Journal of ISMAC (2021)
Vol.03/ No.02
Pages: 132-148
http://irojournals.com/iroismac/
DOI: https://doi.org/10.36548/jismac.2021.2.006

Design of Accurate Classification of COVID-19 Disease in X-Ray Images Using Deep Learning Approach

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Abstract- COVID-19 appears to be having a devastating influence on world health and well-being. Moreover, the COVID-19 confirmed cases have recently increased to over 10 million worldwide. As the number of verified cases increase, it is more important to monitor and classify healthy and infected people in a timely and accurate manner. Many existing detection methods have failed to detect viral patterns. Henceforth, by using COVID-19 thoracic x-rays and the histogram-oriented gradients (HOG) feature extraction methodology; this research work has created an accurate classification method for performing a reliable detection of COVID-19 viral patterns. Further, the proposed classification model provides good results by leveraging accurate classification of COVID-19 disease based on the medical images. Besides, the performance of our proposed CNN classification method for medical imaging has been assessed based on different edge-based neural networks. Whenever there is an increasing number of a class in the training network, the accuracy of tertiary classification with CNN will be decreasing. Moreover, the analysis of 10 fold cross-validation with confusion metrics can also take place in our research work to detect various diseases caused due to lung infection such as Pneumonia corona virus-positive or negative. The proposed CNN model has been trained and tested with a public X-ray dataset, which is recently published for tertiary and normal classification purposes. For the instance transfer learning, the proposed model has achieved 85% accuracy of tertiary classification that includes normal, COVID-19 positive and Pneumonia. The proposed algorithm obtains good classification accuracy during binary classification procedure integrated with the transfer learning method.

ISSN: 2582-1369 (online)
Submitted: 30.04.2021
Revised: 26.05.2021
Accepted: 7.06.2021
Published: 15.06.2021

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Keywords: *Convolution Neural Network, COVID-19*

1. INTRODUCTION

As COVID-19 disease is currently increasing every day, there is a lack of accurate detection methods. This sickness has killed a great number of people all across the world. One of the pathways to spread the virus easily and quickly is the airway medium. [1]. This causes inflammation, which can usually be filled airbags with liquid and release. This automatically creates an obstacle to the intake of oxygen. The virus detection is a big challenge for the medical practitioners around the world in order to minimize the death rate and confirmed cases from the virus [2]. Figure 1 shows the confirmed cases of COVID-19 in India for the year 2020-21.

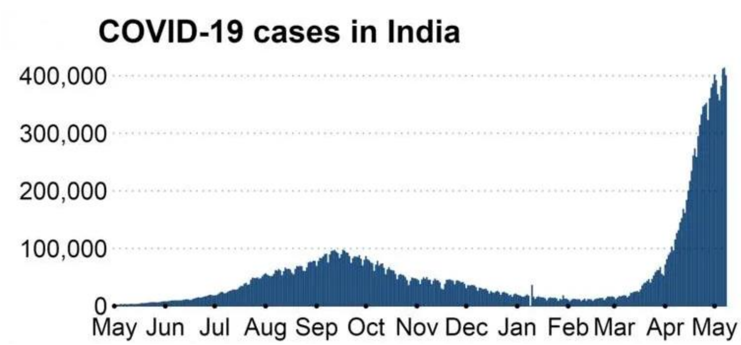

Figure 1 COVID-19 cases in India at 2020-21 (source from WHO)

As a result of the changing global climate, many other diseases have already occurred to people with a huge impact from COVID-19. Today, almost every country in the world has been rapidly infected by the coronavirus [3]. India recently recorded the highest number of verified COVID-19 cases in the world. The World Health Organization (WHO) is reporting the authenticate news about confirmed cases and death cases of COVID-19 in and around the world. -Currently, an extensive research work is required to diagnose the viral patterns and separate the affected individuals into an effective testing process [4].

