COVID-19 DETECTION USING XRAY IMAGES

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COVID-19 DETECTION USING XRAY IMAGES

ABSTRACT

COVID-19 is a disease caused by a new strain of coronavirus. 'CO' stands for corona, 'VI' for virus, and 'D' for disease. Formerly, this disease was referred to as '2019 novel coronavirus' or '2019-nCoV.' The COVID-19 virus is a new virus linked to the same family of viruses as Severe Acute Respiratory Syndrome (SARS) and some types of common cold. A person can show symptoms of a fever, cough and shortness of breath. In severe cases, pneumonia or breathing difficulties are the infections of COVID-19. The symptoms are very similar to the flu (influenza) or the common cold than COVID-19. Testing is required to verify if a person has been infected with COVID-19. The virus can be transmitted through direct contact with respiratory droplets of an infected person (through coughing and sneezing). Other than that, we can also be infected from and touching surfaces contaminated with the virus and touching their faces. The COVID-19 virus may survive on surfaces for several hours, but simple disinfectants can kill it. We are learning more about how COVID-19 affects people every day. The virus can be fatal in rare cases, so far mainly among older people with pre-existing medical conditions. There is no currently available vaccine for COVID-19. However, many of the symptoms can be treated and getting early care from a healthcare provider can make the disease less dangerous. (WHO, 2020). Using current technology such as Artificial Intelligence can help in detecting early signs of COVID-19. One of it is by detecting the presence of COVID based from Xray images. Doctors frequently use Xray and CT scans to diagnose pneumonia, lung inflammation, abscesses, and enlarged lymph nodes. Since COVID-19 attacks epithelial cells that lines our respiratory tract, Xray can be used to analyses the health of a patient's lungs. Using these Xray images, we could perform early detection of COVID-19 by using Artificial Intelligence.

ACKNOWLEDGEMENTS

With the name of Allah (most gracious and merciful), I am grateful to Him in blessing me with the knowledge, giving me the courage to tackle the problems and always help me in each step of my life. In successful completion of this work, I owe an enormous debt of gratefulness to my supervisors, Dr. Woo Chaw Seng. I cannot find the right words to express the admiration and sincere gratitude towards my lecturer who gave me the opportunity to be a part of this work. They helped, encouraged and motivated me in every step of this project, during the time I have spent with them. Their suggestions were always valuable and their technical comments lead to the completion of this assignment project.

Lastly, I would also like to thank all my family members for their encouragement and support.

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LIST OF SYMBOLS AND ABBREVIATIONS

For examples:

COVID-19	:	Coronavirus
POC	:	Proof of Concept
AI	:	Artificial Intelligence
WHO	:	World Health Organization

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CHAPTER 1: INTRODUCTION

Artificial intelligence (AI) in healthcare and medicine field has been a particularly hot topic in recent years. While there is a sense of great potential in the application of AI in medicine, there are also concerns around the loss of the 'human touch' in such an essential and people-focused profession. Since May 2017, developments in automation and artificial intelligence are revolutionized the workplace. AI in medicine refers to the use of artificial intelligence technology in the diagnosis and treatment of patients who require care. Whilst diagnosis and treatment may seem like simple steps, there are many other background processes that must take place for a patient to be properly taken care of.

The examples are:

- gathering of data through patient interviews and tests,
- processing and analyzing results,
- using multiple sources of data to obtain an accurate diagnosis,
- determining an appropriate treatment method and preparing

As days passed by, the argument for increased use of AI in medicine is a lot as automation often means tasks are completed more quickly and frees up a medical professional's time when they could be doing their duties, ones that cannot be automated and also are seen as seen as more valuable use of human resources. The example of task is performing surgery. Nowadays, we already have an incredible amount of technology and automation in play of medicine, medical records has been digitalized, appointments can be scheduled ahead of time, patients can check in to the health centers or clinic by using their phones or computers as technology usage has increased in all areas of life. The potential for increased usage of AI in medicine is not just the reduction of manual tasks and optimizing a professional's time, efficiency and productivity, it is also presenting the

opportunity for our generation towards more precision medicine. Ever since COVID-19 strikes the world economy and health, it causes a huge warning to the people to stay alert with its surroundings. AI is one of such technology which can easily track the spread of this virus, identifies the high-risk patients, and is useful in controlling this infection in real-time. It can also predict mortality risk by adequately analyzing the previous data of the patients. AI can help us to fight this virus by population screening, medical help, notification, and suggestions about the infection control.

