INTELLIGENT MASK

Project Reference No.: *45S_BE_0245*

College ***:*** *B.M.S. College of Engineering, Bull Temple Road, Bengaluru*
Branch ***:*** *Department of Telecommunication Engineering*
Guide(s) ***:*** *Dr. C Gururaj*
Student(s) ***:*** *Mr. SHASHANK C*
Mr. MOHITH M
Mr. GAGAN M
Mr. SRI KRISHNA L

Keywords:

Breathmetrics, Lungs Health, Temperature Dataset, Inhalation, Exhalation, Breathing Volume, Web Application, Inhale onsets and Exhale Onsets.

Introduction:

Amidst the hellacious circumstances of COVID-19, medical systems are toiling to keep up with the escalating infection rate. The main motive was to aid the system in this juncture. Since the majority of deterioration of human health was caused by infections in the lung, it increased the need for analysing lung health. Further examinations showcased that nasal inhalation mechanisms were used to predict lung health. Research about many respiratory medical equipment and related topics of this particular field was done and an existing software tool (Breathmetrics) became apparent. Breathmetrics was a tested toolbox limited to only MATLAB, which is narrowed by factors like device dependency, that eventually led to further development of a python-written version and employ it on web applications.

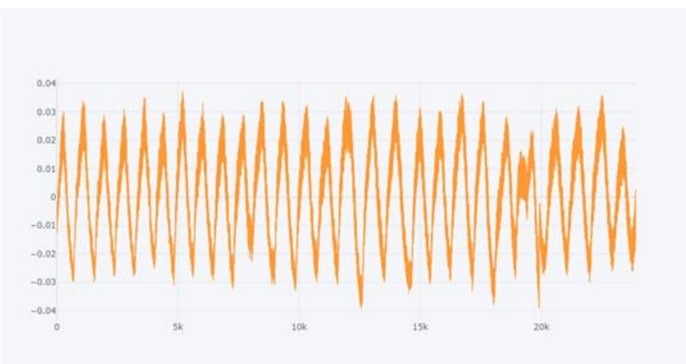
The prime aim is to analyse the respiratory airflow based on the temperature datasets obtained by a respiratory assessment module developed. The analysis consists of determining the vital respiratory parameters which includes breathing rate, inhale-exhale onsets, tidal volume of the lung and additional parameters in order to examine the health of an individual. Humans naturally breathe at varying rates with different individual breath volumes and pauses which makes the airflow recordings complex with non-sinusoidal waveforms having non stationary statistics. The electrocardiogram (ECG), which defines various components of the waveform based on certain calculation techniques, but this technique for analysing respiratory signals is relatively limited. Alternatively magnetic resonance imaging (MRI) was found to have a false respiratory parametric estimation. This demands for more accurate respiratory signal processing methods to create advancements in the understanding of human respiration.

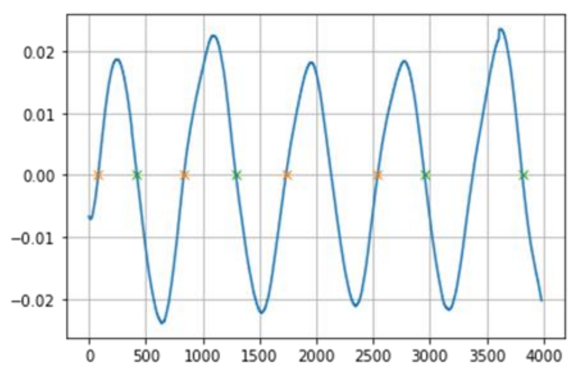
Objectives:

The basic need of the project and algorithm is to denoise the signal. The algorithm deals with statistical analysis of defining inhale and exhale onsets, keeping in mind about the inhale and exhale pauses. On defining the necessary parameters i.e., Breathing Rate and average Inter breath interval, Average Inhale and Exhale Volumes, Average Tidal volume, Maximum inhale and exhale peaks, Average Minute ventilation, Over all Duty Cycle. The output is of the project is presented in the form of a web application, where every user should record their breathing in the mask and can sign into their respective accounts to see the results and store them for future medical references.

