A Deep Learning Approach For COVID 19 Detection Via X-Ray Image With Image Correction Method

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Abstract In the mitigation effort for reducing the spread of the SARS-CoV-2 pandemic in Indonesia, finding, detecting, and containing the suspect be a very crucial step to contain the virus. One of the ways that this can be detected is by thorax x-ray examination by the expert. Transferring the doctor's knowledge to a computer makes the task more scalable and precise. This can be done by building a small artificial intelligence using a simple CNN model to detect COVID biomarkers' presence in x-ray images. As the AI relies heavily on the x-ray dataset as the system's underlying basis has a good quality dataset is very important. However, the x-ray data tend to have a noise problem that will affect their overall system quality. We did a little comparative study with the objective to improve the quality of the dataset with three techniques of image enhancement, namely color denoising, mean denoising, and contrast enhancement, with the mean denoising outperform the other image manipulation method by 4%, which yield the accuracy of the system to 95% with 100 pieces of real-world test data. Hopefully, this study would inspire future studies improving the tech-based pandemic mitigation technology In the future.

***Index Terms*—CNN, COVID-19, X-Ray Image, Image Correction and Denoising.**

I. INTRODUCTION

SARS-CoV-2 or also known as novel coronavirus (2019-NCoV is a respiratory virus originated in Wuhan, Hubei Province, Tiongkok [1]. This virus caused a respiratory pneumonia disease which first discovered at the end of 2019 and reported to World Health Organization (WHO) on 31st December 2019. The virus is declared as public health emergency and international concern by WHO and escalated to the world pandemic on March 2020 [2].

Since then, the virus has spread to more than 212 countries, with more than 432,902 recorded deaths and 7,898,442 confirmed cases worldwide so far (on June 14, 2020) so put many countries into economic lockdown due to the massive infection rate of the virus outbreak [3].

Global health experts argue that the mitigation and containment of the invented person are critical aim to reduce the case numbers to low levels of virus spreading. Furthermore, the early detection of the virus outbreak is important as once the infected person is identified by the measurements of contact tracing and mass testing that can be deployed more rapidly that leads to the containment of the virus suspect which can be done within the short amount of time and helping the authorities to flatten the curve of virus infection in the particular area as well as preventing the virus spreading massively.

One of the simplest way to detect the infection of coronavirus is through thorax x-ray examination since the coronavirus leaves distinct biological marker in patient lung (a somewhat cloudy stain inside the lung) that is visible through x-ray scanning of the patient thorax. The proposed method is a simple CNN (Convolutional Neural Network) model to automatically detect the infection of SARS-CoV-2 by examining the thorax x-ray medical record owned by the patient.

Compared to another approach that utilized computer to detect the severity of COVID 19 based on blood sample and urine test data and the study of AH hasanien that utilize the multi throsehold and SVM to detect covid in an x ray images our approach using a deep learning method should yield more consistent result and also the study from china led by xueyian mai that using multilayer perceptron and random forrest algorithm to detect covid from x ray file data that perform well but could be better as now the dataset is more robust and developed and make the training of the deep-learning model easier to perform Deep leaarning to analyze medical problem is a not a new feat whaatsoever, it has been utilized to detect pneunomia, skeletal bone age assasement and in general chest x ray classification.

The model itself has been trained to distinguish the biological marker of normal lung on x-ray image against the SARS-CoV-2 infected one. The model which is trained by the public data set of coronavirus x-ray image and the case of data field in Indonesia.

We also compare the performance of the model based on the presence of preliminary treatment image which divided into preprocessing and pretraining and those kind of image manipulation in which are applied into the system. The reason is because since the data is taken through the x-ray image scanning so that the dataset tends to make the noise problem. This research concludes that if we tune the model

and give the image denoising and processing method, we can improve the robustness of the classifier slightly but unfortunately it does not give the impact significantly.

Hopefully, when this system can be well-integrated in terms of implementation, we can do screening of SARS-CoV-2 to the patient efficiently as a professional pulmonologist examination which can be delegated into a computer system so that the large number of confirmed cases can be reduced and decreasing the overloaded capacity of Indonesia healthcare system during this global pandemic.

II. Literature Review

A. State Of The Art

In previous research, one of our team successfully implemented CNN to create a smart food analyzer system in a journal entitled "Predicting Food Images Using Convolutional Neural Networks to Determine Food Calorie Amounts"[4]. The computing point of view in the problem domain of the COVID-19 classifier has been made a lot since the beginning of this case, in a journal entitled "Coronavirus (COVID-19) Classification using CT Images by Machine Learning Methods"[5], using a support vector machine. To diagnose cases of COVID 19 using CT scan image input. In another study entitled "Large-Scale Screening of COVID-19 from Community-Acquired Pneumonia using Infection Size-Aware Classification" using the random forest to analyze pneumonia with ct-scan image input [6].