The main objective of this research is to detect the positivity of COVID-19 from lung Xray images and evaluate the correctness in detecting COVID-19 using Xray images using confusion matrix. In this paper, we could perform early detection of COVID-19 using the Xray images. Given an image, a Xray image as input, and the output image will have a text included to tell the status of COVID-19.

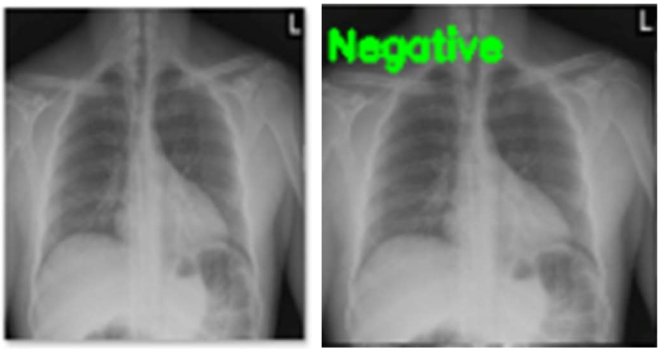

Figure 1: Input and expected output of picture

Dataset initially obtained and processed in the research paper (Kermany, D. et. Al 2018). In the paper, their initial intention is to use image-based deep learning that classify macular degeneration and diabetic retinopathy using retinal optical coherence tomography images and their future potential could generalized applications in biomedical image interpretation and medical decision making.

The highlights of this paper are:

- An artificial intelligence system using transfer learning techniques was developed
- It effectively classified images for macular degeneration and diabetic retinopathy
- It also accurately distinguished bacterial and viral pneumonia on chest X-rays
- This has potential for generalized high-impact application in biomedical imaging

There are multiple processing layers to which image analysis filters, or convolutions, are applied. The abstracted representation of images within each layer is constructed by systematically convolving multiple filters across the image, producing a feature map that is used as input to the following layer.

The architecture makes it possible to process images in the form of pixels as input and to give the desired classification as output. The image-to-classification approach in one classifier replaces the multiple steps of previous image analysis methods. Dataset obtained for this project is curated by Dr. Joseph Cohen, a postdoctoral fellow for Artificial Intelligence in Medicine & Imaging at Stanford University as well as at Mila the Quebec AI Institute. Joseph is currently focusing on the limits of AI in medicine with respect to computer vision, genomics, and clinical data. In one of his project, COVID chest Xray Dataset, the objective of their project is to build a public open dataset of chest Xray and CT images of patients which are positive or suspected of COVID-19 or other viral and bacterial pneumonias such as (MERS, SARS, and ARDS). Data is collected from public sources as well as through indirect collection from hospitals and physicians. The images and data are released publicly in this GitHub repository. There are 25 Xray images of positive COVID-19 cases and 25 Xray images from healthy patients.

CHAPTER 2: METHODOLOGY

2.1 Overview

This chapter describes the method performed for COVID-19 Detection using Xray images. In completing this chapter, consideration for the flowchart, spiral model, and the technical implementation proposed.

