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Editors

Control and Information Sciences

Select Proceedings of CISCON 2022

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Preface

Control Instrumentation System (CISCON) is the annual conference event organized by the Department of Instrumentation and Control Engineering, Manipal Institute of Technology. The department initiated CISCON in the year 2004 to provide a platform for its first batch of B.E. in instrumentation and control engineering students to have interaction and exchange of ideas with their counterparts in and outside the institution. This is the first of its kind in the institute and under the able leadership of Dr. V. I. George. With very few institutes in the country offering this specialized interdisciplinary course, people working in both Instrumentation and Control Engineering sought after for this conference every year and have gained lots of recognition. The conference has been sponsored by national research organizations like Defence Research and Development Organization (DRDO), Board of Research in Nuclear Sciences (BRNS), Indian Space Research Organization (ISRO), and Council of Scientific and Industrial Research (CSIR) to name a few. The proceedings of CISCON has been brought out regularly since its inception. In 2015, it was decided to bring out the published papers in Scopus indexed journals to give additional incentive to authors who put forward their research articles to CISCON, and the same trend has continued till 2017 with the rapid increase in submission. Later, presented papers were published in Lecture Notes in Electrical Engineering published by Springer Nature. The conference has attracted a large number of papers in varied disciplines like process control, automation, renewable energy, robotics, image processing, sensor and instrumentation, etc. Out of the total 136 papers submitted, 120 papers were sent for double-blind review after preliminary inspection and plagiarism check. Out of these, 35 papers have been accepted and presented in the conference and 29 would be considered for publication in this book as chapters. We believe that the proceedings of the conference will be well received by researchers working in the domain and get inspiration for budding researchers to explore more into the varied domains in which the papers are presented. The papers presented in this proceedings are mainly in the domain of process control automation, instrumentation, robotics, image processing, and many more. The readers of this proceedings will get an insight into the varied areas in which contemporary research is being carried forward in this domain and get

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started to go ahead. These papers will give openings for beginners and also the direction for those who are working in these specific domains already. We are confident that the proceedings will be accepted by prospective researchers very well and give encouragement for us to go ahead with organizing CISCON every year with many new ideas and scope. This event was made possible by the utmost support from Chancellor of MAHE Padmashree Awardee Dr. Ramadas M. Pai, Pro-Chancellor Dr. H. S. Ballal, Vice-Chancellor Lt. Gen. (Dr.) M. D. Venkatesh, Registrar Dr. Narayana Sabhahit, and Section Heads of finance and other logistic services, and they deserve our heartfelt gratitude. Director of Manipal Institute of Technology Cdr. (Dr.) Anil Rana; Joint Director Dr. Somashekara Bhat and Dr. Shreesha C.; and Head of the Department, Instrumentation and Control Engineering, deserve lots of appreciation for their constant guidance and motivation. Our sincere gratitude goes to Dr. Ramakrishna Raman, Dr. Prashanth Maskar, Dr. Sudhir Raj, and Dr. Chinmay Rajhans for sharing their knowledge and views at the conference gathering. The convener of the conference, Mr. Ganesh Nayak, deserves special recognition for his several months of untiring work toward this conference. A special mention to the administrative staff of Manipal Academy of Higher Education (MAHE), Manipal Institute of Technology, and also the Department of Instrumentation and Control Engineering for their wholehearted support in making the conference event. Our sincere acknowledgment to the unanimous technical reviewers, to all contributing authors for taking time and effort to send their research work and adhering to all review comments and formatting requirements. We also wish to place our gratitude to Springer Nature for accepting our request to publish the accepted/presented papers in CISCON 2022. Finally, our acknowledgment for all who have directly or indirectly helped us in organizing this event successfully and bringing out these proceedings.

