COVID-19 Face Mask Detection Alert System

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Abstract
Study shows that mask-wearing is a critical factor in stopping the COVID-19 transmission. By the time of this article, most states have mandated face masking in public space. Therefore, real-time face mask detection becomes an essential application to prevent the spread of the pandemic. This study will present a face mask detection system that can detect and monitor mask-wearing from camera feeds and alert when there is a violation. The face mask detection algorithm uses a haar cascade classifier to find facial features from the camera feed and then utilizes it to detect the mask-wearing status. With the increasing number of cases all over the world, a system to replace humans to check masks on the faces of people is greatly needed. This system satisfies that need. This system can be employed in public places like transport stations and malls. It will be of great help in companies and huge establishments where there will be a lot of workers. Alongside this, we have used basic concepts of transfer learning in neural networks to finally output the presence or absence of a face mask in an image or a video stream. Experimental results show that our model performs well on the test data with 100 percent and 99 percent precision and recall, respectively. We are making a savvy framework that will identify whether the specific user has worn the mask or not and further tell the accuracy level of the detection. Our framework will be python and AI-based which will be safe and quick for implementation. This system will be of great help there because it is easy to obtain and store the data of the employees working in that Company and will very easily find the people who are not wearing the mask and a will be sent to that respective person to take Precautions not wearing a mask. Potential delays are analyzed, and efforts are made to reduce them to achieve real-time detection. The experiment result shows that the presented system achieves a real-time 45fps 720p Video output, with a face mask detection response of 0.15s and the accuracy of detection 99%.
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1.0 Introduction

According to recently published research on COVID-19, every 10% increase in mask-wearing means a three-fold likelihood of stopping the breakout in a community, and other policies, such as social distancing, are not near as effective [1]. Mandating the face mask thus is urgent and essential. In fact, at the time of this article, most states in the US have mandated mask-wearing in public space by law. However, enforcing the mandate by pure human force can be tedious since the task needs continuous focus for hours and is dangerous as it increases the exposure risk for the enforcer. A face mask detector is an algorithm that detects the mask-wearing status of a person. Using a face mask detector can relieve human factors from the mask-wearing enforcing task. Another application of the face mask detector is for quite the opposite purpose. In some sensitive security zones where masking is prohibited, face mask detection can alert a masked person in the security footage. The wide range of applications of face mask detection makes it a popular research topic. A popular algorithm for face mask detection is the Haar cascade classifier (HCC) [2]. In a recent work [3], they proposed human face detection algorithm by primitive Haar cascade algorithm combined with three additional weak classifiers. The test results are efficient and achieve state-of-the-art performance by detecting people under different occlusions and illuminations and some orientations and rotations. A precise face and eye detection method using HCCs was proposed in [4]. Nowadays there was a great usage of face masks publically due to the increase of the number of Covid19 cases which is reported in and around the world. Normally from a recent survey, we came to know that people don’t wear a face mask to shield their health condition from air pollution but rather they use to hide their emotions from the general public who try to watch their current activities. But now a day it is becoming very mandatory for each and everyone to wear a facemask to protect from spreading the corona virus from one person to another. In 2020, we faced a lot of deaths due to the corona virus, and the world declared COVID 19 as an international pandemic due to the fast spreading of multiple covid deaths. This infection is increased by over 6 million cases in not less than 10 days across 180 countries. This virus is mainly spread through close contact who is packed in certain crowded areas or inside a closed room through the air. Hence the usage of face masks is becoming more and more mandated to prevent the fast-spreading of this virus [5].

Figure 1. Represent the COVID 19 Pandemic Situation

The algorithm can detect faces in most orientations and provides lightweight and accurate predictions for classification based on mask-wearing. Similar research on face mask detection sometimes focuses on detecting masked faces from all faces, usually for security or even anti-terrorist aims [6]. Although the false negative in this and medical face mask detection scenarios can have different significance, the design logic shows a certain degree of resemblance.

The proposed system can detect automatically whether people are following the safety guidelines or not. In [7], a detailed comparison is done between the various deep learning approaches to monitor the disease from medical imaging. In another study [8], an IoT system based on temperature sensing, mask detection, and social distancing is suggested for the protection against COVID-19. Arduino Uno is used for the infrared sensing of temperature while Raspberry Pi is used for mask detection and social distancing using computer vision techniques. In [9], an innovative mask identification technique is proposed by preprocessing of the image followed by face detection and image super-resolution. The system is found to be very much accurate as far as the identification of mask-wearing is concerned. In [10], a model based on a deep neural network is proposed for monitoring people and social distancing even in poor light conditions. The technique is found to be better than many other past techniques in terms of speed and accuracy. In [11], a computer vision-based deep learning approach is used to examine mask detection and social distancing automatically in real-time. The model is developed on Raspberry Pi to monitor the different activities. It is found to save time and reduce the spread of COVID-19. In [13], an IoT-based deep learning foundation is provided for the detection of COVID-19. The provided model is used for the detection of a pandemic by applying this model on the X-ray of the chest. It is proved to be very accurate and hence quite helpful for the medical experts for the prompt 2 Computational Intelligence and Neuroscience detection of COVID-19. In [14], a technique based on open-source computer vision is proposed to detect masked persons. The technique is found to be efficient, especially in industrial applications. In [15], the contribution of IoT and the concerned sensors for tracking and mitigating the virus is discussed. The study provides deep insight into e-health services based upon sensors for managing COVID-19 and discusses the subsequent IoT networks for the post-pandemic era. In [11], a review of the technologies that may be used to detect COVID-19 is discussed. The review also discusses the future challenges in implementing these technologies. The technologies discussed are deep learning associated with X-ray, in vitro diagnostics (IVDs), and wearable sensors based on IoT for monitoring the COVID-19 patients. In [15], detection of the face wearing the mask in the fine state has been done with context attention R-CNN technique with the help of special features for region proposal and by dissociation of localization and classification fields. The context approach R-CNN is highly accurate. The authors in [16] have proposed a cellphone system-based detection system to extract four different kinds of features using the K-Nearest Neighbour algorithm system excellent in terms of accuracy, precision, and recall. A system based on real-time has been analyzed in [17] that uses the concept of generic detection. The accuracy of this systemic may further be improved by including more parameters despite having a large computation time. Further, in [8], a high-performance face mask detector based on deep learning has been proposed that is computationally less complex. The feature extraction has been improved by regression modules. Recently, many deep learning-based models have been developed for mask detection. The convolutional model is based on automatic recognition while the deep learning of face mask detection technique is used for the high speed and accurate detection and feature extraction in a real-time environment even in bad light conditions. IoT-based models can be used for high accuracy detection while some systems based on super-resolution image processing give extremely high accuracy. To overcome the gaps, the proposed system is based on IoT, deep learning, convolution, automatic face recognition, and computer vision to combine the advantages of all the techniques. Further, the proposed system uses the faster R-CNN technique to mitigate the effects of COVID-19.

