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Estimation of Respiratory Rate through Breathing Audio

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Abstract: To overcome the major obstacle posed by a lack of access to physical examination, which includes inexpensive and accurate remote measurements of vital signs. Here, we use audio to estimate the patient's respiratory rate using machine learning. There are other strategies (non-learning based), but their precision is restricted, and the research we realize about utilizing ML is either not straightforwardly valuable or non-public datasets are used. There is only one accessible dataset that is public, hence it is used for the evaluation of the Proposed methods.

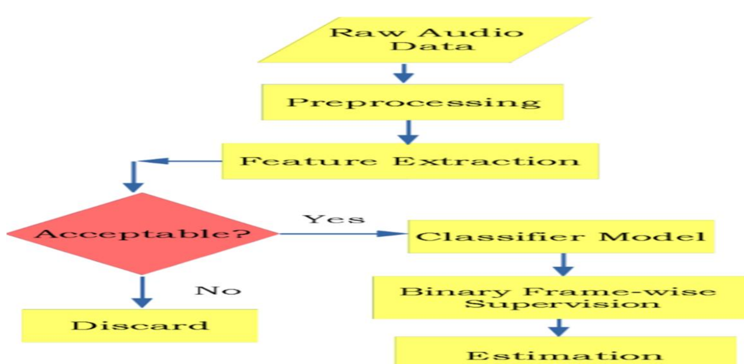
Considering the above, we propose a novel data augmentation technique to increase its effective size to avoid the overfitting issue. Our calculation utilizes the depiction of the spectrum of frequencies and the need for names for relaxing cycles, which are used to make a repetitive neural network that can see the cycles. Using only the breathing audio of the patient, our augmentation technique makes use of the independence of the majority of the spectrogram's periodic frequency components and their order is calculated for generating multiple signals representing it. The smartphone is used to collect those signals allowing doctors to accurately and automatically determine the respiratory rate of patients from a distance.
Keywords: Vital signs, raw audio data, respiration rates, a classifier model, binary framewise supervision, and inspiration and expiration.

I. INTRODUCTION

Respiratory rate is among four clinical vital signs, stated as the number of times a person breathes in a minute. Due to Covid-19, telemedicine is considered an essential mode of health care delivery. The majority of covid-19 patients were admitted to hospitals and were not able to breathe by themselves, resulting in abnormal respiratory rates. A common symptom of covid-19 found was respiratory distress. In various diseases, changes in respiratory rate were found to be a detector of clinical declination and an increase in the number of deaths. As a result, determining a patient's stability necessitates a precise rate of breathing. Counting a patient's breaths over 60 seconds is the widely used standard for determining their breathing rates. This method will be ineffective in a crowded clinic or triage setting and frequently shortens by observing breaths for shorter periods, such as 10 seconds, which can result in inaccurate estimates. To overcome the major obstacle posed by a lack of access to physical examination, which includes inexpensive and accurate remote measurements of vital signs.

Here, we use audio to estimate the patient's respiratory rate using machine learning. An alternative that is accurate, highly efficient, and easy to use, for respiratory rate estimation that is suitable for both hospitals and telemedicine (remote) is provided by an estimation system that relies solely on audio signals.

II. SYSTEM DESIGN



III. METHODOLOGY

To determine whether the audio data satisfies the specified constraints, a breathing data sample is taken for preprocessing, and manually samples are removed by the following 4 Constraints:
(1) Distinctly irregular heartbeats containing samples.
(2) Too many random background sounds in the samples.
(3) An excess clamor or murmur present in the sound sample.
(4) Pattern of breathing that is not periodic or irregular.
As a result, the audio samples that meet the above criteria are taken out and put into the classifier model. The dataset is then sent to a technique called Binary Frame Supervision. The supervision signals should be kept as simple as possible, due to limited training datasets. We hypothesize that rather than estimating the number of inspire/expire regions in the sample, representing transitions between different points at the frame level shall give the supervision better, due to respiration's periodic nature. The breathing signal's fundamental periodicity dictates that each of its many frequency parts ought to be periodic. To avoid overfitting, and to propose a different type of data augmentation, frequency independence is used. Rather than giving the spectrogram with no guarantees, we haphazardly permute the recurrence parts each time we elapse a preparing information test to our model. After permutation, the input still contains periodicity information, but the training data sample's exact form will vary from time to time. Not being able to overfit any frequency-related data pattern, we hypothesize that the model finds periodicity by learning and finding for periodicity in each channel.
The respiration rate must be calculated using the model's framewise class probabilities after training is finished. There is a good chance that the output classes 0 and 1 will alternate in this sequence. For the earlier inspiration/expiration regions, it is empirically observed whether the predictions are confident and accurate, and over time, we become less confident. As a result, we decided to predict the underneath breath duration based on the length of the first region. A model is also trained separately in which the audio is flipped and the same estimations are made to improve the prediction. As a result, the test set is used to estimate the respiratory rate for all methods and depending upon the estimated lengths of the first and last parts of the inspiration or expiration known as breathing intervals to arrive at the final estimation, which is the average of estimations made by both the models individually.