Peermade, India — V. I. George
Manipal, India — K. V. Santhosh
Singapore — Samavedham Lakshminarayanan

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About the Conference

Professor V. I. George:

The Control Instrumentation System Conference (CISCON) 2022 was held during October 28–29, 2022. This conference was for nineteenth time organized by the Department of Instrumentation and Control Engineering, Manipal Institute of Technology. Due to the pandemic, it was organized in hybrid mode. Around 136 manuscripts were received, and the acceptance rate was 25%. Four plenary lectures were delivered. While on the first day, Prof. Dr. Ramakrishna Raman, Fellow at Honeywell, and Dr. Chinmay Rajhans of Manipal Institute of Technology, the undersigned delivered the keynote addresses, and Dr. Prashanth Maskar of the Mcmaster University, Canada; and Dr. Sudhir Raj of the Justice K. S. Hegde Institute of Management, Nitte, were invited to present the keynote addresses on the second day. There were thirty-seven **(37)** oral presentations. The papers were categorized into six groups—(a) Power Systems and Drives; (b) IoT, Automation, Robotics; (c) Electronics; (d) Instrumentation; (e) Control Systems; and (f) Biomedical, Image Processing, and Signal Processing that were presented in six sessions. All the papers submitted went through a double-blind review process by two or three reviewers prior to being accepted to the conference. Overall, the e-proceedings presents a comprehensive overview of ongoing research in the field of instrumentation, control, and automation in India and abroad. I hope that we will meet at the next CISCON conference in 2023 in physical mode.

Prof. V. I. George, Principal, Mar Baselios Christian College of Engineering and Technology, Peermade, Kuttikkanam, Kerala.

Professor Samavedan Lakshminarayan:

I am very glad that CISCON 2022 held during October 28–29, 2022, XIX in the series is a grand success. Started in 2004 when first batch of instrumentation and control engineering undergraduates of MIT Manipal are in the verge of entering to final year of engineering, with an objective to give them an opportunity to explore about trends in instrumentation, control, and systems engineering, this annual event

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has grown year after year with support from MAHE management, industry, and research organizations of the country like ISRO, DRDO, VSSC, BRNS, DST, CSIR etc.

Since 2020 due to the pandemic, we conducted this event as a virtual conference. In spite of this, the response from researchers across the country is tremendous, and this year we also had an international contribution as well as invited talk. With the proceedings of the presentation being published as Scopus indexed Lecture Notes in Electrical Engineering by Springer Nature, the value of the presentations has been enhanced. The quality of the conference can be measured with the fact that only 37 of the submitted 136 articles have been accepted for presentation.

This year's conference had representation from both academia with professors from reputed institutions like Mcmaster University, Canada; and Justice K. S. Hegde Institute of Management, Nitte, and experts from industry like Honeywell presenting invited talks.

Overall, all deliberations and presentations are very informative and provided very good input to all participants especially to our faculty and students. I congratulate and acknowledge all participants, resource persons, and conveners for taking out their time and expertise to organize and make the event a very successful one. I wish this annual event of the Department of ICE, MIT Manipal, would leave up to expectations of all key stakeholders and grow as a sought after multidisciplinary conference in contemporary domains.

Professor Samavedan Lakshminarayan, College of Design and Engineering, National University of Singapore, Singapore

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About the Editors

V. I. George is currently serving as a Professor and Head of the Department of Electrical and Electronics Engineering at Mar Baselios Christian College of Engineering and Technology, Peermade, Kerala. He earned his bachelor's in electrical power engineering from Mysore University (1983) and his master's in instrumentation and control engineering from the National Institute of Technology (NIT), Calicut (1987). He has a Ph.D. in robust control of dynamic systems from NIT Tiruchirappalli (2004). He has served as the National Vice President of System Society of India (2005–2007) and National Vice President of ISSE (2014–2017). He has authored over 100 technical research papers that have been published in peer-reviewed national and international journals. He has served as a member of the board of studies for various academic programs. Over his academic career, he has received several grants from agencies such as DST, DRDO, ISRO and AICTE.

K. V. Santhosh is presently working Associate Professor in the Department of Instrumentation and Control at Manipal Institute of Technology, Manipal and Deputy Director of Research (Technical) at Manipal Academy of Higher Education. He received bachelor's and master's degrees from VTU, Belgaum, and a Ph.D. from the National Institute of Technology (NIT) Silchar. His research interest is in sensors. He has published over 100 publications in peer-reviewed journals and delivered several technical talks. He is serving as a reviewer and editorial board member for several peer-reviewed journals.

