Neural Network based Lungs Infection Detection System

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Abstract
The corona virus disease 2019 (COVID-19) has become a global pandemic since the beginning of Dec 2019. The World Health Organization (WHO) and the end of Nov2020 have regarded the disease as a Public Health Emergency of International Concern (PHEIC). Automated detection of lung infections from computed tomography (CT) images offers a great potential to augment the traditional healthcare strategy for tackling COVID-19. However, segmenting infected regions from CT slices faces several challenges, including high variation in infection characteristics, and low intensity contrast between infections and normal tissues. Further, collecting a large amount of data is impractical within a short time period, inhibiting the training of a deep model. To address these challenges, a novel lungs infection Segmented system on SqueezeNet and is a convolutional neural network is proposed to automatically identify infected regions from chest CT slices. In CNN, a parallel partial decoder is used to aggregate the high-level features and generate a global map.

Keywords: CNN, SqueezeNet, CT Scan, Neural Network, Lungs Infection Detection System

1. Introduction
The corona virus disease 2019 (COVID-19) has become a global pandemic since the beginning of 2020. With over 12 million COVID19 positive cases around the world, causing over 5,50,000 deaths already (according to World Health Organization) statistics this pandemic poses the biggest healthcare threat towards humanity as of now. The symptoms of covid19 are two symptoms. There are common symptoms and serious symptoms. The common symptoms are fever, flu, cough, tiredness. The serious symptoms are shortness of breath, chest pain. The shortness of breath can scan the Lungs. The tests for detect the infected lung. The image based approaches has been proposed by multiple works recently showing great promise for application of Artificial Intelligence (AI) and Deep Learning (DL) based approaches for efficient detection of the disease from lungs CT images. Motivated by the need for extensive evaluation of such AI based approaches, in this work, Deep CNN based strategies are explored and studied experimentally to assess the usefulness of the approaches in the present crisis.

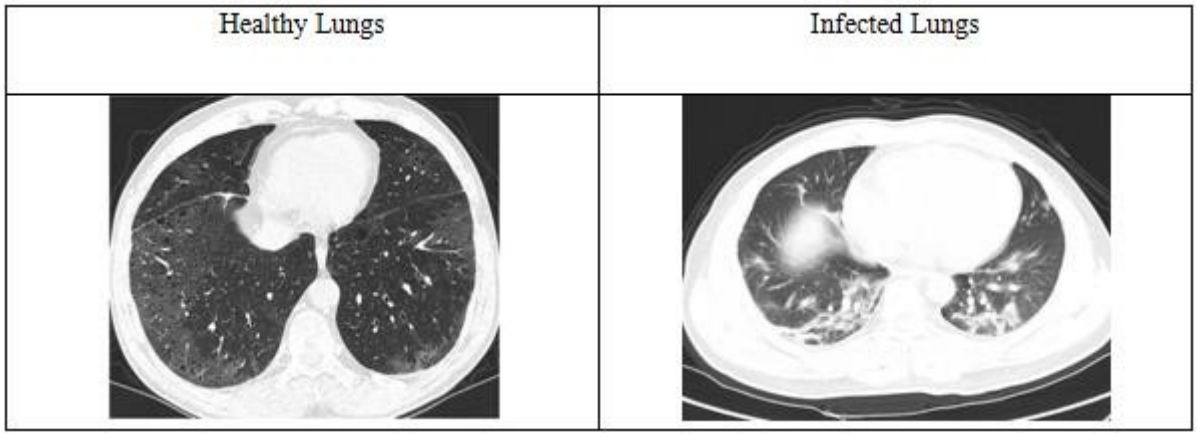

Figure 1: The Sample CT Slice Images of COVID-19 Infected Regions in Lungs and Normal Healthy CT Slice Images in Lungs

1.1 CNN (Convolutional Neural Network)

A convolutional neural network (CNN) is a type of artificial neural network used in image recognition and processing that is specifically designed to process pixel data. CNNs are powerful image processing, artificial intelligence (AI) that use deep learning to perform both generative and descriptive tasks, often using machine.

