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Enhancing Face Detection and Recognition through Machine Learning Algorithm

Manu Y M
Department of Computer Science
BGS Institute of Technology
Adichunchanagiri University
BG Nagara, Mandya
manugowdaym3@gmail.com

Gagana R
Department of Computer Science
BGS Institute of Technology
Adichunchanagiri University
BG Nagara, Mandya
gaganar95@gmail.com

Shashikala S V
Department of Computer Science
BGS Institute of Technology
Adichunchanagiri University
BG Nagara, Mandya
shashisv7@gmail.com

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***Abstract*—Face recognition is a rapidly growing field with multiple applications. Numerous face recognition algorithms have been developed over the years. In this research, use a Histogram of Oriented Gradients (HOG) based face detector for precise face detection, which surpasses other machine learning techniques, such as Haar Cascade. The suggested approach uses HOG for feature extraction and Contrast Limited Adaptive Histogram Equalization (CLAHE), two generally used pre-processing methods, throughout the recognition process. The test picture and the training images are both used to extract HOG features. Lastly, this system employs Support Vector Machine (SVM) for classification, as it effectively classifies the HOG features. Pre-processing techniques are utilized to equalize illumination, reduce noise, and enhance contrast. The study's findings show the dependability and effectiveness of this approach in achieving superior face recognition performance.**

Keywords—Machine Learning, Face Recognition and Detection, SVM.

I. INTRODUCTION

Understanding the intricacies of human faces and developing accurate machine-based recognition systems have become pivotal in the field of computer vision. While humans effortlessly detect and recognize faces, machines face challenges in achieving the same level of proficiency. Various machine learning techniques have been developed to address these challenges and improve face detection and recognition capabilities.

The human face is a complex multidimensional structure, necessitating sophisticated computational methods for reliable recognition. Recognizing a face involves identifying patterns such as facial dimensions, colors, and proportions of facial components like lips, nose, and eyes. Different faces exhibit unique patterns, and similar faces share similarities in their dimensions. To enable machine learning algorithms to process this information, facial features need to be converted into numerical representations.

Researchers such as C. Rahmadet. al [1] have compared face detection techniques based on Haar Cascade and Histogram of Oriented Gradient (HOG), and found HOG to be more accurate. Enhancing face recognition performance has been an ongoing challenge since the advent of the first face recognition algorithm. In 1991, Alex Pentland and Matthew Turk [2] introduced the eigenface method, applying Principal Component Analysis (PCA) to face recognition, which still influences contemporary algorithms. NavneetDalal et al. [3] further improved the approach by introducing HOG features instead of eigenfaces in PCA algorithms. In In a 2016 study, Dadi HS and Pillutla GM [4] compared HOG and PCA-based face recognition techniques, showing that HOG produced an 8.75% improvement because of its advantages in spatial binning, orientation binning, scale gradient, and local contrast normalization.

However, further improvements are necessary, particularly in preprocessing steps and contrast where the approach involves employing steps and contrast enhancement techniques to improve the performance of face recognition. This paper proposes a method to address these challenges by employing Contrast Limited Adaptive Histogram Equalization (CLAHE) for noise removal, contrast enhancement, and illumination equalization in the preprocessing step. Subsequently, a The HOG features extracted from the input image are classified using the Support Vector Machine (SVM) classifier. Although the input dimensions of the SVM classifier are constant, the quantity of essential points collected from different photos may vary. Thus, the dimension of the input is not constant. The SVM results enable the computer to identify the person based on the analysis of the classification outcomes.

A. Face Recognition

The field of face recognition has emerged as a highly successful application of image analysis, particularly in the realm of surveillance and security. This technology focuses on verifying a person's identity by analyzing and comparing patterns derived from their facial features, including the eyes, nose, mouth, and chin. Face recognition plays a vital role in granting authenticated and authorized access to various systems and services. As a biometric identification system, it harnesses the unique biometric patterns present in an individual's face to facilitate accurate identification.

