TSfN 2020
Interdisciplinary Neuroscience Congress
跨領域神經科學國際研討會

EEG-based Absence Seizure Prediction Using Convolutional Neural Networks

Ya-Lin Huang[1](黃雅琳) Chun-Shu Wei[2](魏群樹)

bai06hua28lin.bt06@nctu.edu.tw cwei@nctu.edu.tw

1 Department of Biological Science & Technology, National Chiao Tung University, Hsinchu, Taiwan

2 Department of Computer Science, National Chiao Tung University, Hsinchu, Taiwan

Abstract

Epilepsy with recurrent epileptic seizures has been influenced around 50 million people worldwide. Among several kinds of generalized seizures, absence seizure (AS) is more common to occur upon children between ages four to 14. Patients may experience 10 to 100 times AS in a day while it may not be perceived during the ictal period. There has been a lack of effective prediction techniques that alert AS patients in advance to prevent potential AS-induced danger. As convolutional neural network (CNN) based models are commonly used to decode EEG, we applied CNN to the prediction of AS using 10 sessions of EEG recordings from five subjects selected from The TUH EEG Seizure Corpus (TUSZ), an EEG-based epileptic seizure database built by Temple University.

Background

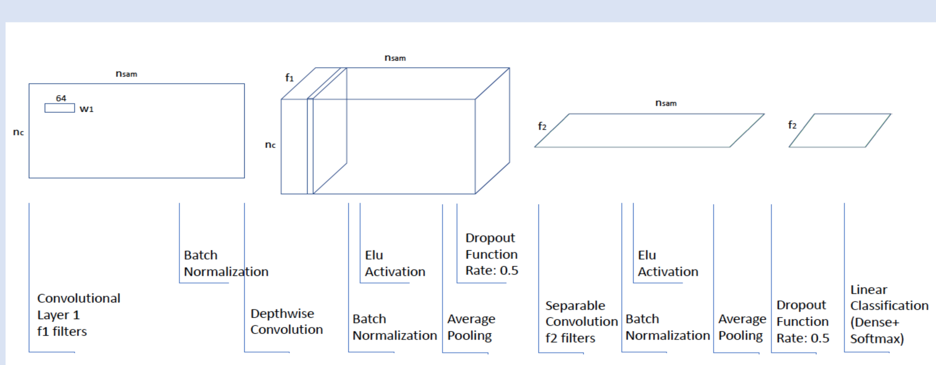
Recent breakthrough in data science using deep-learning modeling has boosted the improvements in decoding brain signals. Compared to seizure detection that acquires ictal-time information only, seizure prediction emphasizes on the inter-relationships between inter-ictal and pre-ictal periods. CNNs can utilize automatically learned features in the EEG data instead of handcrafted features, and therefore accelerate the pace of developing practical EEG-based seizure predictive models.

Method

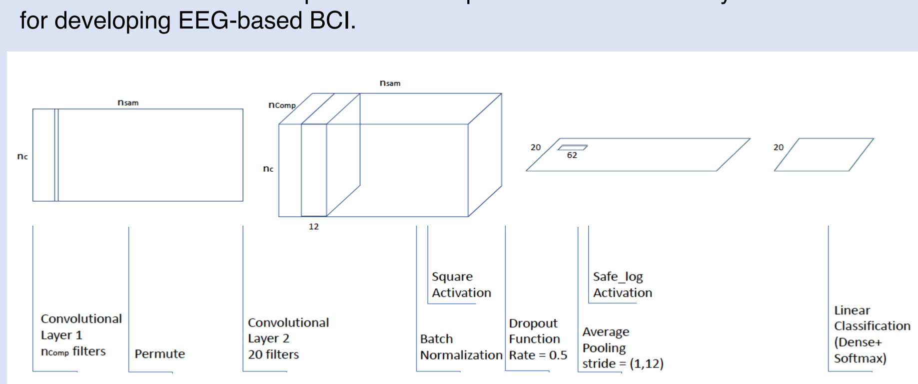
1. **TUSZ database**
   - TUH EEG Seizure Corpus (TUSZ)
   - EEG recordings of epilepsy patients
   - Five subjects with 10 sessions of AS are randomly selected.