IV. COMPONENTS

Available datasets: ICBHI 2017 Respiratory Sound Database

V. LITERATURE SURVEY

[A]. Azadeh Yadollahi(Student Member), Zahra M. K. Moussavi(Senior Member) IEEE "A Robust Method for Estimating Respiratory Flow Using Tracheal Sounds Entropy",12 May 2014. Due to the difficulties and inaccuracies of the majority of flow measurement methods, numerous researchers have tried to predict flow based on breathing sounds. However, the application of each of the suggested approaches is constrained by the requirement for various flow rates for the calibration of the model. In this paper, a novel and reliable approach to flow estimation is proposed by making use of the tracheal sounds which is a bandpass filter and whose Entropy is calculated and hence used. The proposed method can estimate any flow rate and only requires one breath to calibrate, regardless of the flow rate chosen for calibration, even when flow rates are outside the given limits of the calibration. After eliminating the sounds of the heart, which deforms the tracheal sounds' low-frequency parts, the efficacy of the method across a variety of frequency ranges is evaluated. In addition, the proposed method's effectiveness for calculating entropy was validated using six distinct segment sizes. Estimates were made for inhaling and exhaling with the best segment sizes.
Keywords: Tracheal sounds, Entropy, heart sound, flow prediction.
Advantages: It shows a reliable method for estimating flow that can adapt to flow variability and doesn't need more than one breath to calibrate.
[B].Ethan Grooby, Jinyuan He, Julie Kiewsky, Davood Fattahi, Lindsay Zhou, Arrabella King, Ashwin Ramanathan, Atul Malhotra, Guy A. Dumont(Life Fellow), Faezeh Marzbanrad,(Member) IEEE "Neonatal Heart and Lung Sound QualityAssessment for Robust Heart and Breathing Rate Estimation for telehealth Applications", May 31, 2021. Chest sounds can be fetched easily and sent to the virtual cloud for monitoring remotely and diagnosing thanks to advancements in the processing of signals, ML, IOT, stethoscopes which are digital, and other technologies. But, for taking care of newly born specifically, poor-quality recordings are hindering remote monitoring and diagnostics. In order to improve the accuracy and dependency of estimations of rates of heart and breathing from chest sounds of newly born who are noisy, this paper presents a novel approach for automatically and specifically evaluating the quality of the signal.

From 76 preterm and full-term infants, a total of 88 information sources and 10-second lengthy sounds of the chest were collected. The recordings' breathing times, the quality of the signal, and delectable beats were evaluated by observers. Heart sound contained 187 features and lung sound contained 182 features that were used for quality categorization.

A binary categorization model which is dynamic was tutored following the application of class balancing and hyperparameter optimization in addition to feature selection. After that, the chest sound was used to automatically estimate heart rates and breathing rates, and a comparison of many methods was made for the same thing. cross-validation done subject-wise and also leaving one out revealed that the high-quality recordings were distinguished from the low-quality recordings by the model in the data which was used to test with a specificity of eighty-six percent, sensitivity of sixty-nine percent and accuracy of eighty-two percent for lung sounds and specificity of Ninety-six percent, sensitivity of Eighty-one percent and accuracy of Ninety-three percent for heart sounds, respectively. The sounds of high quality had estimations with a lower absolute error of median than those of low-quality sounds, with a difference of 4bpm and 12bpm, respectively.

Keywords: Newborn monitoring, Heart and respiration rates, assessment of Quality, dynamic selection classification.

Advantages: Both heart and lung sounds have had their signal quality accurately assessed. Additionally, the strategies applied here with Robotized chest sound recognition of newborns are valuable for future uses of telehealth.

Disadvantages: For high-quality sounds, the estimates have a lower median absolute error. As a result, more data must be trained and the median absolute error for low-quality sounds must also be reduced.

[C].Mohammod Abdul Motin(Student Member), Chandan Kumar Karmakar(Member), and Marimuthu Palaniswami(Fellow) IEEE “Selection of Empirical Mode Decomposition Techniques for Extracting Breathing Rate From PPG”, April 2019.

A huge biomarker that gives both predictive, as well as demonstrative data with the purpose of checking biological state, is the Breathing rate(BR). The harmless and ready-to-wear pulse oximeter-based photoplethysmogram (PPG) can be used to extract BR in addition to vital biomarkers like pulse rate and blood oxygen saturation. Empirical mode decomposition (EMD) and its types are frequently utilized for the decomposition of inclined, which are not linear and moving signals. The study looked into how each EMD variant affected the extraction of BR from PPG. BR was extracted from PPG using a hybrid model based on the EMD family and PCA. The datasets used to Validate each model's performances were MIMIC and Capno-base. The absolute error for the median ranged from 0 - 5.03 breaths per minute and from 2.47 - 10.55 breaths per minute for both datasets, respectively.

Keywords: Pulse oximeter, EMD, and variants.

Advantages: Created best execution with relatively exact outcomes.

Disadvantages: Since the hybrid model in this paper is based on a variety of EMD variants, it is necessary to estimate each variant to determine its applicability. As a result, we require a setup for quick and simple respiratory rate estimation that takes time.

[D]. Chien-Lung Shen, Tzu-Hao Huang, Po-Chun Hsu, Ya-Chi Ko, Fen-Ling Chen, Wei-Chun Wang, Tsair Kao, Chia-Tai Chan “Respiratory Rate Estimation by Using ECG, Impedance and Motion Sensing in Smart Clothing”,1 July 2017.

