iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** V **Month of publication:** May 2023

DOI: https://doi.org/10.22214/ijraset.2023.53137

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

Obstructive Sleep Apnea Prediction Using Machine Learning

Prof. Balaji Bodkhe[1], Mandar Phirke[2], Sankalp Oimbe[3], Jayesh Khairnar[4], Amol Kengar [5]
[1, 2, 3, 4, 5] *Department of Computer Engineering, Modern Education Society's College of Engineering, Pune,* Maharashtra*, India*

Abstract: A common sleep problem called obstructive sleep apnea (OSA) is characterized by periodic breathing pauses while you're asleep. For OSA to be effectively treated and related health concerns to be avoided, an early and precise diagnosis is essential. Machine learning approaches have become effective tools in recent years for managing and diagnosing OSA. The research that used machine learning techniques for OSA detection and prediction are reviewed in detail in this publication. A large dataset made up of polysomnography recordings and clinical data from OSA sufferers was gathered in order to achieve this. Using this dataset, many machine learning models were trained to categorize the severity levels of OSA or predict the occurrence of OSA, including support vector machines, random forests, and deep neural networks. The findings demonstrated the powerful ability of machine learning algorithms to recognize OSA and distinguish between various severity levels. These models outperformed conventional diagnostic techniques in terms of high sensitivity and specificity rates. To further shed insight on the underlying patterns and processes of the illness, feature selection approaches were used to determine the most pertinent physiological parameters for OSA detection. The effectiveness and precision of screening and therapy strategies may be improved by incorporating machine learning algorithms into OSA diagnosis. This study advances our understanding of the use of machine learning in sleep medicine and paves the door for the creation of automated and individualized OSA diagnostic tools.
Keyword: Machine Learning, algorithms, apnea-hypopnea index (AHI), Obstructive sleep apnea (OSA) disease, Support vector machine, random forest algorithm.

I. INTRODUCTION

Obstructive sleep apnea (OSA) is a common sleep disorder affecting a significant portion of the population. It is characterized by recurrent cases of partial or complete apnea during sleep, leading to sleep disturbances and hypoxia. OSA is associated with many health risks, including cardiovascular disease, daytime sleepiness, cognitive decline, and reduced quality of life. Therefore, accurate and timely detection of OSA is crucial for effective diagnosis and appropriate treatment.

Machine learning algorithms have demonstrated great potential in a variety of fields, including healthcare, by efficiently analyzing large data sets and extracting valuable patterns and insights treat. In the context of OSA, machine learning algorithms can use features extracted from physiological signals, such as electroencephalogram (EEG), electrocardiogram (ECG), airflow and oxygen saturation, to develop models capable of accurately classifying OSA severity or predicting OSA presence.

One of the main advantages of using machine learning in OSA diagnostics is its automation and scalability. By developing powerful and accurate machine learning models, it is possible to streamline the diagnostic process and reduce the burden on sleep laboratories. This could allow broader access to OSA diagnosis and speed the initiation of treatment for those affected. Several studies have investigated the application of machine learning algorithms in OSA detection and classification. These studies used a variety of machine learning techniques, including support vector machines, random forests, decision trees, artificial neural networks, and deep learning models. By training these models on a comprehensive dataset that includes physiological signals and clinical information from OSA patients, researchers have obtained promising results for accurately identifying OSA and distinguish between different degrees of severity. Apnea-Hypopnea Index (AHI) index is used to determine the levels of OSA in which (AHI 5), mild (AHI is in 5–14), moderate (AHI is in 15–30), and severe (AHI 30) respectively.

In addition, feature extraction and selection techniques were used to identify the most suitable physiological features for OSA detection. This process reduces computational complexity, improves model interpretability, and provides valuable insight into the underlying OSA models and mechanisms. The integration of machine learning algorithms in OSAS diagnostics has the potential to revolutionize the field of hypnotics. By harnessing the power of machine learning, clinicians and researchers can develop automated and personalized diagnostic tools for OSA. These tools can not only improve the efficiency and accuracy of screening and management, but also contribute to a better understanding of the pathophysiology of OSA. In summary, OSA is a common sleep disorder with important health implications.

The use of machine learning techniques in OSA detection and classification holds promise for improving the diagnostic process. By taking advantage of physiological signals acquired during sleep, machine learning models can accurately identify OSA and distinguish between severity levels. The development of automated and personalized OSA diagnostic tools could improve access to diagnosis and enable prompt initiation of treatment. In addition, application of machine learning can provide valuable insights into the underlying mechanisms of OSA, enhancing our understanding of this complex disorder.

II. PROBLEM STATEMENT

The sleep disorder obstructive sleep apnea (OSA) has long-term effects. Cardiovascular disorders and sleep-related problems are examples of long-term impacts. A polysomnogram, an overnight sleep test, is frequently used to diagnose OSA. Long diagnostic wait times can make monitoring expensive. So, in this study, we developed a machine learning-based OSA prediction system to determine if a patient has obstructive sleep apnea or not.

III. PROPOSED SYSTEM

In the proposed system, we have built machine learning algorithm based OSA prediction system using Random Forest algorithm and Support vector machine. Based on the patient medical inputs that are entered by the user the disease is predicted. In this prediction system we are going to predict apnea disease.

In obstructive sleep apnea prediction, there is possible to predict obstructive sleep apnea at a time. So, by which user doesn't need to go for heavy systems initially which will save the time and money.

IV. LITERATURE REVIEW

According to the paper, this paper focuses about as obstructive sleep apnea is one of the dangerous diseases in the world. OSA can cause many varieties of disorders to the patients which includes heart disease etc. In this paper author has used machine learning algorithms to find out disease.

The results that we obtained show very good ability to identify patients with OSA using data collected during wakefulness and deployment of machine learning techniques. These promising results can be the seed for a new diagnostic modality that allows rapid diagnosis and treatment without the need for overnight sleep testing. More experiments and data are needed to optimize this method and select more discriminatory features, which is subject of future studies [1].

