Automatic Frequency Band Selection for BCIs with ERDS Difference Maps

Martin Billinger[1], Vera Kaiser[1], Christa Neuper[1,2] and Clemens Brunner[1]

[1]*Institute for Knowledge Discovery, BCI Lab, Graz University of Technology, Austria*
[2]*Department of Psychology, University of Graz, Austria*

Introduction

- Band power discriminates motor imagery (MI) tasks [1]
- ERDS maps visualize task related changes in band power [2]
- **New algorithm**: band selection based on image segmentation [3]
- Mimics an expert inspecting ERDS maps
- Performance compared to manual band selection by an expert

Methods

ERDS Difference Maps:

- Difference between two ERDS maps (Figure 2)
- Find significant areas (Figure 1)
- Results in ERDS Difference map (Figure 2-D)
- Not limited to ERDS: any measure in the t/f–plane (Figures 4, 5)

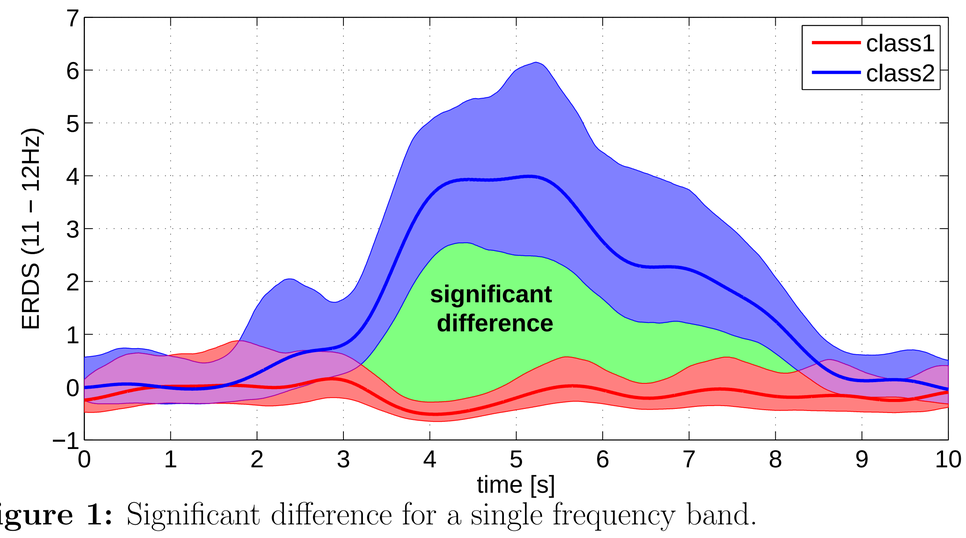

Figure 1: Significant difference for a single frequency band.