Since the past decade, the demand for soft, lightweight, and smart clothing in-home care has increased. Automated biological and user-specific status recognition of the environment has been made possible by the development and application of numerous smart textile sensors. An affordable electrode fabric containing higher elasticity and lower resistance is considered the basis for the ready-to-wear multi-sensor clothing(smart) that is proposed in this study for homecare monitoring. Many biosignals of humans such as breathing rates, ECG, information on the gyro, and other things, can be measured by the ready-to-wear smart clothing's integration of multiple sensors. Five free signals of respiration specifically, impedance plethysmography which is electric, actuated recurrence variety for respiration, incited adequacy variety for respiration, respiratory prompted power variety, and respiratory initiated development variety are bought. Using three distinct methods Kalman filter both Static, and dynamic, naive Bayes inference, the straightforward clothing can be used to accurately estimate respiratory rate. In the experiment of static, the frequency variation is respiratory induced performs best, while respiratory-induced amplitude variation performs best during the running experiment. The Guileless Bayes induction and dynamic Kalman channel have shown great outcomes.

Keywords: Many sensors, Clothing which is smart, electrode(textile).

Advantages: The novel smart clothes are washable, soft, and elastic, indicating that they are fitting for monitoring which is long-term in the service of medical which is home-care based, and in the healthcare industry.

[E]. Carlo Massaroni, Daniela Lo Presti, Domenico Formica, Sergio Silvestri and Emiliano Schena “Non-Contact Monitoring of Breathing Pattern and Respiratory Rate via RGB Signal Measurement”,19 June 2019.

The intrusiveness of the sensors that are typically used means that the breathing rate is measured least frequently in a number of situations. This is why contactless monitoring systems in general are receiving more and more recognition.

A computing system for the extraction of breath-by-breath respiratory rate, also a contactless measurement of the respiratory pattern is proposed in the paper. An algorithm and built-in camera(RGB) of the laptop are used in this system to post-process video data. A waveform indicating the respiratory pattern is produced by recording the chest movements and analyzing the Switching in pixel intensity. 12 men and women were asked to sit in front of the laptop's camera and we were asked to wear both slim and loose-fit t-shirts to test the proposed system. Recording of the signal consisting of a drop in pressure was done at the point of the nostrils using ready-to-wear devices fixed to the head(head-mounted), which served as the reference for the pattern of breathing. The percentage, standard and absolute error mean are used to compare the two approaches. In addition, a plot was utilized to interrogate the method bias known as Bland-Altman. Slim and loose fit clothing with both of them, the system was able to accurately record respiratory rate, as demonstrated by the results. Females perform better on the measuring system.

Keywords: Built-in RGB camera, head-mounted device.

[F]. Claudia Floris, Sarah Solbiati, Federica Landreani, Gianfranco Damato, Bruno Lenzi, Valentino Megaleand Enrico Gianluca Caiani "Feasibility of Heart Rate and Respiratory Rate Estimation by Inertial Sensors Embedded in a Virtual Reality Headset",14 December 2020.

Using the ballistocardiographic principle, Headsets known as Virtual reality headsets with built-in microelectromechanical systems can assess the mechanical heart's functionality and respiratory activity without the need for additional sensors. 30 people with good health, at rest in various body positions were studied. The body positions were standing, supine, and sitting Using a virtual reality (VR) headset, gyroscope and accelerometer data were recorded for a duration of thirty seconds, and a 1-lead electrocardiogram (ECG) signal was used simultaneously to estimate mean heart rate (HR). 3 approaches based on frequency have been validated for the purpose of extracting the PSD and its corresponding frequency to it. The results showed that the gyroscope was more accurate than the accelerometer when a comparison was done with the gold standard. Additionally, the position which is supine demonstrated the greatest feasibility (98 percent) for estimating the respiratory rate, through which it was identified that the one which contains the most breathing information is the transversal direction. Findings also demonstrated that the feasibility of the proposed strategy is dependent on the posture and this strategy can be carried out the performance of some degree.

1) Virtual reality device provides a reference for linear and rotational accelerations.
2) During the acquisition of VR signals, a device monitoring the heart rate was utilized in the experiment to obtain the gold standard ECG measurement: For the first measurement, its placement was on the chest (ECG-Chest), and for the second measurement, Between the middle fingers and thumb it was held(ECG-Thumb).

Keywords: VR headsets, gyroscope, accelerometer, power spectral density PSD ballistocardiography.

Advantages: A good level of performance and evidence of feasibility.

[G]. Jorge Brieva, Hiram Ponce, and Ernesto Moya-Albor "A Contactless Respiratory Rate Estimation Method Using a Hermite Magnification Technique and Convolutional Neural Networks", 15 January 2020.

In both medical applications and everyday activities, it is difficult to monitor the respiratory rate.In most cases, contact sensors were used as a direct solution. They have also been shown to be effective, but have some drawbacks, such as not working well on the sensitive skin of burn victims.As a result, more and more people are using contactless breath detection and looking for a monitoring system.In this paper, a system is based on a Convolutional Neural Network (CNN) and the Eulerian motion video magnification technique with Hermite transform which is a novel non-contact method that estimates respiratory rate. The subject's chest movements are tracked by the system using two methods.By using manually selected ROI and not selecting the ROI in the image box. Using CNN, the system determines whether a frame is an inhalation or an exhalation. The mean average error and a Bland and Altman analysis are used to compare how well the methods for detecting respiratory rate work together.

