ISSN: 2586-7652 (Print) Vol. 04, No. 01, March 2020
ISSN: 2635-7607 (Online)
International Journal of Advanced Engineering
Source: http://ictaes.org
Manuscript received: January 15, 2021 ; Revised: February 15, 2021 ; Accepted: February 17, 2021

Convolutional Neural Network for Covid-19 Chest X-ray Detection

Lujina Maharjan [1], Gyanendra Karn [2], Monika Pokharel [3], Dipinti Manandhar[4], Lisa Rajkarnikar[5], Surendra Shrestha[6]

[1]*Nepasoft Solutions Pvt. Ltd., Nepal,*
[2]*Concordia College, MN, USA,* [3]*Nepasoft Solutions Pvt. Ltd, Nepal,*
[4]*Indian Institute of Technology Jodhpur, Rajasthan 342037, India,*
[5]*Nepasoft Solutions Pvt. Ltd., Nepal,*
[6]*Department of Electronics and Computer Engineering, Pulchowk Campus, Institute of Engineering, Lalitpur, Nepal*

lujinamaharjan@gmail.com [1], gkarn@cord.edu [2], monikapokharel1@gmail.com [3], manandhar.1@iitj.ac.in [4], lisarajkarnikar@gmail.com[5], surendra@ioe.edu.np[6]

Abstract

The new outbreak of corona virus disease has affected millions of people globally. According to some research, the people infected with Corona Virus showed symptoms like fever, dry cough, fatigue along with lung infection. Chest X-Ray plays a significant part in the detection of lung disorders. Radiologists have been efficient in detecting COVID-19 using Chest X-Ray. To automatically diagnose COVID-19 from chest X-Ray images, we present a deep learning technique based on Convolutional Neural Network (CNN) to diagnose COVID-19 automatically from chest X-Ray images. On the currently available dataset of 2905 X-Ray images including 219 COVID-19 positive images, the system obtained an accuracy of 95.7%. The accuracy can be improved further when more COVID-19 images become available. The paper aims on identifying COVID-19 infected patients and does not assert any medical accuracy. The system can be taken as an instant decision-making tool in controlling the COVID-19 pandemic in the scenario where there are soaring COVID-19 cases and limited availability of expert radiologists.

Keywords: *Corona virus; COVID-19; SARS-COV-2; CNN, X-ray, Deep learning*

1. Introduction

The Novel Corona virus, officially declared a pandemic, is a respiratory infection that has affected a global population of 96 million.[5] It is a chain process that has a fatality of about 2.08 million and has caused health system a massive crisis. It is highly contagious as it transfers from one infected person to the next after being in contact [8]. Many experiments are being carried out to help this massive pandemic and put out a cure. The lock-

Corresponding Author : Surendra Shrestha
Author's affiliation : Department of Electronics and Computer Engineering, Pulchowk Campus, Institute of Engineering
Email: surendra@ioe.edu.np
Copyright © ICT-AES

down seems to have been the only way to avoid the widespread corona virus along with quarantine, proper monitoring, and adequate prevention measures to protect healthy people.

The main symptoms being chest pain, dry cough, trouble breathing, and lack of speech or movement, are apparent within 2-14 days after being exposed to the virus. Various methods have been put forward to detect Covid-19, one of them being medical imaging [9]. We propose a method focused on the comparison of chest X-Ray images of infected individuals to those of healthy individuals that analyzes and predicts the effects of Covid-19. The chest X-Rays are fed to the CNN model where features are extracted and analyzed to identify the existence of the corona virus. The model helps to detect the virus along with existing methodologies of testing and provides better efficiency in virus detection.

2. Materials and Methods

The detection of Covid-19 using chest X-Rays dataset and overall methodology are explained below in figure 1

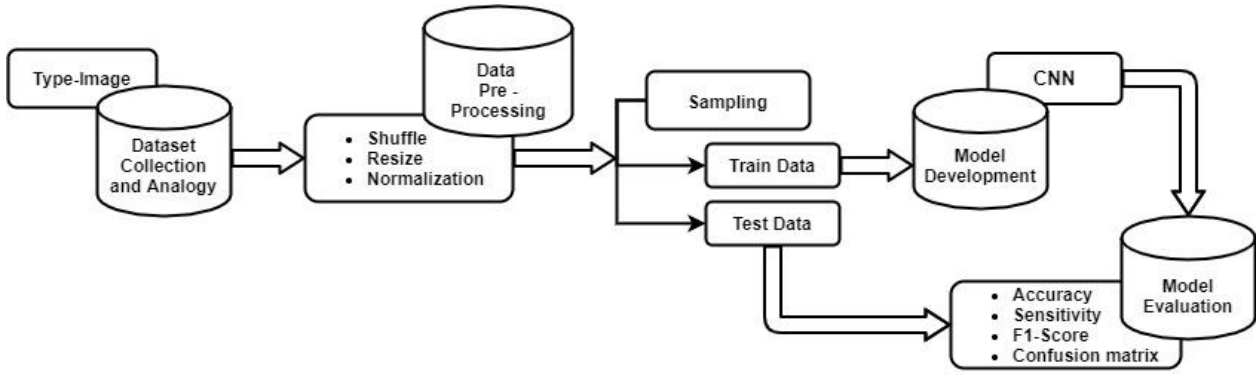


Figure 1. Block diagram of COVID-19 detection system

2.1. Dataset

The dataset has been collected from Covid-19 Radiography Dataset [11]. The collected dataset consists of 2905 total chest X-Ray Images. The dataset consists of normal, Covid, and pneumonia X-Rays as 1341, 219, and 1345 files respectively.[10] The total of 304 X-Rays after ignoring PA views was further divided into training 216 X-Rays and testing 88 X-Rays set of normal, Covid affected, and pneumonia.