II. RELATED WORKS

The study compared the Histogram of Oriented Gradients (HOG) and Viola-Jones Haar Cascade Classifier for face detection. The researchers observed that the HOG algorithm achieved approximately 5% higher accuracy in comparison to the Haar cascade algorithm [5]. Additionally, the Haar cascade algorithm demonstrated increased frequency of false-positive image detections. Face recognition methods often encounter challenges with images of large dimensions,

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making recognition difficult. To address this issue, dimension-reduction techniques were introduced. One commonly used algorithm for dimension reduction and subspace projection is Principal Component Analysis (PCA). PCA is an unsupervised machine learning algorithm that takes into account the complete set of d-dimensional samples without taking into account class labels. Along with computing the eigenvectors and matching Eigen values, it also computes the scatter and covariance matrices.

Highlighted the growing prominence of face recognition research in computer vision, especially in network security systems, access control systems, and other multimedia information processing domains. The effectiveness of face verification systems relies on different conditions, which present challenges for achieving precise and dependable recognition [6].

The authors used Haar Cascade Classifiers to develop a hierarchical face and eye detection system. Improving detector training was their principal goal [7]. Moreover, they performed a comparative study between the effectiveness of Castrillon-Santana's eye detectors and Lienhart's face detectors in relation to other trained detectors [8].

Support vector machines (SVM) were introduced as a novel pattern recognition technique. The authors applied SVM with a binary tree recognition strategy for face recognition [9]. Through their experiments, they demonstrated the capability of SVM on face databases, such as the Cambridge ORL face database and a larger database containing images of multiple individuals.

Real-time image enhancement using the contrast limited adaptive histogram equalization (CLAHE) method was addressed. Despite CLAHE being frequently used for offline image enhancement due to its computational complexity, the author presented a system-level implementation suitable for VLSI or FPGA to reduce latency while maintaining precision [9]. This approach proves advantageous for enhancing image quality in real-time scenarios, such as X-ray imaging with low-level exposure. [10].

III. PROPOSED METHOD

Based on the findings of paper [11], it was observed that the HOG (Histogram of Oriented Gradients) based face detector outperforms the Haar Cascade algorithm in terms of accuracy. Consequently, opted for the HOG based face detection algorithm. HOG is an innovative approach to face detection, utilizing a rotating detection window that scans the image. Typically used for object detection, HOG algorithms leverage the way an image's edge directions or intensity gradients are distributed.

True Positive rate is for recall and it can be finding as shown in “(1)”:

$$TPR=TP/TP+FN \tag{1}$$

False Positive rate is can be finding as shown in “(2)”:

$$FPR=FP/FP+FN \tag{2}$$

Softmax is finding by the formula shown represented in “(3)”:

$$\text{softmax}(z_i) = \frac{\exp(z_i)}{\sum_j \exp(z_j)} \tag{3}$$

A contrasted object can be identified by its differences in colour and fluorescence by “(4)”.

$$Contrast = I\text{min} - I\text{max}(Imax + Imin) \tag{4}$$

Where I_{max} is the highest and I_{min} is the lowest fluorescence.

These gradients are computed from image blocks and serve as descriptors. The resulting descriptor is then passed to a trained SVM (Support Vector Machine) for classification, determining whether a face is present or not. Although the SVM algorithm requires more computational time compared to the Haar Cascade Algorithm, it delivers higher accuracy in face detection.Fig.1 shows the block diagram of proposed system, and it tells about from input image to identifying the person.

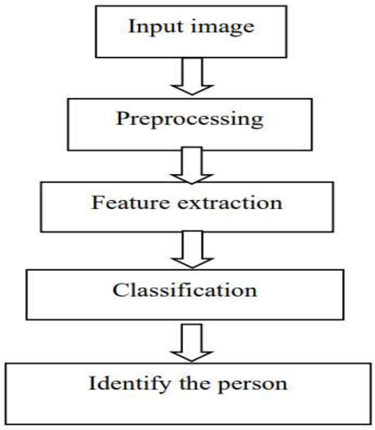

Fig.1. Proposed Block Diagram.

A. *Dataset Collection*

Manually collected images of people with different face expressions and also with and with out mask. Currently the proposed model has eight different people face data images in real time. More faces can be added using the real time code. Individual folders with their respective names folder are created and stored for further training purpose.

