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COVID - 19 Detection Using Medical Imaging and Health Parameters

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***Abstract*- This research paper focuses on the use of advanced technology in confluence with readily available machinery to create a testing environment for COVID-19 that is more efficient, accurate, and has a higher reachability. This paper aims to develop a unique algorithm for detection of COVID-19 based on chest X-Rays, in combination with the patient's medical information including symptoms, age, bloodwork, and possible contact with someone infected with the virus. This proposal will especially be instrumental in locations with inadequate medical staff, and can drastically reduce the diagnosis time that is otherwise required.**

***Keywords*- COVID-19, X-ray, Health Parameters, Neural Networks, Image Processing, Medical Imaging.**

I. INTRODUCTION

Ever since the rise of the COVID-19 pandemic since last year, healthcare systems seem to have broken down worldwide. Healthcare officials have exhausted resources and there is no mechanism in place to counter the massive influx of patients or probable patients. And yet the pandemic continues to grow in all parts of the world, infecting millions.

One of the major reasons for this exponential growth of the virus is due to the fact that there is no absolute testing facility in place that can counter the spread of this deadly pandemic. As a COVID-19 infected person shows symptoms many days after being exposed to the virus, it becomes a necessary task to identify such individuals at the earliest and have them admitted to the nearest healthcare facility for treatment.

It is observed with the current testing mechanisms that they are not adequately accurate, and could take a long time to diagnose the presence of the disease. This disables the course of action and decelerates the process drastically. It is important to overcome this hurdle and to develop a system more sustainable and faster, while being affordable to the general populace.

The RT-PCR tests that are currently used widely have been known to not be the most ideal. According to the Vanvitelli COVID-19 group, the RT-PCR tests take around 190 minutes to produce results [1]. However, with administrative processes that the hospitals are forced to undergo, this gap can increase manifold taking upto two days from the point of testing till the result is conveyed to the candidate.

Another test that the aforementioned study mentions, is the Antigen test. The turnaround time for the antigen test can range upto 245 minutes. It also has a sensitivity rate (the ability to identify true positive cases) marked at around 70-86%. These statistics are abysmal in practice and can have devastating effects on the population, as they are having now.

It was observed in the SOPs being defined for transportation of tested specimens, that the average time can take even upto 72 hours for transportation. Moreover, those tests are carried out by collecting specimens from nasopharyngeal and oropharyngeal swabs which are intrusive in nature [2]. Apart from this, the cost borne by the state for the collection, storage, maintenance, and transportation of those specimens is one that cannot be neglected.

Medical Imaging can effectively counter these hurdles. The tests that involve Medical Imaging can be faster, deterministic and low-maintenance. X-ray imaging technology can be made available in rural areas as well, thus presenting itself for access to the deprived sections of the society.

Using the finding from the research conducted by Garches COVID-19 collaborators [3], it can be clearly determined that the virus directly affects the lungs. The study found that exhaled breath of the COVID-19 infected patients carried peculiar properties. This the reason, the major medical imaging tests for COVID-19 are focused on the chest areas of the patient.

The two types of imaging that are most commonly considered are Chest X-ray images, and Chest CT scan images. It is necessary for the sake of this project to proceed with the X-ray images as the CT scan mechanism

is not readily available throughout all geographic areas and can be inaccessible.

II. LITERATURE SURVEY

In [4], the scientists at Institute of Smart Systems and Artificial Intelligence (ISSAI), Kazakhstan, had developed a network-model simulator to understand the spread of COVID-19. Through rigorous testing with numerous scenarios, it was observed that the location-specific policies are necessary to control the spread of the pandemic. Location of an individual happens to play an important role in determining the probability of the patient being infected by the virus.

The study also admits that the actual number of infected people is far less than what appears from the laboratorial data, and hence suggests that a more rigorous testing regimen needs to be set in place as not all infected patients explicitly display symptoms, but are still carriers of the virus.

