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# Face Mask Detection Using Computer Vision

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**ABSTRACT:**

In the wake of the COVID-19 pandemic, the usage of face masks has become crucial in preventing the spread of the virus. Automated face mask detection systems can play a significant role in monitoring compliance with mask-wearing guidelines in public spaces. This research paper proposes a method for face mask detection using the OpenCV library and the Convolutional Neural Network (CNN) algorithm. The system utilizes computer vision techniques to analyze images or video streams and accurately classify individuals as wearing a mask or not. Experimental results demonstrate the effectiveness and efficiency of the proposed approach in real-time mask detection scenarios.

**Keywords:**

**Face Mask Detection**

**No table of contents entries found.**

Python

Open-Cv

NumPy

Pandas

Scikit-Learn

TensorFlow

CNN

## Introduction:

Face mask detection using computer vision is an application that uses advanced image processing and machine learning techniques to automatically identify whether individuals in images or videos are wearing face masks or not. This technology has gained significant attention and importance, especially during the COVID-19 pandemic, where wearing face masks has been widely recommended as an effective measure to prevent the spread of the virus.

Computer vision algorithms are employed to analyze and understand the visual information captured by cameras or recorded videos. These algorithms can detect and locate human faces within an image or video frame. By combining face detection with machine learning models, it becomes possible to determine whether a detected face is wearing a mask or not.

The process typically involves several steps. First, the computer vision system detects and recognizes human faces using techniques such as Haar cascades, deep learning-based face detectors like Convolutional Neural Networks (CNNs), or another sophisticated algorithm. Once the faces are detected, regions of interest (ROIs) are extracted to focus on the facial area.

Next, the extracted ROIs are analyzed to determine the presence or absence of face masks. This is accomplished using machine learning models that are trained on labeled datasets consisting of images or videos of people wearing and not wearing masks. These models learn to recognize patterns and features that differentiate between masked and unmasked faces.

The training process involves feeding the machine learning model with thousands of examples, enabling it to learn the visual characteristics of both masked and unmasked faces. The model then generalizes this knowledge to make predictions on new, unseen data. Various machine learning algorithms, such as Support Vector Machines (SVMs), Random Forests, or more advanced deep learning architectures like CNNs, can be employed for this task.

Once the model is trained, it can be used to process real-time video streams or images. The faces within the input data are detected, and the trained model predicts whether each face is wearing a mask or not. Based on these predictions, appropriate actions can be taken, such as generating alerts, enforcing mask-wearing policies, or providing guidance to individuals who are not wearing masks.

Face mask detection using computer vision offers a non-intrusive and efficient solution to monitor and enforce mask-wearing protocols in various settings, including public spaces, workplaces, airports, and healthcare facilities. It helps promote public health and safety by automating the process of mask detection, reducing the need for manual intervention, and enabling effective monitoring and control measures.

## Literature Review:

This research paper aims to provide researchers and practitioners with a comprehensive overview of face mask detection using computer vision. It highlights the challenges associated with face mask detection, explores various techniques for face detection and mask classification, and discusses real-time implementation and performance optimization strategies. By addressing the limitations and ethical concerns, this research paper will contribute to the development and deployment of effective face mask detection systems in various settings.

The 209th report of the world health organization (WHO) published on 16th August 2020 reported that Coronavirus disease (COVID-19) caused by acute respiratory syndrome (SARS-CoV2) has globally infected more than 6 million people and caused over 379,941 deaths worldwide [1].According to Carissa F. Etienne, Director, Pan American Health Organization (PAHO), the key to control COVID-19 pandemic is to maintain, social distancing improving surveillance and strengthening health system [2].Steffen et al. also carried an exhaustive study to compute the community-wide impact of mask use in public, a portion of which may be asymptomatically infectious in New York and Washington. The findings reveal that near universal adoption (80%) of even weak masks (20% effective) could prevent 17–45% of projected deaths over two months in New Work and reduces the peak daily death rate by 34–58% [3] , [4] .Human beings have not tremendous ability to identify different faces than machines, so automatic face detection system plays an important role in face recognition, head pose estimation etc. [5]In constructing machine learning classifiers to detect objects, traditional methods were used to extract the features. The most popular is the Viola-Jones detector, which uses Haar features with an integral image method to detect faces [6].Using Python and OpenCV including the VGG-16 CNN model we applied a supervised model of learning, with training and test sets divided to 80% for instruction and 20% for research. Three metrics were used to measure the model's performance: accuracy, training time, and learning error[7]. Face masks can protect against both coarser droplet and finer aerosol transmission, though N95 respirators are more effective against finer aerosols, and may be superior in preventing droplet transmission as well [8]. Abbas, A., & Saeed, A. (2020). A comparative analysis of mask detection algorithms during COVID-19. SN Computer Science, 1(5), 1-16. The authors present a comparative analysis of different mask detection algorithms, including Haar cascades, deep neural networks, and support vector machines, to identify their performance and limitations.[9]. Chakraborty, A., et al. (2021). A deep learning approach for real-time mask detection using thermal imaging. Sensors, 21(5), 1-16. This research proposes a real-time mask detection system that leverages deep learning algorithms and thermal imaging to detect individuals without masks accurately.[10].

