# COVID-19 Detection on Chest X-Ray and CT Scan Images Using Multi-image Augmented Deep Learning Model

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# Motivation

- COVID-19 is an infectious disease which has so far infected millions of people and deaths are increasing day by day.
- The RT-PCR test for COVID-19 takes hours to give the results.
- Sometimes the test gives false positive results.
- In highly affected regions, it is difficult to provide sufficient number of test kits for testing COVID-19 infection.
- To re-confirm the outcome of the RT-PCR test of a suspect, X-Ray or/and CT scan would be an added advantage to have a more accurate result on detection of COVID-19.
- Therefore, to test COVID-19 rapidly and in a efficient way, chest X-Ray or CT scan images of the suspects are used.

# Problem Definition

- To detect COVID-19 on chest X-Ray and CT Scan images of suspected individuals.
- To develop a model which uses CNN fused with the image processing based data augmentation.
- To resolve the issue of smaller number of images for training the deep-model.
- To increase the data by using multiple representations of the same X-Ray and CT scan images, produced through sharpening filters.

# Methodology

- Hybrid filter generation
- Multi-image representation
- Training and classification of CNN based deep learning model

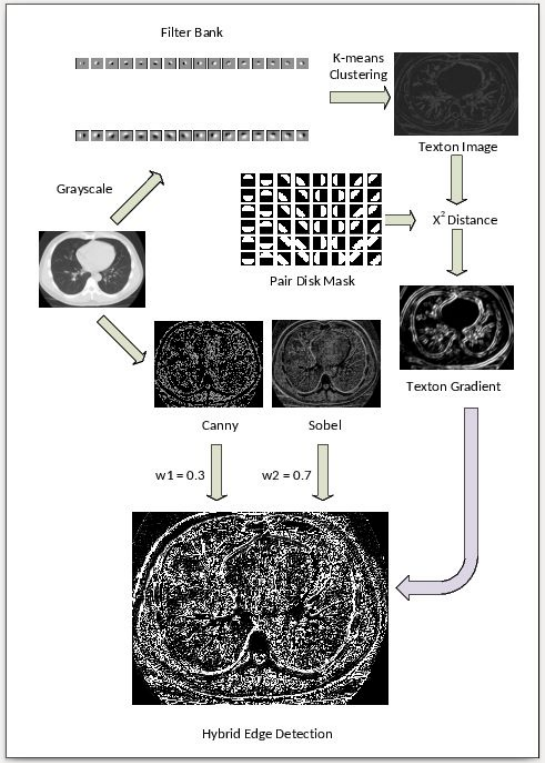



Fig 1: Design process of Hybrid Edge Detector

# Methodology (Cont.)

**Data Augmentation using Image Processing consists of the following steps:**

**Step 1:** Accept the coloured input image from the data set.

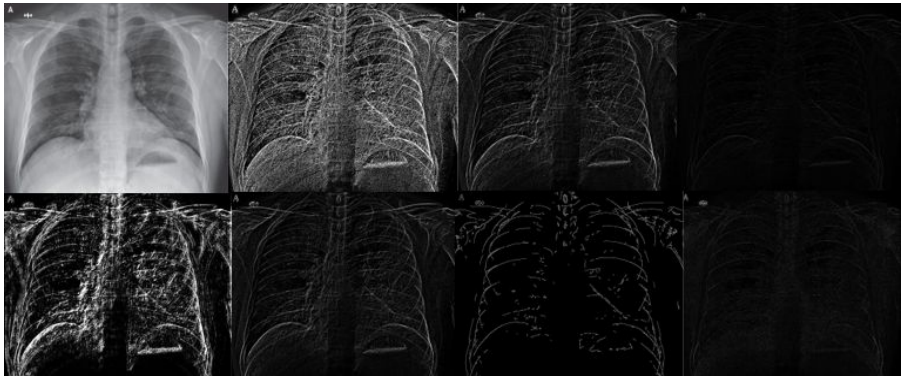
**Step 2:** Convert the image into grayscale.

**Step 3:** Histogram Equalization is initiated to correct the contrast of the given grayscale input image.

**Step 4:** Find edges by applying edge detection operators, viz. Sobel, Prewitt, Roberts, Scharr, Laplacian, Canny, and Hybrid (combination of Canny and Sobel edge detector).

