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Comparative Analysis of Object Detection Algorithms for Face Mask Detection

Rohan Kanotra, Akash, Neelendu Wadhwa, N. Jeyanthi

Abstract: ***COVID-19 has made mankind see unprecedented and unbelievable times with millions of people being affected due to it. Multiple countries have started vaccinating their populations in the hope that it will end the pandemic. Given the inequitable access to vaccines across the world and the highly mutating coronavirus it remains to be seen when will everyone get access to vaccines and how effective the vaccines might prove over the virus variants. Therefore, standard COVID behaviour is here to stay for some time. Wearing face masks is one such etiquette which greatly reduces risk of getting infected. Employing public face mask detection systems has helped multiple countries to bring the pandemic under control. In this paper we have done a quantitative analysis of different object detection algorithms namely ResNet,MobileNetV2 and CNN on face mask detection on accuracy and recall parameters using an unbiased, large and diverse dataset in order the algorithm which can be applied on a mass scale.***

Keywords*:* ***COVID, Coronavirus, Pandemic, Object Detection, Res Net, MobileNetV2, CNN***

I. INTRODUCTION

COVID-19 is the disease caused by a new coronavirus called SARS-CoV-2. The disease is highly contagious and can spread from person to person through small droplets from the nose or mouth when a healthy person inhales the droplets from a COVID infected person. Wearing face masks greatly reduces the spread of infection. Japan the country with world's oldest population which are most susceptible towards the virus was able to control the pandemic through the mask culture prevalent in the country for many years now. However general public have not adhered to wearing face masks in many countries despite government guidelines. Once the worst affected COVID-19 hit country China was able to successfully combat COVID-19 due to deployment of public face mask detection systems which helped it identify people not wearing masks and penalise them. Object detection is a technology that deals with detecting and locating instances of semantic objects of a certain class like humans, buildings etc. in digital images and videos.

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*Correspondence Author

Rohan Kanotra*, Member of Technical Staff-1, VMWare, Bangalore, India.

Akash, Analyst, BlackRock, Bangalore, India

Neelendu Wadhwa, Intern, Octonius, India

Dr. N. Jeyanthi, Associate Professor Senior, School of Information Technology and Engineering, VIT, Vellore, India.

CNN, YOLO, SSD are some examples of object detection algorithms. Object detection algorithms when applied for face mask detection purpose can help in differentiate masked faces from the unmasked ones with high accuracy. Object detection algorithms can also differentiate properly masked faces which have nose and the mouth fully covered from improperly masked ones on a large scale. Given the deadly nature of the coronavirus the need of the hour is to employ the best possible object detection algorithm for face mask detection on a large scale. Through our research we plan to do a comparative analysis of object detection algorithms for face mask detection using quantitative parameters like precision and recall so as to find the most efficient algorithm among them. We have chosen three most commonly used algorithms for face mask detection in our study namely ResNet, MobileNetV2 and CNN. Given the dearth of research in comparative analysis of algorithms our research can be highly beneficial to help bring the pandemic under control. We have used an unbiased, random and large dataset of images for training purposes to improve the accuracy of our results.

II. LITERATURE SURVEY

Mohammed L. et al [1] presented a hybrid model using deep and classical machine learning for face mask detection consisting of two components one of which is designed for feature extraction using Resnet50 while the other is designed for the classification process of face masks using decision trees, Support Vector Machine (SVM), and ensemble algorithm. Mundial I. et al [2] presented a methodology that can enhance existing facial recognition technology capabilities with masked faces using a supervised learning approach to recognize masked faces together with in-depth neural network-based facial features. Ahmed A. et al [3] propose a detector which employs SSD for face detection and a neural network to detect presence of a face mask. The implementation of the algorithm is on images, videos and live video streams. Shantaiya. S et al in [4] have demonstrated the different object detection approaches currently used. Object detection approaches are based on feature, colour, template, classifier and motion. Feature based object detection is not effective for multiple objects while it is difficult to locate reappearing objects in template-based object detection.

