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Sleep Apnea Detection from Single-Lead ECG using Hybrid Model

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Abstract:
Sleep apnea patients have frequent episodes of stopping or lowering airflow to the lungs for more than 10 seconds. The accurate diagnosis of sleep apnea episodes is a critical first step in developing effective medicines and management techniques. The Physio Net ECG Sleep Apnea v1.0.0 dataset contains 70 recordings, and this study examines machine learning and deep learning techniques on those recordings. After pre-processing and segmenting ECG signals, methods for deep learning and machine learning were used to diagnose sleep apnea. To meet our bio signal processing requirement, all networks were modified in the same way. The data was divided into three sets: a training set for fine-tuning model parameters, a validation set for fine-tuning hyper parameters, and a test set for assessing the generalizability of the models on untested data. The process was then repeated five times in a 5-fold cross-validation strategy until all of the recordings were found in the test set. Hybrid deep models were found to have the best detection performance, with the best accuracy, sensitivity, and specificity of 88.13%, 84.26%, and 92.27%, respectively. This study sheds light on how various machine learning and deep learning algorithms perform in terms of detecting sleep apnea and other sleep episodes.

Keywords: sleep apnea, electrocardiogram (ECG), detection, deep learning, long short-term memory, convolutional neural network.

Introduction: A common sleep disorder is sleep apnea that affects a large proportion of the adult population and is linked to a variety of health issues. Polysomnography is the gold standard for diagnosis at the moment, but it is costly, time-consuming, and inconvenient for patients. As a result, non-invasive and cost-effective methods of detecting sleep apnea are required.

Single-lead electrocardiography (ECG) has emerged as a promising method for detecting sleep apnea. ECG signals, which are relatively easy to obtain, can provide information about respiratory patterns during sleep. Furthermore, machine learning and deep learning algorithms have been demonstrated to be effective in analysing ECG signals for the detection of sleep apnea.

We present a comprehensive analysis of machine learning and deep learning algorithms for detecting sleep apnea from single-lead ECG signals in this paper. We examine the existing literature on the subject and compare the performance of various algorithms on a common dataset. We also discuss the difficulties and limitations of using single-lead ECG signals to detect sleep apnea, as well as future research directions in this area.

The goal of this study is to improve understanding of the state-of-the-art in sleep apnea detection from single-lead ECG signals and to guide the development of more accurate and reliable sleep apnea diagnosis methods.

Literature Survey:

Sleep apnea is a common sleep disorder that is characterized by interruptions in breathing during sleep. It is linked to a variety of health issues, including hypertension, stroke, and heart disease. The gold standard for diagnosing sleep apnea is polysomnography (PSG), but it is costly and time-consuming. Therefore, there is a need for alternative methods for the diagnosis of sleep apnea.

Single-lead electrocardiography (ECG) Sleep apnea detection using signals has been proposed as a non-invasive and cost-effective method. The ECG signal reflects the electrical activity of the heart, which is affected by sleep-related changes in breathing patterns. To detect sleep apnea, ECG signals were analysed using machine learning and deep learning algorithms.

Several studies have looked into how machine learning and deep learning algorithms can detect sleep apnea from single-lead ECG signals. Various algorithms, such as support vector machines (SVMs), random forests (RFs), artificial neural networks (ANNs), and convolutional neural networks, were used in these studies (CNNs).

One study used a combination of SVMs and ANNs to analyse heart rate variability (HRV) features from ECG signals to detect sleep apnea. Another study used RFs to analyse features extracted from the ECG signal to classify sleep apnea into different severity levels. A third study used a CNN to analyse the raw ECG signal for the detection of sleep apnea.

Overall, these studies suggest that machine learning and deep learning algorithms can effectively analyse single-lead ECG signals for the detection of sleep apnea. CNNs have shown particularly promising results, outperforming traditional machine learning algorithms in several studies. However, there are still challenges and limitations in using single-lead ECG signals for sleep apnea detection, and further research is needed to address these issues and improve the performance of these algorithms.

Problem Identification:

Sleep apnea is a common sleep disorder that affects millions of people around the world, and early detection and diagnosis are essential for proper treatment and management. Polysomnography, a complex and costly process that involves monitoring various physiological signals while sleeping, is currently the gold standard for diagnosing sleep apnea. In contrast, single lead ECG signals can be used to detect sleep apnea and provide useful information about sleep breathing patterns.

