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Research Article

Diagnosis, visualisation and analysis of COVID-19 using Machine learning

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Abstract:

The Focal point of this paper is to point out or analyse the different kinds of symptoms and other complications COVID-19 Positive and Negative patients undergo. Coronaviruses are a club of viruses that attack humans with respiratory illness and their impact ranges from mild cold, fever, and dry cough to severe breathing problems, fatigue, chest pain and some other chronic problems. The objective of this research is to analyse the various chronic and other complications undergone by a COVID-19 patient. By considering most standard symptoms (given by WHO and Ministry of Health, govt of India), the data is collected from a renowned data repository called Kaggle and employed the best data analytical techniques to clean it so that it must befits our higher Machine Learning prediction aspirations. In this study, Ensemble machine learning models have been used, which take user input on some of the pre-defined approved standard symptoms and predict whether COVID-19 is present or not. The developed Machine Learning model cannot be left out like this, without any proper interface for duly picking up each data from the users, so we managed to reach out to a best and weighted framework termed Streamlit, for transforming our Machine Learning model into a fully-fledged and dual-faceted (Fill out the data manually by going into each cell or directly drop patient data in CSV file format) Web Application.

1. Introduction

COVID-19 virus, no introduction is required for this word, as it has come into our busy world with the greater buzz that everyone who was embroiled in their greater works had to take a while to know about this menacing thing. This unwelcome disease trespassed into every corner of human land and made the actual inhabitants of the land sit inside their homes. COVID-19 is a contagious and unprecedented disease because this virus started to sprout out from nowhere in every section of society. COVID-19 directly attacks the human lungs by damaging the air sacs, The initial responsibility of air sacs is to carry up the oxygen to blood vessels, then these vessels further transfer the oxygen to red blood cells and finally to all other organs of the body [1]. When COVID-19 affects the human body, it first starts with mild fever, cold or sometimes runny nose, cough, etc. or might even not show any symptoms but later the infection will make progress in the human body and may have severe symptoms [2]. Hence, this paper mainly focuses on analysing the major or minor symptoms experienced by the patients. Due to this disease, many people took their last breath across the globe because COVID-19 predominantly infects the lungs and, in some instances, the infection turns severe and causes death due to acute respiratory distress syndrome (ARDS) and viral Pneumonia. According to some sources on the internet says that 80% of COVID-19 patients exhibit mild symptoms, 14% will turn up having

Pneumonia, 5% of the patients will end up having respiratory organ failures and 2% of the cases lead to death. It has been almost two years since we have been through many waves of COVID-19, and COVID-19 led to harsher lockdowns. But still, investigations and examinations are going on to figure out the root cause of the disease. Many say that the disease got leaked from a biological laboratory in the city of Wuhan, but till today the WHO has not found any rocky evidence to prove it. In future these kinds of things might occur often as the technology grows the human mind hankers to find newer things which sometimes might turn fatal on the race of the pioneers, which happened in the case of COVID-19. Machine Learning is also a technology of today and the future with which we can do wonders in any field, including in the healthcare and medical sectors, and one such instance you will find while reading this paper [3-7]. In this research, our efforts mainly focused on providing cleaned data (containing all major and minor COVID-19 symptoms a patient underwent) for training the Machine Learning models and by detecting the patterns it should spill out whether the patient has COVID-19 or not without much human interference. Therefore, there will not be any human error in detecting the disease and the upshot of the trained models will be accurate leaving behind all the uncertainties of the physician.