Mohammed L. et al [5] have displayed the findings of their developed model for face mask detection. The first component is designed for the feature extraction process based on the ResNet-50 deep transfer learning model.

While the second component is designed for the detection of medical face masks based on YOLO v2. Chavda A. et al [6] have introduced a Deep Learning based system that can detect instances where face masks are not used properly. The first stage uses a pretrained RetinaFace model for robust face detection. The second stage involved training three different lightweight Face Mask Classifier models. Chowdhary G. et al [7] proposed a transfer learning model to automate the process of identifying the people who are not wearing mask

which is built by fine-tuning the pre-trained state-of-the-art deep learning model, InceptionV3. Vinitha. V and Velantina. V in [8] have used a hybrid model using deep and classical machine learning for face mask detection on real time video stream using OpenCV, TensorFlow, Keras and MobileNetV2 deep learning model to train the algorithm.

Inamdar M. and Mehendale N. in [9] have proposed a deep learning-based object detection algorithm called Facemask Net using this deep learning method called Facemasknet. Adithya K. and Jismi B. in [10] have demonstrated the effectiveness of using CNN for face mask detection purposes. Nagrath P. et al in their research in [11] have used Single Shot Multi-Box Detector as a face detector and MobilenetV2 architecture as a framework for the face mask detection.

Shiming G. et al in [12] have done an extensive study on face mask detection by proposing a method called LLE-CNN's for masked face detection consisting of three major modules. Two pre-trained CNNs are combined to extract candidate facial regions. Jiang M. et al propose a one stage detector called RetinaFaceMask in [13] which consists of a feature pyramid network to fuse high-level semantic information with multiple feature maps and novel context attention module to focus on detecting face masks.Rahman M. et al [14] proposed a CNN based face mask detection system which is trained on images obtained from closed circuit cameras.Sammy V. et al [15] used deep learning techniques in distinguishing whether the person is wearing a mask or not on a large dataset which contains 25000 images. The architecture developed a Raspberry Pi- based real-time facemask alarming the person if detects no face mask.Yuzhen C. et al[16] proposed a novel face mask detection service based on mobile phone. The first step extracted four features from the GLCM's of the face mask's micro-photos. The next stage comprises a three-result detection system accompanied by using KNN algorithm.

Changjin L. et al [17] have improved on the existing YOLOv3 object detection algorithm by using multi-scale training. Nuanmeesri S. et al [18] used IoT devices to develop novel face mask detection and warning system which has HAAR like features and cascade classify training techniques. Goswami K. and Sowjanya A. in [19] have used MobileNetV2 classifier in order to build a real time system to perform face mask detection. Sen S. and Patidar H. et al [20] present a mask detection system that is able to detect any type of mask and masks of different shapes from the video streams. Pytorch python library had been used for data pre-processing. MobileNetV2 for training the model.

Ref. No.	Author	Methodology used	Efficiency	Challenges faced
[1]	Mohammed L.	A hybrid model using deep learning and classical machine learning is used in which feature extraction is sone through Restnet50 and the classification is done through support vector machine.	An overall accuracy of 99.64% was attained.	The implementation detected face masks in low light intensity with less efficiency.
[2]	Mundial I.	Facial recognition is enhanced using deep learning models and SVM is used state-of-the-art Facial Recognition Feature vector on a dataset with masked faces.	An accuracy of 97% was achieved.	Face masks were detected with less accuracy is less lit areas.
[3]	Ahmed A	A detector was proposed with uses SSD for face detection and neural network to detect face masks.	The implementation is having 100% precision and 99 & accuracy	The dataset didn't comprise of images in areas which are poorly lit.
[9]	Inamdar M. and Mehendale N	Face Masks were detected using deep learning methodology called Facemask Net.	98.6% accuracy was achieved.	Making the system robust to detect face masks in din light was not included.
[16]	Yuzhen C.	KNN Is used to detect face masks.	An overall accuracy of 83% was attained.	This detection is done using mobile phone, and might have been a little difficult to promote that on a large scale.
[17]	Changjin L	YoloV3 is used for detecting face masks.	An overall accuracy of 86.3% is attained.	The dataset was labelled manually which is a tedious job to do.
[20]	Sen S. and Patidar H	Presented a mask detection system that is able to detect any type of mask and masks of different shapes from the video streams. The system uses Pytorch python library for data pre-processing and MobileNetV2 for training the model.	The accuracy for the training and validation set is compared and found to be of 79.24 %	Feature based object detection is not effective for multiple objects. With classifier-based approach the object boundaries are not always perfectly located and achieved low efficiency.