2.2 Analysis and Design

2.2.1 Flowchart

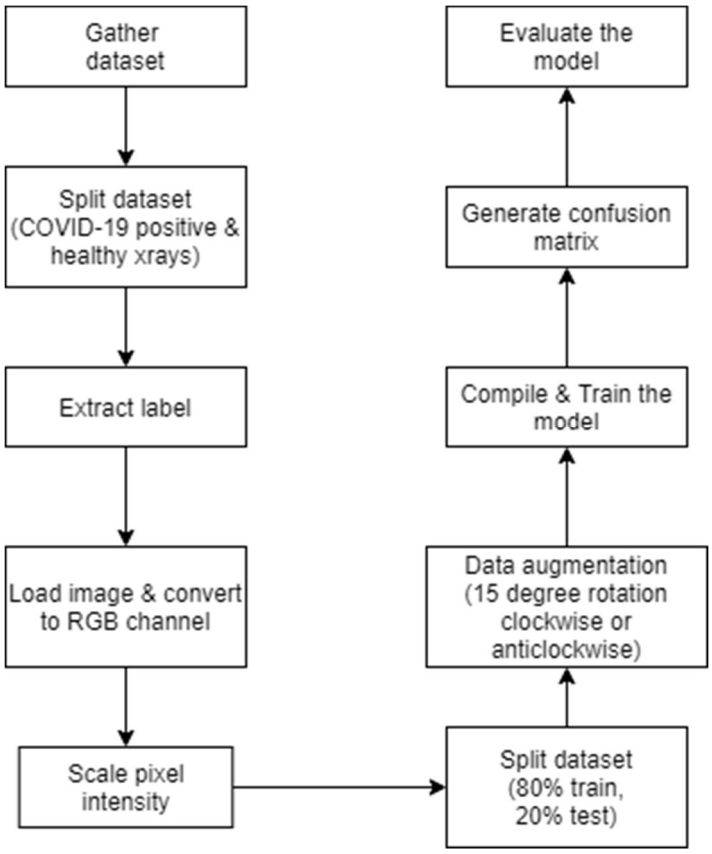

Figure 2: Flowchart of this project

The first step is to gather dataset, the dataset can be found inside GitHub repository. Where metadata.csv it is parsed from Dr Cohen's repository. Then the rows are selected that are positive for COVID-19. A total of 25 Xray images of positive COVID-19 cases. In order to obtain dataset for healthy patients, I sampled the 25 Xray images from healthy patients (number of reference). There are some noisy and incorrect labels of dataset.

However, it serves as a good proof of concept COVID-19 detector. For each image loaded, it will be converted the channel of color from BGR to RGB. Then for each image, the image is resized to 224 x 224 pixels and augmented up to certain degree before it is ready for training. After the model is compiled, confusion matrix is generated, and evaluation of the model has been performed.

2.2.2 Spiral model

There are 4 phases in this spiral model, which are planning, risk analysis, development & testing, and evaluation. In the planning phase after choosing the topic of the project, libraries that needed to use. In the risk analysis, suitability of dataset has been analyzed. This is to ensure the reliability of dataset, either it has been curated by the professional, in this case, it has been curated by professional Dr. Joseph Cohen. Then, the dataset obtained is loaded into the model for training purposes. After that, evaluation of the model has been performed by using confusion matrix. For testing purpose, I can use the dataset that has been split before we load for training or use another test image that we obtain online.

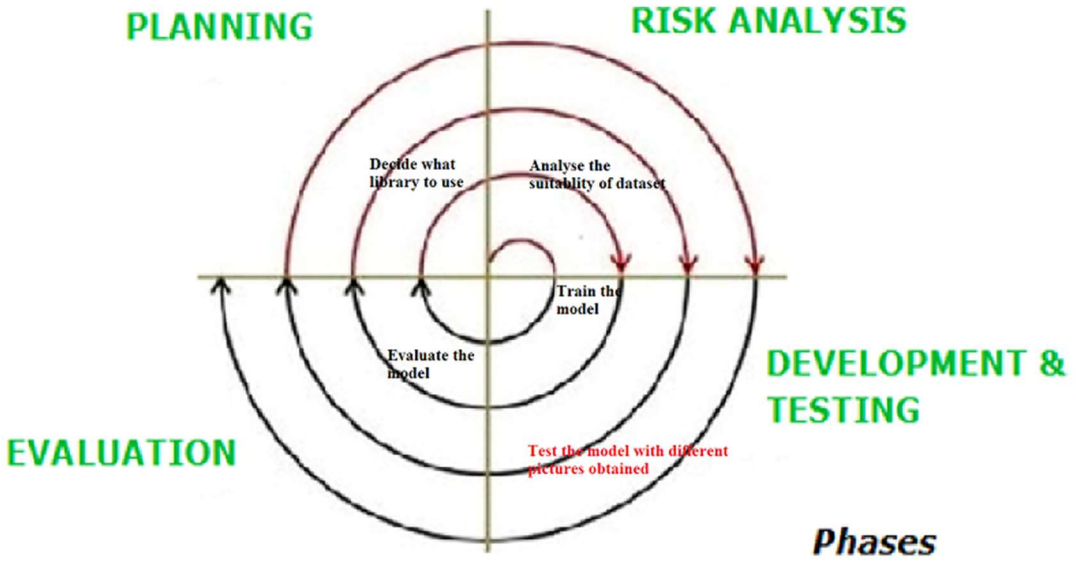

Figure 3: Spiral Model

2.3 Image Preprocessing

Preprocess the image is an important stage before we train the model. The images need to be in the same size before entered as input into the training phase. After that, the labels for each image are extracted from the metadata. Once the labels are extracted, the images and labels will be converted into NumPy array.

