

Image Super-resolution based classification of COVID-19 patients using CNN-SVM

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Abstract: *The first case of the Coronavirus Disease (COVID-19) was registered in December 2019 in Wuhan, China. This extremely contagious disease spread worldwide in a very short time, thus resulting in a global pandemic. To curb the spread of COVID-19, it is important to detect the virus in an infected person at the earliest. In this paper, a downright study of Multimodal Convolutional Neural Networks (m-CNN) and Support Vector Machines (SVM) will be presented for the classification of patients infected with the virus using X-ray and Computerized Tomography (CT) images. Using Transfer learning, features are extracted from the images using the fully connected m-CNN model and fed into the SVM for coronavirus classification.*

Keywords: *Coronavirus, COVID-19, m-CNN, SVM, image-based diagnosis, Computerized Tomography, Transfer Learning.*

I. INTRODUCTION

The COVID-19 is an ongoing pandemic whose origins trace back to Wuhan. In December 2019, a virus similar to the SARS coronavirus emerged in Wuhan, China. This deadly and contagious virus was later renamed to SARS-CoV-2. Extensive research and studies conclude that this family of coronaviruses generally infect bats and pangolins in Asia. A little over 4 months from the first reported case of COVID-19, the World Health Organization (WHO), on 11th March 2020, announced the pandemic. Over

2020, this virus has infected 109 million people worldwide resulting in over 2.4 million deaths. The mortality rate of this virus is approximately 3.4%.

Virus	Year	Mortality Rate
SARS	2002	10%
MERS	2013	34%
SARS-CoV-2	2019	3.4%

Table 1 : Mortality Rates Comparison

The incubation period of COVID-19, which is the time between exposure to the virus and symptom onset, is on average 5-6 days, but can be as long as 14 days. In many instances, the infected people are asymptomatic. One of the vital reasons for the need to use intelligent systems for diagnosing COVID-19 is the high transmission rate of this disease among the people of a community. The time taken to generate the test result is comparatively greater than the time required to transmit this virus from one person to another. In such cases, X-ray images or CT scans can provide a faster and a convenient way to test the suspected individuals.

This study is intended for the same. It is targeted towards the employment of intelligent AI systems that can assist in the early detection of COVID-19 using chest X-ray images. These systems will use Convolutional Neural Networks (CNN) for feature extraction and a Support Vector Machine (SVM) for disease classification.

II. LITERATURE REVIEW

Papers	DataSets	Images	Classes	Techniques & Performances(%)				
[1]	Not mentioned	Not mentioned	2 COVID-19(+) COVID-19(-)	Model	ACC	SEN	SPE	
				MODE based CNN	98	98.2	92.2	
[2]	[21], [22], [23]	341 COVID-19(+) 2800 Normal 1493 Viral Pneumonia 2772 Bacterial Pneumonia	4 COVID-19(+) Normal Viral pneumonia Bacterial Pneumonia	Model	ACC	REC	SPE	F1
				ResNet50	96.1	91.8	96.6	83.5
				ResNet101	96.1	78.3	98.2	81.2
				ResNet152	93.9	65.4	97.3	69.8
				InceptionV3	95.4	90.6	96.0	81.1
				Inception-ResNet	94.2	83.5	95.4	74.8
[3]	[21]	341 COVID-19(+) 310 Normal 310 Pneumonia	3 COVID-19(+) Normal Pneumonia classes	Model	ACC	SEN	SPE	
				AOTCNeT-Softmax	99.24	99.24	99.62	
				SVM	98.60	98.60	99.30	
				RF	99.46	99.46	99.73	
				KNN	99.46	99.46	99.73	
				MobileNet-KNN	99.46	99.46	99.73	
				ShuffleNet-KNN	99.35	99.35	99.68	
[4]	[21]	150 COVID19(+) 150 Normal	2 COVID-19(+) COVID-19(-)	Model	ACC	REC	SPE	F1
				CNN-Adam	94.6	93.5	94.5	90.7
				CNN-RMSprop	88.9	85.9	88.9	86.6
				CNN-SGD	88.4	88.7	88.5	83.0
[5]	[21], [22]	284 COVID-19(+) 310 Normal 330 Pneumonia Bacterial 327 Pneumonia Viral	4 COVID-19(+) Normal Viral pneumonia Bacterial Pneumonia	Model	ACC	REC	SPE	F1
				CORO-Net	90.21	90	95	91
[6]	[27]	219 COVID-19(+) 1341 Normal 1345 Pneumonia	3 COVID-19(+) Normal Pneumonia classes	Model	ACC	SEN	SPE	F1
				mAlexNet	98.14	98.26	99.06	98.2
				mAlexNet + BiLSTM	98.7	98.76	99.33	98.76
[7]	[25]	349 COVID-19(+) 360 Normal	2 COVID-19(+) COVID-19(-)	Model	ACC			
				GoogleNet CNN	82.14			