III. IMPLEMENTATION

A comparative analysis has been done to depict which method is best suited for detecting if a person is wearing a mask or not in different intensities of surrounding light. Analysis is done by using OpenCV, MobileNetV2 and CNN. A single dataset is used in all the different approaches of analysis to eschew from any sort of bias towards any approach. Dataset is chosen from Kaggle which consists of over 4000 images of people with and without masks in different areas with varying light intensity. Firstly, Data Visualization is done to categorize the images into YES (people wearing mask) and NO (people not wearing masks),then data is augmented to include a greater number of images for our training. The images are rotated and flipped to enhance the dataset.

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Pre-processing steps as mentioned below were applied to all the images to convert the raw images into clearer ones, which can be fed to the models.

1. Resizing of the image.
2. Applying color filtering.
3. Scaling and normalizing of images.
4. Center cropping of images.
5. Finally converting them into tensors.

Data is split into training set(80%) which will contain the images through which the models will be trained, and testing set(20%) on which the models will be tested. To implement the algorithms TensorFlow has been used as a Deep Learning Framework. Sequential CNN model is built using various layers such as Conv2D, MaxPooling2D, Flatten, Dropout and dense. In the dense layer the SoftMax function is applied to get the probability of the person either wearing a mask or not.

1. CNN

The layers of the sequential CNN model built using keras framework include 4 Conv2D layers followed by MaxPooling2D layers. ReLu activation function has been used. SoftMax layer is used to get the probability of person either wearing mask or not. Binary cross entropy is used as the loss function.

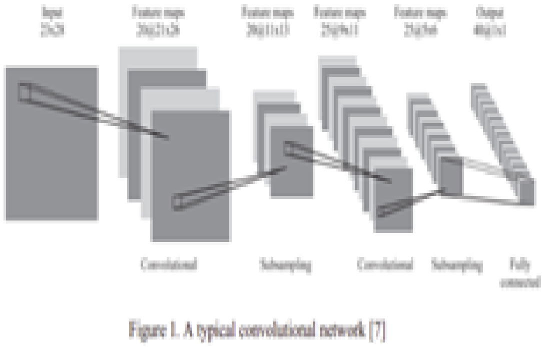

Fig.1. CNN Architecture

2. ResNet SSD

Weights from ResNet SSD model were used for face detection and facial landmark detection from OpenCV was used along with passing the output from the facial landmark detection to the model for classifying the image into with mask as well as without mask. Fully connected layers were appended to the base model and model was trained with the dataset of with mask and without mask images and fine tuning was done. Facial Landmark detection was done to augment the database of the images.

