DEVELOPMENT AND VALIDATION OF AN AUTOMATIC REFERENCE POLYSOMNOGRAPHIC SYSTEM FOR QUANTIFYING DROWSINESS

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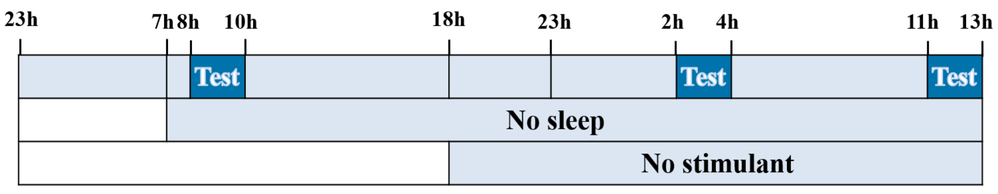
Objective

Drowsiness is a major cause of various types of accidents [1]. Therefore, preventing such accidents is a critical issue of safety and public health. Since polysomnography (PSG) is considered as the "gold standard" for sleep [2], we have developed and validated a new, automatic PSG-based system for quantifying drowsiness. This system is primarily intended to be used as a reference for the validation of non-PSG-based drowsiness monitoring systems. The objective of this study is to show that the level of drowsiness produced automatically by our system is in excellent accord with that produced visually/manually by experts.

Data acquisition

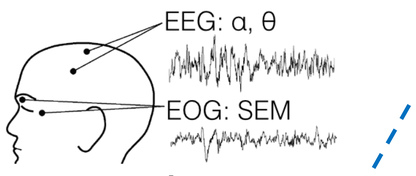


- **24 participants (11 M, 13 F, mean age of 22.7 years, range of 19-32 years)**
- **Test = Psychomotor Vigilance Test (duration of 10 minutes)**
- **Protocol approved by Ethics Committee of university.**

Methods

Each 20 second epoch was processed in two distinct ways:

AUTOMATICALLY



Automatic processing

Drowsiness quantification using KDS* [4]

Automatic level of drowsiness

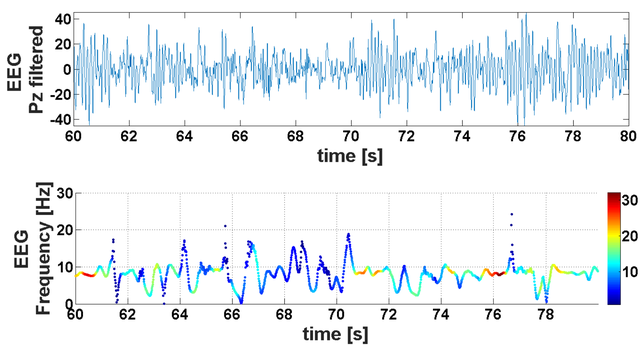
Filtering [1-25] Hz

Hilbert Vibration Decomposition [3]

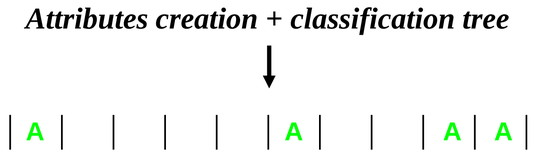
Classification tree

α, θ, and SEM automatic extraction*

EEG example

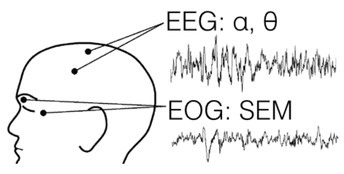


Attributes creation + classification tree



*KDS = Karolinska Drowsiness Score
*SEM = Slow Eye Movement

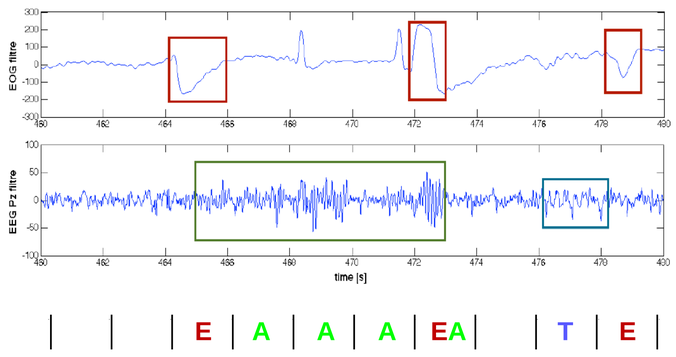
VISUALLY



Visual observation

Drowsiness quantification using KDS*

Visual level of drowsiness



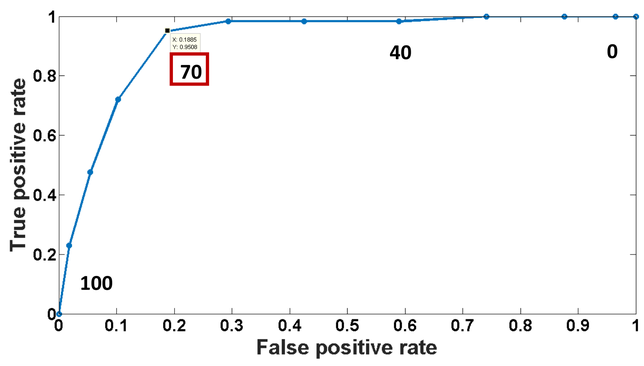
Results

1) Comparison between automatic and visual/manual extractions of features

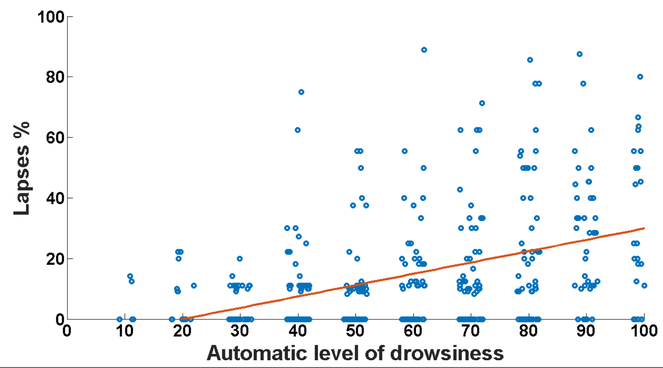
HVD* Method	Sensitivity	Specificity
α detection	0.92	0.93
θ detection	0.71	0.76
SEM detection	0.88	0.83
Level of drowsiness ($\lambda_{auto} = 70, \lambda_{visual} = 50$)	0.95	0.81

*HVD = Hilbert Vibration Decomposition

2) ROC curve in comparison to the visual processing for different values of λ_{auto}



3) Correlation between automatic level of drowsiness and percentage of lapses (R=0.43)



Conclusions

This study shows that our automatic PSG-based system has the potential
(1) to become a promising reference for drowsiness quantification, and
(2) to help scoring experts save time.
Moreover, this system could also be used as a diagnostic tool for people with excessive daytime sleepiness (EDS) which may be due to sleep disorders.

References

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[4] M. Feldman, "Hilbert transform in vibration analysis," *Mechanical Systems and Signal Processing,* , 2011, vol. 25(3), pp. 735-802.

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