In research "COVID-CAPS: A Capsule Network-based Framework for Identification of COVID-19 cases from X-ray Images offers a solution using the capsule network framework approach" [7]. Also in a journal entitled "Automatic X-ray COVID-19 Lung Image Classification System based on Multi-Level Thresholding and Support Vector Machine" offers a double pass approach using multi-level thresholding and SVM [8].

Emphasis on the importance of the role of radiologists in pandemic mitigation measures is emphasized again in the journal "CT radionics can help screen the coronavirus disease 2019 (COVID-19): a preliminary study" [9]. A study by Farid et al also strengthens this research in his journal entitled "A Novel Approach of CT Images Feature Analysis and Prediction to Screen for Coronavirus Disease (COVID-19)" in which he offers the latest solutions for the feature selection model [10] will help diagnose COVID digitally. Hyperlocal research is also popular such as research by Gong et al., entitled "A tool to early predict severe 2019-novel coronavirus pneumonia (COVID-19): a multicenter study using the risk nomogram in Wuhan and Guangdong, China [11] and Al-karawi et al., who proposed a digital device as a doctor's assistant in making COVID 19 screening decisions in a journal entitled "Machine Learning Analysis of Chest CT Scan Images as a Complementary Digital Test of Coronavirus (COVID-19) Patients" [12]. In another study, Sethy et al., succeeded in developing the application of deep features extraction in a journal entitled Detection of coronavirus Disease (COVID-19) based on Deep Features and Support Vector Machine [13]. Based on the previous research, the novelty contained in this study are a hybrid approach of image correction to improve the quality of x-ray images and uses deep learning combined with deep feature selection, which is expected to improve accuracy.

B. CNN (Convolutional Neural Network)

A Convolutional Neural Network or CNN is a level up of a prevalent artificial neural network technique called multilayer perceptron, designed to tackle 2-dimensional data problem like images. CNN is falling into a category of a deep neural network because of the network's added depth [14]. The CNN is popular among researchers who tackle image recognition problems, the problem which MLP fails to solve effectively because MLP does not store the information of image spatial data and assume that every pixel is an independent feature, limiting the ability of MLP to solve the image recognition problem.

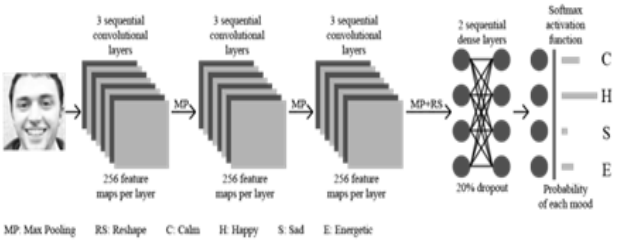

Fig. 1. CNN Method Process

CNN is a term coined originally by a researcher Kunishiko Fukushima from NHK broadcasting science research laboratory Kinuta Setagaya in Tokyo, Japan, with the name of Neocognitron. The concept which Kunishiko coined later was perfected by Lichen, a researcher from AT&T Bell Laboratories in New Jersey USA, Lecunn implements a full-pledged CNN model he named Le net that he trained to recognize a written digit. Flies a couple of years, a man named Alex Krizhevsky, with his CNN implementation, can win an ImageNet Large Scale Visual Recognition Challenge 2012. A contest that later propels the popularity of deep learning to the mainstream scene as a powerful solution. More potent than SVM (Support Vector Machine), a popular method at that time.

C. Structure of Convolutional Neural Network

A common convolutional neural network consist of one or more so called convolutional layer which is a stack of artificial neuron that feeding from the input data with a subsampling layer that also known as pooling layer and one connected layer that will be led to a final layer that always contain the final classification layer that the classification algorithm reside. In other word the convolutional neural network is also can be classified as feedforward perceptron layer because of the way is working. In the past the application of deep neural network is often limited by the limitation of personal computing power of the household computer frame but nowadays that limitation is resolved using a gigantic cloud architecture that is available for the public cheaply thus making the implementation of CNN and deep learning in general not only popular but preferable.

D.Convolutional Layer

The convolutional layer which is the first layer of the group is a layer that make a deep learning network possible the artificial neurons that resides in convolutional layer bridge the network into a so called local regions of the data (input) slightly process and compute their outputs based only on these specialized local regions [15].

This layer is have its own set of parameter that consist of learnable filters (kernels) that is passed over the each pixel one by one until every pixel that equal of width and height of the input image is covered and give the result of each filter in a matrix called a feature map.