A convolution is the simple application of a filter to an input that results in an activation. Repeated application of the same filter to an input results in a map of activations called a feature map, indicating the locations and strength of a detected feature in an input, such as an image.

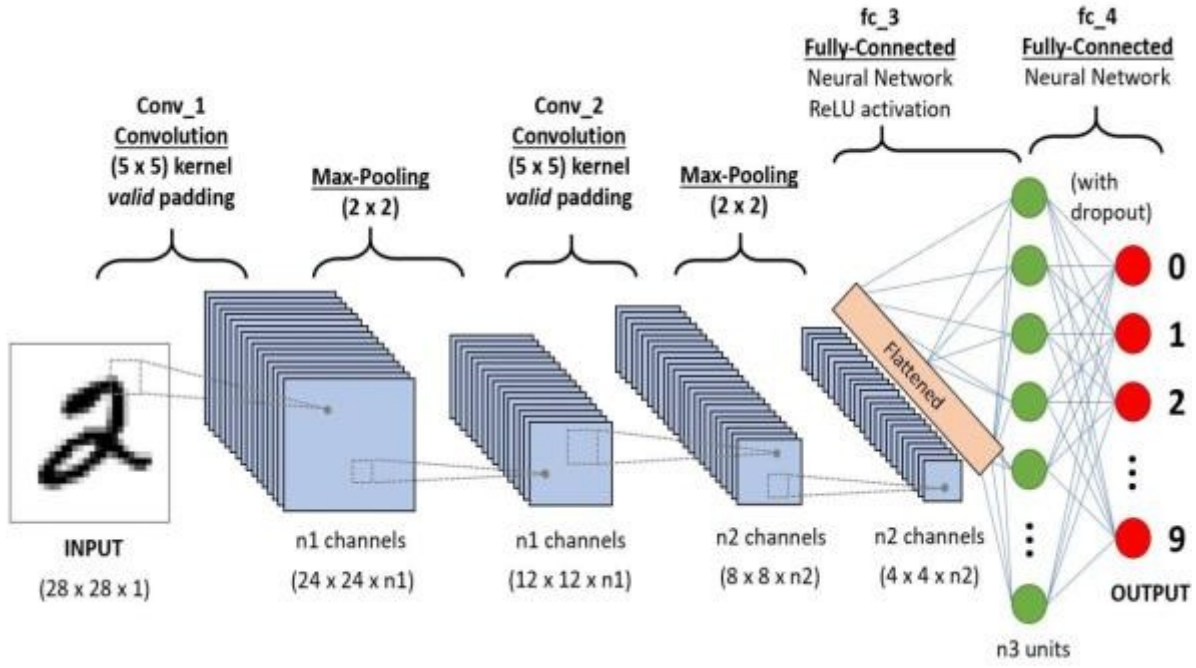

Figure 2: CNN Architecture

1.2 SqueezeNet

The squeeze net is a convolutional neural network. It is pre-defined module, Deep neural network is focused primarily on improving accuracy. These have extra model than other model and they are fire model. These model is used to process a compressed form.