Samavedham Lakshminarayanan is an Associate Professor with the Department of Chemical and Biomolecular Engineering at the National University of Singapore (NUS). In the recent past, he held appointments as the Director of the Institute of Applied Learning Sciences and Education Technology (ALSET), Centre for Development of Teaching and Learning (CDTL) and founding Master of Residential College 4 all within the NUS ecosystem. He earned his bachelor's in chemical engineering from BITS Pilani (1988) and his master's in chemical engineering from the Indian Institute of Technology (IIT) Madras (1991). He has a Ph.D. in process control from the University of Alberta, Canada (1997). Due to extensive academic and industrial experience, he has developed deep expertise in machine learning, artificial intelligence, multivariate time series analysis, model-based advanced process control and biomedical applications. In August 2020, he was awarded the Public Administration Medal (Silver) by the Government of Singapore.

Face Mask Detection and alert system using Artificial Intelligence for COVID-19 prevention

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Abstract. The COVID-19 pandemic has facilitated many changes in our day-to-day life including working from home, distance learning, reduced capacity in malls and other indoor places. While restrictions are now being lifted in some countries, social distancing is still practiced. As countries start to restart economic activities, schools and universities start to go back to in-person learning, it is important that another pandemic is avoided. This paper discusses and presents a methodology for one of theways artificial intelligence can be used to aid in the detection of COVID-19 prevention measures that are implemented to negate the effect of the pandemic. Use of such measures can ensure that local authorities can enforce these measures without being in risk themselves.

The proposed method uses a MobileNetv2 model pre trained using the ImageNet dataset as a base model and a FC head layer is fine-tuned onto it to achieve fast and accurate real time detection. The model is trained using two different datasets; one small and one big to see the effects of the size of the dataset on the accuracy of detection. The first stage detects all the faces in the frame after which the mask detection model predicts whether a mask is worn or not. If a mask is worn incorrectly,no mask is predicted. If a violation is detected, an email alert is sent to notify the authorities. After testing, a highly accurate model is obtained which requires low computational power and can be run in real time.

Keywords: Alert system; Deep CNN; Deep learning; Mask detection; MobileNet v2; Neural networks

1 Introduction

The novel coronavirus (COVID-19) is one of, if not the most influential and the contagious diseases of the 21st century. Owing to the slow acting symptoms and fast spreadof the SARS virus, the coronavirus pandemic all over the world has affected all aspects of society including the way we live, work, study and socialize. The best way to combat and mitigate the

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effects of the pandemic is to practice simple prevention measures such as wearing masks and maintaining a distance of avoiding physical greetings [1]. The use of artificial intelligence (AI) in automating these tasks is advantageous as social distancing regulations are extremely difficult to enforce purely using human labor and also eliminatesthe risk of further spread of the virus by removing the need for human interaction. While rules and regulations are now being lifted in some countries, social distancing and COVID-19 prevention measures are still practiced indoors in places such as universities, malls, hospitals and so on. As countries start to restart economic activities and educational institutes start to resume in person learning, it is important that another pandemic is avoided.

Deep learning and machine learning techniques have recently shown impressive performances on multi class object recognition and detection. This is mainly due to the biological inspired structure of neurons and neural networks that allow them to be capableof learning and extracting hidden patterns and features from the dataset it is trained and thenthen use that information to create object descriptors. This behavior mimics how human brains work and allow them to make predictions without human input [2].

Convolutional Neural Networks (CNN) are a type of network used in image and video processing. CNNs are made up of four layers, these are the convolution layer, ReLu layer, pooling layer and finally the flattening layer. R-CNN and Mask-R-CNN belong to a family of Convolutional Neural Networks (CNNs) that use data in regions, allowing it to perform object detection in images and videos. R-CNNs work by splitting the image into around 2,000 different region proposals and then the CNN is applied to each proposal separately. Due to this, RCNNs are extremely slow and suffer from high computation times and difficulty in training the network [3].

Sirajuddin et al propose a mask detection model that uses a two-stage approach using Faster RCNN. The Fast RCNN model is an improvement to the RCNN model. By sharing the feature maps from the convolution layers, the need for feature extraction from the selective search module is removed. Fast RCNNs also make use of Region of Interest (ROI) pooling network instead of the regular pooling layer used by CNNs. The Faster RCNN model is a modified version of the fast RCNN model. Faster RCNN uses Region Proposal Network (RPN) to help reduce the time required in finding candidate regions and employs a deep fully convolutional network instead of the selective search module [4].