[10]	[23], [25]	136 COVID-19(+) 310 Normal 162 Pneumonia	3 COVID-19(+) Normal Pneumonia classes	Model	ACC	REC	SPE	F1
				Improved ResNet	96.30	96	98	96
				ResNet 50	92.59	92.5	94	92
				AlexNet	88.89	88.2	95	86.5
				GoogleNet	90.74	92.5	96.1	90.12
				VGG-16	91.66	96.49	92.2	91.5
[11], [12]	[21], [27]	125 COVID-19(+) 500 Normal 500 Pneumonia	3 COVID-19(+) Normal Pneumonia classes	Model	ACC		F1	
				COVID-Net	92.4		90	
				Bayes-SqueezeNet	98.3		98.3	
				VGG-19	93.48		-	
				MobileNet-V2	94.72		-	
				ResNet 50+SVM	-		95.52	
				DarkCOVIDNet	87.02		87.37	
				CORO NET	95		95.6	
				VGG-16	99.57		99.36	
[14]	[28]	430 COVID-19(+) 550 Normal	2 COVID-19(+) COVID-19(-)	Model	ACC	REC	F1	
				MLP	0.9400	0.8715	0.9268	
				CNN	0.9760	0.9724	0.9724	
				SVM	0.9920	1.000	0.990	
				NB	0.9400	0.9541	0.9327	
				AdaBoost	0.9600	0.9633	0.9545	
				GBDT	0.9520	0.9816	0.9469	
[15]	[21], [29]	912 images	2 COVID-19 (+ve) COVID-19 (-ve)	Model	ACC	SEN	SPE	
				CNN-Softmax	95.2	93.3	100	
				CNN-SVM	90.5	86.7	100	
				CNN-RF	81	76.5	100	
[16]	No access link (only mentioned GitHub)	No access link (only mentioned GitHub)	2 COVID-19 (+ve) COVID-19 (-ve)	Model	ACC			
				GLCN -> SVM	57.1			
[17]	Manual Data Collection through Google Forms. (text format)	Manual Data Collection through Google Forms. (text format)	2 COVID-19 (+ve) COVID-19 (-ve)	Model	Mean (%)		STD(%)	
				LR	96.667		10	
				SVM	97.78		6.67	
				DT	93.33		13.333	
				KNN	78.33		23.629	

[18]	[27]	1200 COVID-19 (+) 1345 Pneumonia 1341 Normal	3	COVID-19 Normal Pneumonia classes	Model	Class	ACC	REC	F1
					CNN	COVID-19 Pneumonia Normal	99.79 96.90 90.94	99.69 99.44 94.89	
					CNN-SVM	COVID-19 Pneumonia Normal	99.75 99.53 99.41	99.85 99.48 99.39	
[19]	[21], [26]	217 COVID-19 108 Other Diseases 112 Healthy	3	COVID-19 Healthy Other Diseases	Model	ACC	F1	MCC	
					CNN ₁	96.67	96.63	93.48	
					CNN ₂	96.73	96.67	93.74	
					SVM _{Lin}	80.79	80.21	61.98	
					SVM _{Pol}	77.90	77.24	56.30	
					SVM _{RBF}	83.45	83.86	67.39	
[20]	[21], [25]	127 COVID-19 (+ve) 127 Pneumonia (+ve) 127 healthy	3	COVID-19 Normal Pneumonia classes	Model	SEN	FPR	F1	
					AlexNet	94.86	2.56	94.85	
					GoogleNet	91.73	4.13	91.74	
					InceptionV3	90.26	4.86	90.28	
					MobileNetV2	94.46	2.76	94.46	
					ResNet18	94.26	2.86	94.25	
					ShuffleNet	65.26	17.36	58.79	
					VGG16	94.20	2.90	94.20	

Table 2: SUMMARY OF ML and DL BASED COVID-19 DIAGNOSIS IN CT IMAGES

III. METHODOLOGY

The methodology that the team has implemented consists of three **pre-trained** models, namely, **EfficientNet B3**, **ResNet50**, and **VGG16**. This methodology is slightly different from the base paper.

