

## **The Wearable Electronic Rescue System for Home Alone Elderly- Labview & Arduino Evaluation**

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**Abstract:** *The socio-economic condition & various health hazards are the main suffering at old age. To combat this situation, we have tried to develop and fabricate one wearable electronic rescue system for elderly especially when he is at home alone. The system can detect abnormal condition of heart as well as sudden accidental fall at home. The system has been developed using Arduino Microcontroller and GSM modem. The entire program and evaluation has been developed under LabView platform. The prototype was built and trialed successfully.*

**Keywords:** *Accelerometer, ECG, Elderly, Micro- controller, LabView, Text message handling process, VISA, Wearable electronics*

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### **I. Introduction**

With the biology of aging the elderly become physically frail and dependent on their family members or care givers. The change in socio-economic status and various health problems elderly are suffering in various directions. There are a wide range of smart technologies are available for wellness and safety for home alone elderly. Many articles were published to describe smart home systems to promote physical activities, technologies for fall prevention, detection of heart attack and system for information sending to doctor or care giver. As for example, Byungkock Jeon, et. al. [1] developed wearable ECG system with smart phone for real-time monitoring, self-diagnosis and remote diagnosis for chronic heart diseased patient before outbreak. Ziya LV et.al in 2010, proposed i-Care mobile health care system [2] for elderly to provide real-time living assistance, which may make lives more convenient and comfortable. The similar work was done by G. Bestente et.al [3], which is rescue system for elderly and ill people. Cling-Chih Lin studied integrated technologies [4] of RFID, GPS, GSM and GIS system to construct a prevention system for elderly suffering with dementia.

The electrocardiogram (ECG) is the traces of Bio-electric potentials generated by heart and perform further diagnosis. The recorded ECG is often contaminated by several noises such as power line noises, patient-electrode motion artifacts, electrode contact noises, EMG signals of chest muscles and base line wandering. Among these noises, the power line interferences and base line wandering are the most predominant. Therefore proper ECG needs some preprocessing or filtering. These preprocessing modules may be hardware based analog/digital filter circuits or software based filter circuits under Math Lab or Lab View platform.

The detection of abnormal condition of heart from remote place is a challenging task. Sudden fall in floor or in toilet may cause abnormal condition of heart followed with arrhythmia, which includes palpitation, ponding in chest, feeling dizziness or light-headed, fainting, shortness of breath, chest discomfort with weakness and fatigue. But these conditions are not detectable from remote place and there is only way to monitor the ECG signal in real time for sudden abnormality of heart. For interrogating ECG, there are several signal processing methods are well established. For example, the detection of ST segment elevation of ECG complex using implantable high fidelity intra-cardiac system from remote as done by Tim A, Fischell, and et.al. in 2006. It uses the principle of sudden elevation in ST segment from normal ECG, which is the indication of severe heart attack. The use of signal-average ECG (SAECG) has also been recommended by doctors for detection Myocardial Ischemia or Myocardial Reperfusion. The detection of ST elevation[12] or signal average ECG[13] has so many patented algorithms and is using in various different type of applications.

In the present work our attempt is to develop low cost wearable electronic system which can detect sudden fall and abnormal heart condition of elderly and send information to care giver or doctor through mobile SMS. We are working on the biomedical embedded system which basically acquires ECG (electrocardiogram) signal as well as body vibration signals from the human body [5], where the system is wearable to all. In any case of abnormality either in both or in any of the two signals, the system sends a text message alert to his family member's mobile, nearby hospital, police station and family doctor's cell phone using GSM module [6].

The whole algorithm is developed in NI LabView software platform using Biomedical Tool box and driver for Arduino microcontroller with necessary fabricated electronic interface circuit. It has its own

intelligence to acquire and analyse the real time ECG & body vibration signals along with message handling system with a suitable external reset [7].

