Figure preserving

Using stimulations

Rationale

Acceleration (ACM), measured through a wrist-band, has been used to automatically identify the motion of convulsive seizures such as generalized tonic-clonic seizures (GTCSs) [1] [2]. However, ACM-based seizure detectors have high false alarm rates, which might prevent daily life use.

Electrodermal activity (EDA) is a physiological signal reflecting the activity of the sweat glands driven by the Sympathetic Nervous System. Direct stimulation of some subcortical regions [3] elicits ipsilateral EDA responses.

Using both EDA and ACM features improves the classification performance of a GTCS detector, reducing the false alarm rate [4] (16 GTCSs from 7 patients).

Using a larger feature set further lowers the false alarm rate while preserving high sensitivity [5] (20 GTCSs from 9 patients).

Here we present the results of further improvements, using a smaller set of features, better matched to use in patient-friendly wearable devices: 38 GTCSs from 18 patients, obtaining similarly high sensitivity (92-95%) with low false alarm rates (0.56-2.26 per day).

Methods

Labeled seizure data were collected during clinical video EEG (v-EEG) monitoring.

Data: 44 recordings from 18 patients wearing a wrist-band able to record EDA and 3-axes ACM (Figure 1(a)).

EDA and ACM signals were analyzed off-line using proprietary software to clean the data and extract signal features over a 10 sec. window every 2.5 sec (overlap: 75%).

Support Vector Machine (SVM) classifiers were trained: one with 46 features (SVM_46), one with 30 features (SVM_30).

A leave-one-patient-out cross-validation approach was used to test classifier sensitivity (Se) and false alarm rate (FAR), defined as number of false alarms per day.

The optimal decision threshold was selected by receiver operating characteristic (ROC) curve analysis.

Results

Recordings included 38 GTCSs from 18 patients over a total of 1027 hours (42.7 days). Both classifiers show acceptable FAR while keeping Se higher than 90% (Figure 2).

SVM_46 at Se=92% (i.e., 35 seizures detected out of 38) showed FAR=0.56 and at Se=95% (i.e., 36 out of 38) FAR=2.26.

SVM_30 achieved similar performance (Se=92% and FAR=0.74, Se=95% and FAR=2.02), using fewer features.

When using SVM_30 with a threshold set to provide Se 95%, most of the patients (10/18 = 55%) had less than 1 false alarm every 2 days and most (16/18 = 88%) had ALL of their GTCSs detected (Figure 3).

Conclusions

A seizure detection system based on ACM and EDA features was developed using clinical data collected from a larger number of patients and seizures with respect to previous work, capturing greater subject variability of GTCSs expression. The classifier obtained allows a higher seizure detection rate while maintaining an acceptable false alarm rate. Furthermore, it is efficiently integrated into a wearable wristband to provide real-time alarms of ongoing seizures.

References


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