Artifacts in the sleep EEG - A database for the evaluation of automated processing methods.

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Introduction

Automated artifact processing methods are one part of an fully automated sleep analysis system[1]. In this work is investigated how frequently artifacts occur and which artifact processing methods can be used automatically.

Methods

Fifteen all-night sleep recordings from 8 European sleep laboratories, ca. ninety minutes each, were scored for artifacts. Nine types of artifacts (Table 1) were differentiated. Seven EEG channels based on a time resolution of one second were analyzed. The raw data and the scoring data was stored in EDF-format[2].

Seven artifacts minimization methods
- (M1) ECG with adaptive FIR filtering[3],
- (M2) EOG and ECG with regression method,
- (M3) EOG with PCA[4],
- (M4) EOG with ICA[5],
- (M5) Muscle artefacts with median filter,
- (M6) 50Hz notch filter,
- (M7) Sweat with phase space embedding

and 3 artifact detection methods
- (M8) adaptive inverse filtering (AIF)[6],
- (M9) bandpass fitering with a LDA classifier (BP+LDA),
- (M10) overflow detection (OFD)[7],

were applied to the data.

The minimization methods were validated visually, the detection methods were analysed by the area-under-ROC-curve (AUC) method[8].

Results

Table 1 summarizes the content of the artifact database. Most frequently occurred ECG artifact, followed by EOG and muscle activity.

Code	Artifact type	epochs [1s]	%
	artifact free	345 254	61.3
A1	EOG	51 427	9.1
A2	ECG	123 886	22.0
A3	muscle	43 861	7.8
A4	movement	20 209	3.6
A5	failing elect.	10 804	1.9
A6	sweat	4 135	0.7
A7	50/60 Hz	11 608	2.1
A8	breathing	2	0.0
A9	pulse	-	0.0
	SUM	611 186	108.5

Table 1: Artifacts in sleep EEG. In total 563.192 1s-epochs were scored, the difference to 611.186 (8,5%) is due to scoring of multiple artifacts in some epochs.

The minimization methods
AFIR (M1) for ECG artifacts (A1) using and
Notch filtering (M6) for 50Hz main interference (A7)
provided some improvements of the data.

The best results of the detection methods (M8-10) were
AIF (M8) for muscle (A3) AUC = 0.857
AIF (M8) for movement (A4) AUC = 0.898
OFD (M10) for failing electrode (A5) AUC = 0.662

The PCA (M3) and BP+LDA (M9) could not be automated.

Conclusion

→ In 38.7% of the recording time at least one artifact was identified.
→ Artifact processing methods can be validated on the existing database.

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