1.2 Statement of the problem

COVID-19 had a massive impact on human lives. The pandemic lead to the loss of millions and affected the lives of billions of people. Its negative impact was felt by almost all commercial establishments, education, economy, religion, transport, tourism, employment, entertainment, food security, and other industries. According to WHO (World Health Organization), 55.6 million people were infected with Coronavirus and 1.34 million people died because of it as of November 2020. This stands next to the black death which almost took the lives of 60 percent of the population in Europe in the 14th century. After the person gets infected, it takes almost fourteen days for the virus to grow in the body of its host and affect them and in the meantime, it spreads to almost everyone who is in contact with that person. So, it is extremely hard to keep the track of the spread of COVID-19.

COVID-19 mainly spreads through droplets produced as a result of coughing or sneezing by an infected person. This transfers the virus to any person who is in direct close contact (within one-meter distance) with the person suffering from coronavirus. Because of this, the virus spreads rapidly among the masses. With the nationwide lockdowns being lifted, it has become even harder to track and control the virus. Face masks are an effective method to control the spread of the virus.

We are creating an application detection mask and social distancing. The face mask detection feature uses visible stream from the camera combined with AI techniques to detect and generate an alert for people not wearing face masks. A user-friendly interface allows monitoring and review of alerts generated by the system. Social distancing is a method used to control the spread of contagious diseases. Social distancing implies that people should physically distance themselves from one another, reducing close contact, and thereby reducing the spread of a contagious disease. In general ML algorithms are used to take bulk amount of information related to COVID 19 patients and try to find out the possible reasons for early prediction of vulnerable situations which are occurred with Covid. The deep learning models are applied to calculate the accuracy and efficiency in detecting the preventive steps against the spread of Covid19. Currently, in many countries, all the public are forced by strict laws and rules to wear face masks when they move in public places. These rules and laws are mainly monitored manually by the concerned police department for identifying the public whether they are wearing a face mask or not. However, this manual method for detecting face masks is very difficult to check everyone who is in a group. This motivated us to design the current application in which by applying several ML or DL models to train the public from a web camera and identify those who are wearing a face mask and those who didn't wear face masks in public places.

1.3 Motivation

My objective is to study a model with the end goal that it picks the right class. The principal aim of this project is to develop a Deep learning model (CNN) with the help of various frameworks to predict in real-time if a person(s) is wearing a mask or not. The project also aims to create a strong and accurate surveillance system by using modern concepts of AI and Computer Vision. It is indirectly useful to all citizens as this system can be adopted at various public and private organizations to monitor people not wearing a mask and keep a regular check on those who violate. There are no efficient face mask detection applications to detect whether the person is wearing a face mask or not. This increases the demand for an efficient system for detecting face masks on people for transportation means, densely populated areas, residential districts, large-scale manufacturers, and other enterprises to ensure safety. This project uses machine learning classification using OpenCV and Tensorflow to detect facemasks on people.

2.0 LITERATURE REVIEW

2.1 overview of COVID-19

In the new occasions, the Coronaviruses that are a major group of various infections have become exceptionally normal, infectious, and perilous to the entire mankind. It spreads human to human by breathing out the contamination breath, which leaves drops of the infection on the various surface which is then breathed in by other individuals and gets the disease as well. So it has become vital to ensure ourselves and individuals around us from the present circumstance. We can avoid potential risks, for example, social separating, washing hands like clockwork, utilizing sanitizer, keeping social separation, and the main wearing a cover. Public utilization of wearing a veil has become extremely normal wherever in the entire world at this point. From that the most impacted and destroying condition is of India because of its outrageous populace in the little region. This paper proposes a strategy identify the facial covering is put on or not so much for workplaces or some other workplace with many individuals coming to work. We have utilized convolutional neural organization for the equivalent. The model is prepared on a genuine world dataset and tried with live video real-time with a decent exactness. Further, the precision of the model with various hyper boundaries and numerous individuals at various distances and areas of the edge is finished. [18]. IT technologies focused on different industries and integrated different types of digital surveillance cameras. The main reason behind this is the decreasing rates of illegal violations and crimes. With recent advances in computing Hardware and Computer Vision (CV) Software, it is time to integrate these technologies into an automated control system. The Automated Control System will largely decrease the direct contact with people who don't wear masks. This will help in infection prevention and provide more care about the health of workers in different environments. The section exposes the hardware and software parts of our proposed solution. Experiments are carried out in section IV where some drawbacks of the system are shown. This task plans to recognize facial coverings and social removing on a video feed utilizing Machine Learning and Object Detection. TensorFlow and Keras were utilized to fabricate a CNN model to distinguish facial coverings and it was prepared on a dataset of 3800 pictures. Just go for it Object location was utilized to recognize individuals in a casing and check for social removing by ascertaining the Euclidean distance between the centroids of the identified boxes. Fostered an Android application named "Stay Safe" where the client will be advised and can screen the infringement.

2.2 Face Masks and Countermeasures

Since the spread of COVID-19, people started to cover their faces to reduce the spread of the virus, which caused a challenge to facial recognition systems to recognize and classify their faces. The NIST has found an error rate of up to 50% of matching between face masked images and unmasked images for the same person, even with using the best facial recognition algorithms. [19]. When people are wearing face masks that sufficiently cover the mouth and nose causes an algorithm rate error of facial recognition. In the NIST study, it was found that wearing black masks causes errors more than wearing blue masks. Also, the more the nose is covered by the mask, the harder the facial recognition systems to identify the face. While facial recognition algorithms work by computing the distances between an individual's facial features, wearing face masks lowers the accuracy of the system's algorithms because most of the key identification features are being removed or hidden by the mask.