B. *Pre-processing*

Pre-processing plays a crucial role within the domain of picture processing. In this action, histogram equalization is applied, which is a technique used to adjust the intensity of an image. It enhances the contrast by redistributing the gray levels. The goal is to achieve an equalized histogram, where all gray levels are utilized in equal quantities and it can be done by using formula as shown “(5)”.

$$Li\ det = - (y\^{}idetlog(pi)+(1-y\^{}jdet)(1-log(pi))) \tag{5}$$

Li det for different image pixels can be find by using below formula using below “(6)”.

$$Li\ det = \|\ y\^{}i\ box - y\^{}j\ box\ \|\ log\ 2 \tag{6}$$

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C. *Feature extraction*

An image analysis technique that is feature-based is called the Histogram of Oriented Gradients (HOG). It is frequently used for object detection in computer vision. HOG captures the distribution of gradient orientations within an image, enabling the identification and localization of objects. This can be done by using “(7)”

Li Landmark = || yˆi Landmark - yˆj Landmark || log 2 (7)

D. *Classification:*

Support Vector Machine (SVM) is a supervised learning algorithm utilized in the classification task. SVM was first created as a two-class classifier, but it has since been expanded to manage regression tasks and multiclass issues. Support vectors are data points that are closest to the hyper plane and have a major impact on its position and orientation. The SVM model finds these data points.

By maximizing the margin between classes, SVM achieves effective classification, and removing support vectors can alter the hyper plane’s position [12].This can be determined by following formulas “(8)” and “(9)”.

$$\text{L2-norm: } f = \|v^2+e^2 \quad (8)$$

$$\text{L1-norm: } f = vv^2+e^2 \quad (9)$$

Now will see how enhancement will be done by using this proposed system by taking different weights.

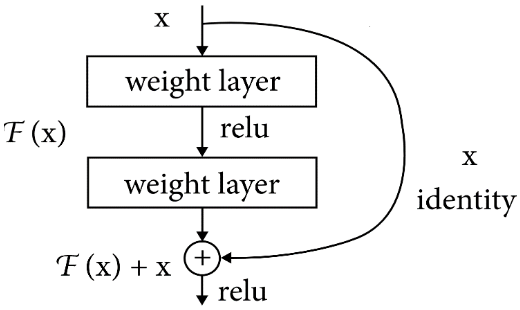

Fig.2. Enhancement of Facial Recognition through machine learning algorithm.

Fig.2 Shows the enhancement of Facial Recognition through machine learning Algorithm by using weight layer and using the function F(x)

IV. RESULTS AND DISCUSSIONS

Model accuracy, also referred to as ACC (an abbreviation for Accuracy), serves as a metric to evaluate the efficiency of a trained machine learning model. It quantifies the percentage of accurate classifications performed by the model.

To compute AI accuracy, one must divide the number of correct predictions by the total number of predictions made for all classes. ACC stands as a crucial indicator of the model's performance and its capability to accurately classify instances.

The provided diagram displays the accuracy progression over epochs. Notably, the accuracy exhibits a rapid increase during the initial two epochs, signifying the network's quick learning ability.

Subsequently, the curve levels off, indicating that further training epochs enhances the model's accuracy with almost 98% in this ML model.

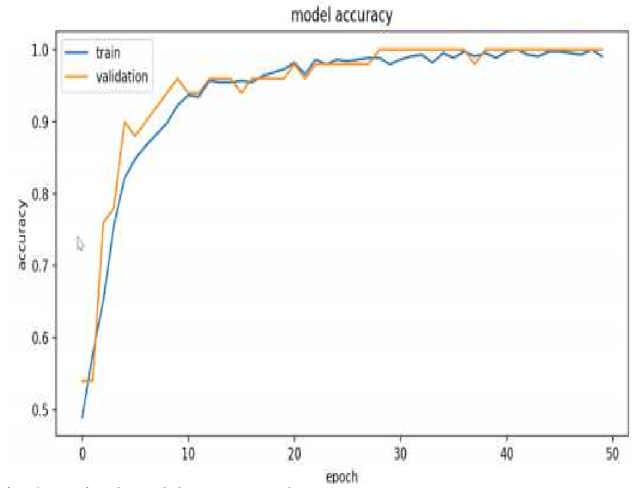

Fig. 3. Trained Model Accuracy Plot.

Fig. 3 Shows the trained model Accuracy Plot and it checks accuracy from model.test_batch_on (x_test,y_test) .

