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Face Mask Detection through Deep Learning Mechanism

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ABSTRACT: With the ongoing threat of one of the deadliest viral outbreak in the history of mankind there has been a considerable amount of stress on the government and the law enforcement agencies. This is due to the extreme lethality of the covid-19 pandemic which has led to a number of restrictions having been placed on the citizens across the world. These restrictions have been crucial in arresting the development of this ailment and are highly useful for the prevention in the spread. The restriction that is being talked about is the use of facial mask in public places and other crowded locations. There have been numerous techniques for facial recognition but most of these have been unable to process the presence of mask for automatic mask detection through image processing. Therefore to provide a solution for this automatic mass detection this research article utilizes image processing approaches for the purpose of achieving the goal. The methodology implements recurrent neural network and decision tree for achieving the facial mask protection accurately. The experimental results for error rate evaluation have provided promising levels of accuracy which have been stipulated.

KEYWORDS: Recurrent neural network, YC_BC_R model, Color models.

I. INTRODUCTION

A person's facial features are very distinctive and easily distinguishable from those of another. This is why people can tell one person from another based just on their visual traits and attributes. Humans have a particular area of the brain dedicated to recognizing facial traits and other traits to identify different people. Due to trauma or other events, this area of the brain might be injured, resulting in an individual's inability to recognize and collect various people. However, because humans are highly social beings that efficiently interact with one another through facial expressions, this particular characteristic is extremely valuable for communication.

For many people who have grown up in a normal and sociable environment, nonverbal communication comes naturally. Because humans are social creatures, this is a big component of their day-to-day interactions. As a result, unique qualities and qualities play a major role and differ greatly from person to person. As a result, facial features and other aspects of the face are increasingly being used in many applications for easy verification and identification. The biometric analysis of these properties results in a practical and successful implementation that may be used in a range of situations.

A particularly lethal and very infectious strain of influenza has emerged in the last year, causing widespread havoc and death throughout the world. Masks and other protective coverings on the face have been seen as an effective remedy for this problem, preventing the transmission of the virus to a great extent To slow the spread of the virus, governments throughout the world have made it mandatory for people to wear masks when they leave the house.

Therefore there is a requirement of an effective methodology that can automatically identify the existence of a mask for an individual is required to decrease law enforcement agencies' efforts in scanning every person. For this strategy to identify the existence of the mask on an individual's face, computer vision and other image processing techniques might be

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useful. However, due to the presence of the Mask, most existing algorithms that have been designed specifically for this face recognition method are unable to recognize the facial characteristics, resulting in failure.

Therefore this survey article will focus on the examination of common face recognition and face mask identification approaches that have proven useful in developing our strategy for face mask identification using Recurrent Neural Networks and Decision Trees. This strategy will be discussed in greater depth in future editions of this research piece.

This literature survey paper dedicates section 2 for analysis of past work as a literature survey, and finally, section 3 concludes the paper with traces of future enhancement.

II LITERATURE SURVEY

Wei Bu explains that there has been an upsurge in the threat of terrorist strikes in recent years. These assaults are extremely debilitating and can result in extensive property destruction as well as large-scale loss of life [1]. This is a troubling event that must be drastically reduced to establish peace. However, the majority of these attacks are carried out by criminals wearing masks. Therefore, the machine learning approach to image processing may be useful for these techniques to recognize and identify a masked face. Doctors have proposed using a convolutional neural network to execute deep learning for masked face decoding in this technique.

Gayatri Deore states that the traditional video surveillance methods require a security professional to monitor the numerous surveillance cameras for a set period of time. To assure your effective security off the premises, these surveillance systems necessitate the presence of a security employee in the monitoring room at all times [2]. This is a difficult strategy that demands a great deal of commitment from a single individual and may result in numerous human blunders. To improve this method, the authors of this research paper advocated using the viola Jones method and projection histograms to develop an excellent solution for detecting a masked face in a video stream.

