**1.1 Background of Study**

The Coronavirus (Covid-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus strain. This disease had its first strike in Wuhan (a city in China) in the year 2019 and subsequently began to spread globally to become the fifth documented pandemic since 1918 flu pandemic which claimed many lives. The main symptoms shown include respiratory distress, fever and cough, the severity of the infection may be visible as pneumonia, acute respiratory syndrome, septic shock, multi-organ failure and, finally, death (Ohata *et al*., 2021).

In the city of Wuhan in China’s Hubei Province, the coronavirus came in guise of pneumonia and several cases were detected on December 31, 2019. Whereas, the causative agent was later identified as a new coronavirus (2019-nCoV) on January 7, 2020 and the disease was named as COVID-19.(Zhan *et al*., 2020) According to the World Health Organization (WHO), as of December 22, 2021, the total number of worldwide confirmed cases of coronavirus is 275,233,892 including 5,364,996 deaths (WHO, 2021).

The disease is contagious, and the virus gets spread amongst human via respiratory droplets, physical contact, and also through fecal-oral transmission. Specialists depend on radiological studies, either by chest X-ray (CXR) or computer tomography (CT) to follow the break out of the disease. The use of CT as a diagnostic method for covid-19 has several disadvantages. In many hospitals the necessary equipment to acquire the image is not available and the cost of a tomographic study is high (López-Cabrera *et al*., 2021).

The rate of human to human transmission of this disease is high and is a matter of concern for the regulatory authorities globally. At large, the control depends on early diagnosis at the right time. The method available for diagnosis is laboratory tests like Reverse-Transcription Polymerase Chain Reaction (RT-PCR) requires testing kits which have limited availability in the supply chain and the test takes time due to laboratory processes involved (K. K. Singh & Singh, 2021).

On the other hand, CXR images have some benefits compared to CT, which makes this modality a more extended way to patients. There is a minimal possibility of spreading the virus and exposing the patient to a lower dose of ionizing radiation. The chest radiography (X-ray) is a method adopted by many worldwide because it is less expensive, fast and common clinical method (Narin *et al*., 2021).

The World Health Organization (WHO), with the support of the Strategic Advisory Group of Experts (SAGE) on immunization and its COVID-19 Vaccines Working Group, continues to review the emerging evidence on the need for and timing of a booster dose for the currently available COVID-19 vaccine which have received Emergency Use Listing (EUL). This statement reflects the current understanding of vaccine performance and supply as presented to SAGE on December 7, 2021. It summarizes and contextualizes current evidence on booster vaccination. In recent weeks, the SARS-Cov2 Omicron variant has emerged. Data are currently insufficient to access the impact of this new variant of concern in vaccine effectiveness, in particular against severe disease.(He *et al*., 2021)

The WHO has said that the omicron variant is reported to be causing infections in people that are already vaccinated or who have recovered from the covid-19 disease as they could be re-infected. This is as it said that there is now consistent evidence that the omicron variant is spreading significantly faster than the Delta variant as covid-19 continues to account for about 50,000 deaths globally every week.(Eyre *et al*., 2022).

Feature Extraction is the process of transforming raw data into numerical features that can be processed while preserving the information in the original dataset (Jogin, 2018). It yields better results than applying machine learning directly to the raw data. Deep Learning technique is a type of machine learning based on Artificial Neural Network in which multiple layers of processing are used to extract progressively higher level features from data (Duran-Lopez *et al*., 2020). Classification is a supervised learning that refers to a predictive modeling problem where a class label is predicted for a given example of input data(Asif *et al*., 2020).

**1.2 Problem Statement**

There are several machine learning models developed to detect the severity and alertness for necessary precaution against covid-19, but these models are plagued with non-substantial chest x-ray images, non-deployment on handheld devices, problem of overfitting and high memory requirements and computational cost of the model are challenges faced. (Abbas *et al*., 2021). Also, to improve the classification accuracy of chest x-ray images of covid-19 patients and other related diseases affecting the lungs, parameter optimization can be used. (Ismael & Şengür, 2021). An in-depth analytical comparison of performances between conventional algorithms and deep learning methods in establishing its clinical acceptability is needed. (Aradhya *et al*., 2021). Consequently, robust extraction feature technique that will enhance the classification of CXR will be employed. In this research work, histogram of oriented gradient (HOG) and local Binary Pattern (LBP) will be used to classify chest x-ray images to make detection more accurate using convolution neural network (CNN) as classification algorithm is proposed.

