Breathing Analytics

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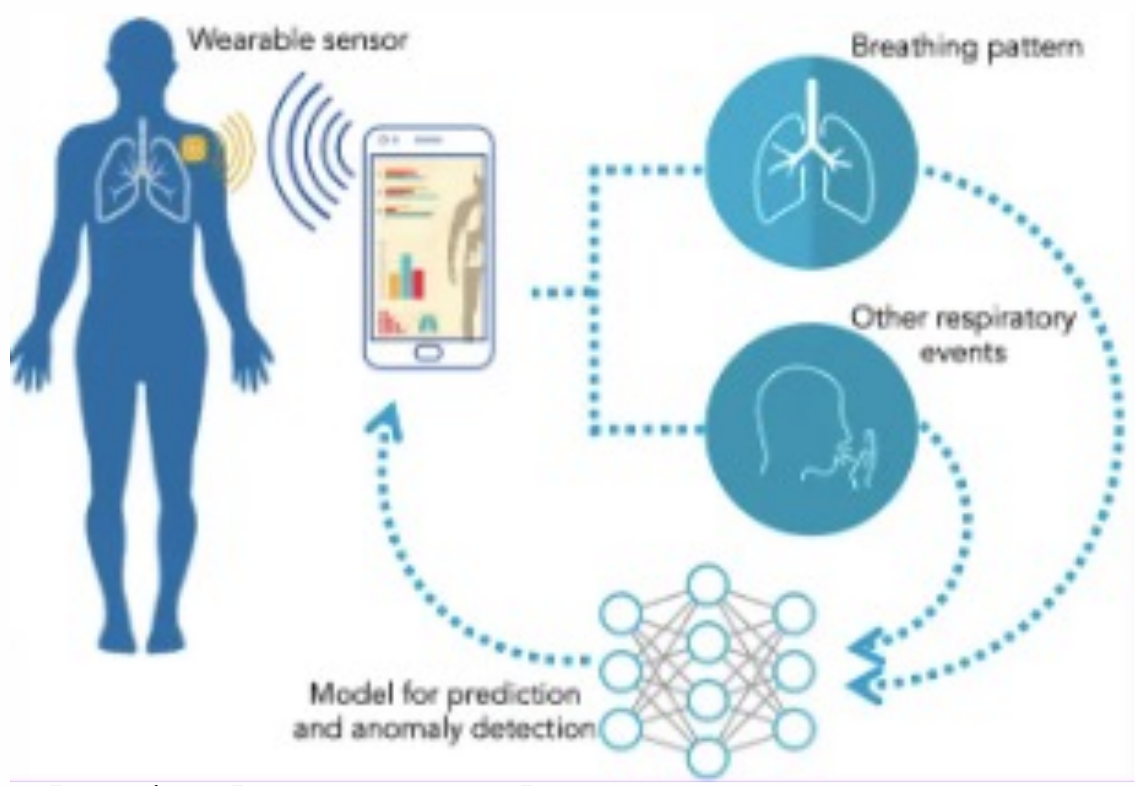
Breathing Analytics

The unique breathing pattern of an individual can yield a wealth of information. In fact, the 24-hour activity supports life by continuously driving gas exchange with incredible efficiency for up to a billion breaths in a human life span. With the advancements in sensor technology and Human Computer Interaction (HCI), our research aims to bridge the gap between computer science and health experts by building a personalized model that can detect physical and mental state events and provide corrective action through biofeedback. For example, it is known that respiratory illnesses such as influenza and COVID affect our breathing directly, and their early detection can lead to a more effective intervention or treatment.

Research Problems:

1. Identify different types of breaths and classify various respiratory events, including sneezes, coughs, speech, and other abnormalities like hypoxemia or sleep apnea.
2. Predict obstructive or restrictive respiratory conditions
3. Utilize accelerometer to enable human activity recognition (HAR)
4. Correlate breathing patterns to various physical or mental state.



Sensor:

We utilize a wearable sensor that captures the abdominal or thoracic expansion of the chest cavity through a piezoelectric force sensor. Our wearable also has a triaxial accelerometer and PPG,, all measuring at 25Hz. As this device is non-invasive and has a long battery life, a participant can wear one tag throughout an entire day, allowing us to collect data 24/7 in the participant's everyday setting.
We conducted tests to measure noise and eliminate drift algorithmically.

