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Enhancing COVID-19 Safety: Exploring YOLOv8 Object Detection for Accurate Face Mask Classification

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Abstract: These The COVID-19 pandemic has emphasized the importance of wearing face masks as an effective measure to reduce the spreading of the virus. With the increasing demand for automated systems capable of detecting and classifying face mask wearing conditions, deep learning models have emerged as a powerful tool in this domain. In this research paper, we investigate the performance of the YOLOv8 (You Only Look Once) object detection algorithm for the classification of face mask wearing conditions. YOLOv8 is a state-of-the-art deep learning model known for its real-time object detection capabilities. The model is trained with Face Mask Detector(FMD) dataset to provide ground truth labels for training and evaluation purposes. We fine-tune the YOLOv8 model using transfer learning techniques on this dataset, enabling it to classify face mask wearing conditions accurately. The experiments performed demonstrate that the YOLOv8 model achieves excellent performance in face mask wearing condition classification. We evaluate the model on various metrics, including precision, recall, mAP, to assess its accuracy, sensitivity, and overall performance. The results show that the model successfully distinguishes between individuals wearing face masks, not wearing face masks, or wearing face masks incorrectly, with high precision and recall rates.The YOLOv5 model was also trained using the same dataset for comparative analysis.

Keywords: *Face mask detection, Deep Learning, YOLO v8*

1. Introduction

COVID-19 gave us a hard time. We lost our near and dear ones, faced lock-downs, saw inflation and scarcity ,lost jobs, and what not. More than 6.8 million lives have been claimed by the pandemic[1]. It is still an ongoing pandemic and continues to affect different countries around the world. Thanks to health experts and Government for vaccination and public safety guidelines, daily cases are going down and world is recovering slowly. However, we must be cautious and prepared as these viruses tend to mutate and who knows what deadly variant emerges next and creates havoc. We must take measures and stay prepared for situations like this. Wearing of mask is the best way to decrease the rate of transmission. It is 96% effective in blocking germs and virus from entering or leaving our mouth and nose[2]. Wearing mask is the new normal in public places. During COVID-19 unlock phases, it was mandatory to wear masks in public places like hospitals, airports, malls, etc for the safety of public.We are motivated to design a face mask detection system to minimize the human efforts in surveillance to make sure everyone is properly masked. Face mask detection system can be achieved by training object detection models to detect face mask.

In this paper, YOLOv8s, has been trained with a Face Mask Detector[3] dataset to detect facemask and classify into three different classes: Mask, No mask and Improper mask. The YOLOv5s model was also trained with same dataset for comparative analysis. After this section related works and literature have been discussed,

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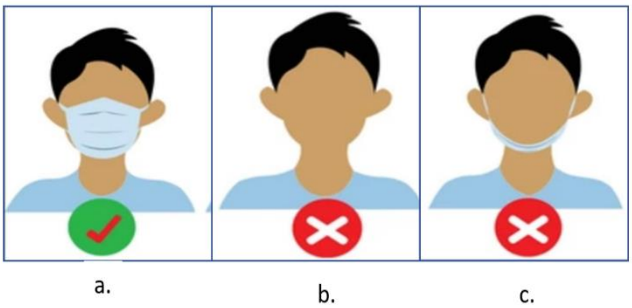

Fig. 1. a. Masked **b.** No Mask **c**. Improper Mask. Three Different classes.

2. Literature Review

There has been a significant amount of research and contributions in Face mask detection system in last three years after wearing of face mask was made compulsory in public places.Different object detection models have been trained to detect face mask. We can categorise face mask detection approaches in two types based on the number of classes: Two class(mask and no mask) and Three class(mask, no mask and improper mask). The authors of[4] demonstrated automatic face mask detection system based on CNN classifiers and the VGG16 model. It was trained with 686 images with mask and 690 images without mask. The model outperformed AlexNet,MobiNet and YOLOv1 in terms of accuracy and error rate. The authors of [7]customized CNN for face mask detection task and proposed FMRN(Face Mask Recognition) model which achieved 95.8% accuracy when trained with custom dataset of 2192 images. The authors of [8] Manas,Vhaivav and Anmol have made a Mask Detection Model(MDM) based on YOLOv3 and achieved Average