**1.3 Aim and Objectives of the Study**

The aim of this research is to employ cascaded feature extraction using HOG in conjunction with LBP and CNN for classification of Covid-19 Chest X-ray images.

The aim of this research work will be achieved with the following objectives:

1. To identify the challenges of the existing models in the detection of chest x-ray images (CXR) for Covid-19
2. To employ HOG and LBP for feature extraction and CNN for classification to address the existing problem in (i).
3. To evaluate the performance of the (ii) above using metrics: Accuracy, F1-score, Recall and Precision.

**1.4 Significance of the Study**

The significance of this study are as follows:

1. Suggested a COVID-19 prediction method can improve the diagnosis accuracy and performance.
2. It will be useful to health practitioners in the diagnosis of COVID-19 disease.

**1.5 Scope and Limitation of the Study**

The scope of the study span across chest x-ray images for covid-19 infection detection. Hence, the scope can be widened to other related diseases.

1. **LITERATURE REVIEW**

**2.1 History of Covid-19**

Coronavirus popularly known as Covid-19 caused by SARS-Cov-2, a severe acute respiratory syndrome, is an unprecedented and highly infectious disease in the world. It been declared as pandemic by World Health Organization (WHO). The first case was reported in December 2019, reaching approximately 21.3 million confirmed cases and 761,799 deaths as of 16 August 2020 (Lee *et al*., 2020). Due to the high contagious rate of the disease, there is need for early detection of the virus since there is no vaccine as at then. For early diagnosis of COVID-19, the reverse transcription polymerase chain reaction (RT-PCR) test is commonly done. However, it suffers from a high false-negative rate of up to 67% if the test is done during the first five days of exposure. As an alternative, research on the efficacy of deep learning techniques employed in the identification of COVID-19 disease using chest X-ray images is intensely pursued (Science *et al*., 2021).

In the last few years, deep learning has grown exponentially and in the medical imaging world, the potential of automated disease discovery framework has been highlighted by many scientists (Singh *et al*., 2021). Considering the success and potential of AI and deep learning in the medical imaging field, many computer scientists are exploring the possibility of automatic detection of COVID-19 using chest X-rays. However, any deep learning-based solution needs sufficient training data to produce generalizable results. The research community has therefore been pooling a lot of data to enhance the knowledge bank which we use for the purpose of this study. Motivated by the recent progress made by the scientific community, we proposed to explore the use of chest X-rays images for the detection of COVID-19 in this work.

**2.2 Machine Learning Algorithm**

Machine learning (ML) is the scientific study of algorithms and statistical models that computer systems use to perform a specific task without being explicitly programmed (Batta, 2020). ML is used to teach machines how to handle the data more efficiently. Sometimes after viewing the data, we cannot interpret the extracted information from the data. In that case, we apply machine learning algorithm for better understanding and interpretability. With the abundance of datasets available, the machine learning algorithms are needed. Depending on the availability of types and categories of training data one may need to select from the available techniques of “supervised learning”, “unsupervised learning”, “semi supervised learning” and “reinforcement learning” to apply the appropriate machine learning algorithm (Shrestha & Mahmood, 2019).

**2.2.1 Supervised Learning Algorithm**

Supervised learning is the machine learning task of learning a function that maps an input to an output based on example input-output pairs. It infers a function from labeled training data consisting of a set of training examples. The supervised machine learning algorithms are those algorithms which needs external assistance. The input dataset is divided into train and test dataset. The train dataset has output variable which needs to be predicted or classified. Classification and regression are the types of Supervised Learning (Fatima & Pasha, 2017).