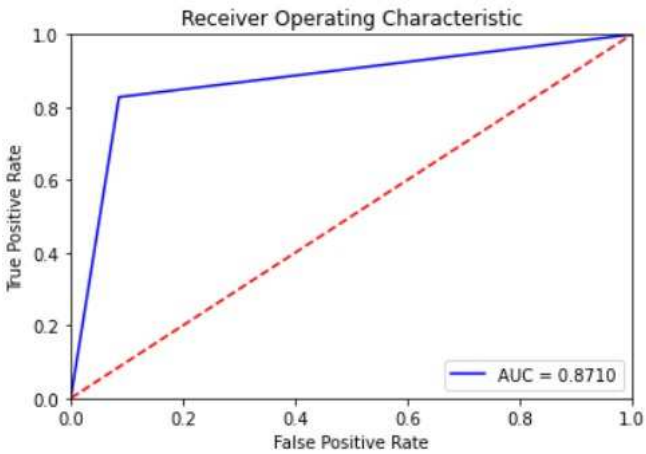

Fig.4. Different ROC curves representation

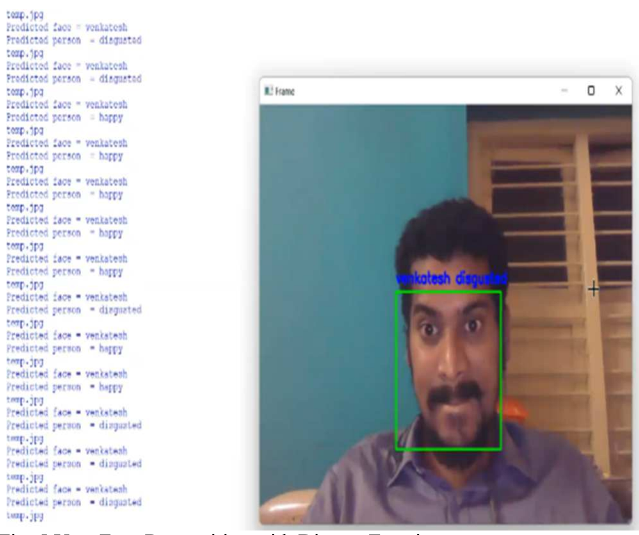

Fig. 5.User Face Recognition with Disgust Emotion.

In proposed system, it has basically implied face detection and recognition with emotions like happy, disgust, surprise and fearful. The following images show the face recognition with emotions. Also, the dataset collected are trained and observed accuracy of 98% with SVM method.

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An ROC curve (receiver operating characteristic curve) illustrates the classification model's performance at various classification thresholds. The curve plots two parameters: True Positive Rate and False Positive Rate. The ROC curve depicts TPR vs. FPR for different classification thresholds. By reducing the classification threshold, more items are classified as positive, leading to an increase in both False Positives and True Positives. Fig. 4 presents a typical ROC curve.

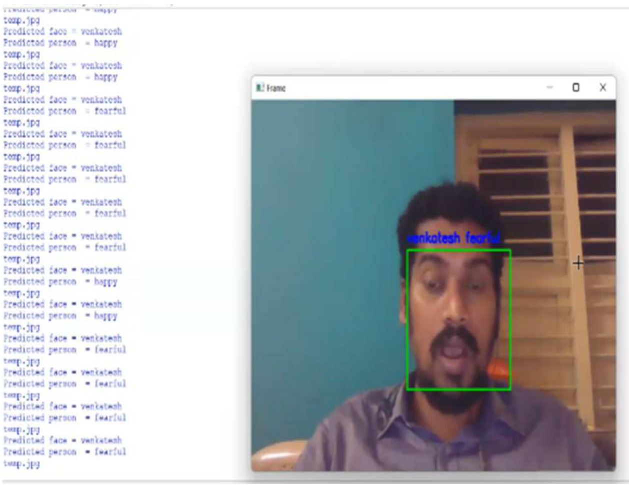

Fig. 6.User Face Recognition with Fearful Emotion.