Precision of 93%.In[9],authors have implemented YOLOv5 model for classifying mask and no mask. It was trained with dataset of 9000 images which achieved accuracy of 92%. The authors of [5] proposed a novel single stage face mask detector named RetinaFaceMask which was trained with MAFA-FMD dataset. The dataset had three classes which include improperly mask. This model was trained with 26,463 images without mask, 28233 with mask and 1388 with improper mask. The no. of instances in improper mask category is very low compared with other two categories. The model was compared with other algorithms. like SSD, Faster R-CNN, YOLOv3 and gave promising results.Youwen and Yicheng[6] have given a good summary of existing techniques and their performance. They also have proposed a OOD(Out Of Distribution) model which can classify three different classes using the dataset of two classes as OOD model was able to detect abnormal cases. They claimed that their model is capable of doing so however it needs more improvisation in performance. The authors of [10] have developed SMD-YOLO which is based on YOLOv4- tiny. It was trained with dataset of three classes and achieved average of 67.01%. The authors in [11] proposed a dataset called vidMask which contains 12000 video frames with labels. This dataset was used to train and compare Mask RCNN,YOLOv4,YOLOv5 and YOLOR. The highest accuracy was achieved by YOLOR(92.4%). Ushman and Johnson have used a customized mask-face dataset containing three classes of data to train HIC-DEEP, a model based on InceptionV3 which achieved accuracy of 85%.The different related works in face mask detection is summarized in table 1.

Table 1. Related works.

Reference No.	***Year***	***Model***	***Description***	***Accuracy***	***Dataset used***
[4]	2020	CNN and VGG16	The model was trained to detect two categories(mask and no mask) which outperformed models like AlexNet,MobiNet and YOLOv1 in terms of accuracy and error rate	89.6%	686 images with mask & 690 without mask
[8]	2020	MDM(Mask Detection Model)	The model MDM was based on YOLOv3	93.0%	Custom dataset of 975 masked and 850 unmasked
[9]	2020	YOLOv5	The YOLOv5 model was used to detect two classes and was compared with other SOTA algorithms	92.0%	Dataset of 9000 images. Source was private.
[30]	2020	SRCNet(Super-Resolution and classifier Network)	The SRCNet is a deep learning based neural network which can detect and classify different mask wearing conditions.	98.7%	Medical Masks Dataset-contains 671 images without mask ,134 images of incorrectly worn mask & 3030 images of correctly worn mask. Total of 3835 images
[31]	2020	Inceptionv3 : A model based on Convolutional Neural Networks(CNN)	Inceptionv3 is a 22 layers deep module from GoogleNet. The model was trained detects a person who is not wearing a mask.	99.9%	The study used Simulated Masked Face Dataset.
[32]	2021	SSDMNV2: A novel deep learning-based face mask detection model that is composed of single shot multi-box detector and MobileNetV2	The SSDMNV2 model uses a single shot multi-box detector and MobileNetV2 . This can be implemented in low computational device like Raspberry Pi.	92.64%	The PyImage dataset that consists of 1,376 images was used for training and testing theSSDMNV2 model.
[33]	2021	YOLO-v2 and ResNet-50 were combined as a unified model.	The study implemented YOLOv2 and Residual networks for detecting face mask.	81%	Medical Masks Dataset and Face Mask Dataset from Kaggle
[34]	2021	MobileNetv2 was used with SVM classifier for detecting and classifying images	The model MobileNetV2 is lightweight because it has less dense convolutional neural network	99.98%	Face mask dataset and Medical Mask dataset from kaggle were combined to train the model
[35]	2021	The model utilized MobileNetV2 which is a CNN based architecture along with OpenCV .	The MobileNetV2 uses frameworks such as TensorFlow, Keras, and OpenCV libraries for running.	99%	Medical Masks dataset from Kaggle.
					Face mask detection