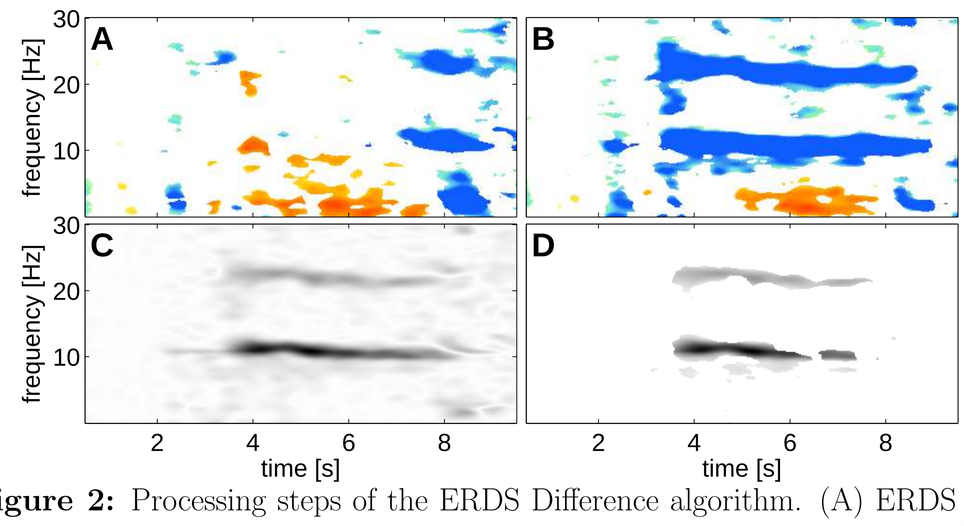

Figure 2: Processing steps of the ERDS Difference algorithm. (A) ERDS map for class 1. (B) ERDS map for class 2. (C) Difference of A and B. (D) Significant differences.

Automatic Frequency Band Selection:

1. Small significant spots removed by area-opening [3] (Figure 3-B)
2. Define one frequency band for each remaining area (Figure 3-C)
3. Merge overlapping frequency bands (Figure 3-D)

Comparing Automatic and Manual Band Selection:

- Left vs. right hand MI data from 18 participants [4]
- Three channels (C3, Cz, C4), avg. number of trials: 167±44 SD
- Manual and automatic band selection performed using ERDS maps
- Classification Accuracy on unseen data compared by paired t-test

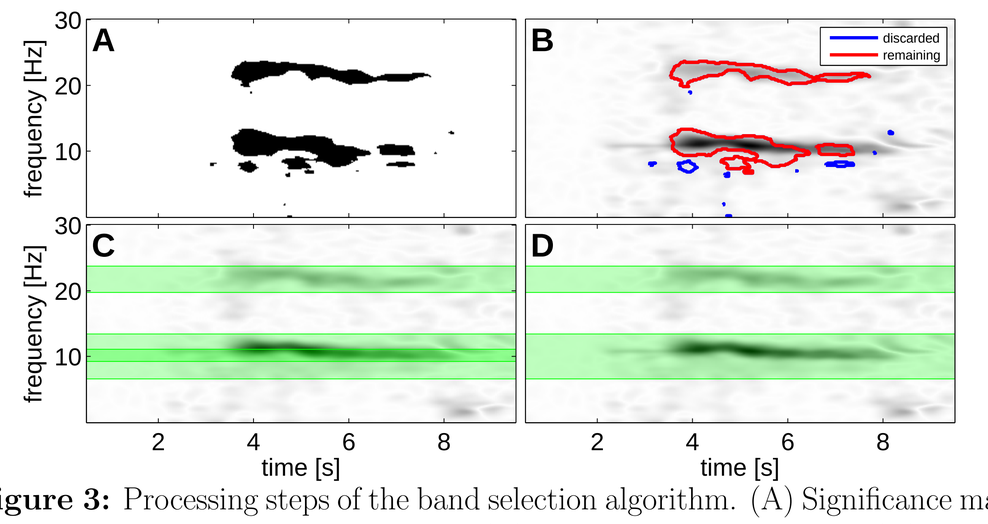

Figure 3: Processing steps of the band selection algorithm. (A) Significance map. (B) Rejection of small significant areas. (C) Selected frequency bands. (D) Merged overlapping frequency bands.

Results

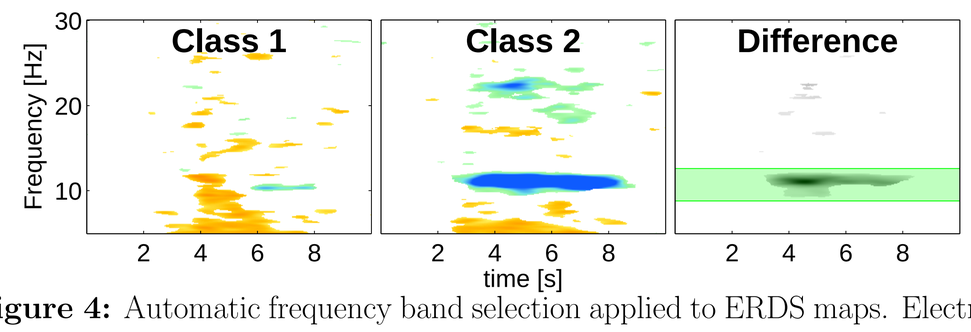

Figure 4: Automatic frequency band selection applied to ERDS maps. Electrode position C4, left and right hand MI.

