TinySleepNet: Learning from Biosignal

Tags

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Problem Statement

- Labor-intensive and time-consuming
- Too many signals to collect at home à not portable and troublesome device setup

Biosignal analysis

1. **Data preparation:** Before analyzing the biosignals, we need to clean them up. This involves removing noise and artifacts that can disrupt the analysis.
2. **Feature extraction:** Once the data is clean, we identify meaningful characteristics, or "features," from the signals. These features are chosen by experts who understand what's important for sleep stage scoring.
3. **Model building:** Using the extracted features, we train machine learning models. These models learn to recognize patterns in the features and associate them with different sleep stages (e.g., REM, NREM).

> Deep Learning Utilize multiple layers of non-linear transformation to convert from inputs into representations that are useful for subsequent tasks such as classification

Sleep stage scoring

NREM sleep is further divided into three stages:

- **N1** is the lightest stage of sleep, and it is characterized by slow, rolling eye movements and reduced muscle activity.
- **N2** is a deeper stage of sleep, and it is characterized by more regular brain waves and decreased muscle activity.
- **N3** is the deepest stage of sleep, and it is characterized by very slow, delta waves and the absence of muscle activity.

REM sleep is characterized by rapid eye movements, increased brain activity, and muscle paralysis. It is thought to be important for memory consolidation and dreaming.

The normal sleep pattern involves cycling through all stages of NREM and REM sleep several times during a night. The first sleep cycle is typically shorter and lighter than later cycles. REM sleep periods become longer and deeper as the night progresses.

Awake is a fifth stage of sleep that is characterized by the absence of sleep stages N1-REM. It is typically brief and occurs between sleep cycles.

Sleep stage scoring is a multi-class classification problem in machine learning. This means that there are five classes to classify: N1, N2, N3, REM, and Awake.

To assess the quality of sleep, researchers use a variety of metrics, including:

- **Total sleep time (TST)**: The total number of minutes spent asleep.
- **Time in bed (TIB)**: The total time spent in bed, including time spent awake.
- **Sleep efficiency (%):** The percentage of time spent in bed that is spent asleep.

Model

Feature	DeepSleepNet	TinySleepNet

Representation learning	Two branches of CNNs	Single branch of CNNs with hierarchical structure
Sequence learning	Bidirectional RNNs	Unidirectional RNNs
Data augmentation	Signal augmentation	Signal augmentation and sequence augmentation
Computational resources	More	Less
Parameters	More	Less
Performance	Similar	Similar
Deployment	More challenging	Easier

Evaluation

- **Experimental Setup**
  • k-fold cross-validation (non-overlapping patient split)
- **Performance Metrics**
  • Overall: accuracy (ACC), macro-averaged F1-Score (MF1), Cohen's Kappa ( )
  • Per-class: precision (PR), recall (RE), F1-Score (F1)
- **Visualization**
  • Hypnogram

Conclusions

- **Deep learning is mostly used for supervised learning with biosignals.** This means it relies on labeled data to learn and predict outcomes.
- **Transforming raw signals into spectrogram or image representations can be an alternative.** This allows using CNNs, which are good at processing images. However, this is not always ideal for end-to-end training.
- **Directly applying deep learning on raw signals is challenging.** This is mainly successful when the signals have clear patterns for each class and enough training data.
- **Remote monitoring is a promising area for deep learning in biosignals.** This involves adapting models from clinical settings to work with wearable devices.