**Step 5:** Mix the result obtained after applying Edge Detection Operators to the data set.

# Methodology (Cont.)



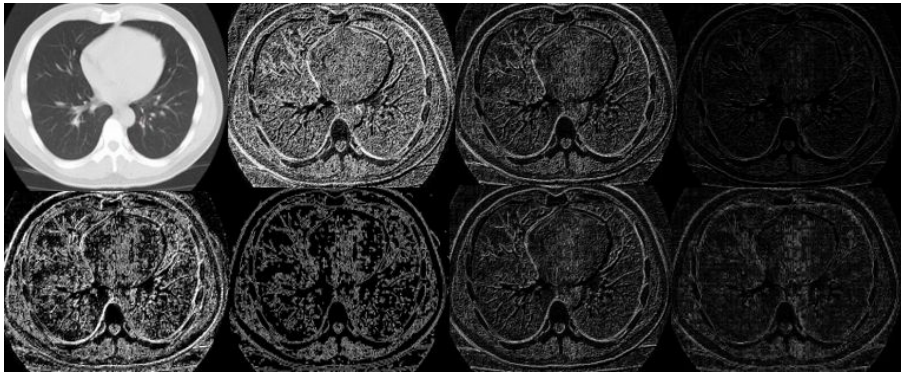


Fig 2: Multiple Representations of chest images of X Ray and CT Scan of Covid infected person

# Methodology (Cont.)

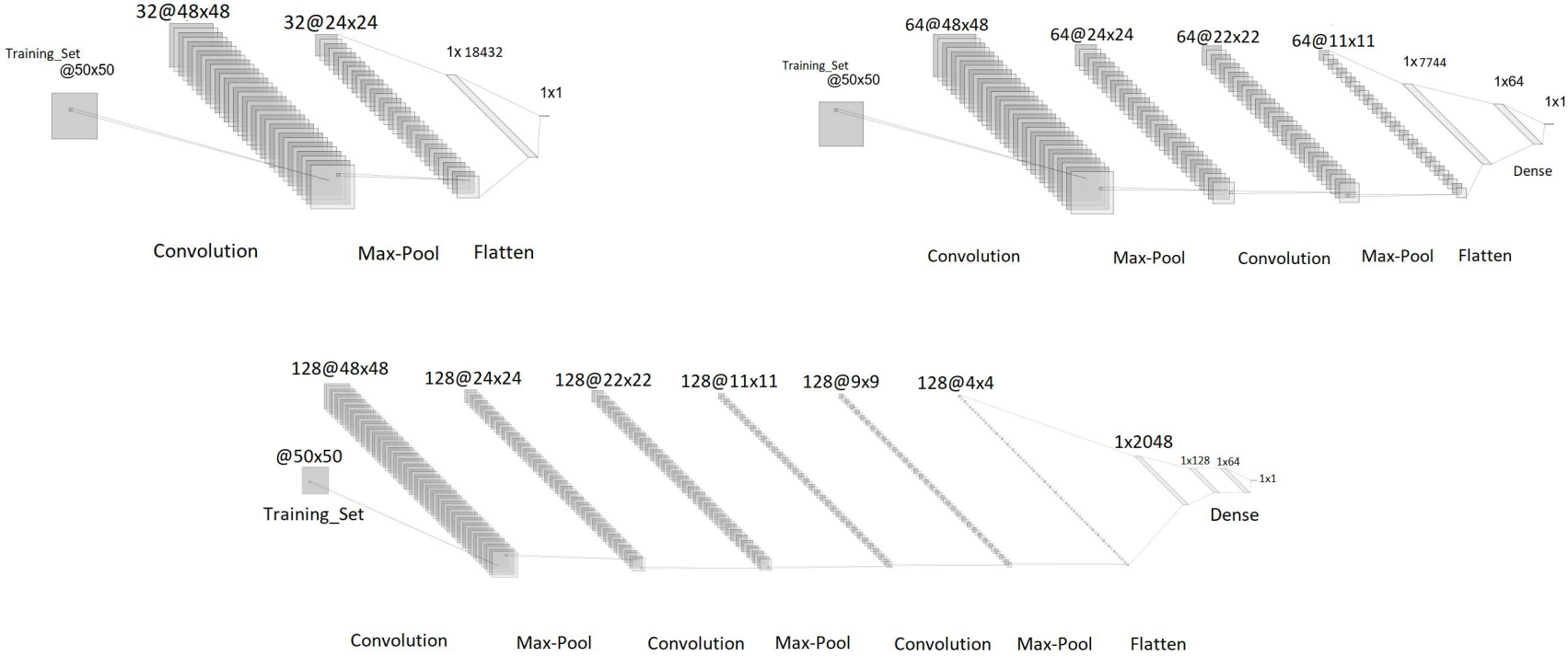



Fig 3: Convolutional Neural Network of Layer Size 32, 64 and 128.