In the previous section, three threat types were introduced that can be challengeable to facial recognition systems. However, the companies that create facial recognition systems are rapidly adapting to the new world and its challenges. Scientists are already boosting their systems to recognize individuals with half-covered faces where the identification accuracy reached almost 90%. The new adaptive systems work by focusing on the uncovered areas of the face, such as eyes, eyebrows, hairline, and forehead. Another way to overcome wearing a face mask challenge, many companies are planning to provide face masks with customers' faces printed on them. These face masks can help people to unlock their smartphones without having to take their face masks off. These companies are not only working on helping people to unlock their smartphones but also, they are working on calculating the ability of Artificial Intelligence systems to collect and match images of people wearing different types of face masks in international airports from around the whole country [20]. The US Department of Homeland Security (DHS) was able to identify people who are wearing masks with an identification accuracy of 77% [21].

2.3 Computer Vision-Based Video Analytics

Pattern learning and object recognition are the inherent tasks that a computer vision (CV) technique must deal with. Object recognition encompasses both image classification and object detection [22]. The task of recognizing the mask over the face in the pubic area can be achieved by deploying an efficient object recognition algorithm through surveillance devices. The object recognition pipeline consists of generating the region proposals followed by the classification of each proposal into related classes [24]. We review the recent development in region proposal techniques using single-stage and two-stage detectors, general techniques for improving detection of region proposals, and pre-trained models based on these techniques. Automated monitoring systems are used to monitor and control activities, behaviors, changing data information of people, in the purpose of protecting, managing, or directing them. CV helps to take this control and decisions, by being a good replacement of human visual ability. In surveillance systems, cameras are used for detecting or tracking objects, parking analysis, traffic detection, or even crowd analysis [11], [15], [19]. Many kinds of research have been conducted on aspects of face detection, such as identification, verification [16], or alone face detection [24], [27]. Using mask detection in such a system plays the main role such as protecting from intruders [25], [26]. This paper seeks to design a real-time solution for an automated control system that reads streaming videos from multiple IP cameras connected to a network. The proposed software detects any face present in the field of view of the cameras, measures the temperature, and detects the mask to decide by sending a dedicated notification. The system is running seamlessly without any connectivity with the user, easy to set it up, flexible, and extendable.

2.4 Artificial Intelligence and Machine Learning

Artificial intelligence (IA) is any technique that aims to enable computers to show similar human behavior, including, machine learning, natural language processing (NLP), speech synthesis, artificial vision, robotics, analysis sensor, optimization, and simulation. Machine learning (ML) is a subset of artificial intelligence techniques by which computer systems can do this learn from previous experiences (i.e., observe data) and improve one's behavior for a particular task. ML techniques include support for vector machines (SVM), decision trees, Bayesian learning, k-means grouping, learn to join rules, regression, neural networks, and more. Artificial neural networks are a subset of ML techniques freely inspired by biological neural networks. Deep learning (DL) is a subset of LV that enables multi-layer computational LV.

Machine learning techniques are nowadays routinely used in commercial systems for speech recognition, computer vision, and spam detection. To date, the primary theoretical advances in machine learning have been for passive supervised learning problems [28], where a target function (a classification rule) is estimated using labeled examples only. For example, in spam detection, and automatic classifier to label emails as "spam" or "not spam" would be trained using a sample of previous emails labeled by a human user. The goal here is then to get as high accuracy as possible using as little labeled data as possible. For most modern practical problems, however, there is often useful additional information available in the form of cheap and plentiful unlabeled data: e.g., unlabeled emails for the spam detection problem. However, their theory has been lacking in several substantial ways. For example, there has been significant disagreement over when unlabeled data or interaction can help, and how to reconcile mathematical and intuitive views of kernel functions. In this thesis, we develop a new and fundamental theoretical understanding for these new learning approaches, as well as new robust learning algorithms with strong sample size and accuracy guarantees. The idea of image retrieval was created by the Database Management community in a conference organized [29]. The early schemes consisted of annotating the images by text to consequently use database management systems. However, these kinds of approaches have problems in generating descriptive texts for large collections of images. Automatic generation is not yet feasible, thus a lot of labor is required to manually annotate the images, which is an expensive task. Moreover, manually image annotations (e.g. metadata) are affected by the subjectivity of human perception and different people might perceive images in different ways. Faced with these limitations, the computer vision (CV) community introduces [30]. Image Classification is based on visual features of images and puts textual representations in the second plan. After that and until today, a lot of new techniques were developed around the concept of Image Classification.

Finally, we also revisit the classic problem of Clustering (or unsupervised learning) that has not been satisfactorily captured by existing models. In the following, we describe the main learning approaches we analyze in this thesis.

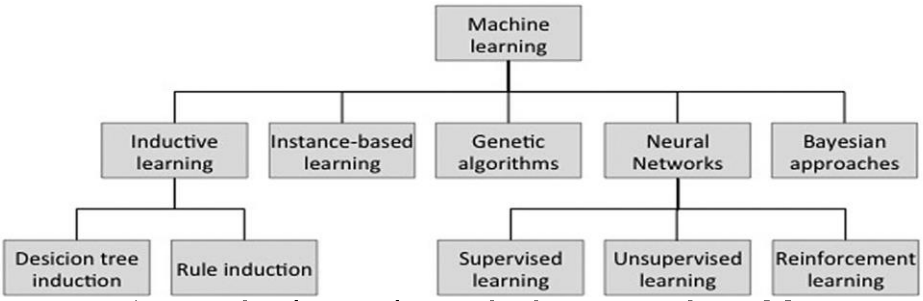

Figure 1. Classification of main Ml techniques according to [2].

2.4.1 The Machine Learning Process

The application of DM in many areas of life has led to a cycle of the inter-industry standard data mining process consists of six phases:

1. Business insight is mainly based on the formulations provided for research and data description.
2. Understanding of the data is based on the submitted data and accompanying documentation.
3. Data preparation consists of data transformation, data analysis (EDA), and data engineering.

Features Each of them can be divided into smaller secondary passages; for example design, a feature is feature selection.