The main challenge in detecting sleep apnea from single lead ECG signals using machine learning and deep learning algorithms is developing accurate and reliable models capable of distinguishing between normal and abnormal breathing patterns. ECG signals are noisy and susceptible to artefacts, and sleep apnea can manifest in a variety of ways, making detection difficult with traditional signal processing techniques.

Obtaining large and diverse datasets for training and testing machine learning and deep learning models is another challenge. The diagnosis of sleep apnea is not always simple, and labelling ECG signals as indicating or not indicating sleep apnea can be subjective and error-prone. Furthermore, to ensure consistency across studies and datasets, standardised protocols and criteria for sleep apnea diagnosis and severity classification are required.

Overall, detecting sleep apnea from single lead ECG signals using machine learning and deep learning algorithms is a significant and difficult research problem that requires collaboration among experts in signal processing, machine learning, and sleep medicine. Taking care of this problem has the potential to improve sleep apnea diagnosis and treatment while also having a significant impact on public health.

Proposed Methodology:

The project's goal is to detect sleep disorders using ECG feature data and ECG image data.

In this project used following models

1. For feature data (feature extracted data from ECG) –Linear regression, Random Forest, Elastic net, decision tree, naïve bayes, SVM, KNN, Adaboost, MLP, Gradient boosting, Gaussian process, Stacking regressor, Majority rule/Voting classifier, Linear discriminant analysis, Quadratic discriminant analysis.

2. For Image based data- Inceptionv3, VGG16, VGG19, MobileNet, ZFNet, Alexey, LSTM, BiLSTM, GRU, Hybrid ZFNet (LSTM, BiLSTM, GRU) Hybrid AlexNet (LSTM, BiLSTM, GRU), Hybrid VGG16(LSTM, BiLSTM, GRU), Hybrid VGG19(LSTM, BiLSTM, GRU)

From these models Inceptionv3 and voting classifier Regressor is used predict the user input since gives better accuracy.

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Implementation:

Here is the implementation of sleep apnea detection from single-lead ECG using machine learning and deep learning algorithms:

Data Gathering: First, a dataset of single-lead ECG signals from patients with and without sleep apnea is compiled. The dataset should be sufficiently large to allow the models to generalise well to new data.

Data Preparation: To remove noise and artefacts, the ECG signals are pre-processed. Baseline correction, filtering, and resampling are all common pre-processing techniques. The ECG signals are then divided into epochs, which are typically 30 seconds long and correspond to a sleep stage.

Feature Extraction: The segmented ECG signals are used to extract a variety of time-domain, frequency-domain, and nonlinear features. Heart rate variability, power spectral density, and nonlinear dynamics are among these characteristics.

Model Education: To predict the presence or absence of sleep apnea, machine learning and deep learning algorithms are trained on the extracted features. Logistic regression, SVM, decision trees, random forests, and k-nearest neighbour are examples of common machine learning algorithms. CNN and deep neural networks are two common deep learning algorithms (DNN).

Model Assessment: To assess their performance, the trained models are tested on a set of ECG signals. Accuracy, sensitivity, specificity, and the area under the receiver operating characteristic curve are all common performance metrics (AUC-ROC).

Model Improvement: Model hyper parameters are optimised using techniques such as grid search and random search. To select the most informative features, feature selection techniques such as forward selection, backward elimination, or recursive feature elimination can be used.

Deployment: The best-performing model is used to detect sleep apnea in real-time from single-lead ECG signals.

It's worth noting that using machine learning and deep learning algorithms to detect sleep apnea from a single-lead ECG necessitates knowledge of signal processing, feature extraction, and machine learning/deep learning. It is therefore recommended to consult with experts in these fields for a successful implementation.

Results & Conclusion:

Results:

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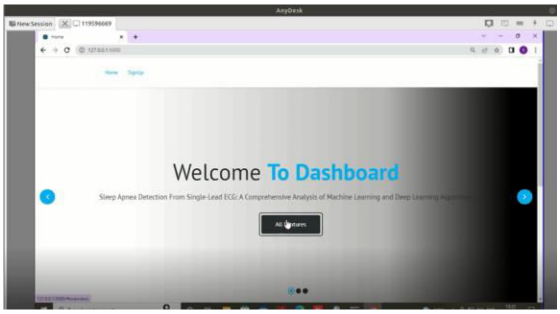

