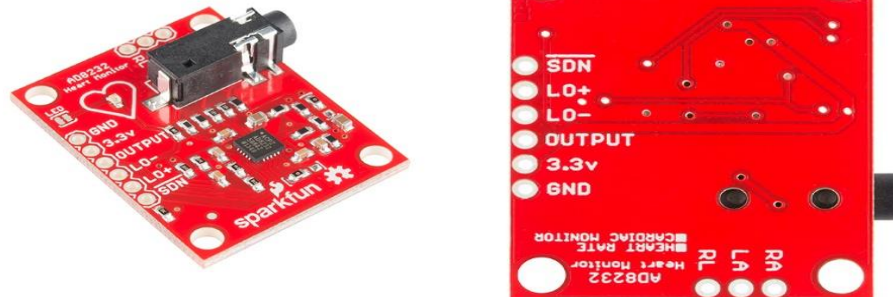


Fig 2. Ecg Module

Understanding the ECG

In general terms, let's look at what an ECG is representing and how we're able to sense it. The ECG is separated into two basic Intervals, the PR Interval and the QT Interval, described below:

PR Interval

The PR interval is the initial wave generated by an electrical impulse traveling from the right atrium to the left. The right atrium is the first chamber to see an electrical

impulse. This electrical impulse causes the chambers to "depolarize". This forces it to contract and drain deoxygenated blood from both the Superior and Inferior vena cava into the right ventricle. As the electrical impulse travels across the top of the heart it then triggers the left atrium to contract. The left atrium is responsible for receiving newly oxygenated blood from the lungs into the left ventricle via the left and right pulmonary veins. They are still called veins because veins carry blood towards the heart.

QT Interval

The QT Interval is where things get really interesting. The QRS is a complex process that generates the signature “beep” in cardiac monitors. During QRS both ventricles begin to pump. The right ventricle begins to pump deoxygenated blood into the lungs through the left and right pulmonary arteries. They are still called arteries because arteries carry blood away from the heart. The left ventricle is also beginning to pump freshly

oxygenated blood through the aorta and into the rest of the body. After the initial contraction comes the ST segment. The ST segment is fairly quiet electrically as it is the time where the ventricles are waiting to be “re-polarized”. Finally the T wave becomes present to actively “re-polarize”, or relax the ventricles. This relaxation phase resets the ventricles to be filled again by the atriums.

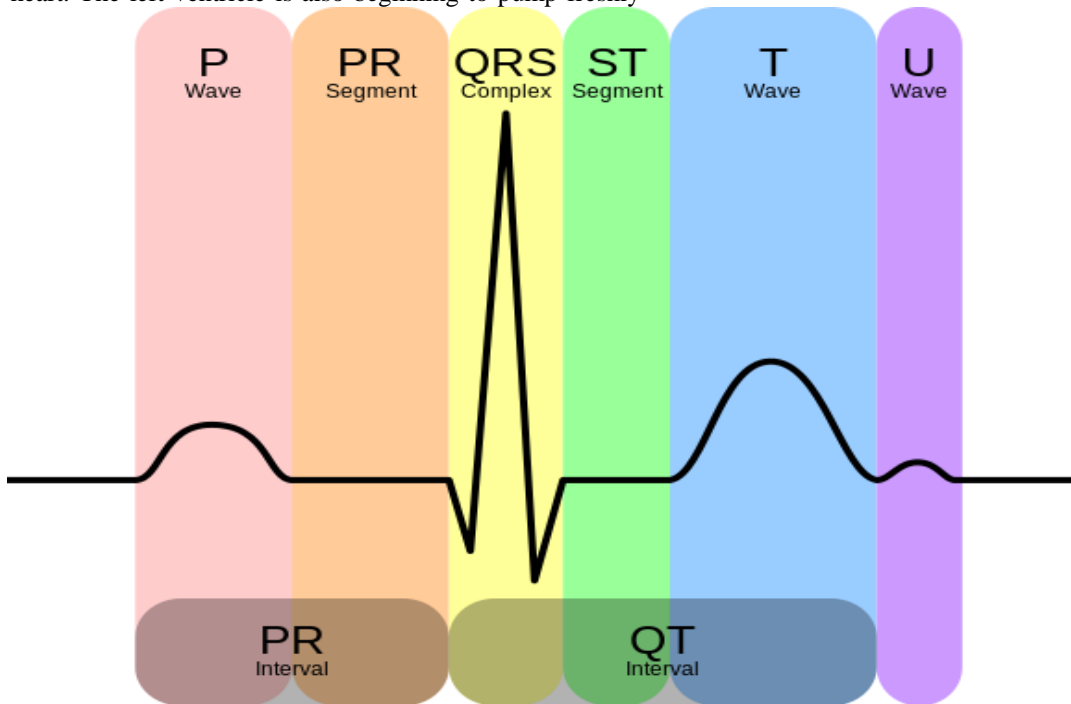


Fig 3. Parts of a heart wave

C. Arduino Uno

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery.