2.2. Methodology

For modeling the dataset first, we filtered normal X-Ray and Covid X-Ray images to be only Posterior-Anterior (PA) which gave us around 216 images for Covid X-Ray. We then randomly selected 216 normal X-Ray images from the filtered images to make it 50-50. These X-Ray images are preprocessed using data resizing, shuffling, and normalization. The training set and testing set were subdivided through a preprocessed dataset which then implemented on Convolutional Neural Network architecture.

In deep learning, a Convolutional Neural Network (CNN or ConvNet) refers to the class of deep neural networks, most ordinarily applied to analyzing visual aspects of an image [3]. CNN uses additional layers at the start of the neural network to reduce the size of an image and pre-process them. CNN encompasses Convolutional, pooling, and fully-connected layers as shown in Figure 2.

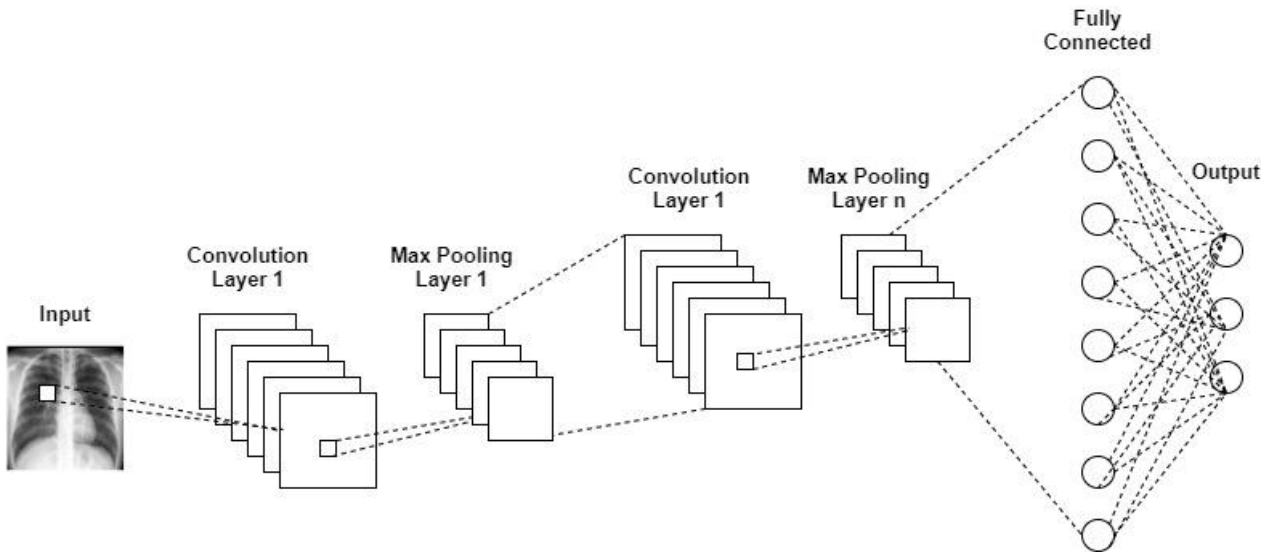


Figure 2. Architecture of the convolutional neural network

2.2.1. Convolutional Layer

The convolution layer performs the extraction of features from an input image and hence outlines filter or kernel. It learns the image features and uses small squares of input data preserving the connection between pixels named Convolved Feature/Feature Map. [4]

2.2.2 Pooling layer

The pooling layer reduces the dimensionality of each map.[6] Spatial pooling preserves a significant amount of information while reducing the number of parameters on the training set. Since Max Pooling performs better and identifies the largest element from the rectified feature map hence preserving significant information Pooling operation is performed by sliding the 2*2 filter over the feature map by 2 cells (Stride=2) and fetching to the pooling function

2.2.3 Fully connected layer

The Fully Connected layer acts as a Multi-Layer network that implements activation function in the output layer [7]. The output from both Convolutional and pooling layers aggregates to high-level features of the input image as shown in Figure 2.

For the implementation of Convolutional Neutral Network, Keras library is imported to create CNN based model in Keras. It used a 3x3 kernel size for CNN modeling and pooling size of (2, 2). The model had 4 CNN layers each followed by a max-pooling layer. With this modeling, it obtained a total of over 10 million params. After this, 70% of the data are taken for training while the rest of 30% was used for testing the accuracy of the model. Normal and Covid X-Ray images are both chosen to be the same number in both training and testing data sets. After that, the model fit on the trained dataset using 10 different epochs each containing 10 different epoch steps to calculate the accuracy of the test dataset. The more epochs we have, the better the accuracy is with less loss.