Methodology

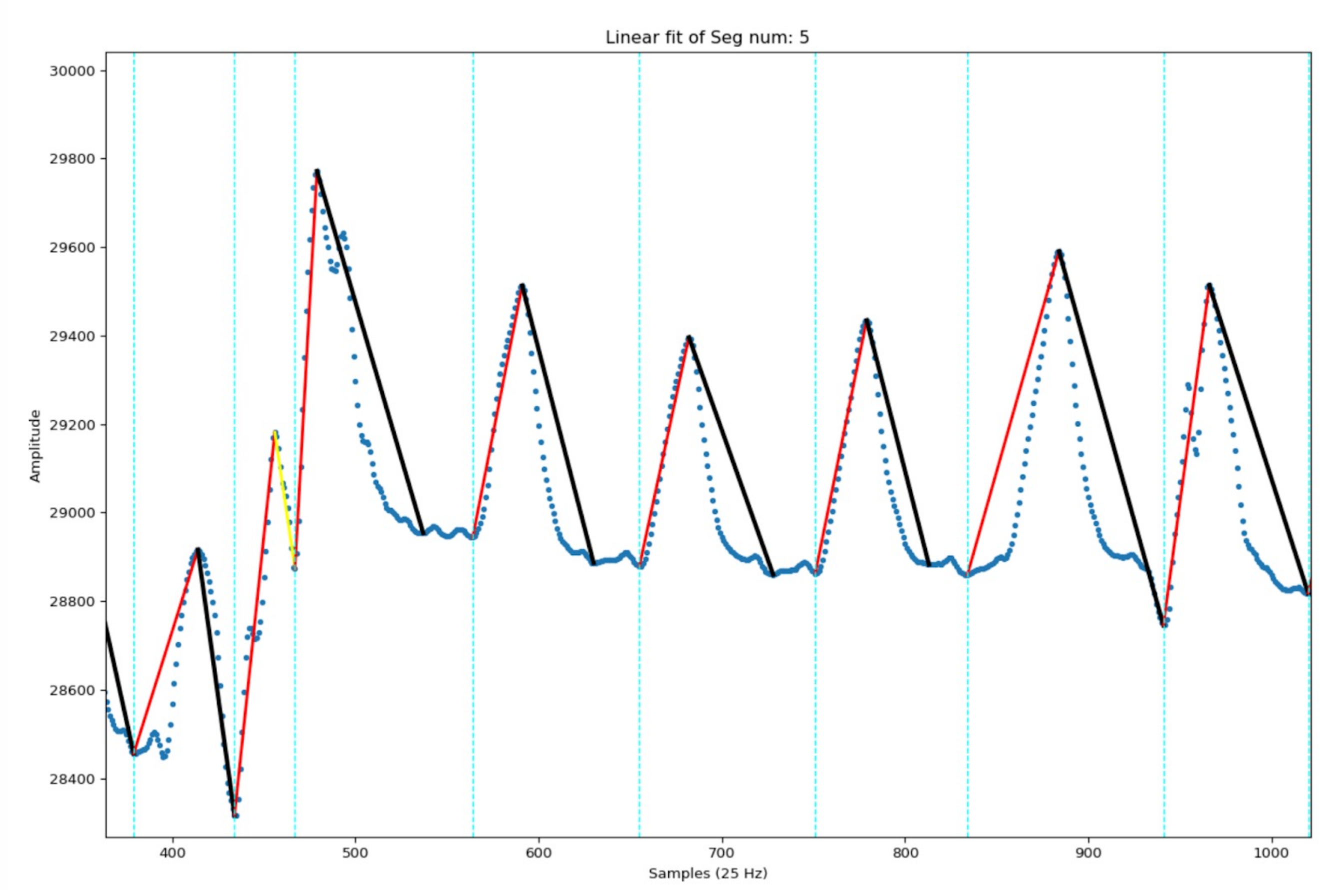
Breath Segmentation

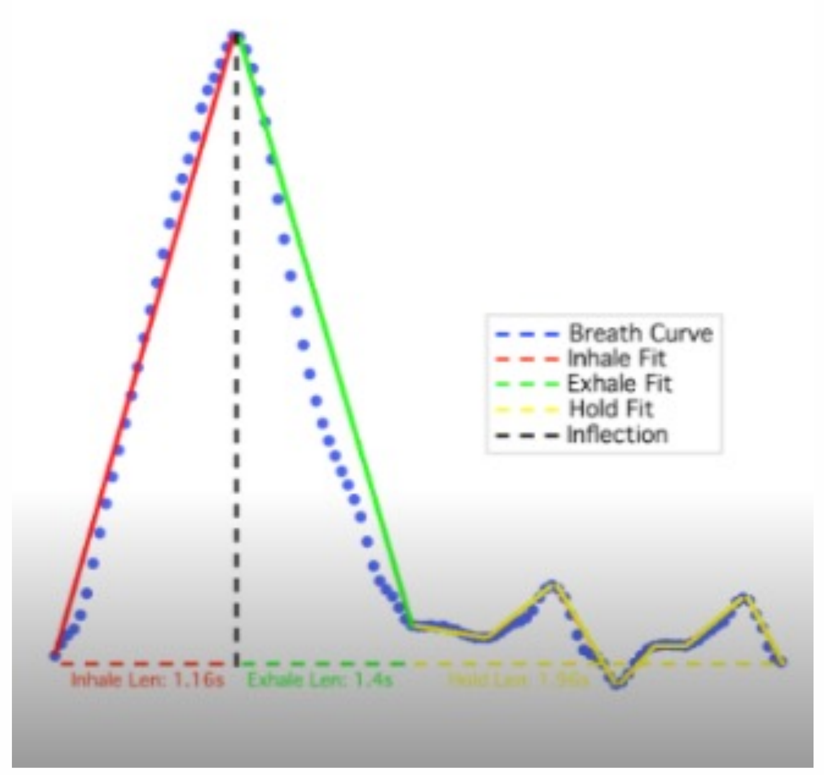
We take a close look by segmenting the sequence of breaths into individual breaths based on their behavior. We then fit lines over the waveform to capture the dominant shape of each breath. Our approach is to observe and analyze each individual breath.

Breath Features

We identify the following features:

- **Breath Duration** defined as the total time of the breath
- **Breath Amplitude** defined as the maximum value in the breath signal serves as the transition between inhale and exhale. This inflation point describes the height of the breath.
- **Inhale and Exhale Periods** define as the range of x-values for each separated by the height





Conclusion and Future Work

•We've developed precise online and offline segmentation algorithms, allowing us to create unique feature representations for individual breaths
•Notably, per-breath analysis revealed significant variability, underscoring the role of inhalation and exhalation patterns in event detection
•Sequence of breaths tend to follow a cyclical pattern (highlighting the correlation between minute-to-minute depths of breaths)

Customized Health Models

•While breaths look similar, the significant variations from person to person, including differences in height, timing, and inter-breath intervals, highlight the need for tailored approaches in health monitoring and interventions

Future Work:

- assess normal breaths under various activities
- detect deviations from normal
- correlate deviations to health conditions