**2.2.2 Unsupervised Learning Algorithm**

Unsupervised learning technique tries to find out the similarities between the input data and based on these similarities, un-supervised learning technique classify the data. The unsupervised learning algorithms learn few features from the data. (Batta, 2020). It is mainly used for clustering and feature reduction.

**2.2.3 Semi-Supervised Learning Algorithm**

This learning also used unlabeled data for training purpose (generally a minimum amount of labeled-data with a huge amount of unlabeled-data). Semi-supervised learning lies between unsupervised-learning (unlabeled-data) and supervised learning (labeled-data) (Sarker, 2021).

**2.2.4 Reinforcement Algorithm**

This learning is encouraged by behaviorist psychology. Algorithm is informed when the answer is wrong, but does not inform that how to correct it. It has to explore and test various possibilities until it finds the right answer. It is also known as learning with a critic. It does not recommend improvements. Reinforcement learning is different from supervised learning in the sense that accurate input and output sets are not offered, nor sub-optimal actions clearly précised. Moreover, it focuses on on-line performance (Fatima & Pasha, 2017).

**2.3 Feature Extraction Techniques**

The selection of features, also known as the selection of variables or attributes in the data, is the process of choosing a subset of unique features (variables, predictors) to use in building machine learning and data science model. It decreases a model’s complexity by eliminating the irrelevant or less important features and allows for faster training of machine learning algorithms (Sarker, 2021). Feature extraction techniques usually provide a better understanding of the data, a way to improve prediction accuracy, and to reduce computational cost or training time. The aim of feature extraction is to reduce the number of features in a dataset by generating new ones from the existing ones and then discarding the original features.

In this research, we will focus on two feature extraction namely: Histogram of Oriented Gradients (HOG) and Local Binary Pattern (LBP).

**2.3.1 Histogram of Oriented Gradients (HOG)**

Dalal(2006) introduced Histogram of Oriented Gradients(HOG) features in 2005. Histogram of Oriented Gradients (HOG) is a feature descriptor used in image processing, mainly for object detection. A feature descriptor is a representation of an image or an image patch that simplifies the image by extracting useful information from it.

The principle behind the histogram of oriented gradients descriptor is that local object appearance and shape within an image can be described by the distribution of intensity gradients or edge directions. The x and y derivatives of an image (Gradients) are useful because the magnitude of gradients is large around edges and corners due to abrupt change in intensity and we know that edges and corners pack in a lot more information about object shape than flat regions. So, the histograms of directions of gradients are used as features in this descriptor.

HOG is standard technique of object. It counts incidences of edge directions in a local neighborhood of an image. This detection task is performed by applying HOG in the acquired image. Before applying HOG, the input image is transformed from RGB into gray scale image for simplicity (Ahamed *et al*., 2018).

**2.3.2 Local Binary Pattern (LBP)**

**Local Binary Pattern**(LBP) is a simple yet very efficient texture operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number. Due to its discriminative power and computational simplicity, LBP texture operator has become a popular approach in various applications. It can be seen as a unifying approach to the traditionally divergent statistical and structural models of texture analysis. Perhaps the most important property of the LBP operator in real-world applications is its robustness to monotonic gray-scale changes caused, for example, by illumination variations. Another important property is its computational simplicity, which makes it possible to analyze images in challenging real-time settings (Lahdenoja *et al*., 2005). LBPs are local patterns that describe the relationship between a pixel and its neighborhood.

The LBP combines the structural and statistical image analysis approaches into a single high efficiency transformation which is invariant with respect to monotonic grayscale transformations and scaling (Huang *et al*., 2011).

**2.4 Related Works**

Owing to the outburst of covid-19 pandemic, there are numerous machine learning model developed for classification and prediction. Singh and Singh (2021) proposed an automated method for detection of covid-19 from CXR with improved depthwise convolution network that incorporates spectral analysis. A comparative study is also performed to evaluate the performance of the method with existing methods which yields 95.83%, 95.67%, 96.07%, 95.63% accuracy, precision, sensitivity and F1-score respectively.

