Template based Mole Detection for Face Recognition

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Abstract— **Face recognition is used for personal identification. The Template based Mole Detection for Face Recognition (TBMDFR) algorithm is proposed to verify authentication of a person by detection and validation of prominent moles present in the skin region of a face. Normalized Cross Correlation (NCC) matching, complement of Gaussian template and skin segmentation is used to identify and validate mole by fixing predefined NCC threshold values. It is observed that the NCC values of TBMDFR are much higher compared to the existing algorithms.**

Index Terms— **Face Recognition, Mole Detection, Normalized Cross Correlation, Segmentation.**

I. Introduction

Some of the common physiological characteristics used for personal identification include finger prints, palm prints, hand geometry, retinal patterns, face patterns, iris patters, etc. Behavioral characteristics include signature, voice pattern, keystroke dynamics etc. A biometric system works by capturing and storing the biometric information and comparing the captured information with the data base. The finger print verification has received considerable attention and has been successfully used in law enforcement applications. Face recognition and speaker recognition have been widely studied over the last 20 years.

Everyone has fairly unique face and can capture without user cooperation (passive). The goal of face recognition system is to separate the characteristics of a face that are determined by the intrinsic shape and color (Texture) of the facial surface from the random conditions of image generation. For the past decade, major advances have occurred in face recognition. A large number of systems have emerged that are capable of achieving recognition rates of greater than 90% under controlled conditions. The face recognition techniques include recognition from three-dimensional scans, high resolution still images, multiple still images, multi-modal face recognition, multi-algorithm and preprocessing algorithms to correct illumination and pose variations. Successful application under real world conditions is still a challenge.

Skin does not possess a general spatial structure; instead, it is formed by repetition of texture units called Textons. The face recognition concentrates on capturing the irregular details of the face like moles and birthmarks caused by temporary contamination. The local details of moles are considered by satisfying the conditions; i) Distinctiveness*:* they have special local pattern and do not resemble other parts of the faces such as skin texture. *ii) Stability:* they should stably occur in nearly all images of a person and repeatedly detected.

Contribution: In this paper we proposed mole candidate detection using Normalized Cross Correlation matching and validation through facial skin segmentation. The complement of the Gaussian filter mask is used as the template for NCC matching.

Organization: The rest of the paper is organized into the following sections. Section 2 is the overview of related work. Section 3 describes the model. Section 4 gives the algorithm. Performance analysis of the model is discussed in Section 5 and conclusion is given in Section 6.

II. Related Work

Yuri Y Boykov and M. P. Jolly [1] presented interactive segmentation which gives better results compared to fully automatic segmentation. Image is classified as object and background, the cost function is defined in terms of boundary and region properties of the segments. Interactive segmentation method provides a globally optimal solution for an N-dimensional segmentation when the cost function is clearly defined. Soft constraints are combined with user defined hard constraints and optimal segmentations are efficiently recomputed if the hard constraints are added or changed.

Cootes et al., [2] described Active Appearance Model (AAM) contains a statistical model of the shape and gray level appearance of the object of interest can generalize to any valid example. AAM algorithm is used to locate deformable objects in many applications, in which the image difference patterns corresponding to changes in each model parameter are learnt and used to modify a model estimate. Volker Blanz and T. Vetter [3] proposed a parametric Face model technique to solve the problem of automated matching corners of the eyes and mouth as well as separation of natural

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faces from nonfaces. Arbitrary human faces are created simultaneously controlling the likelihood of the generated faces. The algorithm adjusts the model parameters automatically for an optimal reconstruction of the target requiring a minimum of manual initialization. The output of the matching procedure is a 3D face model that is in correspondence with the morphable face model. The disadvantage is that it consume more time due to the computation of the derivatives for each iteration.

Walker et al., [4] developed a statistical model for each possible feature, representing the Probability Density Function (PDF) results in corresponding feature vectors form a number of training features. The PDF of any feature is compared with all other features to estimate the probability of misclassification. The values of feature with low misclassification rate are salient features. Volker Blanz and T.Vetter [5] proposed surface reconstruction and face recognition morphable models of 3D faces. The surface reconstruction algorithm is based on analysis-by- synthesis technique to estimate shape and pose by fully reproducing the appearance of the face in the image. The face recognition is based on a set of feature point locations producing high resolution shape estimates in computation of 0.25sec.

