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Detection of COVID-19 from C-X-Ray Scans Empowered by Machine Learning

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ABSTRACT: The first case of COVID-19 was reported from China and it spread throughout the globe in no time and was declared a pandemic by World Health Organization (WHO). Different measures are taken by the government to stop the spread of COVID-19. Still, the number of infected cases is very high and alarming situation in many countries. It destroyed the normal life, general activities of all sectors and the global economy. The polymerase chain reaction (PCR) belongs to the family of pathogenic laboratory tests which were considered initially for diagnosis of COVID-19. But PCR shows false-negative results as well as takes a long time for examination. Therefore, for combating with COVID-19, there is a need of a fast and accurate method for detection and diagnosis. Artificial intelligence (AI) shows remarkable results in all fields with diverse applications. The combination of radiography and AI-empowered machine learning is one of the significant solution. In this paper, we have proposed a machine learning-enabled classification model to detect and classify the COVID-19 infected cases by examining the chest x-ray scans. Dataset is taken from Kaggle which contains normal, COVID-19 and pneumonia infected images. Two well-known machine learning classifiers, Support Vector Machine (SVM) and Random Forest are used to train and predict the infected cases. Histogram of Oriented Gradients (HOG) is used for feature extraction from images. The proposed model shows 99.27% accuracy for SVM and 96.89% accuracy for random forest. Furthermore, a comparison of the results of the proposed approach is performed with relevant four approaches from the literature. Comparative analysis shows that the proposed approach performed significantly better.

Keywords: COVID-19, Machine Learning, Detection and Diagnosis, HOG, SVM, Random Forest, Chest X-Ray

I. INTRODUCTION

A large number of outbreaks and epidemics took place in the past century but coronavirus such as SARS-COV and MERS-COV were mainly responsible for a majority of these outbreaks [1]. Coronavirus disease 2019 is known as COVID-19 and belongs to the family of viruses which include severe acute respiratory syndrome (SARS). COVID-19 symptoms are headache, fever, fatigue, cough, and difficulty while breathing [2]. Scientists have determined that SARS-COV is a member of the coronavirus family, which typically spreads from bats and rodents [3]. The first case was reported in December 2019, in Wuhan, China [4]. Since then, this disease has spread very rapidly throughout the world in more than 200 plus countries. Most of the countries have taken strict measures such as a lockdown or staying at home to control this virus from spreading. According to the World Health Organization, there are 167,492,769 coronavirus cases while the number of deaths has reached 3,482,907 till date [5].

SARS and COVID-19 are similar to each other as they both are types of coronavirus. SARS started in China in 2003 and spread to different countries. This disease ended in 2004 but it seems that COVID-19 spreads faster than SARS. Coronaviruses are mainly RNA viruses that range from 600-A to 1400-A in diameter [6]. The birthplace of the COVID-19 virus is Wuhan, China. The cause of this virus might be linked to the seafood market, but this is not the exact source from where the disease spread in China. The investigations are going on to determine how this virus started. The SARS-COV first case was also reported in China and after that it spread to 37 more countries in 2004 [7]. Due to SARS-COV, 8000 people were infected and 774 people lost their lives. In comparison, the coronavirus disease has spread to more than 215 countries worldwide. On 31 December 2019, the World Health Organization reported 27 cases in China; this was linked to the Wuhan seafood market, which includes animals like bats and rodents. The disease spread rapidly from Wuhan to other cities of China and then it started to spread worldwide. It takes around 5 – 14 days for the symptoms to be visible for this virus. It has been observed that the majority of the patients show symptoms such as fever, breathlessness, and sore throat. Whereas other symptoms such as diarrhea, nausea, coughing up blood are very rare. According to the CDC, the people that are most likely to be infected by this disease are the people who are above 60.

