Enhanced Epilepsy Seizure Detection and Smart Phone APP for Monitoring Seizures Based on EEG Classification

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Abstract- Automated epilepsy seizure detection is the solution to the limitation and time consuming of manual epilepsy monitoring and detection using EEG signals. We developed a technique for epilepsy seizure detection using EEG signals. The signal will be pre-processed and filtered using multiple filters. Then, the filtered signal will be decomposed into sub-bands. Furthermore, feature extraction is applied; we developed a combined feature consists of combining three features into one. Finally, we used well-known classifiers such as Support Vector Machine (SVM), Artificial Neural Network (ANN), and K-Nears Neighbor (KNN) to differentiate between epileptic and no epileptic signals, and we achieved an accuracy of 98%. Furthermore, we developed an Android-based smartphone application for monitoring epilepsy detection based on the classification results of the EEG signal. A notification will be sent to the patient, doctors, and family members when an epilepsy seizure occurs. Once the EEG signal is classified as epileptic, the App will display a visual notification indicating that Epileptic Seizure has been detected. Moreover, it will trigger an alarm and send a message notification to all associated phone numbers. Although we are using an EEG signal from a dataset, we have generated both normal and epileptic EEG signals using a waveform generator, and we have displayed those signals on the spectrum analyzer for future real
time detection using our Android App.

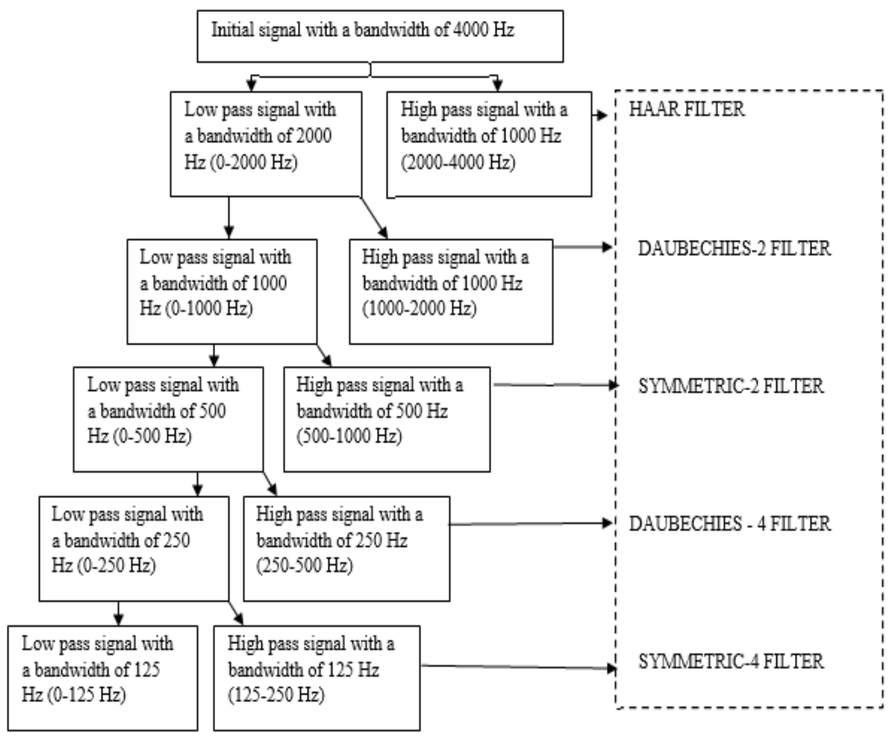
Introduction

Epilepsy is a neurological disorder disease that affects the central nervous system of the human brain that can disrupt the activity of the nervous cells in the brain which will result in unusual behavior that can lead to loss of consciousness called epileptic seizure. Nowadays, Health organization relay more and more on smartphone applications to play an important role in improving the patient's daily life. Therefore, developing a smartphone app that can monitor the epileptic patient's behavior, and notify the care takers of seizure occurrence would be a great contribution.

Proposed Method

- **Signal acquisition**
  - EEG
  - Dataset
- **Pre-processing**
  - FIR filter
  - Low pass filter
  - FFT filter
- **Decomposing**
  - Enhanced Wavelet Analysis
- **Feature extraction**
  - Amplitude range
  - Bandpower
  - Crest Range
- **Classification**
  - SVM
  - ANN
  - K-NN
- **Post-processing**
  - Mobile App development

Newly introduced techniques



Crest Range: (designed feature)
Crest factor = (Peak to peak of the signal) / (RMS value of the signal)
RMS value of the signal = $\sqrt{\frac{1}{T}\int_0^{133} x^2(t)\,dt}$

Crest Range = crest factor + amplitude range

Results

Percentage using Maximum-Minimum feature	Classifiers		
	ANN	SVM	K-NN
20% testing and 80% Training	96.49%	94.13%	98.61%
30% testing and 70% Training	96.18%	94.57%	97.7%
40% testing and 60% Training	95.77%	93.27%	96.54%
50% testing and 50% Training	94.95%	93.18%	95.06%

