A HYBRID SYSTEM FOR REAL-TIME FACE MASK DETECTION

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Abstract : ***Mask is crucial for preventing spread of airborne diseases/viruses. One can protect themselves and others by wearing a mask , it's considered to be the first step form prevention to airborne diseases/viruses,Thus we aim to design a hybrid deep learning model which can detect the presence of a mask before one enters an institution, firm, shop,school etc, and in case one hasn't applied mask to his/her face, the model will be capable of detecting and distinguishing such people from those who have applied mask to their faces. Hence for this purpose we wish to use CNN with SVM-Classifier as our deep learning model provided by the keras library(most probably) in python.***

I. INTRODUCTION

With this growing world everything is developing and even the germs, bacteria and viruses are developing day by day, but with the initial and crucial steps of hygienation one can keep themselves healthy for life. And we all know how bad and crucial the period of 2019-20 was. Also, in recent times we are witnessing a major surge in COVID-19 cases. Many people lost their loved ones in that pandemic and still the issue isn't resolved properly. Sanitization and mask is the first step which can prevent us from all the types of viruses and bacteria. Not just COVID-19 but there are many airborne diseases which can be stagnated with the use of a mask. For eg:- Influenza,chickenpox,tuberculosis etc.

Thus with this vision we thought of building a tool/machine/model to help people prevent themselves from getting affected by various types of viruses and diseases. A mask is the initial prevention measure one can take. Masks not just help one to protect oneself but also the people around him/her.

We thus thought of using deep learning techniques for mask detection, which can detect application of facial masks using real time audio and video inputs. Embedding it into cctv cameras,so that mass monitoring of public places can be efficiently done in order to contain the surge and reduce the case tally of the epidemic.

If we consider a real life example one can determine a person wearing a mask by looking at their appearance and learning how a mask covers half of their face. If we look at it closely then we can notice that neurons are the key components of the human brain that carries out this complex task about which we so loosely speak. Thus we intend to use CNN as a key concept for building our model and face detection models could be helpful while building the network.

II. LITERATURE SURVEY

<table>
<tr><th>S.no</th><th>Title</th><th>Year</th><th>Methodology and Results(%)</th></tr>
<tr><td>1</td><td>A hybrid deep transfer learning model with machine learning methods for face mask detection in the era of the COVID-19 pandemic</td><td>2020</td><td>
<table>
<tr><th>Models</th><th>Results</th></tr>
<tr><td>On RMFD dataset:
● CNN with SVM
● CNN with Decision Tree
● CNN with ensemble
On SMFD dataset :
● CNN with SVM
● CNN with Decision Tree
● CNN with ensemble
On Combine Dataset:
● CNN with SVM
● CNN with Decision Tree
● CNN with ensemble</td><td>Accuracy
100%

93.44%

99.64%

99.5%

95.4%

Nan

99.53%

96.5%

Nan</td></tr>
</table>
</td></tr>
<tr><td>2</td><td>A Review on Face Mask Detection using Convolutional Neural Network</td><td>2020</td><td>
<table>
<tr><th>Models</th><th>Results</th></tr>
<tr><td>● CNN</td><td>Accuracy:-98.7%</td></tr>
</table>
</td></tr>
<tr><td>3</td><td>Implementation of Principal Component Analysis on Masked and Non-masked Face Recognition</td><td>2019</td><td>
<table>
<tr><th>Models</th><th>Results</th></tr>
<tr><td>PCA
● Masked
● Unmasked</td><td>Accuracy:
73.75%
96.83%</td></tr>
</table>
</td></tr>
<tr><td>4</td><td>Machine Learning (Convolutional Neural Networks) for Face Mask Detection in image and video</td><td>2020</td><td>
<table>
<tr><th>Models</th><th>Results</th></tr>
<tr><td>CNN(Mobilenetv2)
● 10 epoch without</td><td>Accuracy
98.97%</td></tr>
</table>
</td></tr>
</table>

			GPU • 20 epoch with 8 cores GPU	99%
5	A Novel GAN-Based Network for Unmasking of Masked Face	2019	Models	Results
			• CNN WITH GAN	Nan
6	A real time face emotion classification and recognition using CNN	2018	Models	Results
			• VIOLA-JONES ALGORITHM with • CNN(VGG16)	**Accuracy** 88%
7	Identifying Facemask-Wearing Condition Using Image Super-Resolution with Classification Network to Prevent COVID-19	2020	Models	Results
			• Simple Srcnet • Srcnet without sr network • Srcnet without transfer learning • ProposedSRCNet without transfer learning or SR network,	**Accuracy** 98.70% 98.17% 98.91% 97.39%
8	Multi-Stage CNN Architecture for Face Mask Detection	2020	Models	Results
			1. Face Detector :- Dlib Hog MTCNN(Haar Cascading with three stage CNN) Retina Face 2. Face Mask Classifier ROI CNN(Transferred Learning)	Model **1.MobileNetV2** Accuracy :- 99.23 F1 Score:-99.12 Recall:-99.12 Precision:-99.12 **2. DenseNet121** Accuracy :- 99.49 F1 Score:-99.40

