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Face Recognition and Skin Classification using SVM and CNN

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***Abstract*— Face recognition software's are very helpful to identify a person from the face image database. Most of the times in surveillance cameras partial views of the faces are captured with different angles and resolutions. Thus, it is necessary to efficiently utilize each and every information that is available. There is great demand for alternate biometrics modalities in forensic applications that can handle all kinds of real-word challenges such as partially visible face, pose variation, occlusion in such case palmprint recognition and skin classification can proposed as a potential alternative. Numerous presentation attack instruments like realistic three-dimensional face masks are available in the market that can be used to deceive the face recognition system (FRS). Detecting spoof attack is a challenging issue. The proposed approach for face and palmprint recognition system using support virtual machine (SVM) algorithm along with Local Binary Pattern (LBP) and Histogram of Oriented Gradients (HOG) showed good recognition rate for face images in complex illumination, poses. To detect the presentation attack using silicone masks or other presentation attack instruments skin classification using convolutional neural network (CNN) algorithm is proposed which detects and classifies whether the image is of fake skin or real skin and showed overall accuracy rate of 96%.**

***Index Terms*— presentation attack, complex illumination, poses, recognition rate, presentation attack instrument, recognizer system.**

I. INTRODUCTION

Face recognition is a process to identify a person against his/her image or frames from a video stored in database. Humans do these tasks effortlessly as their eyes and brains are pre-trained but this is not the case when we think of a software to recognize a person from images or video. Initially we need to train the system to recognize and then classify the person to add-in the complexity to this if the images are not well lit or if images are tilted there will be a sharp decline in the recognition rates. Thus, there is a need for proper training and testing of these recognizer systems. These systems have caught the attention of many researchers in the past few decades due to its diverse applicability. To mention few of them: these are used to gain access to laptops, smartphone, office buildings etc., attendance marker system, facial emotion detection, classify the gender, recent smartphone cameras have inbuilt feature to recognize the face where it auto focuses the face and blurs out the unwanted surrounding area which has given a boost to the craze of selfies, to extract features from images like eyes, skin-tone, nose etc., not only commercial usage but also facial recognition is used in the area of security from airports to smartphones it is being used in various forms in everyday activities.
As the recognizer systems applicability is increasing, it is high time that we focus on its drawbacks and make

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efforts to improve them. Few of the drawbacks are as follows: Complex illumination conditions, pose variation, age variation, presentation attacks, facial expressions, facial hairs like moustache and beard covering the face can also cause hinderance Ref. [1] all of which will contribute towards the drop in the rate of recognition. In this paper we made an effort to address few of the issues and also tried to improve the recognition rate compared to the existing techniques. The LBP and HOG methods are used for extracting features from images. SVM algorithm was used for face and palmprint matching and to classify fake skin and real skin CNN was used which showed 96% accuracy overall.

This approach was trained and tested with different conditions of lighting, ages, gender and the colour of the skin from database which was constructed for the project. The rest of the topics in this paper are arranged as follows: Related work (Section □) briefs about some of the previous work carried out by various authors over the period of time in the field of face recognition system. Proposed methodology (Section □) presents the steps and methods used in the proposed new hybrid face recognition system and also presents proposed system flow diagram. Experimental outcome (Section □) briefs about the outcomes of the experiment. Conclusion and future work (Section □) concludes paper and also briefs about the summary along with future work.

II. Related Work

This section provides a brief summary of the research done by various authors and the issues they have addressed;