People having existing diseases such as asthma, diabetes, hypertension etc [8]. Coronavirus is generally transferred from one person to another through coughing and sneezing, from the spread of respiratory droplets in the air and these droplets tend to cover a distance only up to 6 feet [9]. Respiratory infections are mainly transmitted by various sizes of droplets. Therefore, the person is at risk when he gets close to the one who is infected with this virus. This virus lasts up to three days on the surface of plastic and steel, 4 hours approximately on the copper surface and up to 24 hours on the surface of the cardboard [10]. According to the World Health Organization, the pandemic of COVID-19 is categorized into four different stages [11]. This categorization helps the other countries to implement the rules such as closing the educations system and enforcing lockdown. In the first stage, the disease does not spread in the whole country. Only infected peoples are locked in affected regions. The second stage takes place when there are some infrequent cases in the country. This stage mainly occurs when the people who are infected contact with their family members or friends. Therefore, to stop this disease from spreading, infected people must stay in quarantine. When this disease starts to circulate and affect those who are not in contact with the people who are already having this disease then this is the third stage of an outbreak, which is termed as the cluster of cases. In this stage, the lockdown becomes necessary to stop this disease from spreading. In the fourth stage of this pandemic, there are very large outbreaks of locally transmitted cases in a country. It is almost impossible to control the outbreak at this stage, and developing a cure is the only option available. This causes a significant increase in the number of reported cases and deaths.

Because of lockdowns, the economy of the world is facing huge crises [12]. All small businesses are forced to shut down by the governments which increases poverty, especially in underdeveloped countries. Furthermore, all the trades have been stopped between countries, which causes a large collapse on the economy of those countries that are fully or partially dependent on the trade [13]. COVID-19 caused a shocking impact on the healthcare system across the world. COVID-19 cases are increasing day by day, but hospitals across the world are currently facing a shortage of hospital equipment i.e. PPE (protective equipment), ICUs (intensive care unit), and especially the shortage of ventilators. Many scientists, laboratories and organizations all over the world are busy doing researches in order to find the reason behind this virus so that proper treatments and vaccines could come into existence. Various research papers were published explaining different aspects behind the COVID-19. Laboratories are conducting reverse transcription-polymerase chain reaction (RTPCR) test for diagnosis of COVID-19. This test is reliable with great chances of false positive or negative cases in the initial stage of coronavirus infection [14]. Efficient diagnosis of coronavirus with high accuracy are required to combat with COVID-19. Machine learning techniques can be used for the fast and precise identification of coronaviruses.

The following of the article is sectioned as; second section illustrates the literature to highlight the recent contributions. Section 3 shows the methodology by specifying the applied algorithms and dataset. Section 4 elaborates the experimental results. At the end, section 5 concludes the applied research work and shows the future directions.

II. LITERATURE REVIEW

Machine learning has gained significant interest in medical diagnosis in a recent couple of years. It brings valuable advancement in the healthcare sector along with Internet of Things (IoT) to uplift human lives and medical standards [15]. COVID-19 has imposed a global threat on public health and become a foremost challenge for scientists. Timely diagnosis of coronavirus leads to minimizing the spread of COVID-19. Image testing and processing is one of the early considerations for the detection of COVID-19. Multiple efforts have been made for early diagnosis of the corona virus. According to World Health Organization, chest X-rays and CT scans play a vital role in the diagnosis of COVID-19. In paper [16], authors proposed a new approach based upon ensemble machine learning to classify the textual clinical reports to diagnose the COVID-19. They used data of 212 patients available on the open source data repository of GitHub. Data consist of 24 attributes having personal and medical details. Textual features are explored by document length, bag of words and inverse document frequency. Multiple algorithms are implemented within model but logistic regressions showed comparatively better results with 96.2% testing accuracy.

Author in [17] proposed a machine learning-based model for the prediction of survival of corona virus-infected patients. The main aim of this work to decrease the mortality rate by highlighting the severe patients so they can be prioritized for treatment. For the training of model, they used a blood samples database of 404 COVID-19 infected peoples from Wuhan. Out of 404 patients, 213 are recovered and 191 died. Three attributes, lymphocyte, Lactic dehydrogenase (LDH) and high-sensitivity C-reactive protein (hs-CRP) are used to identify the severity level. High level of LDH shows the sensitivity level of the patient and requires quick medical attention. Overall the proposed model shows the 90% accuracy in prediction. In another research, various machine learning algorithms are used for the diagnosis of COVID-19 [18]. They compared the results of the proposed system and radiologist to check the accuracy of the proposed model. In a test case of 279 patients, the proposed system achieved 92% accuracy. Many patients having normal CT scan declared as negative by the radiologist and the system correctly identify them as COVID-19 positive and improves the detection rate. Based on clinical history and CT scan, the system rapidly diagnoses the COVID-19 patients with high accuracy.

