Channel Selection Methods Evaluation for EEG Motor Imagery Classification with Neural Network Architectures for Evidence of a Global Channel Set

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February 1, 2024

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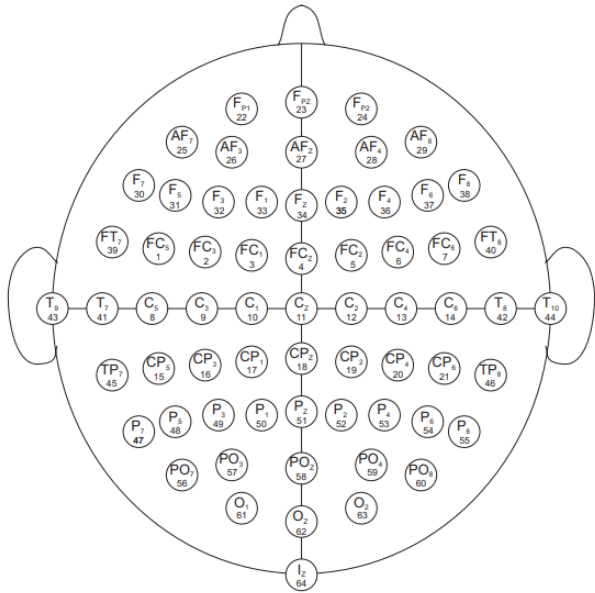Methods

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State of the art

- Filtering techniques
    - Correlation criteria
    - Chi-squared
- Wrapper techniques
    - Sequential feature selection
    - Plus-L-Minus-R

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Contribution

- Evaluate different techniques
  - Method providing higher accuracy.
  - Channel set commonalities between methods.
- Finding a global channel set to avoid the use of channel selection methods and reduce the number of electrode channels used during experimentation.

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Referred Dataset and Pre-processing

'EEG Motor Movement/Imagery Dataset' [1] [2]

- 64-channel EEG, 109 subjects, 1500 recordings
- Chose Task 2 (open/close fist) out of 4

Pre-processing

- Bandpass 8 - 33 Hz order 4 Butterworth filter
- Data segmentation (Rest & Motion Imagery)
- Min-max normalization

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[1] G. Schalk, D. J. McFarland, T. Hinterberger, N. Birbaumer, and J. R. Wolpaw, "BCI2000: A general-purpose brain-computer interface (BCI) system," IEEE Transactions on Biomedical Engineering, vol. 51, no. 6, pp. 1034–1043, 2004.

[2] A. L. Goldberger, L. A. Amaral, L. Glass, J. M. Hausdorff, P. C. Ivanov, R. G. Mark, J. E. Mietus, G. B. Moody, C.-K. Peng, and H. E. Stanley, "Physiobank, PhysioToolkit, and PhysioNet," Circulation, vol. 101, no. 23, 2000.

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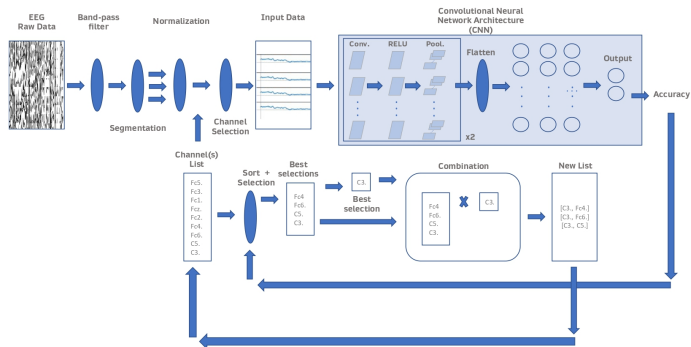Methods
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Sequential Selection

Figure 2: Overview of sequential selection algorithm on CNN classifier.

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Principal Component Analysis (PCA)

Technique for multivariate analysis

- Reduce data size in the form of feature selection
- Extract the most significant components for classification
- Use the significance acquired from said components to select the most significant channel

Method B4 [3] [4]

- p components which represent λ_0 of the variance are selected
- $p = 6$ is selected to equal channel selection in sequential method
- Probabilistic PCA

[3] Jolliffe, I. T. (1972). Discarding Variables in a Principal Component Analysis. I: Artificial Data. Applied Statistics, 21(2), 160. doi:10.2307/2346488

[4] Jolliffe, I. T. (1973). Discarding Variables in a Principal Component Analysis. II: Real Data. Applied Statistics, 22(1), 21. doi:10.2307/2346300

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Sequential Selection Accuracies

Table 1: Channels most commonly selected by the sequential selection algorithm for 1 channel.