2.3.1 Convert BGR to RGB Channel

When the image file is read with the OpenCV function, the order of the colors is BGR (blue, green and red). We can mutually convert using OpenCV function cvtColor(). This is just to swap the color channels from BGR to RGB.

2.3.2 Resize the image

After the color channel has changed. We will resize the image to 224 by 224 while ignoring the aspect ratio of the image.

2.3.3 Data Augmentation

Data augmentation is a method that can be used to increase the variety of dataset for training detectors. By transforming the Xray images obtained during training, data augmentation can improve the performance of the detector in training. Data we rotated 15 degree clockwise or anticlockwise.

2.3.4 VGG16 Architecture

VGG16 is a convolution neural net (CNN) architecture which was used to win ILSVR(Imagenet) competition in 2014. It is one of the excellent vision model architecture till date. Most unique thing about VGG16 is that instead of having many hyper-parameters they focused on having convolution layers of 3x3 filter with a stride 1 and always used same padding and maxpool layer of 2x2 filter of stride 2. It follows this arrangement of convolution and max pool layers consistently throughout the whole

architecture. In the end it has 2 fully connected layers followed by a softmax for output. The 16 in VGG16 refers to it has 16 layers that have weights. This network is a pretty large network and it has about 138 million parameters. (Thakur, Rohit. 2019).

CHAPTER 3: EXPERIMENTAL RESULTS

To evaluate the VGG16 performance to detect the COVID-19, some performance metrics have been conducted throughout this research. The proposed model was implemented on the system having the following specifications. The GPU used Tesla P100-PCIE-16GB with the CUDA with TensorFlow and Keras for GPU learning using Google Colab. The experiment configuration is presented in Table 1.

Model	Batch size	Epoch	Learning	Optimizer
Model	24	250	0.001	Adam

Table 1: Learning Configuration

Dataset split up to 80% for training and 20% for testing. The configuration of VGG16 with initial learning rate, 0.001 and the number of epochs equal to 250 as shown in Table 1. The batch size of the detector is set to 32. In terms of optimizer technique, Adam optimizer was chosen to improve the detector performance.

3.1 Validation, testing accuracy and performance metrics for the proposed model

To evaluate the performance of the proposed model, performance needs to be investigated. The most common performance measures to be calculated are Accuracy, Precision, Recall and F1 score.

	Precision	Recall	F1 score	Support
COVID	0.89	0.67	0.76	12
Normal	0.95	0.99	0.97	73

Accuracy			0.94	85
Macro avg	0.92	0.83	0.86	85
Weighted avg	0.94	0.94	0.94	85

Table 2: Confusion Matrix

Table 2 is the confusion matrix built after we have analyzed the model. Precision is the ratio of the model that correctly predicted the positive observations to the total predicted positive observations. Since we got 0.89 and 0.95 for positive COVID and normal person respectively, it shows the model is pretty good. Recall if the ratio of the model that correctly predicted positive observations to the all observations in actual class. The benchmark to have a good recall is above 0.5. Since both for positive COVID and normal has value that above the benchmark. For f1-score, is the weighted average of precision and recall. which is more useful and better than accuracy.

3.2 Sample input and output

Here the examples of input and output image for this work.