That give us the following equation Given an input volume size Xi × Xi × Li, the filter or receptive field size FL, the depth of the convolutional layer D, the stride parameter STR, and the amount of zero padding Pi, the number of neurons in the output volumes No × No × Do can be calculated by the formula.

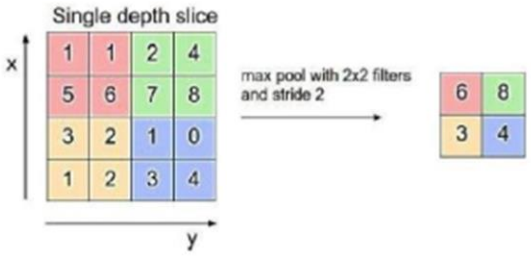

Fig 2. Convolution Operation

E. Subsampling layer

The feature pool that is resulted from the first layer can be produced into a neural network map the map is formed into the matrix and is usually subsampled with R × R non-overlapped windows (region), where R is a hyper-parameter that can be empirically guessed by the user. This region is shifted over the feature matrix: each time the value within this region w which is most responsive or has the highest activation value is selected while other values are neglected. The purpose of this layer is to simplified the computational architecture thus reducing the computing power needed to perform a computation.

F. Connection Layer

This layer is commonly dub as a connection layer or connected layer often represents the final layers of a deep neural network architecture. Each node in the fully connected layer (which is a artificial neural network by itself) is completely connected to all of the nodes in the previous layer and is added a special number called weight that represent the connection between them and the previous layer. The number of neurons in the fully connected layers is considered as a hyper-parameter to be empirically chosen by the user.

G.Activation Function

A converter function is used as an activation function or a classifier function for all of the layers (except for the final layer) in our implemented deep neural network a network unit employing the rectifier is commonly called a Rectified Linear Unit (RELU) [14]. This is the most common activation function used in deep neural networks because it is less susceptible to vanishing gradient problems. The rectified function is defined by the formula.

H.Preprocessing

Since the main input of the data here is an image of lung taken by x-ray machine the output of the system is prone to a problem of noise. To counter this and also the as the modifier of the experiment we employ the denoising algorithm into the system before the data is deployed to the first layer of the CNN, in one experiment we also playing with the contrast value of the image to see wherever the combination of it will yield in better result.

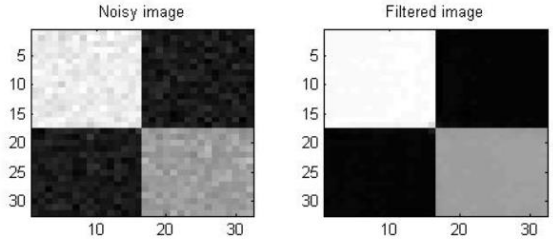

Fig 4. Denoising Process

Image Denoising problem has remained an important problem in the field of digital image processing. Since the invention of Wavelets transform and in results in a largely better performance in the term of image denoising because of the superiority of the method that offer a certain feature such as sparsity and multiresolution structure in the kernel. The popularity of Wavelet Transform in the last 20 years various improvement of the algorithm has provided the field novelty.

We focused here using the classical method of doing image denoising. Propeled it using a mean kernel that says its the optimal linear filter for Gaussian method in the sense of math of mean square error. Linear filters in this case tends to blur sharp edges of the images, destroy lines in the image and distort fine image details, and perform a bit dissapointing in the presence of signal-dependent noise. Compared it to The wiener filtering that requires the information about the source of the noise and the original so called ‘image signal’ and it only give you excelent result if and only if the base signal is smooth.

Fig. 3. Contrast Enhancements

Contrast enhancements is a process of improve the quality of the object with modifying the perceptibility of an image objects in the scene by enhancing the pixel brightness difference between objects and their backgrounds. A contrast

stretch improves the brightness differences uniformly across the dynamic range of the image, whereas tonal enhancements improve the brightness differences in the shadow (dark), midtone (grays), or highlight (bright) regions at the expense of the brightness differences in the other regions.

III. METHODOLOGY

The main model that we proposed on this method is a common convolutional network hence the name of the network is convolutional neural network. But with a litle twist as a mean of research novelty to evaluate the method, we make sure the quality of x ray dataset that will be feed to the network is enchached.

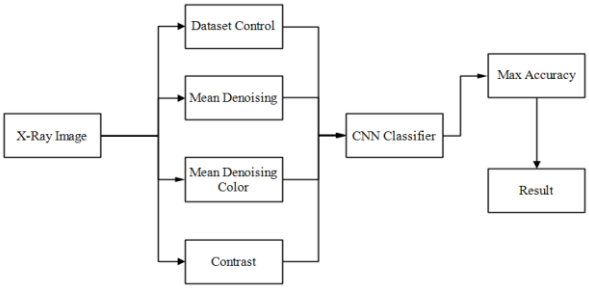

Fig. 4. Block Diagram Proposed Method

We are enchaching the dataset with 3 different image enchachement method, which is image denoising which is counter the noisy problem of the dataset with 2 variant of denoising method as well which is mean denoising method and color denoising method, third option is contrast enchancement to improve the x ray dataset brightness and then the result of each classifier model will be evaluated based on model accuracy which is the highest one is picked at the end. Which the CNN classifier will be the underlying core of this model.