4. In the modeling phase, different ML algorithms with different parameter calibrations can be applied. Combining Variability of data and parameters can lead to extensive repetition of the train test model evaluation cycle, if the data to a large extent, the modeling phase imposes time-consuming and budget-intensive requirements Phase.
5. Evaluations can be conducted according to different criteria for a thorough examination of the AA model to select the best model for the implementation phase.
6. The implementation phase, also known as the production phase, involves the use of a trained ML model for its management functionality, as well as how to create a data pipeline in production. The group of the first five phases, called the development phase, can be repeated with different scenarios based on evaluation results. The

implementation phase is crucial for the actual production below recurring requests; this includes evaluation, monitoring, model maintenance, diagnosis, and online retraining. The need to emphasize that ML algorithms learn from data. Therefore, in practice, the stages of understanding and preparation are expected and the data can take up a large part of the total DM project time.

2.5 Convolution Neural Network and Detection Techniques

An Efficient Moving Object Detection Algorithm Using Multi-mask The advantage of his project is, Motion object detection is the basis of video surveillance, and background subtraction is commonly used to detect moving objects, but how to build and maintain a background model is very critical, and what's more, one background model can't solve all complex background problems. This paper presents the Mask Motion Object Detection (MMOD) algorithm, which synthesizes the thoughts of background subtraction and frame difference, frame difference mask, and background difference mask are generated and utilized to detect moving objects. The morphological post-processing method is introduced to reduce noise and improve detection precision. It is proved by testing with a standard sequence provided by the MPEG organization and outdoor/indoor sequence captured by us that the MMOD algorithm achieves good detection results [32]. This can save human resources, costs and increase the effectiveness of the surveillance system operation. One of the common requirements of Video Analytics for security is to detect the presence of a masked person automatically. In this paper, we propose a technique for masked face detection using four different steps of estimating distance from the camera, eye line detection, facial part detection, and eye detection. The paper outlines the principles used in each of these steps and the use of commonly available algorithms of people detection and face detection. This unique approach for the problem has created a method simpler in complexity thereby making real-time implementation feasible. Analysis of the algorithm's performance on test video sequences gives useful insights to further improvements in the masked face detection performance [33]. The neural network is a collection of artificial neurons interconnected with each other that exchange messages. [34] Connections have numerical weights which are tuned during the training process, so that when obtainable with an image or pattern to be identified, a suitably trained network responds correctly. The network consists of several features detecting "neuron" layers. Convolutional end-to-end pixels have achieved good performance: not only has the overall image classification improved, but also an improvement, advancement/growth has been made on the local task with well-defined output. Hence, it has been substantially used for image classification and detection. If a standard multi-layer perceptron is used, then CNNs will soon find it difficult to calculate because the dimensions of the image are too high. CNN does not list any space-related information. If we utilize the pooling layer feature, the overall efficiency will be low. Because only the most active neurons can be diffused amongst each layer during the transfer of neurons, CNNs provide low spatial resolution due to the large loss of neurons from the pooling layer. CNNs will not be able to correctly interpret the differences in posture and other aspects. There are many diverse methods for solving this problem, but it usually requires more time and more computing resources. Traditional neural networks are poorly indicative for images with a lot of overlap, mutual occlusion, and different backgrounds. The results of classifying these data are not accurate enough. Over several years, updates have been made to CNN to optimize its performance in the diagnostic process. The first current CNN network was first established by [35] and his LeNet model. As a result, many basic architectures have been proposed by CNN. Lu showed the efficacy of CNN with a sparse 1-layer architecture and a low filter size to recognize faulty data in biomedical signal data.

2.6 Face Mask Detection Techniques.

There are many techniques are used for face mask detection. Some of them are explained below. In 2012, Face Detection using Convolutional Networks and Gabor Filters [36] proposed by Bodan Kwolek was used to detect facial regions by composing a Gabor Filters and a convolutional neural network. Gabor Filter is concentrated on extracting the intrinsic facial features. The main advantages of the Gabor Filter allow the signal analysis at different scales and resolutions. The convolutional neural network layer consists of one or more planes. Totally 6 convolutional neural networks were used here. As a result, it showed providing better recognition and high rate in face detection than the alone performance of CNN. In 2016, Face recognition and authentication using LBP and BSIF [4] was proposed by Naveen, Dr. R.S Moni. Here introduce a face recognition and authentication method for the detection and elimination of masks. The local and global facial features are used to realize a real face and a masked face. A 3D mask data-based 3DMAD used here by the combination of LBP (Local Binary Pattern) and BSIF (Binarized Statistical Image Features) extract textures for face authentication. The steps are included here face detection, feature extraction, face recognition, and face authentication. Feature extraction finds out the global and local features for the face region. The nose and eye region features are included in local features. By the classification of these features, finds the real or masked face through the face recognition process.

2.7 Industrial Internet of things (IoT) In Image Detection.

Presently, IoT is a rapidly emerging technique in the industry context. It is the union of wireless networking, software processing, and computer networking. Internet of things combines various physical things such as buildings, vehicles, and dissimilar devices embedded with intelligent sensors and allows these objects to exchange and collect data [37]. The aim of using IoT is to share information and data all around the world. In addition, it provides automation by using various procedures to enhance our daily life [38]. IoT is an energetic worldwide wireless networking of daily objects connected to the Internet. IoT is the connection of virtual and physical things accessed via the Internet. A Wireless Sensor Network is used to connect sensors, in get data with a server or unique system to work. IoT aims to connect the whole world through many intelligent places to automate, develop, and simplify human life [37]. IoT transmits the information from systems that examine and command the physical world to data managing systems that intelligent cloud computing has presented to be an essential platform for meeting the data handling constraints. Our research introduces an intelligent IoT remote sensing of face detection and control system based on UAV. The IOT gateway provides automatic integration of UAV into an industrial system, while UAV photographs are scientifically and instantaneously calculated and examined in the cloud [39].