The recognition of facial characteristics, according to Naveen S, is an emerging and cutting-edge technology that is extremely valuable for personal identification. This is because face traits are very distinct and may be straightforwardly used for efficient authentication [3]. Various face recognition authentication systems exist, however they are particularly sensitive to various attacks such as spoofing. To counteract this impact, the authors propose that binarized statistical image characteristics and local binary patterns be used in conjunction with local binary patterns to provide extremely accurate facial authentication.

Yasaman Heydarzadeh discusses face recognition and its applications, which have shown to be extremely effective in a variety of applications such as surveillance, authentication, and inspections. In recent years, one of the most challenging applications of image processing has been the technique for the successful implementation of facial feature detection [4]. To increase the accuracy of facial detection and organs on the face such as the eyes, nose, and mouth, the authors suggest using the viola algorithm, which enhances performance by dramatically reducing false negatives and false positives.

R. Raghavendra discusses how facial identification and authentication may be used to provide successful biometric recognition in a variety of applications. The biometric technique has gained traction in recent years because it provides a highly individualized and effective authentication mechanism that is difficult to spoof or defeat [5]. These methods have proven to be effective in increasing the security of various implementations through the use of biometric authentication, which considerably improves the overall security of the process. Traditional techniques employ a variety of biometric solutions that cater to fingerprints or other non-accurate aspects of the individual. The authors suggest a face recognition attack detection methodology using support vector machines and binarized statistical image features in a 3D mask face features attack for this aim.

Almabrok Essa examines the viability of face recognition in a variety of pattern recognition and image processing applications. Facial feature detection is extremely beneficial for a wide range of applications that may be both effective and precise. In the current study, several techniques for feature extraction official features employ holistic features based on subspace for the usage of local appearance, which is not as accurate for detection [6]. Therefore, the authors describe a unique strategy that employs oriented directional features and modular histograms to accurately perform illumination independent facial identification.

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According to Mitsuhiro Fujita, there has been a rise in the use of various surveillance systems throughout the world as a result of increased security risks. Various measures, such as the use of biometric authentication to improve the dependability of the technique, have been successfully used to minimize the occurrences of security breakdowns in high-security implementations. In various surveillance systems, a large variety of approaches for facial recognition and character identification have been developed [7]. To enhance these approaches for implementing biometric authentication, the authors investigated several ways for a region of interest mask that are used for facial identification.

Toshanlal Meenpal, states that the paradigm of facial recognition has been adopted and employed with remarkable intensity in recent years. This might be owing to increased monitoring and the availability of picture and video capturing equipment, which has made such techniques feasible. Most traditional research has been aimed at establishing effective face detection, which has several limitations [8]. To solve these challenges and execute them, this research study proposes a semantic segmentation methodology for face mask recognition. To get the results, the scientists applied gradient descent and training weights to a fully convolutional network.

M. S. Ejaz discusses that the facial recognition paradigm is a recent and extremely beneficial implementation in the computer vision category. This has been complemented by rising interest in this sector since it may enhance a variety of applications such as criminal investigations, voter verification, smart doors, airport passport checks, and so on. Therefore, to improve the methodology for detecting facial masks on a person's face, the authors advocated the use of support vector machines and the creation of a cascaded multi-task convolutional neural network [9]. The method was tested on a Google facenet and yielded extremely promising results.

M. R. Bhuiyan discusses the numerous advancements in computer vision that have been adopted throughout the world as a result of an increasing study on the image processing paradigm. These advances in computer vision are extremely valuable and may be employed in a wide range of applications to produce considerable gains over previous paradigms. One such use is the use of automated facial mask detection, which has been authorized by several countries throughout the world because of the covid-19 epidemic [10]. The authors propose using the Yolo V3 technique to use deep learning features for the categorization of face masks to increase resident safety.

