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Face Mask Detection using Machine Learning and Deep Learning

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Abstract - *The world was introduced to the term Corona Virus at the very end of 2019, following which everyone was thrown into stress and anxiety of what this deadly virus was capable of and how long before it reached them. Since then, the doctors have been trying to find a cure relentlessly. But it was only a matter of a few weeks when they realized that they were not against some typical virus, but a highly contagious deadly disease which was spreading across thousands of people every day all around the globe. A state of emergency was declared everywhere, and wearing face masks was made a must for people to move out of their homes. Everyone was prone to the virus, irrespective of how they stood in the society. The policemen were on the roads, trying to deal with any situation that could arise to boost the spread of the virus. But there is only a little you can do when the world is suffering from a Global Pandemic. Amidst all the chaos, the only weapon which was useful at the moment was technology. If people could be monitored via CCTV cameras and an algorithm was developed to identify those without masks for the authorities to take action, it could have saved thousands from suffering, considering how fast the virus spreads among the crowds. It is possible using deep learning, and we just came up with that.*

Key Words: **Machine Learning, Deep Learning, OpenCV, Tensorflow, Keras, MobileNetV2.**

1. INTRODUCTION

Corona Virus was originated in Wuhan, China at the end of 2019. Since then, it has been spreading like a wild fire in a forest. Millions have been affected and around 1,799,505[10] have unfortunately passed away as on 30th of December 2020, almost a year since this virus came to existence. People who have this illness can take up to 2 weeks to cure, with the risk of having to suffer additional medical problems caused by it. Children and old people have proved to be at the highest risk to contract the disease, which may even result in death. Hence, it has been made a priority to contain the virus than to cure it. The virus spreads through the air, transmitted by one person to another not only by touch, but also by speaking and coughing. The concern was put forward to WHO(World Health Organization) which suggested that face masks and social distancing is the answer to it, until a cure is invented. Putting a face mask on can reduce the risk of getting infected by a great extent, not only to the one wearing it but also to the others that he comes in contact with. Wearing masks every time we go out is something we can do with little effort that can effectively save lives, and that is precisely why it is in so much demand at this point of time.

In this paper, we propose a Face Mask Detection project that consists of 2 phases, namely training and deployment. The first stage detects human faces, while the second stage uses deep learning to firstly, identify the ROI(Region Of Interest) being the person's face and secondly identify the faces detected in the first stage as either 'With Mask' or 'Without Mask' and draws boundary of colors either green or red, depending on the output. The project takes JPG and PNG files as inputs, but it has also been tested on videos. The project can give accurate results if set up with a CCTV camera to track people without masks to ensure the safety and wellbeing of others, thus help controlling the spread of the virus.

2. BACKGROUND OF THE STUDY

2.1 Machine Learning

Machine Learning or ML is a study of computer algorithms that learns and enhance automatically through experience. It seems to be a subset of artificial intelligence. A machine learning algorithm builds a mathematical model based on "training data", in order to make decisions or predictions without being explicitly programmed to do so.

Machine learning algorithms are used in a variety of applications from email filtering to computer recognition, where it is difficult or impossible to develop general skills to perform the required tasks. These studies are closely related to computer statistics, which focus on computer-generated domain. The data prediction and mining is a coherent field of study, focusing on the analysis of experimental data by unsupervised learning. In its application to business problems, machine learning is also called predictive analytics.

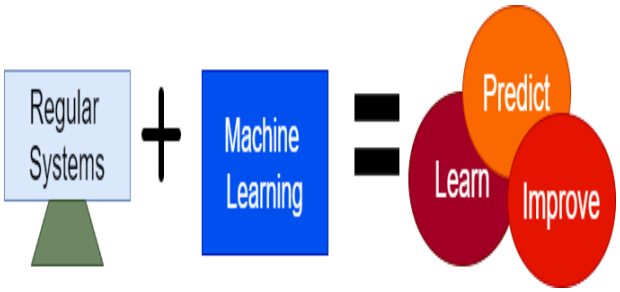

Fig-1- Machine Learning Process

2.2 Deep Learning

Deep learning methods aim to learn feature hierarchies with a high-level hierarchy which is structured by the construction of lower-level features. Automated learning at multiple levels of extraction allows a system to learn complex tasks to do input mapping directly from data to output, without relying entirely on man-made features. Deep learning algorithms capture unspecified structure inside the input distribution to find better characterization frequently at multiple levels, with high-level learning features in the context of low-level features.