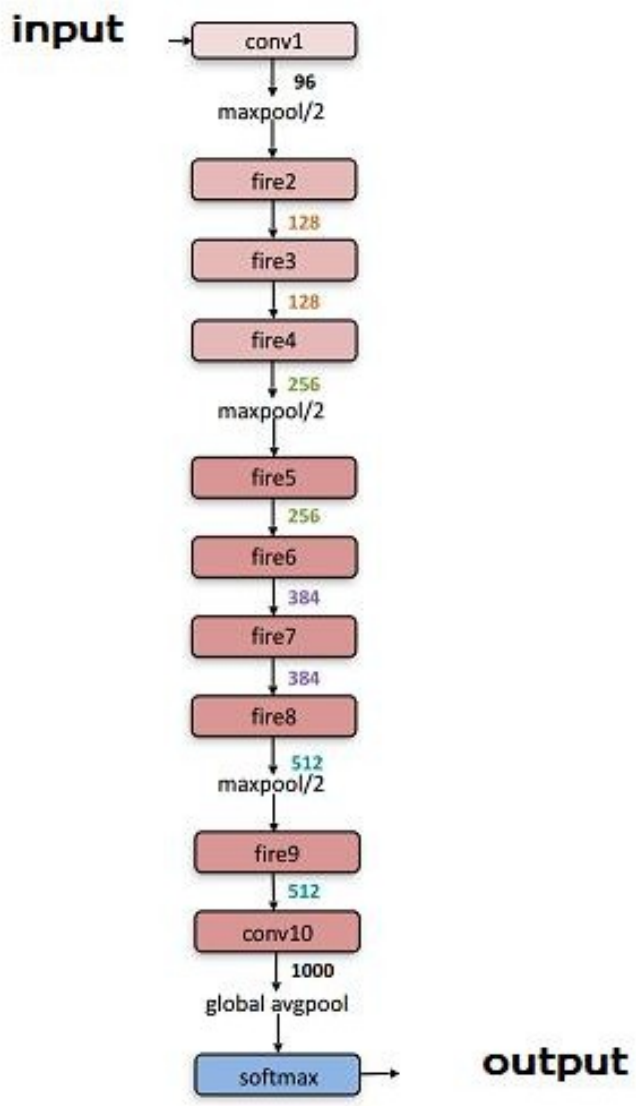

Figure 3: SqueezeNet Architecture

1.3 Fire Module

A Fire module is comprised of: a squeeze convolution layer (which has only 1×1 filters), feeding into an expand layer that has a mix of 1×1 and 3×3 convolution filters.

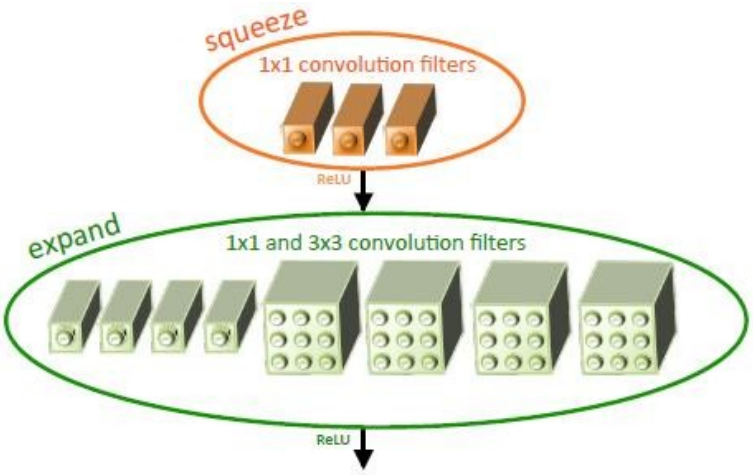

Figure 4: Fire Module

1.4 ResNet

Residual Network (ResNet) is a Convolutional Neural Network (CNN) architecture. Deep learning is thought of as learning a hierarchical set representations such that it learns low, mid and high level features. The ResNet is more layers enrich than the levels of the features of previous net models. The ResNet typically has depths of 16 and 30 layers.