2. **Signal preprocessing**
   - Common (21) channels selected across subjects.
   - Inter-ictal and pre-ictal data labeling and segmentation (~ 2230:410).
   - EEG band-pass filtering at 1-50 Hz

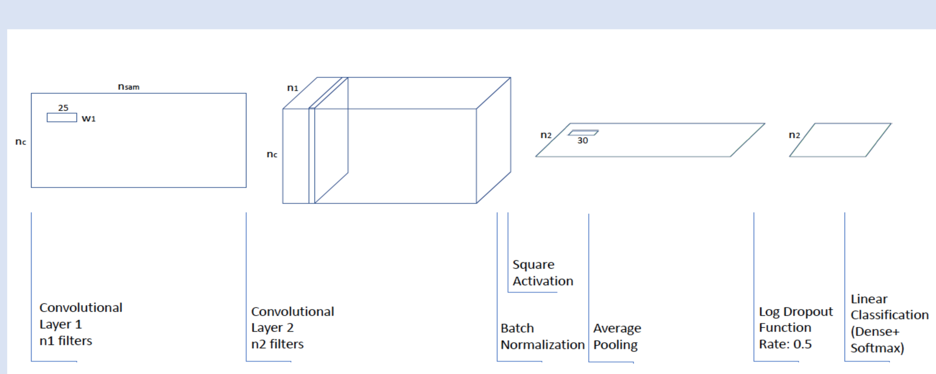
3. **CNN models**
   - Three CNN models including EEGNet, SCCNet, and ShallowConvNet are implemented.



EEGNet architecture.[3] Depthwise and separable convolutional layer are constructed for developing EEG-based BCI.



SCCNet architecture.[4] It consists two convolutional layer, spatial first then temporal.



ShallowConvNet architecture.[5] It's common to solve the oscillary signal classification task. It is composed of two convolutional layer, temporal first then spatial.

Prediction Performance of CNN models

Accuracy of 5 individual subjects and that of 3 models are showed below. Each subject is trained 84 epochs independently.

- **Subject**

	S1	S2	S3	S4	S5
ACC	0.382716	0.590888	0.631944	0.39895	0.920558

Huge accuracy gaps between subjects is found.

- **Model comparison**

	EEGNet	SCCNet	ShallowNet
ACC	0.428218	0.588382	0.738434
Precision	0.379825	0.599578	0.799286
Recall	0.551788	0.524523	0.699639
F-measure	0.365817	0.559047	0.745804
kappa	0.013372	-0.000762	-0.001251

The accuracy ranking of three models :ShallowConvNet >SCCNet> EEGNet.

Discussion and Conclusion

- CNN models are capable of predicting AS using EEG data.
- ShallowConvNet yields the best performance among the three recent classic CNN models.
- Due to the huge different accuracy is found on 5 subjects. Variant of subjects might be the crucial factor which should be carefully considered.
- Further investigation required to complete for more subjects.

References

1 Zhang, Y., Guo, Y., Yang, P., Chen, W., & Lo, B. (2019). Epilepsy seizure prediction on eeg using common spatial pattern and convolutional neural network. IEEE Journal of Biomedical and Health Informatics, 24(2), 465-474.

2 Gemein, L. A., Schirrmeister, R. T., Chrabąszcz, P., Wilson, D., Boedecker, J., Schulze-Bonhage, A., . . . Ball, T. (2020). Machine-learning-based diagnostics of EEG pathology. NeuroImage, 220, 117021. doi:10.1016/j.neuroimage.2020.117021

3 Lawhern, V. J., Solon, A. J., Waytowich, N. R., Gordon, S. M., Hung, C. P., & Lance, B. J. (2018). EEGNet: A compact convolutional neural network for EEG-based brain–computer interfaces. *Journal of Neural Engineering, 15*(5), 056013. doi:10.1088/1741-2552/aace8c

4 Wei, C., Koike-Akino, T., & Wang, Y. (2019). Spatial Component-wise Convolutional Network (SCCNet) for Motor-Imagery EEG Classification. 2019 9th International IEEE/EMBS Conference on Neural Engineering (NER). doi:10.1109/ner.2019.8716937

5 Schirrmeister, R. T., Springenberg, J. T., Fiederer, L. D. J., Glasstetter, M., Eggensperger, K., Tangermann, M., ... & Ball, T. (2017). Deep learning with convolutional neural networks for EEG decoding and visualization. Human brain mapping, 38(11), 5391-5420.