A. Image Preprocessing:

All the images of both the classes are resized. The images will be resized thrice. For EffNet B3, ResNet50, and VGG16, the images would be resized to 300*300*3, 512*512*3, 224*224*3 respectively.

B. Dataset Split :

The dataset will be split into 7:3 ratio i.e. into training and validation sets respectively.

C. Feature Extraction :

We used a pre-trained Convolutional Neural Network model that has been trained on Imagenet dataset, for key feature extraction from the dataset we provide. As you might have noticed the 3 models used were VGG16 which has 138M parameters and a depth of 23, Resnet 50 which has 25M parameters and EfficientNet B3 which has 12M parameters. After extracting features from the whole dataset individually, we split them into train and test sets and pass through different classifiers.

D. Classifier :

For this component, we have tested our features from all 3 Neural network models on SVM using Radial Basis Function (RBF) as a kernel in our classifier.

We train the model on the train set and finally test our model by passing the test set through the classifiers.

All three classifiers will provide us with 3 sets of results where each result in the set will be the probabilities of all possible class labels.

E. Fusion Mechanism :

We combine the three result sets by taking the average of the three results. The combined result set will have the probability of each class label for each test. This set would be our final result.

The final result will be a classification between 2 classes (Normal, COVID-19(+)).

Below is the aforementioned methodology in a Graphical representation

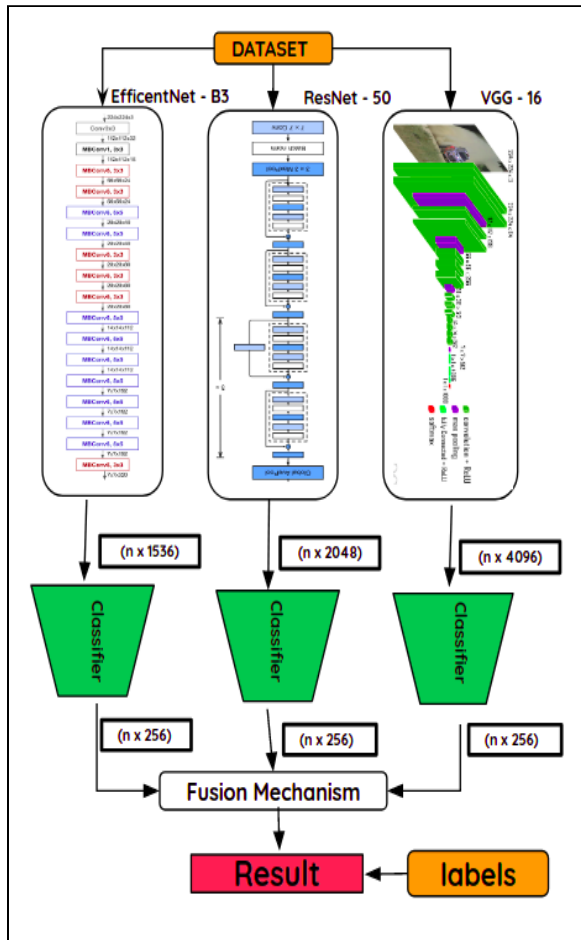


Figure 1 : Graphical Methodology.

IV. DATASET

The dataset used is the Mendeley Dataset. It contains images of two classes, namely COVID and non-COVID. There are 5500 and 4404 Non-COVID and COVID X-ray images respectively.

Class	No. of Images
Non - COVID-19	5500
COVID-19	4404

Table 3 : Dataset 2 summary

V. SOFTWARE AND HARDWARE REQUIREMENTS

Software	Hardware
Numpy	Intel i7
Pandas	18 GB RAM(Colab)
Pytorch	NVIDIA GTX(Colab)
Sklern	
Pickle	
Keras	
OpenCV	
Tensorflow	

Table 4 : Requirements

VII. RESULTS

Our initial results are obtained by testing the neural networks individually.

The final result is an agglomeration of all the predictions or commonly known as feature fusion. The vgg16 pre trained neural network model with svm classifier provides us with an approximate accuracy of 92.7%. Similarly, the resnet50 neural network model with SVM as the classifier yielded an approximate accuracy of 96.68% and EfficientNet-B3 Model provided an accuracy of 96.298%. The confusion matrix for the same is shown below:

Confusion Matrices:

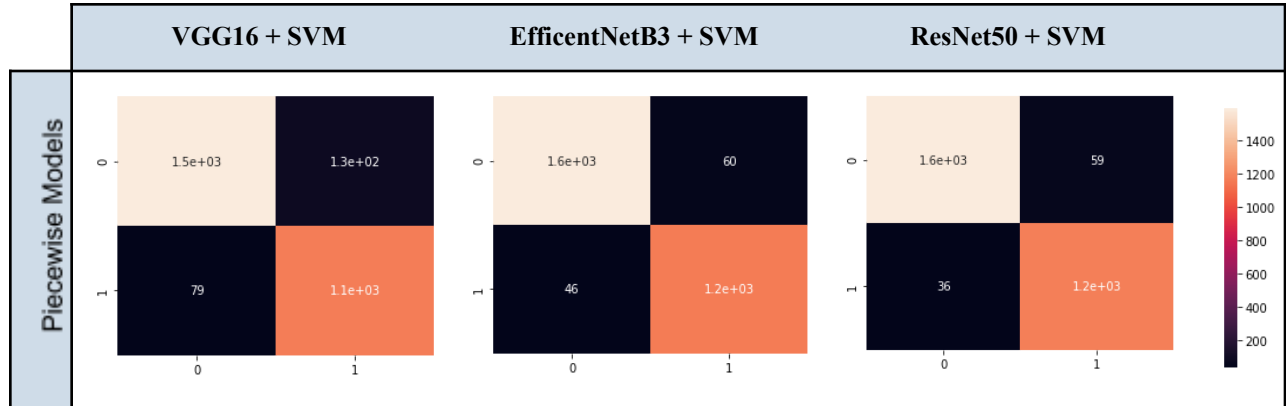
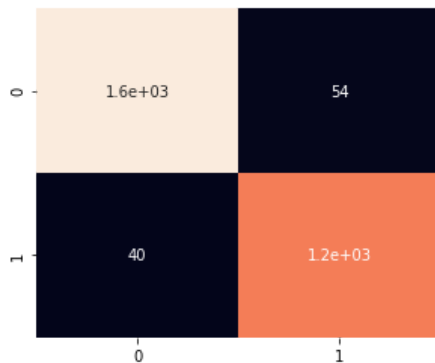


Table 5: Confusion Matrices of piecewise models.

Model	Accuracy
VGG16 + SVM _{rbf}	92.70%
Resnet50 + SVM _{rbf}	96.68%
EffcientNet-B3 + SVM _{rbf}	96.29%
After Fusion	96.71%

Table 6: Accuracy Split of Models



Final Model After Voting

VIII. GUI

The team has implemented this project on a GUI. The GUI was designed in Python using the PySimpleGUI module.

The PySimpleGUI window allows the user to browse through files and select an X-ray image of his/her choice for testing. After the selection of the image, the image is passed into the 3 models after pre-processing.

After classification, the result is displayed in the form of a table, as shown below:

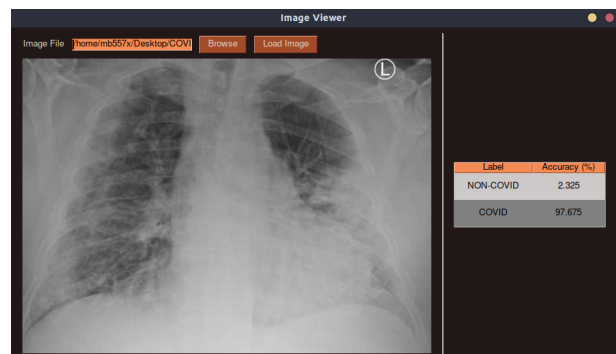


Figure II: COVID Positive X-ray.

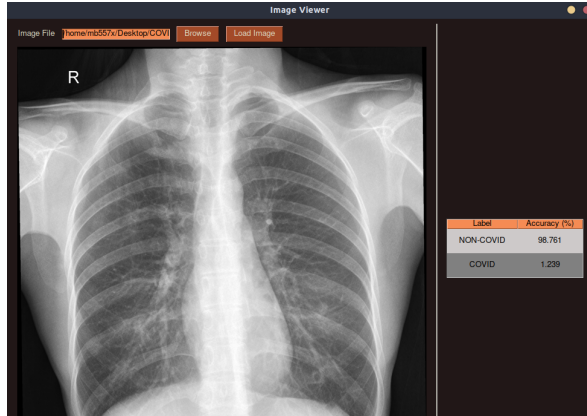


Figure III: COVID Negative X-ray.

IX. CONCLUSION

The 96.7% accuracy validates state of the art technology to accurately distinguish between covid and non covid swiftly. Since an x-ray can be taken out in a few minutes and the model can accurately identify covid individuals within a few seconds, and with the GUI developed, we could use this technology in the real world as early as possible.

X. REFERENCES

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