An approach using extreme value statistics to detect rare movement events in a bio-medical dataset

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ABSTRACT

Nocturnal home monitoring of epileptic children is often not feasible due to the cumbersome manner of seizure detection with the standard method of video/EEG-monitoring. We propose a method for hypermotor seizure detection based on accelerometers attached to the extremities. Hypermotor seizures often involve violent movements with the arms or legs, which increases the need for an alarm system as the patient can injure himself during the seizure.

In the literature, classification models are commonly estimated in a supervised manner. Such models are estimated using annotated examples. This annotation of data requires expert (human) interaction and results therefore in a substantial cost in the estimation process of the seizure detection model. In this work we propose the use of an unsupervised approach for estimating seizure detection models. This method does not require any annotation of data while obtaining state-of-the-art classification scores that are comparable to those of a model estimated in a supervised manner. The proposed methodology is based on extreme value statistics (EVT).

The EVT approach starts from a model of normal behaviour. This model is estimated using a multivariate kernel density estimation. Based on this estimation extreme value statistics are used to model rare events. These rare events are situated in the tails of the model. Generally however the approach also models rare events lying between multiple modes in case of a multimodal dataset. Finally, the model of rare events can be used to judge new incoming data to be rare or not.

In this work epilepsy seizure detection is based on data, recorded during the night using accelerometers attached to each limb of a patient. After segmenting the acquired acceleration signals in movement events, features are extracted for further processing. The fact that the dataset is heavily unbalanced (roughly only 3% of the data is coming from seizures) allows to use all data to estimate a model of normal behavior. The small portion of seizure-related data will only have a minor effect on the parameters of this model. Signals and/or features are determined such that extremities with respect to this model of normal movements can be considered as seizure related movements.

As a consequence, a person-dependent epileptic seizure detector can be estimated with little human interaction. The EVT-methodology is applicable on a broad range of datasets and was able in our example to detect all hypermotor seizures in five of the seven patients with a satisfying sensitivity and positive predictive value.

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