Coronavirus Disease (COVID-19) Detection System using Histogram Oriented Gradients and Feed Forward Neural Network

Darli Myint Aung
University of Computer Studies (Pang Long)
darlimyintaung@gmail.com

Yuzana
University of Computer Studies (Hinthada)
yuzana.yzn@gmail.com

Abstract

Coronavirus disease 2019 (COVID-19) has started in China. The Covid-19 are spreading around the world who are living people and animals. Although the test kit is donated from China to Myanmar, there are not enough in all area. Therefore, Coronavirus Disease (COVID-19) detection system using Histogram Oriented Gradients and Feed forward Network is proposed for diagnosing as COVID-19 instead of using test kits. These system is divided into three parts. Firstly, the chest X-ray image of the patient is preprocessed by using median filter that reduces noise. Secondly, the feature descriptor is extracted by using Histogram Oriented Gradients (HOG) as feature extraction step. Lastly, feed forward neural network is used as a classifier for classifying COVID-19 patient or normal patient. The proposed system is tested on. Experiments are carried out on open database of COVID-29 and give the correct performance in terms of 100 percent of accuracy for training set and 80.45 *percent of accuracy for test set.*

Keywords: COVID-19, Chest X-ray, HOG, Feed Forward Neural Network

1. Introduction

The China's seventh largest city is Wuhan city in Hubei Province which has a population of 11 million at which became the center of a pneumonia outbreak of unknown cause, with global implications in December 2019 [1]. These outbreak was believed to have started at a local seafood/wild animal market [2].

Coronaviruses are a large family of viruses. Some coronaviruses cause illness in people, and others circulate among animals including camels, cattle, cats, and bats. Animal coronaviruses seldom evolve into human coronaviruses that subsequently infect individuals, and then they spread between people. This occurred previous outbreaks with the first known SARS [3].

China's National Health Commission (NHC) announced ongoing human to human spread, and there is no vaccine that is currently available to prevent COVID-19 [4].

Although Myanmar accepted coronavirus test kits from foreign donations, this will not be enough. Therefore, this system is proposed for diagnosing coronavirus with effectively and efficiently. The contribution of this paper is the use of feature descriptors for chest X-ray image by applying Histogram Orientation Gradients.

The remainder of this paper is structured as follows. We introduce some related works in section 2. The overall system design is described in section 3. The experimental result is shown in section 4. Finally, we conclude about this system in section 5.

2. Related Work

In recent years, many computer vision applications such as classification of medical images became a lot of challenges to use deep learning techniques [5] [6].

The authors [7] proposed three different convolutional neural network based models (ResNet50, InceptionV3 and Inception-ResNetV2) for detecting of coronavirus pneumonia infected patient using chest x-ray radiographs.

In [8], they demonstrated how to classify positive and negative pneumonia data from a collection of X-ray images. They constructed a convolutional neural network model from scratch to extract features from a given chest X-ray image and classify it to determine if a person is infected with pneumonia.

A Convolutional Neural Network (CNN) constructed based on various ImageNet pre-trained models for extracting the high level features from Chest x-Ray images. Support Vector Machine SVM classified those features in order to detect the COVID-19 cases.

In [10], the authors proposed the eighteen Convolutional Neural Network (CNN) architecture that called COVID-Net based on transfer learning. That system classified nineteen the CXR images into four classes: normal, bacterial infection, non-COVID and 20 COVID-19 viral infection.

3. Proposed System Design

The Coronavirus disease (COVID-19) detection system is proposed to find corona virus disease using the x-ray images. Figure 1 illustrates the flow chart of the Coronavirus disease detection system.

This system is divided into three phases: preprocessing and median filtering of x-ray image, feature extraction from the cropped region using Histogram Orientation Gradients and finally classification using feed forward neural network.

