Microsleep Prediction Using an EKG Capable Heart Rate Monitor

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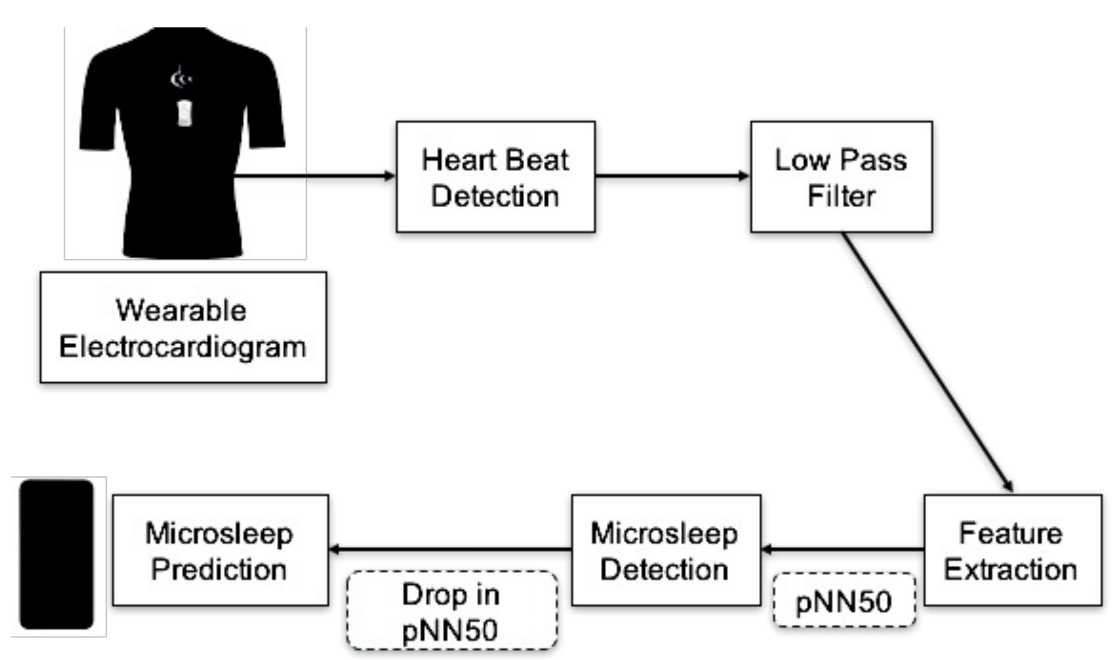
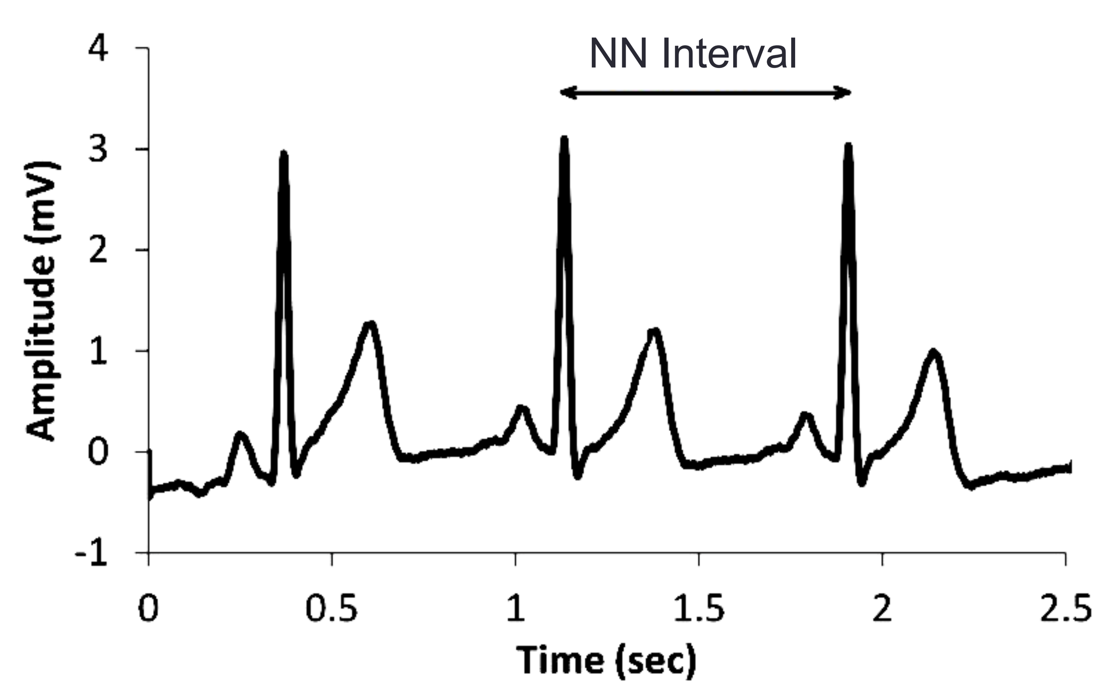
Introduction

