International Journal of Engineering Sciences &Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

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THOMSON REUTERS

[NACETEC' 19]
ICTM Value: 3.00

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

AUTOMATED EPILEPTIC SEIZURE DETECTION BASED ON WEARABLE ECG

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DOI: 10.5281/zenodo.2631557

ABSTRACT

One of the most disabling aspects of epilepsy is the sudden and apparently unpredictable nature of seizures. An added value of Electrocardiography is to automatically detect seizures in patients having Temporal Lobe Epilepsy(TLE). At home long term seizure detection is not suited because of wired hospital systems. A wearable device is introduced to address this need. Based on heart rate features, the algorithm used here identifies the seizures. To identify the location GPS is used and for communication purpose wireless technology is used. The information is observed by the doctor via an android app.

KEYWORDS: TLE.

1. INTRODUCTION

The fourth most common neurological disorder that affects people of all ages is epilepsy. The average prevalence of active epilepsy is between 0.5 and 1%. Among the total world population, 65 million suffer due to this condition. Seizure duration can vary nearly undetectable periods to long periods of vigorous shaking. Even though there is availability of an antiepileptic drug, it accounts for the treatment of only 70% of patients. Even though after the diagnosis in the hospital, the follow up of disease and evaluation of the patient has been necessary. The follow up mentioned here includes a seizure logging system that is operational in a daily life environment outside the hospital, most commonly a seizure diary. Seizure diary is kept by the patient or the family members. Unfortunately, this type of diary mentioned may not be reliable. Hence there is a need for an automatic seizure detection device, which records biomedical signals of patient during daily life. Since these patients may suffer from personal stigmatization we need to be more careful and provide an accurate and high value data description possible within device. There is a need for an automatic seizure detection device to log seizure. Electroencephalography is the golden standard for recording epileptic seizures in hospital. A well trained nurse and wet electrodes is required for EEG recording. Wet electrodes can in turn cause discomfort to patient. Due manual human assessment based detection a trained EEG analyst is needed to analyze EEG which in turn needs a large time duration. Draw-backs of scalp-EEG based seizure detection systems include the complexity of the EEG signal, attenuation of the EEG signal by skull and scalp and the fact that large parts of the cerebral cortex including mesial frontal, basal frontal, and mesial temporal areas are not accessible to the scalp EEG. The most significant limitation remains the application of scalp-EEG based seizure detection systems in an outpatient setting because it is not acceptable for patients to wear EEG electrode arrays for prolonged time periods in everyday life. Therefore, EEG cannot be used for automated long term seizure detection at home. Electrocardiography (ECG) is the process of recording the electrical activity of the heart over a period of time using electrodes placed on a patient's body. These electrodes detect the tiny electrical changes on the skin that arise from the heart muscle depolarizing during each heartbeat. ECG deals with the study of the electrical activity of the heart muscles. When it is normal, the heartbeat is regular and has just the right rate as shown in Fig.1. But when the heartbeat is too fast, too slow, or beats in an irregular rhythm, it is known as a cardiac arrhythmia (abnormal heart rhythm), which is among the most common of the heart disorders. Arrhythmia is caused due the abnormalities in the heart's normal electrical system which regulates the heart rate and heart rhythm.

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Impact Factor: 5.164
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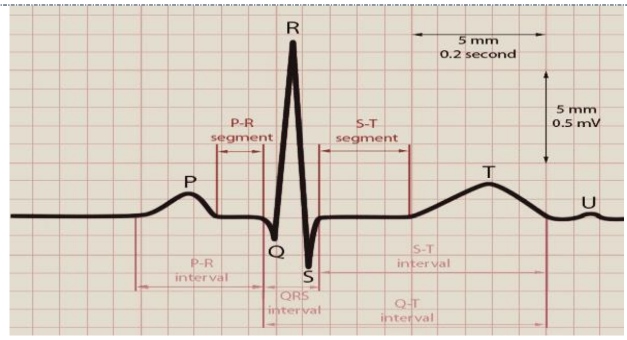