You Only Look Once (YOLO) is a type of model that achieves object detection in images in only one stage instead of the two stage propose and classify system use by RCNNs. This enable the YOLO model to run at frames per second at the cost of some of its accuracy. The original YOLO model had several limitations owing to the way the algorithm worked. However, the model has undergone many changes and improvements and the result is the YOLO v3 model, which is highly accurate and offers low computational costs, allowing the algorithm to run at 30 frames per second on a Pascal Titan X GPU [5]. Liu et al propose a mask detection method by adjusting a YOLOv3 model and employing the use of simple CNAPS to resolve issues caused by small and imbalanced datasets. CNAPS use a feature extractor that is adjusted using the images specific to that task. Using the proposed method, they

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achieve 2 frames per second on a modest dual-core Intel Xeon CPU in 1920 × 1080 resolution [3].

The MobileNet model is a small and efficient lightweight network developed by Google that offers high accuracy and is used in many real time face detection algorithms. Although MobileNet fails to achieve the high accuracy of RCNN methods, the model is computationally simple and can be run on devices without a lot of processing power such as microcomputers like the Raspberry Pi and even smartphones. Instead of standard convolution layers, MobileNetuses depth wise separable convolution which is a mixture of depth wise convolution and pointwise convolution. This greatly reduces the number of parameters required and hence decreases the computational cost [6]. MobileNet v2 builds upon the MobileNet v1 algorithm with the addition of 19 linear bottleneck layers and shortcuts between those layers. This helps MobileNet v2 models achieve a 30-40% increase in speed and an overall increase in accuracy due to the fact that using linear layers prevents loss of information. Overall, the MobileNet v2 model offers highly accurate results and is capable of being run without dedicated hardware.

Image processing algorithms have also been aided in their success due to the easy availability of good quality datasets. ImageNet is a database that is built upon the backboneof the hierarchical structure of WordNet. WordNet is a database of each possibly meaningful concept called a “synonym set” or a “synset”. ImageNet tries to illustrate eachsynset with around 500 to 1,000 images. The images are quality controlled and annotated by a human which ensures that the dataset consists of millions of clean and sorted images [7]. ImageNet utilizes an architecture of eight layers – five convolutional and three fully connected layers that allows it to interlink images in a comprehensive and useful manner. Hence, ImageNet is a widely used resource in visual recognition tasks such as object detection and localization [8].

Currently, RCNN and YOLO are the most common methods of providing real time mask detection. However, both these methods have tradeoffs in either speed and simplicity of computation or accuracy. Inspired by Adrian Rosebrook’s approach to the problem, this paper proposes the use of MobileNet v2 trained on the ImageNet dataset and implementing transfer learning by finetuning a Fully Connected (FC) head layer trained on a dataset with images of masked and un masked people. The goal is to achieve a simple and fast network that is highly accurate and can be run in real time. The system is also designed with an email alert feature that can be used to limit the number of social distancing violations taking place by notifying the relevant authorities.

2 Methodology

The block schematics of the proposed mask detection and alert system is depicted in Fig. 1. The mask detection and alert system can be broken down into two main tasks:

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- Creating and training the neural network to detect whether a mask is worn or not and save it to disk.
- Using the trained network to detect whether people are wearing masks or not in agiven image or video stream and sending an email alert if the number of violations exceeds a set threshold.

Since the network is to be used for a binary classification purpose (mask or no mask), a simple architecture can be chosen to give accurate and quick results. In order to make the algorithm computationally efficient such that even microcomputers like the Raspberry Pi can run it, the base model is chosen to be a lightweight MobileNetv2 model. The base model is pretrained using ImageNet weights. As the base model is trained on ImageNet, the final target model will also have all the knowledge from the ImageNet dataset through transfer learning. This allows the target model to be more robust and can extract better general features from the images such as textures, shapes and edges.