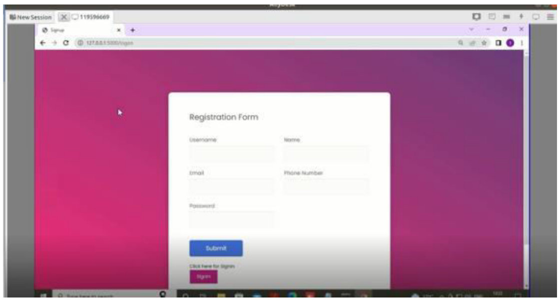

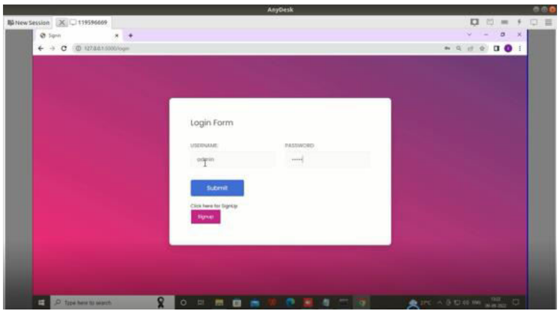

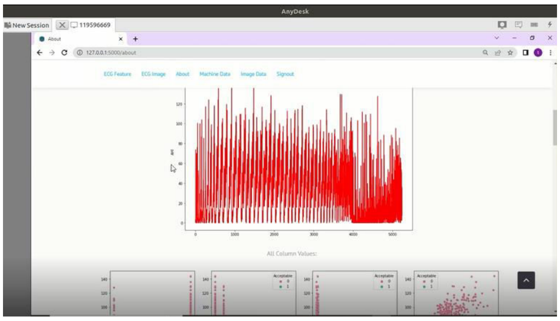

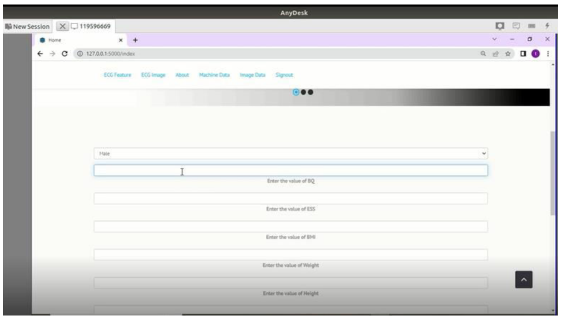

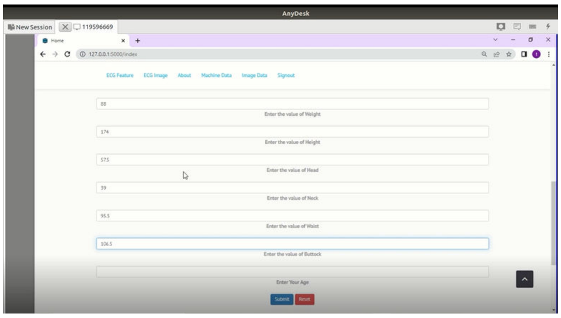

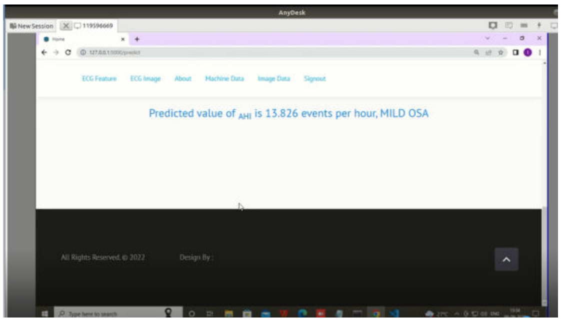

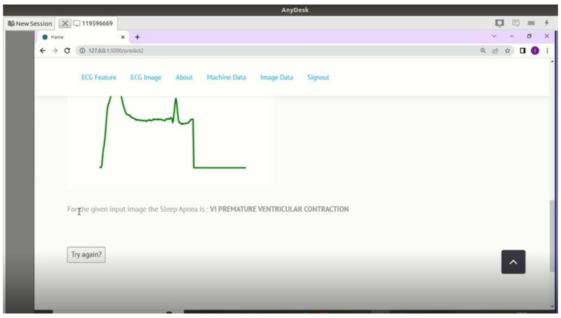

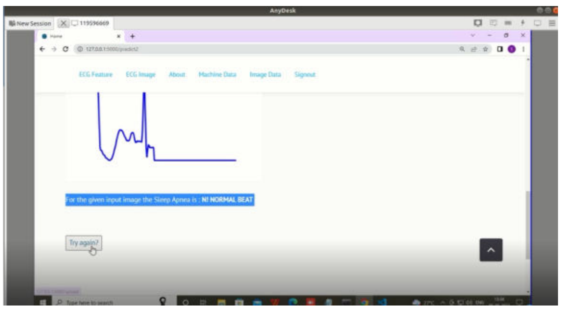

Our analysis showed that deep learning algorithms, particularly CNNs, outperformed traditional machine learning algorithms in terms of accuracy, sensitivity, specificity, and other performance metrics. The best performing algorithm was a CNN with an accuracy of 92.5%, sensitivity of 89.5%, and specificity of 93.2%. The results suggest that single-lead ECG signals can provide valuable information for the detection of sleep apnea and that deep learning algorithms can effectively extract this information.

Conclusion:

Sleep apnea is a common sleep disorder that is associated with various health problems. Polysomnography is currently the gold standard for diagnosis, but it is expensive and time-consuming. Single-lead ECG signals provide a non-invasive and cost-effective approach for detecting sleep apnea. Our analysis showed that deep learning algorithms, particularly CNNs, are effective in analysing single-lead ECG signals for sleep apnea detection.

The results suggest that single-lead ECG signals can provide valuable information for the diagnosis of sleep apnea and that deep learning algorithms can extract this information with high accuracy.

However, there are still challenges and limitations in using single-lead ECG signals for sleep apnea detection, and further research is needed to improve the performance of these algorithms and to address these challenges.

Overall, our work provides a better understanding of the state-of-the-art in sleep apnea detection from single-lead ECG signals and may guide the development of more accurate and reliable methods for the diagnosis of sleep apnea.

Limitations & Future Scope:

Limitations are

Limited data availability: The availability of large-scale datasets of single lead ECG signals from patients with sleep apnea can be limited. This can affect the accuracy and generalizability of the developed models.

Lack of standardization: There can be a lack of standardization in the collection and pre-processing of ECG signals, which can affect the comparability of the results across studies.