The dataset used in this research is secured from the Kaggle data repository. The dataset contains 5434 records of COVID-19 positive and negative patients with no null values. This data is split into two variables X and Y, one variable holding entire symptom records dropping behind some peripheral columns which does not play any vital role in predicting the disease and another holding COVID-19 (positive or negative) column respectively. Once the data is split it is sent for the training, and after which the model will start predicting the disease based on the input parameters. In this study, the data collection from the patient is made more feasible by building a web application using Streamlit framework which contains the cells of each symptom of the disease, which the intended patient had to fill or the physician can drop a CSV formatted file containing intended patient details to predict the disease. COVID-19 has now halted in throwing new waves but still takes a pinch of time to completely wipe it away from our motherland; thence some news chimes about the daily cases around the world even today. Experts from medical fields state that COVID-19 will remain with us for some time and will throw new cases but there is no need for any panic situations because like other diseases such as Tuberculosis, etc are not completely wiped out but they will soon. That is the reason, Artificial intelligence and its sub-branches can be very helpful to the world to counter imminent hurdles and we humans should not be sluggish in taking full leverage of these technologies [8-42].

2. Literature Review

The advent of machine learning (ML) techniques has significantly advanced the diagnostic accuracy and analysis of COVID-19, offering innovative solutions to combat the pandemic. Dang Nhu Phu et al. [1] demonstrated the efficacy of XGBoost and Random Forest algorithms in distinguishing COVID-19 from influenza-like illnesses using clinical symptoms and diagnostic parameters. Their study achieved an area under the curve (AUC) of 98.8% for XGBoost, highlighting its applicability for community-based testing, particularly in resource-limited settings.

Similarly, Dawaba et al. [2] introduced a Computer-Aided Diagnosis System (CADS-Covid-19) employing feature selection through the Grey Wolf Optimizer (GWO). Their model demonstrated over 95% accuracy using Support Vector Machines (SVM) to classify blood test data, showcasing the importance of feature selection in enhancing model performance. Wei et al. [3] explored machine learning and deep learning algorithms for CT image classification. Models like ResNet50 and DenseNet121 achieved 100% accuracy, precision, sensitivity, and specificity, underscoring the potential of automated feature extraction in medical image processing.

A comprehensive overview of ML approaches was provided by Al-Sabbagh [4], who highlighted methods like XGBoost and Logistic Regression for early COVID-19 detection. Incorporating Internet of Things (IoT) sensors for real-time data collection further enriched the diagnostic process. Additionally, Mulawka et al. [5] utilized convolutional neural networks (CNNs) for radiomic feature extraction from chest CT scans, achieving a diagnostic accuracy of 98.01%. Their study also introduced a U-Net-based model to compute a severity score by analyzing pathological tissue changes, aiding personalized therapeutic strategies.

Ayus and Gupta [6] reviewed multiple ML and deep learning (DL) techniques, achieving accuracies of 99% and above in diagnosing COVID-19 using CT and X-ray images. Their work emphasized the significance of preprocessing and feature extraction techniques in addressing data scarcity and improving model robustness. Dabbagh et al. [7] conducted a systematic review of ML models applied to COVID-19 diagnosis, reporting high accuracy, sensitivity, and specificity across 66 studies. However, they also highlighted concerns regarding selection bias and

the novelty of these models, calling for further research to enhance robustness.

Sharma et al. [8] focused on predicting COVID-19 cases using an adaptive gradient LSTM (AGLSTM) model, achieving a remarkable accuracy of 99.81% with multivariate time-series data. Their study underscored the role of parameter optimization in improving prediction accuracy. Lastly, Alqaissi et al. [9] utilized graph data science and ML techniques to detect COVID-19 from symptoms, demonstrating the utility of combining symptom data with ML algorithms for effective diagnosis.

Solayman et al. utilized various machine learning techniques such as logistic regression, random forest, and ensemble models, alongside deep learning algorithms like artificial neural networks and convolutional neural networks (CNN). Their hybrid CNN-LSTM approach, coupled with the SMOTE technique for data balancing, achieved an impressive accuracy of 96.34% in detecting COVID-19 cases. Additionally, the study employed the LIME framework to ensure explainability of the predictions, contributing to the reliability of AI in healthcare diagnostics [10].

Ali et al. introduced a Densely Connected Squeeze Convolutional Neural Network (DCSCNN) to classify chest X-ray images into COVID-19, pneumonia, and normal cases. Employing interpretability techniques such as Grad-CAM and LIME, the study addressed the black-box nature of deep learning models, making predictions transparent and trustworthy [11]. Similarly, Alqahtani et al. developed a novel COV-Net framework that utilized CNN for extracting COVID-specific patterns from chest X-rays, complemented by machine learning classifiers for improved generalization and discrimination across categories [14].