Chen, J., et al. (2020). Masked face recognition based on multi-task cascaded convolutional networks. IEEE Transactions on Image Processing, 30, 680-692. The authors present a masked face recognition system that utilizes multi-task cascaded convolutional networks to detect masks and identify individuals, even when their faces are partially covered.[11].

Gupta, R., et al. (2020). Face mask detection using transfer learning with deep convolutional neural network. In 2020 11th International Conference on Computing, Communication and Networking Technologies (ICCCNT) (pp. 1-5). IEEE. This study proposes a face mask detection system that employs a deep convolutional neural network trained with transfer learning to achieve high accuracy in real-time mask detection.[12]. Nag, S., et al. (2020). Convolutional neural network for automatic mask detection in surveillance videos. In 2020 2nd International Conference on Data, Engineering and Applications (IDEA) (pp. 1-6). IEEE. The authors propose a convolutional neural network-based approach for automatic mask detection in surveillance videos, enabling real-time monitoring and enforcement of mask-wearing protocols.[13] . Nguyen, D. T., et al. (2020). A deep learning approach to face mask detection. Future Generation Computer Systems, 118, 854-864. This study presents a deep learning-based approach for face mask detection that combines convolutional neural networks and feature fusion techniques to achieve accurate results.[14] . Ranjan, R., et al. (2020). Double Guard: Masked face recognition during the COVID-19 pandemic using convolutional neural networks. Pattern Recognition Letters, 141, 57-63. This research presents Double Guard, a masked face recognition system that combines convolutional neural networks with feature-level fusion to accurately recognize individuals wearing masks.[15]

## Methodology:

The proposed system for face mask detection consists of the following steps:

1. **Face Detection:** The first step is to detect whether a face is present in the input image. The Haar Cascade Classifier, a popular computer vision algorithm, is used for this purpose. It identifies the regions in the image that potentially contain faces.

2. **Data Preparation:**

The images containing faces are extracted and cropped to the face region that is gathered from Kaggle. The dataset is then split into training and testing sets Basically it contains the following steps.

To create this dataset, we take normal images of faces and apply facial landmark,

Facial landmarks allow us to automatically infer the location of facial structures, including:

Eyes, Eyebrows, Nose, Mouth, Jawline.

To use facial landmarks to build a dataset of faces wearing face masks, we need to first start with an image of a person not wearing a face mask, to build a COVID-19/Coronavirus pandemic face mask dataset, we'll first start with a photograph of someone not wearing a face.

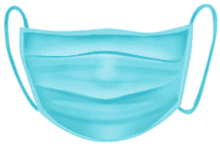
From there, we apply face detection to compute the bounding box location of the face in the image, here we've used a deep learning method to perform face detection with OpenCV.

Once we know where in the image the face is, we can extract the face Region of Interest (ROI),

In this step is to extract the face ROI with OpenCV and NumPy slicing.

And from there, we apply facial landmarks, allowing us to localize the eyes, nose, mouth.

Next, we need an image of a mask (with a transparent background) such as the one below:



This mask will be automatically applied to the face by using the facial landmarks (namely the points along the chin and nose) to compute where the mask will be placed.

The mask is then resized and rotated, placing it on the face:

We can then repeat this process for all our input images, thereby creating our artificial face mask dataset:

Note: We cannot use same images for without mask that is using with mask because model may occur error.