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



pNN50 Calculation



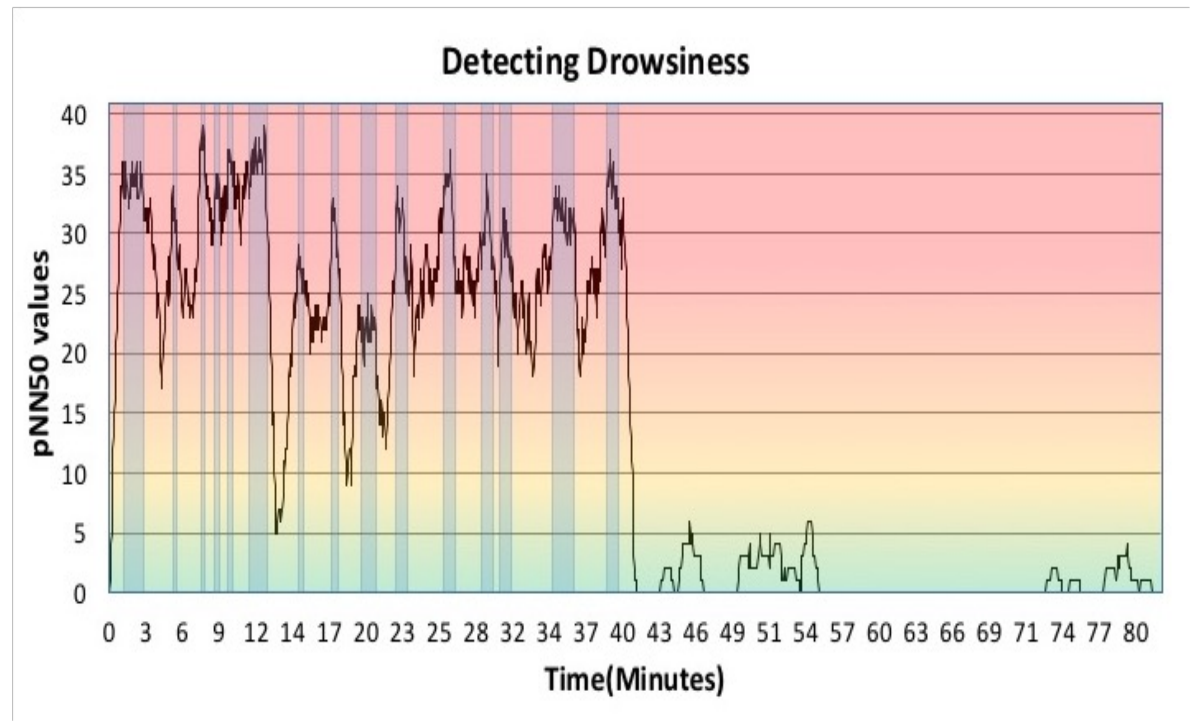
pNN50: number of pairs of consecutive NN intervals with a difference greater than 50 milliseconds.

If $NN_k - NN_{k-1} > 50\ ms,$

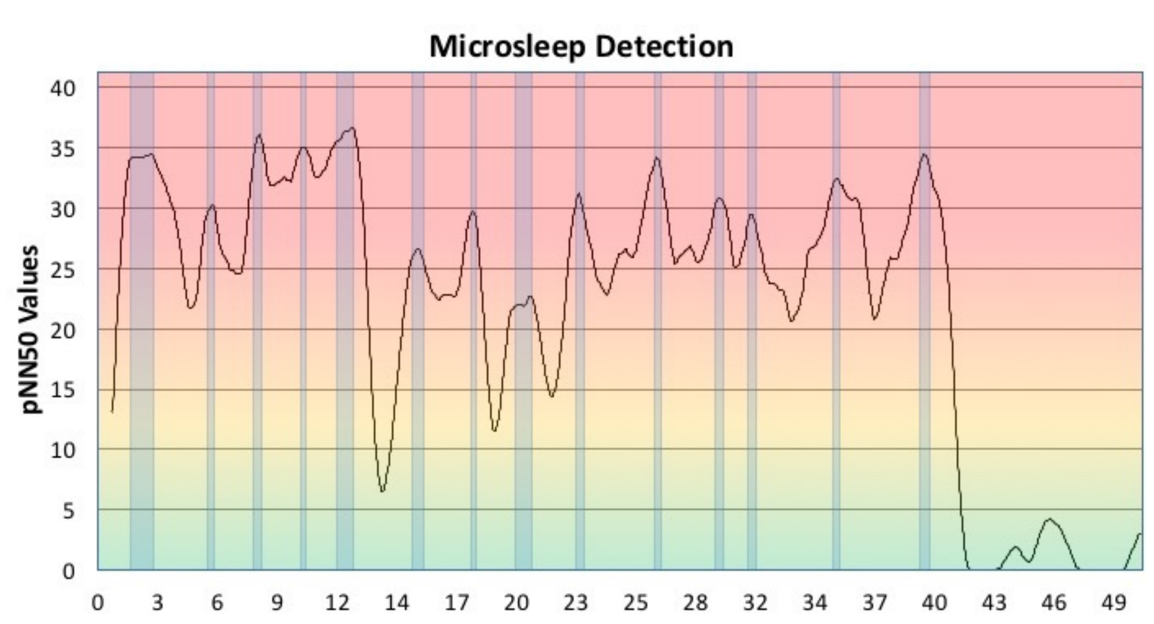
$$pNN50 = \frac{\#\ of\ NN50}{n} * 100$$