Authors in [19] developed a machine learning-based model to detect the symptoms of COVID-19 in early stage patients. This model considers the age, gender, travel history, medical history and clinical details such as fever, lung infection and cough to detect the coronavirus. They implead various machine learning algorithms within model and comparatively, analysis shows that XGBoost algorithm performed well with 85% accuracy. It is revealed by statistics analysis that the predictive ratio of fever is 41.1%, lung infection is 13.1%, runny nose is 8.43% and cough is 30.3% presented in COVID-19 positive patients. 54.4% peoples did not show any symptoms in early stage. In [20], a depth analysis is performed to predict the transmission of coronavirus, recovery and mortality rate. Machine learning algorithms are used to measure the statistics. Rough set support vector machine, polynomial regression, RNN, SIR model and Bayesian Ridge are implemented for analysis. The used dataset of Johns

Hopkins center and comparatively RNN algorithm provided best results with greater accuracy and precision.

The research carried out in [21] presents a machine learning method to detect the coronavirus in early phase. The technique is based upon Computed Tomography (CT) images. The dataset is consist of 150 CT images in which 53 belong to infected cases. Local Directional Pattern (LDP), Grey Level Co-occurrence Matrix (GLCM), Grey Level Run Length Matrix (GLRLM), Discrete Wavelet Transform (DWT) and Grey-Level Size Zone Matrix (GLSZM) algorithms are used as feature extraction methods. Extracted features are classified using support vector machine and 2 fold, 4 fold, 5 fold and 10 fold cross validation implied. Classification performance is evaluated using accuracy, sensitivity, precision, specificity and F-score matrix. GLSZM give best classification accuracy results with 99% on 10 fold cross validation. Authors in [22] implemented different machine learning algorithms to predict the transmission ration of COVID-19 by considering number of confirmed cases and weather variables such as temperature and humidity. Results show that the weather variables are more relevant to predict the mortality rate and higher temperature reduces the number of infected cases. Authors in [23] developed a machine learning-based classifier to detect the positive cases from chest X-ray images. The classifier generates results with high accuracy. In research [24], a new machine learning-based approach is proposed to detect the corona virus via chest X-rays. The features are extracted with Fractional Multichannel Exponent Moments (FrMEMs) from chest X-ray images and modified Manta-Ray Foraging Optimization method is used to select the most significant features. Two datasets are implied and the proposed approach achieved great accuracy rates 98% and 96% for both datasets respectively.

III. PROPOSED MODEL

Figure 1 elaborates the working flow of the proposed model which is based on 5 main steps.

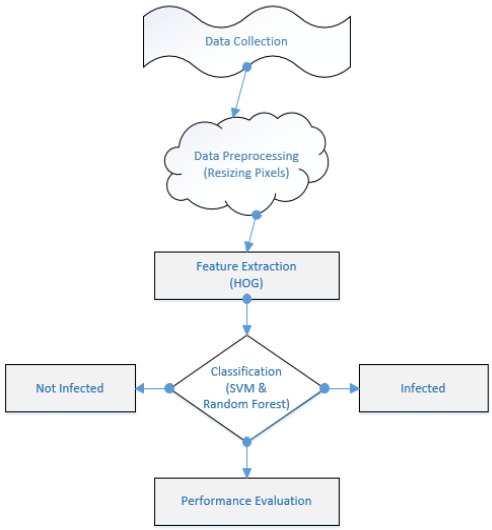

Fig. 1. Proposed Model.

The very first step is data collection from a dataset which is taken from Kaggle [25], [26] and extensively discussed with features in the first sub-section. The second step is data preprocessing which resize the x-ray scans inconsistent pixels and handles the missing points. The third step is most import and feature extraction which provides a base to the proposed model. After training, the 4th step is a classification of given scans that are classified as infected or non-infected. The last step is the performance evaluation of the proposed model and comparison with previous work.