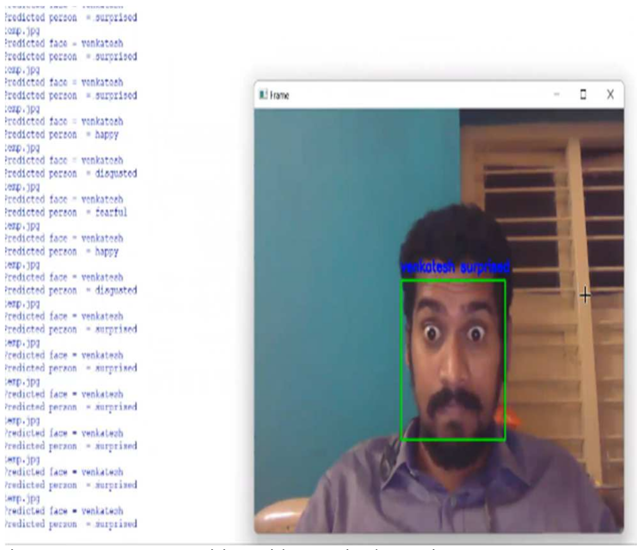

Fig. 7.User Face Recognition with Surprised Emotion.

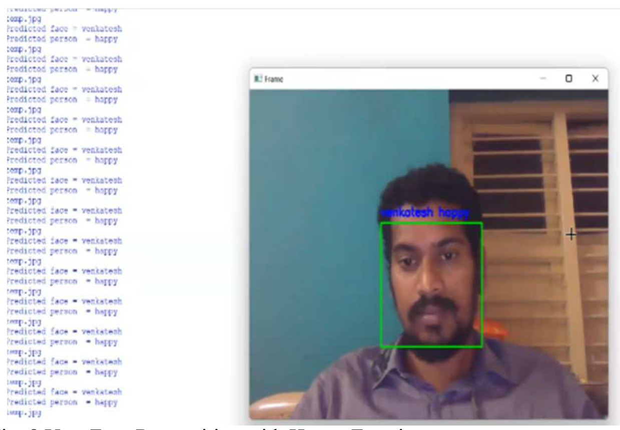

Fig. 8.User Face Recognition with Happy Emotion.

Fig. 5 to Fig.8 shows different user face recognition with different emotions.

TABLE I. FACE DETECTION EVALUATION RESULT.

	Total Faces	Haar	LBP	Proposed Method
False Positive	226	208	206	215
True Positive	226	18	20	11
False Negative	226	55	41	33
Detection Accuracy Rate		92%	91%	95%

Table I gives Accuracy rate of this proposed system and also compares proposed system with different algorithms (Haar and LBP) by taking different face images as different number of total faces.

V. CONCLUSION AND FUTURE ENHANCEMENT

In conclusion, face recognition has emerged as a rapidly growing field with diverse practical applications. Throughout the years, several face recognition algorithms have been developed, and in this study, successfully employed a Histogram of Oriented Gradients (HOG) based face detector. This method has proven to outperform other popular machine learning algorithms, such as Haar Cascade, in terms of accurate face detection.

The suggested system uses HOG for feature extraction and Contrast Limited Adaptive Histogram Equalisation (CLAHE), both of which are known for their efficacy, for pre-processing in order to improve the recognition process. HOG features were extracted from both the test and training images, and the subsequent classification was carried out using Support Vector Machine (SVM), a robust technique for classifying HOG features.

To ensure the reliability of this approach, various pre-processing techniques were implemented to eliminate noise, improve contrast, and equalize illumination. The comprehensive findings of this study unequivocally demonstrate the superiority of this method, showcasing its capability to achieve remarkable face recognition performance.

In conclusion, this work adds to the expanding corpus of knowledge on face recognition research and offers insightful information in successful combination of HOG-based detection, CLAHE-based pre-processing, and SVM-based classification. As face recognition technology continues to evolve, this approach holds promising potential for practical deployment in various real-world scenarios, including security, biometrics, and human-computer interaction.

In the future, the face recognition system can be improved by combining deep learning methods, like CNNs (convolutional neural networks) for more precise face detection and recognition.

Data augmentation and transfer learning can improve performance by increasing dataset diversity and leveraging pre-trained models. Real-time processing, 3D face recognition, and privacy measures are essential for real-world applications. Additionally, handling occlusions, benchmarking against diverse datasets, adaptive learning,

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and deployment on edge devices will further refine the system's capabilities and ensure its continued success in various domains.

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