Methodology:

In the mechanical dataset, the respiratory airflow is based on the temperature datasets obtained by a Intelligent Mask. The concept of pressure difference resulted in the fluctuation of temperature data in the module which was further converted into voltage digital signals from the analog readings. Respiratory data was considered by amending the algorithm with the determined sampling rate, window size and limiting the data set for a duration of 120 seconds which eventually resulted in approximately 4000-5000 samples. Prior to calculating respiratory parameters, sampling of recording sinusoidal wave values from mask must be done for the wave. The zero crossings along with noise must be separated from the desired signal. The python function “detrend ()” imitates the transfer function of the detrending the data to zero threshold and is imported from the library “scipy.signal”. The python function “savgol_filter()” imitates the transfer function of the Savitzky-Golay filter and is imported from the library “scipy.signal”.





The inhale onsets are defined at the point where the wave starts to rise just at the zero-crossing level, and the exhale onsets are defined at the point when the wave starts to sink just after the zero-crossing level. When someone breathes in, oxygen from the environment enters the lungs. It subsequently diffuses into arterial circulation via the alveolar-capillary junction. At the same time, carbon dioxide is produced indefinitely as long as metabolism occurs. The breathing rate is defined as the inverse of average duration between inhale onsets, or the number of single complete breaths over a minute of time. The algorithm is designed to analyse respiratory airflow, wherein, a normal single complete breath including inhale and exhale airflow defines inter breath interval. It gives an accurate value when sampled over a set of intervals. The tidal volume is calculated by the sum of average inhalation volume and the average exhalation volume. In a healthy adult male, it measures roughly 500 mL, while in a healthy female, it measures around 400 mL. It is an important clinical measure that allows for optimal breathing.

The web application which acts as a User Interface for the practical implementation of the algorithm. It is built on Flask and its constituent libraries with custom-written HTML and Cascading style sheets implemented over the Bootstrap framework. The final page displays the computed results in a very less time (say <2s). The user can safely log-out after viewing the results. The parameters considered to be within the normal range are indicated in green and those with abnormalities are indicated in red. The result is the output of the algorithm whose computations and comparison are discussed in detail in the next section.

Results:

Analysis of the resulting parameters is done with respect to the average values of a normal human being. The data may not be sufficient or sophisticated enough for deeper analysis for medications, but is still usable to act as an early indicator of any ailment in the respiratory tract.

Parameters	Result	Normal Range
Number of Inhale and Exhale Onsets	23	22 - 26
Breathing rate	13.462	12 - 16
Average Inhale Volume	0.25	>0.2
Average Exhale volume	0.21	>0.2

Average Tidal Volume	0.477	0.4 - 0.6
Minute Ventilation	6.422	5 - 8

Conclusion:

Nasal airflow analysis, as mentioned earlier, has numerous implications in pulmonology. Any physical sinusoidal data extracted from the airflow, can be employed in the analysis of various respiratory parameters. The only thing that needs additional attention is the fact that the recordings are highly sensitive to both internal and external factors. The data extraction must take place under surveillance of a professional so as to ensure uniformity and consistency. The data hence obtained can be analysed for parameters such as lung capacity, breathing rate, inhale-exhale onsets etc. These results may not be completely accurate with respect to average values of human beings, but are legitimate enough to get an overview of any underlying abnormalities. The airflow data is also associated with neurology owing to the olfactory senses linked to the limbic regions of the brain. This fact can be further exploited to extend the application of this study into fields of human emotions detection or neural impulse analyses. There is a vast space into which this process can be unfurled making it a field of prominence in this pandemic.

Future Enhancements:

The data which is handled is highly sensitive to the internal and external factors. This makes the output vulnerable to false detections. To enhance the accuracy, the algorithm can be tuned in an appropriate manner so as to overcome error-prone data.

Trial and error can be done in the field of data detrending and filtering and experimented on the different available filter functions in python. Few other parameters can also be included in existing parameter list which can increase the scope of application.

Due to the olfactory senses' connections to the limbic regions of the brain, airflow data is also linked to neurology. This finding can be used to broaden the scope of this study's application to areas such as human emotion detection and brain impulse analysis. Because this process can unfold across a large area, it is a prominent field in this pandemic.

The web application can be updated by adding a feature to store the history of the user's test results which can be used to provide timely updates on their health. Further integrating the web application with other telemedicine apps wherein the doctors can directly refer and suggest some medicines to their patients. And with enough datasets available one can go ahead and use ML, DL to understand the breathing wave patterns and predict lungs disorders and even add preventive measure to control it.