Keywords: Non-contact monitoring, motion video magnification, respiratory rate estimation, and the Hermite transform.

[H].Alexis Martin, Jérémie Voix*" In-Ear Audio Wearable: Measurement of Heart and Breathing Rates for Health and Safety Monitoring", 2016.

The subject of this study is the integration of vital sign monitoring functions in workplace hearing protection devices (HPDs). The testing subjects were approached to inhale at different rhythms and forces and they were reasonable sounds that were kept in the ear trench. For the purpose of measuring heart and breathing rates, digital signal processing algorithms are developed. Finally, an adjustable denoising filter was used to add industrial noise in the in-ear recorded signals in order to measure the algorithms' accuracy in a noisy environment. The HPD is also possible to run in high ambient noise after checking the heart rate and respiration rate with a closed ear canal. The absolute mean error of the algorithm is 2.7 cycles per minute (CPM).

Keywords: Biosignals, in-ear wearables, processing of acoustic signals, monitoring of health and safety, and heart and breathing rates.

Similarities: With an in-ear microphone-equipped wearable audio device, physiological sounds were recorded in the ear canal. As a reference, a commercial device was used to simultaneously record heartbeats and breathing.

Advantages: The noise disturbance has a clear impact on the performance of breathing rate detection, resulting in absolute errors below 7.4 CPM.

[I].Xiangyu Xu, Jiadi Yu, Yingying Chen "Leveraging Acoustic Signals for Fine-grained Breathing Monitoring in Driving Environments", 2020.

The energy spectral density (ESD) of an acoustic signal describes how the energy of the acoustic signal is distributed in space with frequency, and environmental movement can be interpreted as changes in the energy distribution. This paper includes a fine-grained respiratory monitoring system called BreathListener. BreathListener uses your smartphone's audio device to estimate detailed breathing waveforms in a driving environment. BreathListener uses background subtraction and variational mode decomposition (VMD) to remove interference from the driving environment of the ESD signal and extract the respiratory cycle. A deep learning architecture based on a Generative Adversarial Network (GAN) is then developed to generate fine-grained respiratory waveforms from the Hilbert spectrum of the respiratory patterns extracted in the ESD signal. The RF card on smartphones cannot be used as an active RF radar, which is more powerful at tracking breathing patterns, because smartphones are embedded with NFC chips that support RF recognition.

Similarities: Using smartphone acoustic devices to estimate the fine-grained breathing waveform in driving conditions.

Advantages: Because the correlation coefficient is greater than 0.77, a deep learning architecture that uses a Generative Adversarial Network (GAN) to generate fine-grained breathing waveforms indicates that BreathListener can still function in these circumstances, albeit with a decrease in accuracy.

[J].Tianben Wang, Daqing Zhang, Leye Wang, Yuanqing Zheng, Tao Gu, Bernadette Dorizzi, Xingshe Zhou "Contactless Respiration Monitoring using Ultrasound Signal with Off-the-shelf Audio Devices", 2018.

One of the most important ways to help older people live their best lives while they sleep is by monitoring their respiration in a real-time and continuous fashion. The model employs an MDL-based algorithm that is capable of capturing the Doppler effect brought on by exhaled airflow. For respiration monitoring, this system has a median error of less than 0.3 breaths per minute or 2%, and it can accurately identify apnea. to make the system better so that it can lessen the effects of sporadic body movements while you sleep. Our system will be further evaluated in the future through larger-scale deployment in typical homes.

Keywords: Acoustic sensing, the Doppler effect, respiration detection, and contactless sensing.

Advantages: Low respiration error detection (less than 0.3 breaths per minute, or 2 %) can be detected by a real-time and continuous respiration monitoring system.

[K].Jyotibdha Acharya, "Deep Neural Network for Respiratory Sound Classification in Wearable Devices Enabled by Patient-Specific Model Tuning",3 June 2020.

Classification is carried out employing a Mel-spectrogram-based deep CNN-RNN model of respiratory sounds. With limited patient data, this model will first screen respiratory patients and create patient-specific classification models for anomaly detection. The weight quantization method will quadruple the cost of memory overall without sacrificing performance. The main contribution of the paper is the significant memory savings from local log quantization of trained weights. It gives a score of 66.31% for the four-class respiratory cycle classification on the 80–20 split. This model received a score of 71.81 percent in leave-one-out cross-validation, indicating that its results are significantly more reliable than those of the initial train-test split. Second, when pre-prepared with breathing information, profound learning models have been displayed to effectively obtain area explicit information and perform better compared to summed-up models. The hybrid CNN-RNN model may perform slightly worse than the VGG-16 model because the LSTM layer requires a higher bit precision than the CNN counterpart.

Keywords: Weight quantization, respiratory audio analysis, CNN, LSTM, and a patient-specific model.

Similarities: Makes use of breathing audio as an input for enhancing data.

Advantages: This model reduces the minimum amount of memory required by four times without sacrificing performance or the ability to classify four classes of the respiratory cycle.

[L].Tamer Elfaramawy, Cheikh Latyr Fall, Soodeh Arab, Martin Morissette, Francois Lellouche and Benoit Gosselin "A Wireless Respiratory Monitoring System Using a Wearable Patch Sensor Network",2018.