# Methodology (Cont.)

**Model Used**

- Deep CNN model
- Ratios applied for training & testing - 90:10, 80:20, 70:30 and 60:40.
- Optimizer Used- SGD, batch size- 32, epochs- 30, loss function- binary cross entropy
- Activation function- Relu after Convolution, Sigmoid for classification
- Dense layers=[0,1,2], layer sizes=[32,64,128], conv layers=[1,2,3]

**Performance Metric**

Accuracy, Loss, AUC, Precision, Sensitivity, Specificity and F1 score.

**Database Description**

- X-Ray database(Augmented)- 536 Covid, 536 non-Covid images
- CT Scan database(Augmented)- 2760 Covid, 2760 non-Covid images

# Results and Analysis

| | CT Scan Images | | | | | X-Ray Images | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Proposed | | | Resnet | VGG | Proposed | | | Resnet | VGG |
| Train-Test | Layers | | | | | Layers | | | | |
| **70%-30%** | **32** | **64** | **128** | **50** | **16** | **32** | **64** | **128** | **50** | **16** |
| Accuracy (%) | 95.05 | 95.38 | 92.46 | 89.02 | 88.99 | 98.97 | 99.44 | 98.69 | 90.76 | 92.26 |
| Loss (%) | 19.44 | 26.97 | 37.33 | 52.16 | 35.49 | 7.4 | **1.91** | 8.05 | 48.19 | 17.81 |
| AUC (%) | 97.8 | 98.4 | 97.2 | 89 | 93.4 | 99.7 | 100 | 99.6 | 90.8 | 92.3 |
| Precision | 0.96 | 0.96 | 0.95 | 0.9 | 0.9 | 0.99 | 1 | 0.99 | 0.99 | 0.99 |
| Sensitivity (%) | 93.64 | 94.78 | 89.38 | 87.71 | 87.83 | 99.07 | 99.07 | 98.33 | 82.27 | 85.82 |
| Specificity (%) | 96.48 | 95.98 | 95.54 | 90.32 | 90.14 | 98.88 | 99.81 | 99.06 | 99.25 | 98.69 |
| F1 Score | 0.95 | 0.95 | 0.92 | 0.89 | 0.89 | 0.99 | 0.99 | 0.99 | 0.9 | 0.92 |
| **80%-20%** | **32** | **64** | **128** | **50** | **16** | **32** | **64** | **128** | **50** | **16** |
| Accuracy (%) | 96.47 | 96.99 | 95.45 | 92.75 | 91.16 | 99.07 | 98.88 | 99.16 | 96.18 | 93.1 |
| Loss (%) | 13.79 | 16.39 | 21.58 | 31.42 | 26.25 | 7.63 | 5.18 | 4.87 | 20.58 | 17.35 |
| AUC (%) | 98.6 | 99 | 98.2 | 92.7 | 97.1 | 99.5 | 99.7 | 99.8 | 96.2 | 93.1 |
| Precision | 0.96 | 0.97 | 0.95 | 0.94 | 0.96 | 0.99 | 0.99 | 0.99 | 0.99 | 0.97 |
| Sensitivity (%) | 96.73 | 97.39 | 95.83 | 90.83 | 86.38 | 99.25 | 99.25 | 99.44 | 92.91 | 88.99 |
| Specificity (%) | 96.2 | 96.6 | 95.07 | 94.65 | 95.94 | 98.88 | 98.52 | 98.89 | 99.44 | 97.2 |
| F1 Score | 0.96 | 0.97 | 0.95 | 0.93 | 0.91 | 0.99 | 0.99 | 0.99 | 0.96 | 0.93 |

Table 1: Results of proposed model with Data Augmented images along with ResNet-50 and VGG-16 using CT Scan and X-Ray images for train-test ratio- 70:30 and 80:20.

- We can see that proposed model with Data Augmented images outperforms other models like Resnet 50, VGG 16 in both CT Scan and X-Ray images.

