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Automated classification of sleep and wake from single day triaxial accelerometer data

Actigraphy, or the non-invasive study of human activity-rest cycles, is a field of study of growing importance as ambulatory and at-home monitoring of patients becomes more popular. It has the potential to revolutionize clinical trials, sleep studies, and even patient monitoring of recovery after injury or surgery. One of the most important applications of actigraphy is to understand natural sleep-wake patterns, especially since these are nearly impossible to truly replicate in a clinical or laboratory setting. With actigraphy, we can quantify the duration, timing, and quality of sleep experienced at home using automated algorithms. Actigraphy traditionally relies on data across multiple days or weeks to characterize routines and activity-rest cycles of a single person. While this may be possible for those who follow strict routines, reliance on longitudinal data collection to establish sleep patterns is not possible for those with erratic sleeping patterns or changing schedules, or in cases of shorter duration studies.

The Coleman Lab at Stanford has invented an algorithm capable of classifying sleep and wake states in a single day from triaxial accelerometer data. Traditional actigraphy relies on days to weeks' worth of activity data to characterize patterns of activity and rest within individuals, but reliance on longitudinal data is challenging for short studies and for individuals with irregular schedules. This novel, two-stage algorithm classifies sleep and wake states from a single day. The algorithm uses many features of triaxial accelerometer data to capture the signal variability, and a two-step process modeling reduces the noise from each single-stage classification alone. Additionally, existing algorithms classify sleep from proprietary actigraphy device outputs, but triaxial accelerometers are built into most smart devices and can be used by this algorithm, making tracking activity cycles more accessible. The invention is more accurate (97%) than the gold standard Cole-Kripke algorithm (60-70%) used in commercial clinical devices. This simple, automated algorithm capable

of classifying sleep and wake robustly using triaxial accelerometer data on a single day basis would broaden the usability of actigraphy for clinical, research, and consumer device purposes.

Applications

- -Compatible with any wearable device that has triaxial accelerometer data capture, such as smartwatch devices from Apple, Fitbit, Garmin, and others.
- -Can be implemented in products to help determine sleep duration, timing, regularity, and quality for consumers who purchase these products.
- -Can be integrated into clinical grade wearable devices for assessing sleep, such as for at-home sleep studies or to track patients over time.

Advantages

- -Widely available measure, compared to existing methods such as the Cole-Kripke algorithm that is built for proprietary measures only
- -Compatible with all smart devices that have built-in triaxial accelerometers
- -More accurate (97%) than the gold standard Cole-Kripke algorithm (60-70%) used in commercial clinical devices

Publications

- S. Subramanian and T. P. Coleman, " Automated classification of sleep and wake from single day triaxial accelerometer data", 2022 44th Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), Glasgow, Scotland, United Kingdom, 2022, pp. 3665-3668, doi: 10.1109/EMBC48229.2022.9871823.

Patents

- Published Application: 20230320655

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