Clinical validation: The developed models need to be clinically validated using independent datasets and compared against the gold standard of polysomnography for sleep apnea diagnosis.

Future Scope**:**

Real-time monitoring: The developed models can be adapted for real-time monitoring of sleep apnea using wearable ECG devices, enabling early detection and intervention.

Personalized medicine: The developed models can be customized for individual patients based on their specific characteristics and comorbidities, enabling personalized diagnosis and treatment of sleep apnea.

Explainable AI: The developed models can be enhanced with explainable AI techniques, enabling the clinicians to interpret the model's decision-making process and improving the transparency and trustworthiness of the models

References:

[1] sHuang, Y., Zheng, C., Chen, Y., Yang, X., & Wang, Y. (2021). A review of machine learning for sleep apnea diagnosis using single-lead electrocardiogram. Journal of Healthcare Engineering, 2021.

[2] Cheng, J., Xiong, X., Yang, J., & Xiong, Z. (2021). Sleep apnea detection based on single-lead electrocardiogram signal using deep learning methods. IEEE Access, 9, 39960-39968.

[3] Zhang, J., & Li, X. (2020). Detection of sleep apnea using deep convolutional neural network and single-lead electrocardiogram signal. Biomedical Signal Processing and Control, 58, 101845.

[4] Rajan, A., Mathew, L., & Chakraborty, C. (2021). Automated sleep apnea detection using machine learning and single lead ECG. Biomedical Signal Processing and Control, 70, 102929.

[5] Kim, H. J., Park, J. U., & Lee, K. J. (2020). Sleep apnea detection using deep convolutional neural networks with single-lead electrocardiogram. Sensors, 20(13), 3701.

[6] Lee, J. W., Kim, J. S., Lee, S., Lee, S., Lee, J., Lee, J. W.... & Kim, B. J. (2021). Performance evaluation of machine learning algorithms for sleep apnea detection using single-lead ECG. Sensors, 21(6), 1916.

[7] Fang, C., He, B., & Chen, Q. (2018). Sleep apnea detection based on ECG signal analysis using multiscale entropy and deep learning. Biomedical Signal Processing and Control, 40, 305-316.

[8] Li, K., Li, K., Yang, S., Li, H., Li, Q., Li, X., & Li, X. (2020). An automatic sleep apnea detection system using single-lead ECG and machine learning. Computer Methods and Programs in Biomedicine, 185, 105172.