A wristband assessment of accelerometry and autonomic activity of epileptic patients

C Caborni[1*], F Onorati[1], G Regalia[1], M Migliorini[1], R Picard[1,2*]

1. Empatica, Inc, Cambridge, MA and Milan, Italy, www.empatica.com **2.** MIT Media Lab, Massachusetts Institute of Technology, Cambridge, MA

*emails: cc@empatica.com or rp@empatica.com

Rationale

Electrodermal activity (EDA) is a physiological signal reflecting the activity of the sweat glands driven by the Sympathetic Nervous System. EDA and wrist acceleration (ACM) measurements can be used to automatically identify generalized tonic-clonic seizures (GTCSs) **[1]**.

Our prior work **[2-3]** showed that using 30 features from EDA and ACM, and a Support Vector Machine approach, it was possible to obtain a detector (SVM_30) with sensitivity (Se) of 95% and false alarm rate (FAR) of 2.02 events/day on a set of 38 GTCSs from 18 epilepsy patients.

It is important to continue to test these methods on more patients, more seizures, more false-alarm-eliciting activities, and over longer periods of time.

Methods

In collaboration with top hospitals, we collected clinically labelled seizure data using video EEG (v-EEG), consisting of 192 recordings taken from 53 patients wearing an Empatica E3 or E4 wrist sensor recording EDA and 3-axis ACM (**Figure 1(a)**).

The data were analyzed off-line using proprietary software (Empatica, Inc.) to clean the data and extract signal features on a 10 seconds window every 2.5 seconds (overlap: 75%) (**Figure 1(b)**).

Next, SVM_30 was employed in order to evaluate the Se and FAR on this test set. The optimal decision threshold to discriminate between seizure and non-seizure epochs was selected by means of receiver operating characteristic curve analysis on a prior-collected training set (38 GTCSs from 18 patients over 43 days).

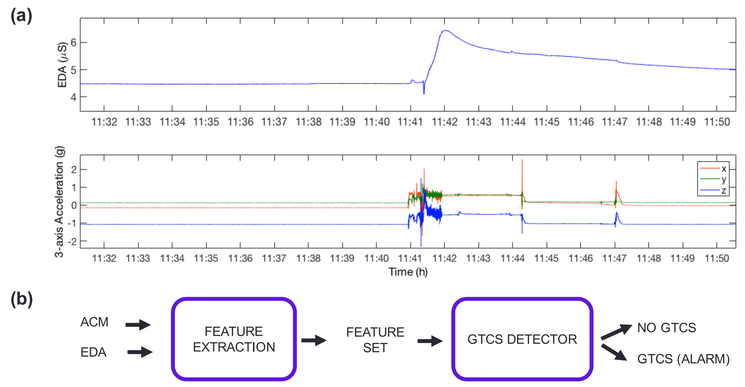

Figure 1. (a) EDA and 3-axes ACM signals of a patient recorded during a generalized tonic-clonic seizure (GTCs) with a wrist-worn device. **(b)** Schematic workflow of the GTCs detector.

Results

The SVM_30 classifier was tested on data from five new patients having more diverse seizures, using none of their data in the training set. The new test data consisted of **8 GTC and 4 focal motor (FOCM) seizures from 5 patients over 378 hours** (15.75 days). To further raise the difficulty, we also included test data of non-seizure wearable sensor recordings from **48 epilepsy patients** over a total of **3564 hours** (148.5 days) in order to mimic the realistic utilization of the wearable detector over **a total of 164 days**.

The classifier was able to provide an alarm before the seizure had finished in **100%** of the cases, with a mean delay in the 12 cases of **29 seconds** (SD=12 sec). As a percentage of the seizure duration, the detection occurred on average after 39% of the seizure had occurred. (**Figure 2**)

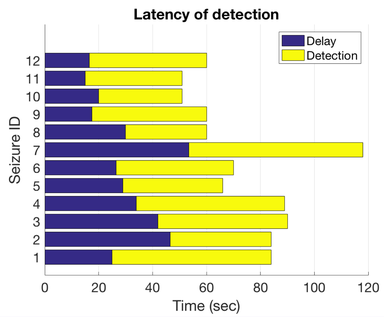

Figure 2. Latency of detection (delay between EEG onset of seizure at time 0 and first epoch classified as seizure) for each test GTC seizure

The SVM_30 automatically recognized 12/12 of the new seizures (**Figure 3(a)**), achieving for 164 days of recording from 53 patients, a **sensitivity of 100% and FAR of 0.93 events/day**. Of the **53 epilepsy patients**, 40 patients (most of them) averaged less than or equal to 1 false alarm/day. Of these, 18 had no false alarms (**Figure 3(b)**). Six had a FAR higher than 2, while seven had from 1-2 false alarms/day.

Figure 3. (a) The histogram shows the number of patients having each false alarm rate per day. **(b)** The five new patients had from 1-4 seizures each, all perfectly detected, even though the automated method had not been previously shown any FOCM events or any data from these patients.

Conclusions

In this work, the performance of an automated seizure detection system based on ACM and EDA features measured from the wrist was presented using clinical data collected from a total of 53 patients having two types of seizures.

The classifier we tested achieves a high seizure detection rate for GTC and FOCM seizures that had never been trained by the model (Se=100% on 12 new seizures) **while maintaining an acceptable false alarm rate** of 0.93/day on average over 164 days.

Furthermore, the method is efficiently integrated into a hardware platform to provide real-time alarms of seizures while they are occurring.

In the future, the model will be tested on data collected outside the clinic, where the test conditions are expected to be much more challenging.

References

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