1) Programming

The Arduino/Genuino Uno can be programmed with the (Arduino Software (IDE)). Select "Arduino/Genuino Uno" from the Tools > Board menu (according to the microcontroller on your board).

2) Power

The Arduino/Genuino Uno board can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector.

The board can operate on an external supply from 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

3) Memory

The ATmega328 has 32 KB (with 0.5 KB occupied by the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

4) Input and output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can

provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor (disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller.

5) Specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the `attachInterrupt()` function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the `analogWrite()` function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- LED: 13. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.
- The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts,

though is it possible to change the upper end of their range using the AREF pin and the `analogReference()` function.

There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with `analogReference()`.
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

6) Communication

Arduino/Genuino Uno has a number of facilities for communicating with a computer another Arduino/Genuino board, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The 16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino Software (IDE) includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows serial communication on any of the Uno's digital pins.

The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino Software (IDE) includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library

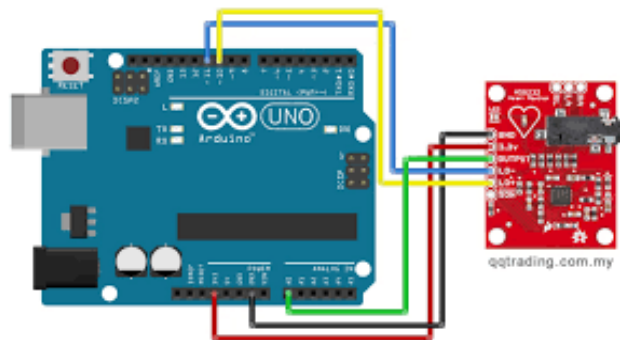


Fig 4. Arduino connection to ecg module

D. GSM module

GSM SIM300/900 GSM/GPRS RS232 Modem is built with SIMCOM Make SIM900 Quad-band GSM/GPRS engine, works on frequencies 850 MHz, 900 MHz, 1800 MHz and 1900 MHz. It is very compact in size and easy to use as plug in GSM Modem. The Modem is designed with RS232 Level converter circuitry, which allows you to directly interface PC Serial port. The baud rate can be configurable from 9600-115200 through AT command. Initially Modem is in Auto baud mode. This GSM/GPRS RS232 Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS as well as DATA transfer application in

M2M interface. The modem needed only 3 wires (Tx, Rx, GND) except Power supply to interface with microcontroller/Host PC. The built in Low Dropout Linear voltage regulator allows you to connect wide range of unregulated power supply (4.2V -13V). Using this modem, you will be able to send & Read SMS, connect to internet via GPRS through simple AT commands.

Features:

- High Quality Product (Not hobby grade)
- Quad-Band GSM/GPRS
- 850/ 900/ 1800/ 1900 MHz

- Built in RS232 Level Converter (MAX3232)
- Configurable baud rate
- SMA connector with GSM L Type Antenna.
- Built in SIM Card holder.
- Built in Network Status LED
- Inbuilt Powerful TCP/IP protocol stack for internet data transfer over GPRS.
- Audio interface Connector
- Most Status & Controlling Pins are available at Connector
- Normal operation temperature: -20 °C to +55 °C
- Input Voltage: 5V-12V DC