Alexei A. Efros and Thomas K. Leung [6] proposed a non parametric method for texture synthesis with one pixel at a time and this process grows a new image outward from an initial seed. With the Random Markov Field assumption, the conditional distribution of a pixel for the given neighbors are synthesized and estimated by querying the sample image and finds all similar neighborhoods. Perceptually intuitive parameter controls the degree of randomness. The disadvantage is a tendency for some textures to occasionally slip into a wrong part of the search space and start growing garbage.

Daniela Hall et al., [7] described the definitions of the notion of saliency based on the probability density in feature space and evaluated three state-of-the-art interest point detectors with respect to their capability of selecting salient image features in two recognition settings. The Harris-Laplacian detector selects a small number of points which are in turn highly salient. Selecting only salient features by means of an approximate interest point detector has the potential to improve the overall result of the matching as well as to reduce computational time. Vladimir Vezhnevets et al., [8] discussed pixel based skin detection methods. The algorithm classifies each pixel as skin or non-skin from its neighbors. Region based methods considered pixels into account during the detection stage to improve the performance compared to pixel based skin detection method. The description, comparison and evaluation results of different methods for skin modeling and detection are discussed.

Carsten Rother et al., [9] proposed the graph-cut segmentation approach in three ways viz., i) iterative version of the image segmentation optimization ii) the power of iterative algorithm is used to simplify the user iteration for a given quality of result iii) algorithm for border matting to estimate simultaneously the alpha-matte around an object boundary and the color of foreground pixels. Behnam Karimi and Adam Krzyzak [10] discussed the significance of color in face recognition using several eigenface algorithms. The accuracy of each algorithm is determined and ranked according to recognition rates. David S. Bolme et al., [11] presented three different biometric performance benchmark algorithms for face recognition, such as Harr-based face detection, Principal Component Analysis (PCA) and Elastic Bunch Graph Matching (EBGM). Harr-based algorithm uses Ada-boost based classifier to locate faces in the image. PCA represents face image as vectors where each element in the vector corresponds to a pixel value in the image. PCA process is used to determine basis vectors for subspace in all common facial variations is expressed in a smaller dimensionality. The EBGM algorithm identifies a person by comparing new face image to faces stored in a database.

Sheeba Rani J et al., [12] proposed two step methodologies to overcome the illumination problem and variation in size tilt, rotation and noise as well as to improve face recognition rate. The method uses Integral Normalized Gradient Image for illumination insensitive image and discrete orthogonal tchebichef moment is used to classify extracted features. Scott Von Duhn et al., [13] proposed multiple view face tracking system in order to build 3D models of individual faces based on the Active Appearance Model and a generic facial model. A generic model is adjusted to the different views of the face. The multiple views of models are combined to create an individualized face model. Wen Gao et al., [14] proposed the CA-PEAL large-scale Chinese face database and baseline evaluations. The data base with pose, expression, accessories and lighting (PEAL) gives different source of variations for face recognition. CAS-PEAL face data base contains 99594 images of 104 individuals, out off which 595 males and 445 females. Kui Jia and Shaogang Gong [15] proposed a generalized face Super resolution model capable of hallucinating face images across multiple modalities such as expression, pose and illumination, for a given low resolution face image input of a single modality. Formulated a unified Tensor Space representation which incorporates both global and local Tensors.

Jean-Sebastien Pierrard and Thomas Vetter [16] presented a technique for detection and validation of moles, birthmark (nevi) that are prominent enough for person’s identification based on face which is independent of pose and illumination. Sensitive multiscale template matching procedure is used to detect potential nevi. The two complementary methods to filter the candidate points are (i) skin segmentation scheme based on gray scale texture analysis developed to perform outlier detection in the face and it do not require color input. (ii) A local saliency measure to express a point’s uniqueness and confidence taking the neighborhood’s texture characteristics into account.