Figure 1. Normal ECG waveform

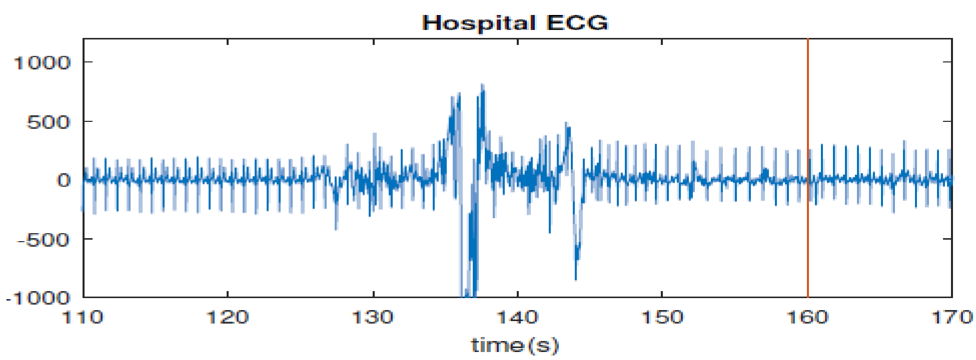
2. MATERIALS AND METHODS

Data reception

There is a need for an automatic seizure detection device, to log seizures in an objective way which records biomedical signals of the patient during daily life. A computer-based algorithm using signal processing and machine learning can be used to automatically to detect seizures on the basis of observed signals. An electronic diary can be generated, using this information. In order to continuously measure the seizure values it should be ensured that, the device will be worn continuously day and night and is important that the device is wearable and comfortable. Most importantly it should be as concealable as possible to reduce stigmatization. However, it is important to have high data quality in order to have a reliable seizure detection. In order to extract the HRV (heart rate variations) from the ECG, a method developed was used. In the first step, the ECG signal is segmented into epochs of 60 s. Thereafter, the power line interference at 50 Hz is removed by a notch-filter, and the mean of the signal is removed. An algorithm is used to find the R-peak locations. Instead of the classical filtering steps (bandpass, derivative, and integrator), the upper (Uecg) and lower (Lecg) ECG envelopes are calculated. A flattened version of the ECG is defined as Fecg = Uecg □ Lecg, which is used to find the possible locations of the R-peaks. The HRV is calculated from the differences between the locations of the R-peaks.

Seizure Detection Algorithm

In order to perform seizure detection, an algorithm developed is used. The algorithm uses the HRV as input. After filtering, the algorithm looks online for a HR increase. If this HR increase satisfies the preimposed rules, features are extracted and classification is performed. Three features are extracted for classification: HRpeak, HRbase and the STDHRbase. HRpeak is the peak HR at the end of the HR increase. HRbase is the average HR over the 60 s before the start of the HR increase. STDHRbase is the standard deviation of the HR over the 60 s before the start of the HR increase.



Data reception and processing

The wireless ECG Data Acquisition system described above requires very low power and is small in size. The digital data acquisition is managed by the android application in the smart phone. In the application Bluetooth is selected as the wireless transmission mode. Switch is pressed after selecting the transmission medium to find the

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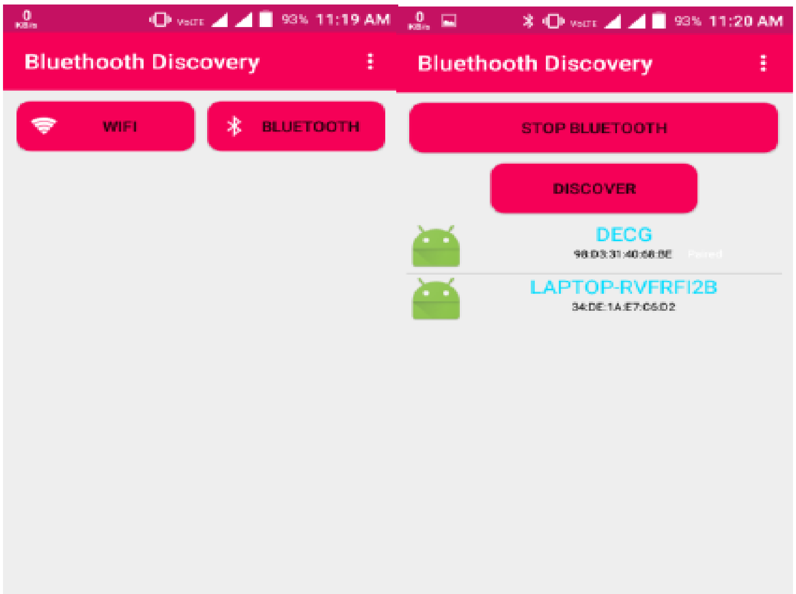
available devices within the range. ECG is selected in the application which will connect the android phone with the data acquisition system. After selecting, START button is pressed to begin the transmission of ECG data from the data acquisition system to the android smart phone wirelessly. The data acquisition can be stopped by pressing the STOP button. After stopping the data acquisition, the ECG data is stored in the file in the smart phone.

The ECG data received at the microcontroller is transmitted wirelessly to Android phone. By using Bluetooth, the lossless wireless data transmission is done. For transmission through Bluetooth, the Bluetooth module is used. The microcontroller and the Bluetooth module are connected through RS-232 interfacing. After receiving the data from the data acquisition system in the smart phone, the leads are displayed on the mobile phone in real time. The smart phone also streams the data to the web using 3G/4G mobile internet links on the phone. The android appilication used here consist of both user and doctor module. User can acquire data from user module similarly doctor can also acquire data, the doctor uses these data to analyze the patients.



A sample screenshot of Data acquisition android application

The system is small in size and portable. It is also cost effective. This device helps the patients to acquire the ECG data wirelessly and store it in a file using the smartphone android application. The acquired ECG is plotted and displayed in phone screen.