3.0 PROPOSED MASK AND UNMASKED DETECTION TECHNIQUE IN A VIDEO

3.1 Proposed System Approach

Our proposed system approach upgrades the existing detection and controls systems using Artificial Intelligence. The system must have a modular architecture and be configurable based on the application (e.g. access control, intrusion detection, fleet management, etc.). The proposed system must be reliable, easy to operate, and implemented using low-cost hardware and software. It should also benefit from the use of existing hardware such as Closed-Circuit TeleVision (CCTV) and access control systems. In the context of the new COVID19 pandemic, the aim is to prevent the spreading of the coronavirus inside premises such malls, shops, cafes, or public places. In this case, access to the premise is granted based on mask detection and body temperature. In the proposed system we try to design a hybrid model for image analysis. A hybrid model using deep and classical machine learning for face mask detection will be presented. A face mask detection dataset consists of a mask and without mask images, we are going to use OpenCV to do real-time face detection from a live stream via our webcam. We will use the dataset to build a COVID-19 face mask detector with computer vision using Python, OpenCV, Tensor Flow, and Keras. Our goal is to identify whether the person on the image/video stream is wearing a face mask or not with the help of computer vision and deep learning. Machine learning works with large amounts of data. It is useful for small amounts of data too. Deep learning on the other hand works efficiently if the amount of data increases rapidly. This proposed hybrid model use OpenCV library to train the images for the system by taking a collection of both mask images and images without a face mask. This proposed hybrid model can easily find out those who are having face masks and those who are not having face masks easily from a static image or a video sequence.

3.2 System Architecture

The proposed system approach has a simple architecture. It is mainly composed of three parts namely, the sensing module, the remote processing module, and the notification and control module. These modules are implemented using hardware and software components. In a typical access control scenario, when the user shows up at the main entrance of a premise, his face is detected and recognized by the system and the door opens granting the user access to enter the premise. In the particular case of the COVID-19 pandemic, access is not granted unless the user wears properly a mask on his face and has an appropriate body temperature. Thus, when the user is in the proximity of the system sensors, his face is captured, and his temperature is measured. These data are fed to the remote processing system for more analysis. At this stage, CV-based video analytics algorithms are applied to detect the mask on the user's face, measure the temperature, and, if allowed, grant access. Access is granted using the control and notification module. Each part of the system architecture is detailed in the following paragraphs.

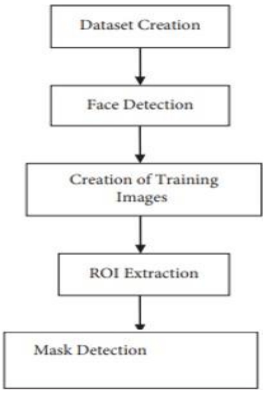

Fig.1 System Architecture

3.2.1 Convolutional Neural Network

The convolutional layer performs as the main building block of the CNN process, which does most of the computing operations. In this layer, the CNN usually detects basic features, such as the shape of edges from the input image. In this paper, three convolutional layers were applied to achieve the best performance of the model. Conservatively, the first layer is responsible for capturing the low-level features, such as color, gradient coordination, edges, and angles. When the architecture goes through another convolutional layer, the output of the first layer becomes the input of the second layer. With more layers being added, the architecture adapts to high-level features, such as a combination of curves and straight edges.

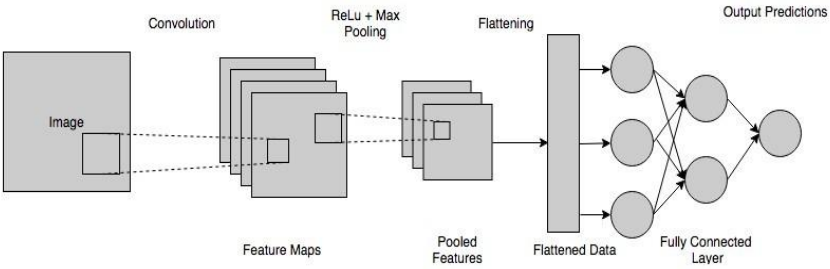

Fig.3 A. Experimental setup

An object detector is designed to extract features from input images and then to feed these features through a prediction model that draws boxes around objects and predicts their classes. The model is the first object detector to connect the procedure of predicting bounding boxes with class labels in an end-to-end differentiable network. Figure 3 gives a full functional description of the automated software. During the first process, the captured image undergoes multiple steps. First, the image is converted from RGB to grayscale to reduce the image variability, because luminance is by far more important in distinguishing visual features. Second, histogram equalization is applied to help adjust the contrast of the image in two different cases: dark or light background. Third, noise reduction removes color noise. This will help increase the focus on the detected object. And the fourth step, image resizing is applied. As known, less size gives fewer pixels which means fewer details. The second process consists of analyzing the preprocessed images to detect the mask. It is a CNN-based algorithm that aggregates and forms image features at different granularities.

3.2 2 Dataset Description and Using Tensorflow

We have been using the latest versions of Tensorflow. It comes with some advantages, such as:

We do not need to implement lower-level operations. It allows us to focus on higher-level implementations, such as pruning, or factorization. Machine learning models depend mainly on data. Without applying high-quality training data even, the most well-functioning computer algorithms can be impractical. Hence, no other element is more fundamental in machine learning techniques other than quality training data. Training data indicates the original data that is used to improve the model. The model uses the training data to build and improve itself. The quality of this data has deep effects on the model’s succeeding development, which helps in setting a powerful model for any future applications that may use the same training data. Training data in machine learning involves a human contribution to examine and develop the data for machine learning procedures. The dataset consists of 703 images of people who inappropriately wear a mask, 690 images of people who wear masks, and 686 images of people who do not wear a mask at all.

1) Data Collection Module

The majority of the images were augmented by OpenCV. The set of images was already labeled “mask” and “no mask”, seen in the appendix column. The images that were present were of different sizes and resolutions, probably extracted from different sources or machines (cameras) of different resolutions.

2) Data Pre-Processing Module

Pre-processing steps as mentioned below was applied to all the raw input images to convert them into clean versions, which could be fed to a neural network**.** Resizing the input image (256 x 256). Applying the color filtering (RGB) over the channels (Our model MobileNetV2 supports 2D/3 channel image) 3.Scaling / Normalizing images using the standard mean of PyTorch build in weights

3) Training the CNN Model Apply Mask Detector Using Image Or Video

To implement this deep learning network we have the following options.