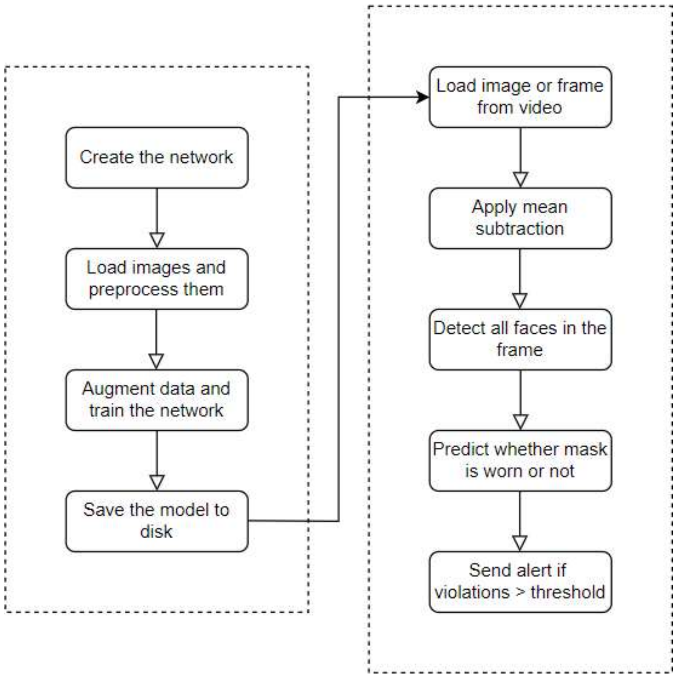

Fig. 1. Mask Detection and alert system

Next, a head model is created with two dense layers. A pooling layer is used to down samplethe image to 7×7 pixels format and then flattened. The first dense layer consists of 128 weights and the last layer contains two neurons with the softmax activation function. The softmax function is given in equation (1) [9]. The softmax function converts the scores into a normalized probability distribution and predict a 'no mask' or 'mask' label.

$$\sigma(\vec{z})_i = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_i}} \qquad (1)$$

where, $\vec{z}$ is the input vector to the SoftMax function, the z_i terms are the elements of the input vector and K is the number of classes in the classifier network. The denominator is the normalization term and ensures that the output values of the function to a total of one and are in the range (0,1).

To further improve the accuracy of the network and prevent underfitting or overfitting, the following strategies are employed:

- Data augmentation and preprocessing: Adding random distortions to the images in the training dataset such as rotations, scaling, flipping and shearing are done in the hopes of generalizing the model and prevent overfitting. The data is also resized to a format of 224 × 224 pixels.
- Learning rate decay: An initial learning rate of 0.0001 is chosen. While training, a learning rate decay is applied using the Adam Optimizer that decreases the learning rate in subsequent epochs. This helps the network train faster and avoids oscillating around spurious local minima.
- Loss function: Binary cross entropy is the most frequent loss function used when training a binary classifier. Binary cross entropy uses logarithmic values of the probabilities of the labels. This means that as the probability of the prediction of the mask class (true or 1) gets closer to zero, the loss increases exponentially and hence improves accuracy while training.
- Tuning the parameters: Finally, the number of epochs, batch size and training schedule is selected.

Two datasets were used in the training of the network to create two mask detection models. They are:

- Dataset 1 – In this proposed work, the research on facial landmarking done by scholars is used to create the first data set [10]. It contains 1,376 images in total. 690with masks and 686 without masks. Images of people without masks were taken fromthe internet and an algorithm was used to localize the eyes, nose, mouth etc. after which masks were placed on them. For the images without masks, new images were scraped from the web and left as is. This prevents the model from becoming biased as using the original images used to generate masked images will prevent the model from generalizing well.

- Dataset 2 – The second dataset was acquired from Kaggle [11] and contains 11,792 images. 5,883 with masks and 5,909 without masks. In this dataset, the images with masks were scraped from online search engines and all the images without masks were taken from another dataset named CelebFace, created by Jessica Li.

In order to implement and visualize the results of the face mask detector model trained, OpenCV is used to read from and write onto the image/video input. OpenCV's Caffe basedface detector is also the chosen model to be used to detect faces. While testing, it was foundthat some of the faces in images weren't detected properly. After reducing the confidence threshold to 0.3 to remove weak confidence detections, the faces were detected accurately.It is based on the Single Shot Detection Framework which was fine-tuned onto a ResNet base network. The image is copied, and mean subtraction is applied.

The bounding box surrounding the faces are then calculated and after preprocessing, the Region of Interest (RoI) are then fed into the mask detection algorithm. The mask detectionalgorithm then predicts whether a mask is worn or not and the final prediction is displayedon the image in the form of green (mask detected) or red (no mask detected) bounding boxesalong with the probability of the prediction.

