Microsleep Prediction Using an EKG Capable Heart Rate Monitor

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Introduction

Microsleep is a short period of sleep which can last for up to 2 minutes where an individual fails to respond to outside sensory input. Because of the lapsed time, microsleep can create dangerous situations, for example when a user is driving a car, any microsleep can result in unsafe situations or even death.

System Architecture

The system architecture includes wearable electrocardiogram monitoring which continuously captures EKG data, a low pass filter to remove high frequency noise, and a microsleep detection module. This module calculates the pNN50 value and uses it to determine if the user is drowsy. If the pNN50 value exceeds a certain threshold, it alerts the user and predicts future microsleeps.

pNN50 Calculation

pNN50: number of pairs of consecutive NN intervals with a difference greater than 50 milliseconds.

\[ pNN50 = \frac{\text{number of pairs of consecutive NN intervals with a difference greater than 50 milliseconds}}{n} \times 100 \]

Microsleep Detection

High levels of drowsiness are the first sign that a microsleep will occur. While we classify the individual as drowsy above a pNN50 value of 15, the higher the score the drowsier and vice versa.

Microsleep Prediction

Once we know a microsleep has occurred, we predict when the next microsleep will occur using the change in drowsiness. To do this we calculate the change in pNN50 values (\( \Delta p \)) after the last microsleep and the change in time (\( \Delta t \)) from the last microsleep to the current microsleep.

We calculate a regression model using 9 of the 10 data sets. We calculate a linear, quadratic, and cubic model to find which has the best fit for prediction.

Linear model:

\[ \Delta t = 13.060 + 5.2257\Delta p \]

Quadratic Model:

\[ \Delta t = 10.444 + 10.890\Delta p - 0.9107\Delta p^2 \]

Cubic Model:

\[ \Delta t = 7.397 + 23.135\Delta p - 6.549\Delta p^2 + 0.05405\Delta p^3 \]

Evaluation

We evaluated each of our models using the final data set containing 50 possible microsleep predictions. We consider a microsleep correctly predicted if the prediction is within a 30 second window of the actual microsleep.

Application Scenarios

1. Automated System – alert the user before microsleep occurs.
2. Productivity – alert the user when it is in their best interest to sleep, even if it is not a full night’s rest to increase productivity and quality of work.
3. Steering Wheel Application – Adding EKG sensing fabric to a steering wheel, will allow a noninvasive system to predict microsleep while driving.

Conclusion

Because of the repercussions of even a short episode of microsleep, it is necessary that we learn to track it and alert the user to an occurrence or the probability of a near future occurrence. The results of our study suggest that EKG data can be used to accurately detect and predict microsleep.

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