The severity of the cough is crucial when dealing with other conditions like chronic obstructive pulmonary disease (COPD). A remote respiratory observing framework with hack discovery is made to gauge the breathing rate and the recurrence of the hack. The respiratory frequency and coughing events are calculated using data processing and fusion algorithms. Through an SPI interface bus, the IMU transmits the data from the accelerometer and gyroscope to the MCU.

The Savitzky-Golay smoothing filter was chosen because it is simple to use and works well in many systems. The thoracic and abdominal cages contain the two sensor nodes. A chest belt served as a point of reference. A performance test was carried out while the observer was moving around to demonstrate its robustness.

Keywords: Coughing detection, breathing rate, inertial measurement unit, wireless, low-power, real-time, wearable, patch sensor network, and data fusion.

Similarities: System for wirelessly monitoring the respiratory system and detecting coughing.

Advantages: The setup takes a lot less time and is easier to use. In order to provide maximum comfort, it makes use of electronic building blocks with low power consumption.

[M].Saba Emrani, Thanos Gentimis, Hamid Krim "Persistent Homology of Delay Embeddings and its Application to Wheeze Detection", April 2014.

The periodic structure of dynamical systems can be quantified through the use of topological methods. The proposed autocorrelation-like (ACL) function of the signals is used in the algebraic topological approach to analyze breathing sound signals for wheeze detection. For periodicity analysis in the time domain, which is a continuous piecewise sinusoidal function with various periods and phases and a time-varying amplitude, strict autocorrelation functions cannot be implemented because breathing sound signals are time-varying and non-stationary. A small number of data points from each point represent the sound signal. Using a subsampling method, the algorithm's computational complexity is reduced.

Keywords: Coughing detection, breathing rate, inertial measurement unit, wireless, low-power, real-time, wearable, patch sensor network, and data fusion.

Similarities: Analyzing breathing sound signals in order to identify wheezes.

Advantages: The method we propose is 98.39 percent accurate.

[N]. Yolanda Castillo-Escario, Ignasi Ferrer-lluis, Josep Maria Montserrat and Raimon Jane "Entropy Analysis of Acoustic Signals Recorded With a Smartphone for Detecting Apneas and Hypopneas: A Comparison With a Commercial System for Home Sleep Apnea Diagnosis", September 5, 2019.

The majority of patients with obstructive sleep apnea (OSA) do not receive treatment or a diagnosis, despite the condition's prevalence. The algorithm for identifying silent events, classifying them as apneas or hypopneas, evaluating how well they work, and comparing the data from three different portable sleep monitors that are primarily based on nasal airflow. The smartphone correctly identifies and categorizes all OSA patients, and the predicted apnea-hypopnea indices are highly consistent between the two systems. Since the majority of hypopneas are heard to be snoring, there was no reduction in noise. OSA is a disease that affects a lot of people, especially the elderly and obese. One of the straightforward, non-invasive methods for determining blood oxygen saturation (SpO2) is pulse oximetry.

Keywords: Biomedical signal processing, mHealth, acoustics, smartphone, monitoring, and sleep apnea.

Similarities: To screen OSA patients at home, the model uses a smartphone that analyzes audio signals.

Advantages: The accuracy of the classification increased to 82%.

[O]. Lukui Shi, Kang Du, Chaozong Zhang, Hongqi Ma, and Wenjie Yan "Lung Sound Recognition Algorithm Based on VGGish-BiGRU", September 19, 2019.

Since lung sounds are intricate and nonstationary signals, it is hard to ascertain their data utilizing regular highlights. The transient qualities of the lung sounds can't be separated by utilizing the traditional convolutional brain organization. BiGRU-VGGish is the lung sound acknowledgment calculation, which depends on move learning and joins the VGGish network with the BiGRU (bidirectional gated repetitive unit brain organization), which can successfully further develop the acknowledgment exactness of lung sounds utilizing state-of-the-art calculations, headways in computerized signal handling and man-made consciousness advances, and customary acoustic. The electronic stethoscope slowly replaces the stethoscope. The wavelet change is utilized to separate lung sound signs into recurrence subbands, and a bunch of measurable elements is taken from the subbands to address the wavelet coefficient dissemination. Rather than different strategies, BiGRU can catch the time series elements of the lung sounds, which works on the precision of the asthma sounds.

Keywords: Mel spectrogram, BiGRU, lung sound recognition, transfer learning, and VGGish.

Similarities: The lung sound data are used to retrain the BiGRU network, which then extracts the sounds from the lungs.

Advantages: In contrast to the most recent algorithms, The proposed algorithm effectively improves lung sound recognition accuracy.

[P]. Pedro Matias, Joao Costa, Andre V. Carreiro, Hugo Gamboa, Ines Sousa, Pedro Gomez, Joana Sousa, Nuno Neuparth, Pedro Carreiro-Martins and Filipe Soares “Clinically Relevant Sound-Based Features in COVID-19 Identification: Robustness Assessment With a Data-Centric Machine Learning Pipeline”,3 October 2022.