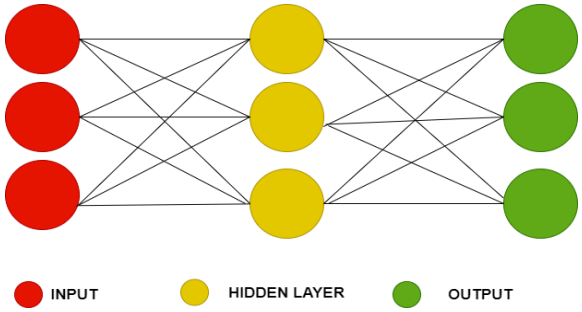

Fig. 2 – Deep Learning

Inputs and outputs are in-depth study of the analog Excel problem domain. Meaning, they are not some size in table format, but they are pixel data, text data documents or data from audio files. Deep learning empower logical and mathematical models to find representations of data with numerous levels of abstraction, multiple processing layers.

2.3 OpenCV

OpenCV is a library which is use to develop computer based real-time applications. It majorly focuses on analysis including features like image processing, video capture and object detection and face detection.

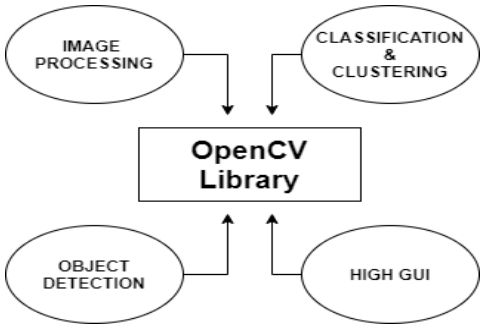

Fig-3- OpenCV

We use the OpenCV library to execute infinite loops using our webcam, which detects faces using cascade classifications. The library has over 2000 optimized and advance algorithms for computer vision based machine learning. These algorithms can be used for face detection and recognition, object detection, classifying human movements in video, tracking camera actions, tracking objects, taking 3D objects, adaptive thresholding and assembling together to produce high resolution image. It can also be useful in finding similar images from the database, removal of red eyes from photos taken with flash, follow the facial movements, and add tags to transition with advanced reality. It is continuously adding new modules to the latest algorithms from machine learning.

2.4 Tensorflow

Tensor Flow is a standalone and open-source software library for Dataflow for a variety of tasks and a wide variety of programming. It is also used for machine learning applications such as the Symbolic Mathematics Library, and Neural Networks. TensorFlow is a great system for handling all aspects of a machine learning system. However, this class focuses on using the unique Tensor Flow API to train and deploy machine learning models.

We used TensorFlow and Keras to train the classifier to automatically identify if a person is wearing a mask. Since reference implementation runs on single devices, TensorFlow is able to runs on multiple Processing Units and GPUs having extensions regarding general use.

2.5 Keras

Keras is an API for high level neural networking. It follows best practices to reduce the major burden and provides consistent and flexible APIs that reduce the number of user actions required for normal usage situations and provide clear and actionable error messages. It is written in Python programming language and has a large developer community and support.

Keras includes several implementations of commonly used neural-network architecture, such as hosting devices to simplify the coding required to write layers, targets, optimizers, activation tasks, and an intensive neural network. It make easy to work with image and text data. The Keras models are easily deployable among various platforms.

2.5 MobileNet V2

MobileNet is a Convolution Neural Network architecture model for various categorical classification and object detection work. This architecture is easily executable on mobile devices with a high rate of accuracy when compare to other light weighted CNN architectures. Also, it is ideal for mobile devices that do not have GPUs and highly embedded computational efficiency. It is significantly faster and accurate on results. It is also well suited for web or browsers as the browser has limitations on computing, graphic processing and storage.

