Yolo4Apnea: Real-time Detection of Obstructive Sleep Apnea*

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Problem description

Obstructive sleep apnea is a serious sleep disorder that affects an estimated one billion adults worldwide with a large amount of cases being undiagnosed [1]. It causes breathing to repeatedly stop and start during sleep which over years increases the risk for cardiac disease, stroke, neurodegenerative-diseases like Alzheimer's and cancer.

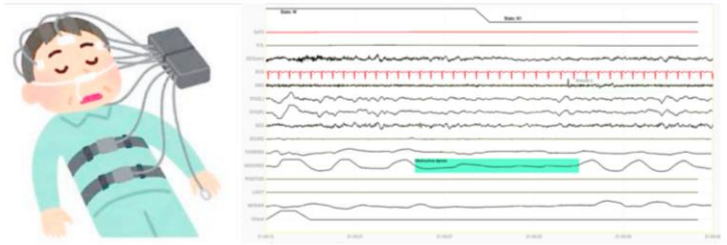

Figure 1: Example of a person sleeping with multiple sensors.

The current gold standard for detecting obstructive sleep apnea is by performing a *polysomnography (Figure 1)*. It requires a patient to spend a night at a sleep lab with sensors recording brain waves, oxygen levels, heart rates, ribcage and abdominal breathing, as well as eye and leg movements.

A sleep technician or doctor needs to manually examine the whole nights recording for apnea events. These recordings are often over 8 hours per patient. This is time consuming for the expert, and expensive.

The combination of a large population of undiagnosed apnea-cases, the need for sleep labs, and the cost of examining a sleep recording are reasons that a cost-effective and automated solution for detecting obstructive sleep apnea is needed.

Approach and Tool: Yolo4Apnea

Yolo4Apnea is *real-time apnea detection system* based on training You Only Look Once YOLO [2] to detect sleep apneas in ***images and videos of time series data*** from abdominal breathing data in a polysomnography. It allows detection in real-time using only a single abdominal sensor and can be recorded from the users own bed.

YOLO is a fully convolutional neural network (FCNN) that passes an image only once through the FCNN and generates an output bounding box around one or more objects found in the image. The bounding box can dynamically change in size to identify object of varying sizes in real time.

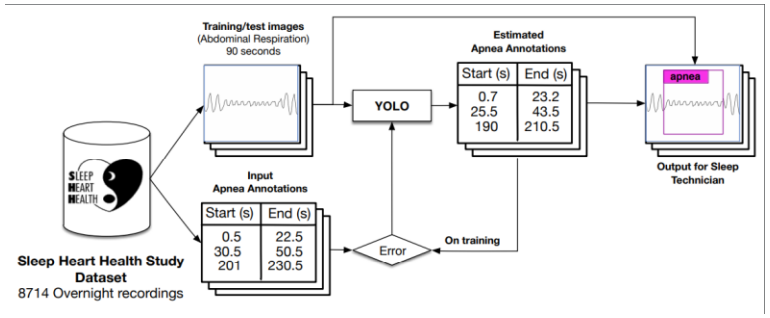

Figure 2: The Yolo4Apnea architecture

We train our model on the Sleep Heart Health Study (SHHS) dataset [3] which is a multi-center cohort study. A total of 8714 annotated polysomnographies are included in this study. From this dataset we plot the 10hz abdominal movement as an image representing a 90 second time period. We then select and plot the images with the bounding boxes of the apnea, and train using YOLO (Figure 2).

Demonstration

Yolo4Apnea is able to predict apneas in real-time. A tool for showing the model in action can be found here:
https://github.com/simula-vias/Yolo4Apnea

As seen in Figure 3 it is able to detect apneas varying in length and intensity. It is also posible to change the confidence threshold to reduce the amount of false positives.

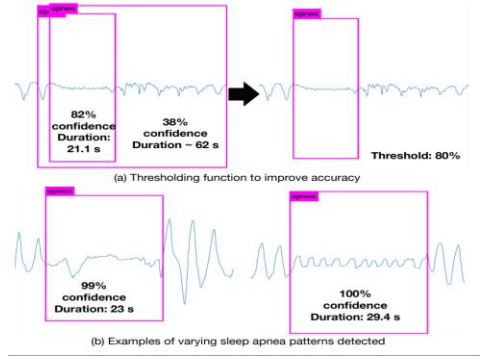

Figure 3: Filtering of predictions based on confidence, different types of apneas.

References

[1] Adam V Benjafield et al. Estimation of the global prevalence and burden of obstructive sleep apnoea: a literature-based analysis. The Lancet Respiratory Medicine, 7(8):687–698, 2019.
[2] Joseph Redmon et al. You only look once: Unified, real-time object detection. In Proceedings of the IEEE conference on computer vision and pattern recognition, pages 779–788, 2016.
[3] https://sleepdata.org/datasets/shhs

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