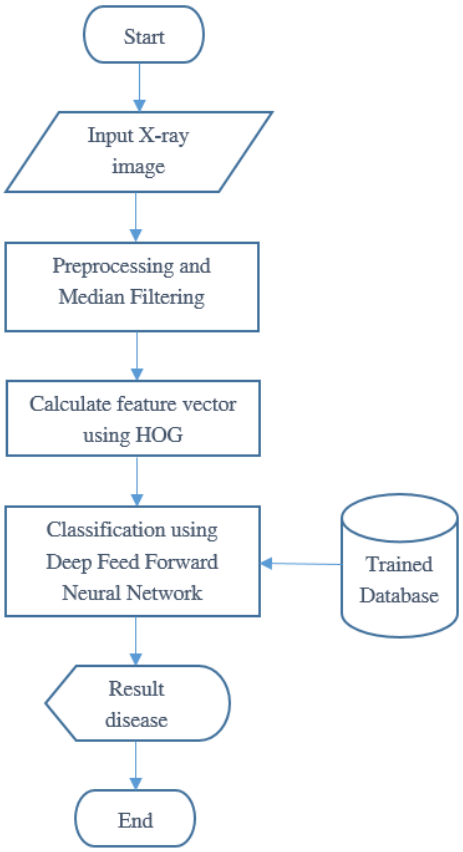


Figure 1. Flowchart for Coronavirus Disease Detection System

3.1. Median Filter

Median filtering is that each pixel is set to an "average" of the pixel values in the neighborhood of the corresponding input pixels. However with median filtering, the value of an output pixel is determined by the median of the neighborhood pixels, rather than the mean. The median is much less sensitive than the mean to extreme values. Median filtering is therefore better able to remove this outlier without reducing the sharpness of the image.

The 0^{th} percentile filter is the min filter that is shown in equation (1).

$$\hat{f}(x,y) = \min_{(s,t)\in S_{xy}} \{g(s,t)\} \qquad (1)$$

where S_{xy} is corresponds to the set of coordinates in a rectangular image window which has center at (x,y). The median filter calculates the median of the corrupted image g(x,y) under the area S_{xy}. Therefore, $\hat{f}(x,y)$ represents the restored image.

This filter is useful for finding the darkest points in an image [11].

3.2. Histogram Oriented Gradient (HOG)

In the first step for HOG feature descriptor, the x-ray image gradients are computed in both the *x* and *y* direction. Convolution operation is applied to find the gradient images from the following equation (2).

$$G_x = I \times D_x \quad and \quad G_y = I \times D_y \qquad (2)$$

where I is the input image, D_x is the filter in the x-direction, and D_y is the filter in the y direction.

After the gradient images getting, the final gradient magnitude representation of the image can be computed from equation (3).

$$|G| = \sqrt{G_x^2 + G_y^2} \qquad (3)$$

A histogram of oriented gradients can be computed in equation 4.

$$\theta = arctan2(G_y, G_x) \qquad (4)$$

where the bin of the histogram is based on θ and the contribution or weight added to a given bin of the histogram is based on $|G|$.

3.3. Feed Forward Neural Network

This system can classify the coronavirus disease by using feed forward neural network which is among the pattern recognition. There are several different types of network structures in literature. Feed Forward Neural Network (FFNN) is the simplest structure in the neural network and used for classifier. In a typical three-layer Feed Forward Neural Network, the first layer connects the input variables and is called the input layer. The last layer connects the output variables and is called the output layer. Layers in-between the input and output layers are called hidden layers; there can be more than one hidden layer. The parameters associated with each of these connections are called weights. All connections are ``feed forward"; that is, they allow information transfer only from an earlier layer to the next consecutive layers [12]. Figure 2 shows the neural network for the proposed system.

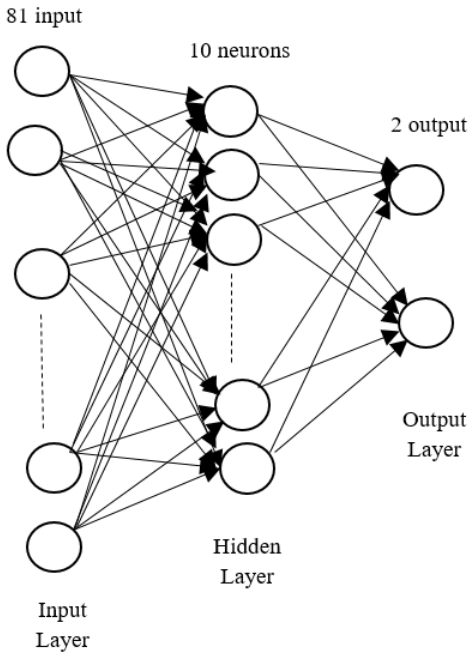


Figure 2. Multilayer Network Structure of the proposed system

This system network included that the input layer has 81 inputs, the hidden layer has 10 neurons and the output layer has 2 neurons. Output layer has 2 neurons that has the number of coronavirus images and normal images in database. Then, the network is trained to classify the x-ray images with respect to database. The trained database is created before testing image. This system trained with 90 sample. In order to show network vectors that concerns with Corona virus disease, the target matrix is generated. The training of feed forward neural network can be performed.