Around the world, the medical professionals and researchers have attempted to enhance their treatment plan and testing capacity by carrying out multifunctional tests to stop spreading

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the virus and prevent the deadly virus [5]. Recently, the reverse transcription-polymerase chain reaction (RT–PCR) diagnostic method has been found effective in the detection of virus. However, the existing method has some inconveniences such as long-time detection and lower virus detection. The disadvantages could be attributed to stringent laboratory requirements and various test features [6]. Researchers are working to address the limitations of RT–PCR tests to improve the COVID-19 diagnosis and detection. But the chest imaging review is an effective method used for detecting the symptoms of virus in clinicians, who were affected by and recovered from the virus, as recommended by WHO. Further the diagnostic tests, including ultrasound, x-rays, and chest MRI and CT, and lung needle biopsy are also proposed [7].

Currently, chest radiology is widely used for detecting the cases of COVID-19 compared with the CT image, as it takes longer for imaging, and in many underdeveloped countries, CT scanners are not available [8]. CT imaging is also extremely costly and as a result of its high irradiation, pregnant women and children may be exposed to health risks. However, in many medical and epidemiological cases, x-ray imaging was important because of its wider availability. Chest X-ray is a very promising medication and treatment in emergency situations due to its rapidity, cost, and simplicity [9]. Figure 2 shows the simple CNN classifier approach for medical image processing.

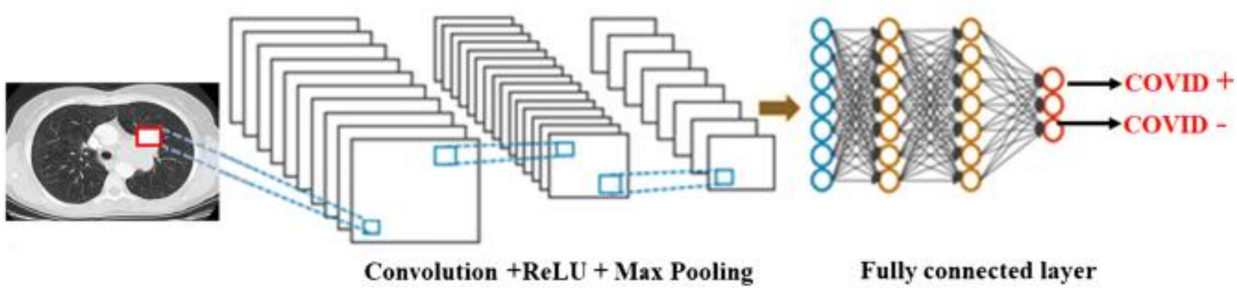

Figure 2 CNN Approach with Activation Functions

Some incoherence for the chest X-ray images taken from COVID-19 affected individuals was observed in thes existing researches [10] [11]. The machine learning approach includes

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diagnostics and bioinformatics and it is currently being implemented in various fields [12]. A CNN is a deep learning algorithm, which can be implemented in the processing of the medical image to support a proper and fast decision-making. In the field of medical image processing, the overall idea is that several medicinal pictures are used to develop a profound CNN study, which can differentiate the noise and useful diagnostic data [13].

The training by CNN is then used to interpret new medicinal images through the recognition of patterns, which show certain conditions in the individual images. However, this imitation of a doctor's training has the theory that the CNN method has more accurate results since it can learn from a much larger set of pictures than any human being [14] [15].

2. ORGANIZATION OF THE RESEARCH

The structure of research article is as follows; Section 3 contains current research papers on COVID-19 virus detection methods. The proposed methodology for performing accurate detection of COVID-19 virus in X-ray frames is discussed in Section 4. Section 5 provides a description and comparison of the different classifications with the proposed method. Section 6 discusses about the conclusion and the future research directions.

3. RELATED WORKS

In the diagnosis of diseases such as cancer, deep learning with CNN was also used through image classification. For instance, Li and Shen [16] have proposed to provide segmentation, feature extraction, or classification of images from skin lesions for two completely convolutional residual networks. The classification results were refined by using a lesion index calculation unit. The results of the profound learning frameworks have demonstrated good accuracy with 91% around the cancer diagnosis.