Percentage using Band-bower feature	Classifiers		
	ANN	SVM	K-NN
20% testing and 80% Training	90.97%	89.89%	92.92%
30% testing and 70% Training	88.41%	89.99%	91.60%
40% testing and 60% Training	89.01%	88.27%	90.42%
50% testing and 50% Training	86.21%	88.27%	89.23%

Percentage using Crest Range feature	Classifiers		
	ANN	SVM	K-NN
20% testing and 80% Training	98.03%	95.34%	97.92%
30% testing and 70% Training	96.05%	93.56%	97.93%
40% testing and 60% Training	95.17%	94.73%	96.54%
50% testing and 50% Training	94.48%	94.92%	95.68%

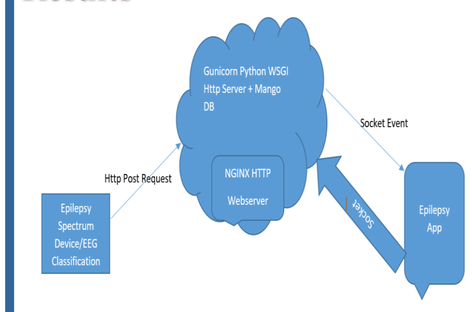
Percentage using Crest Range feature	Classifiers		
	ANN	SVM	K-NN
20% testing and 80% Training	97.87%	96.40%	96.72%
30% testing and 70% Training	95.91%	95.97%	95.63%
40% testing and 60% Training	94.72%	93.53%	93.62%
50% testing and 50% Training	94.40%	93.21%	93.23%

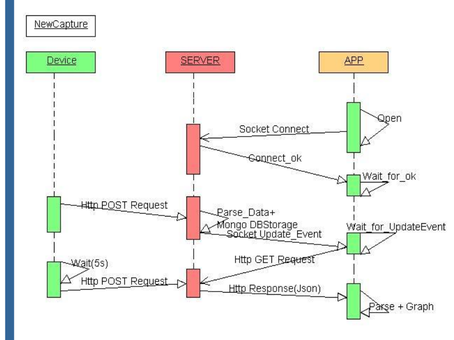
Percentage using BandPower and Crest Range feature	Classifiers		
	ANN	SVM	K-NN
20% testing and 80% Training	96.66%	97.06%	96%
30% testing and 70% Training	96.02%	96.20%	95.51%
40% testing and 60% Training	95.07%	94.64%	93.70%
50% testing and 50% Training	94.24%	93.57%	92.71%

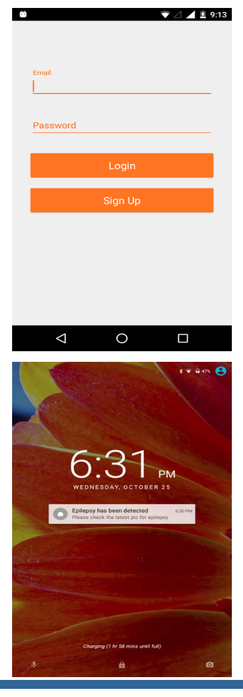
Percentage using Amplitude Range & Crest Range	Classifiers		
	ANN	SVM	K-NN
20% testing and 80% Training	97.25%	96.94%	98.27%
30% testing and 70% Training	96.44%	95.40%	97.36%
40% testing and 60% Training	94.75%	94.25%	96.23%
50% testing and 50% Training	94.17%	93.82%	95.76%

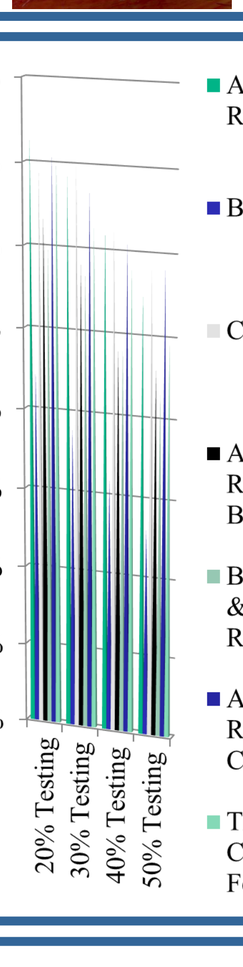
Percentage using three combined features	Classifiers		
	ANN	SVM	K-NN
20% testing and 80% Training	98.43%	97.92%	98.10%
30% testing and 70% Training	96.38%	97.20%	96.52%
40% testing and 60% Training	96.20%	96.55%	95.68%
50% testing and 50% Training	96.06%	94.32%	93.83%

App Development and Results









Conclusion

In this work we have used EEG signal dataset available from the University of Bonn . We have preprocessed the signal by using three different filters as explained previously; then after decomposing the signal three features were extracted from the EEG signal including new designed feature in order to evaluate our work. In addition, we have used some of the mostly used machine learning algorithms for classification. We have randomly tested the classification ten times for each of our three classifiers using different testing and training percentage at each time, then we have recorded the average accuracy at each percentage level. We developed an APP that monitors the behavior of epileptic patients based on EEG processing and classification. The APP is connected to the classification procedure through the sever, and updates the results instantly whenever a new signal is processed. Upon classification completion, an alarm will be triggered should an epilepsy seizure detected, and notifications will be sent to all associated numbers.