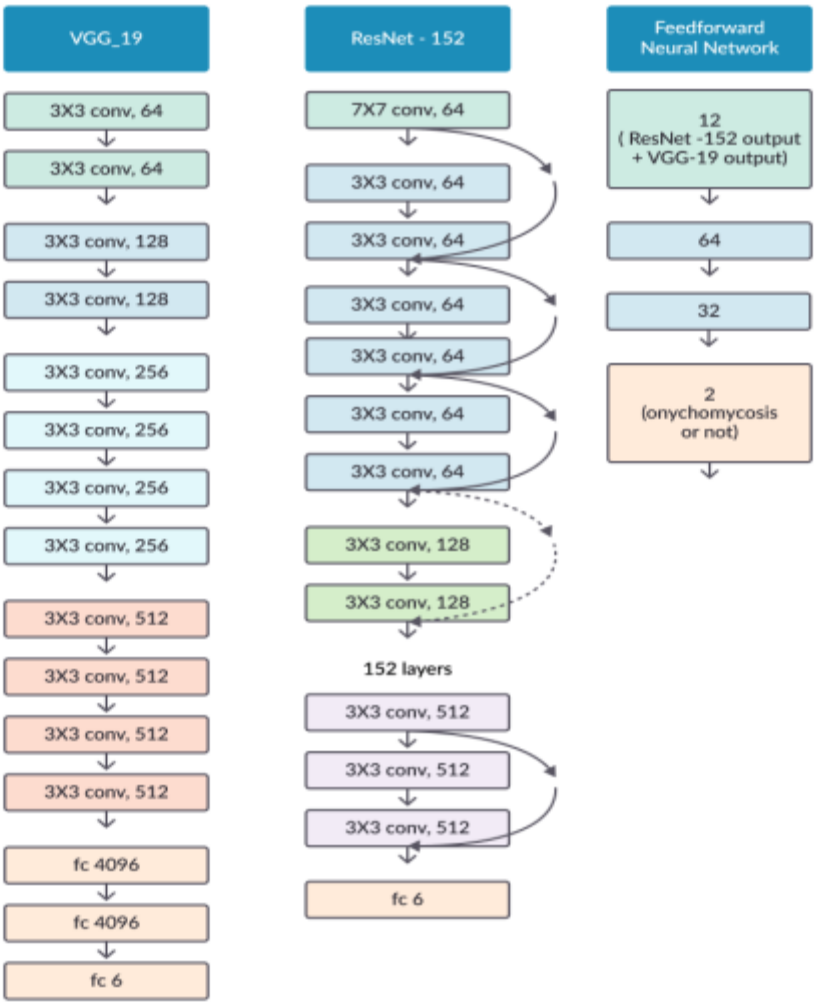

Figure 5: ResNet Architecture

2. System Design

In the system design to identity the affected person and it reduce the time complexity. More than one affected person can't be identified by an existing system.

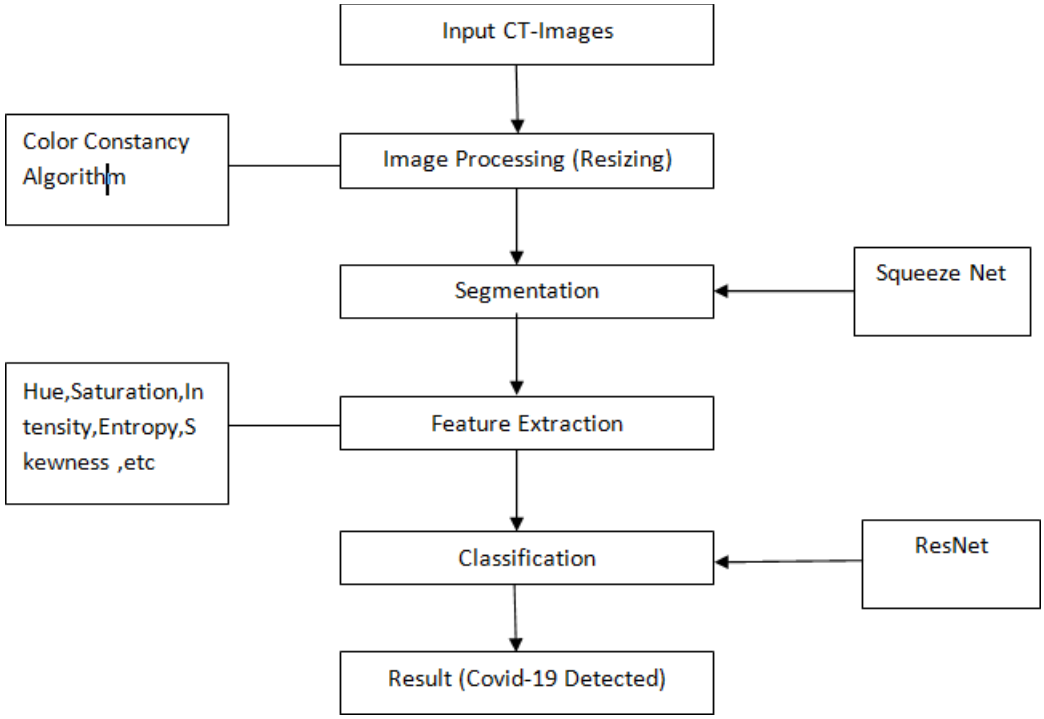

Figure 6: System Architecture

Module Description

The various modules involved in this work are:

- Image Pre-processing
- Segmentation
- Feature Extraction
- Classification
- Infection Detected

These modules are processed in step-wise manner to detect the COVID-19 virus in the lungs.

2.1 Image Pre-processing

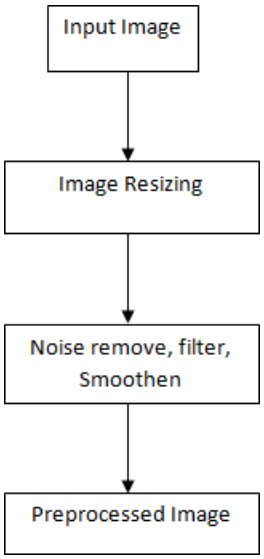

Figure 7: The Step-wise Procedure for the Image Pre-processing

Here the input image undergo three stages in the pre-processing step. Image resizing is the first step in pre-processing. After the image is resized the color constancy algorithm is applied to each image The algorithm has been implemented as illustrated below in which first stage accounts for a RGB color convert into Gray scale images the output range to implement an accurate tone mapping/Single band Scale (Gray Scale).

2.1.1 Color Features

Color features are measures that characterize color distribution in an image. Color features are mainly used to compare images how they are similar based on color.

Formula are used to calculate hue, saturation, intensity of the segmented image.

1. The R,G,B values are divided by 255 to change the range from 0..255 to 0..1:

   R' = R/255

   G' = G/255

   B' = B/255

2. **Find** C_{max}

   C_{max} = *max(R', G', B')*

3. **Find** C_{min}

   C_{min} = = *min(R', G', B')*

4. **Find delta**

   $\Delta = C_{max} - C_{min}$

2.1.2 Filtering

Filtering is a technique for modifying or enhancing an image. For example, you can filter an image to emphasize certain features or remove other features. Image processing operations implemented with filtering include smoothing, sharpening, and edge enhancement.

Filtering is a *neighborhood operation,* in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel.

$$g(x) = \sqrt{\frac{a}{\pi}} \cdot e^{-a \cdot x^2}$$

The Formula of a Gaussian Filter Function

2.1.3 Smoothing

The Gaussian smoothing operator is a 2-D convolution operator that is used to `blur' images and remove detail and noise. In this sense it is similar to the mean filter, but it uses a different kernel that represents the shape of a Gaussian (bell-shaped) hump. This kernel has some special properties.

$$G(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}}$$

The Formula of a Gaussian Smoothing Function

2.2 Segmentation

The segmentation takes a vital role in this system. With the help of segmentation the actual image is

spitted into multiple segments. While extracting the features of an entire image, all features are not taken into account. Many features are ignored while extraction.

Hue is identified as the color family or color name (such as red, green, purple). Hue is directly linked to the color's wavelength. Hue ranges from 0 degree to 359 degree. **Saturation,** also called "chroma," is a measure of the purity of a color or how sharp or dull the color appears. **Intensity** refers to the value of pixel. The intensity of image could refer to a global measure of that image, such as mean pixel intensity.