To improve diagnosis performance for 12 types of cancer, Liao et al [17] have proposed the multi-work profound learning method (MTDL). They expressed the data with insufficiency. Their experiments have demonstrated that, the proposed method is accurately diagnosed by aggregating the expression data for 12 cancer types. But the authors have not compared the results with similar works in existence. Yoo et al have[18] developed an automated CNN method

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in which 427 patients have collected diffusion-weighted magnetic resonance imaging (DWI) for performing the detection of prostate cancer. Statistical characteristics at a first-order level were extracted from probabilities at slice level, which were used to compile slice level results into the level of patient. The proposed procedure has been tested on 108 patients and it has been successful in both slices and patients. They developed a system, which could use 3D CNNs and other methods to improve the diagnosis of cancer.

Esteva et al [19] have shown a pre-trained classification of skin cancer Inception V3 CNN model with 129k pictures of clinical skin cancer and 33k pictures of dermatoid cancer. The CNN was fully trained from pictures by using input pixels and disease labels. Two dermatologists have achieved accuracies of 65.56% and 66.0% in a subset of the test set. Chowdhury et al [20] have developed a new PDCOVIDNet framework based on CNN with parallel-dilation in the chest X-ray imagery. The authors have used a spread convolution in the parallel stage for the proposed method, which could capture and extend the features that are necessary to obtain a precision of 96% detection. Abbas et al [21] have suggested and validated a profound neurotic network that has been known to detect COVID-19 patient's chest x-ray images called decomposing, transferring, and composing (DeTraC). They have proposed a breakdown mechanism to verify dataset irregularities by examining class limits in order to achieve high accuracy and sensitivity (93%) (100 percent).

The deep learning methods based on the CNN model of the ResNet 101 have been used by Azemin et al [22]. Thousands of images have been used in its proposed approach during the pre-trained period to detect meaningful objects and retrain them to predict the chest x-ray abnormalities. This method's accuracy was only 71%. The framework has combined with various levels of frameworks named as patient layer, cloud layer, and hospital layer. El-Rashidy et al several patient layer data have been collected by wearable sensors and a mobile application. To detect COVID-19 with patient X-ray images, a neural network-based deep learning model was used. 97.9% accuracy and 98.85% specificity were achieved in the proposed model [23].

In the form of COVID-19 or normal X-ray images with pre-trained profound learning models like ResNet5, VGG16, VGG19, and the DensNet121, VGG16 and VGG19 to demonstrate the best accuracies, Khan et al [24] developed a new diagnostic architecture. Two

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phases such as pre-processing, data increase, and transmissions were included in the proposed models and 99.3 percent accuracy was demonstrated. The proposed Loey et al model was [25] Based on a dataset of 307 images of four class types using three deep transfer models such as AlexNet, GoogleNet, and ResNet18: COVID-19, normal, bacterial pneumonia, and pneumonia. The work was performed in several scenarios to reduce the storage and execution time. GoogleNet has achieved 100% accuracy and 99.9% validation precision in the last profound transmission model.

Minaee et al [26] reported on the use of four tuning models such as ResNet18, ResNet50, and DensSkeezeNet and 121 in the detection of COVID-19 from the chest of the X-ray image. A transformed version of the images of COVID-19 is developed by using the proposed method to increase samples and ultimately achieve 98% sensitivity and 90% specialty. Sekeroglu et al [27] developed a model with profound education and machine-learning classifications that conducted several tests of the CNN with high precision chest X-ray images for the COVID-19 detection. Several experiments were conducted by using various algorithms for machine learning and it is performed by the advanced pre-trained transference learning network. 99% accuracy, 99% specificity, and 94% sensitivity were demonstrated. The researchers found that the CNN architecture could identify COVID-19 from a limited number of images without pre-processing and with minimal layers. [28] [29].