The study in "SmartCare: A Symptoms Based Disease Prediction Model Using Machine Learning Approach" introduces SmartCare, a machine learning-based disease prediction algorithm based on symptoms. With the help of machine learning algorithms, SmartCare seeks to reliably detect diseases using symptom data. The algorithms in the model are trained and optimized using a sizable dataset of symptoms and associated disease diagnoses. The development and assessment of SmartCare utilizing different machine learning methods, including decision trees, random forests, support vector machines, and neural networks, are covered in the study. These algorithms examine the symptom data and identify patterns to anticipate outcomes in cases that have not yet occurred. Metrics including accuracy, precision, recall, and F1 score are used to evaluate the model's performance. The outcomes show how well SmartCare does disease prediction based on symptoms. The model achieves excellent accuracy and exhibits the potential in helping medical practitioners identify disorders early and treat them effectively. SmartCare offers the potential to increase healthcare decision making and patient outcomes by utilizing machine learning. In conclusion, SmartCare is a machine learning-based disease prediction model based on symptoms. The model has the potential to help medical personnel identify patients more quickly and provide better care because it accurately predicts diseases based on symptoms. To guarantee its dependability and performance in actual healthcare settings, more study and validation are required [2].

The study "Diagnosis of Obstructive Sleep Apnea during Wakefulness Using Upper Airway Negative Pressure and Machine Learning", instead of using conventional techniques that call for nightly sleep testing, researchers concentrated on developing a means to identify obstructive sleep apnea (OSA) in people while they are awake. OSA, a sleep disorder that can have negative effects on one's health, is characterized by frequent breathing pauses while one is asleep. The researchers used machine learning methods and upper airway negative pressure (NP) to accomplish this. To diagnose OSA and gauge its severity, participants underwent nocturnal polysomnography (PSG), which is regarded as the gold standard in the field. The subjects in separate tests were then exposed to NP while they were awake. Participants' airflow waveforms were recorded during these experiments. These waveforms' shape properties and other features were retrieved by the researchers as more accurate diagnostic performance.

The findings of this study suggest that using NP and machine learning techniques has the potential to diagnose OSA during wakefulness, providing an alternative to conventional overnight sleep tests. This approach could make OSA diagnosis more accessible, convenient, and less intrusive for individuals, potentially leading to earlier detection and treatment.[3]

The goal of the paper "Sleep Apnea Event Prediction Using Convolutional Neural Networks and Markov Chains" by Rim Haidar, Irena Koprinska, and Bryn Jeffries is to forecast sleep apnea occurrences using machine learning methods. A sizable portion of adults suffer from sleep apnea, a breathing disorder that is frequent. The authors suggest three techniques for anticipating sleep apnea occurrences based on Markov chains and convolutional neural networks (CNNs). analyzing the data from the previous 60 seconds, they anticipate apnea and hypopnea events within a 30-second window by analyzing respiratory signals such as nasal flow, abdominal, and thoracic signals. On a sizable dataset with 48,000 examples from 1,507 people, the effectiveness of the suggested strategies is assessed. The accuracy of 80.78% and the F1 score of 80.63% obtained in the results show the CNN method's efficacy. The authors also examine the Markov chain laws and offer information on how apnea and regular events change with time. The linked works discussed above use feature engineering and neural networks to produce accurate predictions. Overall, this research advances the use of machine learning techniques to predict sleep apnea events and offers insights into the potential of CNNs and Markov chains in this field.[4]

The study's main goal is to forecast diseases using symptoms and machine learning methods. Using symptoms to predict diseases can help in early discovery and prompt treatment, improving patient outcomes. Large datasets of symptoms can be analyzed using machine learning algorithms to find trends and provide precise disease predictions. The research investigates the use of different machine learning techniques, including neural networks, support vector machines, decision trees, and random forests, for illness prediction. These algorithms are trained using a dataset that includes disease classifications and symptoms. The computers can forecast new, unforeseen cases based on their symptoms by learning from this data. The major objective of the project is to predict diseases using symptoms and machine learning techniques. In order to improve patient outcomes, early diagnosis and fast treatment are two benefits of using symptoms to forecast diseases. Machine learning algorithms can be used to examine large datasets of symptoms to uncover trends and make accurate disease predictions. The study examines the application of various machine learning methods, such as neural networks, support vector machines, decision trees, and random forests, to the prediction of sickness. A dataset with disease diagnoses and symptoms is used to train these algorithms. By studying this data, computers can forecast future, unforeseen cases based on their symptoms [5]

The research paper titled "Obstructive Sleep Apnea Prediction Using Deep Learning Techniques" presents a unique method for predicting OSA using deep learning. The authors analyze and categorize sleep data using a variety of deep learning approaches, including convolutional neural networks (CNNs) and recurrent neural networks (RNNs). The suggested approach seeks to precisely predict OSA, a prevalent sleep disease, by utilizing the power of deep learning. In order to enhance patient outcomes and provide the right interventions, the paper emphasizes the significance of early OSA detection and prediction. The algorithm can automatically learn and extract significant elements from sleep data according to the deep learning techniques used in the study, enabling precise OSA prediction. The outcomes reveal promising OSA prediction ability, highlighting the promise of deep learning for improving the detection and treatment of sleep disorders. In conclusion, the study offers a novel method for anticipating obstructive sleep apnea utilizing deep learning approaches. The model efficiently analyses and categorizes sleep data to determine whether OSA is present using CNNs and RNNs. In terms of prediction accuracy, the suggested method shows encouraging results. It also has the potential to improve the early identification and treatment of sleep disturbances, which will eventually help people who are at risk of OSA [6].