A. X-Ray Scans Dataset

The dataset is taken from Kaggle [25], [26] which contains the x-ray scans of the chest. It includes the 3 categories as normal scan, pneumonia scan and COVID-19 scans. The prepared dataset contains 550 total scans in which 200 scans of normal people, 200 scans of pneumonia patients and 150 scans of COVID-19 infected. The dataset is further divided with the ratio of 75% for training and 25% for testing. The following figure 2 shows the sample of all scans.

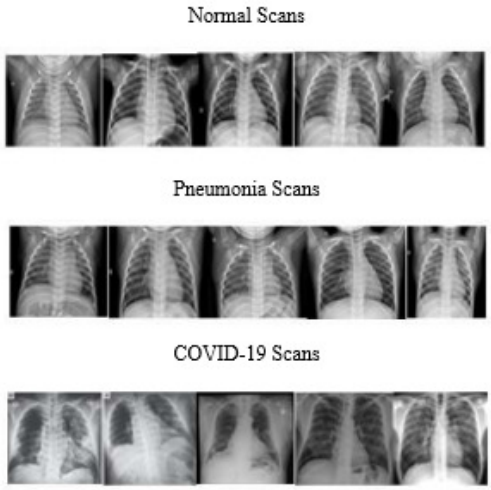

Fig. 2. Scans of Normal, Pneumonia and COVID-19 Infected Chest- X-Rays.

B. Preprocessing

We have extended the pixels of the dataset to the available level. Then resized all scans with 128×256 pixel so all the scans have the same size which provides consistency of training and testing to the proposed model.

C. Feature Extraction

The features of scans are extracted using a well-known method, Histogram of Oriented Gradients (HOG) [27]. This method counts the gradient orientation of an image by its local portions. It recognizes the contour properties of the image by describing its shape or structure.

D. Classification

Two well-known machine learning algorithms, support vector machine (SVM) and random forest are implemented by the proposed model to classify the given scans.

SVM falls under the supervised machine learning algorithms which are extensively used for classification and regression-related problems [28]. Generally, the SVM performs better in terms of efficiency, speed and accuracy for general nature problems. It is also recognized as a best algorithm for classification-related problems for small datasets. It efficiently finds the hyperplane upto n dimensions to differentiate the different points in data. Hyperplanes are used as a decision body for classifying the data. Figure 3 shows the working of SVM which classifies data into 2 classes

based on their properties. The gap shows the line of the normal hyperplane which divides the classes into two sections.

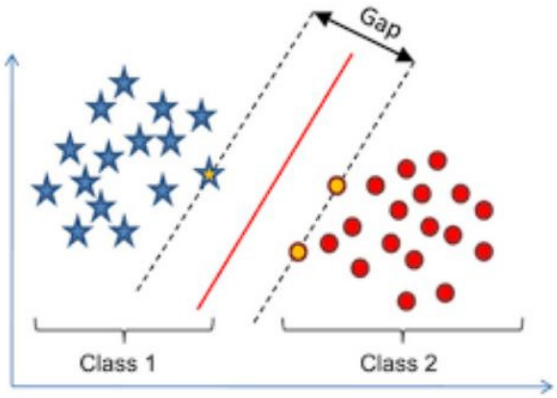

Fig. 3. Support Vector Machine.

Random forest is another ensemble machine learning algorithm that is used for regression, classification and decision trees related problems [29]. It generates the output without the need of hyperplane tuning. It is normally trained using the bagging method for constructing the decision trees. Figure 4 shows the working procedure of the random forest algorithm.

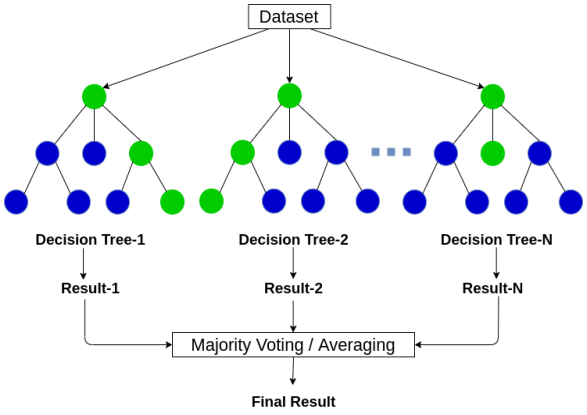

Fig. 4. Random Forest.