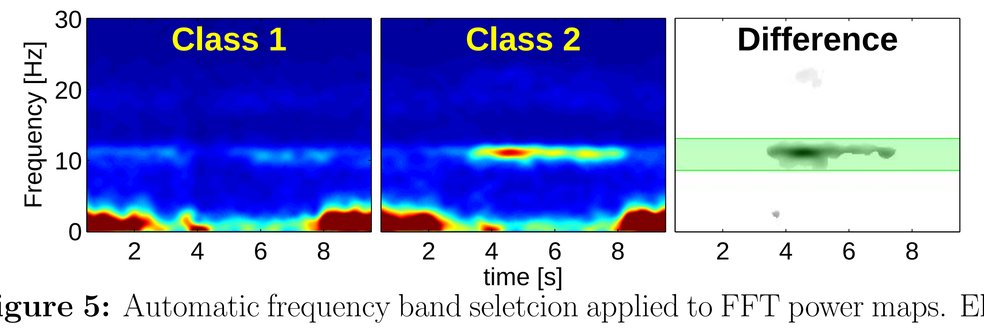

Figure 5: Automatic frequency band seletcion applied to FFT power maps. Electrode position C4, left and right hand MI.

Comparing Automatic and Manual Band Selection:

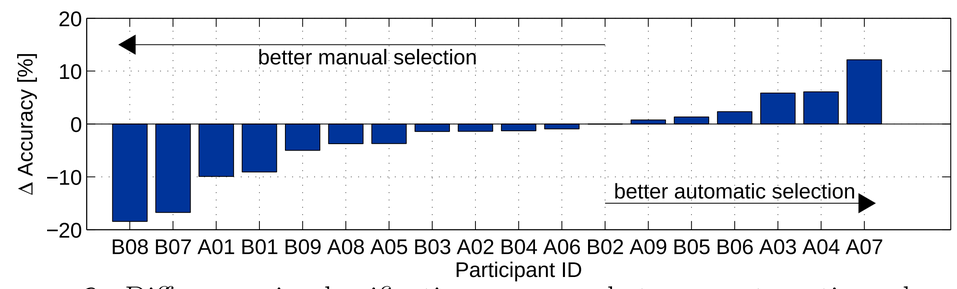

Figure 6: Differences in classification accuracy between automatic and manual band selection for each subject.

- Automatic accuracy: 68.13 % ± 13.49 % SD
- Manual accuracy: 70.53 % ± 14.51 % SD
- Paired difference: 2.40 % ± 7.61 % SD (t-test: $p = 0.198$)

Conclusion

- Manual band selection slightly better than automatic selection
- However, **not significantly** so
- Difference too small to be evident in the data
- Small loss in classification accuracy may be acceptable

References

[1] G. Pfurtscheller and C. Neuper. Motor imagery and direct brain-computer communication. *Proceedings of the IEEE*, 89:1123–1134, 2001.

[2] B. Graimann, J. E. Huggins, S. P. Levine, and G. Pfurtscheller. Visualization of significant ERD/ERS patterns in multichannel EEG and ECoG datas. *Clinical Neurophysiology*, 113:43–47, 2002.

[3] S. T. Acton and N. Ray. Biomedical image analysis: Segmentation. *Synthesis Lectures on Image, Video, and Multimedia Processing*, 4(1):1–108, 2009.

[4] BCI Competition 2008 - Graz data sets 2A and 2B. *http://www.bbci.de/competition/iv/*.

Acknowledgements

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