# Results and Analysis (Cont.)

| | Original | | | | | | Augmented | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CT Scan Images | | | X Ray Images | | | CT Scan Images | | | X Ray Images | | |
| Train-Test | Layers | | | Layers | | | Layers | | | Layers | | |
| **70%-30%** | **32** | **64** | **128** | **32** | **64** | **128** | **32** | **64** | **128** | **32** | **64** | **128** |
| Accuracy (%) | 89.57 | 92.03 | 90.29 | 98.25 | 97.1 | 97 | 96.05 | 96.38 | 95.46 | 98.97 | 99.44 | 98.69 |
| Loss (%) | 29.79 | 26.81 | 50.84 | 5.21 | 12.09 | 2.22 | 19.44 | 26.97 | 37.33 | 7.4 | 1.91 | 8.05 |
| AUC (%) | 94.8 | 95.9 | 95.7 | 100 | 99.8 | 100 | 97.8 | 98.4 | 97.2 | 99.7 | 100 | 99.6 |
| Precision | 0.91 | 0.93 | 0.87 | 0.99 | 0.99 | 0.99 | 0.96 | 0.96 | 0.95 | 0.99 | 0.99 | 0.99 |
| Sensitivity (%) | 87.25 | 91.01 | 95.07 | 100 | 94.03 | 100 | 93.64 | 94.78 | 89.38 | 99.07 | 99.07 | 98.33 |
| Specificity (%) | 91.88 | 93.04 | 85.51 | 98.51 | 100 | 100 | 96.48 | 95.98 | 95.54 | 98.88 | 99.81 | 99.06 |
| F1 Score | 0.89 | 0.92 | 0.91 | 0.99 | 0.97 | 0.99 | 0.95 | 0.95 | 0.92 | 0.99 | 0.99 | 0.99 |

Table 2: Results of proposed models with Original images and Data Augmentation with CT Scan and X-Ray images datasets for train-test ratio-70:30

- We can see that after augmentation we achieved higher accuracy compared to the original dataset.
- Our model exhibits higher classification accuracy around 95% and 99% for CT scan and X-Ray images respectively.

# Results and Analysis (Cont.)

| Study | Images | Subjects | Methodology | Accuracy (%) |
|---|---|---|---|---|
| Hemdan et al. [6] | X Ray | Covid 19(+ve) - 25<br>Normal(25) | CovidX Network | 90 |
| Wang and Wong [15] | X Ray | Covid 19(+ve) - 53<br>Healthy(8066)<br>Covid 19(-ve) - 5526 | Covid Network | 92.4 |
| Ghoshal et al. [5] | X Ray | Covid 19(+ve) - 25<br>Others - #Not available | CNN | 92.9 |
| Ioannis et al. [1] | X Ray | Covid 19(+ve) - 224<br>Healthy(504)<br>Pneumonia(700) | VGG-19 Network | 93.48 |
| Murugan & Goel [8] | X-Ray | Covid 19(+ve) - 900<br>Healthy(900)<br>Pneumonia(900) | E-DiCoNet | 94.07 |
| Sethy et al. [12] | X Ray | Covid 19(+ve) -25<br>Covid 19(-ve) - 25 | ResNet 50 and SVM | 95.38 |
| Narin et al. [9] | X Ray | Covid 19(+ve) - 50<br>Covid 19(-ve) - 50 | ResNet-50 and Deep CNN | 98 |
| Tulin et al. [10] | X Ray | No Findings - 500<br>Covid 19(+ve) - 125<br>Pneumonia(500) | DarkCovidNet | 98.08 |
| Wang et al. [16] | CT Scan | Covid 19(+ve) - 195<br>Covid 19(-ve) - 258 | M-Inception | 82.9 |
| Ying et al. [13] | CT Scan | Healthy(708)<br>Covid 19(+ve) - 777 | DRE-Net | 86 |
| Xu et al. [17] | CT Scan | Healthy(175)<br>Covid 19(+ve) - 219<br>Viral pneumonia(224) | Location Attention + ResNet | 86.7 |
| Zheng et al. [18] | CT Scan | Covid 19(+ve) - 313<br>Covid 19(-ve) - 229 | 3D Deep Network + UNet | 90.8 |
| Pathak et al. [11] | CT Scan | Covid 19(+ve) - 413<br>Normal(439) | Fine-tuned ResNet32 | 93.01 |
| Chen et al. [3] | CT Scan | Covid 19(+ve) - 51<br>Others(55) | UNet++ Network | 95.2 |
| **Proposed Method** | **X ray** | **Covid 19(+ve) - 536**<br>**Covid 19(-ve) - 536** | **Multi image augmentation + CNN** | **99.44** |
| | **CT Scan** | **Covid 19(+ve) - 2760**<br>**Covid 19(-ve) - 2760** | | **95.38** |

Table 3: Comparison among various Covid 19 detection techniques based on deep learning

# Conclusion

- To make the model learn about the patterns more effective, multiple representations of the X-Ray and CT scan images are produced using sharpening filters.
- This augmentation technique provides a sufficient number of examples for training the model. Hence makes the model robust.
- We obtained the classification accuracies of 99.44% for X-Ray images and 95.38% for CT Scan images.
- Our model overcomes the issues of shortage of test kits, minimizes the cost of testing, easy to use by diagnostic and medics persons, and can be used for rapid testing.

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***Thank You***