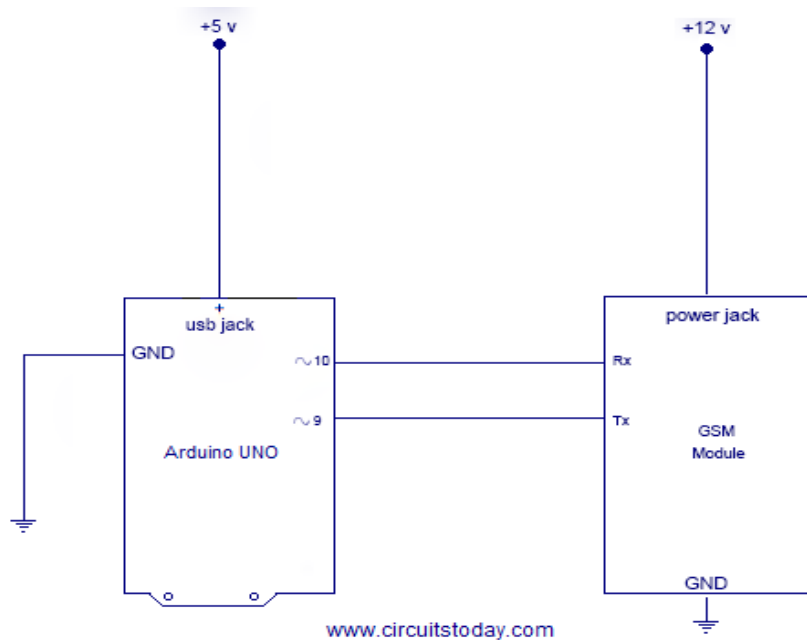


Fig 5. GSM connection to Arduino

VI. ALGORITHM

- Initialize sampling frequency, maximum and minimum threshold.
- Initialize minimum and maximum absolute period and array size.
- Level at which only the QRS pulse should exceed is initialized.
- Initialize maximum allowable width.
- Initialize how many alerts to take before calling emergency number.
- Read the analog value coming in a serial input and store it in an array of size ARRAY SIZE
- Find the baseline as the average of all the data points in the array.
- For checking pulse rate
 - Check if current sample is lower than 50% of the first peak relative to baseline.
 - Check for all the samples and find if first peak reached.
 - Wait for repolarization, don't search for the second peak until samples has returned to baseline check similarly if second peak has reached.
- Check if pulse width is between the threshold levels.
- Determine the maximum and minimum amplitude peak.
- For alert activation
 - Determine the percentage decrease in the peak. If percent decrease exceeds threshold limit the alert is activated.
 - Sample period is calculated as difference between the two peaks.
 - If the sample period is not between minimum and maximum period alert is activated.
 - Finally if the width of the pulse is greater than maximum width then alert is activated.
 - If the alert level increases the specified limit, the GSM module is used to send a message or call an emergency number.

f) After few minutes the alert level is set back to zero.

VII. OUTPUT

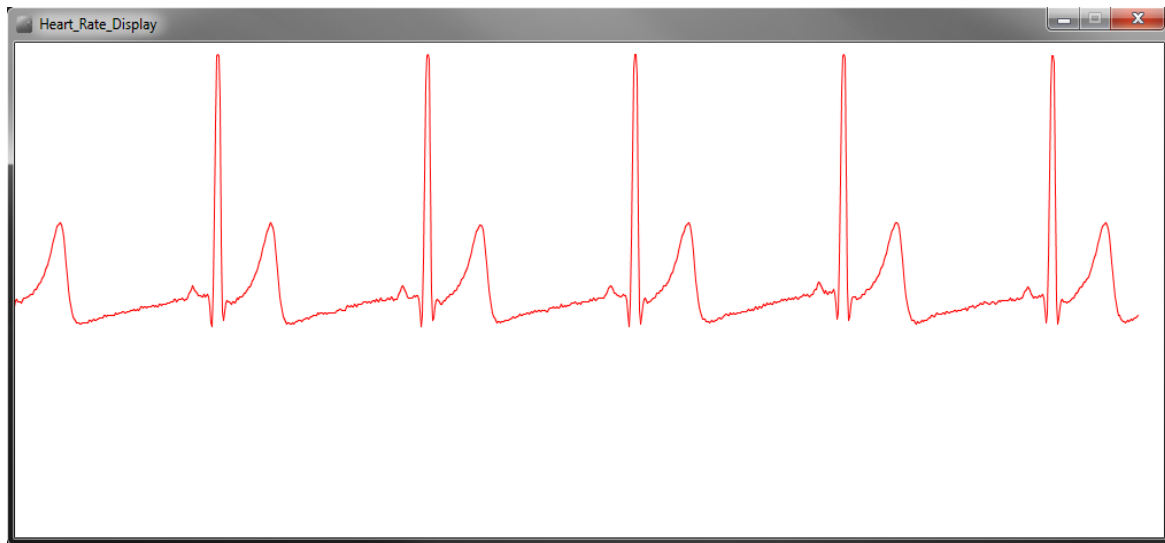


Fig 6. The output waveform representing a normal ecg wave of a person

VIII. CONCLUSION

The walking stick with heart attack detection functions have been designed overall. ECG waves were properly collected from analog circuitry unit using an ECG module. The most significant improvement was the emergency calling part using the GSM module which is way more efficient than using a Bluetooth module. Possible future improvements are better packaging of the wrist circuitry, lower power consumption for main units, more common media rather than just walking sticks, shorter delay between heart attack detection and more accurate and faster heart attack algorithm.

ACKNOWLEDGEMENT

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