The network is working on a image this time which is composed by pixel the model will build convolutional neuron and multiplies it to a matrix of pixels with a filter matrix or commonly known as 'kernel' and sums up the multiplication values. Then the convolutional neuron slides over to the next pixel and repeats the same process until all the image pixels have been covered. The explanation of the network can be visualized below.

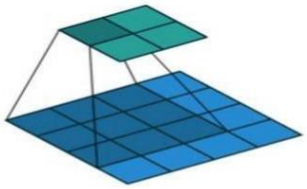

Fig. 5. Matrix of Pixels With a Filter

The benefit of this model of unsupervised learning method In contrast to common in depth model that are popular to use for example neural network and SVM (Support Vector Machine) is in a feature extraction area , for which a feature extraction step is essential, hierarchies of significant features are learned by an algorithm called a deep learning algorithm and is learned directly from the input data report suggest this kind of method is generally yield more consistent result in a field of computer vision in many popular application point such as object recognition, point localization or even a image classification in general furthermore this kind of approach is popular also in medical field for aiding professional of making AI based diasnotc tool. for example in field of bone fracture, membrane recognition or womb health recognition.

We choose the use of rectified linear units (ReLU) as the activation function in this deep neural network (DNN). commonly used as an activation function in DNNs, with Softmax function as favorite classification function. However,there is a few other option as well that we didnt explore , and this study is an addition to those common practice. our approach is taking the activation of the learning layer in neural network , then multiply it by weight parameters θ to get the total raw scores. Afterwards, we threshold the raw scores oi by 0, i.e. f (o) = max(0, oi), where f (o) is the said ReLU function. We provide class predictions yX through arg max function, i.e. arg max f (x).

IV. RESULT

In this experiment we are using the x ray database dubbed "x-ray SARS-CoV-2 dataset" which consist of 400 image file with size of 128 x 128 pixel that divided into 2 class a normal thorak lung x ray and a covid positive x ray which each of the data would be enchached digitally using the denoising and constrast method specifically. So we have 4 (four) group to compare first a control dataset, a dataset improved with mean denoising dataset , a dataset with mean denoising plus coloring and a dataset with constrast enchancement applied to it. The dataset would be later compared if the enchancement influence the result of the model effectiveness to detecting covid

From the experiment conducted with 400 training data the average accuracy of the model is 99.8% with mean denoising outpetform the other model with 100 percent with the least sucessful one yielding the effetiveness of 99.8 %.

TABLE I
RESULT OF TRAINING X-RAY DATASET

Type of Dataset	Number of Training Data	Training With CNN	
		Loss (%)	Accuracy (%)
X-Ray Control	400	5.7	99.2
X-Ray Mean Denoising	400	0.74	100
X-Ray Mean Denoising Coloring	400	1.67	100
X-Ray Contrast Enhancement	400	1.03	100

The model results from the CNN training method, then tested with new x-Ray data of random corona-infected lungs that exist in the world with 100 test data, yielding an average accuracy of 92.5% and the most satisfying results of 95%.

TABLE 2
RESULT OF X-RAY DETECTION

CNN Model	Number of Testing Data	Corona Prediction	
		False (%)	True (%)
X-Ray Control	100	9	91
X-Ray Mean Denoising	100	5	95
X-Ray Mean Denoising Coloring	100	8	92
X-Ray Contrast Enhancement	100	8	92

The test results in table 2 show that the system's highest accuracy value in predicting lung x-rays is generated when using the CNN training model using lung x-ray data, which was previously corrected using the mean denoising method. The lowest accuracy results are obtained in system testing when using the x-ray model results without using image correction first (image x-ray control). Based on these tests' results, the authors recommend an approach using image correction using the mean denoising method before the x-ray images are trained using the CNN method.

V. Conclusion

The deep learning training model for analyzing COVID 19 by analyzing x-ray data of the patient's lungs yielded satisfactory accuracy with an average result of above 90% (91-95%). Processing x-ray data with denoising algorithms to solve common problems in the x-ray data set produces positive results with an increase of 1-4% without performing image correction before deep learning training. The Mean Denoising algorithm shows the highest increase in accuracy with an accuracy value of 95%. This experiment shows that image correction with the denoising algorithm can improve image quality so that the system can recognize the image accurately.

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