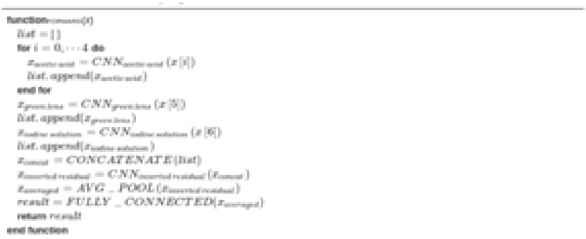

Fig.2. ResNet SSD Pseudocode

3. MobileNetV2

HAAR Cascade was used for face detection and weights of pre trained MobileNetV2 model were used to predict whether the image was with mask or without a mask. Face frames were extracted from the image using HAAR cascade and were used as an input to the trained MobileNetV2 model which predicted the probability of a mask in the image and a probability value along with a bounding box was appended to the output image in the area where the mask was present.

```
Algorithm 1 Object removal cross classes
Require: selected face: D'_f, C'_f; selected mask D'_m, C'_m
  for p_f in predictive face detection D'_f do
    for p_m in predictive mask detection D'_m do
      if IoU(p_f, p_m) > thresh then
        remove the object of lower confidence
      end if
    end for
  end for
```

Fig.3. MobileNetV2 Pseudo Code

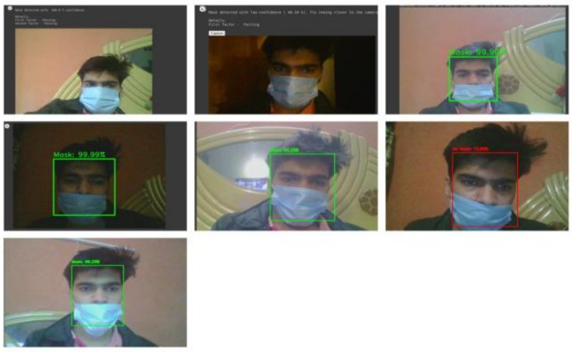

Fig.4. (a) Mask Detection on Image Dataset with images labelled from left to right. (b) Custom CNN well lit. (c) Custom CNN low lighting (d) MobileNet well-lit (e) MobileNet low lighting (f) ResNet SSD well lit (g) ResNet SSD in low light (h) ResNet SSD in slightly poor lighting.

IV. DISCUSSION

The performance of MobileNet , ResNet SSD and Custom CNN models was compared in order to assess which model performs better in both low light as well as well lit conditions and it was found that MobileNet achieved higher confidence values than both the other models in both poorly lit as well as well lit conditions. The confidence values achieved by the respective models along with the recall values are depicted in the graphs given below. Recall values achieved by the MobileNet model are higher than the recall values of the custom CNN model and ResNet SSD model by 8.2 % and 3.9% respectively.

Fig.5. Confidence Values Graph

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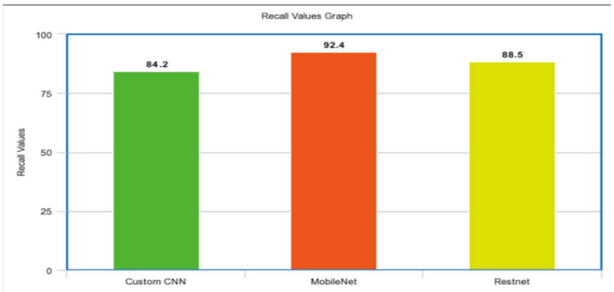

Fig.6. Recall Values Graph

V. CONCLUSION

In this paper , we have done a comparative analysis of three algorithms for mask detection. We have done a comparative analysis of MobileNet , ResNet SSD and Custom CNN model used for mask detection.We have done a comparative analysis of the confidence values obtained on testing the images from the dataset with the models and it was found that MobileNet model was able to classify the images with the highest degree of precision in low light as well as well lit conditions with confidence values of 99% while Custom CNN model was the second best model for well lit conditions and ResNet SSD model was the second best in poorly lit conditions. Haar Cascade from Open CV was used for facial feature extraction and the output was used as input to the model for classification into masked and non masked facial images. The respective models were tested with images with well lit backgrounds as well as with images with poorly lit backgrounds, in order to come up with a robust model which works in both conditions. Mobile Net model proved to be the best performing model in both conditions with an added benefit of not being computationally resource intensive thus it can be deployed to computational resource limited platforms.

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