Cross-site generalization for imbalanced epileptic classification

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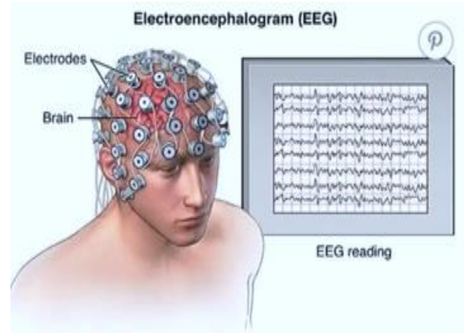
1. Context and Objectives

- Epilepsy is one of the most common neurological conditions defined by the recurrence of epileptic seizures
- Automatic seizure detection is highly needed since visual detection of seizures in EEG signal takes time and effort
- Our objective is to propose a model robust to cross-site patient variability and imbalanced data



2. Originality and main contribution of the work

- Applying data augmentation (DA) techniques on the seizure class followed by a hybrid CNN-LSTM classifier
- Validation of the cross-site generalization ability of our DA-CNN-LSTM method: the model was trained on the publicly Children's Hospital of Boston (CHB) data and it achieved great performance on a three times larger local French data acquired at the Centre Hospitalier Universitaire of Angers (CHU)

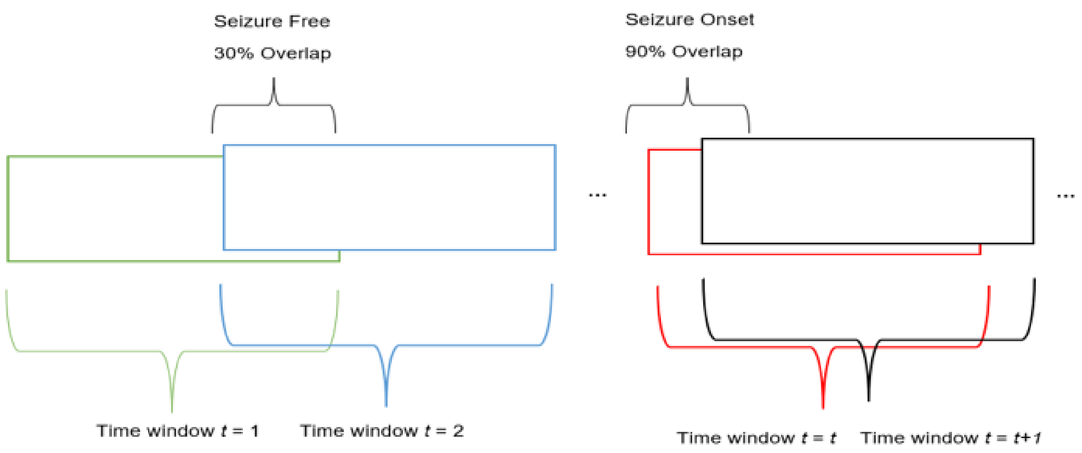
3. Datasets

Children Hospital Boston data set (CHB-MIT) :
- Online dataset
- 9 paediatric patients with 302 hours of recording
- 18 common electrodes, bipolar montage
- Sampling Frequency of 256 Hz

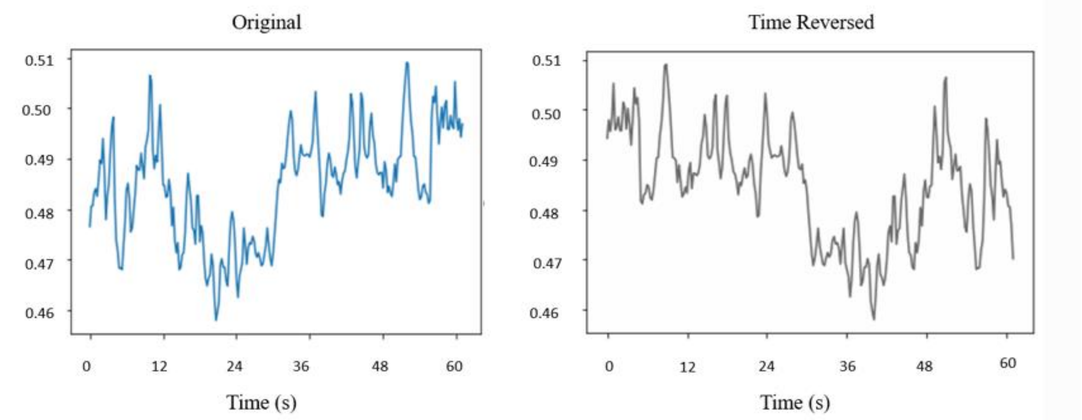
CHU of Angers:
- Local dataset with ethics approval by the agreement of the CHU Angers committee
- 20 paediatric patients with 960 hours of recording
- 18 common electrodes, monopolar montage
- Sampling Frequency of 256 Hz