Rehman *et al* (2021) proposed a real-time computer aided diagnosis (CAD) approach to support physicians and avoid further spreading of the disease. A convolutional neural network (CNN) -based Residual neural network (Resnet50) was utilized to detect covid-19 through CXR images and achieved 98% accuracy. The CAD system uses advanced load balancer and resilience features to achieve fault tolerance with zero delays and perceives more infected cases during this pandemic. This work used limited number of X-ray images for the diagnosis.

Karim *et al* (2020) proposed an explainable deep neural network (DNN)-based method for automatic detection of COVID-19 symptoms from chest radiography (CXR) images called ‘DeepCOVIDExplainer’. CXR images are first comprehensively preprocessed and augmented before classifying with a neural ensemble method, followed by highlighting class-discriminating regions using gradient-guided class activation maps (Grad-CAM++) and layer-wise relevance propagation (LRP). Furthermore, human-interpretable explanations were provided for the diagnosis. Evaluation results show that the approach can identify COVID-19 cases with a positive predictive value (PPV) of 91.6%, 92.45%, and 96.12%, respectively for normal, pneumonia, and COVID-19 cases, respectively, outperforming recent approaches. This work has problem of overfitting due to limited number of CXR images used to train the models and inability to verify the diagnosis and localization accuracies with radiologists.

Elaziz *et al.* (2020) adopted a new machine learning method to classify CXR into covid-19 patient and non-covid-19 person. The features extracted from the chest x-ray images uses new Fractional Multichannel Exponent Moments (FrMEMs). A parallel multi-core computational framework utilized to accelerate the computational process, then, a modified Manta-Ray Foraging Optimization based on differential evolution used to select the most significant features. The method is evaluated using two COVID-19 x-ray datasets which achieved accuracy rates of 96.09% and 98.09% for the first and second datasets, respectively.

Che Azemin *et al.* (2020) used a deep learning model based on the ResNet-101 convolutional neural network architecture, which was pretrained to recognize objects from a million of images and then retrained to detect abnormality in chest X-ray images. The performance of the model in terms of area under the receiver operating curve, sensitivity, specificity, and accuracy was 0.82, 77.3%, 71.8%, and 71.9%, respectively. The strength of this study lies in the use of labels that have a strong clinical association with COVID-19 cases and the use of mutually exclusive publicly available data for training, validation, and testing.

Ensemble Deep Learning (EDL-COVID) was employed by Tang *et al*. (2021) by combining deep learning and ensemble learning for predicting covid-19 cases. Then, this model will be compared with COVID-Net, which is an open-sourced network architecture for Covid-19 cases detection. The aim of this work is to overcome the shortcomings of high variance and generalization errors caused by noise and limited number of datasets. The results show that EDL-COVID offers better result for covid-19 cases detection with an accuracy of 95% than COVID-Net of 93.3%.

Deb and Jha (2020) proposed a Deep Convolutional Neural Network based ensemble architecture for extracting features from CXR images and then, classify them into three cases: Community Acquired Pneumonia (CAP), Normal and Covid-19. The ensemble network uses three pre-trained DCNN networks: NASNet, MobileNet and DenseNet. The low-level features extracted from the three DCNN architectures are later concatenated and applied to a classifier for final classification. An accuracy of 91.99% was achieved which is slightly better than the state-of-the-art performances.

A new family of models based on the EfficientNetFamily of deep Artificial Neural Network was used by Luz *et al*. (2021) for classifying covid-19 CXR images. The aim of this work is to develop an accurate yet efficient method in terms of memory and processing time for the problem of covid-19 screening in CXRs. This approach produced a high-quality model with an overall accuracy of 93.9%, sensitivity of 96.5%, and positive prediction of 100% with a computational efficiency more than 30 times higher.

Oh *et al*. (2020) proposed a patch-based convolutional neural network approach with a relatively small number of trainable parameters to address the difficulty involved in the collection of large CXR data set for deep neural network training. The method uses statistical analysis of the potential imaging biomarkers of the CXR radiographs. The method achieved state-of-the-art performance and provides clinically interpretable saliency maps, which are useful for covid-19 diagnosis and patient triage.