3.4. Data Acquisition

The dataset can be downloaded from the Kaggle website which can be found in [13]. They are building a database of COVID-19 cases with chest X-ray or CT images. All images and data released publicly in this GitHub repo. At present, they are constructing the images database from publications that are already available. A total of 146 X-ray images of chests were carefully chosen from patients.

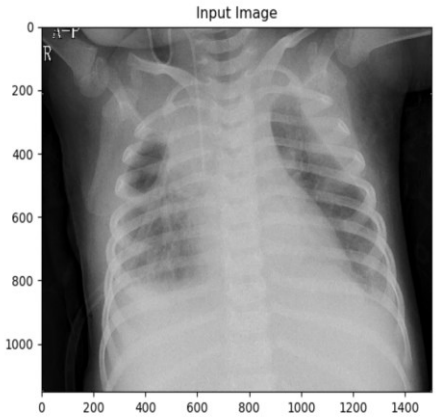
4. Experimental Results

This system is implemented with python 3.7. The experiment is performed on open database of COVID-29. A total of 90 images were allocated to the training set and 56 images were assigned to the validation set to improve validation accuracy.

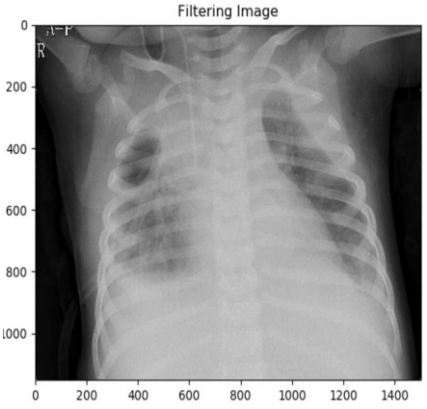
For preprocessing step, the median filter is applied for reducing the amount of noise in the x-ray image because the high accuracy is achieved. In Python, the 'medianBlur' function from the Open-CV library can be used to implement a median filter. Figure 3 shows the input image and image using median filter. After filtering, image is resized to 128 × 64 because of the processing time. Then, the resized image is cropped automatically in this system as shown in figure 4.

For feature extraction, the orientation histogram is used to extract the feature vector. The histograms are only generated for the cropped image. This system calculates Histograms of edge gradients with 9 orientations from each cell and therefore the 3,780 features vectors are achieved for this system. The sample of histogram orientation gradients of cropped image is shown in figure 5.

The correct classification rate of the x-ray image is 100 % for training set and 80.45% for test set. This system uses feed forward neural network that is simple and with low complexity. These results can be concluded the HOG feature vector is useful for classification. Figure 6 shows that this system displayed the input image and the result.

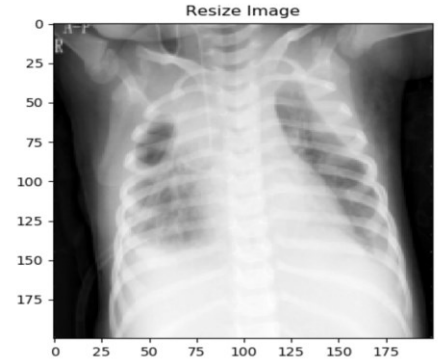


(a)

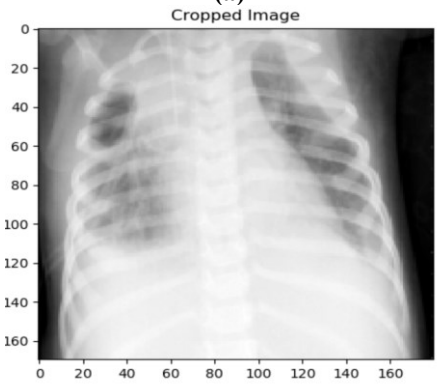


(b)

Figure 3. (a)Input image (b) Median filter of input image



(a)



(b)