Hue calculation:

$$H = \begin{cases} 0^{\circ} & \Delta = 0 \\ 60^{\circ} X \left(\frac{G' - B'}{\Delta} mod\ 6 \right) & , C_{max} = R' \\ 60^{\circ} X \left(\frac{B' - R'}{\Delta} + 2 \right) & , C_{max} = G' \\ 60^{\circ} X \left(\frac{R' - G'}{\Delta} + 4 \right) & , C_{max} = B' \end{cases}$$

Saturation calculation:

$$S = \begin{cases} 0 & , C_{max} = 0 \\ \frac{\Delta}{C_{max}} & , C_{max} \neq 0 \end{cases}$$

Intensity calculation:

$$I = \frac{1}{3} (R + G + B)$$

Formula used to Calculate Hue, Saaturation, Intensity of the Segmented Image

2.3 Feature Extraction

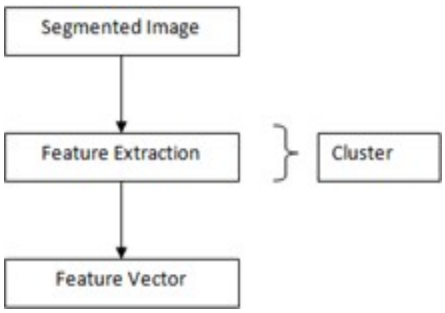

Figure 8: Flow Chart for Feature Extraction from Segmented Image

The feature extraction process involves obtaining features from the images. The feature vector is constructed by taking out color features, statistical features, texture features from the images. The lungs image feature vector size is 12 and we have considered color, statistical, texture feature from the images. The virus detection feature vector size is 8 and color, statistical features are considered for it.

2.3.1 Clustering

Simple Clustering is the state of the art algorithm to segment superpixels which doesn't require much computational power. In brief, the algorithm clusters pixels in the combined five-dimensional color and image plane space to efficiently generate compact, nearly uniform superpixels. A superpixel can be defined as a group of pixels which have similar characteristics. It is generally color based segmentation. Superpixels can be very helpful for image segmentation.

2.3.2 Statistical Features

Statistical features are derived from the statistical distribution of pixels. The features can be easily compared to structural features (features based on topological and geometric property of object). Statistical features are not affected too much by noise or distortions.

2.3.3 Filtering

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Filtering is a *neighborhood operation,* in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel.

$$g(x) = \sqrt{\frac{a}{\pi}} \cdot e^{-a \cdot x^2}$$

The Formula of a Gaussian Filter Function

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The Gaussian smoothing operator is a 2-D convolution operator that is used to blur images and remove detail and noise. In this sense it is similar to the mean filter, but it uses a different kernel that represents the shape of a Gaussian (bell-shaped) hump. This kernel has some special properties.

$$G(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2}{2\sigma^2}}$$

The Formula of a Gaussian Smoothing Function

2.3.5 Blur

In image processing, a **Gaussian blur** (also known as **Gaussian smoothing**) is the result of blurring an image by a Gaussian function. Gaussian smoothing is also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales. The scale space representation and scale space implementation. Since the Fourier transform of a Gaussian is another Gaussian, applying a Gaussian blur has the effect of reducing the image's high-frequency components; a Gaussian blur is thus a low pass filter.

The Gaussian blur is a type of image-blurring filters that uses a Gaussian function (which also expresses the normal distribution in statistics) for calculating the transformation to apply to each pixel in the image.

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{x^2}{2\sigma^2}}$$

The Formula of a Gaussian Function in One Dimension

2.4 Classification

The classification done by two set of images training and testing images for identifying only the virus in the images. The res-net was used to classify the image for layer by layer procedure.

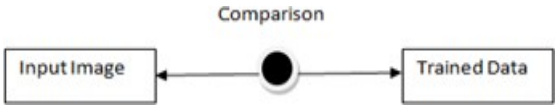

Figure 9: Compare the CT Images with Trained Dataset

2.5 Infection Detected

After finishing the classification, they predict the COVID-19 is present or not. With the input data, they give the output message if it was positive or negative. To differentiate the infected person and normal person, the threshold value to be predicted. The threshold value greater than 60 is normal person, and the threshold value less than 60 is infected person.