## II. METHODS & MATERIAL

The whole system has been divided into three essential parts such as – (a) ECG signal acquisition and analysis, (b) body vibration signal, (c) text message handling process respectively. The algorithm development and hardware interfacing procedures of each step are as follows:

### (a) ECG signal acquisition and analysis

ECG signal or electrocardiogram is the graphical output of the bioelectric potential and electro conduction system of heart, of which the action potential peak at heart muscle reaches maximum of +20 millivolts and resting potential lies between -70 to -80 millivolts for a normal heart. Hence the nodal conduction process rises with a PQRS 2D curve continuously with respect to time (milliseconds) [8].

In the present work, we have used three disposable Ag-AgCl button type surface electrodes attached to right arm, left arm and right leg and are connected to the AD 620-B instrumentation amplifier [8] with own designed circuit board through three individual ECG cables. The electrode placement and the circuitry are shown in Fig1. The whole circuit parameters are designed in accordance with the needed signal strength. The Arduino (microcontroller) is used to interface to computer on which LabView software is running to acquire ECG and Vibration signal.

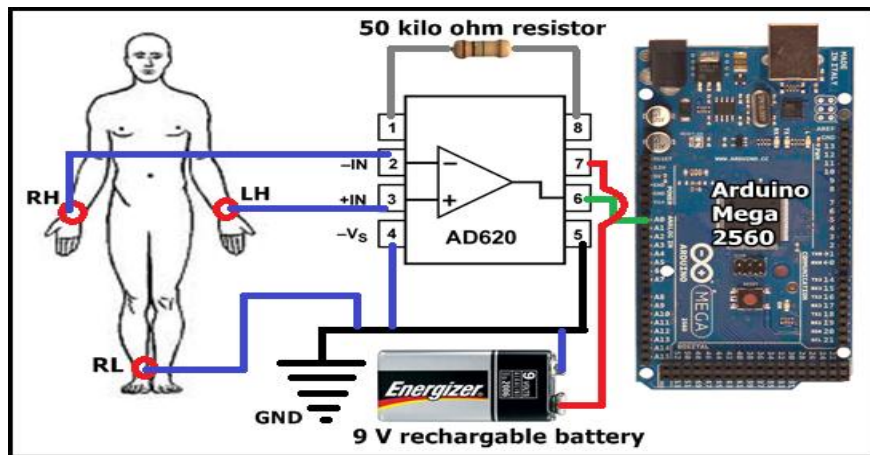


Figure 1: Raw ECG signal acquisition process

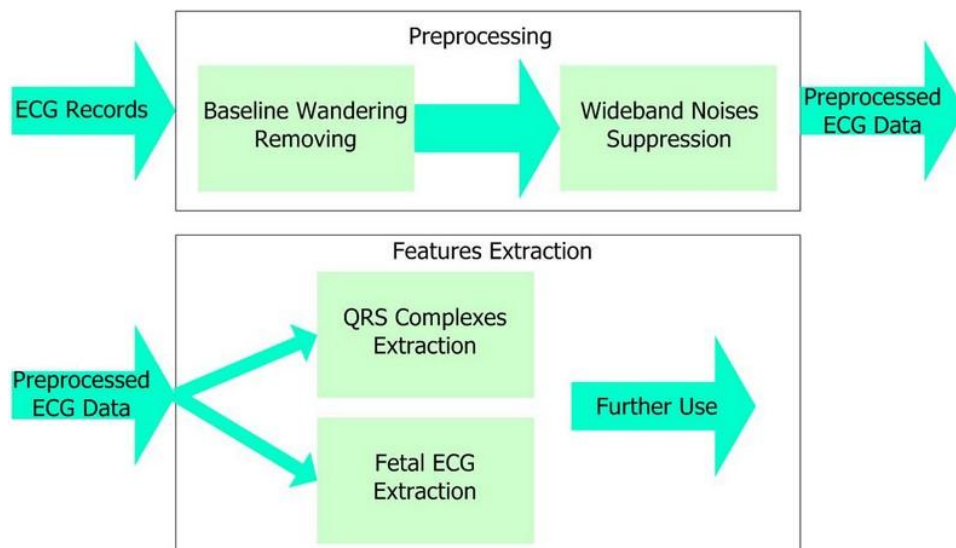


Figure 2: Typical ECG signal processing flowchart used