If any violations such as mask not worn or incorrectly worn are detected, an email alert is sent to the authorities using a separate mailer function via the Simple Mail Transfer Protocol(SMTP). The content of the email can be modified to suit the user's preference such as specifying where and when the violation took place, include the image/frame where the violation took place and the number of violations detected.

3 Results and Discussion

Two mask detection models were trained using the data sets for 20 epochs and a testing-training split ratio of 20:80 was used. These were named 'model 1' (trained using 1,100 images) and 'model 2' (trained using 9,433 images). After training, the algorithm tests the model obtained on the testing set created from the testing-training split from the original dataset and compares its predictions to the label of the image. The accuracy obtained is saved. The training loss, training accuracy, validation loss, and validation accuracy are thenplotted onto an Accuracy versus Epoch graph using the matplotlib library. The models after training generate a very efficient and lightweight file requiring only 11.2MB of storage.

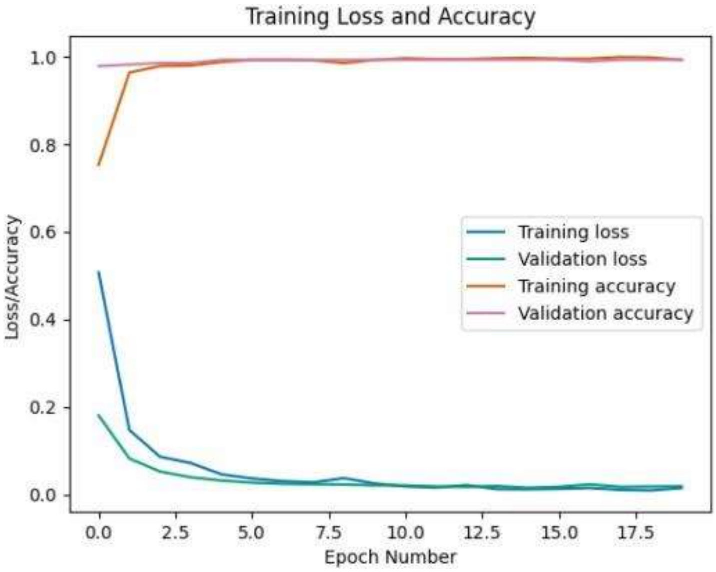

Fig. 2. Loss and accuracy vs Epochs graph for model 1

It is evident from Fig. 2 that, the validation accuracy increases slowly over the course of the training and achieves a final value of 0.9964 and a validation loss of 0.0137. Table 1 shows the Testing model 1 against the testing set.

Table 1: Testing model 1 against the testing set.

Class	Precision	Recall	Score
With mask	0.99	1.0	1.0
Without mask	1.0	0.99	1.0

The validation loss obtained is slightly above the training loss which indicates that themodel is neither underfit or overfit and can generalize well.

Table 2: Comparison of different models [3].

Method	Precision
Faster R-CNN	0.932
YOLO v3	0.905
Proposed method	0.996

From Table 2, we can see that the proposed method presented in this paper offers a higher precision than models that use YOLO or Faster R-CNN. The model is very quick and lightweight, being able to run in real time via a webcam.

Similarly, model 2 was also trained. However, due to the size of the dataset, accurate dataon the validation loss and accuracy while testing was not obtained. The validation accuracy of model 2 after 20 epochs was noted to be 0.9936 and had a validation loss of 0.0179.

Fig. 3 shows the results of testing the model with images of the author, depicting the accuracy of the proposed method.

