Classification of Adaptive Autoregressive Models at Different Sampling Rates in a Motor Imagery-Based BCI

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Introduction

Autoregressive (AR) models have been employed for feature extraction in brain–computer interfaces (BCIs) using either AR coefficients directly [1] or the estimated spectrum [2]. From the perspective of spectral analysis, a model of order \( p \) can resolve \( p/2 \) frequency peaks. With sampling rate \( f_s \), the frequency resolution of an AR spectrum depends on the time window of length \( p/f_s \) spanned by the AR model [2]. To increase the length of the time window, the model order can be increased, which may lead to overfitting caused by increased model complexity. Alternatively, reduction of \( f_s \) does not increase model complexity, but limits bandwidth.

This work attempts to provide an answer to the question: Can we improve AR–based classification of motor imagery by reducing the sample rate?

Methods

Data

- 9 trained subjects
- Motor imagery with feedback
- 2 classes: left vs. right hand
- 80 randomized trials per class

Recording:

- 3 bipolar EEG channels (C3, Cz, C4)
- 250 Hz sampling rate

Signal Processing:

- Resampling to 5–245 Hz in 5 Hz steps
- A: Adaptive AR Model
  - Model order \( p = 6 \)
  - Update coefficient \( UC = 10^{-5} \)
- B: Bandpower
  - 10–12 Hz
  - 16–24 Hz

Classification:

- Linear Discriminant Analysis (LDA)
- Running Classifier procedure finds optimal training time
- 10×10 cross-validation

Figure 1: Block diagram of the offline system. For classification either AR or Bandpower features were utilized.

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Figure 2: Individual results. The effect of sampling rate on classification accuracy varies considerably between subjects.

- Subjects 2 and 3 did not perform above chance level.
- Bandpower does not depend on sampling rate
- Prominent rise in accuracy for subject 6 below 125 Hz

Figure 3: Mean classification accuracy of all subjects. The dashed line shows the 95% confidence limit of classification accuracy compared to 250 Hz sampling rate.

- t–statistics for improvement of classification accuracy
- significant improvement at 75 and 80 Hz

Discussion

The significant improvement in classification accuracy for 2 out of 50 sampling rates is meaningless, considering that 5% of all results are expected to be significant by chance.

In general, it cannot be stated that classification of AR features can be improved by reducing sample rate, but when tuning a system for an individual subject this is an option to consider.

References


Acknowledgements

This work is supported by the FWF Project “Coupling Measures in BCIs” (P20848-N15).


http://www.bbci.de/competition/iv/