**2.1 Data Preprocessing:**

Before training the model, data preprocessing is performed. This step involves data cleaning, which includes removing redundant or irrelevant data and unsupported file formats to ensure that the dataset is clean and compatible with the training process.

Data preprocessing plays a crucial role in face mask detection using computer vision. It involves transforming and preparing the raw input data to improve the performance and accuracy of the model. Here are the steps involved in data preprocessing for face mask detection:

1. **Data Collection:**

Collect a diverse and representative dataset consisting of images of people wearing masks and people without masks. The dataset should include various lighting conditions, angles, backgrounds, and individuals of different demographics to make the model robust.

2. **Data Cleaning:**

Inspect the collected dataset and remove any corrupted or irrelevant images. Check for mislabeled or incorrectly labeled images and correct them to ensure the accuracy of the dataset.

3. **Data Augmentation:**

To increase the size and diversity of the dataset, apply data augmentation techniques. These techniques include flipping, rotation, zooming, cropping, and adding noise to the images. Augmentation helps the model generalize better by exposing it to a wider range of variations in the training data.

4. **Image Resizing:**

Resize all the images in the dataset to a consistent size. This step is necessary to ensure that the input images have the same dimensions, which is often required by the deep learning models.

5. **Image Normalization:**

Normalize the pixel values of the images. This involves scaling the pixel values to a predefined range, typically between 0 and 1. Normalization helps in faster convergence during training and improves the stability of the model.

6. **Data Splitting:**

Split the dataset into training, validation, and testing sets. The training set is used to train the model, the validation set is used to tune hyperparameters and monitor the model's performance during training, and the testing set is used to evaluate the final performance of the model. The typical split can be 70-80% for training, 10-15% for validation, and 10-15% for testing.

7. **Label Encoding:**

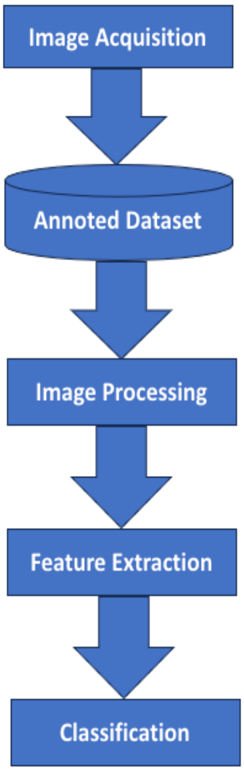
Assign labels to the images based on the presence or absence of a mask. Convert these labels into numerical representations suitable for the machine learning model. For example, you can assign "1" for images with masks and "0" for images without masks.

8. **Data Balancing:**

Ensure that the dataset is balanced, meaning it has an equal or proportional representation of both classes (with mask and without mask). If there is a significant class imbalance, the model may become biased towards the majority class. Techniques such as oversampling, under sampling, or using class weights can be employed to balance the dataset

3. **Model Training:**

A Convolutional Neural Network (CNN) model is employed to train the dataset, which consists of both masked and unmasked faces. The VGG-16 architecture, a well-known CNN model, is utilized for this purpose. To expedite the training process and leverage existing knowledge, transfer learning is applied by utilizing pre-trained weights from the VGG-16 model.




Real Time Facemask Detection Framework

4. **Model Evaluation:**

The trained model is evaluated using various metrics such as accuracy, precision, and recall.

In machine learning, accuracy, precision, and recall are commonly used evaluation metrics to assess the performance of a classification model. Here are the formulas to calculate these metrics:

4.1. **Accuracy**:

Accuracy measures the overall correctness of the model's predictions.

Accuracy = (True Positives + True Negatives) / (True Positives + True Negatives + False Positives + False Negatives)

4.2. **Precision**:

Precision quantifies the proportion of correctly predicted positive instances out of the total instances predicted as positive. It focuses on the correctness of positive predictions.