By developing a low-cost, non-invasive, and more decentralized technology that can educate people about the COVID-19 infection. The sensitivity scores varied between 60.00% and 80.00% in Coswara and between 51.43% and 77.14% in COVID-19 Sounds. By validating the quality of the samples, segmenting the speech events, and examining interpretable features with their physiological significance, this study takes a data-centric approach. These findings are confirmed by an examination of two huge databases: The COVID-19 Sounds and Coswara datasets were used to explore the audio samples by enhancing the speech types in order to find disease-specific biomarkers. Since speech disturbances and respiratory problems (shortness of breath, dry cough) are some of the most common symptoms of COVID-19 disease, the best results were achieved with an SVM (Support Vector Machine) model (approximately 97% and 98% of sensitivity, respectively). the objective of collecting additional meta-data and describing the respiratory tract using various speech sounds like cough, breath, and voice.

Keywords: Signal processing, feature extraction, data-centric, machine learning, COVID-19, speech, vocal tract.

Similarities: COVID-19 Identification Features Based on Breathing Sound.

Advantages: The COVID-19 detection model may be the most effective obtained performance when evaluating the COVID-19 Sounds dataset.

[Q]. Heng Zhao (Student Member), Hong Hong(Member), Dongyu Miao (Student Member), Yusheng Li, Haitao Zhang, Yingming Zhang, Changzhi Li(Senior Member), and Xiaohua Zhu(Member) IEEE “A Noncontact Breathing Disorder Recognition System Using 2.4-GHz Digital-IF Doppler Radar”.

This paper proposes a noncontact breathing confusion acknowledgment framework for recognizing sporadic breathing examples. A sensor module based on Doppler radar and a breathing disorder recognition module is used in this system. A custom 2.4GHz continuous wave(CW) digital-IF Doppler radar is used as the radar sensor module to precisely record the time-domain breathing waveform. After that, optimized classifiers and selected features are incorporated into a recognition module. In order to provide a comprehensive evaluation of the proposed system, four sets of experiments have been carried out. A linear SVM classifier with seven selected features is used in the proposed system's laboratory experiments to achieve a classification accuracy of 94.7 percent.

Keywords: Non-contact vital sign detection, doppler radar, breathing disorder, and support vector machine.

Advantages: The system's robustness and accuracy in the long-term diagnosis of breathing disorders are demonstrated by clinical experiment results. also demonstrates the possibility of auxiliary disease diagnosis under the proposed solution.

Disadvantages: Only 2.4 GHz is the frequency used in this case. As a result, the procedure can only be carried out with sufficient bandwidth.

[R]. David C. Mack, James T. Patrie, Paul M. Suratt, Robin A. Felder, and Majd Alwan “Development and Preliminary Validation of Heart Rate and Breathing Rate Detection Using a Passive, Ballistocardiography-Based Sleep Monitoring System”,1 JANUARY 2009.

A BCG-based monitoring system is the NAPS system for the analysis of physiological signals. Measurements of heart rate, breathing rate, and musculoskeletal movements are taken with the NAPS Heart Rate Algorithm, the ECG and Pulse Oximetry Heart Rate Algorithm, and the Breathing Rate Algorithm. This demonstrates their potential as a general tool for studying sleep. The NAPS system's measurements of heart rate and breathing rate are compared to the ECG, pulse oximetry, and respiratory inductance plethysmography (RIP).

The BCG system isn't as important for monitoring sleep as other applications like activity tracking because it can't provide data 24 hours a day. The oximeter tracks the oxygen saturation. A SANDMAN computerized sleep system stores all of the data. The NAPS system has difficulty analyzing the data due to the assumption made by the algorithm that heart rate variability is relatively normal.

Keywords: Sleep, home health care, long-term monitoring, and ballistocardiography (BCG).

Similarities: Respiration rate detection monitoring system

Advantages: Accurately measure heart rate.

[S]. Georges Matar, Georges Kaddoum, Member, IEEE, Julie Carrier, Jean-Marc-Lina “Kalman filtering for posture-adaptive in-bed breathing rate monitoring using bed-sheet pressure sensors”,2017.

Abdominal belts are also used to detect breathing movements, while esophageal pressure is typically used to measure breathing effort. The wired thermistor must be attached to the Bucco-nasal area for BR monitoring to measure airflow, causing the subject discomfort. In order to carry out the Kalman filter optimization step, the four-bed postures are identified by means of an artificial neural network (ANN) model.

Following a Bland-Altman (BA) analysis, the Pearson Correlation Coefficient (PCC) is utilized to evaluate the linear relationship that exists between the belt data and the pressure. An unobtrusive method of monitoring one's breathing that makes use of a pressure sensor mattress and can be utilized both at home and in a medical setting. The station-installed developed algorithm and a control interface are included in the software.

Keywords: Unobtrusive monitoring, breathing rate, a mattress with a pressure sensor, respiration, and breathing movements.

Similarities: Respiratory rate monitoring.

Advantages: It is easy to use in clinical settings because there is no obstruction in the field of view (FOV), which prevents patients from being covered.

[T]. Kuo-Kai Shyu, Luan-Jiau Chiu, Po-Lei Lee, Tzu-Han Tung and Shun-Han Yang "Detection of Breathing and Heart Rates in UWBRadar Sensor Data using FVPIEF Based Two-Layer EEMD",2018.