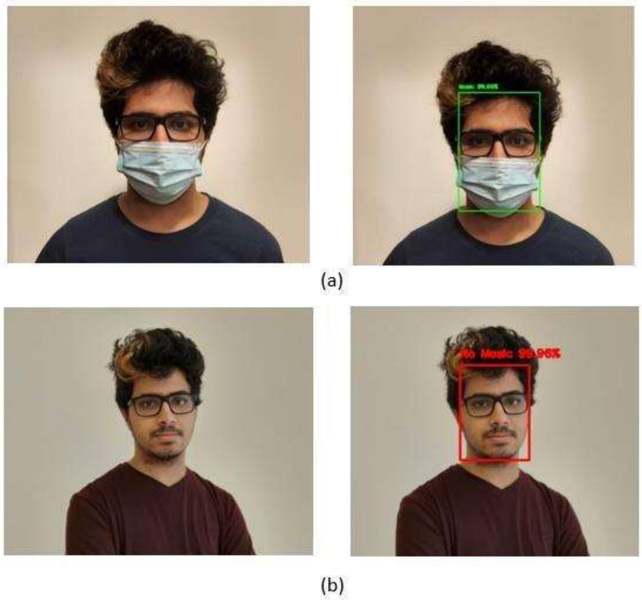

Fig. 3. Images used (left), and output produced by detection model (right) (a) Images of the author with a mask and, (b) Images of the author without a mask.

Several images were then used to test the accuracy of both the models and to check whether the models predict accurately with non-traditional images such as images having large groups of people, different lightings and masks, some of which are shown in Fig 4 [12-15].

(a)

(b)

Fig. 4. Testing results (a) Images of people without mask predicted correctly by the model (red outline) (b) Images of people wearingmasks predicted correctly (green outline) [12-15]

Out of the 40 predictions done during testing, 3 images were incorrectly classified. In two images, model 1 correctly predicted the lack of a mask while model 2 incorrectly predicted the presence of a mask when a mask was not worn, giving a false positive. On the other hand, in one image model 1 inaccurately predicted the lack of a mask when a mask was worn giving a false negative.

In real applications, a false negative (detects no mask when mask is worn) is much preferredto a false positive (detects mask when no mask is worn) as a false negative is safer and can always be reviewed by manual inspection. On the other hand, a false positive could spreadthe virus and the system wouldn't detect it. Surprisingly, model 2 even with ~8.5 times larger training dataset than model 1 (11,792 versus 1,376 images) had a lower accuracy than the model 1. This can be caused due to the quality of the datasets used. The quality of the dataset were not controlled.

The algorithm was also tested in real time on a device with a modest mobile i7- 8750 H processor and 16 GB of DDR4 RAM. A webcam was used as the video source and the detection algorithm was run for 5 minutes to measure its speed. The algorithm is fairly efficient, performing at 12.8 frames per second with high accuracy.

The email alert system can be seen in Fig. 5 where mail alert was sent when violations are detected.

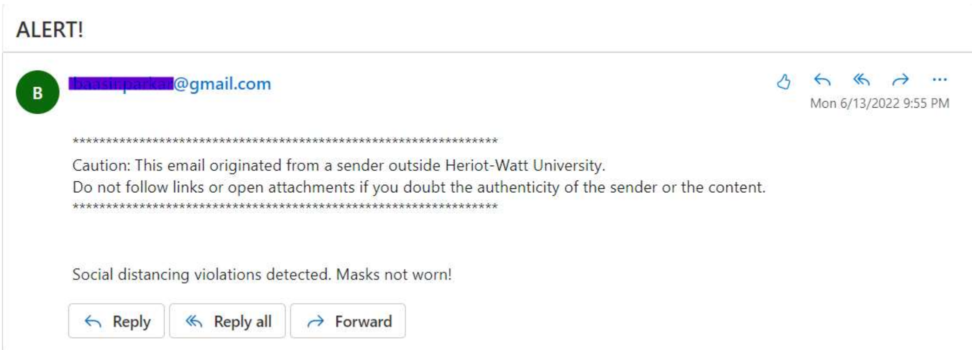

Fig. 5. Mail alert system

4 Conclusion

In this paper, the use of Artificial Intelligence to aid in COVID-19 prevention measures through Machine Learning was examined. The novelty of this work lies in creating a model more suitable for real time mask detection using MobileNetv2 along with an in real time email alert system. A mask detection model is proposed that involves finetuning the highly efficient network MobileNetv2 and using a FC head layer trained on a mask/unmasked dataset to create a mask detection and alert system. The modelobtained is highly accurate and efficient. The experimental results show that the model achieves an extremely high accuracy score of 99.64% and outperforms many of the current mask detection technologies used. The model also attains a frame rate of 12.8 fps on a modest laptop. For future research, a means of improving the speed of the algorithm and implementing the system using a microcomputer such as a Raspberry Pi and camera would be considered.

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