Genetic algorithm applied to hyperparameter selection for fMRI neurofeedback scores prediction from EEG signals

Caroline Pinte, Claire Cury, Pierre Maurel

Can neural networks help improve portability of combined EEG – fMRI neurofeedback?

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Introduction

- Neurofeedback (NF) training is more effective with **simultaneous EEG-fMRI** acquisitions [1].
- However, **the use of MRI is expensive** and draining for the subject.
- So, we need to **reduce its use**.

→ We propose a method based on a **one-dimensional convolutional neural network (1D CNN)**.

Objective

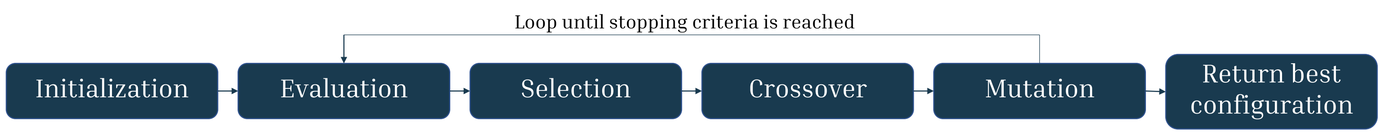
Design a neural network **model** from simultaneous EEG-fMRI data to **predict fMRI NF scores** from EEG **signals alone**.

Methods

1. **Data:** We acquired **simultaneous EEG-fMRI data** on 15 healthy subjects in a motor imagery context, described in [2]. This includes fMRI and EEG data for three NF runs of five minutes per subject, with their respective NF scores.

2. **Preprocessing:** We compute a **supervised learning dataset**, where a certain number of timesteps from a selection of EEG channels become one sample that has one fMRI NF score as target.

3. **Genetic search:** We use a **genetic algorithm** to search for the 1D CNN architecture hyperparameters.



4. **Training:** We **train the 1D CNN model**. Since we have 15 sujects with 3 runs each, the training dataset consists of the first run of every subject, the validation dataset of the second runs and the test dataset of the third runs.

5. **Analysis:** After the model is trained, **fMRI NF scores are predicted**, and compared to the ground truths with the MSE and Pearson's correlation metrics. Then, **we add EEG NF scores** to our predictions to compare it with bimodal EEG-fMRI NF scores.

Discussion

We are currently working on improving the correlations, which are negatively impacted by:
- Noisy nature of the EEG modality
- Lack of diversity in data

Conclusion

- The interest of this method compared to the previous modeling [3] is to train a **single deep learning model** for **all subjects**, which would eventually allow the use of the model to predict these fMRI NF scores directly online.
- An important aspect of the issue is to **interpret this model**, in order to better understand links between EEG and fMRI.

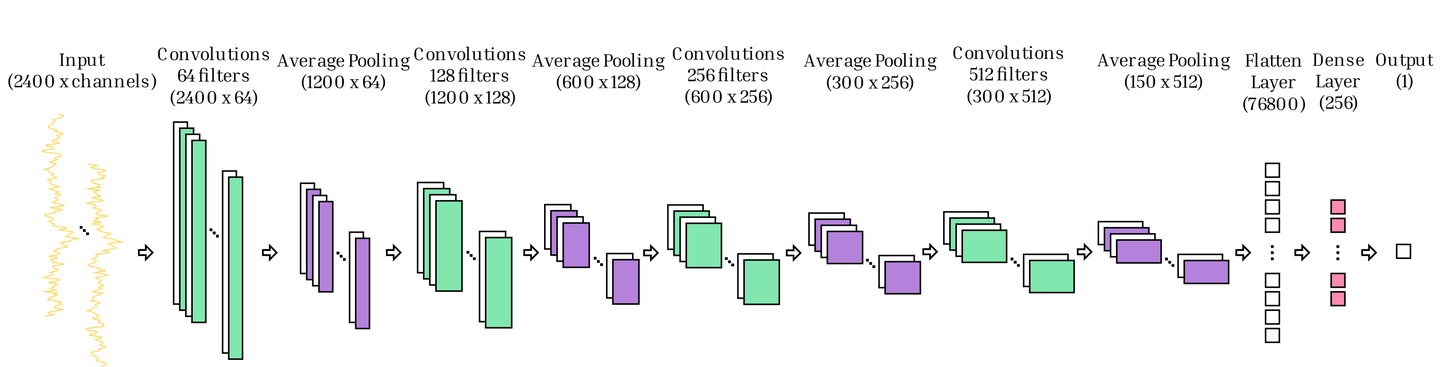


Fig. 1: Architecture of the 1D CNN used to predict fMRI NF scores from raw EEG signals. The input sample consists of 2400 timesteps from 25 EEG channels selected above the motor area.

Results

	fMRI NF scores	EEG-fMRI NF scores
Mean MSE	0.13	0.41
Mean correlation	0.19	0.60

Predicting fMRI NF scores:

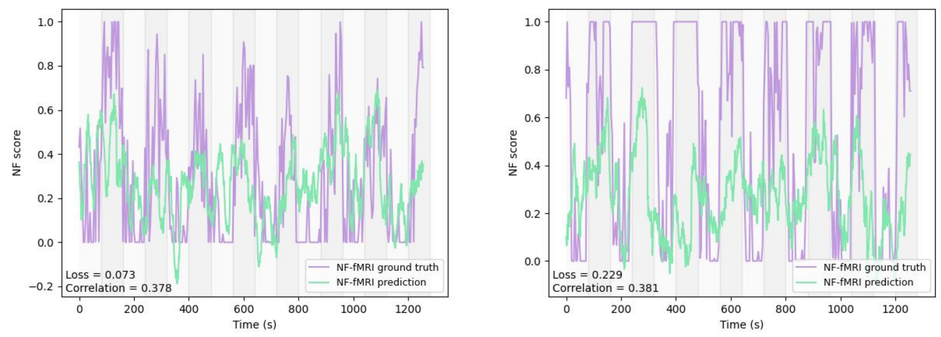


Fig. 2: Comparison between fMRI NF scores ground truth and fMRI NF scores prediction for two example test runs.