After suitable acquisition of ECG signal and digitization, the digitized ECG with noise fed to USB port of computer under LabView platform having Advance Signal Processing Toolkit (ASPT) and Biomedical Toolkit. We have used wavelet transform approach using ASPT which provides WA Detrend VI, will remove the low frequency trend of a signal such as base line wandering. After the elimination of all noises, processed

ECG data are used for features extraction using biomedical toolkit. The ECG signal algorithm, the serial communication parameters are set via LIFA toolkit settings. Then the real-time raw ECG signal is acquired and filtering, baseline wandering removal is done to get noise free ECG signal.

Now in an ECG signal, the peak amplitude, valley voltage level and the QRS complex are the three major factors with which we have performed. Hence with proper application of GUI blocks and with some logical operations the feature extractions are done, which is shown in the following diagrams (Fig.3, Fig.4) step by step.

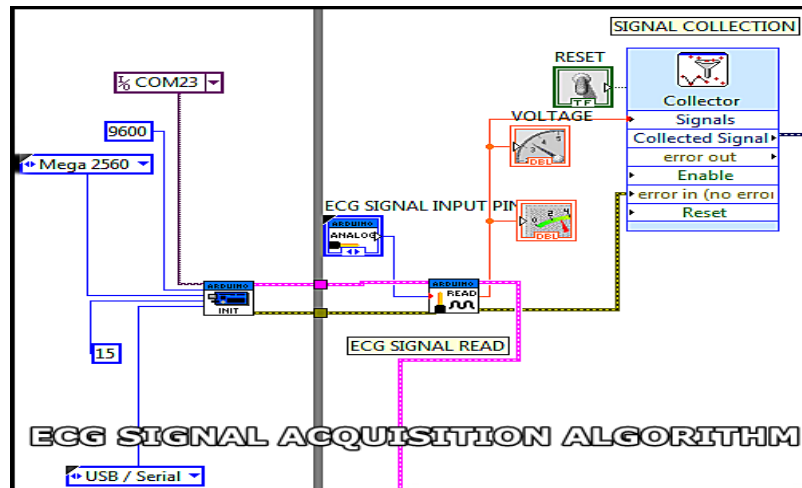


Figure 3: ECG signal collector VI

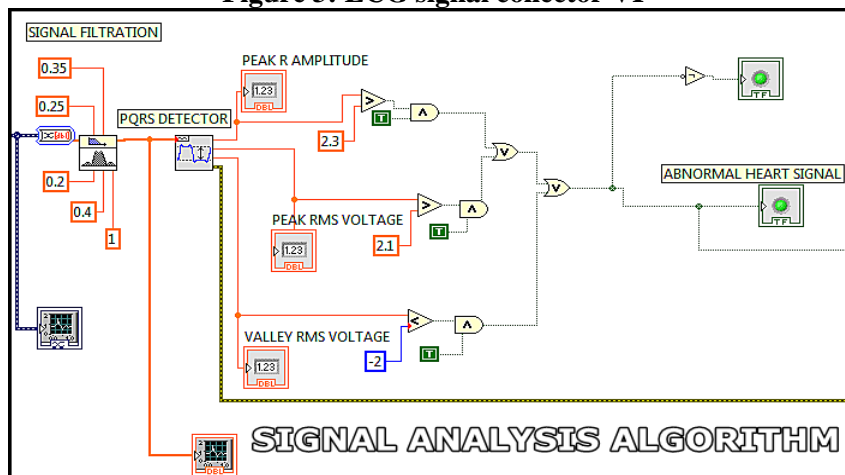


Figure 4: ECG signal analyzer VI

In the analysis part, if the ECG parameters go beyond the threshold or normal, then the logic circuit displays abnormality and tends to send a text message. Fig.5 & Fig.6 are the display output part of the LabView console where normal ECG and abnormal ECGs are shown. The normal and abnormal conditions of ECG are also visualized by color indicators in monitor view.