4. PROPOSED WORKS

4.1 Convolutional Neural Network

Recently, CNN approaches are used to solve many issues for medical imaging classification problems in a good manner [30]. Due to its encompassed complex features, when getting input for the process. Figure 3 shows the simple proposed CNN algorithm flow. The enhancement of CNN algorithm is incorporated with HOG following as,

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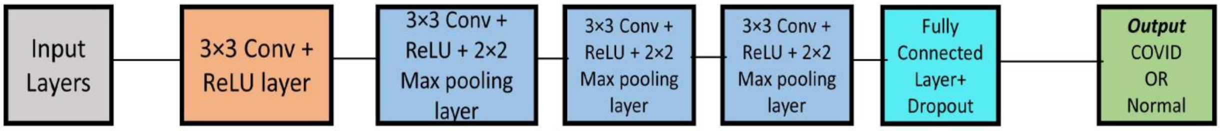

Figure 3 Proposed Algorithm flow

Algorithm:

Step 1:

Get the input from Chest x-ray image dataset

Step 2:

(i) Pre-processing of input image

(ii) Extract the feature

Step 3:

Feature matrix initializes $F_c \geq M_i . i = 1$

Step 4:

Feature extraction from each image features with $N(i, 1{,}550)$

Step 5:

$F_c(i, 1) = M(x, 1) + F_c(i, 1)$

Step 6: Determining Histogram oriented gradients (HOG)

(i) Let's assume $H_0(i, 1) is\ Low\ pass\ filter\ output$ & $H_1(i, 1)\ is\ bandpass\ output$

(ii) $HOG(i, 1) = H_0(i, 1) + H_1(i, 1)$

(iii) Obtaining overall HOG by combining of features in Vector (V)

(iv) Training feature (V) = [F_c, HOG]

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The complex features from the input images should be classified with primary importance in radiology. Similarly, the bone joins the muscle, where the lung tissues are incorporated with the infected cells of spatial relationship [31] [32] [33]. The proposed CNN architecture contains 5 convolutional layers for chest x-ray images as its input. It starts with 244x244 in the opening layers and it is used 5*5*3 kernel filter coefficients. The next layer will receive the input from the previous layer output and contained a max-pooling layer to reduce space with 2*2 strides [34] [35]. Besides the pooling layers output data passing through the activation function ReLU feature which is producing the nonlinear output into the next convolution layer with 5*5*64 of 128 filters with the same stride value. This can be used to reduce the image size yet more. After the operation of the activation function, the output will feed into the convolution layer [36] [37]. This process can be repeated with kernel size reduction process of same stride 1*1 due to less number of matrix features. The kernel size is used to accommodate output from all the filters from configured layers in the network. At last, the resulting tensor flow has the shape of the feature 7*7*512 with flattened array values are 25k neurons. Figure 4 shows the internal architecture of the proposed work.

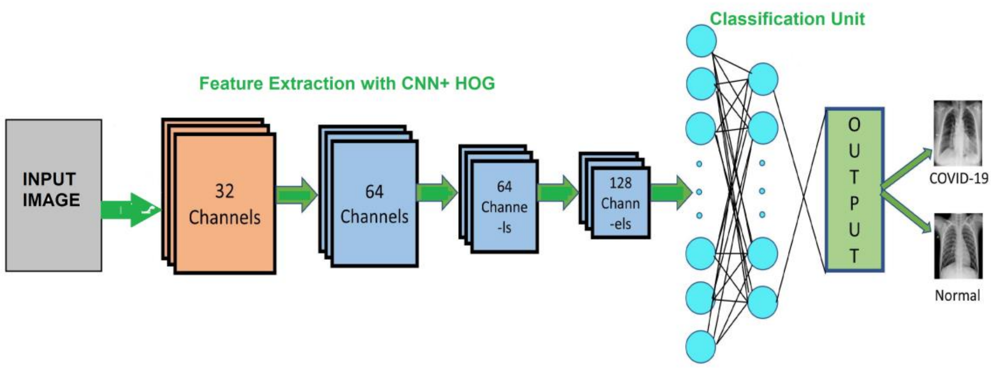

Figure 4 Internal architecture of proposed work

This way the neurons can have the capability to establish the symptoms of COVID-19 from the features. Finally, the drop-out layer is used to handle the overfitting issues in the network effectively [38] [39]. This feature extraction component can be incorporated with the classification section. The classification sections are connected layers with the fully connected

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and dense version in the network. The flatten array value can be classified and provides the number of categories to determine the COVID-19 positive or negative or pneumonia.