[38]	2021	Deep Residual Learning for Image Recognition	The model was two-stage detector using Alexnet	98.2%	A manually customized face mask dataset from Kaggle
[39]	2021	YOLO v3 and YOLO v4	A custom dataset was created and YOLO versions were trained using it. The variants are: YOLO v1,YOLOv2,YOLO v3,YOLO v4	71.69%	A novel dataset comprising of 52635 images was proposed.
[40]	2021	YOLOv4	YOLOv4 model was used to detect the condition of wearing face mask	98.90%	7,959 images were taken from WIDER-FACE and MAFA dataset. 6120 images were used to train the model and 1,839 images were used for testing.
[41]	2021	YOLOv4	YOLO v4 has CSPDarknet53 as a backbone and PANet path-aggregation network as neck. The head is made up of Neural networks with three layers.	99.5%	7320 images were used for training and, 2139 images were used for testing the model. Total of 9459 images.

3. Methodology

For achieving face mask detection and classifying intro three classes, we have used YOLOv8[12]. YOLO stands for You Only Look Once, and it is a single-shot object detection model that performs object detection in one pass of the neural network. Basically, there are two types of approaches for object detection using deep learning:

• One-Stage Detector: Models that detect, identify and localize an object in one forward pass of the neural network which results in faster detection. Single-Stage Detector(SSD)[14] & YOLO falls under this category.

• Two-Stage Detector: Models that detect, identify and localize an object in two pass of the neural network[17]. In first stage, Region Proposal is done which helps model to classify the image in second stage more accurately. The two approaches are better in their own way. In Object Detection there is always a trade-off between speed and accuracy[17].One-stage detector has high detection speed which makes it suitable for surveillance, automatic driving, license plate detection etc. On the other hand two-stage detector can be where accuracy is a priority like face recognition, Finger print and pattern recognition, etc.[16]

3.1. History of YOLO

YOLO was developed in 2015 by Joseph Redmon and his team[13].The YOLOv1 was efficient and had high interference speed which quickly rose into popularity among other state of art object detection models like R-CNN[18],MobileNet[19],AlexNet,etc. With gaining popularity, many researches began contributing to YOLO and improvising in different areas. Joseph Redmon,the original author and developer of YOLO continued its development and released YOLOv2[20] and YOLOv3[21] with improvements and additional features to its previous versions[21]. After the release of YOLOv3, Joseph Redmon quit the further development of YOLO as he thought that his tech was being misused especially referring to military and unethical applications[22].YOLOv4 was developed by Alexey Bochkovskiy,Chien Yao Wang and Hong-Yuan Mark Liao which brought the YOLO back into action[23]. After that team Ultralytics in the leadership of Glenn Jocher launched YOLOv5 which was the best among all YOLO versions[26]. Other versions like YOLOv6,YOLOvx , PP-YOLO& YOLOv7 emerged from around the world which was variations and modifications of the YOLOv5 model[27]. YOLOv8 was released on January 2023 by ultralytics which gave better results than its predecessor versions[25]. The comparison of different YOLO versions are shown in table 2.The Precision is calculated by training the models with COCO dataset.

Table 2. Units for magnetic properties

YOLO version	Year Released	Framework	Backbone	Average Precision (in %)
YOLOv1	2015	DarkNet	DarkNet24	63.4
YOLOv2	*2016*	DarkNet	DarkNet24	63.4
YOLOv3	*2018*	DarkNet	DarkNet53	36.2
YOLOv4	2020	DarkNet	CSP-D53arkNet	43.5
YOLOv5	2020	Pytorch	Modifies CSP v7	55.8
YOLOv6	2022	Pytorch	Efficient Rep	52.5
YOLOv7	2022	Pytorch	RepConvN	56.8
YOLOv8	2023	Pytorch	YOLOv8	53.9

3.2. YOLOv8 Architecture

YOLOv8 is the latest State of the art object detection model in the YOLO series. It is developed by team Ultralytics. The official paper is not released for YOLOv8 however it is available for training and tesing by the public[28]. The architechture of YOLOv8 is shown in fig 2. The figure is not from official site but from a github user RangeKing. YOLOv8 has two parts: Head and Backbone. Backbone is responsible for generating feature pyramids after feature extraction. Head is responsible for identification and displaying bounding boxes along with objectness score.[28]