E. Performance Evaluation

Accuracy, precision and recall matrices are used for performance evaluation of the proposed model. Equation 1 shows the method to measure the accuracy of the proposed model which is examined as the number of accurate predictions from the total number of scans.

$$Accuracy = \frac{No.of\ Accurately\ Classified\ Scans}{Total\ No.of\ Scans} \times 100$$

Equation 2 shows the formula for measuring the precision matric while equation 3 shows the formula of recall.

$$Precision = \frac{No.of\ Accurately\ Classified\ Scans\ per\ Class}{Total\ No.of\ Scans\ per\ Class} \times 100$$

$$Recall = \frac{No.of\ Accurately\ Classified\ Scans\ per\ Class}{No.of\ expected\ Scans\ in\ corresponding\ Class} \times 100$$

IV. EXPERIMENTAL RESULTS

Dell XPS 15, i7, 10th generation laptop having 16GB DDR4 ram is used for experimentation. Python is used as a programming language. HOG is used for feature extraction from scans by both classifiers. Table 1 shows the accuracy of classification, precision and recall values of SVM while table 2 shows the same parameters for the random forest. SVM performs significantly well and returns the 99.27% accuracy while the precision and recall values are 1 for normal scan, 0.99 for Pneumonia and 0.97 for COVID-19 scans. Random forest also performs good and returns 96.89% accuracy in classification.

Table 1: Accuracy, Precision and Recall of SVM.

	Normal	COVID-19	Pneumonia
Accuracy	99.27%		
Precision	1	0.97	0.99
Recall	1	0.97	0.99

Table 2: Accuracy, Precision and Recall of Random Forest.

	Normal	COVID-19	Pneumonia
Accuracy	96.89%		
Precision	0.95	1	1
Recall	1	0.95	0.95

The accuracy of the proposed work is compared and analyzed with relevant work of literature. Results show that the proposed model performed significantly well in terms of accuracy. The table 3 elaborates the comparison with literature.

Table 3: Comparison of Proposed Model with Literature.

Sr. No.	Author	Method	Accuracy
1)	Sethy et. al [30]	SVM with ResNet 50	95.33%
2)	Duaa et al [31]	SVM with HOG	98.14%
3)	Ohata et al [32]	SVM with MobileNet	98.5%
4)	Ahmad Sarhan [33]	SVM with Wavelets	94.5%
5)	Proposed Model	SVM with HOG over Improved Pixels	99.27%

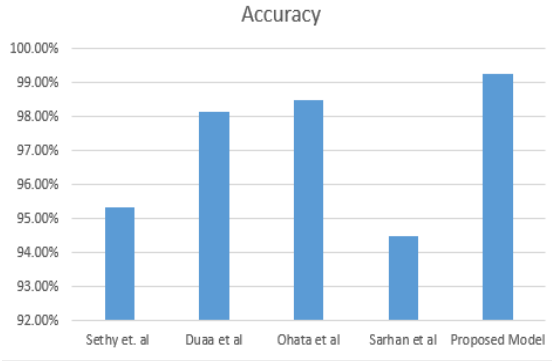

Fig. 5. Comparative Graph of Accuracy.

Figure 5 shows the performance of the proposed model with relevant literature comparison. Results show that the proposed model performs comparatively better than previous approaches.

V. CONCLUSION

World Health Organization (WHO) declares the COVID-19 as a global pandemic and it drastically impacts on the world population. It spread exponentially throughout the world. PCR was considered the fundamental test with various drawbacks like the number of false negatives and it takes much time for examination. We proposed a machine learning-based classification approach that detects more accurately and timely the COVID-19 infected cases from chest x-ray scans. We implemented SVM and random forest for COVID-19 detection and SVM shows 99.27% while random forest shows 96.89% accuracy. Further for results validation, we have performed a comparative analysis of the results of the proposed approach with other approaches proposed in the literature. These improved results may contribute to the detection and diagnosis of COVID-19.

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Conflict of Interest. We behalf of all authors, the corresponding author states that there is no conflict of interest.

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