3. Result and Discussion

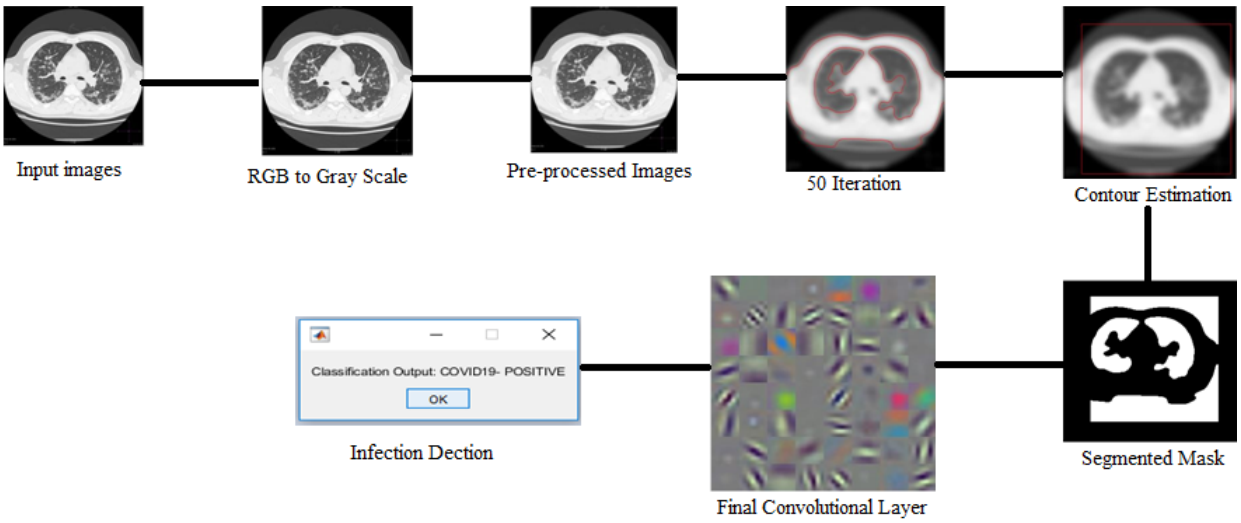

Figure 10: The Steps to Verify that the Person was Infected or Not

In the first step, CT slice lungs' images are input. In the step 2, input images are processed to

convert from RGB to Gray scale image. In the step 3, the converted images are further processed, which include: resizing, remove noise, apply filter, and smoothing to the images. In the steps 4 and 5, the images are input for segmentation and feature extraction. Hue, saturation and intensity are applied on the images. And then, the affected areas are clustered and blured in iterations. Total 50 iterations are done for feature extraction. In the step 6, boundary mask is marked as segmented mask. The step 7 is the Final Convolutional Layer. This layer is split into number of layers depending on weight of images, also known as convolutional layer weight. In the step 8, finally message is shown whether the person was infected by COVID-19 or not.

Input Images	Success Rate	Sensitivity	Specificity	F_Score	Threshold	Predict Value
1	99.9868	0.5000	0.5000	0.0257	57.9734	COVID
1	99.9713	0.5000	0.5000	0.0543	64.2907	Normal

Table 1: The Table showing Data for Affected Person and Normal Person

The deep learning systems have been proposed to detect patients infected with COVID-19 via CT-imaging. For example, an Inf-Net was proposed to detect COVID-19 cases from chest CT-images. For CT-imaging, a location-attention oriented model was employed to calculate the infection probability of COVID-19. A convolutional neural network is deep learning-based software system developed using CT volumes to detect COVID-19. A paper list for COVID19 imaging-based AI works could be found. Although plenty of AI systems have been proposed to provide assistance in diagnosing COVID-19 in clinical practice, there are only a few works related infection segmentation in CT slices. COVID-19 infection detection in CT slices is still a challenging task, for several issues: (1) The difficult to found the patient was affected or not in N-Number of patients CT slice. (2) Time Complexity to find the infected patients. (3) A single person cannot detect the infected patients.

4. Conclusion

Deep learning practices are an area where high scientific achievements are obtained in different scientific fields day by day. One of these fields is medical practices and studies such as disease detection, disease classification, and detect location of the disease. Datasets were used as input data to the SqueezeNet network using image processing techniques. The network, achieved higher accuracy. SqueezeNet structure, which has been used less than other popular deep learning methods in previous studies, combined with image processing methods, has shown successful results.

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