			MobileNetv2 DenseNet121 NASNet	Recall:-99.12 Precision:-99.70 **3.NASNetMobile** Accuracy :- 99.23 F1 Score:-100 Recall:-99.13 Precision:-99.28
9	Face Mask Detection using Transfer Learning of InceptionV3	2020	Deep Transfer Learning Using InceptionV3 CNN	Performance Metrics Training / Testing Accuracy 99.92% / 100% Precision 99.9% / 100% Specificity 99.9% / 100%
10	Glasses Removal from Facial Image Using Recursive Error Compensation	2005	Recursive PCA Reconstruction	Nan
11	Pynq-YOLO-Net: An Embedded Quantized Convolutional Neural Network for Face Mask Detection in COVID-19 Pandemic Era	2020	1) Train a large dataset on Yolo with CNN. 2) Optimize output using pruning and quantization. 3) Retrain using Yolo with CNN. 4) Implement on PYNQ Z1 board.	1) Accuracy = 97.00% 2) Precision = 94.60% 3) Recall = 95.80%
12	Detecting Masked Faces in the Wild with LLE-CNNs	2017	Proposal Module: 1) PNet-CNN 2) VGGFace CNN Embedding Module:	Average Precision: 76.40% Outperforms other models all facial orientation categories

			1) Locally Linear Embedding (LLE) algorithm 2) Dictionaries Verification Module: 2) FC layer of CNN	
13	System for Medical Mask Detection in the Operating Room ThroughFacial Attributes	2015	Models	Results
			1.1. Face Detector Module: Viola and Jones Algorithm with AdaBoost **1.2.** Mask Detector Module: Viola and Jones Algorithm with LightBoost **2.** Images converted to HSV colour model **3.** Cascaded Decision Tree Classifier	1) True Positive: 95.00% 2) False Positive: 5.00%
14	Validating the Correct Wearing of Protection Mask by Taking a Selfie: Design of a Mobile Application “CheckYourMask” to Limit the Spread of COVID-19	2020	Models	Results
			Haar-like feature descriptors are used to detect key features of the face and a decision-making algorithm is applied	Face Detection: 1) 99% True detection 2) 8% False Detection Nose Detection: 1) 100% True Detection 2) 29% False Detection
15	Identifying Facemask-Wearing Condition Using Image Super-Resolution with Classification Network to Prevent COVID-19	2020	Models	Results
			1) Uses CNN for face isolation from image 2) Isolated Face image is passed to SRC-Net for facemask-wearing condition detection	1) Accuracy - 98.70% 2) PNSR - 29.1508 3) SSIM - 0.939 Outperformed traditional methods by 1.5% Kappa
16	Real-Time Facemask Recognition with	2020	Models	Results

	Alarm System using Deep Learning		Implements VGG-16 CNN Model	Accuracy: 96.00%Batch Size: 64 Iterations: 100
17	Face Detection and Segmentation Based on ImprovedMask R-CNN	2020	Models	Results
			1) Uses Res-Net-101 2) Uses G-Mask RCNN	Runtimes on Datasets: 1) FDDB = 0.30 2) AFW = 0.32 3) Choke Point = 0.28 Precision: 95.97%
18	An autonomous system to limit Covid-19 using facial mask detection in Smart City Network	2020	Models	Results
			1) Uses CNN 2) Requires CCTV	1) Accuracy: 98.70% 2) AUC: 0.985, on test images
19	RETINAMASK: A FACEMASK DETECTOR	2020	Models	Results
			1) Uses Res-Net and Mobile-Net as backbone 2) Feature Pyramidal Network as Neck 3) Context Attention Module as Head	The proposed method achieves state-of-the-art results on a public face mask dataset, where we are 2.3% and 1.5% higher than the baseline[23] result in the face and mask detection precision respectively, and 11.0% and 5.9% higher than baseline for recall.
20.	A real time DNN-based face mask detection system using single shot multibox detector and MobileNetV2	2020	Models	Results
			1) Uses SSMD-ResNet10 2) Uses MobileNetV2	1) Accuracy score: 0.9264 2) F1 score: 0.93

III. PROBLEM STATEMENT AND OBJECTIVE

Our problem statement involves real time face mask detection for covid spread prevention measures specifically but it has a vision for other diseases as well. Mask is crucial from prevention to airborne diseases or viruses. These diseases/viruses could lead to the death of a person. Spreading which can lead to a pandemic and as we know how novel coronavirus led to pandemic in 2020.