Deep learning applications in medical imaging have also been extensively reviewed. One comprehensive survey highlighted their roles in image classification, lesion localization, and severity quantification for COVID-19 diagnosis. The study discussed the preprocessing techniques and datasets used in various research, emphasizing the challenges and future prospects of deploying AI in combating pandemics [13].

Machine learning techniques for predictive analysis have been pivotal during the pandemic. Hussain et al. applied time series models like ARIMA and LSTM to predict confirmed COVID-19 cases and mortality rates, demonstrating the utility of ML in forecasting and aiding decision-making [15]. Additionally, the comparative analysis by Andrade et al. benchmarked classification algorithms using a large dataset of COVID-19 patients, showcasing the potential of ML in evaluating clinical outcomes [16].

Natural Language Processing (NLP) also played a vital role in enhancing accessibility during the pandemic. One study integrated NLP with machine learning methods, developing a chatbot trained on WHO data to provide accurate responses to frequently asked questions, thereby improving public engagement and awareness [12].

The integration of AI with medical imaging has further enabled advanced diagnostic capabilities. Alnedawe and Aljobouri proposed a model combining CNN for feature extraction and Support Vector Machine (SVM) for classification of lung CT scans, achieving remarkable accuracy of 98.95% [17]. Similarly, a survey by Almotairi et al. explored the use of CT scans for identifying disease patterns such as ground-glass opacification, which are critical in understanding COVID-19 progression and aiding clinicians in timely intervention [18].

3. Problem Statement

During the time of COVID-19, we all have seen how difficult it was to get the test results on time. Moreover, due to some human glitches or because of a mix-up of saliva many tested positive for COVID-19, which is incorrect, due to which many people faced economic challenges for paying hefty hospital bills. To avoid these cases many artificial intelligence developers built deep learning models to get the people the right diagnosis by avoiding any more glitches, which was a good initiative to come up with at that time of ordeal. However, the problem that the model had was the chest X-ray image as its input. To get their chest X-ray image soft copy is not that easy, because the physicians must deal with many such cases and sending chest X-ray images to the requested people will be hard, so we have decided to build a model that takes only those standard and primary symptoms as input to our model which is duly approved by WHO and Govt of India (Ministry of Health). Due to this model, many people can easily test themselves at home by just filling up YES or NO in front of each given cell containing the name of the symptoms or creating a CSV formatted file containing all symptoms and dropping it to get the results.

4. Methodology

Our main goal was to build a model that should be simple and realistic in understanding so that anyone can use it without many technicalities. Nowadays Artificial intelligence and its sub-branches i.e., Machine Learning are being used for diagnosis in healthcare which is a good deed, so we have also decided to do a similar thing in the case of COVID-19 which should help many people like a first aid kit in testing their own COVID-19 infection. Then

started our hunt for a good and most-suited dataset for training a model, which is the most important task of data science models. Kaggle is one of the largest data repositories which is specially used for carrying out most data science studies, we found a dataset called ‘symptoms and COVID presence’ for our model which has 5434 records of both COVID-19 positive and negative patients. The dataset contains around 15 COVID-19-related primary and standard symptoms as its column names and some 7 columns contain data of those passengers who travelled abroad, contacted with COVID-19 positive patients, attended large gatherings, visited public exposed places, family working in public exposed places, etc.

Data analytics has played a pivotal role in cleaning the dataset by removing null values and correcting incorrect text or values to their original form. The Pandas library in Python proves to be very handy for achieving this task. One such instance involved converting the data type since the dataset contained responses as 'Yes' or 'No'. To prepare the data for training our machine learning model, we needed to convert these responses into numerically represented values. Our first task was to replace 'Yes' with '1' and 'No' with '0' and then convert the data type to an integer. We easily accomplished this for all relevant columns using the Factorize method in Pandas, which automatically assigns a numeric representation to unique values in the column, starting from 0.