3. Results and Discussion

Novel Covid-19 Detection System can be considered as an innovative tool during ongoing COVID-19 Pandemic. Assisting people to have early diagnosis, it can prevent the spread of disease tremendously.

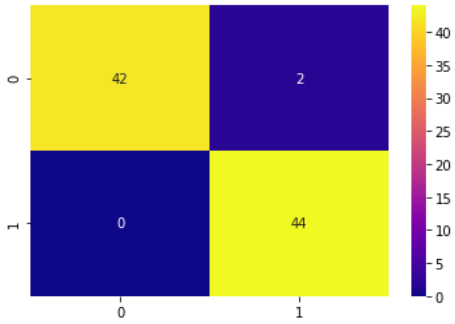


Figure 3. Confusion Matrix

The results obtained through this project is pretty accurate providing us with 97.7% accuracy rate on the test set. We found out 42 out of 44 which were tested True Positive (TP), which indicates that Covid X-Rays were correctly identified as Covid X-Rays. 2 X-Rays were found False Negative (FN), which indicates Covid X-Rays were identified negative. This is the kind of error that could be bring potential threat that we need to minimize. We received a 100% accuracy on predicting normal X-Rays as normal X-Rays with a total of 44 True Negative (TN) counts. And we got 0 counts for False Positive (FP) which indicates normal X-Rays were incorrectly identified as Covid X-Rays.

After modeling, Figure 3 shows the performance of the proposed system through a confusion matrix. There was a better result on the testing set. The model was able to correctly identify all the normal X-Rays as normal X-Rays. It correctly identified all Covid X-Rays as Covid X-Rays giving 97.5% accuracy. It identified 2.5% Covid X-Rays as normal X-Rays which are the flaws of this model.

4. Conclusion

The early detection of Covid-19 from chest X-ray is very crucial for both patients and doctors. The experiment using Convolutional Neural Network has resulted in high accuracy detecting Covid-19 in chest X-ray. The X-ray images with normal X-rays, Covid X-rays and pneumonia X-rays were implemented on network architectures and it generates 97.5% accuracy identifying all Covid X-rays. There have been some mismatched images which can be eliminated with the use of better modeling and techniques with CNN models, using more layers, and using more images to train the data. It can also work on model optimization with cross-validation to ensure a better accuracy model. The accuracy can be improved further by increasing the number of the dataset. The result clearly focuses on classifying COVID-19 infected patients and does not claim any medical accuracy.

References

[1] Islam, Z., Islam, M., & Asraf, A. (2020). A combined deep CNN-LSTM network for the detection of novel coronavirus (COVID-19) using X-Ray images. Informatics in Medicine Unlocked. Volume 20, 2020, 100412, ISSN 2352-9148.

[2] Jain, R., Gupta, M., Taneja, S. et al (2020). Deep learning based detection and analysis of COVID-19 on chest X-Ray images. Appl Intell. https://doi.org/10.1007/s10489-020-01902-1

[3] Zhang, Z. (2016). Derivation of Backpropagation in Convolutional Neural Network(CNN)

[4] Dertat, A. (2017). Applied Deep Learning - Part 4: Convolutional Neural Networks. Retrieved from https://towardsdatascience.com/applied-deep-learning-part-4-Convolutional-neural-networks-584bc134c1e2

[5] WHO Coronavirus Disease (COVID-19) Dashboard. (2020, Jan 24). Retrieved from https://Covid19.who.int/

[6] Manli, S., Song, Z., Jiang, X., Pan, J., & Pang, Y. (2016). Learning Pooling for Convolutional Neural Network. Neurocomputing 224. DOI: 10.1016/j.neucom.2016.10.049

[7] Wang, Y., Li, Y., Song, Y., & Rong, X. (2020). The Influence of the Activation Function in a Convolution Neural Network Model of Facial Expression Recognition. Appl. Sci. 2020, 10, 1897; doi: 10.3390/app10051897

[8] Lauer, S.A., Grantz, K.H., Bi, Q., et al. (2020). The Incubation Period of Coronavirus Disease 2019 (COVID-19) From Publicly Reported Confirmed Cases: Estimation and Application. doi: 10.7326/M20-0504

[9] Khan, S.H., Sohail, A., et al. (2020). Coronavirus Disease Analysis using Chest X-ray Images and a Novel Deep Convolutional Neural Network, preprint. DOI: 10.13140/RG.2.2.35868.64646.

[10] Pham, T.D. (2021). Classification of COVID-19 chest X-rays with deep learning: new models or fine tuning. Health Inf Sci Syst 9. Retrieved from https://doi.org/10.1007/s13755-020-00135-3

[11] COVID-19 Radiography Database. (2020, July 2). Retrieved from https://www.kaggle.com/tawsifurrahman/Covid19-radiography-database.