3.3. YOLOv8

YOLOv8 is released by Ultralytics in January 2023, the same team had released YOLOv5 in 2020. YOLOv8 can be run from the command line interface (CLI), or it can also be installed as a PIP package. Moreover, it comes with multiple integrations for labelling, training, and deploying. They have made several changes to increase the accuracy of the model by increasing augmentation during training process.YOLOv8 augments images during training online. At each epoch, the model sees a slightly different variation of the images it has been provided. YOLOv8 uses mosaic augmentation during training; however, because it has been found that this augmentation can decrease precision if used during the whole training process, therefore it is disabled for the last ten epochs.[28]Mosaic augmentation is a technique where 4 training images are stitched together to form new image. This augmentation technique help model to train and learn more efficiently[29].YOLOv8 is more efficient than previous versions because it uses a larger feature map and a more efficient convolutional network[25].More details about how YOLOv8 works and in-depth details of its architecture can be found in [12].

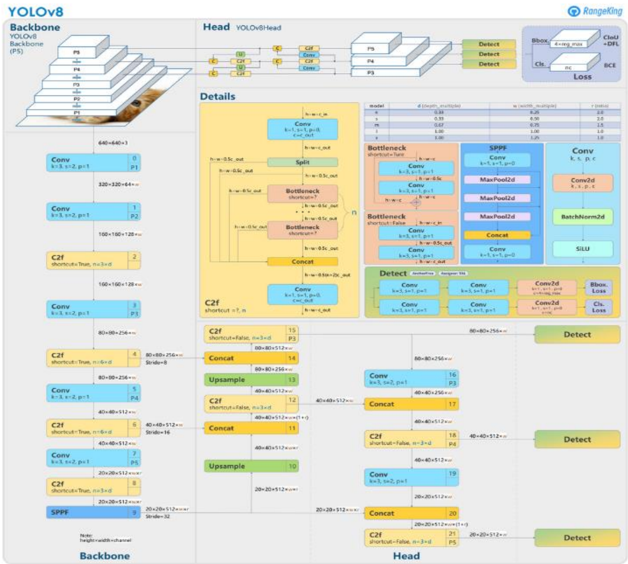

Fig. 2. Architecture of YOLOv8[23]

abbreviation "i.e.," means "that is," and the abbreviation "e.g.," means "for example" (these abbreviations are not italicized).

3.4. Dataset

Face Mask Detector[3] is a public dataset in kaggle that has that has 690 mask images,686 without mask , and 703 incorrect mask, which makes total of 2079 images. This dataset was chosen because of the quality and the balance in no.of instances of each class. The dataset also had variations of mask in both incorrect mask and mask categories so that that model can identify diverse range of masks.

Fig. 3. Samples from the dataset

3.5. Data Annotations

To train YOLO models we need to annotate images. Our dataset should be well annotated.Here a bounding boxes method is used. It creates a rectangle area over images that needs to be recognized by the model.Annotation was done using a tool called LabelIMG[15] to annotate our data.

