

Using Signal Quality Assessment (SQA) to help sleep stage classification

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Among all of the measured signals in polysomnography, ECG signal acquisition is one of the easier to measure. We hypothesize that during deep sleep the signal quality (SQ) will be different from the other stages such as awake, Rapid Eye Movement (REM), and light sleep. The Sleep Heart Health Study visit 1 (SHHS1) dataset was used (6,441 subjectst) in this study. In this database, around 4000 subjects had at least more than 5 consecutive minutes for each stage (awake, light, deep sleep, and REM). As SQ assessment (SQA) features, we used the kurtosis, the skewness, the Shannon entropy, and the standard deviation of the signal after high-pass filtering using a cut-off frequency of 40 Hz. For each of the stages with a duration of more than 5 minutes, the features were estimated in epochs of 30 s using a sliding window with increments of 1 s from the start of the stage to its end. The prediction power of each feature was assessed using the Area under the ROC Curve (AUC). According to the results for the first 1140 subjects, SQA indices have a median AUC that ranged from 71% to 87% (when comparing awake against light sleep), 76% to 82% (awake against deep sleep), 74% to 82% (awake against REM sleep), 63% to 66% (light sleep against REM sleep), 66% to 72% (light sleep against deep sleep) and 69% to 72% (deep sleep against REM sleep). In addition, the observations showed that kurtosis provided on average, higher AUC than the other features. The table below shows the median and interquartile range of the features by pooling all the subjects and computed for each sleep stage. In a conclusion, SQA features may help to improve the classification of sleep stages in automatic classification systems.

The result of median \pm interquartile range SQA indices.

Feature	Awake	Light sleep	Deep sleep	REM sleep
Kurtosis	10.93 \pm 4.35	11.71 \pm 0.53	11.60 \pm 0.75	11.40 \pm 0.51
Skewness	-0.38 \pm 0.35	-0.26 \pm 0.15	-0.24 \pm 0.21	-0.25 \pm 0.38
Shannon Entropy	3.78 \pm 0.58	3.76 \pm 0.16	3.72 \pm 0.25	3.82 \pm 0.07
Standard deviation of the HP filtered ECG(μ V)	3.2 \pm 9.0	1.9 \pm 0.1	1.9 \pm 0.11	1.8 \pm 0.07