We have used the MobileNetV2 architecture, for it computational efficiency, making it easy to set up models for embedded systems (Raspberry Pi, Google Corel, Jetson, Nano, etc.).

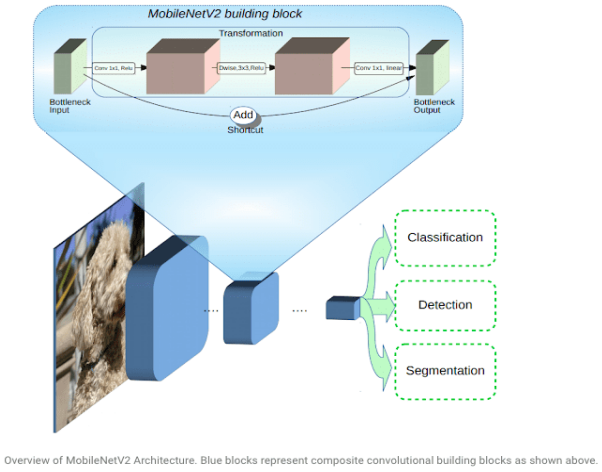

Fig-4- MobileNet V2 architecture

3. METHODOLOGY

This proposed model focuses on identifying face mask in a person through an image or video stream with the help of Deep Learning and Machine Learning using Keras, TensorFlow, OpenCV and the Scikit-Learn library. We have designed our model in two phases:

1. Training (Training the model on the dataset using Tensorflow & Keras)

2. Deployment (Loading the trained model and applying detector over images/live video stream)

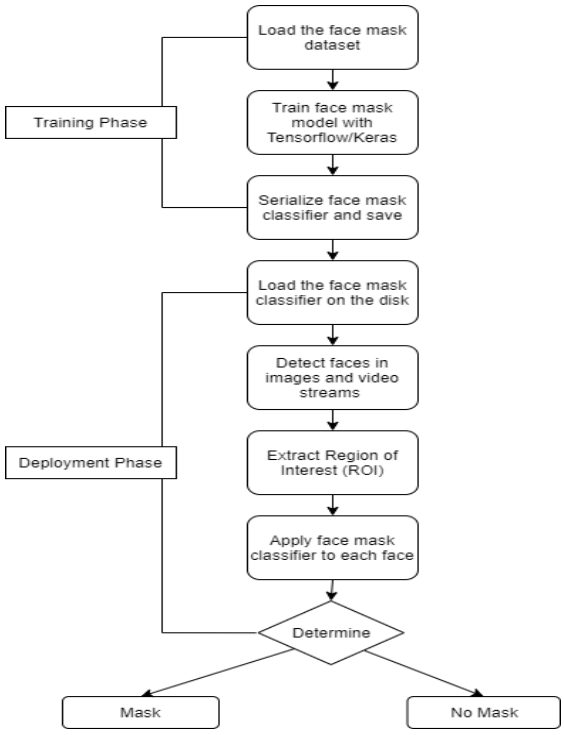

Fig- 5 Flowchart showing the training and deployment phase.

The above figure depicts the training and deployment phases of our face detection model.

The dataset is loaded first in the training phase. Training and modeling are streamlined during the training phase. After serializing face mask classifier to the disk, model is loaded to detect the face mask on the images or real-time video.

The model will calculate the ROI (Region of Interest) for the determination. We then compute bounding box value for a particular face and ensure that the box falls within the boundaries of the image. We then determine the class label based on predictions returned by the mask detector model and colors are assigned for interpretation. The "Green" will be for with mask and "Red" will be for without mask. Once all detection is executed we will display the output.

We have used MobileNetV2 architecture which is a accurate and efficient and can be applied to embedded devices. We have specified the constants i.e. Initial Learning rate to be 1e-4, batch size to be 32 and no of epochs to train the model as 20. After preprocessing, the input images are resized as 224 x 224 x 3 pixels and then compiled and evaluated on the test set. Face detection is similar to what was discussed earlier. A special frame is held in place by a stream and re-shaped. Then the face mask detection is processed . The results are displayed on the screen after post processing.