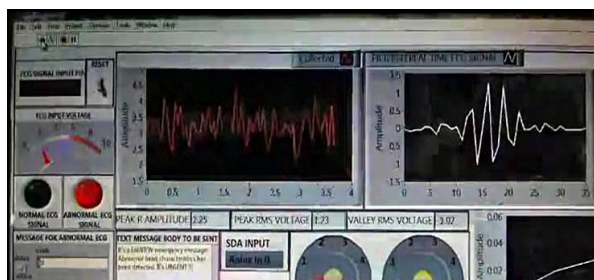


Figure 5: Normal ECG detection

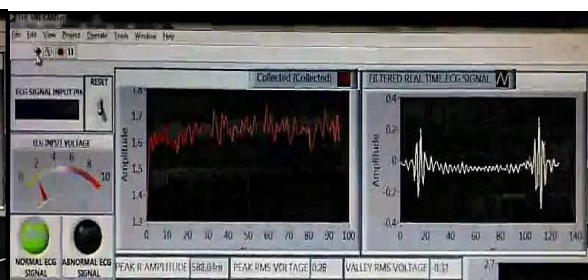


Figure 6: Abnormal ECG detection

**(b) Sudden fall signal acquisition and analysis**

The ADXL 345 is a small, thin, highly sensitive, ultra power three axis accelerometer with a high resolution (13-bit), measurement up to  $\pm 16g$ . Digital output data is formatted as 16 bit two's complement and is

accessible through either a SPI (3-or-4-wire) or I2C digital interfaces. Since it has three axes x, y and z, its magnitude is given [10] by:  $\sqrt{x^2 + y^2 + z^2}$

At first, the accelerometer pins are soldered and its Vcc, GND, SDA and SCL ports are connected to 3.3 Volt pin, GND pin and Analog input pin 1 and 2 of the arduino mega 2560 board. Reset of the ports in the ADXL 345 is grounded virtually as there is no need of interrupt services & peripheral power up. Now, the arduino is connected to the computer with serial cable on which the LabView algorithm has been developed. Here, the SDA (Self Diagnosing Accelerometer) pin connected to analog input 1 pin of arduino gives us the actual magnitude of the vibration signal of body. However, the angular placement of this accelerometer is parallel to the ground of a standstill human's wearable prototype. The analog signal is firstly acquired and then filtered. Next it is analyzed by setting a threshold value, in exceeding of which the text message is delivered. The algorithm is shown in Fig.7.