Our team's objective is to let automation do the work of monitoring the masses and less human interaction between people can be observed in public places and social-distancing norms can be administered effectively, from prevention of spreading diseases/viruses. Which we aim to attain by the use of cameras and CNN with SVM as our deep learning tool. Here we aim to use SVM as a final classifier, which can effectively reduce the requirement of processing resources and increase efficiency.

IV. MOTIVATION

As we know, in current times the world is under a constant threat of coronavirus and it's reemergence(which now is the case). Thus, there is a need for researching and developing methods that can cure, detect and prevent humankind effectively from the coronavirus and the subsequent pandemic caused by it. As students of a government funded institute we feel this as our responsibility to help prevent spread of coronavirus with help of technology(preferably CNN with SVMC) and an apt opportunity to hone our skills in this domain.

Besides coronavirus it can also help prevent spread of airborne diseases, like, influenza, common cold, chicken-pox, etc., in some disease exposed areas preventing sudden outburst of cases. It can also help in surveillance and monitoring.

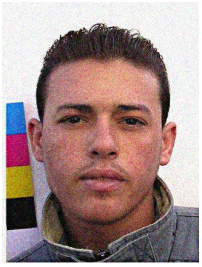
So the basic basic idea is as follows, a room fitted with a camera on some height with the ability to view the entire room. So with the help of a camera the proposed model finds if the person is wearing a mask or not. If the person is not wearing a mask then a siren alarms the security or the required personnel who may deal as per their protocol. Thus, it will considerably reduce human effort and at the same time help in preventing the spread effectively.

V. DATASET DESCRIPTION

- We have tentatively decided to use Kaggle Face Mask Detection Dataset by Omkar Gurav.
- It contains 7553 images of people with or without facial masks. It basically contains two folders named, with_mask and without_mask.
- Link: https://www.kaggle.com/omkargurav/face-mask-dataset
- Access Date: 09/02/2021
- This dataset contains sharp images with proper resolution sufficient for the task at hand.

Mask

WithoutMask:



VI. PROPOSED METHODOLOGY

A. ImageProcessing :

For building the proposed system we intend to do some image preprocessing on the dataset used to improve the results, i.e., increase accuracy, decrease loss or improve upon any other benchmark desired. The image pre-processing consists of three steps, namely:

1. Resizing the input image to a (100, 100) matrix
2. Grayscaling the images
3. Dumping the images as pickle files

There are a total of two files dumped as pickle, namely, resized_image and labels.

B. Dataset Split:

After pre-processing the second part consists of splitting the dataset used in two parts for training and testing purposes. An ideal train-test split falls between 60%-80% for training and the rest for testing. However, the splitting criterion differs for different studies we observed in our literature survey. Firstly, the dataset is randomly shuffled. Then, we have decided to use 80%-20% split for training and testing respectively.

C. Feature Extraction Using CNN :

We've used a self built CNN model which consists of three layers. There might be a question: why not a pre-trained CNN that is used for the purpose ? We intend to go with this self built model in order to have more controls on our features and thus lower the execution time by suppressing unwanted features.We took help of keras inbuilt python library in order to create our CNN model , We've Defined our model in the following manner :-