Lijun Yin et al., [17] presented 3D facial expression database which is valuable resource for algorithm assessment, comparison and evaluation. This includes prototypical 3D facial expression shapes and 2D facial textures of 2500 models from 100 subjects to solve the problems inherent in the 2D based analysis. Stan Z et al., [18] presented illumination invariant face recognition system for indoor, cooperative person using active near infrared imaging hardware techniques. The AdaBoost procedure is used to learn face recognition based on the invariant representation. The disadvantages of the algorithm are not suitable for outdoor and uncooperative user applications. Shahin Azuan et al., [19] presented a face representation and recognition using Artificial Neural Networks. Performance evaluation of the system is done by applying two photometric normalization and homomorphic filtering, and comparing with Euclidian distance, and Normalized Correlation Classifiers.

Anil K. Jain and Unsang Park [20] presented soft biometric for face recognition. Primary facial features nose, mouth and eyes are located and segmented using Active Appearance Model. Facial marks like freckles, scars and moles are detected using Morphological and Laplacian-of-Gaussian (LOG) operators, Kailash J. Karande asnd Sanjay N. Talwar [21] addressed the face recognition using edge information as independent components. LOG and Canny edge detection methods are used to obtain edge information then preprocessing is done using PCA before applying the Independent Component Analysis (ICA) algorithm for training of images. The independent components generated by ICA algorithm are used as feature vectors for classification. Images were tested by using Euclidean distance and mahalanobis distance classifiers. Zhang et al., [22] proposed a method to extract illumination insensitive features for face recognition using varying lighting grandientfaces. The algorithm is insensitive to illumination and robust to different illumination, under uncontrolled, natural lighting. Grandientfaces is obtained from the image gradient domain so that it discovers inherent structure of face images since the gradient domain explicitly considers the relationships between neighboring pixel points. Vishwakarma et al., [23] presented an approach for illumination normalization under varying lighting conditions. Contrast stretching is obtained by applying histogram equalization on low contrast images. The Discrete cosine transform (DCT) low-frequency coefficients correspond to illumination variations in a digital image are scaled down to compensate the illumination variations. The value of scaling down factor and the number of low-frequency DCT coefficients, which are to be re-scaled, are obtained. The classification is done using k-nearest neighbor classification and nearest mean classification on the images obtained by inverse DCT on the processed coefficients. The correlation coefficient and Euclidean distance obtained using PCA are used as distance metrics in classification.

III. Model

A. Block diagram of the TBMDFR

Figure 1 gives the block diagram of Template based Mole Detection for Face Recognition.

B. Raw Image

Raw color or gray scale image is considered for the analysis. Morphological processing is used to enhance the contrast of an image.

C. Illumination compensation

The illumination compensation is used to remove the illumination variation in the image so that moles and birth marks are clearly visible using homomorphic filtering. In general, an image is represented as a two-dimensional function of the form $I(x, y)$, whose value at spatial coordinates (x, y) is a positive scalar quantity and is determined by the source of the image. The intensity of an image is a product of the amount of source illumination incident on the scene being viewed and the amount of illumination reflected by the objects in the scene as given in Equation (1).

$$I(x, y) = R(x, y) * L(x, y) \tag{1}$$

Where, R(x, y) amount of illumination reflected and L(x, y) is the amount of source illumination incident. I(x, y) intensity of an image and is the illumination-reflectance model which is used to address the problem of improving the quality of an image acquired under poor illumination conditions.

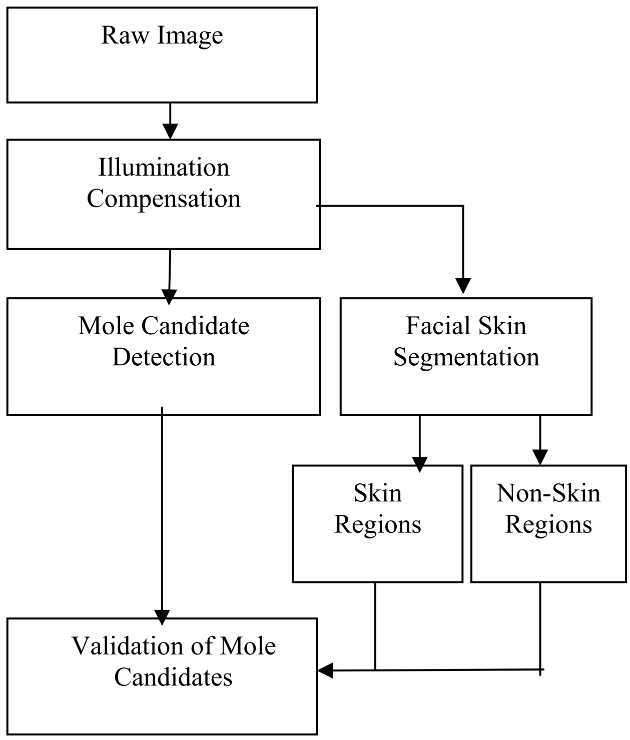


Fig 1: Block diagram of the TBMDFR.