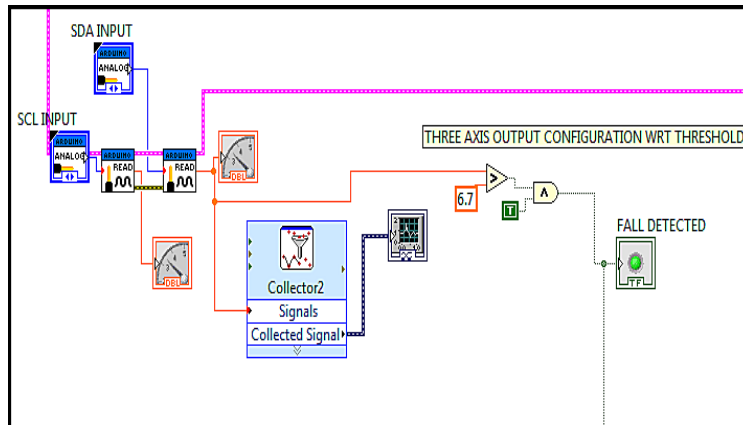


Figure 7: Vibration monitoring VI

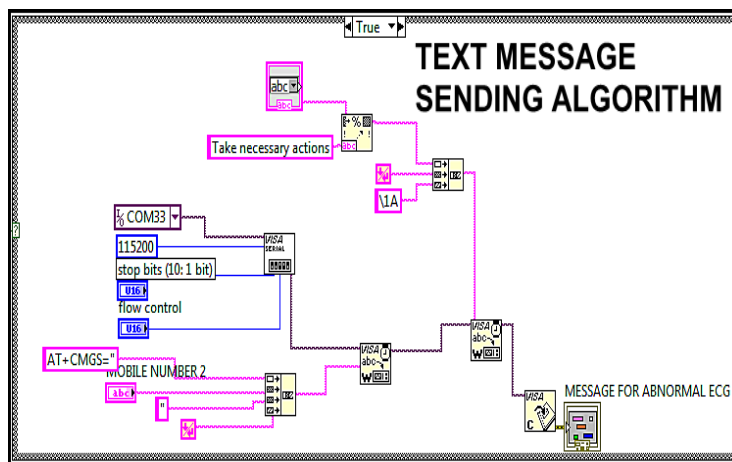


Figure 8 Text message (SMS) VI

The vibration monitoring VI is given in Fig.7 and SMS generation against fall detection is given in Fig.8

(c) Text message handling process

In the algorithm of text message algorithm process, at first the serial communication settings are provided with suitable COM port and baud rate, and thereafter AT commands are applied to write a text message to a particular cell phone number. The algorithm is shown in the Fig.8. If the ECG signal or the vibration signal is or both are natural, then this device runs normally with its continuous signal acquisition process. However, when any of the signal goes beyond the natural limit (in terms of voltage),



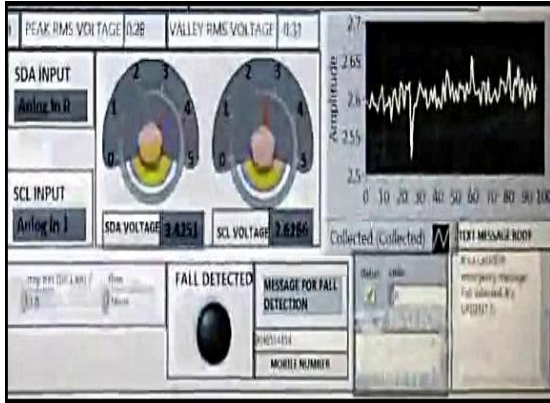


Figure 9: normal body vibration

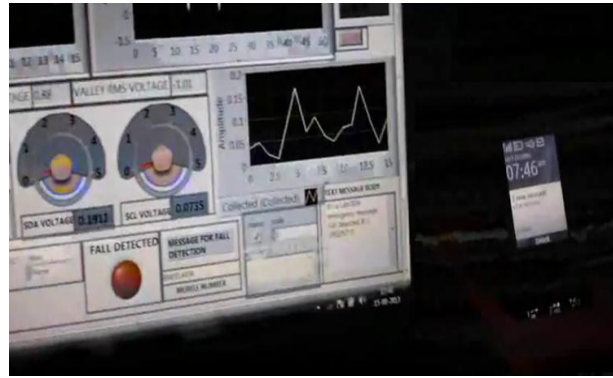


Figure 10: Vibration under accidental fall

the GSM sends a text message [10] [11]. Actually, there are two individual GSM algorithm is placed for each of the ECG & vibration signals respectively within a TRUE-FALSE case structure. For normal movement of human being, we get output as follows given in Fig.9 but for accidental fall we get output as given in Fig.10.