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.



The combination of the moving average, peak detection, and slope pattern analysis create this graph. If each of the adjacent slopes is above the threshold, 0.075, then we have detected a microsleep. The detected microsleeps are shown in the blue boxes. Notice the varying degrees of time for each microsleep.



Evaluation: Cross validation was run on the data set and it showed a 96% accuracy when detecting microsleep with a 1.6% false positive rate. We used 3 of the individuals' data to create our training set and the remaining 7 for our testing set.

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 (Δp) after the last microsleep and the change in time ($\Delta time$) 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:

$$\Delta time = 13.060 + 5.2257\Delta p$$

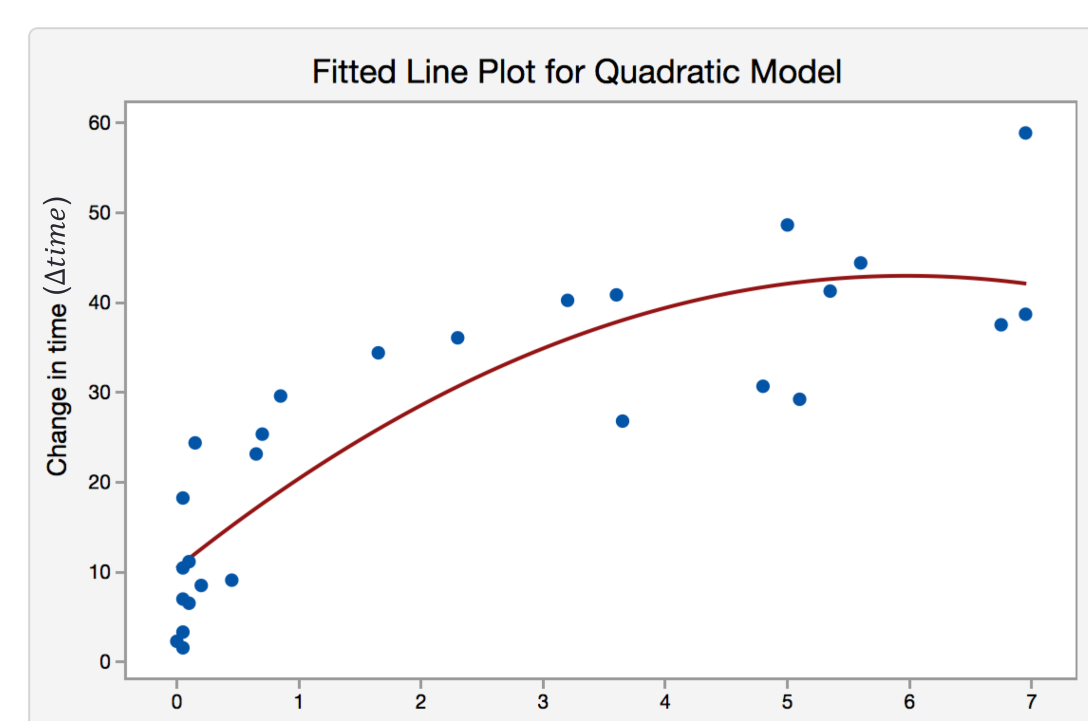
Quadratic Model:

$$\Delta time = 10.444 + 10.890\Delta p - 0.9107\Delta p^2$$

Cubic Model:

$$\Delta time = 7.397 + 23.135\Delta p - 6.549\Delta p^2 + 0.05405\Delta p^3$$

Model	Predicted R^2
Linear	65%
Quadratic	67%
Cubic	72%



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.

Model	Correct Predictions
Linear	42/50
Quadratic	38/50
Cubic	18/50

Even though the cubic model had the highest predicted R^2, it performed the worst in the real world environment. The false positive rate is 12% due to the participant leaving the situation that is causing his microsleeps. These predictions occur from up to 5 minutes before the next 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 micro sleep, 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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