Hira *et al*. (2021) introduced a deep learning-based approach that can differentiate COVID- 19 disease patients from viral pneumonia, bacterial pneumonia, and healthy (normal) cases. This work used nine convolutional neural network-based architecture (AlexNet, GoogleNet, ResNet-50, Se-ResNet-50, DenseNet121, Inception V4, Inception ResNet V2, ResNeXt-50, and Se-ResNeXt-50). Experimental results indicate that the pre-trained model Se-ResNeXt-50 achieves the highest classification accuracy of 99.32% for binary class and 97.55% for multi-class among all pre-trained models.

Abbas *et al*. (2021) validated a deep CNN, called Decompose, Transfer, and Compose (DeTraC), for the classification of COVID-19 chest X-ray images. DeTraC can deal with any irregularities in the image dataset by investigating its class boundaries using a class decomposition mechanism. The experimental results showed the capability of DeTraC in the detection of COVID-19 cases from a comprehensive image dataset collected from several hospitals around the world. High accuracy of 93.1% (with a sensitivity of 100%) was achieved by DeTraC in the detection of COVID-19 X-ray images from normal, and severe acute respiratory syndrome cases.

1. **Methodology**

This section presents the techniques that will be used to achieve the aim of this study. Figure 1 presents the proposed techniques.

Data Collection

Image Preprocessing

Perform

Normalization

Covid-19

Non-Covid-19

Feature

Extraction

Histogram of Oriented Gradients (HOG)

Local Binary Pattern (LBP)

Perform Classification

(CNN)

Figure 1 The Proposed System

**3.1 Data Collection**

Data will be collected from Kaggle repository. Kaggle is a free, open access that allows users to find and publish data sets, explore and build models in a web-based data-science environment, work with other data scientists and machine learning engineers, and enter competitions to solve data science challenges.

**3.2 Image Preprocessing**

The CXR images will be resized and transformed from RGB to grayscale to ensure uniformity across the datasets. Preprocessing of images involves grayscale conversion, noise removal and image segmentation.

**3.3 Block Normalization**

After the creation of histogram of oriented gradients we need to do something else. Gradient is sensitive to overall lighting. If we say divide/multiply pixel values by some constant in order to make it lighter/ darker the gradient magnitude will change and so will histogram values. We want that histogram values be independent of lighting. Normalization is done on the histogram vector v within a block. One of the following norms could be used:

* L1 norm
* L2 norm
* L2-Hys(Lowe-style clipped L2 norm)

Now, we could simply normalize the 9×1 histogram vector but it is better to normalize a bigger sized block of 16×16. A 16×16 block has 4 histograms (8×8 cell results to one histogram) which can be concatenated to form a 36 x 1 element vector and normalized. The 16×16 window then moves by 8 pixels and a normalized 36×1 vector is calculated over this window and the process is repeated for the image.

**3.4 Feature Extraction**

Feature extraction is an important step in the construction of any pattern classification and aims at the extraction of the relevant information that characterizes each class. In this process relevant features are extracted from chest x-ray images to form feature vectors. These feature vectors are then used by classifiers to recognize the input unit with target output unit. It becomes easier for the classifier to classify between different classes by looking at these features as it allows fairly easy to distinguish. Feature selection is critical to the whole process since the classifier will not be able to recognize from poorly selected features (Kumar & Bhatia, 2014). In this research work, Histogram of Oriented Gradients (HOG) and Local Binary Pattern (LBP) will be used.

**3.4.1 Histogram of Oriented Gradients (HOG)**

HOG is a standard technique of object in terms of magnitude and direction. It counts incidences of edge directions in a local neighborhood of an image. This detection task is performed by applying HOG in the acquired image. Before applying HOG, the input images are transformed from RGB into gray scale images for simplicity (Ahamed *et al*., 2018). HOG is divided into 3 compulsory steps based on vector theory. Initially, the CXR images will be analyzed roughly by separating object from background. This process is looking for ‘magnitude’ difference in the image. Therefore, for now, we consider only the magnitude part of vector without the direction. The magnitude in the image could be obtained by equation 1.