The heartbeat signal is immaterial in light of the fact that it is covered by breathing sounds and messes. The EEMD technique is effective at separating the small heartbeat signal from the large breath signal and gradually enhancing the evaluation of heart and breathing rates as well as breathing conditions. When the UWB sensor is too close to the chest and too far from the person, it reflects a small echo pulse from the back cavity. The cardio-respiratory activity could be used to find this. The position of the first breath can be used to determine the heartbeat rate. The performance of heartbeat detection is unstable, despite the fact that the frequency window was previously selected based on knowledge of the heartbeat rate range. Comparing the significance of a typical vital sign to the heartbeat signal of a healthy patient. The two-layer EEMD method, which selects the FTI and decomposes it into IMFs, makes it possible to effectively obtain both the breathing rate and the heart rate simultaneously.

Keywords: Remote sensing, ultra-wideband (UWB) radar, heart rate, breathing rate, and ensemble empirical mode decomposition (EEMD).

Similarities: A non-contact monitor of vital signals or a tool for remote life detection.

Advantages: Effectively obtaining both breathing rate and heart rate simultaneously is possible. The UWB echo pulse used to simultaneously detect human breathing and heart activity demonstrates that the proposed detecting method is effective.

Paper name	Author	Model/Algorithm used	Advantages	Disadvantages
Estimation of Respiratory Rates Using the Built-in Microphone of a Smartphone or Headset	Yunyoung Nam, Bersain A. Reyes(Student Member) and Ki H. Chon(Senior Member) IEEE	The Welch periodogram and the autoregressive spectrum.	Feasibility of using smartphones together with their built-in and standard headset recorded from smartphone microphones.	Randomly occurring background noise or other noise during acquisition, so the estimation of respiratory rate became difficult.
Tidal Volume and Instantaneous Respiration Rate Estimation using a Volumetric Surrogate Signal Acquired via a Smartphone Camera	Bersain A. Reyes(Student Member), Natasa Reljin, Youngsun Kong(Student Member), Yunyoung Nam(Member) and Ki H. Chon (Senior Member) IEEE.	Acquisition protocol, chest movement recording algorithm.	Implemented an algorithm that is able to track chest movements directly on a smartphone and found promising results in terms of average RR estimation.	Recording of the breathing activity while the subjects were standing still.This method requires further studies to enable practical implementation of the proposed approach.
Deep Learning versus Professional Healthcare Equipment: A Fine-Grained Breathing Rate Monitoring Model	Bang Liu , Xili Dai , Haigang Gong, Zihao Guo, Nianbo Liu, Xiaomin Wang, and Ming Liu.	Deep learning as fine-grained breathing rate monitoring technique.	They are not just monitoring respiratory rates but also the changes in the Respiratory rate while sleeping as well and using various devices such as mobile phones, earbuds.	More data is required to train DeepFilter. It implies that DeepFilter needs to suit more smartphones from different manufacturers.
Estimation of respiratory rate and exhale duration using audio signals recorded by smartphone microphones	Emer P. Doheny, Ben P.F.O'Callaghana, Vit´oriaS.Fahed, J´er´emy Liegey, Cathy Goulding, Silke Ryan, Madeleine M.Lowery.	Data acquisition through smart phone, respiration algorithm , inter- breather Interval detection, Signal quality classification using XGBOOST.	The method presented accurate, low-cost remote monitoring of respiration in large populations frequency of the audio signal.	The system has been evaluated for unsupervised use, Evaluation has to be carried out to check if the system will gives efficiency in supervised use as well or not.
Breathing Rate Estimation from Head-Worn Photoplethysmography Sensor Data Using Machine Learning	Simon Stankoski*, Ivana Kiprijanovska, Ifigeneia Mavridou, Charles Nduka, Hristijan Gjoreski and Martin Gjoreski.	Respiratory rate estimation algorithm which is based on advanced Signal processing and machine learning techniques. Also includes novel quality assesment and motion artifacts removals procedure.	This algorithm uses a window size of 20 s, which is shorter than state-of-the-art approaches, making our algorithm more responsive to physiological changes.	Inability to detect out-of-distribution breathing rate.Because they are trained with data that covers only the normal range of breathing rate.
Multiparameter Respiratory Rate Estimation From the Photoplethysmogram	Walter Karlen*, Member, IEEE, Srinivas Raman, J. Mark Ansermino, and Guy A. Dumont, Fellow.	Smart Fusion RR estimation algorithm.	The Smart Fusion algorithm is being implemented in mobile phone pulse oximeter device to facilitate the diagnosis of severe childhood pneumonia in remote areas.	Detection of lower rates was poor not designed to detect such events.
Time-Reversal Breathing Rate Estimation and Detection	Chen Chen(Student Member) Yi Han, Yan Chen(Senior Member), Hung-Quoc Lai, Feng Zhang(Student Member), Beibei Wang, Senior Member, and K. J. Ray Liu(Fellow)IEEE.	Contact-free breathing monitoring system, Root-MUSIC algorithm.	Demonstrates a perfect detection rate of breathing. A mean accuracy of 99% can be obtained for single-person breathing rate with only 10 seconds of measurement.	The way to detect and discard CSI samples significantly affected by subject andambient motions need to be investigated ,so as to further enhance the robustness of TR-BREATH.
Breathing Rate Monitoring during Sleep from a Depth Camera under Real-life Conditions	Manuel Martinez, Rainer Stiefelhagen.	Early Fourier Fusion algorithm.	Efficient Performance impact related to different sleep conditions, like apnea, position and staging.	Recognition algorithm need to be improved for better results.
Respiratory Rate Estimation from the Built-in Cameras of Smartphones and Tablets	Yunyoung Nam, Jinseok Lee, Ki H.Chon.	The autoregressive (AR)model,variable-frequencycomplex demodulation (VFCDM), and continuous wavelet transform (CWT) approaches.	Both heart rates and breathing rates can be accurately derived from a video signal obtained from smartphones, an MP3 player and tablets with or without a flashlight.	CWT and VFCDM methods gave good estimates but their accuracy degraded with increase in respiratory rates. It test only with the above mentioned mobile devices, whether it will work with the mobile devices of other companies is unknown.
Estimation of Respiratory Rate From Photoplethysmogram Data Using Time–Frequency Spectral Estimation	Ki H. Chon(Senior Member) IEEE, Shishir Dash and Kihwan Ju.	VFCDM algorithm.	The VFCDM method provided the best results in terms of accuracy,consistency(smaller range of the median value) and computational efficiency (less than 0.3 s on 1 min of data) with breathing rates that varied from 12–36 breaths/min.	Breathing rates higher than 26 breaths/min and the real-time performance of these algorithms are not tested yet.