4.2 Rectified Linear Unit (ReLU) Layer:

Generally, this activation unit provides a nonlinearity function to the networks and it changes all the negative input values into zero. It is defined as,

4.3 Max-pooling Layer:

The sample feature-based discretization can be done here to reduce the space size. The down sampling will take place for input features extraction in the sub-regions. This can decrease the size of learning features for providing the invariance of a depiction of the input images, which can reduce the cost of computation [40]. Our proposed model can be adapted with this 3*3 max-pooling process of kernel size.

5. RESULTS & DISCUSSION

The patient's chest x-ray images were stored in commonplace to evaluate with the intelligent system. The proposed framework avails the standard datasets for evaluation named Cohen's dataset, which consists of 60k around images with 400 positive COVID-19 x-ray images [41].

Figure 5 sample input chest x-ray images with normal conditions

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The databases contain the size of images ranging from 512*512 pixels around. Besides, the proposed work is implemented with a Jupyter notebook with a good high configuration desktop PC. Figure 5 shows some sample input chest x-ray images with normal conditions. Figure 6 shows the results (COVID-19 identified) obtained by our proposed work.

Sensitivity (Recall):

These metrics are used to measure the accurate positive prediction, which is divided by the whole sum of positive. Also, the most sensitive model can be identified by the highest value of sensitivity. It can be calculated by using the following equation,

$$Recall = \frac{TP}{TP + FN}$$

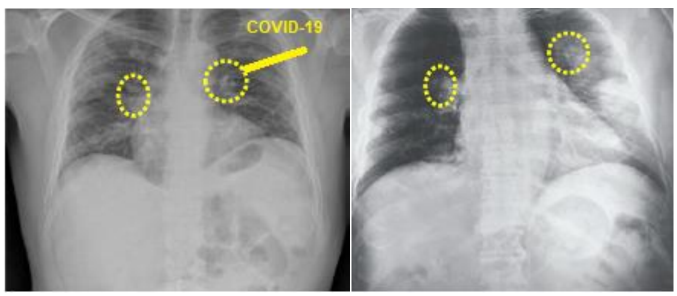

Figure 6 Result obtained by proposed work

Figure 7 shows the inefficiency of the existing algorithm to detect COVID-19 positive in some sort of normal input images, which is available in our database.

Specificity:

It is just a replica of sensitivity that is used to measure the negative predictions divided by the whole sum of negatives. The specificity can be calculated by using the following equation,

$$Specificity = \frac{TN}{TN + FP}$$

Precision:

This metric is used to compute the positive label of our proposed algorithm to all negative labels. It can be computed as follows,

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$$Precision = \frac{TP}{TP + FP}$$

Figure 7shows the yellow circle as COVID-19. But this image is classified as normal conditions of COVID-19 and patients free from the virus by our proposed work. Besides, our proposed work has classified similar images as symptoms of pneumonia in an effective manner.

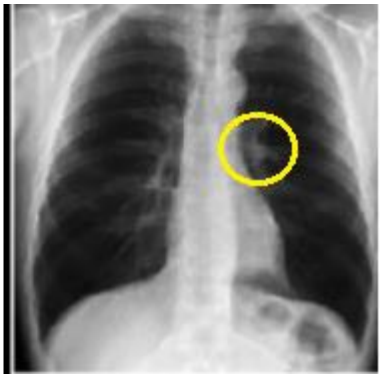

Figure 7 Fails of Existing methods

Figure 8 shows the comparative analysis of the overall performance measure with our proposed algorithm with another existing algorithm.