4. RESULTS

We have taken a total of 3847 images in our Face Mask Detection Dataset belonging to two labels i.e. with mask: 1917 images and without mask: 1930 images.

Fig-6 Some images of with mask dataset

Fig-7 Some images of without mask dataset

Evaluation Table for trained model

	Precision	Recall	F1-Score	Support
With mask	0.99	0.93	0.94	134
Without mask	0.99	0.96	0.94	134

Accuracy			0.98	274
Macro Avg.	0.98	0.98	0.98	274
Weighted Avg	0.98	0.08	0.98	274

As we can see the accuracy obtained by our trained face mask detector model is **~98%.**

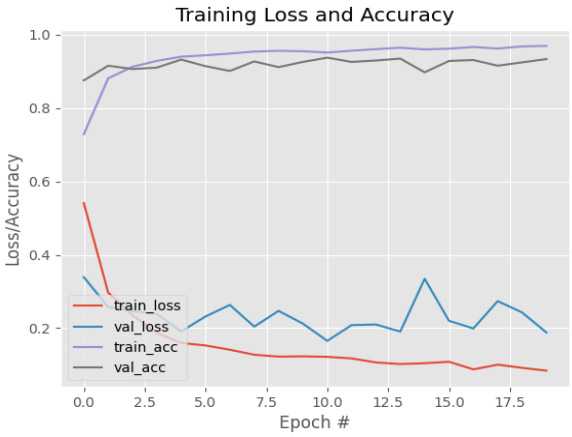

Fig-8 Accuracy/Loss Plot

Test Outputs

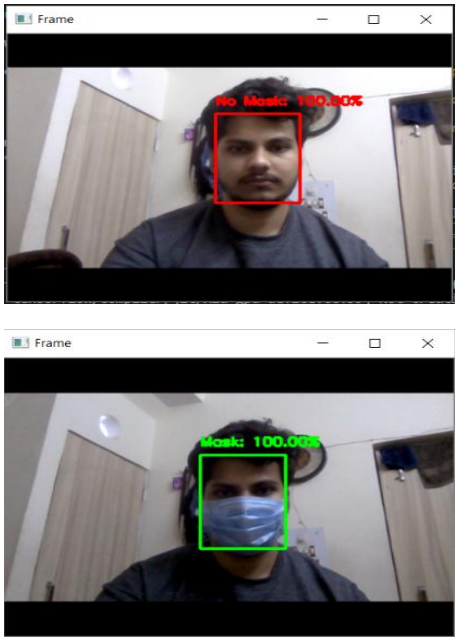

Fig- 9 Output of Face Mask Detector in Real time video stream

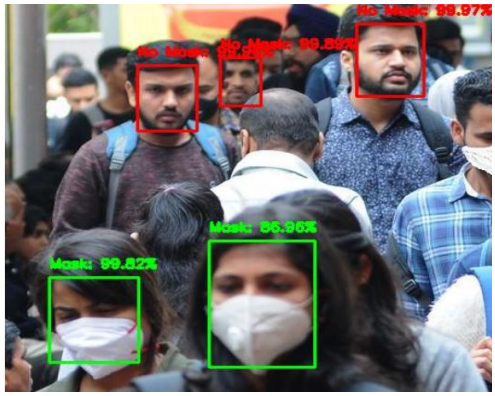

Fig-10 Output of Face Mask Detector in Uploaded Image

5. CONCLUSIONS

We created a face mask detector using Deep Learning, Keras, Tensorflow and OpenCV. We trained it to distinguish between people wearing mask and people not wearing a mask We have used MobileNet V2 classifier with the ADAM optimizer for the best result.

The model is tested with photos and real-time video streams. It detected the face from the images/videos and extracts each individual's face and apply the face mask classifier to it.

Since, we have used the MobileNet V2 architecture we can easily deploy our model to the embedded systems such as Raspberry Pi, Jetson, Google Coral, Nano etc. This can help be very helpful for the society and can possibly contribute to the public healthcare

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