There are three parameters in the ECG analyzer, i.e. peak amplitude, valley amplitude and QRS complex or RMS peak. All of these have their individual threshold values with which the actual accumulated values (Extracted from signal) are being continuously compared. Next all of these three parameter's resultant output is in a logical OR connection in series, so that, if any of the parameter exceeds its own threshold, the net output will have a true logical value, i.e. 1, thereafter the GSM logic automatically turns to TRUE and the text message sending algorithm starts working. The same thing happens for the accelerometer algorithm as well. If the SDA's voltage value exceeds the threshold, GSM algorithm becomes true and works simultaneously along with the ECG logic because, it's also possible in practical issue's that due to strong fall, ECG curve changes or vice- versa.

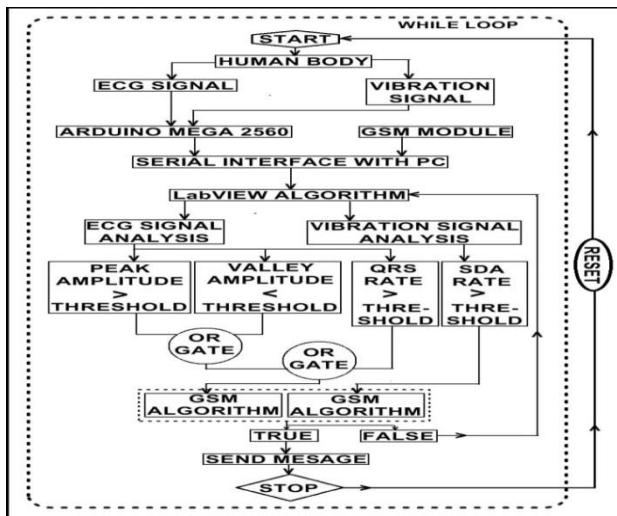


Figure 11: Algorithm for rescue system

NAME OF THE PARAMETERS	Normal value (mV)	Abnormal value (mV)
R peak amplitude voltage	+2.10 mV	+2.3 mV
Valley or depth voltage	-1.76 mV	-2.0 mV
QRS complex voltage rating or RMS peak voltage	+1.82 mV	+2.10 mV
Accelerometer output during sudden fall	+5.80 mV	+6.7 mV

Table 1: Normal and abnormal set values

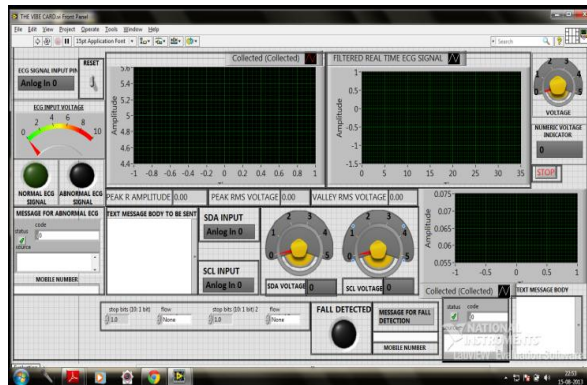


Figure 12: A view of total measuring console in LabView Panel

### III. RESULTS & DISCUSSION

The normal values ECG and vibration signal varies from one person to another so the system calibration is needed for reliable use. The accelerometer sensor needs to be fitted perpendicular to the body to ensure to get the actual normal or abnormal tilt angle or vibration of our body. In order to find the body vibration the output consider for normal body vibration and accidental fall vibration value. The typical values are shown in Table-1

The entire system is fabricated and studied with volunteers and found working satisfactorily. However we could not able to simulated severe heart abnormality during evaluation of the developed system. Sudden accidental fall also changes heart beat i.e. R-R interval of ECG complex and is detectable by the developed system. Therefore detection accidental fall and changes of ECG pattern associated with message to the caregiver may help a lot to the home alone elderly. The future scope of work is miniaturisation of the system to have portability by embedding the developed Lab View application software into an embedded FPGA system. Then it will be cost effective technological assistive tool for home alone elderly.

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