In the study "A New Method for Self-Estimation of the Severity of Obstructive Sleep Apnea Using Easily Available Measurements and Neural Fuzzy Evaluation System", We describe a unique approach for assessing the severity of one's own OSA using easily available data and a neural fuzzy evaluation system. The authors provide a doable strategy that enables people to evaluate the severity of their OSA without specialized equipment or a specialist evaluation. The technique makes use of readily available measures, including neck circumference, age, gender, and body mass index (BMI), which are entered into a neural fuzzy evaluation system. This approach offers a thorough assessment of OSA severity by combining fuzzy logic and neural network algorithms. Using this technique, people can get a rough idea of how severe their OSA is, which can assist in direct subsequent steps like getting medical advice or looking into treatment alternatives. This method's ease of use and accessibility make it a useful tool for gauging one's own OSA severity. In conclusion, the study report proposes a unique technique for determining the severity of OSA utilizing metrics that are easily accessible and a neural fuzzy grading system. This method enables people to understand their OSA status, permitting early intervention and suitable treatment techniques [7]

The study “Explainable machine learning for sleep apnea prediction”, the Author links an open overlay panel The use of explainable machine learning approaches for sleep apnea prediction is covered in the research article. A common sleep disorder called sleep apnea is characterized by breathing interruptions while you’re asleep. The capacity of machine learning models to predict sleep apnea occurrences has shown promise, but its interpretability restricts both their practical application and our ability to comprehend the underlying processes that influence the predictions. The use of explainable machine learning techniques to increase the interpretability of sleep apnea prediction models is explored in this work. These techniques seek to provide light on the traits and tendencies that the models employ when making predictions. Clinicians and researchers can learn crucial information for making decisions about diagnosis and treatment by comprehending the crucial aspects that affect sleep apnea prediction. The work underlines the significance of interpretability in healthcare applications and shows the efficacy of explainable machine learning algorithms in sleep apnea prediction. The results imply that transparent and interpretable outcomes can be produced by explainable models, assisting in the comprehension and acceptance of machine learning models in the medical industry. In order to improve clinical decision-making and patient care, the research emphasizes the necessity for explainable methodologies in sleep apnea prediction [8].

The study “Sleep Apnea Events Detection Using Deep Learning Techniques” provides a unique method for detecting sleep apnea events. To analyze and categorize sleep signals, the authors use a variety of deep learning approaches, including Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) networks. The suggested model intends to precisely identify sleep apnea events, which are essential for diagnosing and treating sleep disorders, by utilizing the power of deep learning. The importance of reliable sleep apnea event detection in enhancing patient outcomes and directing treatment choices is emphasized in the paper. The model can automatically learn and extract useful features from sleep signals according to the deep learning techniques used in the study, which facilitates efficient event classification. The findings show the potential of deep learning for improving the diagnosis and management of sleep disorders by demonstrating promising performance in recognizing sleep apnea occurrences. In conclusion, the study proposes a novel method for employing deep learning to identify sleep apnea occurrences. The model efficiently analyses and categorizes sleep signals to detect sleep apnea occurrences by utilizing CNNs and LSTM networks. The suggested approach gives encouraging accurate findings and has the potential to enhance the identification and treatment of sleep disorders, thereby enhancing patient care [9].

The study paper “Diagnostic Accuracy of Obstructive Airway Adult Test for Diagnosis of Obstructive Sleep Apnea” focuses on assessing the diagnostic precision of the Obstructive Airway Adult Test (OAAT) in identifying OSA. The common sleep disorder OSA is characterized by recurrent bouts of whole or partial obstruction of the upper airway while sleeping, which can cause breathing problems and pose health hazards. For the illness to be properly managed and treated, an accurate OSA diagnosis is essential. The goal of the study is to evaluate how well the OAAT performs as a screening tool for OSA by contrasting its findings with those of the gold-standard diagnostic technique, polysomnography (PSG). They then contrasted the findings to ascertain the OAAT’s diagnostic precision. The study’s conclusions show that the OAAT has good diagnostic precision for detecting OSA. The test has a relatively high degree of specificity and is helpful in identifying upper airway blockage, a major aspect of OSA. This implies that OAAT can be used as a trustworthy and affordable screening tool, enabling medical practitioners to recognize people at risk for OSA and to facilitate early intervention and treatment. The authors place a strong emphasis on the use of readily available, non-invasive diagnostic instruments like the OAAT in advancing OSA diagnosis and treatment [10].

V. SYSTEM REQUIREMENT

A. *Software Requirements*

1) Operating System: Windows 10
2) Front End: HTML, CSS, Bootstrap, JavaScript
3) Back End: Python, Flask
4) IDE: VS Code, PyCharm

B. *Hardware Requirements*

1) Processor: Intel Core I3 or Higher
2) RAM: Minimum 2GB and recommended 8GB or More
3) Operating System: Windows, IOS, Android, Linux
4) Bandwidth: 2 Mbps or more

VI. METHODOLOGY

1) *Data Gathering:* This entails gathering clinical and physiological data from sleep examinations, such as polysomnography, from people who may have obstructive sleep apnea. Clinical data include demographics and medical history.
2) *Data Preprocessing:* This involves cleaning and preprocessing the collected data, which may include data normalization, feature extraction, and feature selection.
3) *Development of a Machine Learning Model:* Based on the preprocessed data, a machine learning model is created to predict the existence and severity of obstructive sleep apnea. The model may employ a number of techniques, including deep neural networks, support vector machines, logistic regression, and random forests.
4) *Model Evaluation:* In this step, the effectiveness of the machine learning model is assessed using the right metrics, including accuracy, AUC, sensitivity, specificity, and F1 score. For this, hold-out validation techniques as well as cross-validation techniques may be employed.
5) *Model Optimization:* Model optimization entails enhancing the performance of the machine learning model by modifying its hyperparameters or by employing methods like ensemble learning, feature engineering, or transfer learning.
6) *Implementation and interpretation:* This integrating the machine learning model into a program or system that can forecast obstructive sleep apnea. Clinicians should be able to input patient data and obtain the model's output through the system's interface. In order to promote openness and interpretability, the system should also be able to explain how the model arrived at its forecast.
7) *Validation and Monitoring:* Monitoring the performance of the deployed model over time to make sure it continues to be accurate and dependable is part of the validation and monitoring process. To ensure its efficacy, the model should be periodically reviewed and changed as required.

