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Classification of interictal and ictal epileptic brain states based on respiratory data acquired with a smart wear

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***Abstract*—Recent studies have explored seizure detection with bracelets or EMG sensors but little attention has been given to connected shirts. In this work, we analyzed respiratory signals recorded with the Hexoskin smart wear. Breathing rate (BR) and minute ventilation (MV) were extracted. A statistical analysis was performed to evaluate the existence of a significant difference between the ictal (i.e. seizure) and interictal (i.e. non-seizure) epochs. Four different classifier models were trained. A total of 67 seizures from 13 patients were analyzed. A significant difference was observed in BR and in MV between the ictal and interictal epochs ($p < 0.01$). The SVM classifer performed the best with an average accuracy of 76.7%.**

***Clinical Relevance*—Our work shows promise for the development of wearable seizure detection devices based on respiratory signals. The ability to detect seizures in an outpatient setting would improve patient management.**

I. INTRODUCTION

Epilepsy is a chronic neurological condition that affects over 50 million people worldwide [1]. While the first line of treatment consists of anti-convulsive drug therapy, more than 30% of patients continue to present seizures [2]. Recent research has investigated seizure detection using wearables, but it has mainly focused on electroencephalography (EEG), accelerometry and electrocardiography (EKG) and has left respiratory signals relatively unexplored. However, respiration is an important feature in epilepsy, particularly in sudden unexpected death in epilepsy, where changes in respiration are believed to be one potential causal mechanism [3]. Our objective is to determine whether respiratory signals acquired with the Hexoskin smart shirt can be used to classify ictal (i.e. seizure) and interictal (i.e. non-seizure) epochs.

II. METHODS

Patients admitted to the University of Montreal Hospital Center epilepsy monitoring unit were asked to wear the Hexoskin smart wear continuously during their stay. Minute ventilation (MV) and breathing rate (BR) were extracted from respiratory signals. Seizure onset and offset were annotated based on video-EEG recordings (blindly to the Hexoskin data) by an expert epileptologist. The Wilcoxon signed-rank test was used to evaluate the existence of a significant difference in terms of BR and MV between ictal and interictal epochs. The number of samples (7237) used for the ictal and interictal epochs was identical. Four classifiers (SVM, Random Forest, KNN and AdaBoost) were trained to classify epochs based on MV and BR. K-fold cross-validation (k=5) was performed to determine optimal hyperparameters using a GridSearch. Accuracy, precision and recall were evaluated.

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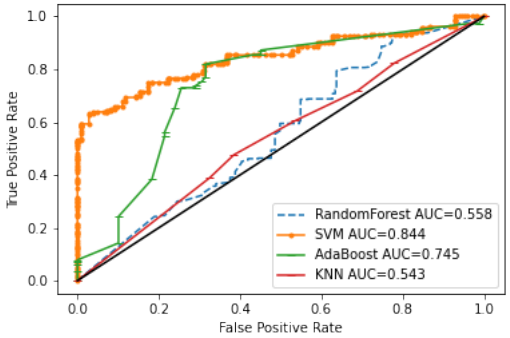

Fig. 1. ROC curves derived from the four tested classifiers

Table. 1. Classification performances

Classifiers	Performance			
	Accuracy	*Precision*	*Recall*	*AUC-ROC*
RandomForest	59.0%	69.0%	63.0%	0.558
AdaBoost	72.7%	81.5%	73.7%	0.745
KNN	55.6%	66.5%	60.6%	0.543
SVM	76.7%	79.9%	84.3%	0.844

III. RESULTS

A total of 67 seizures in 13 patients were analyzed. A significant difference was observed in BR and in MV between the ictal and interictal epochs ($p < 0.01$). Classification performances were evaluated on the held-out test set (20%) for the different classifiers and are compared in Fig.1 and Table 1.

IV. DISCUSSION AND CONCLUSION

Respiratory signals were found to be significantly different between interictal and ictal epochs, suggesting that they can be used as discriminatory features for seizure classification. Classification performances reported in this work are comparable to those obtained in the literature with EEG and EKG signals (accuracy, precision and recall rates ranging from 74% to 99%) [4]. Although our preliminary results are promising, they have to be considered in the light of some limitations such as the use of balanced training and test data, and a limited number of patients and seizures. Further analyses on data from a larger cohort of patients are required.

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