- The authors Liyun, Yepeng Ref. [2] did Illumination pre-processing in order to improve the adverse effects on face images caused by the lighting changes, Log-Gabor filter was used. The Log-Gabor feature was extracted from images which was of distinct scales, directions. The authors Md. Asif Anjum Akash, M. A. H. Akhand, N. Siddique Ref. [3] proposed a novel ideal where they originated an illumination based generalized method which works distinctly towards parts of the picture all of which are based on the rate of illumination.
- The authors Jonguk, Hyansu and Suk Ref. [4] proposed a new type of camera calibration board to verify the distortion calibration in the images. The level of distortion calibration was checked by comparing pixel errors between the calibration of distortion.
- The authors Insaf, Abdeldjalil, Amir and Abdelmalik Ref. [5] in their review paper identified that there is lack in database for 3D facial recognition which is also a huge hinderance in the path of research.
- The authors Deepak, Kavitha Ref. [6] built a FRS in which CNN pretrained Model was used to extract the features and for classification SVM was used through which the system was able to obtain accuracy rate of 95%.
- The authors George, Zohreh, David, Oleg, Andre and Sebastian proposed a new framework Multi-channel CNN which achieves superior performance in detecting presentation attack. They also proposed multichannel dataset which also helped in improving the accuracy Ref. [7].
- The authors Hamed, Sanaul and Farzin used mixed-resolution of skin face image for biometric information and right and left cheek, forehead and chin were investigated as one of these regions are selected in real-world application. LBP is used for feature extraction Ref. [8].
- The authors Aparna, Richa, Mayank, Kevin, Bowyer proposed a novel approach to classify face image as retouched or original using supervised deep Boltzmann machine (DBM) and SVM was used for classification. The experimental results shows that even if images were retouched face recognition system can be trained to detect and classify Ref. [9].
- The authors Slim Ben, Mohammad Hijji, Rafika, Hassene proposed face recognition is done by selecting the statistical features through statistical analysis SVM was used to combine and classify the selected features to improve the recognition rate Ref. [10].
- The authors Arfika and Adams presented an approach to identify a person using permanent pigmentation marks and vascular(veins) skin marks on the person's body when face image was not available Ref. [11].

III. Proposed Methodology

The face recognition process begins with detecting the images of face then advances to normalize the face image to adapt to change in illumination, always choosing appropriate classification algorithm is very important which helps in recognizing the face. The face recognition system generally consists of mainly 3 phases: i) Pre-processing, ii) Feature extraction and iii) Classification.

The pre-processing phase will detect the face, normalizes it and also eliminates the unwanted background which affects the recognition rate. The Feature extraction phase can be further divided into two sub phases 1) Feature based, 2) Holistic based. The analysis of facial features like eyes, mouth, nose and chin is performed in feature-based method and additionally position and relationship among the identified features is also carried out. The analysis is performed on the whole image in the holistic based method. LBP, HOG, Principal Component Analysis (PCA), Independent Component Analysis (ICA), Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT) and many such feature extraction algorithm can be used for dimension reduction and feature extraction. In the classification phase various classification algorithms like SVM, K-nearest neighbour (K-NN) etc can be used to find the best match for the face image against the database.

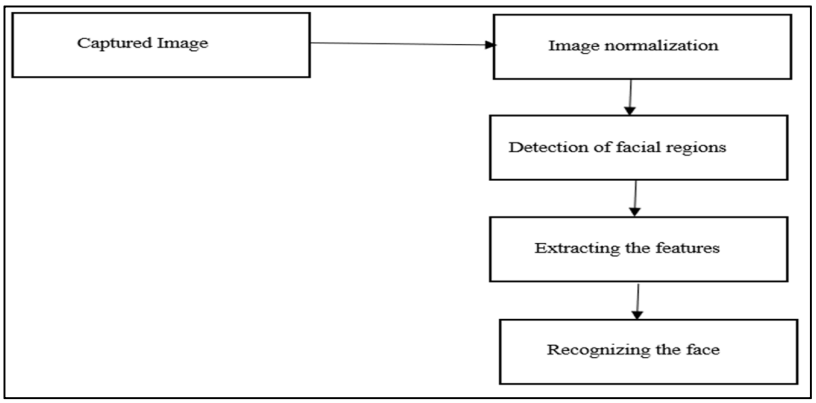

Figure 1. General face recognition system

The FRS using LBP and HOG features with SVM classification is presented. Along with two use cases are presented which addresses few of the drawbacks faced by face recognition system. The proposed approach was found to generate good recognition results. The proposed system can be split into three parts:

A. Face recognition using SVM
B. Palm print recognition using SVM
C. Fake skin classification using CNN

A. Face recognition using SVM

Initial step in the face recognition system is deriving a feature matrix. Feature extraction is a vital step in the process of face analysis which will remove redundant information in input data else it will affect the performance of classification. In the proposed method LBP and HOG methods are used. In the LBP method, histograms are extracted from the small regions of face area which are combined into one single feature vector. This vector is used to find similarities between the images Ref. [12]. To extract features in different illumination condition, poses, occlusions HOG is used. In this method images are divided into small regions which are all connected. These regions are called 'cells' for each cell, edge orientation is calculated and based upon the signed or unsinged gradient it is spread over histogram channels. Histograms counts are normalized to gather the histogram energy over the cells which are further used to normalize all cells which are present in the block. All of these results combination constitutes HOG descriptor. To steady the HOG descriptor's scale and rotation, we can extract the descriptors from salient point using rotation normalization Ref. [13].