3.2.4 Feature Extraction and Selection

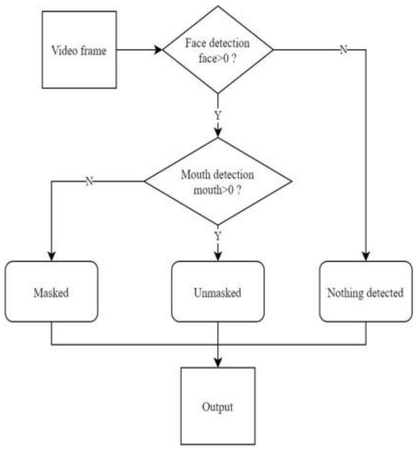

Fig. 7 Feature Extraction and Selection

1) Step 3 Data Pre-processing

Data pre-processing is divided into four steps which are resizing images as we know more the smaller size of the image better will be the model so we will resize images to 224 x 224 pixels, convert images into the array, pre-processing input using and last is performing hot encoding on labels.

The next will be splitting the data.

Final Step: Implementing the model:

Step 4: Testing the model

Step 5: Applying camera in the model

Step 6: Running and checking the output

The video needs to read from frame to frame, for the face detection algorithm to work. If a face is been detected, then it proceeds to the next step. From the frames that detected the containing faces, reprocessing will be carried out which would be including resizing the image size, converting to the array, pre-processing input using OpenCV. The next step is to predict the input data from the model which is saved. Predicting the input image which has been processed using a model built earlier. The video frame will also be labeled according to whether the person is wearing a mask or not and also predictive percentage. It will also start beeping if a person is not wearing a mask. In the proposed work, facemask detection is achieved through deep neural networks because of their better performance than other classification algorithms. But training a deep neural network is expensive because it is a time-consuming task and requires high computational power. To train the network faster and more cost-effectively, deep-learning-based transfer learning is applied here. Transfer learning allows to transferring of the trained knowledge of the neural network in terms of parametric weights to the new model. It boosts the performance of the new model even when it is trained on a small dataset. There are several pre-trained models like AlexNet, OpenCV ResNet50, etc. that had been trained with 14 million images from the ImageNet dataset [40]. In the proposed model, ResNet50 is chosen as a pre-trained model for facemask classification. The last layer of ResNet50 is fine-tuned by adding five new layers.

3.3. Convolutional Neural Network and Convolution process

3.3.1 Training of Model

a) Building the model using CNN architecture: CNN has become ascendant in miscellaneous computer vision tasks [12]. The current method makes use of Sequential CNN. The First Convolution layer is followed by Rectified Linear Unit (ReLU) and Max Pooling layers. The Convolution layer learns from 200 filters. Kernel size is set to 3 x 3 which specifies the height and width of the 2D convolution window. As the model should be aware of the shape of the input expected, the first layer in the model needs to be provided with information about the input shape. Following layers can perform instinctive shape reckoning [13]. In this case, the input shape is specified as data. Shape [1:] which returns the dimensions of the data array from index 1. Default padding is "valid" where the spatial dimensions are sanctioned to truncate and the input volume is non-zero padded. The activation parameter to the Conv2D class is set as "relu". It represents an approximately linear function that possesses all the assets of linear models that can easily be optimized with gradient-descent methods. Considering the performance and generalization in deep learning, it is better compared to other activation functions [14]. Max Pooling is used to reduce the spatial dimensions of the output volume. Pool size is set to 3 x 3 and the resulting output has a shape (number of rows or columns) of: shape of output = (input shape - pool size + 1) / strides), where strides has default value [15].

3.3.2 Data extraction

A. Face Mask Detection

For face mask detection, we choose the Haar cascade classifier (HCC) for face and facial features detection due to its efficiency and availability. HCC is a machine learning approach where the classifier is trained from positive and negative images. The training process consists of two major stages: the Haar features extraction and assignment of the Haar features into a cascade of classifiers [2]. In the feature extraction stage, three groups of features are used as shown in Figure
2. Each feature is calculated using the equation:

$$\text{feature score} \quad \frac{\sum}{\sum}$$

where $\sum$ is the sum of pixels in the white rectangles, and $\sum$ is the sum of pixels in the black rectangles. Figure 3 demonstrates two features calculated on a training image. The training image is of fixed window size, and every feature is calculated on the image to get a feature score. However, a video frame cannot be pushed into the face mask detection algorithm immediately. Another significant delay comes from copying the current video frame to a buffer, Copying frame to buffer is required for freezing the frame, and failing to do so results in the buffer being changed while still waiting for processing in the face mask detection algorithm. The delay cannot be avoided by multithreading as the video buffer needs to stay in the current frame until the copy procedure finishes. In our test, the buffer copying brings about a 47.2ms delay on average. The frame rate thus can be estimated to be

$$G(x,y) = \sum_i \sum_j h[j,k][x+(-j), y+(-k)], \tag{1}$$

where h denotes the input matrix as shown in Figure 2.

(b) Padding of images can be defined as

$$p = \frac{(f-1)}{2}. \tag{2}$$

Here, f is the filter dimension.

(c) Convolutional network can be defined as

$$F(x) = \max(0, x). \tag{3}$$

(d) Final predicted classes can be obtained as

$$C = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_i}}. \tag{4}$$

$$d = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}. \tag{5}$$

Here, $i, j = 1, \ldots, N$, are directions.

(f) Pixel density ratio can be evaluated as

$$\text{pdr} = \frac{R_h}{P_h}. \tag{6}$$

Here, R_h shows the real height of the images in mm. In this paper, $R_h = 1000$. P_h represents the pixel height of the person in the frame in mm.

(g) Dimensions of the output matrix are given by

$$N_{\text{out}} = \text{floor}\left(1 + \frac{n + 2p - f}{s}\right). \tag{7}$$

Here, n is the image size. f is the filter size. p is padding and s is the stride, respectively.

This frame rate can be improved by adding a small delay between each detection, as increasing the detection time will increase the denominator in equation (3), though at the cost of an increased detection delay.