A. Architecture Diagram

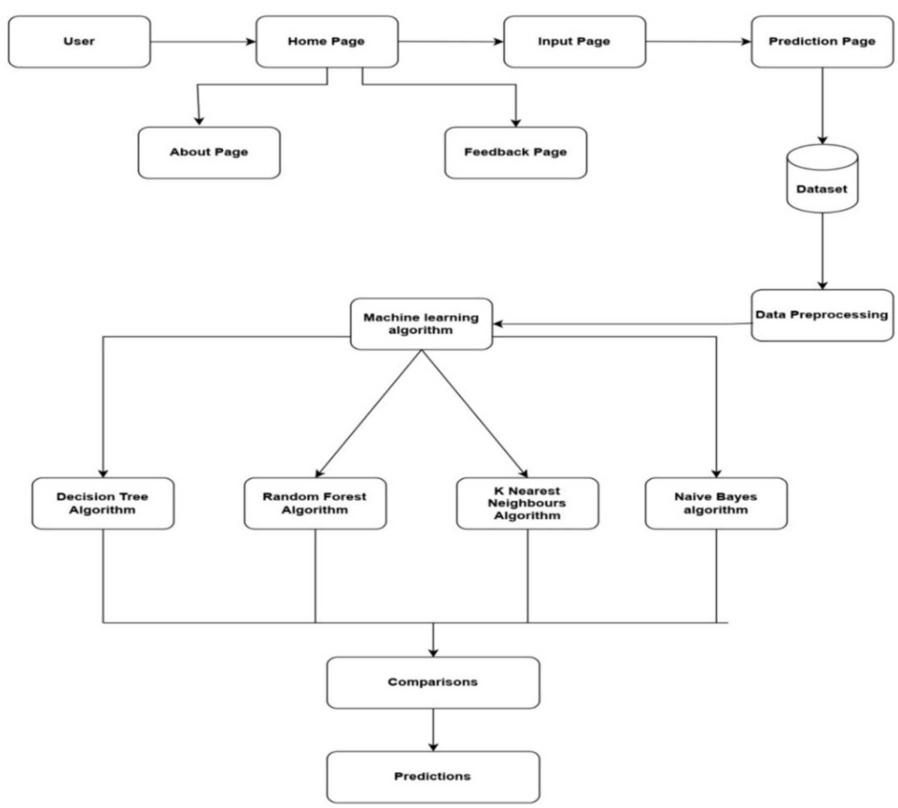

Fig 5.1: Architecture Diagram

In the above diagram, we have experimented on obstructive sleep apnea prediction. From first step, user want to enter the medical attributes then based on inputs, the machine learning-based OSA prediction to determine if a patient has four states of obstructive sleep apnea or not.

In next step we have imported the dataset. Once we have imported the dataset then visualization of each inputted data takes place. After visualization the next step pre-processing of data takes place where we check outliers, missing values and also scale the dataset then on the updated dataset we split the data into training and testing. Next is on the training dataset we had applied various like random forest algorithm. Then we build a pickle file for disease. The pickle file is integrated with the Flask framework for the on the webpage.

VII. IMPLEMENTATION

A. *Algorithm Used*

Random Forest Algorithm:

An effective supervised learning method is Random Forest, a well-known machine learning algorithm. Both Classification and Regression issues in ML can be solved with it.

It is based on the idea of ensemble learning, which is the act of integrating different classifiers to address a complicated issue and enhance the performance of the model.

As the name suggests, "A random forest is a classifier that takes a set of decision trees for different subsets of a given dataset and averages them to improve the prediction accuracy of that dataset."

Instead of depending on a single decision tree, the random forest takes the prediction from each tree and guesses the result based on the predictions that have received the most votes.

First, N decision trees are combined to generate the random forest, and then predictions are made for each tree that was produced in the first phase.

The stages and graphic below can be used to demonstrate the working process:

Step 1: Pick K data points at random from the training set.

Step 2: Create the decision trees linked to the subsets of data that have been chosen.

Step 3: Select N for the size of the decision trees you wish to construct.

Step 4: Repeat the steps 1 and 2

Step 5: Assign new data points to the category that receives the majority of votes by looking up each decision tree's predictions for the new data points.

B. *Performances Metrics Formula*

- $Accuruay = (T + TN) / (TP + FP + FN + TN)$
- $Precision = (TP) / (TP + FP)$
- $Recall = (TP) / (TP + FN)$
- $F1Score = (2 + Recall + Precision) / (Recall + Precision)$
- $Log\ Loss = -\frac{1}{n}\sum\big(\log(pi) * (yi)\big) + \big((1 - yi) * \log(1 - pi)\big)$