Theekapun Charoenpong explains that the usage of surveillance cameras has expanded tremendously over the world due to the growing affordability of image-capturing sensors. As a result, many business owners and law enforcement organizations have used surveillance to combat crime and minimize the number of incidents of illegal behavior [11]. Therefore, the developers of this methodology have developed an effective strategy for detecting the identity of covered faces, such as those covered by masks or helmets, using a single viewpoint. The scientists accomplished this by implementing multi-skin color library and skin ratio detection for very accurate facial detection.

H. S. Lin expresses there has been a major advance in computer vision technologies in recent years that have proved effective for many applications and implementations in the real world [12]. Therefore, the deployment of these techniques can be extremely beneficial for face recognition and authentication. However, there have been occasions when these methodologies have been heavily spoofed by the use of various techniques such as 3D masking and other strategies for tricking the system. Therefore the authors presented an efficient solution for reducing spoofing assaults by implementing liveness detection using machine learning methodologies such as convolutional neural networks.

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III PROPOSED METHODOLOGY

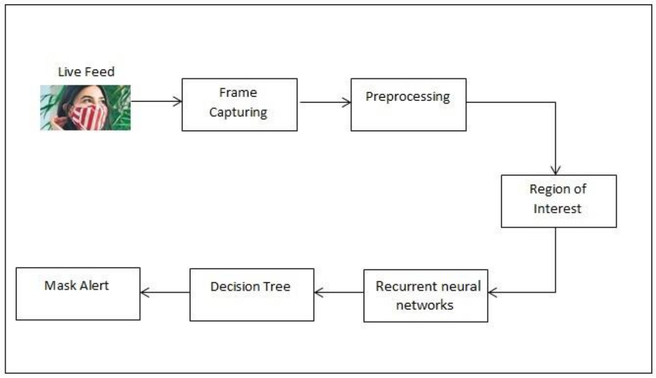

Figure 1: System overview of the Face mask detection

The proposed methodology for achieving a system for automatic face mask detection has been realized using Recurrent Neural Networks and Decision Tree as depicted in figure 1 above. The system has been deployed to execute in a step wise manner as given below.

Step 1: Frame capturing and Preprocessing –The initial step of the proposed system is tasked with providing an input to the system. The video stream being captured by a suitable web camera or the inbuilt camera of the laptop is being used as an input. This is achieved by interfacing the java code through the use of an open source library called OpenCV. This library allows the extraction of the frames from the live stream into the system for processing.

The grabbed frames from the live stream are then processed by the cascade classifier for the extraction of the features. The facial detection is achieved by the extraction of the haar features through the cascade classifier. The achieved features from the grabbed frames are stored in the form of an XML file. These frames are then preprocessed by resizing the image to 150 x 150 width and height. These haar features along with the image is then provided to the next step of the procedure.

Step 2: Region of Interest –The preprocessed images along with the haar features is provided to this step of the approach as an input. The region of interest in our implementation is the face of a person. Therefore, in this step, the detection of the skin is performed through the use of the YCbCr color model. This approach effectively identifies the skin through the evaluation of the information of the pixels of the image. The components of the pixel that provide it color are the red, green and blue components. These components need to be extracted to identify the color of the skin. These values of the pixel are used to measure the red Chroma component and the blue Chroma component of the image by the equations 1 and 2 given below.

$$Cb = -0.169 * R - 0.332 * G + 0.500 * B + 128 \quad (1)$$

$$Cr = 0.500 * R - 0.419 * G - 0.081 * B + 128 \quad (2)$$

These values of red Chroma component and the blue Chroma components are useful in the identification of the skin color for the region of interest detection. The presence of red Chroma component less than 177 and blue Chroma component less than 137 are most likely to be a pixel containing skin. Therefore, these pixels are identified and the resultant values are then subjected to the t value calculation. If the values do not conform to these restrictions, the particular pixel is turned to black. The value of t is measure by the equation 3 below.