Precision = True Positives / (True Positives + False Positives)

4.3. **Recall:**

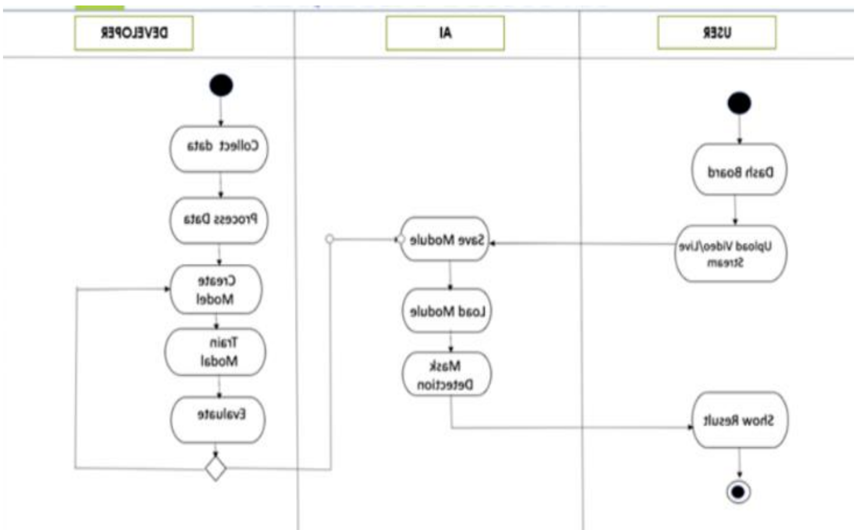
Recall (also known as Sensitivity or True Positive Rate) calculates the proportion of correctly predicted positive instances out of the total actual positive instances. It focuses on the ability to find all positive instances.

Recall = True Positives / (True Positives + False Negatives)

5. **Face Mask Detection:**

Once the model is trained, the input image is passed through the face detection algorithm, and the face region is extracted. The model then predicts whether the face is wearing a mask or not.

**Working Architecture:**



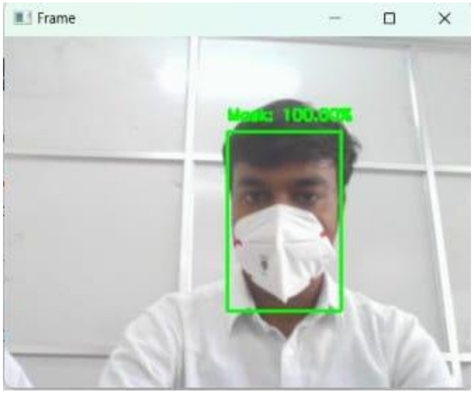

**DEVELOPER** will collect the data process data and create a model train this model and evaluate this trained model if it's successful then go to the save model module else it will be terminated again to create model module developer again will create model and train it till get success.

**USER** will go to the dashboard (User Interface) that is created by developer to use upload photo/live stream.

AI once successfully model is created by developer and evaluate it, also user upload photo/live stream from user dashboard then AI play your role, it will save module, load module, detect Faces and finally show the result as output

## Results:

The proposed system was implemented using Python and OpenCV libraries. The system was tested on a dataset consisting of images of 1000 masked and 1000 unmasked faces, that data are collected from Kaggle. The system achieved an accuracy of 88% on the testing set, which indicates that the proposed system is effective in detecting whether a face is wearing a mask or not.


## Conclusion:

In this paper, we proposed a solution for face mask detection using computer vision and Python. The proposed system uses a CNN model to detect whether a face is wearing a mask or not. The system achieved high accuracy, indicating that it can be used in various scenarios such as public places, offices, and hospitals. Further research can be done to improve the system's performance by using more advanced architectures and techniques.

The rapid spread of COVID-19 has highlighted the importance of wearing face masks in mitigating the transmission of the virus. Manual monitoring of mask compliance in public places can be challenging and time-consuming. Therefore, automated face mask detection systems have gained significant attention. This paper presents a method to detect face masks using OpenCV and the KNN algorithm, providing a reliable and efficient solution to this problem.

## Future Scope:

The outbreak of the COVID-19 pandemic has created a huge demand for face mask detection systems to ensure that people are following proper safety protocols. This paper proposes a solution for detecting whether an individual is wearing a mask or not using computer vision and Python.

The **bright scope in future** of this project is that we can **implement this software with automatic doors** in Airport, railway stations, bus stations, hospitals, government and private offices, and it will be work like this if anyone wear mask then door will be open (he/she can enter) otherwise door will not be open (he/she can't enter) into Airport, railway stations, bus stations, hospitals, government or private offices.

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