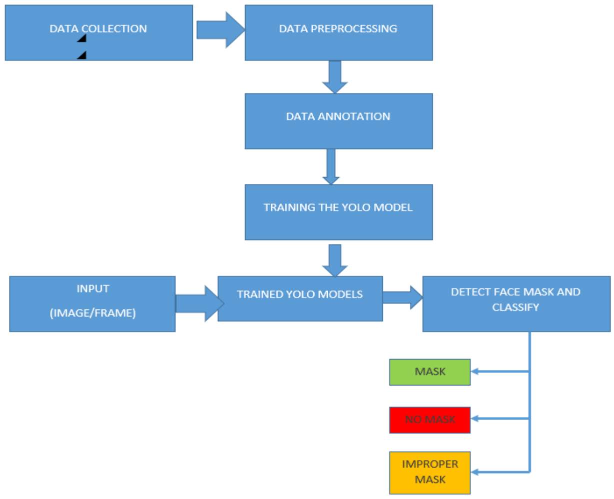

Fig. 4. Work Flow of Methodology

4. Implementation

The YOLOv8 model was downloaded using pip and was trained with the labelled dataset in Jupyter Notebook.The model was trained for 50 ,100,150 and 200 no. of epochs.For Comparative analysis YOLOv5 was also trained with same dataset for same no. of epochs.Both the model were trained in same system with same hardware processor intel 15, with 8 GB RAM. Both models were trained with learning rate of 0.1 and batch size for training was 16. For validation of the model, first 200 images of each category was taken separately from the same training dataset for both the models. There are several scaled versions for both models. YOLOv5 and YOLOv8 both has four scaled versions (small,medium,large,Extra large).For comparison small version were taken for both. In simple words, YOLOv5s and YOLOv8s have been compared.

After comparison YOLOv8 model was used to detect face mask using webcam. For this openCV package was used for activating and feeding frame by frame to YOLOv8 model and classify as mask ,No mask and Improper mask

5. Results and Discussion

YOLOv8 model was trained for 50,100,150 and 200 no. of epochs. The precision, recall, mAP(mean Average Precision) of YOLOv8 is shown in table 3.

No. of epoch	Class loss	Precision	Recall	mAP (0.5)	mAP(0.95)
50	2.08	0.34	0.39	0.25	0.14
100	1.147	0.76	0.85	0.88	0.69
150	0.97	0.84	0.81	0.78	0.82
200	0.81	0.95	0.95	0.96	0.93

Table 3. YOLOv8 performance.

The performance of YOLOv5 for same is shown in table 4 for comparison of the two models.

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Table 4. YOLOv5 performance.

No. of epoch	Class loss	Precision	Recall	mAP (0.5)	mAP(0.95)
50	2.498	0.23	0.30	0.31	0.10
100	2.017	0.69	0.71	0.66	0.54
150	1.54	0.80	0.76	0.79	0.71
200	0.96	0.88	0.86	0.86	0.85

The performance of YOLOv8 for 200 epochs is shown in fig 5. in graph.

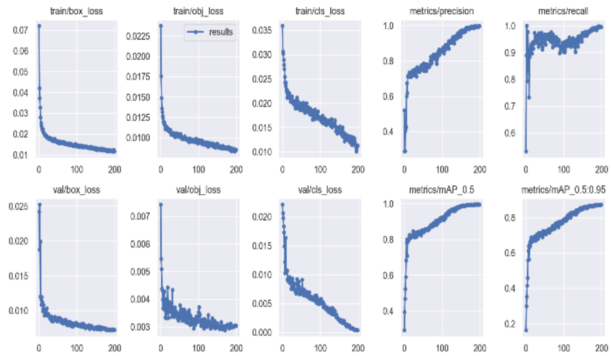

Fig. 4. Results of YOLOv8 for 200 epochs.

From the above graph, we can see that the different loss of the model is decreasing as we train for greater number of epoch.The loss of the model should be as low as possible. We can also deduce the manner of changes in precision, recall & mAP of the model. These parameters must be high for great accuracy. The model was tested in realtime using openCV and gave good results, however we found that the model does not perform well in dim light.In normal light ,it gave promising results.

Fig. 5. Snapshots of Realtime detection of YOLOv8.

6. Conclusion and Future work

In this paper two models of YOLO, YOLOv5 and YOLO v8 was trained with same dataset in same environment.YOLOv5 achieved 0.85 mAP and YOLOv8 achieved 0.93 mAP when trained for 200 epochs This clearly shows that there has been a significant improvement in YOLO model in last two years. This trained model can be integrated with cctv footage for deployment in future when situations like COVID comes again. Places like pharmaceutical companies, food factories, chemical labs where masks is required for health or hygiene can also use the YOLOv8 model for face mask detection. A mechanism can be added which alerts the authority if incorrect or no mask is detected.

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Author contributions

Sanjog Tamang: Data curation, Writing-Original draft preparation, Software, Validation., Field study **Biswaraj Sen**: Conceptualization, Methodology, Software, Field study **Ashis Pradhan**: Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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