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t = Cb + 0.6* Cr_______(3)

Once the value of t is evaluated, it is used for classification of the pixels. If the attained value of t more than 190 and less than 215 is encountered, the particular pixel in question is converted into a white pixel. This is performed iteratively for all the pixels present in the image. This results in a binary image through the use of the YCbCr color model. This binary image is also called the masked image, which is then provided to the next step for further evaluation. The entire procedure is depicted in the algorithm 1 below.

ALGORITHM 1: Region of Interest through YCbCr color model

//Input : Input image I_{IMG}
//Output: Output image O_{IMG}
// function: regionofInterest(I_{IMG})
Start
SIMG = ∅ , count=0
    for i = 0 to size of breadth of I_{IMG}
    for j=0 to size of Height of I_{IMG}
        col = I_{IMG} [i,j] (PIX)
        R= col[0]
        G=col[1]
        B=col[2]
    Cb = -0.169 * R - 0.332 * G + 0.500 * B +128)
    Cr = 0.500 * R - 0.419 * G - 0.081 * B + 128
if (Cr > 137 && Cr < 177), ***then***
if (Cb < 127 && Cb > 77), ***then***
    t = Cb + 0.6 *Cr;
    if (t > 190 && t < 215),*then*
        SIMG [i,j] (PIX)=[255,255,255]
    e***nd if,else***
        O_{IMG} [i,j] (PIX)=[0,0,0]
    e***nd if,else***
        O_{IMG} [i,j] (PIX)=[0,0,0]
    e***nd if,else***
        O_{IMG} [i,j] (PIX)=[0,0,0]
    e***nd if***
    endfor
    endfor
return O_{IMG}
stop

Step 4: Recurrent Neural Network- The skin detected image is provided in the form of an image object as an input to this step of the approach for the identification of the presence of facial mask. The Recurrent Neural Networks have been used to perform the evaluation. This RNN module is trained with the use of an extensive dataset. The dataset downloaded from the URL https://data-flair.training/blogs/download-face-mask-data/ is used for the training. The dataset consists of two directories, the training and testing, where the training dataset consists of 656 images without mask and 658 images with the mask on. The testing dataset consisted of 97 images each for mask on and mask off states.

The Recurrent Neural Networks has been implemented to execute for 50 epochs and the parameters utilized for the creation of the model are depicted in the figure 2 below.

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Layer	Activation
32 X 3 X 3 2D	Relu
MaxPooling2D	
32 X 3 X 3 2D	Relu
MaxPooling2D	
32 X 3 X 3 2D	Relu
MaxPooling2D	
Flatten	
Dense 100	Relu
Dense 1	Sigmoid
Adam Optimizer	

Figure 2: RNN network Architecture

Step 4: Decision Tree –This is the last step of the approach, where the output from the RNN approach is utilized as an input for the purpose of achieving the facial mask detection. The RNN model with the extension of .h5 is being used to classify the frames achieved from the camera. The classification performed through the use of if-then rules has been evaluated for the accuracy of the output which results in a simple Boolean value. The values achieved are used to provide a green box around the face of the individual wearing a mask, whereas the red box is used around the individual not wearing a mask.

IV RESULTS AND DISCUSSIONS

The proposed system for the detection of facial mask on an individuals through the use of Recurrent Neural Network and Decision Tree has been implemented using the Python Programming language. The Spyder IDE has been used to develop the presented approach. The development approach is implemented through the use of a machine powered by an Intel Core i5 processor with 500GB of storage and 4GB of RAM.

An inbuilt camera or an external camera is being used for the purpose of providing the video stream as an input to the proposed system. The system utilizes the RNN model to determine the status of facial mask on an individual's face through the given input video. The evaluation of the performance of the detection methodology needs to be evaluated to quantify the approach.

