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 fs, 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

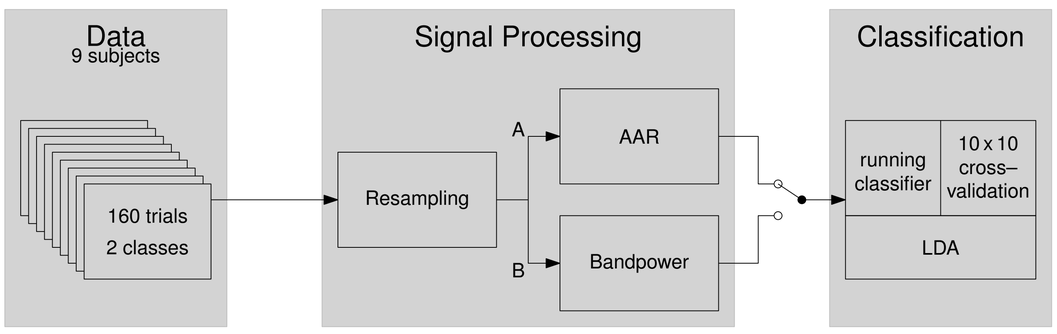

Figure 1: Block diagram of the offline system. For classification either AR or Bandpower features were utilized.

Data: BCI Competition IV, data set 2b [3].

- 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

Results

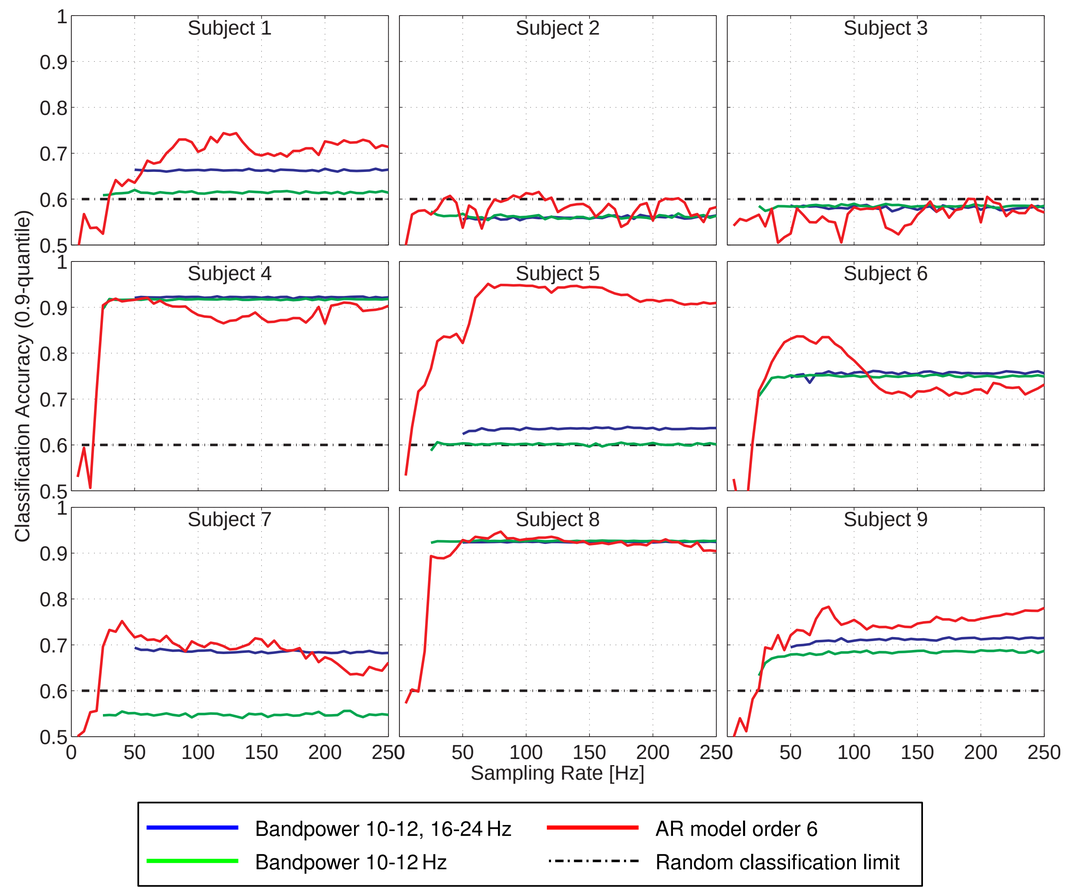

Figure 2: Individual results. The effect of sampling rate on classification accuracy varies considerably between subjects.

- 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

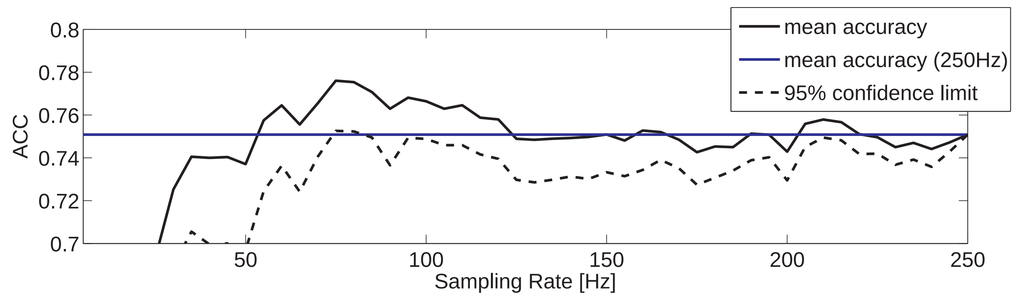

Figure 3: Mean classification accuracy of all subjects. The dashed line shows the 95 % confidence limit of classification accuracy compared to 250 Hz sampling rate.

- 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

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3. R. Leeb, C. Brunner, G. R. Müller-Putz, A. Schlögl and G. Pfurtscheller, BCI Competition IV - Graz data set 2b, *http://www.bbci.de/competition/iv/*.

Acknowledgements

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