3.4 Machine Learning Libraries

These are used to predict the class/target/labels/categories of a given data point. Classification belongs to the category of supervised learning in which the targets are provided with input data. Deep Learning Deep learning is an artificial intelligence function that imitates the workings of the human brain in processing data and creating patterns for use in decision making. Deep learning is a subset of machine learning in artificial intelligence that has networks capable of learning unsupervised from data that is unstructured or unlabeled. Also known as deep neural learning or deep neural network: OpenCV, TensorFlow, Keras, and Python

4.0 EXPERIMENTATION AND DISCUSSION

4.1 Implementation and Experimentation

First, a base model is generated. This is done by using Keras and MobileNetV2. First, a base model is generated and a head model is generated on top of that. The head model consists of a network with 128 layers, an activation function of "Relu" and a dropout of 0.5 followed by another network with 2 layers and an activation function "softmax". All these three layers combined will give out a model which will be trained.

The trained model is loaded and an image that contains human faces with or without masks or a continuous video stream with humans is given as input. The image or a frame of the video, in case the input is a video stream, is first sent to the default face detector module for the detection of human faces. This is done by resizing the image or the video frame first, followed by detecting the blob in it. This detected blob is sent to the face detector model which outputs only the cropped face of a person without the background. This face is given as the input to the model which we trained earlier. This outputs whether there is a mask or not.

Another model is trained with the faces of humans. The images used for the training of the model are provided with the name and email address of that person as the labels of those images. This is done by using Open CV. When an input image is given to the CV model, it detects the face of a person and asks the user to provide the name and email address of that person which will be stored in the database. The output of the first model is given as the input to this model. This face will be compared with the persons present in the database. And if his face matches, then a bounding box will be drawn over his face with his name on it and an email and Sms will be sent to him that he is not wearing a mask. Else, only the words "Mask" will be present below the bounding box if the person is wearing a mask and "No Mask" if the person is not wearing one.

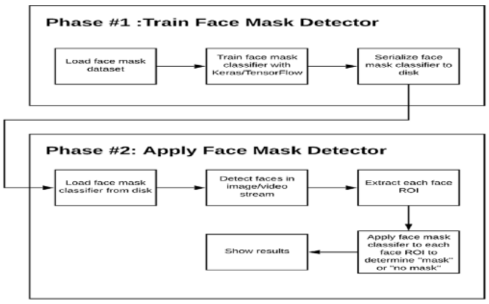

Fig. 8 Implementation and Experimentation

4.2 Data Preprocessing and Training our model

4.2.1 Data pre-processing

In machine learning, performing data pre-processing is a very significant step that helps in improving the quality of data to help the extraction of important understandings from the data. In data pre-processing, the data is getting cleaned and organized to become proper for building and training a model. For both datasets, images were converted to grayscale instead of color channels. The main purpose of using grayscale is to simplify the algorithm as well as reduce computational requirements to help in the extracting descriptors process. Also, for both datasets, images were resized to 100x100, resizing images is a very crucial step in the preprocessing step because machine learning models tend to train faster on small-sized images. Also, resized images are easier for the model to deal with since they are in the same dimensions. Likewise, in both datasets, the data was split into two datasets, which are training and testing.

4.2.3 Data Processing

Data preprocessing involves the conversion of data from a given format to a much more user-friendly, desired, and meaningful format. It can be in any form like tables, images, videos, graphs, etc. This organized information fit in with an information model or composition and capture the relationship between different entities [6]. The proposed method deals with image and video data using Numpy and OpenCV.

a) Data Visualization: Data visualization is the process of transforming abstract data to meaningful representations using knowledge communication and insight discovery through encodings. It is helpful to study a particular pattern in the dataset

4.3 Testing and Implementation of the Model on Real Data IMAGE/VIDEO

In this thesis, a performance accuracy of 97.1% was achieved from using the Deep
Supervised Learning techniques, including Convolutional Neural Network (CNN) and Transfer Learning. The approach did not just stop at finding out the accuracy percentage but also printing out the arguments of the maxima with a given data, and results were tested and found accurate as well. In this approach, the predicted class matched with the real class proving that the model worked. People who wear a face mask were set to class.

4.3.1 Pre-trained Model Training and Testing Results

In this thesis, to achieve the best accuracy results of the pre-trained model, 30 epochs were applied. Figure 33 illustrates a graph of comparison in loss between training and testing of the pre-trained model over 30 epochs. Also, figure 34 presents a graph of comparison in accuracy training and testing of the pre-trained model over 30 epochs. Each graph illustrates that the loss is getting lower while the accuracy is getting higher when applying more epochs. Figure 35 also shows that with every applied epoch, the training accuracy percentage is getting higher.

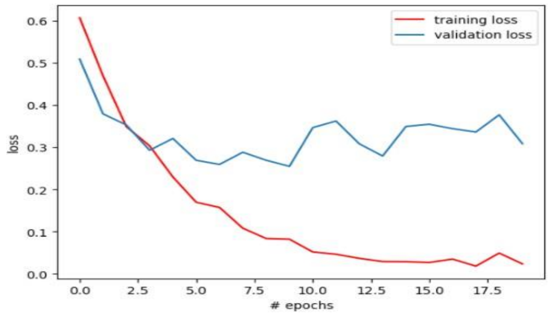

Figure 10: Pre-trained Model Training vs. Testing Loss

In this experiment, the CNN model was built using three convolutional layers by setting kernel size to 5x5, and the stride was set to 1. Also, after each convolutional layer, ReLU was applied. Likewise, 2x2 max-pooling was also used as well as two fully connected layers were added. Additionally, batch size was set to 100, and the learning rate was set to 0.001. Moreover, Adam optimizer and MSE loss function were used during this experiment. The model was set to run for 30 epochs. After 30 epochs, the model achieved 87.5% accuracy results, which are lower than Experiment 1 pre-trained accuracy results. Figure 41 presents the best testing accuracy result was achieved during the pre-trained model.

