Sonification of Sleep Data

Detection of Apnea and Hypopnea Events Using Electronic Music

ENGINEERING HONORS PROGRAM
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Background

Sleep apnea - a complete stoppage of breathing during sleep, signaled by a 95% or greater decrease in nasal pressure

Hypopnea - a period of shallow breathing accompanied by reduced airflow and lower oxygen saturation (≥4% decrease)

Problem: Sleep studies can be complicated to correctly analyze, doctors spend significant time scoring sleep studies by hand, and may have to revisit them to get an accurate diagnosis

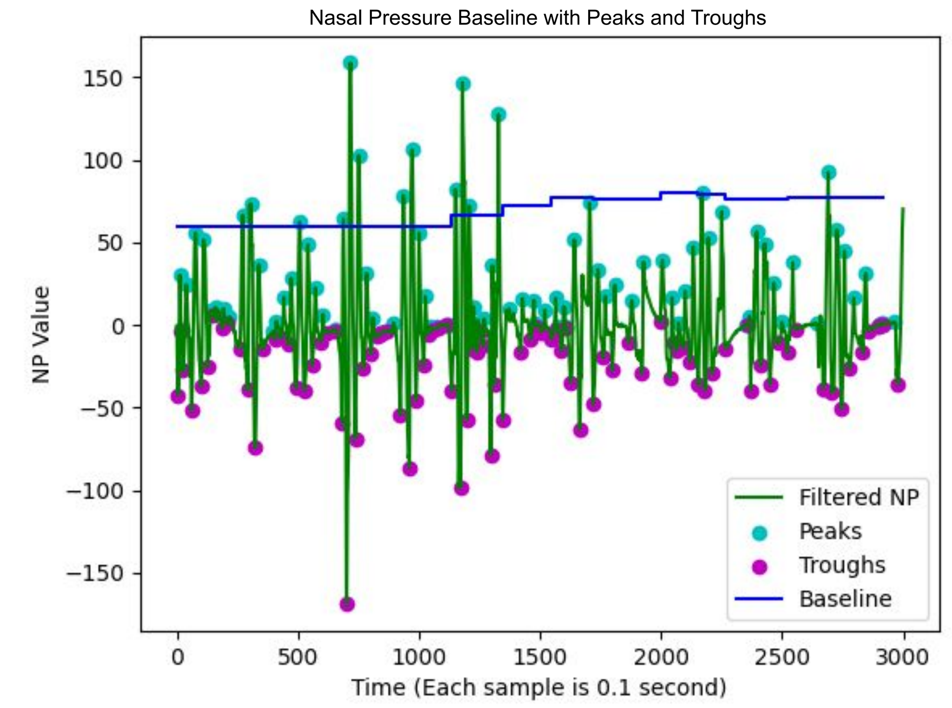
Additionally, sleep apnea and hypopnea can be difficult to identify, particularly if patients do not experience waking symptoms (exhaustion, headaches, congestion), so it is critical that sleep studies are scored accurately

Goal: Sonify data from sleep studies in a way that makes detecting and differentiating between sleep apnea and hypopnea events easier

- In scoring sleep studies, decreases in oxygenation and nasal pressure are referred to as "drops"
- Analogously, "drops" exist in electronic music - triggering musical "drops" when apnea/hypopnea events occur creates an intuitive link that facilitates accurate diagnosis