Mangal, Arpan, et al. [5] proposes the use of modern AI techniques to automatically detect COVID-19 patients. In order to train the model, the algorithm uses open-source datasets of X-Ray images which also helps in making the suggested testing technology scalable in places where proper diagnostic facilities are not available. The study was successful in determining that almost 97% cases could be rightly identified using Artificial Intelligence.

Although the used data might be inadequate, the system can be scaled in the near future to encompass larger data and might produce consistent results throughout.

To detect the presence of COVID-19, the authors in [6] suggest using a Deep Learning model. Deep learning models (MobileNetV2, SqueezeNet) were used to train the stacked dataset and the feature sets obtained by the models were processed using the Social Mimic optimization method. 99.27 percent was the overall classification rate obtained with the proposed approach. The model if used will contribute to COVID-19 disease detection effectively.

The model used in this paper [7] depicts the key factor in the concept of low-risk and high-risk areas and provides geographical recommendations and assessments to combat COVID-19, thereby providing great practical value. The authors concentrated on classifying fields as low risk and high risk, which serves as the main highlight and provides a new insight.

To learn modality-specific feature representations were used by the authors [8], a custom convolutional neural network and a set of ImageNet pretrained models are trained and tested at patient level on publicly accessible Chest X-Ray collections. The information gained is used to fine-tune the model and enhance performance, hence providing a gateway for COVID-19 detection using Chest X-Rays.

Seven different architectures of deep convolutional neural network models are included in the VIDX-Net by the authors in [9], such as the updated Visual Geometry Group Network (VGG19) and the second Google MobileNet edition. The analysis is validated on the basis of 50 X-Ray images. The useful application of deep learning models to identify COVID-19 in X-ray images based on the proposed COVIDX-Net system was demonstrated in this report.

III. METHODOLOGY

The Chest X-rays undergo Image Processing under Neural Networks, and all training data is studied algorithmically. The network adjusts the weights by itself to achieve maximum accuracy and thus, more reliable results.

It is necessary to understand from the above observations that the inclusion of a person's physiological data can enhance the system. Hence, along with the posteroanterior (PA view) of the Chest X-ray, parameters like age, gender, medical history and symptoms are also included.

Generally, the medical history that proves to be most impactful is related to diseases like diabetes, hypertension, heart diseases and lung diseases.

Presence of symptoms like cough, high grade fever, fatigue, breathing difficulties, body weakness, chest pain, or diarrhoea can help the system determine more accurately whether or not the patient is suffering from COVID-19.

The AI-based system takes into consideration this data and applies the knowledge gained by studying past data and applying them further on the tests created.

A combiner model, designed with Regression Analytics, can help find the weightage of both those models accurately in determining the final diagnosis. As both models tend to have a significant weightage, the final results are more enhanced, highly accurate, and more reliable than either model considered individually.

The system consists of three modules. Two for processing the image along with data and one for the UI itself.

1. Website UI: Provides an interface for healthcare professionals to interact with the proposed system. The professionals will upload the Chest X-Ray (CXR) image along with the patient's medical record and obtain the processed output.

2. Model 1: This model is responsible for processing the CXR image and producing output as COVID-19 positive

or negative. The output produced by this model will be used for further processing of information.

3. Model 2: The output obtained from the previous model will be used in conjunction with information pertaining to the individual's medical status to produce final output which will be more accurate as it will take into consideration the patient's history and symptoms, and narrow down the possibility of the patient being COVID-19 positive or negative.

The final output is the output of the third model, it carries the overall diagnosis provided by the system and can be assumed to be received in negligible time.

IV. SYSTEM DESIGN

The system requires two kinds of input to generate the result. One being the Chest X-Ray image itself and the other being information about the patient and his/her clinical data.

