Cross-Paradigm Transfer Learning in Decoding Error-Related Potential with Convolutional Neural Networks

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Main Findings

1. CNN has a low performance with limited data from a single protocol.
2. Training with more data from the same protocol boosts CNN performance but does not allow to outperform LDA.
3. Training CNN on more data from a different but similar protocol can improve the performance, but it does not outperform LDA with latency adjusted between protocols.

Introduction

- Different protocols produce Error Related Potentials with similar wave shapes, but different latency.
- Previous investigations focused on simple machine learning algorithms, such as LDA, with an estimated latency correction. (**Fig.1**)
- CNN is shift invariant. We propose CNN can generalize the data between protocols with latency shift, without manual latency correction.

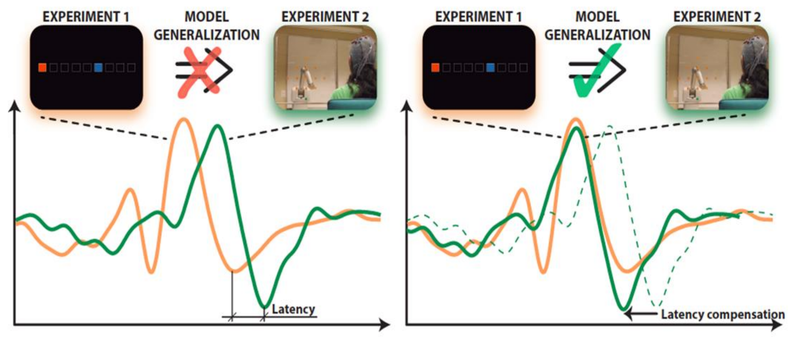
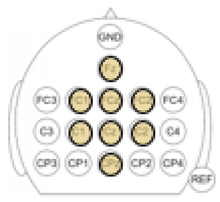


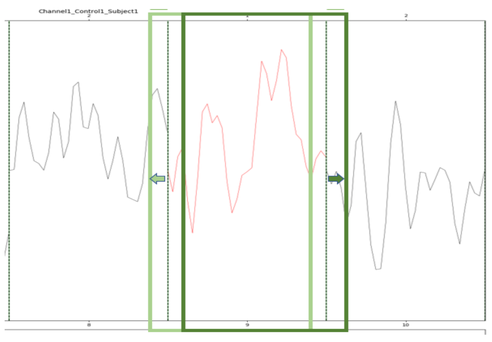
Fig.1: Latency Correction (LC) for Model Generalization[1]

Methods

- Dataset: 3 different experimental protocols. .
- Fixed validation set (200 ErrP offline trials) and test set (400 ErrP online trials)
- N=6 subjects.
- Down sampled to rate: 64 Hz, 8 channels selected.

Channels Selected[2]