Adding EEG NF scores to get bimodal EEG-fMRI NF scores:

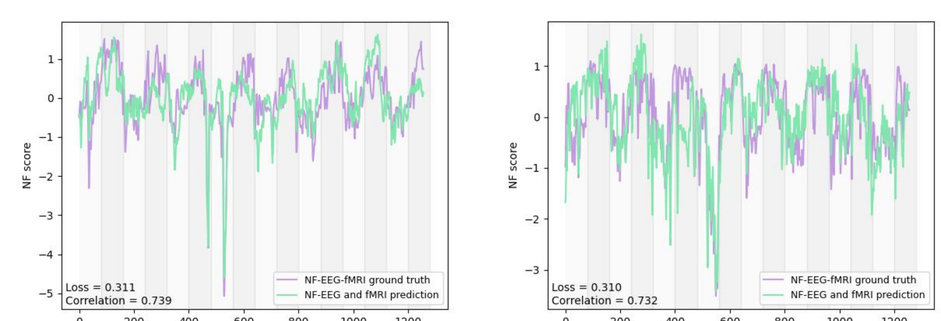
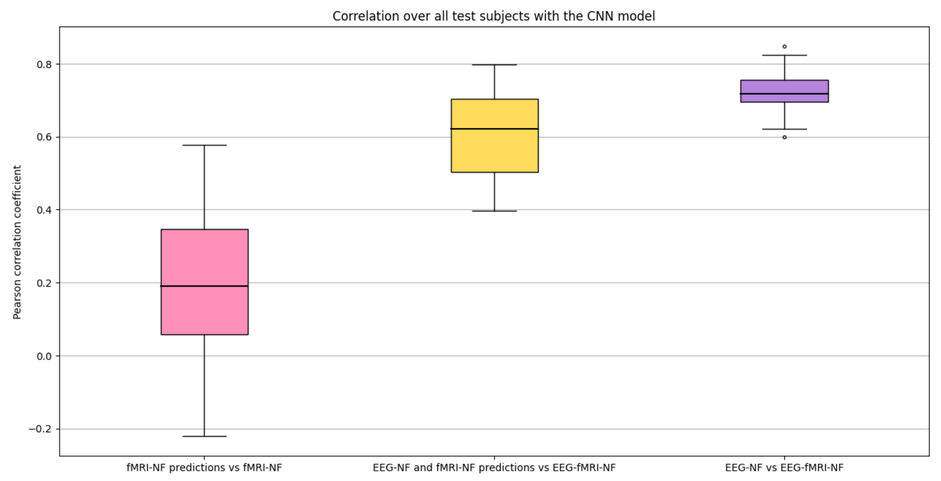
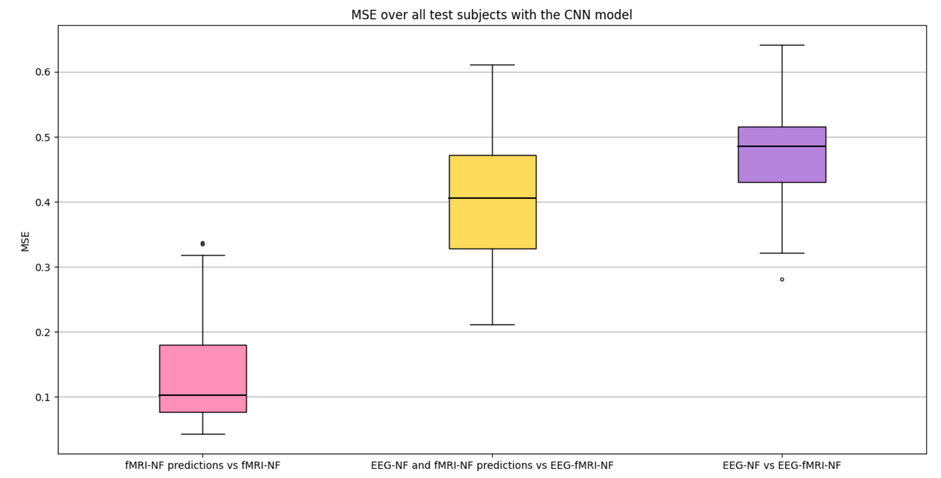


Fig. 3: Comparison between EEG-fMRI NF scores ground truth and EEG NF scores ground truths to which fMRI NF scores predictions are added for the same two example test runs.





1. Perronnet et al. "Unimodal versus bimodal EEG-fMRI neurofeedback of a motor imagery task." (2017)
2. Lioi et al. "Simultaneous EEG-fMRI during a neurofeedback task, a brain imaging dataset for multimodal data integration." (2020)
3. Cury et al. "A sparse EEG-informed fMRI model for hybrid EEG-fMRI neurofeedback prediction." (2020)

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