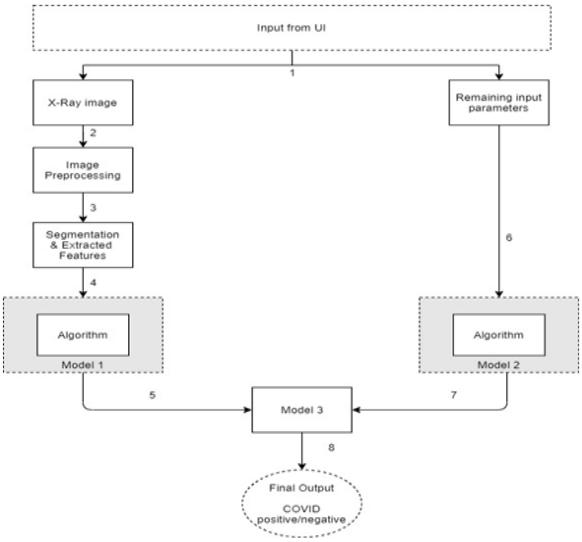

Fig 1. Block Diagram.

Information about the patient includes gender and health parameters Whereas One part of the input i.e., the Chest X-Ray image requires some processing to be done before it can be fed to the model as input.

The steps for this procedure are as follows:

1. **Image Pre-processing:** It is done to enhance certain features of the image as required by the model and suppress distortions for further processing.
2. **Segmentation:** The digital image after pre-processing is segmented into further segments to help extract the features for analysis purpose.

The extracted features are then passed to the first model for evaluation. This model is responsible for determining whether the patient is COVID positive or not, using the X-ray images. The output produced by this model is passed to the third model for further evaluation.

The second model uses the information provided by the healthcare professional related to the individual's medical status to produce a final result which tells us whether the patient whose data was fed to the system is COVID positive or not.

The third model is a combiner that determines the weightage each of those previous models hold in determining the final output.

V. IMPLEMENTATION AND RESULTS

1. Neural Network Model for X-rays:
Research indicates that neural networks are the most preferred method for diagnosing COVID 19 when Medical Imaging is considered. Various models were used to determine COVID-19 using X-ray images in this paper.

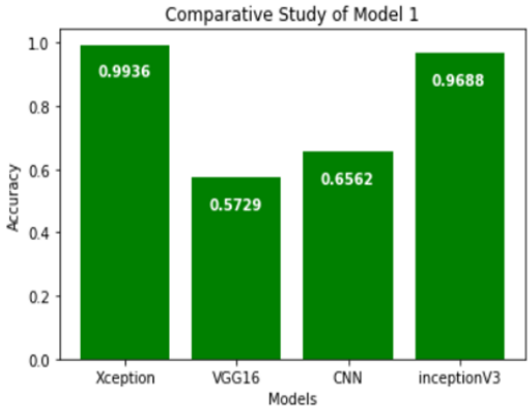

Fig 2. Comparative Study (Model 1).

Several neural network-based algorithms, like VGG16, CNN, InceptionV3 and Xception, were implemented for the comparative study of the images. By virtue of achieving the highest accuracy, the Xception algorithmic model was used for further computations.

2. Symptomatic Analysis:
The second module of the project will involve an analysis of the medical symptoms and patient history that is found to be consistent among COVID-19 positive patients. This will ensure an added layer of accuracy for the diagnosis.

The clinical data considered will include symptoms as follows:

- Cough
- High grade fever
- Fatigue
- Breathing difficulties
- Body weakness(asthenia)
- Chest Pain
- Diarrhoea

Along with the symptoms, the system takes into consideration the patient's medical history. The healthcare professional has to enter whether the patient has or has had diseases like;

- Hypertension
- Type-2 Diabetes
- Coronary Heart Disease
- Lung Disease in the past.

The feature importances for the considered symptoms were found to be as visualized in the following image. A higher value signifies that the presence or absence of that particular symptom is more determinants of the final diagnosis.

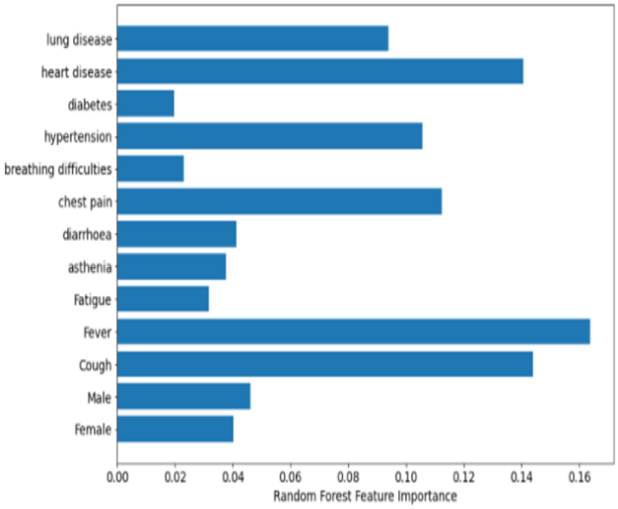

Fig 3. Feature Importance.