Figure 4. (a)Resize image (b) Cropped image

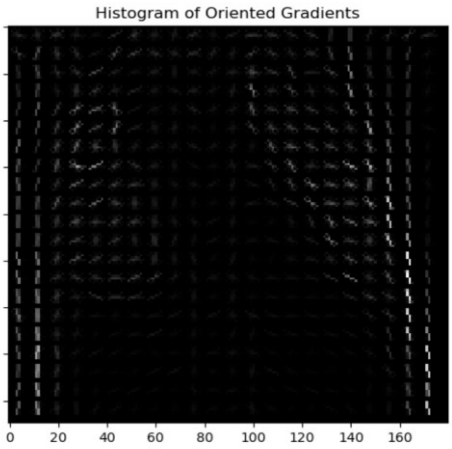


Figure 5. HOG of cropped image

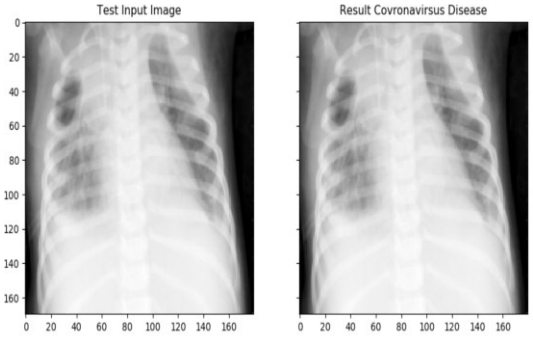


Figure 6. Display Result Image

In order to classify the chest x-ray images concerning database, the network is trained. Before testing, the trained database is created that trained with 90 chest x-ray image in this system. Then, the target matrix is generated to show the network vectors with respect to coronavirus disease. Target vector is created with setting '1' concerning order number of the name in database and other elements '0' for target vector. After that, training of feed forward neural network can be performed. For classifying the given image correctly, the performance of training and goal errors are set to $1e^{-5}$ in this system. The output values are compared with target values. The procedure is repeated to get the desired accuracy. The output is compared with training phase output to match the correct one. Therefore, performance plot is shown in figure 7 that the network learns gradually and reaches towards the goal.

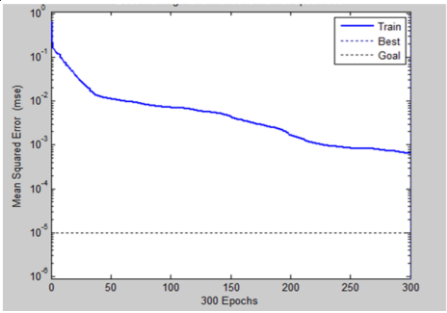


Figure 7. Performance Plot of Neural Network

5. Conclusion

At present, Covid-19 is threatening many countries around the world. Developing countries are adversely harmful to devastate economies because of these coronavirus disease. Although there is the test kid for Covid-19, it is not reliable for testing. Therefore, this system is proposed for detecting the coronavirus disease. The correct classification rate of the x-ray image is 80.45% for test set. Due to the classification rate of testing set, this system will consider to robust and effective.

The future work will apply hybrid feature extraction method to test the recognition performance, therefore the classification rate will be improved.

References

[1] Carlos del Rio and Preeti N. Malani, "2019 Novel Coronavirus-Important Information for Clinicians", JAMA.2020;323(11):1039-1040.

[2] https://edition.cnn.com/2020/03/05/asia/china-coronavirus-wildlife-consumption-ban-intlhnk/i-ndex.html

[3] https://www.whitehouse.gov/presidential-actions / proclamation-suspension-entry-immigrants-nonimmi- grants-persons-pose-risk-transmitting-2019-novel-coronavirus/

[4] World Health Organization, "Novel Coronavirus (2019-nCoV)", Situation Report-1, 21 January, 2020.

[5]Simonyan, K. and A. Zisserman, "Very deep convolutional networks for large-scale image recognition", arXiv preprint arXiv:1409.1556, 2014. 5.

[6]Esteva, A., et al., "Dermatologist-level classification of skin cancer with deep neural networks", Nature, 2017. 542(7639): p. 115.

[7]Ali narin, Ceren Kaya and Ziynet Pamuk, "Automatic Dtection of Coronavirus Disease (COVID-19) using X-ray images and Deep Convolutional Neural Networks", arXiv, March, 2020.

[8] Okeke Stephen, Manggal Sain, Uchenna Joseph Maduh and Do-Un Jeong, "An Efficient Deep Learning Approach to Pneumonia Classification in Healthcare", Journal of Healthcare Engineering, March, 2019.

[9] Sethy PK and Behera SK "Detection of Coronavirus Disease (COVID-19) Based on Deep Features", 2020.

[10] Wang L, Wng A. COVID-Net: "A Tailored Deep Convolutional Neural Network Design for Detection of COVID-19 Cases from Chest Radiography Images", 2020.

[11] Bhausaheb Shinde, A.R. Dani, "Noise Detection and Removal Filtering Techniques in Medical Images", IJERA, Aug,2012.

[12]http://dipastro.pd.astro.it/planets/tngproject/TechRep/rep67/node5.html

[13] https://www.kaggle.com/bachrr/covid-chest-xray/