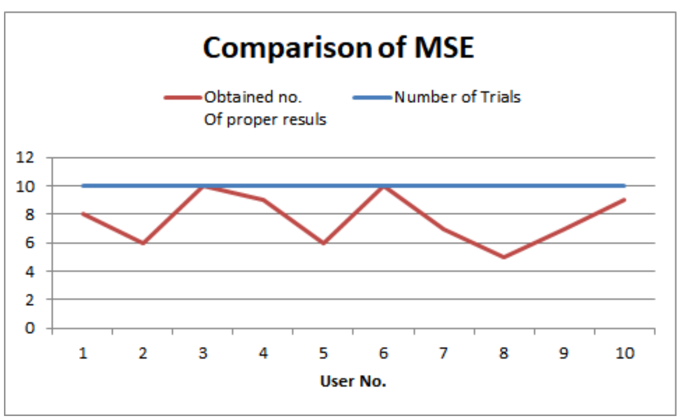

Figure 2: **Performance Evaluation through Root Mean Square Approach**

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The error achieved the presented approach is one of the most effective ways to achieve the performance metrics of the facial mask detection approach. The error is achieved through the use of intensive experimentation and evaluation of the RNN detection approach for its usefulness in facial mask detection through video.

The error for detection has been measured through the use of RMSE or Root Mean Square Error. The error is determined for the identification of the presence or absence of the mask on an individual's face. The RMSE technique is extremely accurate in its realization of the error accurately. The error can indicate the proper implementation of the Recurrent Neural Networks that have been used for the identification. The error is determined between two entities that are mutually correlated. The variables used in our methodology for the error measurement are inaccurate detection of face mask presence and the accurate detection of face mask presence. The equation 1 given below is utilized for achieving the RMSE value.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(x_{1,i} - x_{2,i}\right)^2}{n}} \quad \text{\_ (4)}$$

Where,

$\sum$ - Summation

$(x_1 - x_2)^2$ - Differences Squared for the summation in between the expected No. of facial mask detections and the obtained No of facial mask detections

n - Number of Trails

The extensive experimentation has been performed by a collection of 10 users for two different states, i.e. mask on and mask off. The results of the experimentation are used to make the table displayed by table 1 below.

Table 1: Mean Square Error measurement

User No.	Number of Trials	Obtained no. Of proper resuls	MSE
1	10	8	4
2	10	6	16
3	10	10	0
4	10	9	1
5	10	6	16
6	10	10	0
7	10	7	9
8	10	5	25
9	10	7	9
10	10	9	1

Figure 3: Comparison of MSE in between Expected No of Face mask identified V/s Obtained No of Face mask identified

The attained outcomes for the RMSE have been used to plot the graph given in the figure 3 above. The values of MSE and RMSE attained by the system are 8.1 and 2.84 respectively. These values are expected as the Recurrent Neural Networks have been accurately implemented to achieve highly precise results. The low error rate can be attributed to the implemented Decision Tree approach that can significantly reduce the errors by elimination of the improper results.

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V. CONCLUSION AND FUTURE SCOPE

The proposed system for detection of facial mask has been elaborated in detail in this research paper. Facial mask detection is highly necessary in the current situation to make sure that the citizens comply with the restrictions to reduce the spread of this contagion. As most of these restrictions cannot be effectively enforced in personal and automatic technique through the utilization of image processing is the need of the hour. Therefore this methodology takes input of the subjects face through a live feed. This live feed is processed and individual frames are extracted and resized to determine the facial features. These facial features and the captured frames are provided for region of interest evaluation through the use of skin detection by the YCbCr color model. This result in a binary image called a mask image consists of the area where the person skin is converted to white and the rest of the image is converted to black. This binary image is provided for the detection of the facial mask to the conventional neural network module. A mask image data set is utilized for training the recurrentneural network which is then tested by these input images. The resultant values of mask detection are provided to the decision tree which effectively e classified the accurate detections by providing a green colored rectangle on the masked face and a red colored rectangle around the unmasked face. The error achieved through this process is minimal as depicted through the error rate evaluations.

The future research direction can be focused on deploying this approach on the cloud platform for implementation in public area as such as Bus stands and airports.

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