*m(u,v) =√( fu(u,v)2 + fv(u,v)2)*(1)

According to equation 1, we get the magnitude m of a feature vector at the point (u, v). m(u, v) consists of fu(u, v) and fv(u, v). fu(u, v) is a component in u-direction , and also fv(u, v) is a component in v-direction. After the program estimated the object position in the image, then we train it to determine the object more precisely. This second process is to take the direction of vector into account. This is comparable to the fine adjustment

(2)

Where fu(u, v) is a component in u-direction and fv(u, v) is a component in v-direction.

According to fu(u, v) and fv(u, v), we can use arctangent to get an angle as shown in equation 2. With the help of vector direction which described in detail in equation 2, the object is displayed as continuous variation of gradient depending on the direction of vector. The result will be shown as a gradient; therefore, we will divide the image into a great number of pixels. This will demonstrate that the pixel from background give much lower accumulating result than the pixel from the object. In summary, by evaluate the result from histogram, we will be able to discriminate between object and background correctly and precisely.

**3.4.2 Local Binary Pattern (LBP)**

LBPs are local patterns that describe the relationship between a pixel and its neighborhood. In the LBP method each pixel is replaced by a binary pattern which is derived from the pixel's neighborhood (Lahdenoja *et al*., n.d.). Each grayscale pixel P of an image is used as a centre of a circle with radius r. The number of samples M determines the amount of points that are taken uniformly from the contour of the circle. These points are interpolated from adjacent pixels if needed. The sample points are compared against the pixel P one by one with a simple comparison operation which results a binary zero if the centre point is larger than the current sample point and one otherwise. The processing involves thresholding the center pixel of that window with its surrounding pixels using the window mean, window median or the actual center pixel, as thresholds. Then the LBP code of pixel (xc, xy) is given by Equation 1,

where ic and iP are, respectively, gray-level values of the central pixel and P surrounding pixels in the circle neighborhood with a radius R, and function S(x) is defined as

S(x) = 1 if x >= 0 (2)

0 if x < 0

**3.5 Classification**

Classification is a type of supervised learning. Image classification task can be achieved using various approaches with the help of deep neural network. In this proposed work CNN is used as the training algorithm which has been effectively applied to a wide range of machine learning applications. (Jumani *et al*., 2019). In this research, chest x-ray Images will be grouped into two classes: Covid-19 and Non-Covid-19.

**3.5 Convolutional Neural Network (CNN)**

CNN is a type of deep learning model for processing data that has a grid pattern, such as images. Building CNN plays an indispensable role in moderating both performance and time feeding. CNN is designed to automatically and adaptively learn spatial hierarchies of features through backpropagation by using multiple building blocks, such as convolution layers, pooling layers, and fully connected layers (Yamashita *et al*., 2018). The first two, convolution and pooling layers, perform feature extraction, whereas the third, a fully connected layer, maps the extracted features into final output, such as classification. A convolution layer plays a key role in CNN, which is composed of a stack of mathematical operations, such as convolution, a specialized type of linear operation. In this research work, we are interested in the fully connected layer since the features will be extracted from HOG and LBP.

**3.6 Performance Evaluation**

The proposed system's performance is compared using Precision, Execution Time, Recall, F1-Score, and Accuracy performance evaluation metrics.

**3.6.1 Precision**

Precision measures how correct positive predictions have been made.Precision is the ratio of true positives and total positives predicted:

(1)

**3.6.2 Recall**

A **Recall** is essentially the ratio of true positives to all the positives in ground truth.

The formula for recall is:

(2)

**3.6.3 F1-Score**

The F1-score metric uses a combination of precision and recall. In fact, the F1 score**is the harmonic mean of the two.** The formula of the two essentially is:

(3)

**3.6.4 Accuracy**

Accuracy measures how the rate of correctly classified instances. The formula for accuracy is stated below:

(4)

# 4.0 Expected Contribution to Knowledge

This research adopts a cascaded extraction feature technique which is effective and efficient for predicting Covid-19 cases with low computational cost and also checks the performance of each feature.

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