Figure 2 shows the block diagram of homomorphic filter. The image I(x, y) in the spatial domain is the product of R(x, y) and L(x, y) is converted into additions by applying natural log, which intern converted into Fourier Transform and is low pass filtered. The reverse procedure is adopted to get an illumination compensated image in the spatial domain. Figure 3 shows the original image and illumination compensated image after passing through homomarphic filter.

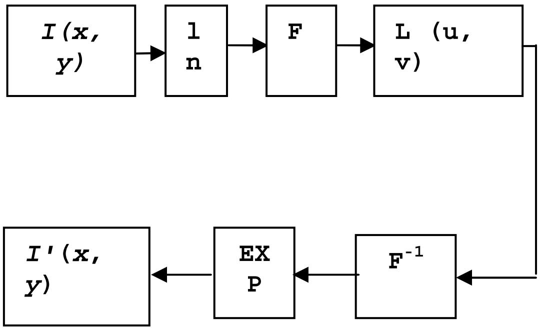


Fig 2: Block diagram of Homomorphic Filtering.

D. Mole Candidate Detection

The Laplacian operator is a template which implements second-order differencing (zero-crossing edge detector) as given in Equation (2)

$$f^{11}(x)=f^{1}(x)-f^{1}(x+1)$$
$$f^{11}(x)=-f(x)+2f(x+1)-f(x+2) \tag{2}$$

First Gaussian smoothing and then Laplacian operation. The convolution operation is associative, we convolve the Gaussian smoothing filter with the Laplacian filter for all, and then convolve this hybrid filter with the image to achieve the required result LOG as given in equation (3)

$$LOG(x,y)=-\frac{1}{\Pi\sigma^{4}}\left[1-\frac{x^{2}+y^{2}}{2\sigma^{2}}\right]e^{-\frac{x^{2}+y^{2}}{2\sigma^{2}}} \tag{3}$$

A complement of Gaussian template filter mask is used as template because of its close resemblance to the blob-like appearance of moles. NCC is computed for a small subset of scales distributed across the desired search range. The output image of each scale (sk), all local maxima (xi, yi: sk) to pinpoint candidate positions in 2D is determined and only these points are further considered. The correlation coefficients for the remaining points are computed using templates that corresponds to mole sizes 0.5sk to 2sk. The point is discarded if the maximum response across these scales is below a fixed threshold, otherwise the points are considered for subsequent processing.

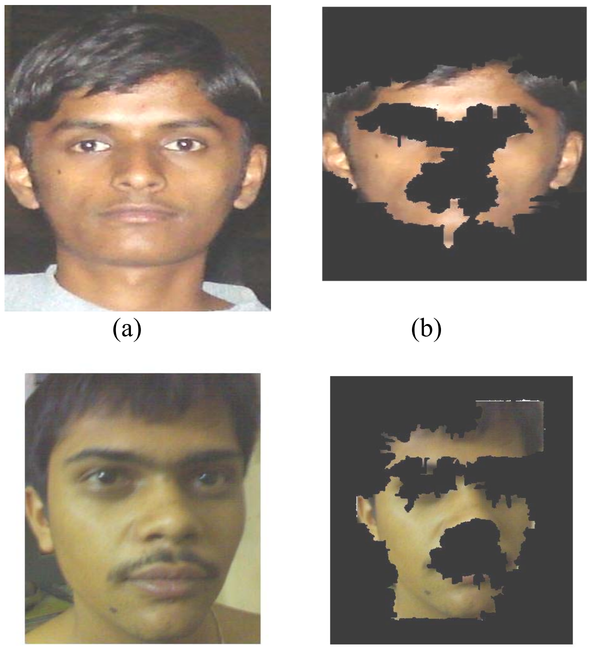
Considering scale and space independently has the drawback of causing duplicate point detections, i.e., candidates located at different scales and/or coordinates are actually responding to the same feature in the image and hence remove all duplicates except for the one with largest scale. The number of scales (range and sample steps) and the NCC threshold is chosen such that all marked points could be located. Template detection typically reduced the number of candidates for further processing to 1-2% of the pixels representing a face. NCC matching with complement of Gaussian filter mask as template is used for valid mole detection, and the same procedure is repeated for moles more than one to get the maximum correlation coefficients for each mole candidate.