3. Model for Symptomatic Analysis:

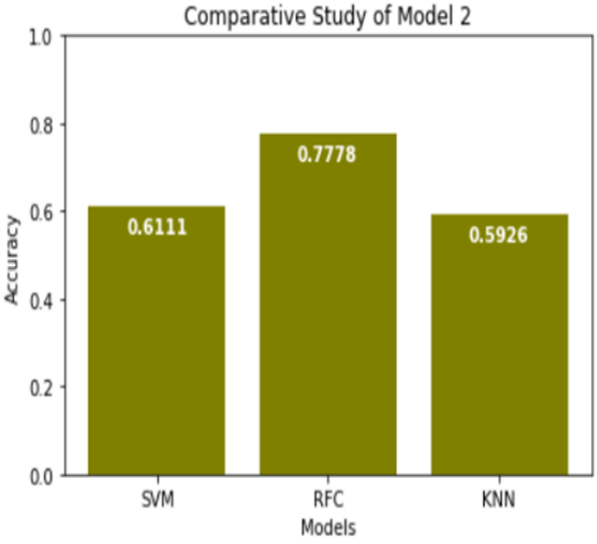

Fig 4. Comparative Study (Model 2).

Decision-tree based algorithms like KNN, SVM, and Random Forest Classifiers were used for qualitative analysis. After the Random Forest Classifier proved to be most effective with an appropriate number of estimators, it was used to procure results that will denote the possibility that the person suffering with the aforementioned symptoms can be COVID-19 positive. The selection was made considering the complete accuracy of each algorithm.

4. Model for Combinational Analysis:

Using the given two models, we can now complete the final step of the diagnostic process. We use results from the previous models to predict the output and compare with previously available findings. When performing a comparative study of several appropriate models, we obtain the following results.

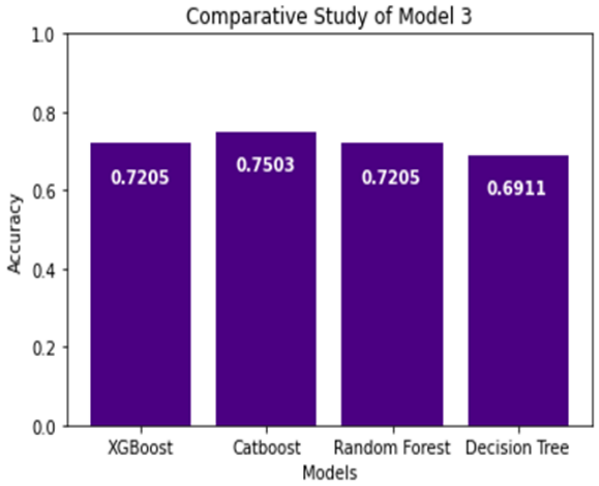

Fig 5. Comparative Study (Model 3).

As depicted in the above image, the ‘Catboost’ algorithmic model seems to be the most accurate of all. With the use of two different approaches merged into one, the final results are much more reliable than if either approach were to be taken individually.

VI. CONCLUSION

In these trying times, we can observe that the world is struggling to keep the healthcare facilities functional in every region. There is a shortage of testing kits, governing doctors, and other resources.

A system like the one proposed above, if implemented successfully, can help reduce this chaos by reducing the time and resources that are spent in testing. With X-ray images and other parameters, it will be able to detect the presence of COVID-19 in patients successfully and efficiently.

As these mechanisms are readily available in even the lesser developed regions, this system will be instrumental in speeding up the processes and may prove helpful to the healthcare facilities in those areas.

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