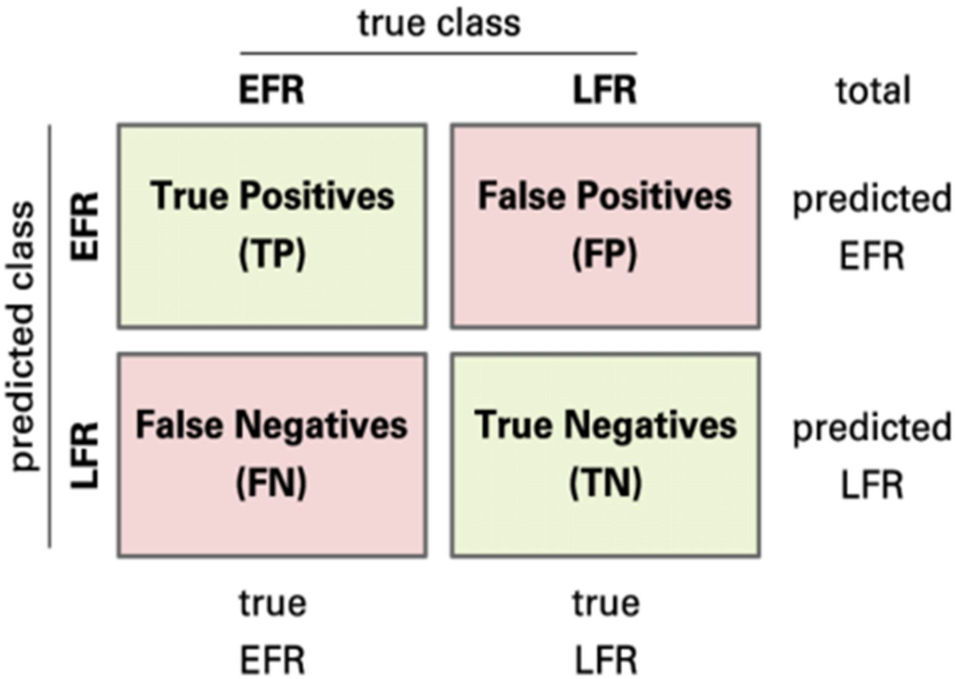

Fig 6.1: Confusion Matrix

VIII. RESULT

In the system, we have used Machine learning especially random forest algorithm for the prediction. When the patient will input the values in system according to that it will show whether the patient has a disease or not. The parameters will show the range of the values needed. The entered value is not between the ranges or is not valid or is empty it will show the warning sign that add a correct value.

	Accuracy	Precision	Recall	F1-Score	Time
Random Forest	91	91	91	91	0.82
Decision Tree	83.1	86	90	86	0.04
Extra Trees	90.3	90	86	90	0.57
Logistic Regression	52.2	52	52	51	0.38
SVC	56.1	58	56	55	3.87
KNN	83.1	83	83	82	0.11
Gaussian NB	57.5	58	58	57	0.57
Linear SVC	31.3	30	31	21	1.32

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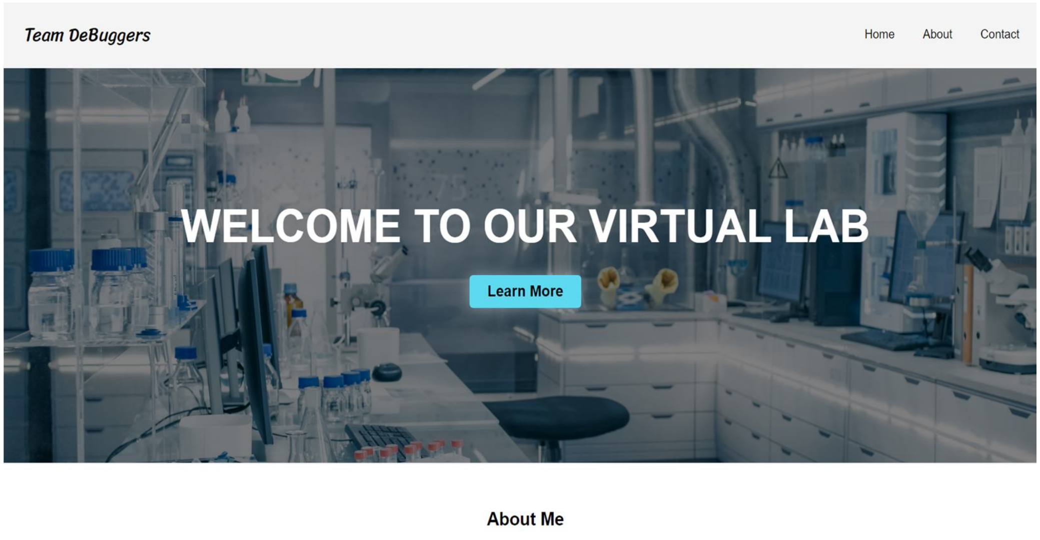