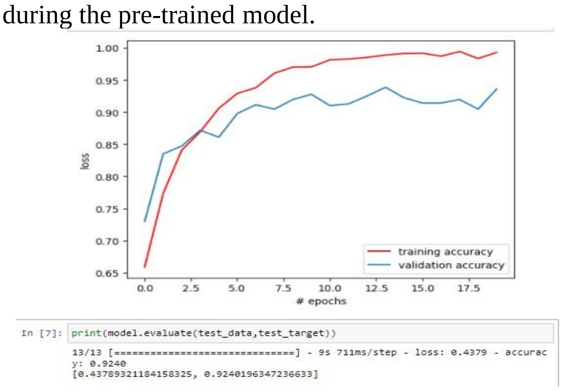

Figure 11 Transfer Learning Training and Testing Results

In the experiment, the Face Mask Detector dataset was applied without the third class, namely images of people who incorrectly wear a face mask. The transfer learning model was built using only two classes, which include people who wear a face mask, and people who do not wear a face mask. During this step, the saved CNN model had been used except the output layer. Thus, adjusting the output layer to the number of target dataset classes was an essential step. For example, the initial pre-trained CNN model had three classes, but the new output layer in the CNN model had two classes. Also, during the transfer learning, the learning rate was lowered to 0.0001, a batch size of 100, MSE Loss function, and Adam optimizer was used. In this experiment, the model achieved a testing accuracy result of a 98.5% after applying just 9 epochs. Figure 42 presents the testing accuracy results after applying transfer learning techniques

4.3.2 Pre-trained Model and Transfer Learning Model

In this approach, the Convolutional Neural Network (CNN) model was initially built to train and identify people who wear a face mask. Later, the same CNN model was reused to apply transfer learning to classify a new dataset that also contains people who wear a face mask incorrectly. Table 2 presents a comparison in loss between the pre-trained model and the transfer learning model. In this approach, the pre-trained model achieved 91.5% accuracy results after applying 30 epochs, while the transfer learning model achieved 97.1% accuracy results after applying 9 epochs only. As the graph shows, the loss started much lower in transfer learning than the pre-trained model, which indicates the application of transfer learning and fine-tuning techniques improved the model's accuracy results. Likewise, figures 36 and 37 present graphs indicating a comparison of loss and accuracy results between training and testing of the transfer learning model.

4.4 Predictions on Video

In this experiment, to ensure the effectiveness and accuracy of the proposed model, testing and predicting real-world images were proposed. In this approach, the CNN model was deployed on images from mobile devices. This approach was presented with new challenges due to the illumination, angle, and resolution of images. All the mentioned challenges were not described in training and testing previous datasets. Feeding real-world images into the proposed model is important to test the effectiveness of the model. Correct predictions indicate that the model is reliably integrated with designing a real-world application for classifying facial recognition and face mask detection. As previously mentioned, people who wear a face mask were labeled with class 0, people who do not wear a face mask were labeled with class 1, and people who wear a face mask but incorrectly were labeled with class figure 12, and 13 present examples of real-world images that were used to conclude that the proposed CNN model was able to match each image with its correct class. This indicates that the CNN model of this experiment is highly effective and provides accurate results.

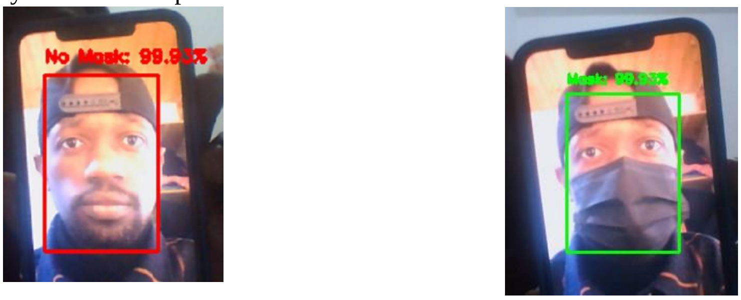

Figure 12: No Mask and Mask Detection)

Validation Accuracy

In this study, the results of the previous capture presented the developed significant performance accuracy results of 99.97 with no mask in the video and 98.14 with mask in the live camera or video%. In experiment 2, Face Mask Detection Dataset was used for the pre-training of the CNN model, but another class was added. The extra class was collected from the Face Mask Detector dataset, the validation accuracy is an important metric used to predict the performance of an algorithm. +e model is validated by calculating both metrics–loss, and accuracy. The validation accuracy against each value of validation loss for the different training images is shown in Table 3. The last column shows that the validation accuracy is always less than 1 and it is expressed as a percentage after multiplying that value by 100. It may be observed that the validation accuracy fluctuates as the validation loss is decreased by increasing the number of training images from 4000 to 14000. So, this portion is referred to as overfitting (as shown earlier). Beyond that, if we increase the number of training images from 16000 to 18000, the accuracy decreases with the increase in loss. It means that the model is learning correctly. Figure 7 shows the variation of the validation accuracy with the increase in the number of training image

CONCLUSION

In this project, a machine learning model is created for face mask detection using Python, Keras, and OpenCV. We developed the face mask detector model for detecting whether the person is wearing a mask or not. We trained the model using Keras with network architecture. Training the model was the first half of our project and testing it using the webcam using OpenCV in the second half. This system can therefore be used in real-time applications and places where required face mask detection for safety purposes due to the outbreak of covid-19. The system can detect the mask-wearing status of persons showing up in a camera feed or video stream in general, and mark the detection result on the video output. Haar cascade classifiers are used for the face mask detection algorithm. Different delays are analyzed in an attempt to reduce the delays in the system to achieve real-time detection. In the end, the detection system is demonstrated to be able to run at 45.79fps in 720P, with a

0.13 detection delay and a detection precision of 96.5%. For future works, the face and facial detection algorithm can be modified to use CNN or other deep learning techniques for a better detection rate. The detection algorithm can also be implemented in the programmable logic array for lower detection delay. In this paper, we briefly explained the motivation of the work at first. Then, we illustrated the learning and performance tasks of the model. Using basic ML tools and simplified techniques the method has achieved reasonably high accuracy. It can be used for a variety of applications. Wearing a mask may be obligatory shortly, considering the Covid-19 crisis. Many public service providers will ask the customers to wear masks correctly to avail of their services. The deployed model will contribute immensely to the public health care system. In the future, it can be extended to detect if a person is wearing the mask properly or not. The model can be further improved to detect if the mask is virus prone or not i.e. the type of the mask is surgical, N95, or not. To deploy this system at locations of Mass populations remotely to maintain the observations of rules and regulations in a strict manner. To integrate the system with a GSM module so that it can raise an alert to the authorities if a mass violation happens. Our future works include alarm if somebody is not wearing a face mask properly, and detection of the social distancing.

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