However, an issue arose because the dataset exclusively contained records of 'Yes' or 'No'. When we applied the 'value_counts ()' method to each column, some columns displayed 'Yes' at the first index position and 'No' at the second, while in other columns, it was vice versa. This raised concerns. The imbalance of 'Yes' and 'No' values in the dataset led to this inconsistency. With the Factorize method, the numeric representation assigned to unique values in the columns depended on whichever value appeared first. This created ambiguity, as in some columns, 0 indicated 'No', whereas in others, it indicated 'Yes'. To avoid this ambiguity, we opted for an alternate approach of replacing the values first and then converting them to integers.

Once the data was cleaned, we utilized the Seaborn and Matplotlib libraries to visualize and analyze the data by creating various plots. The bar graph in Figure 1 illustrates the number of patients diagnosed with COVID-19 infection and their status of chronic lung disease. On the X-axis, a value of 1 represents patients with chronic lung disease, while a value of 0 represents patients without chronic lung disease. The colours salmon and light blue indicate non-COVID-19 and COVID-19 cases, respectively. The figure demonstrates that more than 2000 patients are diagnosed with COVID-19 but do not have any chronic lung disease. Additionally, around 2000 patients have both COVID-19 and chronic lung disease. Regarding non-COVID-19 patients, over 500 patients have chronic lung disease but are not diagnosed with COVID-19. Figure 2 shows COVID-19 patients with heart disease and Hypertension.

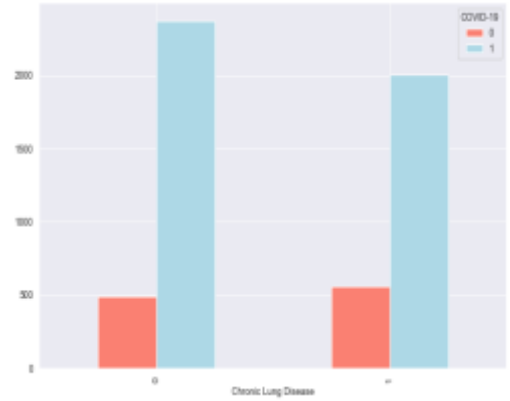

Figure 1. *COVID-19 patients with chronic lung disease*

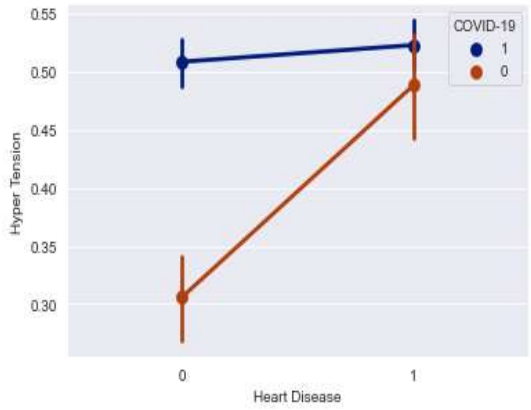

Figure 2. *COVID-19 patients with heart disease and Hypertension.*

Consider the above-drawn point plot to understand the heart disease patients who have hypertension and are also diagnosed with COVID-19 disease. On the X-axis there are heart disease patients and, on the Y-axis, you will find patients having hypertension these two groups of patients are categorised based on COVID-19. In the above show plot 1 represents persons having heart disease and the 0 indicates persons with no heart disease. Please look at the blue line in the graph, which indicates that patients diagnosed with COVID-19 have a higher hypertension prevalence than non-COVID-19 patients, regardless of whether they have heart disease. In Figure 3, the value 0 indicates patients without diabetes, while 1 represents patients with diabetes.