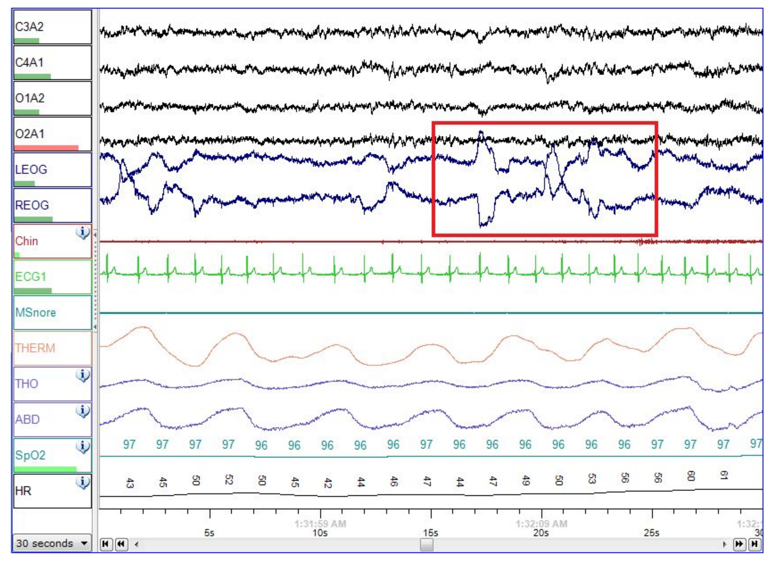
Methods

- Using nasal pressure identify peaks and troughs of respirations, resampled to 10Hz[2]
- Filter the signal with a Butterworth bandpass filter to remove noise
- Calculate the moving average curve with a 4sec window (length of average respiration) to obtain respiratory baseline
- Clean peaks/troughs so that no two consecutive peaks/troughs occur
- Identify hypopneas as 4% or greater drop in oxygen rate[3], apnea events as 95% or greater drop in nasal pressure[1]
- On detection of events, signals are sent to MAX which will trigger a low pass frequency filter or a beat repeater to simulate musical "drops"



Design + Data Pipeline

Polysomnography Data

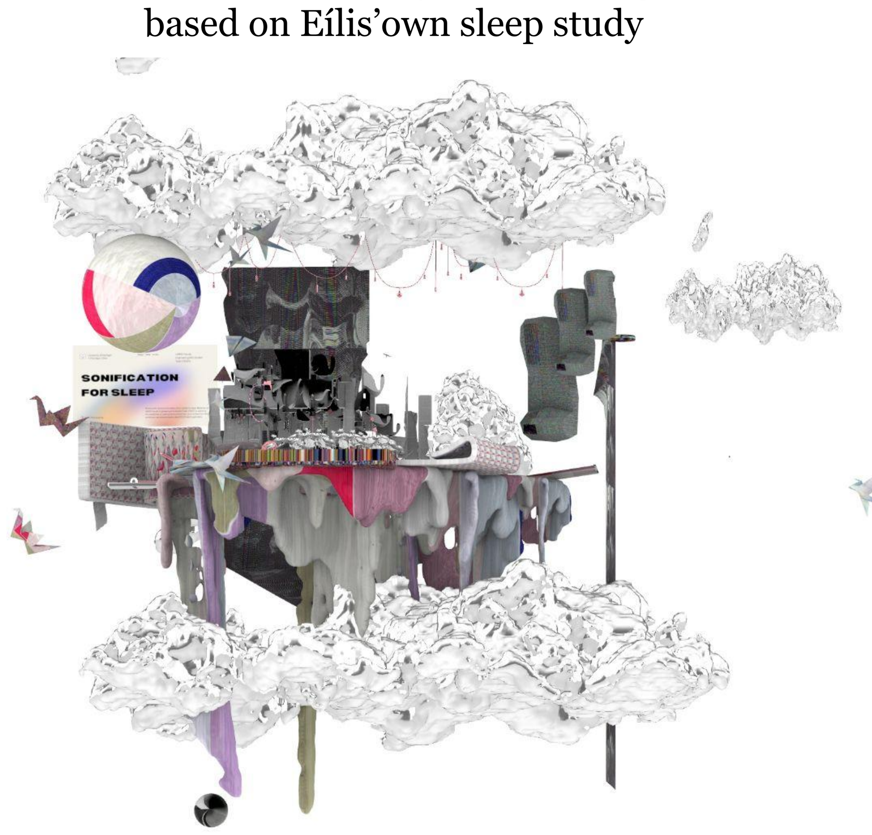


Real time detection algorithm in python

Send apnea/hypopnea signals to MAX via UDP

Alter music in Ableton Live

Below: virtual reality model, designed based on Eilís'own sleep study



Audio and Visual Results

Track 1: listen for the beat repeater (apneas) and low pass filter (hypopneas)

Track 1.5: detecting only hypopneas, listen for low pass filter

Experience the virtual reality model along with the music!

Look around the model!

Future Work

- Obtaining extra datasets to attempt to differentiate between central and obstructive hypopneas/apneas using distinct sonic effects
- Further improving the algorithm to take into consideration pulse, oxygenation, and nasal pressure all together
- Seeking out additional data streams containing muscle activity and brain activity signals (helpful for central/obstructive classification)
- Attempting machine learning classification techniques on respiration data to classify hypopnea/apnea events into their correct groups

Check out our website!

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References
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