Comparative evaluation of Independent Components Analysis algorithms for isolating target-relevant information in brain-signal classification

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Introduction

Like many other researchers, we have previously found that blind source separation using Independent Components Analysis (ICA) can significantly improve classification performance in single-trial brain-signal classification. The following figure illustrates the data presented by Hill et al. (2005) [Advances in Neural Information Processing Systems 17, 369–376], in which auditory ERPs were classified in a binary (left-vs-right) attention-based BCI.

EEG Input

- Data from Lal et al. (2004): Binary motor imagery paradigm (left vs. right hand): 400 trials x 39 ERS channels x 5 seconds.
- Analog band-pass filter 0.1–40 Hz, digitize at 256 Hz.
- Digitally low-pass filter and downsample to 100 Hz.

Analysis

- Recursive Independent Component Elimination (RICE) is retained, but here we illustrate the improvements in classification error rate and feature elimination that can be achieved by combining this with ICA.
- The following spectrograms give a feel for what ICA can do in a motor-imagery paradigm. Note that the higher-frequency band (around 20 Hz) is now visible.

Example results: elimination error traces

- For most subjects and all ICA variants, ICA improves performance considerably (up to 97% correct).
- Our claim in the submitted abstract, that InfoMax is significantly better than the others in this respect, is erroneous and was based on a preliminary subset of the data. Over all performance measures, however, InfoMax compares very favourably with the others.

Example results: consistency of ICA separation

- For some subjects and all ICA variants, ICA improves performance considerably (up to 97% correct).
- Our claim in the submitted abstract, that InfoMax is significantly better than the others in this respect, is erroneous and was based on a preliminary subset of the data. Over all performance measures, however, InfoMax compares very favourably with the others.

Output

- The figures show the 2 top-ranked ICs from each fold (hence, two rows in each).

7 Overview of results

The charts to the right compare the performance of different ICA algorithms. Which ICs, for example, are selected is very variable.

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