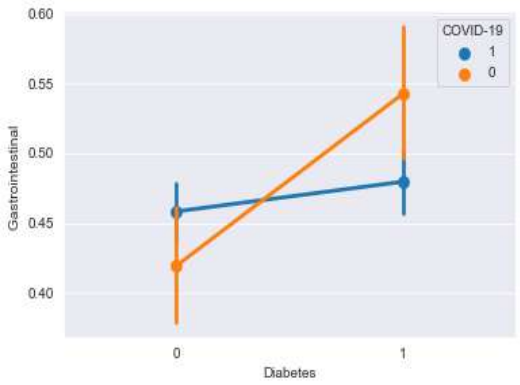

Figure 3. *COVID-19 patients with Diabetes and Gastrointestinal.*

The point plot reveals that COVID-19-infected patients with diabetes have fewer gastrointestinal problems compared to non-COVID-19 patients. However, this scenario is reversed for non-diabetic patients: those with COVID-19 experience more gastrointestinal issues compared to non-COVID-19 patients.

After completing all analytical tasks, it is time to feed the cleaned and corrected data to our machine-learning model. We have considered multiple machine learning algorithms for the training such as Random Forest, Decision Tree Algorithm, Adaboost Classifier, and Gradient Boosting, and the best-performing model is used for building web applications. For training, the data should be split into two different variables X and Y, each containing independent and dependent columns respectively. In variable X, we have dropped three of our columns, in which two independent columns do not play any vital role in predicting the disease, they are 'wearing masks',' sanitization from the market' and one COVID-19 (target variable) i.e., dependent variable. The Y variable contains only column i.e., COVID-19, the dependent variable. After assigning concerned columns to their respective variables, this data will be further divided into training and testing sets to avoid the overfitting problem with the help of the train_test_split() method available in the sklearn (scikit-learn) library. This division of data is of utmost importance in machine learning because we will train the data on the training set and will test the model to validate the accuracy of unseen testing data.

To deploy the model into a web application, the Streamlit framework is chosen for its simplistic approach to building web applications and its wide range of features and methods. The best-performing machine learning model will be saved and downloaded using the Pickle library available in Python. This allows us to avoid lengthy re-training of the model and enables its use in building third-party applications. This web application will serve the people without getting hold of any personal data from the user.

5. Results and Discussion

In this study, the Random Forest machine learning algorithm has outperformed all other algorithms. A random forest algorithm is a club of many decision trees that works like a complete team to make predictions. In this algorithm, each decision tree will make estimations depending upon its training on different subsets or rows of the dataset and at last all these estimations are combined to get the prediction. Due to these many decision trees within one algorithm, it will not let go of even the smallest pattern from the given data. This makes the algorithm viable to handle large amounts of data with any number of attributes without any need from the developer to simplify the data for it. Even after with the 18 columns containing more than 5000 records the random forest worked well compared to other algorithms.

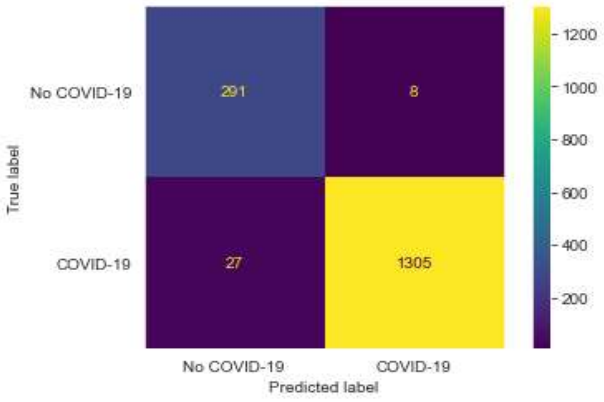

Figure 4. *Random Forest Confusion Matrix.*

The error matrix or confusion matrix in Figure 4 reveals that out of a total of 299 non-COVID-19 cases, it correctly predicts 291 as non-COVID, with only 8 cases being predicted incorrectly as COVID-19. Similarly, for COVID-19 cases, it accurately predicts 1305 cases as COVID-19, while incorrectly predicting 27 cases. The above provided a confusion matrix of a random forest algorithm with 97% accuracy. The data given for the training is not balanced, so we have applied the SMOTENC (Synthetic Minority Over-sampling Technique for Nominal and Continuous Features) technique to balance the data. This technique increases the minority data by creating similar synthetic (artificial) samples that of the majority one until it matches the majority mark. This technique is special because it considers different feature types such as categorical features and continuous features (numbers) so that the artificially generated data should be realistic and portray of original data.