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 98, 98, 200)       2000
_________________________________________________________________
activation (Activation)      (None, 98, 98, 200)       0
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 49, 49, 200)       0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 47, 47, 100)       180100
_________________________________________________________________
activation_1 (Activation)    (None, 47, 47, 100)       0
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 23, 23, 100)       0
_________________________________________________________________
flatten (Flatten)            (None, 52900)             0
```

Thus the layers of the model is defined as follow:

1. Layer1 has a convolution layer followed by a 'Relu' Activation function and a max pooling
2. Layer2 has the same configuration but with reduced input size resulting in further reduction in size .
3. Third layer is nothing but a flatten to get the features.

Thus this gives out a numpy array with N number of objects and 52900 features but as we don't require such a greater number of features we do dimensionality reduction in our next step. **(1376,52900)** is the Output shape yield after this step .

D. Dimensionality Reduction:

In the above process we have used the designed CNN to extract features, weights and biases. We have gathered a total of

52900 features per input image. That is however a lot of features, we may require to scale them down. So, we then fed extracted features to PCA which extracts 256 principal features from the set of 52900. Thus we reduced dimensionality from **(1376,52900)** to **(1376,256).** The gathered 256 principal features are then fed to SVM for classification in the next part.

E. Classifier:

We've used SVM as our classifier for training and testing the data along with rbf kernel and c = 1.0 as the default values. We choose Svm because of its robustness and accuracy . We took help of the sklearn library for this purpose which has svm defined in it. Input at this step is **(1376,256)** and using this we've achieved remarkable results on our dataset .

VII. TOOLS USED

We have used **Python** for the implementation purposes.

We have further used various other tools, such as,

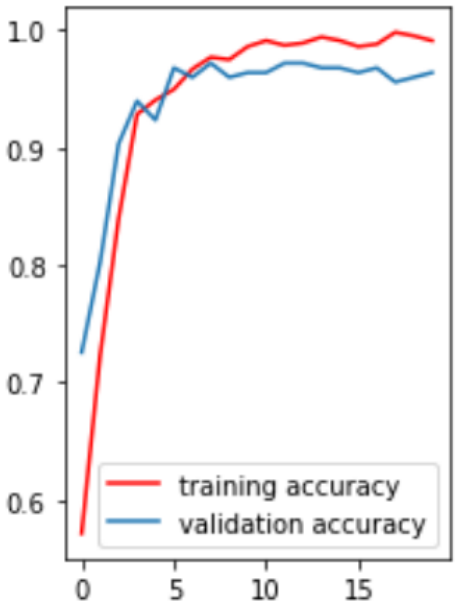
- Anaconda IDE
- Jupyter Notebook

We have further used various python libraries, like,

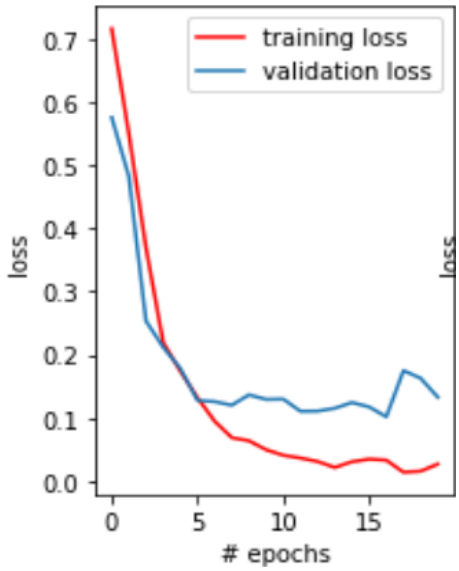
- Numpy
- Matplotlib
- Keras
- Sklearn
- OpenCV

VIII. RESULTS

We've used Adam optimizer for gradient descent/Backward propagation, And model used was sequential for this purpose .
CNN model Training Accuracy plot :
X-Axis :- Epoch
y-Axis:-Loss



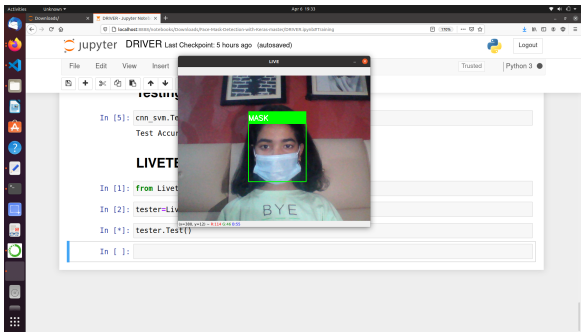
CNN model Training Mse loss plot :
X-Axis :- Epoch
y-Axis:-Loss



Accuracy we achieved while Testing with classifier (SVM) was **96% on Test Set.**

Live Demonstration :-

We've used Opencv and haar cascading templates for face detection and mask recognition.



IX. CONCLUSION

This project enlightens the need of a mask in our day to day life and heavily emphasizes on wearing a mask, Global pandemic is still on us and we need to fight it back, where a system like this can turn the table around in this global pandemic. We were determined to get our work right with this project as this system is an asset to fight covid back by recalling one to wear a mask before entering a public place. This system has potential to be embedded into other systems like cctv or raspberry pi chip with external cameras. Not just costly or highly authorized places can use this system, but people with small businesses, shopkeepers, vendors etc can get benefitted as well. Last but not the least "Save a life wear a mask".

X. REFERENCES

XI.

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