In the proposed approach SVM algorithm is used for classification main objective of this algorithm is to minimize the error while generalizing and to increase the distance between data and hyper plane. SVM algorithm detects a support vector which will perform pattern recognition between two classes. Support vector is the surface of decision in the training set. SVM finds a support vector to perform pattern recognition between two classes which will have maximum distance between the closest points Ref. [14], Ref.[15].

B. Palm print recognition using SVM

Sometimes identifying a person through face image becomes difficult if the person is wearing a mask, cap, spectacles or if face is covered by facial hair or any other obstacle which can be intentional or unintentional. This poses a great threat in the area of security, few of the instance can be: identifying a person in surveillance camera footage will be difficult if his face is hidden, it will be too difficult to identify person in crowded space, if people are wearing uniforms and faces are covered. Pandemic situation like covid also bought in new set of challenges

to face recognition systems as face masks were compulsory. To overcome these problems palmprint recognition can be used. As palmprints are unique for each individual it cannot be falsified. This is also easy to install and also many of the existing system can be upgraded with this feature with very less/ no hustle. This can also be used instead of age-old fingerprint biometric access in the pandemic situation where in hygiene is of top priority. Due to its wide range of applicability palmprint recognition is also proposed as one of the alternative methods to identify a person along with face recognition. The flow process employed in the proposed method for face/palmprint recognition:

1. Data acquisition: Images are selected from database
2. Feature extraction: LBP and HOG features are extracted.
3. Classification: Face and palmprint images are classified as matched or not matched using SVM algorithm

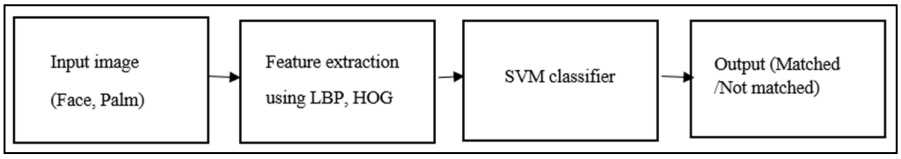

Figure 2. Proposed Face/palmprint recognition system

C. Fake skin classification using CNN

Face recognition system are unguarded towards presentation attack, solely presenting a printed photo can fool the system Ref. [16]. Presentation attack can be defined as "Biometric systems typical operation is disrupted by presenting to the data capture system of the biometric". It has two subtypes:

i. Impersonation- In this type of attack, attacker would try to disguise himself as a different person with the help of some presentation attack instruments. Presentation attack instruments are the instruments/things used in presentation attacks like printed photo, mask, replaying a video of the person, funny glasses, funny eyes, paper mask etc.
ii. Obfuscation- In this type of attack, attacker would try to hide his real identity

Most of the research have been focused on presentation attack performed using printed photos and videos which addresses the two-dimensional attack instruments. Nowadays presentation attack instruments (PAI) are also getting sophisticated with advancements in realistic 3D printers. Thus, there is need for research on presentation attack performed using three dimensional PAI. The proposed approach is one such method which addresses this problem where CNN algorithm is used to identify whether the photo presented is of fake skin or real skin. There are two methods to achieve this using CNN i) to use CNN algorithm along with other classifier algorithm like SVM, K-nearest neighbours etc. ii) Using only CNN algorithm in which, CNN with the help of end-to-end learning will learn about the relationship which exist between class label and raw pixel data Ref. [17]. In the proposed approach only CNN algorithm is used. Fake skin image database was created using silicone face mask, paper mask which were converted to greyscale and stored in the database. The flow process employed in the proposed method for fake skin classification:

1. Images are selected from database
2. Upon the selected images CNN algorithm is applied
3. Labels are assigned as fake/real skin after classification

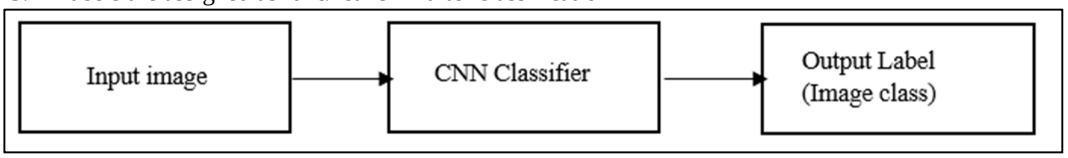

Figure 3. Proposed skin classification system

IV. Experimental Outcome

In this section we brief about the database collection procedure along with the outcome of the experiment.