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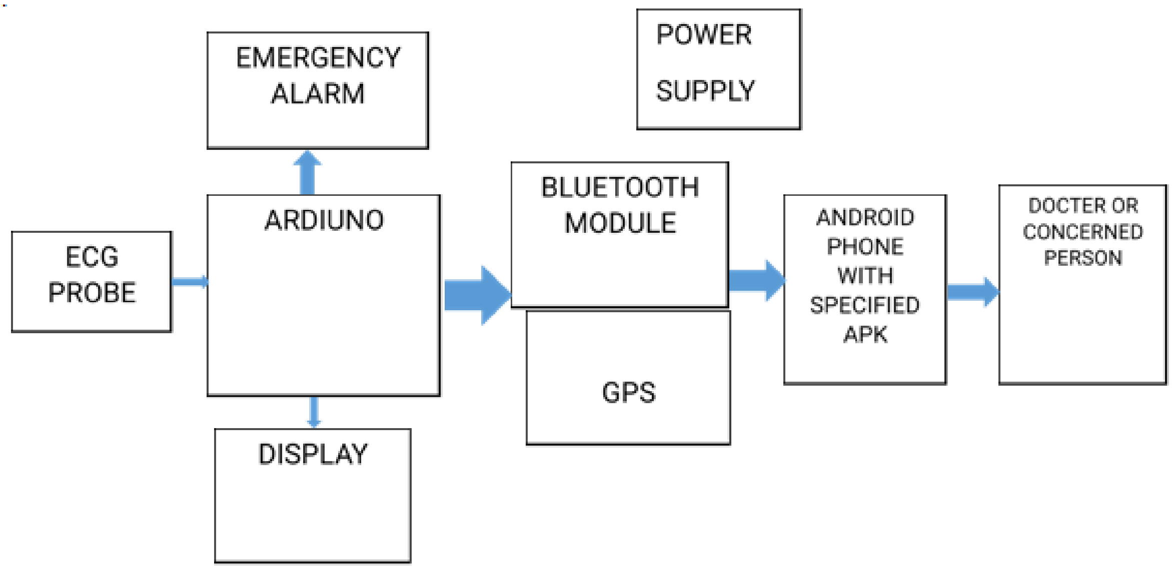

Our system uses an algorithm to identify seizures based on heart rate features. The values are measured by using ECG probe. The paper presents a system to detect epileptic seizures. In addition to this, we propose an android Apk where the doctor can observe the ECG graph and also a prerecorded audio which will automatically play when seizure is occurred so that the person beside the patient can be helpful. The overall developed system consists of following elements:

ARDIUNO:
Here we use Ardiuno that incorporates a number of enhancements and new features. It is a microcontroller board based on 8-bit ATmega328P microcontroller. It performs a processing of input ECG so to compare it with threshold value.

ECG PROBE:
The monitoring system determines the number of leads you'll use. With 3 leads, you get a choice of three views. The main purpose of lead ECG is to screen patients for possible cardiac ischemia. It helps EMS (Emergency medical services) and hospital staff to quickly identify patients who have STEMI (ST elevation myocardial infraction or in other words, heart attack) and perform appropriate medical intervention based on initial readings. To measure the heart's electrical activity accurately, proper electrode placement is crucial. ECG represents a simple and easy to record signals for seizure detection.

BLUETOOTH MODULE:
It's used for telecommunication purpose. The data processed is send to the mobile phone via Bluetooth. HC-05 is a class-2 bluetooth module with serial port profile, which can be configured as either master or slave, a Drop-in replacement for wired serial connections, transparent usage.

GPS:
A GPS tracker utilizes the global positioning system satellites to determine the precise location. A GPS navigation system is a GPS receiver and audio/video(AV) components designed for a specific purpose such as a car based or hand held device or smartphone app. GPS receivers find their location by coordinating information from three or four satellite signals.

3. RESULTS AND DISCUSION

For automated seizure detection, a simple and easy to record signal is ECG. ECG signals is highly robust and less prone to artifacts compared to other signals such as EEG. In an ambulatory setting using an ambulatory

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ECG long term ECG recordings can be easily obtained. This system impose no burdens or restrictions to the patient and can be well tolerated by patients.

The performance of wearable ECG can be compared with hospital ECG. Since the wearable device is automatic the manual error present in the hospital ECG can avoided. Our proposed system provides an electronic gadget to protect them from the seizures and it will also intimate the respective doctor about the patient's condition. When the seizure is occurred a prerecorded audio is played which will useful for person near the patient. Regular checkup in the hospital can be avoided using this device. Thereby reducing transportation cost hospital cost etc.

4. CONCLUSION

Millions of victims of epilepsy around the globe could be helped by developed lightweight, cost effective wearable device. The wired hospital system is not suited for a long term seizure detection system at home. Algorithm used here identifies the seizure on the basis of heart rate feature. This information is send to doctor using wireless technology and by using GPS, the location is also identified. Prerecorded audio is played when abnormalities are detected. Medical expenses and traveling cost can be reduced**.** Automatic epileptic seizure detection is important for objective seizure documentation for SUDEP (sudden unexpected death in epilepsy), to avoid seizure related injuries and social embarrassments and to develop on demand epilepsy therapies. With this device in possession an epilepsy patient can move around freely like normal people sans of worries.

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