4. Data Augmentation (DA) Techniques

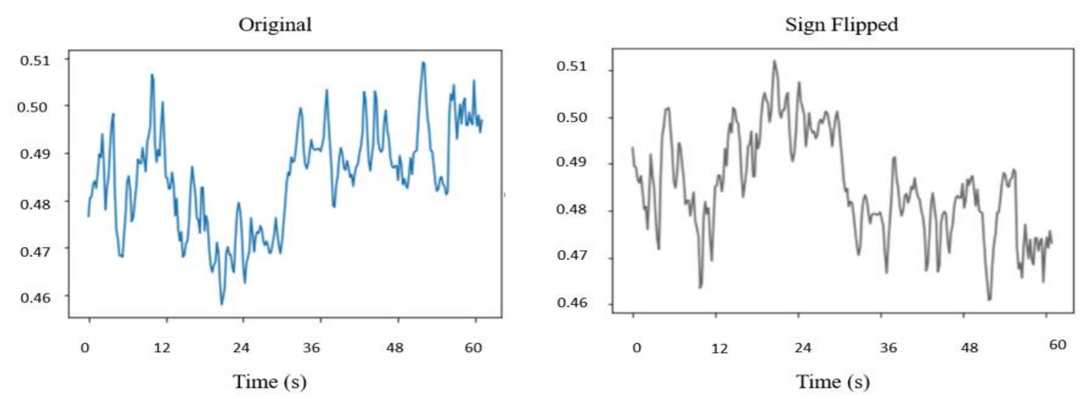
1- Sliding windows:



2- Time Reverse:

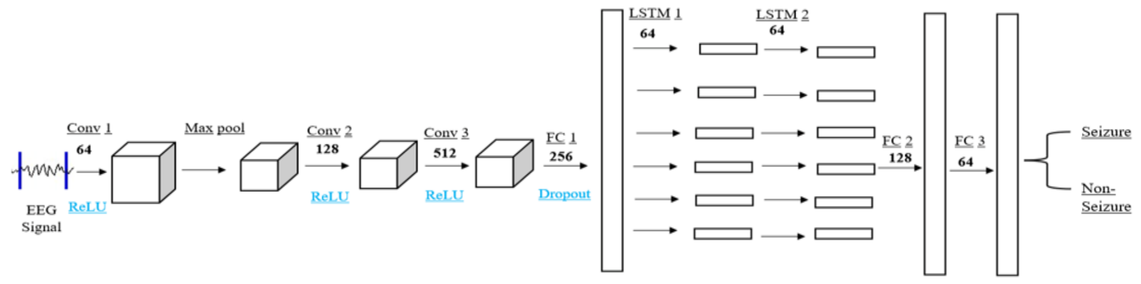


3- Flip Sign:



5. Proposed Method Architecture

CNN-LSTM model:
- CNN to extract EEG feature
- LSTM to benefit from its memory



6. Experiments and Results

Single-Site : Train and test the model on the CHB-MIT data

Cross-Site : Training on the CHB-MIT data and testing on the CHU data

Experiment 1: Single-Site without DA

Experiment 2: Single-Site with DA

Experiment 3: Cross-Site without DA

Experiment 4: Cross-Site with DA

CNN-LSTM	Accuracy	Precision	Recall	F1-score
Experiment 1	98.3% ± 0.06	93.5% ± 0.08	93.5% ± 0.08	93.5% ± 0.08
Experiment 2	**98.7% ± 0.01**	**97.0% ± 0.01**	**96.8% ± 0.02**	**96.9% ± 0.01**
Experiment 3	87.3% ± 0.08	86.5% ± 0.07	87.0% ± 0.06	86.9% ± 0.07
Experiment 4	89.9% ± 0.05	89.1% ± 0.02	89.0% ± 0.04	88.9% ± 0.03

Authors	Years	Methods	Accuracy	Precision	Recall	F1-score
Single-Site: Ozcan et al. [1]	2019	3D CNN	-	-	81.20%	-
Single-Site: Duan et al. [2]	2019	Bi-GRU	94.8%	-	91.7%	-
Single-Site: Sanguk Ryu [3]	2021	Dense-LSTM	93.3%	-	92.9%	92.3%
Cross-Site: Danielle et al.[4]	2021	CNN	-	-	89.3%	-
Our Cross-Site model	**2022**	**CNN-LSTM with DA**	**98.7%**	**97.0%**	**96.8%**	**96.9%**
Our Single-Site model	**2022**	**CNN-LSTM with DA**	**89.9%**	**88.5%**	**89.6%**	**89.0%**

7. Conclusion and Perspectives

- Model robust to cross-site variability and imbalanced datasets
- Very promising results
- For future work, develop reliable models that can be applied to different types of epilepsy

8. References

- [1] Ozcan, A. & Erturk, S. Seizure prediction in scalp EEG using 3D convolutional neural networks with an image-based approach. IEEE Transactions On Neural Systems And Rehabilitation Engineering. 27, 2284-2293 (2019)
- [2] Duan, L., Hou, J., Qiao, Y. & Miao, J. Epileptic seizure prediction based on convolutional recurrent neural network with multi-timescale. International Conference On Intelligent Science And Big Data Engineering. pp. 139-150 (2019)
- [3] Ryu, S. & Joe, I. A Hybrid DenseNet-LSTM model for epileptic seizure prediction. Applied Sciences. 11, 7661 (2021)
- [4] Currey, D., Hsu, D., Ahmed, R., Venkataraman, A. & Craley, J. Cross-site Epileptic Seizure Detection Using Convolutional Neural Networks. 2021 55th Annual Conference On Information Sciences And Systems (CISS). pp. 1-6 (2021)

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