Categorical features are those features that belong to one class, for instance, Cough, Fever, Shortness of breath, Fatigue, headache, etc all these belong to one category i.e., the symptoms category, then all these symptoms mentioned become the categorical features of symptoms class. After applying the SMOTENC to random forest the model has achieved 98% of accuracy. Figure 5 shows streamlit web application drop file option. AdaBoost Classifier has given an accuracy of around 96% which is less compared to a random forest classifier. There might be many reasons for it, like Random Forest classifier will handle the imbalance of data nicely, whereas the Adaboost classifier struggles a bit due to minority classes. The Adaboost classifier becomes a little sluggish when there is noise in the dataset, whereas random forest is more robust in dealing with noisy data due to its many decision trees. One might ask that even after cleaning the data how can there be noise? Even if you clean the data thoroughly there remains a small amount of noise in your dataset which may be an error while collecting the data. For example, there is a very much chance that some of the patients incorrectly reported their symptoms which they did not experience. There is also the chance of a wrong diagnosis of COVID-19 during the testing of the patients. In our dataset, there are columns where there is much ambiguity roaming around, i.e., 'Contact with COVID Patient', 'Attended Large Gathering', 'Visited Public Exposed Places', etc. Here most of the time one cannot certainly say that he or she has met with COVID-19-positive patients, and all individuals visiting public exposed places sometimes cannot be COVID-19 positive or negative. These are some of the noises in the data that the data cleaning cannot remove.

The Random Forest model is deployed into a web application using the Streamlit framework. This web application is dual-faceted, which means the web application provides you with the manual fill-up cells containing all the standard symptoms that the patients must provide as their response, and there is also an option to drop the concerned patient's details in a CSV file format.

6. Conclusion and Future Enhancement

COVID-19 disease has inflicted so much havoc on the lives of the people without any favouritism among the countries. Due to this many people lost their loved ones, employees returned to their homes devoid of jobs, countries had to walk towards recession, and many more. COVID-19 and its following lockdowns have given a new dimension to the nature. As we all saw, on one side there were painful lives of humans and on the other side there

Figure 5. *Streamlit web application drop file option.*

was extraordinary scenery of nature, both unmatchable visuals never seen before by society. The COVID-19 virus has taken down many economies along with air pollution and global warming all around the world. Some of the spectacular things like the Himalayas being visible from far away, river water appearing clean due to the inactivity of factories, many rare wildlife animals coming onto the roads, etc. This virus has also laid avenues for data scientists to develop AI models to help society debacle COVID-19.

This study also helps many technically sound and unsound people to test themselves at home without many hurdles. The developed model is made robust by using one of the best algorithms in machine learning. With the help of cleaned data and a random forest algorithm, the model will leave no stone unturned in detecting minute patterns to predict the disease. After much analysis, we have found out that, in overall 4000 COVID-19 positive records, 67% have a breathing problem, 79% have a fever, 79% have a dry cough and 73% have a sore throat. These are the major portion of symptoms experienced by the COVID-19 patients.

As a part of future enhancement, data science enthusiasts can venture into training a similar model with a large dataset to help the model understand the nature of the data profoundly. Applying some of the well-known unsupervised machine learning algorithms such as K-Means clustering, Principal Component Analysis and so on can be encouraged. COVID-19 dataset with large amount of data will be difficult to understand sometimes, hence unsupervised machine learning will help in simplifying the data by highlighting the most important attributes and variables which may contribute much in predicting the disease. This will further give a new dimension to the model because the unsupervised algorithms can easily analyse the data in such a way that it can even observe how the

data changes over time and pinpoint the patterns in advancements of the COVID-19 symptoms or prevalence of the disease in the human body which will assist the researchers in predicting the future potential outbreaks.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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