MLP				CNN			
Channel	Instances	Percentage	Mean Accuracy	Channel	Instances	Percentage	Mean Accuracy
FC6	33	3.11%	70.37%	FC5	37	3.49%	77.78%
FC4	30	2.83%	79.63%	FCz	34	3.21%	79.37%
FCz	30	2.83%	76.39%	FC1	29	2.74%	83.33%
FC3	28	2.64%	75.00%	FC6	29	2.74%	66.67%
FC5	27	2.55%	73.33%	FC4	28	2.64%	68.25%
FT8	27	2.55%	68.52%	C3	26	2.45%	74.07%
FC1	26	2.45%	75.56%	C5	26	2.45%	71.43%
CP6	26	2.45%	73.61%	FC3	25	2.36%	74.07%
FC2	26	2.45%	69.84%	FC2	24	2.26%	73.02%
C5	25	2.36%	68.52%	C6	24	2.26%	71.11%

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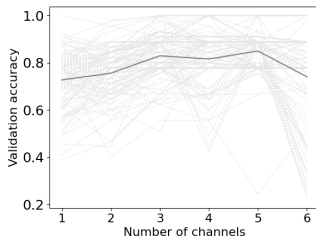Evaluation for
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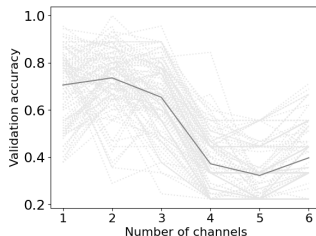Principal Component
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Sequential Selection Learning Curves

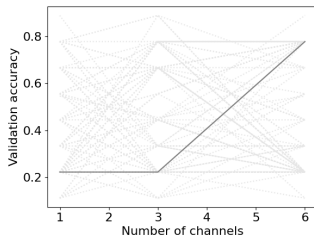(a) MLP Classifier   (b) CNN Classifier

Figure 3: Learning curves of the classifiers through number of channels per subject. Line in bold reflects the mean of each number of channels. Individual results are the ones in grey.
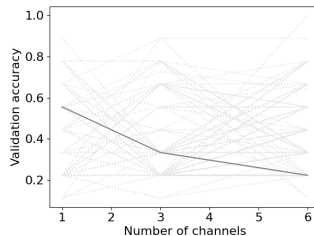
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PCA Accuracies

Table 2: Channels most commonly selected by the PCA algorithm for 1 channel.

MLP				CNN			
Channel	Instances	Percentage	Mean Accuracy	Channel	Instances	Percentage	Mean Accuracy
T9	28	2.64%	33.33%	T9	28	2.64%	22.22%
C6	11	1.04%	33.33%	C6	11	1.04%	77.78%
AF8	6	0.57%	55.56%	T8	6	0.57%	77.78%
T8	6	0.57%	55.56%	T10	6	0.57%	55.56%
T10	6	0.57%	22.22%	AF8	6	0.57%	22.22%
TP7	5	0.47%	66.67%	TP7	5	0.47%	44.44%
TP8	4	0.38%	44.44%	AF7	4	0.38%	66.67%
P7	4	0.38%	11.11%	F7	4	0.38%	44.44%
F7	4	0.38%	11.11%	TP8	4	0.38%	33.33%
AF7	4	0.38%	11.11%	P7	4	0.38%	22.22%

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PCA Learning Curves

(a) MLP Classifier

(b) CNN Classifier

Figure 4: Learning curve of the classifiers through number of channels per subject. Line in bold reflects the mean of each number of channels.
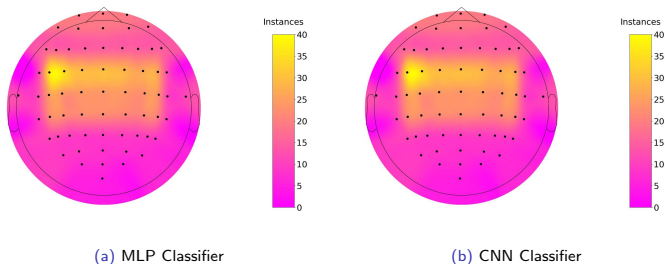
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Sequential Selection Spatial Distribution

(a) MLP Classifier   (b) CNN Classifier

Figure 5: Spatial maps of the number of instances in which channels appear as most significant in the dataset according to the sequential selection algorithm.

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Conclusions

- Sequential Selection yielded higher accuracies than PCA, although they tended downwards as channels increased
- PCA technique selected in a higher rate channels in temporal zone, while Sequential Selection technique in frontal-central channels
- It is not possible to state that a global, optimal channel set for MI classification exists

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Thank you!

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