Fig. 8.1: Welcome Page

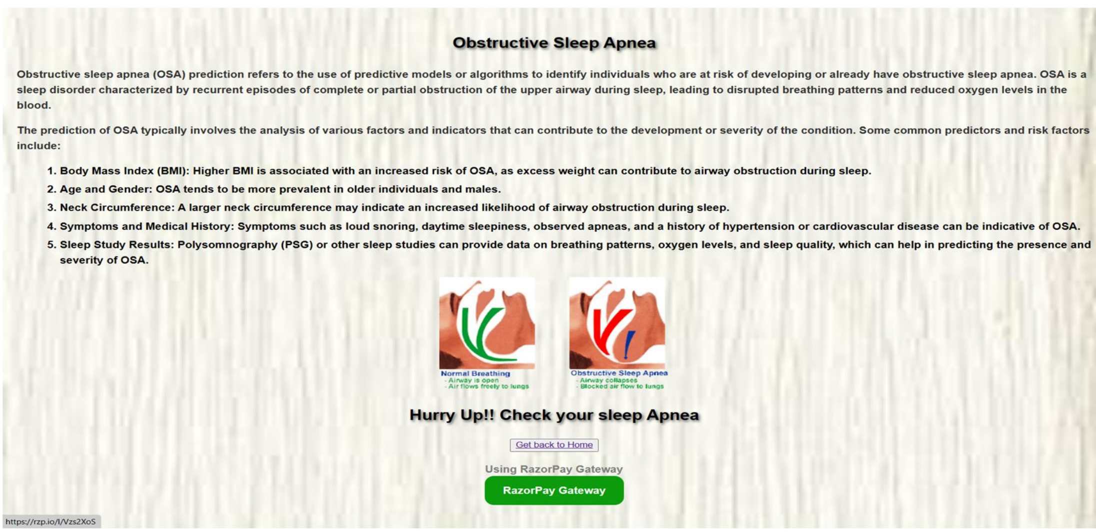

Fig. 8.2: Disease Information field with payment field

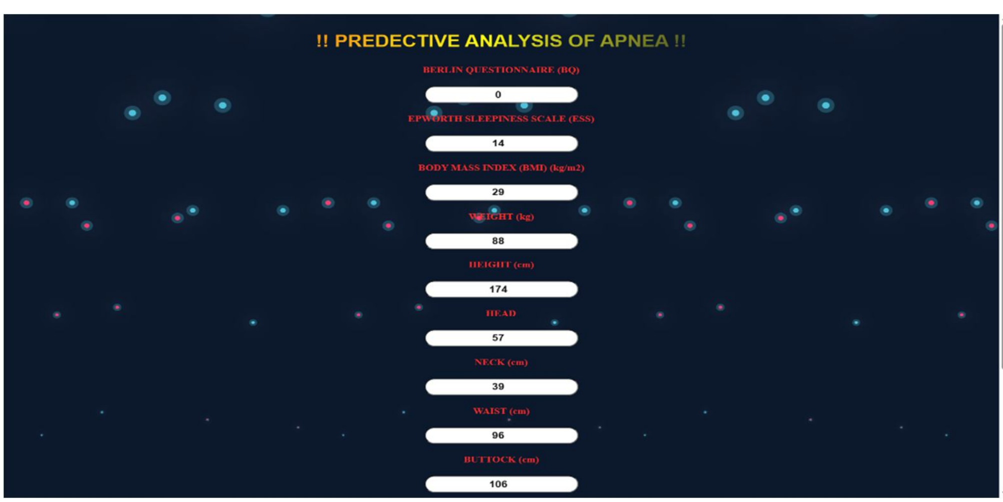

Fig. 8.3: Disease Input Data field

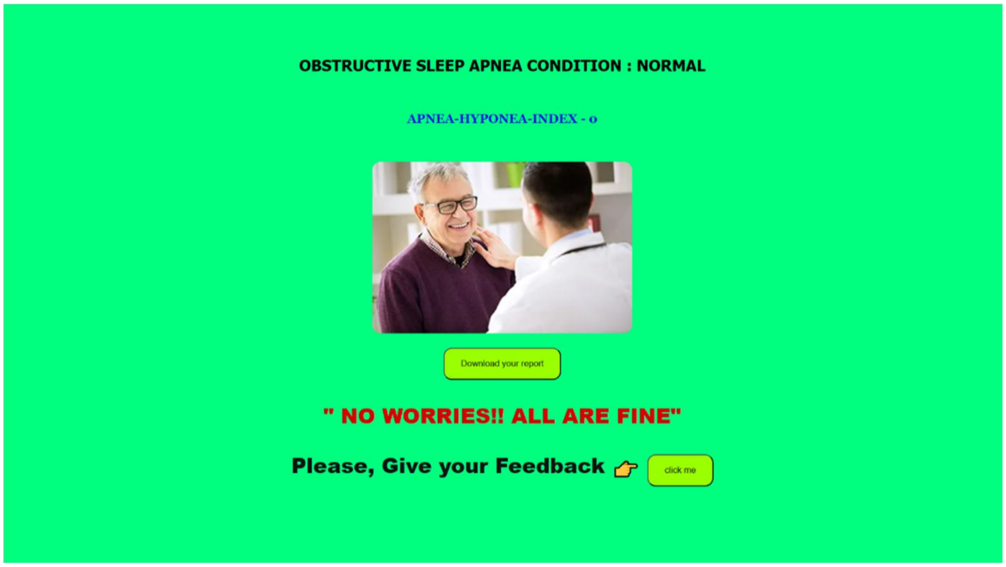

Fig. 8.4: Disease Prediction Normal Stage Output

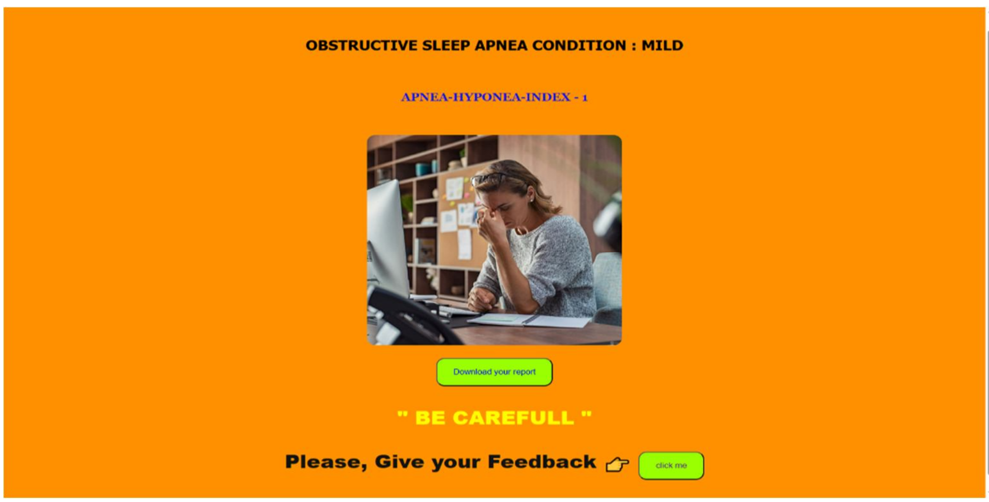

Fig. 8.5: Disease Prediction Mild Stage Output

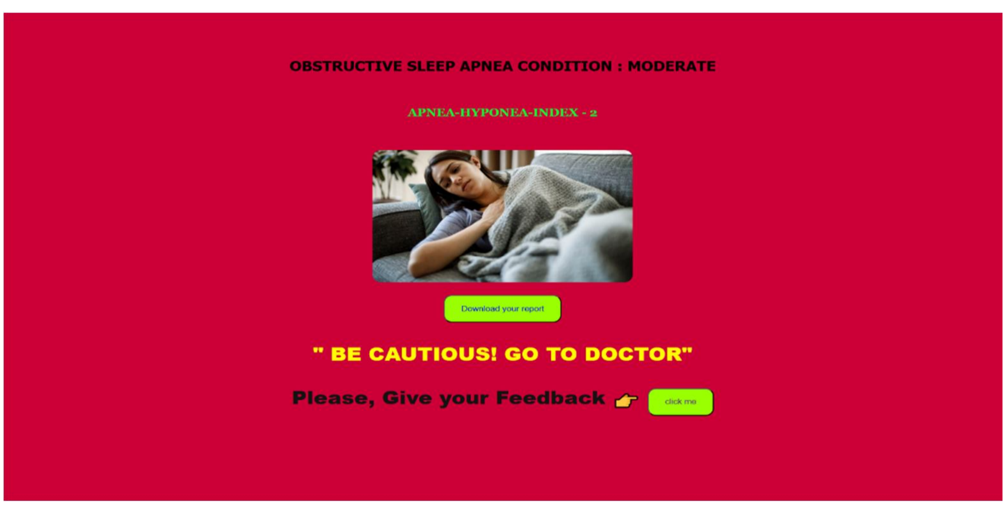

Fig. 8.6: Disease Prediction Moderate Stage Output

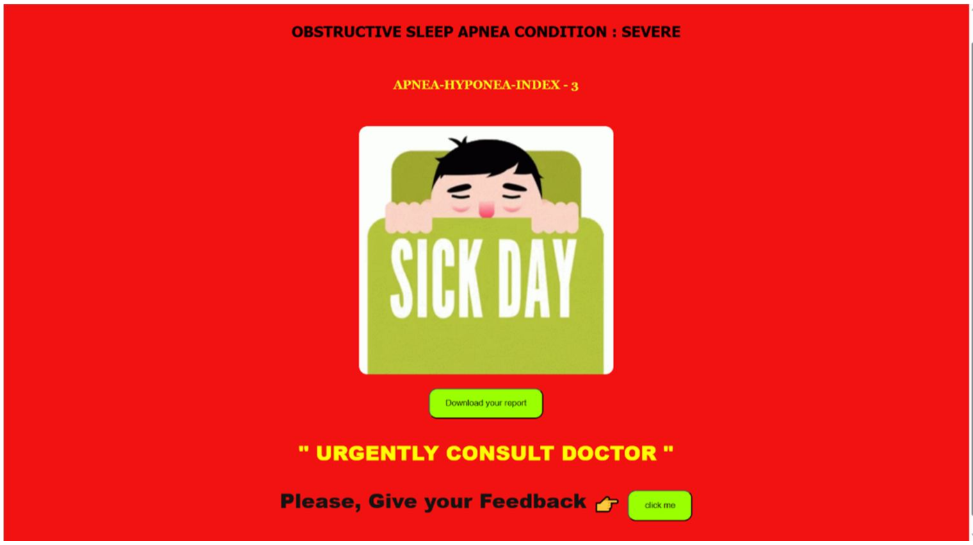

Fig. 8.7: Disease Prediction Severe Stage Output

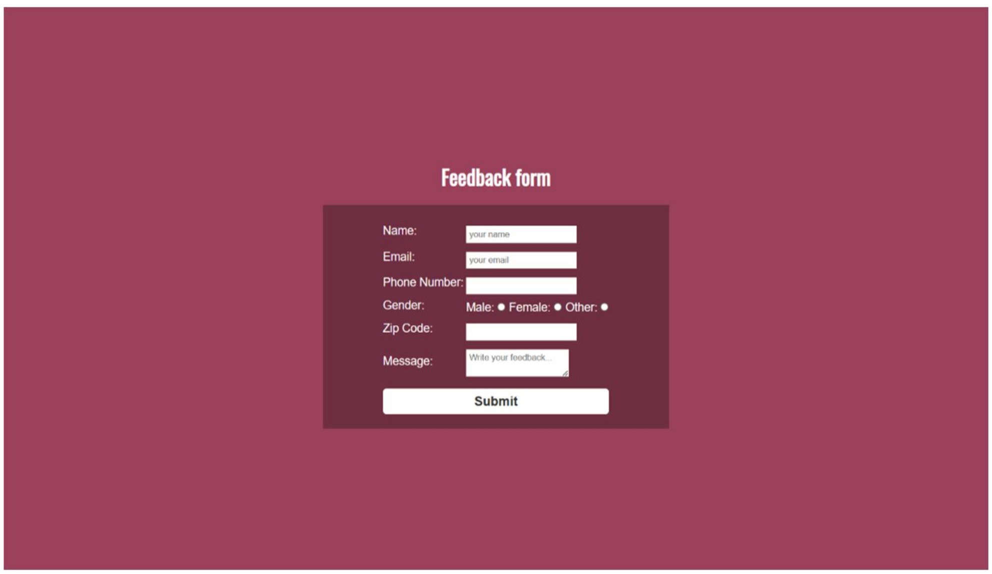

Fig. 8.8 Disease Prediction Feedback form

IX. CONCLUSION

Predicting the disease earlier can improve the patients' health. The aim of this project is to predict obstructive sleep apnea diseases based on patient inputs. The project is built in such a way that the system takes the patients measurements as input and generates an output, which is nothing but the disease prediction. This model can help to reduce the cost required in dealing with this disease and also help to improve the recovery process. By using this system patient can reduce the money required for treatment and can save the time. In this review, we addressed the different machine learning (ML) methods that have been applied to OSA prediction, including the logistic regression, random forest, convolutional neural network, and deep neural network. These algorithms provide tailored prediction models for specific individuals based on a number of physiological and clinical variables, including demographic information, anthropometric measurements, and polysomnography results.

In conclusion, ML algorithms have the potential to increase the precision and effectiveness of OSA diagnosis. To verify these models in larger and more diverse populations and to address the difficulties in interpreting and applying these models in clinical practice, additional research is required. The field of sleep medicine could be completely changed by machine learning algorithms, which would also benefit patients with OSA.