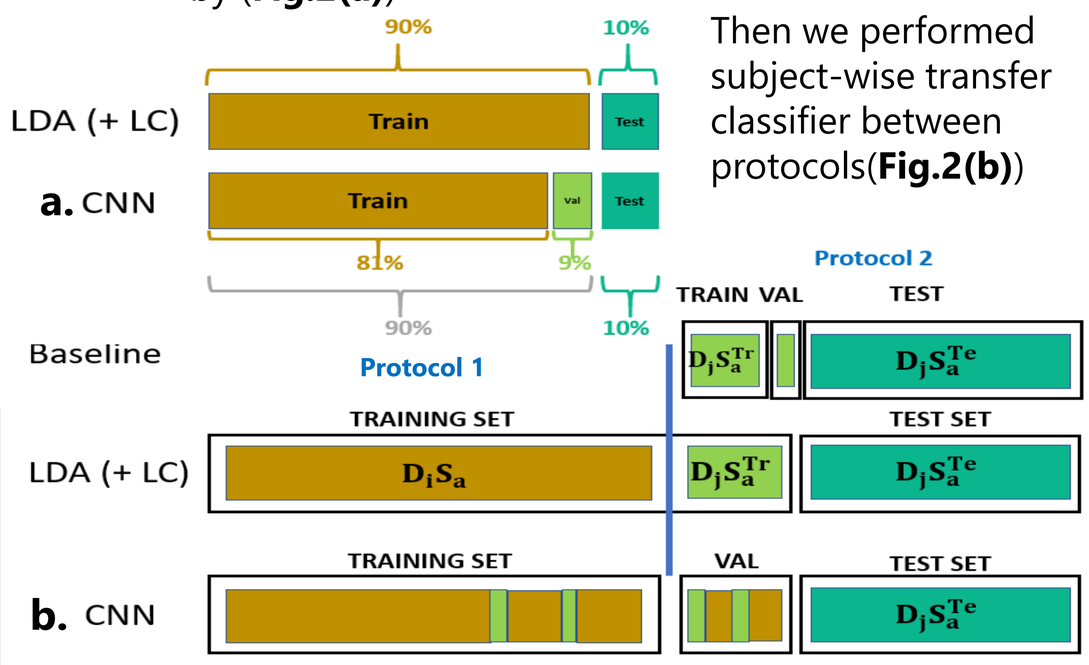




Data Augmentation

We performed model structure and hyperparameters fine tuning on one subject S6 under one experimental protocol E1 (**Fig.2(a)**). The resulting model (**Fig.3**)
In addition, the 10-fold cross validation was performed by (**Fig.2(a)**)

Then we performed subject-wise transfer classifier between protocols(**Fig.2(b)**)



a. Within Protocol
b. Transfer Protocol

Fig.2: Experiment Design[1]