VI. CONCLUSION

The advantages of our proposed method, which performs exceptionally well with very few labeled training examples, are enhanced by the fact that the ICBHI Respiratory Sounds Database is the only publicly available database of labeled respiratory sounds. Using the proposed method, a supervised respiratory rate estimation system can be built with little data. As a consequence of this, the creation of this software might lead to an estimation of human respiration rates that is simple, precise, and highly efficient.

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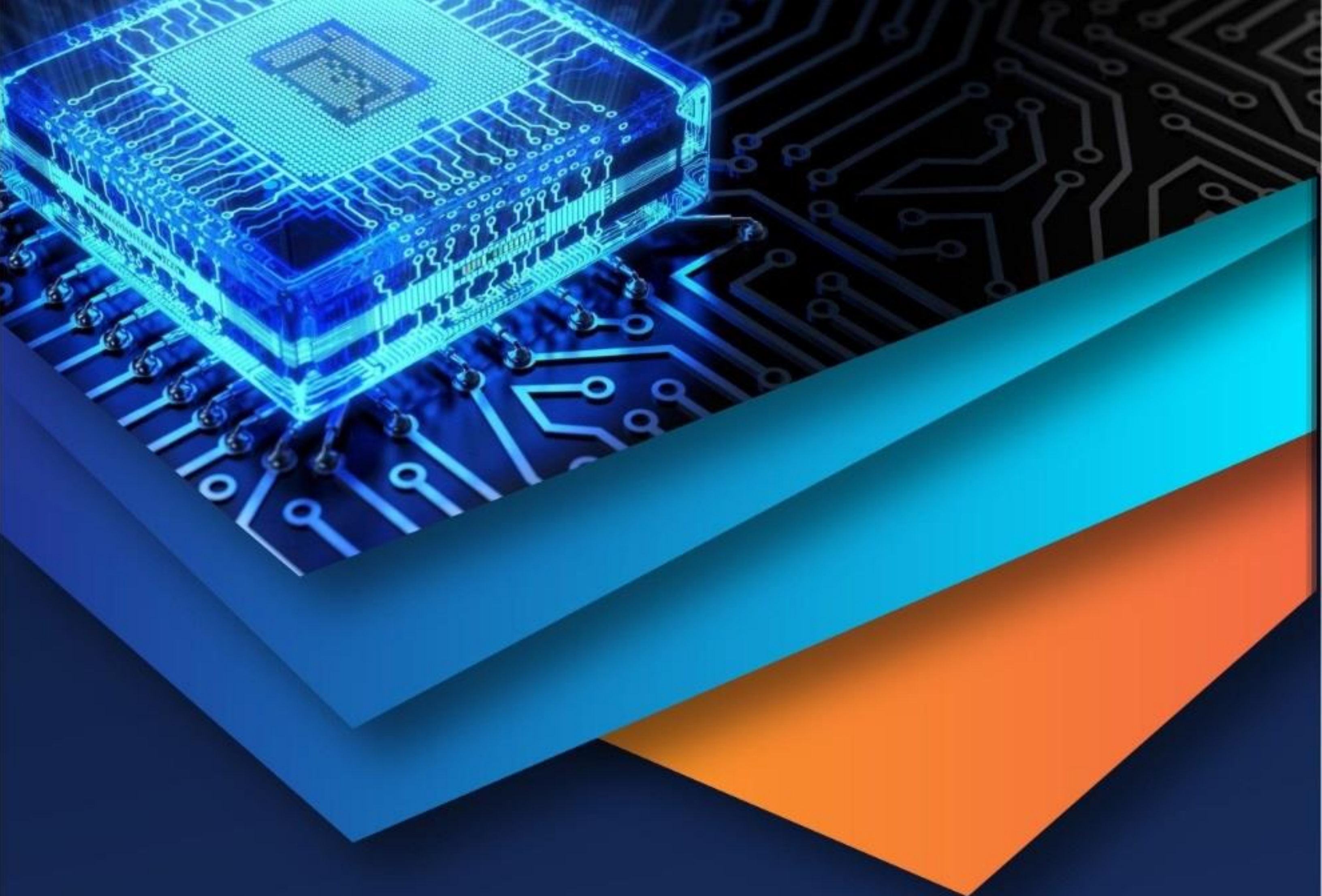

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