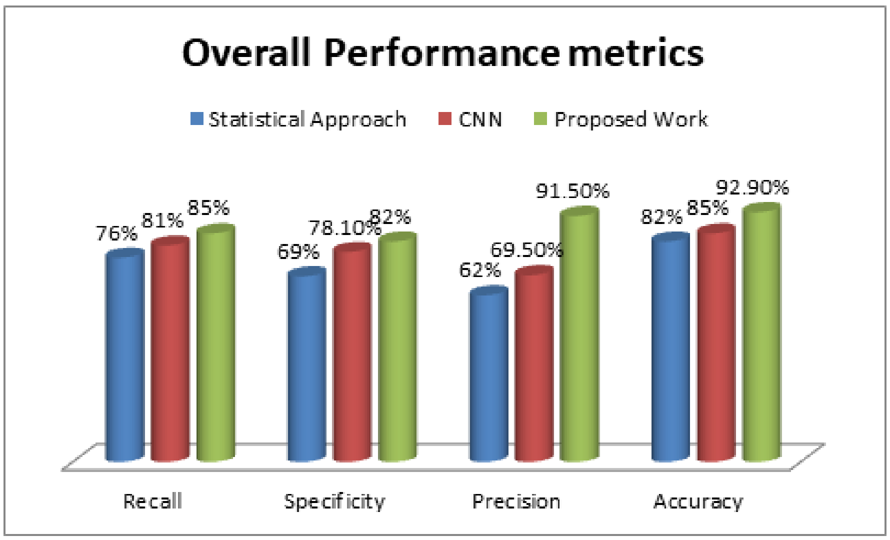

Figure 8 overall performance measure of proposed framework

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Table 1 shows the overall performance measure of our proposed CNN+HOG classifier with existing methods.

Table 1 Performance measure of proposed classifier

S.No	Methods	Accuracy	Recall	Specificity	Precision
1	Statistical Approach	82%	76%	69%	62%
2	CNN	85%	80.5%	78.1%	69.5%
3	Proposed CNN + HOG	92.95%	85%	82%	91.5%

Accuracy

This is the essential metric for the evaluation of proposed CNN classification and existing methods. The most accurate model can be identified by the highest value of accuracy. Here, the features with confusion matrix are determined and computed to evaluate the effectiveness of the proposed framework. We calculated by the following equation,

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

It has proved that, the proposed CNN framework has provided good accurate results to determine COVID-19.

6. CONCLUSION

Thus, the proposed CNN method shows good detection accuracy in a fast and effective manner. This approach is used for classification and detection of COVID-19 cases from medical images in the field of the deep learning [DL] approach. The proposed approach with multiclass categories of 93% shows in the results and discussion section. The proposed framework performs well enough during the shortage of dataset of the pattern of COVID-19. Our algorithm will be more useful in many rural villages in India for performing accurate detection of COVID-19 cases. The proposed CNN algorithm is finding exclusive features from the input and it is automatically detected within the classes. The study has also used limited datasets from various sources in order to analyze the robustness of the systems by responding to real-world scenarios. This approach will effectively prevent the human prejudice of COVID-19. In the future, the

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development of our proposed framework will be extended to similar infectious diseases such as bacterial pneumonia by using X-ray images. The training of the classification section can be focused and modified for limited dataset issues. The construction of an adversary network for CNN will be a good choice for detecting COVID-19. In the future, more lung disease detection will be incorporated along with our algorithm. A dataset from several sources allow the development of robust models.

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Published: 15.06.2021

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ISSN: 2582-1369 (online)
Submitted: 30.04.2021
Revised: 26.05.2021
Accepted: 7.06.2021
Published: 15.06.2021

Journal of ISMAC (2021)
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Pages: 132-148
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ISSN: 2582-1369 (online)
Submitted: 30.04.2021
Revised: 26.05.2021
Accepted: 7.06.2021
Published: 15.06.2021