Overall, these papers demonstrate the potential of machine learning algorithms in predicting OSA, and highlight the importance of incorporating both physiological and clinical features in the models. The latest research is showing that the combination of different machine learning algorithms and the use of novel features can improve the performance of OSA prediction models, which could have significant implications for the diagnosis and treatment of this sleep disorder. This model can help to reduce the cost required in dealing with this disease and also help to improve the recovery process. By using this system patient can reduce the money required for treatment and can save the time.

X. FUTURE SCOPE

The future scope of obstructive sleep apnea (OSA) prediction using machine learning is quite promising, and there are several potential directions for further research and development in this field. Possible future directions include the following, among others.

1) *Customized OSA Prediction:* Presently, OSA prediction models are based on data from the general population and may not take into account physiologic variations between individuals and other OSA-influencing variables. It might be possible to create tailored OSA prediction algorithms in the future that use patient-specific data to raise the predictive accuracy.
2) *Real-time Monitoring:* OSA prediction models can be used to monitor patients and alert medical personnel to any sudden changes in OSA risk or severity. These real-time monitoring devices can aid clinicians in the early detection of complications and the avoidance of those complications.
3) *Wearable Tech:* Wearable tech can be used to gather physiological data in a non-invasive manner and includes smartwatches, fitness bands, and other sensors. Future wearable technology may incorporate OSA prediction algorithms, allowing for real-time feedback and continuous monitoring.
4) *Integration with Telemedicine:* OSA prediction models can be integrated into telemedicine systems to provide remote OSA monitoring and diagnosis. Telemedicine is quickly expanding. In places where access to sleep clinics is limited, this can be extremely useful.
5) *Prediction Models that Combine Many Factors:* Obesity, cardiovascular disease, and diabetes are frequently co-occurring conditions with OSA. Future prediction models may incorporate information from several medical problems to offer a more thorough evaluation of OSA risk and severity.

In future, we can add more features in exiting prediction system. We can try to increase the accuracy of prediction of disease to reduce the morality. Also, we can try to make the system more user friendly by adding new features.

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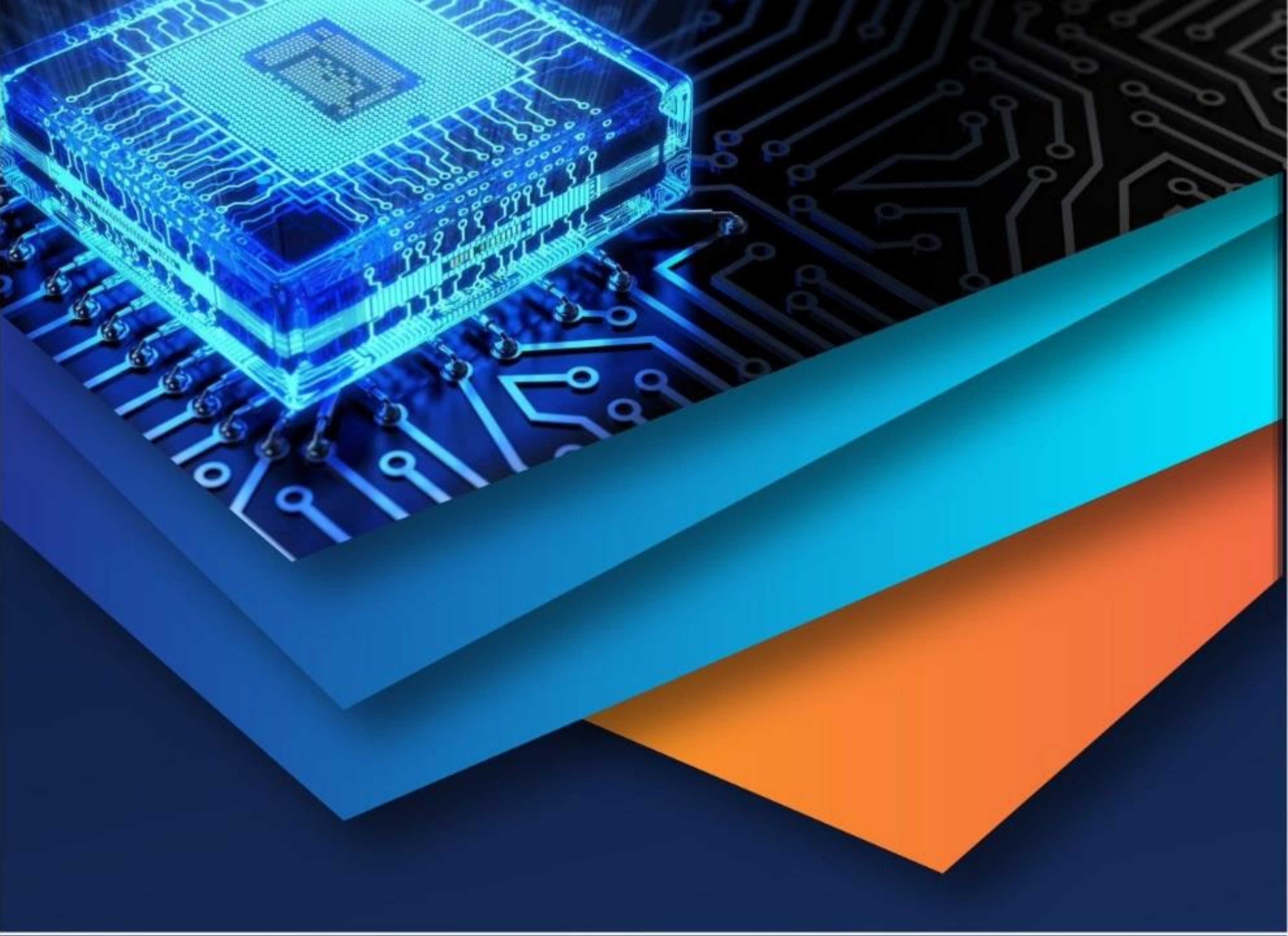

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