Detecting Sleep Disorders from EEG Data

An Annotated Bibliography

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References

[1] Biswal, Siddharth, Joshua Kulas, Haoqi Sun, Balaji Goparaju, M. Brandon Westover, Matt T. Bianchi, and Jimeng Sun, "Automated sleep sating system via deep learning," *arXiv preprint arXiv:1707.08262 (2017).*

Aim:Proposing use of SLEEPNET a deployed annotation tool for sleeping staging to alleviate limitation brought by manual sleep-wake scoring.

Style/Type:Journal Article.

Cross Reference:[O.Faust et al 2019]This review pointed out the limitation of manual sleep scoring which is heavily associated with lack of standardized output from different personal monitoring sleeping patients.This review later proposed use of deep learning and internet of thing as base technology as the tools to be used to monitor sleep scoring.

Summary:This paper they propose a specialized clinical decision support tool SLEEPNET for automated sleep-wake staging. SLEEPNET applies deep neural network modeling on EEG signal features derived from routine clinical PSG data. The deployed algorithm presents the algorithms inferences along with the raw EEG data and automatically calculates sleep quality statistics in an interactive web interface for clinicians and researchers. They experimented with many different variations of the algorithm and input features. The best performing instance of SLEEPNET uses expert-defined features to represents each

30-sec interval and learns to annotate EEG using recurrent neural network (RNN).To measure performance of SLEEPNET they compared automated staging results with de facto gold standard defined by sleep technologists manual annotations. Inter-rater agreement (IRA) for sleep stating (in terms of Cohen's Kappa) between human experts is approximately 65-75 percent (Danker-hopfe et al 2009).In this study SLLEPNET achieves an expect-algorithm Kappa value of 79 percent ,with an overall accuracy of 86 percent ,comparable to human human-level scoring performance.

[2] [L Fiorillo et al 2019] Fiorillo Luigi, Alessandro Puiatti , Michela Papandrea , Pietro Luca Ratti , Paolo Favaro , Corinne Roth , Panagiotis Bargiotas , Claudio Bassetti , Francesca D.Faraci, "Automated sleep scoring: A review of the latest approaches," *Sleep medicine reviews (2019).*

Aim: To understand if the adoption of automatic scoring in clinical practice can be finally facilitated.

Style/Type: Journal Article

Cross reference :[T Penzel and R.Contradt [2000]] The current concepts and results of computerized polysomography and automatic sleep scoring systems are presented and discussed.This review is based on number of fundamental papers and sleep scoring and number of related reviews.

Summary:In this article the latest approaches that are applying deep learning for facilitating and accelerating sleep scoring are thoroughly analyzed and compared with the stated of art methods. The disadvantages of clinical practice are examined. First visual scoring procedure and its complexity is represented. Short presentation of general artificial intelligence algorithm application in sleep scoring ,existing deep learning techniques are thoroughly examined. Alternative methodologies like EOG single channel systems and semi-automated procedures are presented. There after the commercially available software are also summarized. The general barriers to the introduction of automatic scoring in clinical practice are presented to try and understand if deep learning methodologies can overcome some of these disadvantages. In this paper deep learning methodologies present many advantages.

[3] [O.Faust, H.Razaghi and R.Barika et al 2019] Oliver Faust,Hajar Razaghi,Ragab Barika,Edward J Ciaccio,U Rajendra Acharya, "A review of automated sleep stage scoring based on physiological signals for the new millennia," *Computer methods and programs in biomedicine (2019).*

Aim:To provide a comprehensive review of automated sleep stage scoring systems which were created since the year 2000.The systems were developed for Electrocardiogram (ECG),Electroencephalogram (EEG),Electrooculogum (EOG), and a combination of signals.

Cross Reference:[L Fiorillo et al] In this review the latest approaches that are applying deep learning for facilitating and accelerating sleep scoring are throughly analyzed and compared with state of art methods ,in this paper deep learning methodologies present many advantages.

Summary:This article provides a comprehensive review of automated sleep stage scoring systems,which were created since the year 2000.The systems were developed for Electrocardiogram (ECG), Electroencephalogram (EEG), Electrooculogram (EOG), and a combination of signals. In this review, they established that there is a wide range of physiological signals which contain sleep stage related information. This information can be used to support diagnosis, treatment monitoring and drug efficacy tests.But before harvesting these benefits, it is necessary to measure the signals and extract the information. They are many signal extraction methods and indeed it is unclear which signal provide sufficient information for diagnosis.To address this uncertainty, they reviewed information extraction mechanisms for different physiological signals, to provide an indication of the information that is actually contained in the data.Computer machinery can assist to reduce inter- and intra-observer variability as well as costs.Computer based systems can increase the quality of the extracted information including the utilization of decision support systems to assist in signal interpretation.The feature extraction step must be carefully considered,because it reduces the information available for decision making,and its design process can be error prone.They recognize that automatic sleep stage classification is a starting point for sleep stage scoring.To improve outcome, they proposed a general sleep stage scoring systems design based on deep learning and Internet of Health Things (IoHT) technology.

