

# Strategies for real-time detection of nocturnal epileptic seizures

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## Goal

Develop a real time sensor system to detect generalized tonic and tonic-clonic epileptic seizures. Epilepsy affects over 50 million people worldwide. Seizures like generalized tonic and generalized tonic clonic can be life threatening. Tonic seizures are described as rigid, violent muscular contraction, fixing the limbs in some strained position. Figure 1 shows the electromyography (EMG) and accelerometer (ACC) signals during a mimicked tonic-clonic seizure.

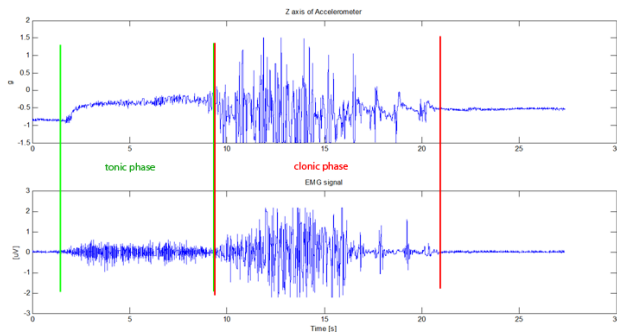


Figure 1: Signals of a mimicked tonic-clonic seizure.

## Materials and setup

We used two sensor nodes (SN) from Shimmer, see figure 2.

- Sensitivity ACC: 800mV/g
- Frequency range EMG: 5-482Hz
- Gain: 682
- Max signal range: 4.4 mV
- Size: 53mm x 32mm x 25mm
- Weight: 22g
- Bluetooth connection
- Battery lifetime at 256Hz > 12h

The setup:

- 2 volunteers simulating 7 seizures
- SN on upper arms
- Input electrodes on Deltoids
- Reference electrode on Sternum
- Sample frequency: 256Hz
- Acquisition via EyesWeb & BioMobius

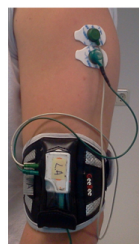


Figure 2: a) Shimmer sensor b) Measurement setup

## Signal processing

1. Highpass filter at 15 Hz for EMG and 1 Hz for ACC.
2. Onset detection on one EMG channel using Bonato method.
3. Eight features were computed using a sliding window of 2 seconds with 50% overlap.

Standard Deviation	Median Frequency (up to 30Hz)
Root Mean Square	Max Frequency (8-30 Hz)
Zero Crossing Rate	Frequency Ratio (max(8-30Hz)/min(8-30Hz))
Squared Integral (SI)	Waveform Length (WL)

4. WL for EMG was selected as most discriminant feature by exhaustive search and sequential forward selection.
5. Linear discriminant analysis (LDA) was used for classification. Two out of the seven simulated seizures are used to train the classifier.

## Combined EMG/ACC classification

Figure 3 shows a diagram of EMG and ACC contributions for different physical activities. The SI is computed on the ACC channels for a sliding window of 16 samples, with 94% overlap. The max(SI) for ACC and WL for EMG in 2 seconds will be used further in analysis.

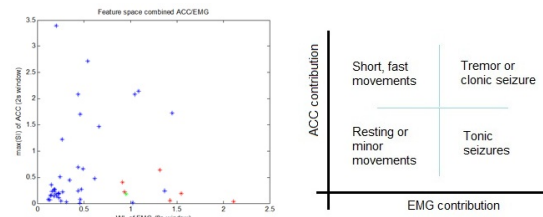


Figure 3: left) feature space, right) Signal contributions

A possible seizure is detected when WL of EMG signal is higher than a threshold (th1) and max(SI) is lower than a threshold (th2) in the same time for both arms.  $th1 = \max(WL(\text{one hour}))$  and  $th2 = \text{mean}(\max(SI)(\text{one hour}))$ ; Figure 3 left shows the feature space for the right arm (the red stars represent mimicked tonic seizures).

## Results

The lower graph in figure 4 shows the detection results of both methods. In the upper graph (figure 4), the EMG signal from the right arm is plotted, with the simulated tonic seizures in red. The green part is a simulated tonic-clonic seizure. The middle graph shows the ACC channels of the right arm.

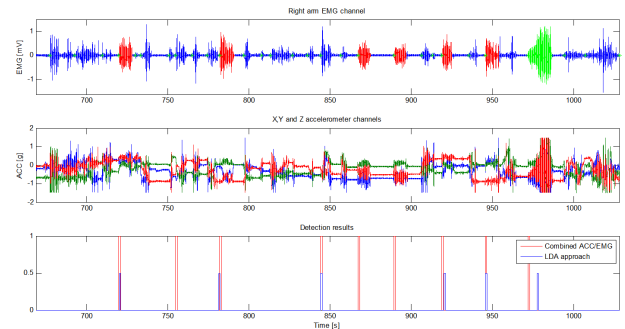


Figure 4: EMG and ACC signal for right arm with detection results of both methods.

The classical method has 2 FN and 1 FP. The combined EMG/ACC method has 0 FN and 2 FP. The FP are moments when the volunteer went to a sitting position in bed. These can be easily removed using ACC data.

## Conclusions

- A real time monitoring system was developed to record EMG and ACC data from patients. Patient data is being recorded using this system in Kempinhaeghe since October this year. Until now the patients in the trial did not have any relevant seizures for our goal.
- WL was found to be the best feature from the ones investigated for EMG.
- The combined ACC/EMG method shows superior results compared with LDA.

Future work:

Account for packet loss in the Bluetooth transmission. Implement the algorithm in realtime in Matlab. Validate the algorithm with patient data.