A. Data collection procedure

The data for face image and palm was gathered over the span of three months comprising of various environmental conditions like illumination and background, age, gender Table below provides further details.

100 participant's face and palmprint images were captured, from each individual 4 face image and palmprint image was captured. The database was divided into 2 sets out of which one is used for training and other for testing. Experiment is performed using MATLAB R2021a from MathWorks.

TABLE I. DATA COLLECTION PROCEDURE

Serial Number	Background	Environmental Condition
1	Uniform and Complex	Illumination - Day light, Light-emitting diode (LED) light, ceiling office light, side illumination with LED lamps, complex ceiling office light, in the shade with minimum light
2	Uniform and Complex	Age - Old adults, Young Adults, Teenagers and children
3	Uniform and Complex	Gender - Female and Male
4	Uniform and Complex	Image Resolution – Ranges from 48MP to 50KB

For skin/palmprint recognition system's accuracy was calculated using ten-fold cross validation technique which displayed 95% accuracy rate. For Skin classification system a confusion matrix was generated and the different parameters were calculated such as accuracy, prevalence, true positive rate (TPR), precision, F1 score, and false positive rate (FRP). To describe the performance of a classification mode or classifier, a confusion matrix was written on a set of test data for which the true value was known Figure 4.

Figure 4. Confusion matrix obtained from skin classification system

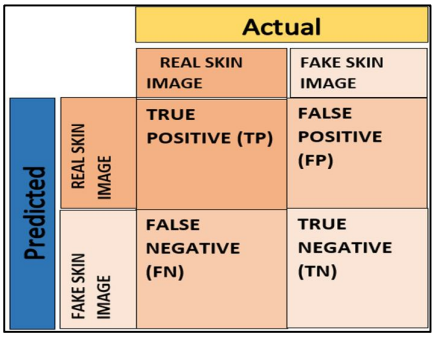

Figure 5. General confusion matrix constructed for reference

Accuracy: To decide how often the classifier was able detect correct result in overall which can be calculated using the formula

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

True positive Rate (TPR): This will display the number of counts the system was able to make correct predications as real skin image and the presented image was also of real skin image. This can be calculated by,

$$TPR = \frac{TP}{TP+FN} \quad (2)$$

False positive Rate (FPR): This will display the no of counts the system predicted the image to be real skin image and the presented image was actually fake skin. This can be calculated by,

$$FPR = \frac{FP}{FP+TN} \quad (3)$$

True Negative Rate (TNR): This will display the number of counts the system was able to make correct predications as fake skin image and the presented image was also of fake skin image. This can be calculated by,

$$TNR = \frac{TN}{TN+FP} \quad (4)$$

Precision: This displays how often the system made correct predictions. This can be calculated by,

$$Precision = \frac{TP}{TP+FP} \quad (5)$$

Prevalence: to decide how often does the real image condition actually occur in our sample. It can be calculated as

$$Prevalence = \frac{Actual\ Real\ image\ count}{Total\ count\ of\ images\ in\ database} \quad (6)$$

F1 score: This can be defined as the harmonic mean of precision and recall.
Table II provides the result obtained for three trails on different parameters

TABLE II. CNN SKIN CLASSIFICATION SYSTEM RESULT

Metrics	CNN method evaluation		
	Trail 1	Trail 2	Trail 3
Accuracy	0.9375	0.8125	0.875
Precision	1	0.727273	0.8
Prevalence	0.5	0.5	0.5
TPR	0.875	1	1
FPR	0	0.375	0.25
FI Score	0.933333	0.842105	0.888889

The proposed approach was tested using ten-fold cross validation technique which displayed 95% accuracy rate overall for both face/palmprint recognition system using SVM and 96% accuracy for skin classification system using CNN.

V. CONCLUSION AND FUTURE WORK

The proposed approach for recognising face/palmprint is based on SVM classifier with LBP and HOG feature extraction. In real word applications LBP and HOG can be used because of their great tolerance towards complex lighting, angles, occlusions. The outcome of the experiment also displayed that face/ palmprint recognition system shows greater accuracy compared to the existing techniques. The proposed approach to classify fake/real skin using CNN also showed improvements compared to the existing systems. As a part of future work, we are planning to test the proposed approach on different database with more test subjects. The research would be done with main focus on developing a simple, secure and easily adaptable model which can adapt to different environment.

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