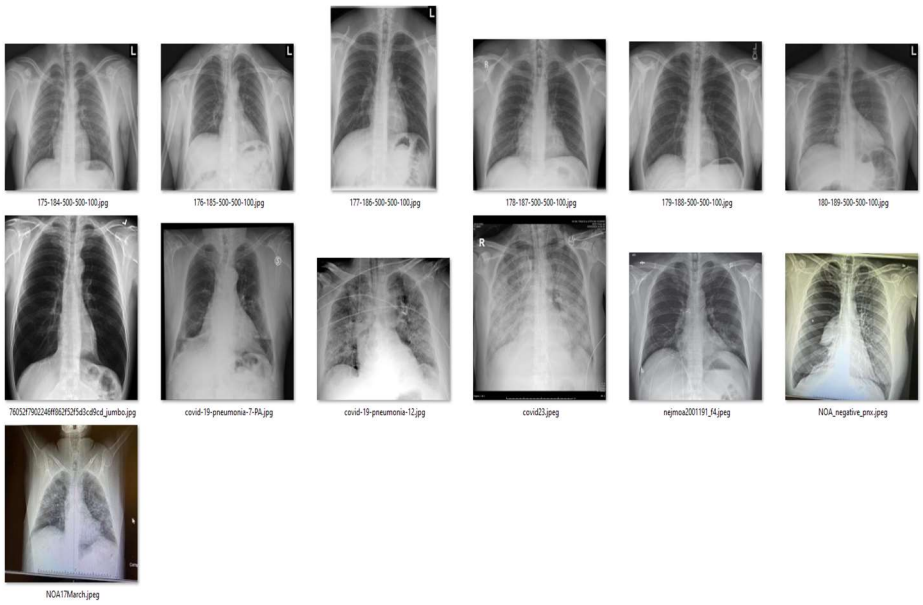

Figure 4: Xray images for testing

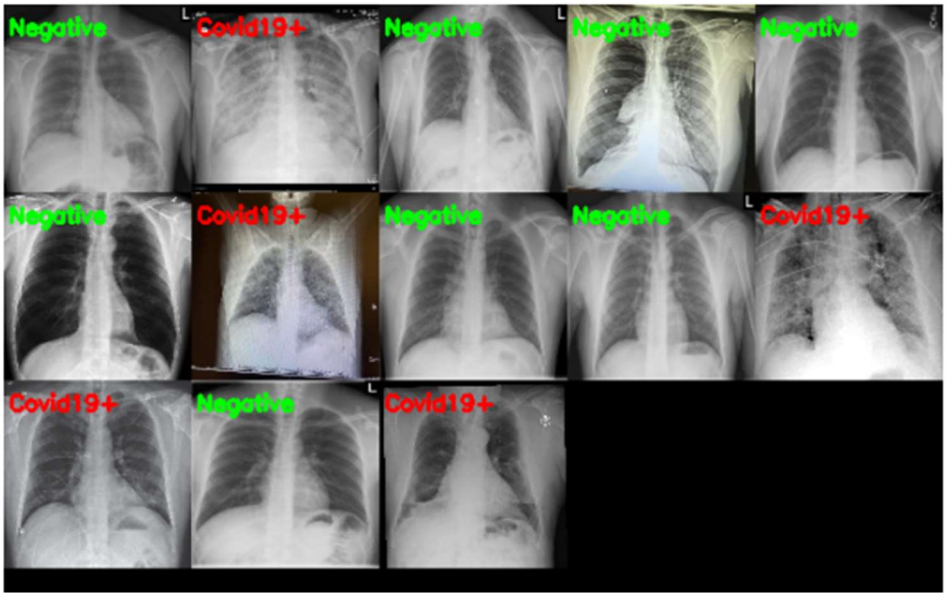

Figure 5: Output for the test images

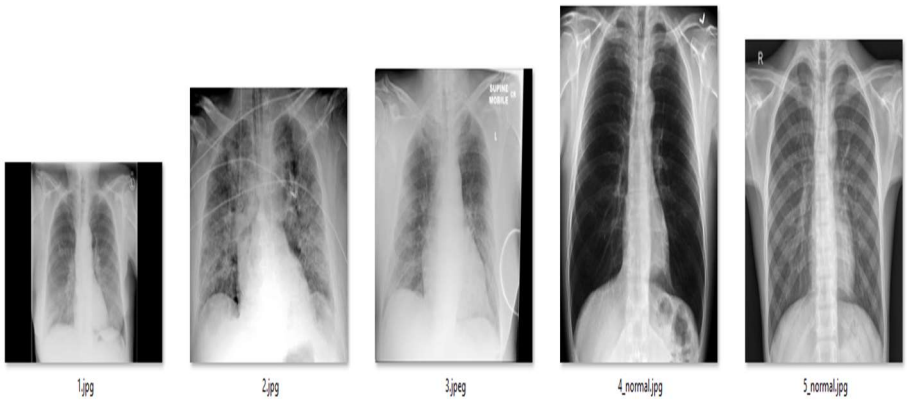

Figure 6: Test image from self-collected

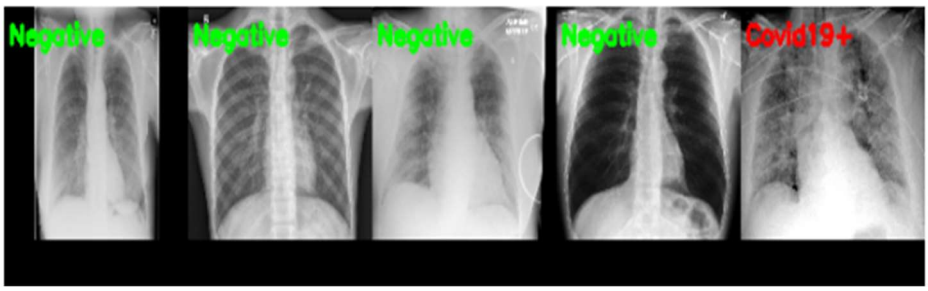

Figure 7: Output of test image from self-collected

CHAPTER 4: DISCUSSION

It is very good to have this project that could be able to detect the presence of COVID-19 from an Xray images. Xray images are easy to get and need expert to be interpreted. Since we need more professional to diagnose real patients, it is good to have a system that can reduce a professional's workload. Early screening done by the system could point out and give reasoning why the Xray images considered as positive COVID-19. On top of that, this system could reduce the use of real swab test kit for COVID-19 as it could be expensive. Therefore, by developing an automated analysis system, it can save medical professionals valuable time.

However, there's always two sides of a coin. The drawback of this system is that we require different perspectives from medical professional regarding the Xray images. As we all know, the professional medical is quite busy handling with positive COVID-19 patients. To be more specific, we require radiology expert to analyze the Xray images. For this project, the dataset has been curated by medical professional. However, it contains noisy and wrong label of the dataset. But it is enough to be used as a proof of concept (POC). By saying so, it is not yet ready to be deployed for the professional medical to use.

For future improvements, for this project, we could have collected more dataset with the help of more radiology from around the world to curate the datasets. By applying the image processing knowledge into this project, since the images are in grayscale, we could apply some contrast to each image loaded into the training or testing. We can also increase the number of rotation degree. We could also have more specified dataset where in the dataset, we could somehow annotate which part of the Xray images, shows the signs of COVID-19. This system is not only to classify the positivity from Xray images, but also draw bounding boxes to detect the signs of having COVID-19. There are many reasons

