Classification of single trial EEG: A comparison of different parameters

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I Introduction

Single Trial Analysis (STA)

•No averaging

•On-line Analysis

AIM:

Find the *best parameters* and *calculation method* for STA

II. Material and Method:

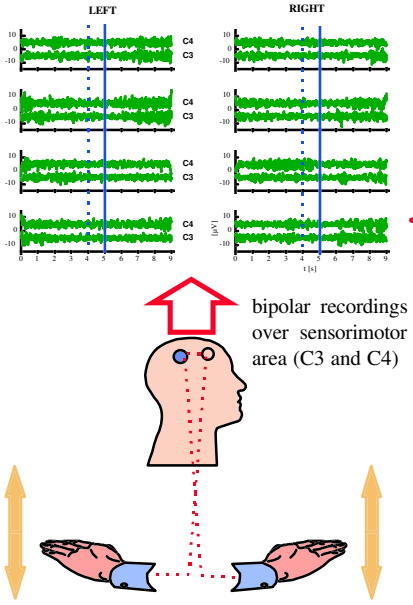
A. Data

The EEG of the sensorimotor area (C3 and C4) were investigated from 3 subjects (Table 1), performing self-paced finger movement. Every subject had a pronounced µ-rythm. The EEG was sampled with 128 Hz.

Subject	LEFT	RIGHT	TOTAL
E08	41	50	91
E10	57	42	99
E15	53	35	88

Table1: Number of Trials after visual artifact rejection

bipolar recordings over sensorimotor area (C3 and C4)



bipolar recordings over sensorimotor area (C3 and C4)

Subject performed finger movement at second 5 (triggered with EMG)

B. Signal processing and feature extraction

The methods applied to the EEG are listed in Table 2. Most of them, except the Adaptive Autoregressive(AAR) models, used the segment of the 1 s prior to movement onset.

Method	#F	ipp	error [%]
Barlow[2] (5-15Hz)	6	☐	17.35
Barlow (5-25Hz)	6	☐	19.89
Barlow (-)	6	☐	21.51
Hjorth[3] (5-15Hz)	6	☐	16.25
Hjorth (5-25Hz)	6	☐	20.26
Hjorth (-)	6	☐	19.93
Hilbert[5] (5-15Hz)	4	☐	20.95
Hilbert (5-25Hz)	4	☐	22.72
Hilbert (-)	4	☐	26.27
BandPower a (10-13 Hz)	2	☐	22.34
BandPower b (20-26 Hz)	2	☐	35.77
BandPower a+b	4	☐	21.85
Complex Dem.[6] a (11.5 ± 1.5	4	☐	21.52
Complex Dem. b (23 ± 3 Hz)	4	☐	35.20
Complex Demod. (a+b)	8	☐	21.74
AR6 (YuleWalker)[4],[6]	12	☐	18.23
AR6 (YuleWalker)+var{E(t)}	14	☐	17.40
AR6 (Burg)[4]	12	☐	16.97
AR6 (Burg)+var{E(t)}	14	☐	16.53
Optim. Band[1]	2	☒	18.82
AAR6 (LMS)[7],[8]	12	☐	13.96
AAR6 (LMS)+var{E(t)}	14	☐	12.77
AAR6 (RLS)[8]	12	☐	9.38
AAR6 (RLS)+var{E(t)}	14	☐	8.70
Average			19.85

Table 2: The different feature extraction methods are listed. Column #F depicts the number of features for classification; ipp shows if individual preprocessing is neccessary; error represents the average classification error across 3 subjects

Feature Extraction

III Results

For the classification Linear Discriminant Analysis (LDA) was used for every subject. To ensure that the classification results also hold for unknown data, a 10x 10-fold Cross-Validation was applied. The average error rates are presented in Tables 2 and 3.

Method	E08	E10	E15	error [%]
Barlow[2] (5-15Hz)	12.5	12.0	27.5	17.4
Hjorth[3] (5-15Hz)	12.7	13.2	22.9	16.3
Hilbert[5] (5-15Hz)	13.3	14.1	35.4	20.9
BandPower a (10-13 Hz)	26.1	13.7	27.2	22.3
Complex Dem.[6] a	24.3	12.2	28.0	21.5
AR6 (YuleWalker)[4],[6]	16.3	18.4	20.0	18.2
AR6 (Burg)[4]	14.6	13.0	23.3	17.0
AAR6 (LMS)[7],[8]	12.8	13.8	15.3	14.0
AAR6 (RLS)[8]	5.2	13.6	9.4	9.4
Average	**19.8**	**14.0**	**25.7**	**19.8**

Table 3: Average Error rate of various methods across 3 subjects

IV. Conclusion

•In Table 2 one can see that filtered-Barlow, filtered-Hjorth and the AR parameters give good results

•Comparing the AR methods, the Adaptive method gives the best results.

•Moreover, the segment length must be optimized. This problem corresponds to the selection of the adaptation ratio at adaptive methods.

References

[1] Pregenzer M., Pfurtscheller G. (1995). Proc. Int. Conf. on Art. Neural Networks, IEEANN'95, 433-436.

[2] Goncharova, I.I. and Barlow, J.S. (1990), Electroenceph. clin. Neurophysiol., 76: 197-204.

[3] Hjorth, B. (1970. Electroenceph. clin. Neurophysiol., 29: 306-310.

[4] Kay, S.M. (1988) Modern spectral estimation: theory and application. Prentice Hall, New York.

[5] Medl, A. et al. (1992). Proceedings of the 14th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. Paris, France, Oct. 29 - Nov. 1, 1992, 2539-2540.

[6] Priestley, M.B. (1981) Spectral Analysis and Time Series. Academic Press, London.

[7] Schack, B., Witte, H. and Grießbach, G. (1993). Biomedizinische Technik, 38: 79-80.

[8] Schlögl, A. (1995). Timevarying Autoregressive Models with Application to the EEG. MSc-Thesis, University of Technology, Graz.