[4] Ozal Yildirim,Ulas Baran Baloglu and U Rajendra Acharya, "A deep learning model for automated sleep stages classification using psg signals," *Int.J.Environ.Res Public Health 2019,16,599.*

Aim:In this study a new deep learning model based on a one-dimensional convolutional neural network(ID-CNN) is proposed for automated sleep stage classification.

Style/Type:Journal Article

Cross Reference:[O.Faust, H.Razaghi and R.Barika et al 2019]In this review they provided a comprehensive review of automated sleep stage scoring system which were created since the year 2000.The systems were developed for Electrocardiogram (ECG),Electroencephalogram (EEG),Electrooculogum (EOG), and a combination of signals.

Summary:In this study,a flexible deep learning model is proposed using raw PSG signals. A one-dimensional convolutional neural network (1D-CNN) is developed using electroencephalogram (EEG) and electrooculogram (EOG) signals for the classification of sleep stages. The performance of the system is evaluated using two public databases (sleep-edf and sleep-edfx). The developed model yielded the highest accuracies of 98.06 percent, 94.64 percent, 92.36 percent, 91.22 percent, and 91.00 percent for two to six sleep classes, respectively, using the sleep-edf database. Further, the proposed model obtained the highest accuracies of 97.62 percent, 94.34 percent, 92.33 percent, 90.98 percent, and 89.54 percent, respectively for the same two to six sleep classes using the sleep-edfx dataset. The developed deep learning model is ready for clinical usage, and can be tested with big PSG data.

[5] Siddharth Biswal,Haoqi,Balaji Goparaju,M Brandon Westover,Jimeng Sun,and Matt T Bianchi, "Expert-level sleep scoring with deep neural networks," *doi:1001093/jamia/ocy131.*

Aim:Outlining the development of a Recurrent Convolutional Neural Network that matches the performance of sleep experts in annotating overnight PSGs.

Style/Type:Journal Article

Cross Reference: [Biswal, Siddharth, Joshua Kulas, Haoqi Sun, Balaji Goparaju, M. Bran-don Westover, Matt T. Bianchi, and Jimeng Sun, "Automated sleep satingsystem via deep learning,"arXiv preprint arXiv:1707.08262 (2017)] In this review they proposed use of SLEEPNET a deployed annotation tool for sleeping staging to alleviate limitation brought by manual sleep scoring. To measure performance of SLEEPNET they compared automated staging results with de facto gold standard defined by sleep technologists manual annotations.The SLEEPNET annotation tool scored amazing results with less intra-variance.

Summary:In this review they used a combination of deep recurrent and convolutional neural networks (RCNN) for supervised learning of clinical labels designating sleep stages, sleep apnea events, and limb movements. The data for testing and training were derived from 10 000 clinical PSGs and 5804 research PSGs. When trained on the clinical dataset, the RCNN reproduces PSG diagnostic scoring for sleep staging, sleep apnea, and limb movements with accuracies of 87.6 percent, 88.2 percent and 84.7 percent on held-out test data, a level of performance comparable to human experts. The RCNN model performs equally well when tested on the independent research PSG database. Only small reductions in accuracy were noted when training on limited channels to mimic at-home monitoring devices: frontal leads only for sleep staging, and thoracic belt signals only for the apnea-hypopnea index.

[6] Sun, Haoqi, Jian Jia, Balaji Goparaju, Guang-Bin Huang, Olga Sourina, Matt Travis Bianchi, and M. Brandon Westover., "Large-scale automated sleep staging," *Sleep 40, no. 10 (2017): zsx139.*

Aim: The objectives are to investigate the extent to which machine learning methods can approximate the performance of human scores when supplied with sufficient training cases and to investigate how staging performance depends on number of training patients,contextual information,model complexity and imbalance between sleep stage proportions

Style/Type:Journal Article

Cross references:[Siddharth Biswal et al] In this review the proposed tool SLEEPNET they overcome the major challenge in automation that is the vast heterogeneity observed in EEG time series data obtained during PSG by training a single powerful algorithm on a large data set of PSGs that captures the heterogeneity across patients while still maintaining performance accuracy.

Summary:In this review they presented automated EEG-based sleep staging system developed on a clinical data set of 2000 patients,split into 1000 patients for training and the other 1000 patients for testing (validation).They investigated how the following factors affect the performance of automated sleep staging:number of training patients,contextual information between epochs ,model complexity and imbalance between stage proportions. They also study the variance in testing performance as a function of the number of patients in the testing set.