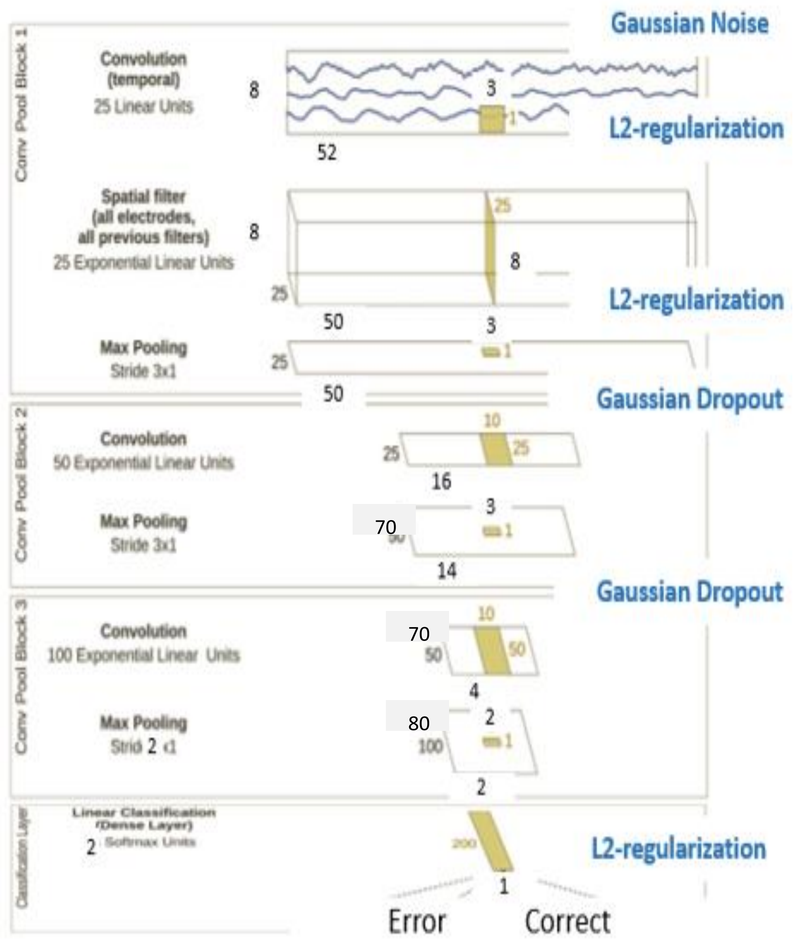


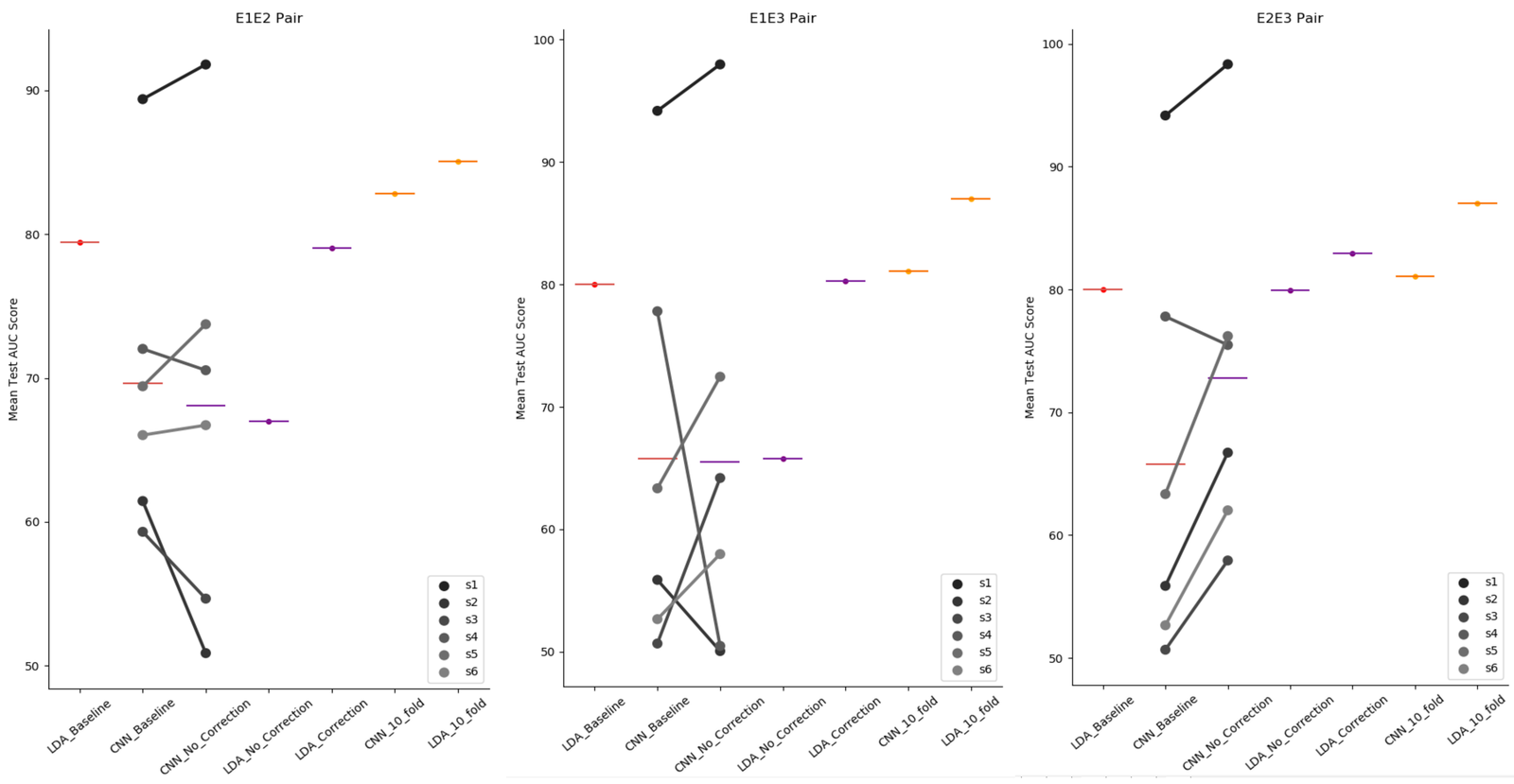
Fig.3: Model Optimized: Three-Layer CNN[3]

Results

Baseline Classifier:
The subject-wise CNN baseline performs worse than LDA, for all three pairs, maybe due to the small sample size.

Pair-Wise Transfer Classifier
The subject-wise average CNN without LC performs worse than LDA without or with correction. The blacklines indicates subject-wise changes in performance, after adding in data from a new protocol.

10-fold Cross Validation
CNN performs worse than LDA on protocols E2 and E3. (82.8% vs 85.0% AUC and 81.0% vs 87.0% AUC)



REFERENCES
[1] Iturrate I., et al., 2014. Latency Correction of Event-Related Potentials Between Different Experimental Protocols.
[2] Leeb R., et al., 2013. Transferring Brain-Computer Interfaces Beyond the Laboratory: Successful Application Control for Motor-Disabled Users.
[3] Schirrmeister R.T., 2017. Deep Learning With Convolutional Neural Networks for EEG Decoding and Visualization