and advantages of having this type of system where it is easier for the professional medical to analyze the type of symptoms that the positive COVID-19 patient is having and can directly prescribe the medications and procedure for it. We could also have a set of datasets, including the annotation from the Xray images, that can classify the level of severity of COVID-19. From the result of severity, we could have dedicated places to quarantine the COVID-19 patients.

CHAPTER 5: CONCLUSION

As a conclusion, by applying for what we have learnt this semester, into the assignment, which are changing the colour channel of an image, resizing the pixel intensity and image rotation does help a lot in developing the system. This automation system that could detect positivity of COVID-19 from Xray images could provide a lot of benefit to all of us especially to professional medicals by saving their times and they could focus on other things such as treat real COVID-19 patients. Thus, it will increase their productivity in this critical time. It is true that the current system is good enough to be the proof of concept, but it is not enough for us to deploy it to the medical field as the level of severity is quite critical and the need of having and using the system is very desperate. With some future improvements, with the help from different professionals, we could upgrade the system that capable to show us the signs with bounding boxes of COVID-19 from the Xray images. I am looking forward for more development on this COVID-19 detection based on Xray images and dataset development from the medical professionals, together we prevent the COVID-19 away.

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APPENDIX

- https://github.com/aqiff12/WID3008-Image-Processing-Assignment