(a) (b)

Fig 3: (a) Original image (b) Illumination compensated image.

E. Facial Skin Segmentation

The mole present on the facial skin is used for the identification process. Grab-Cut segmentation of an image is used for the separation of skin and nonskin regions to identify mole candidates on a skin region and is also used for image synthesis where a cut corresponds to the optimal smooth seam between source and target image. Figure 4 gives the test and segmented images to bifurcate skin and nonskin regions.



(a) (b)

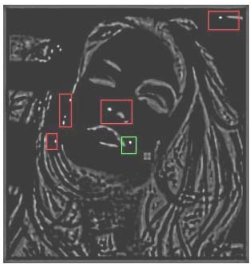
(c) (d)

Fig. 4: (a) Test image (b) Segmented image (c) Test image (d) Segmented image

F. Validation of mole/birthmark candidates

After the detection of mole candidates, their coordinates are checked with segmented image. If the mole lies in the skin region it is considered for further processing and if it is in the nonskin region, it is rejected.

The Figure 5 is used for the validation process to separate the prominent mole required for face detection. The mole candidate is detected by computing NCC coefficient and comparing with pre-defined NCC threshold value is as shown in Figure 5a). The mole is validated after NCC coordinates are checked with the segmented skin region of an image as shown in Figure 5b).




(a) (b)

Fig 5: (a) NCC of test image (b) Segmented test Image

IV. Algorithm

Problem Definition:

Face image with minimum one mole is given as the input, Face recognition is the output.

The objectives are

i) To detect the Mole candidate.

ii) Validation of detected mole candidate using facial skin segmentation.

iii) Face detection using mole.

Assumptions:

i) Pose variation is less than 10°.

ii) Face image should consist of at least one prominent mole.

Table 1 gives the algorithm of TBMDFR to detect and validate the mole present on face for personal identification.

Table 1: Algorithm of TBMDFR

- Input: Face image with minimum one mole.
- Output: Valid mole present in the face.
- Raw color or gray scale image is considered and enhanced by Morphological processing to improve the contrast.
- Illumination compensation is used to remove illumination variant of an image by the use of homomorphic Filter.
- Mole candidate detection by Normalized Cross Correlation matching with the help of complement of the Gaussian filter mask as template.
- Facial skin segmentation by Grab-Cut method to separate skin regions from non-skin regions.
- Validation of detected mole candidate by comparing its NCC coefficient with pre defined threshold value and its coordinates with the segmentation results.

V. Performance Analysis

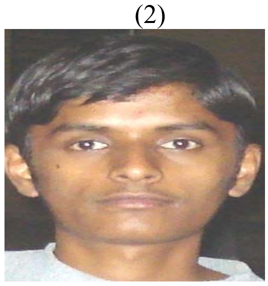
The face images of variable light and pose with at least one mole on a skin region are considered for the performance analysis as shown in Figure 6. The NCC matching technique with complement of Gaussian template gives highest NCC value for a particular mole. The Figure 7 gives the images with the prominent mole shown by rectangular box on images and their corresponding NCC images.

NCC threshold value accepts or rejects a particular NCC value of a mole to classify as valid or invalid depending on its value. The NCC Value depends on the mole size, darkness and uniqueness with respect to its surrounding region.

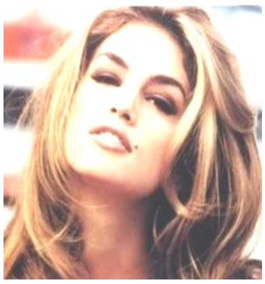
Table 2 gives NCC values for first and second mole of 5 test images for different template sizes viz., 9-15, 16-21, 22-27, and 28-33. It is observed that as template size increases the NCC values decreases in general. The template size 9-15 gives the better NCC values compared to other template sizes since normal mole size lies in this range.

Table 3 gives the different threshold values ranging from 0.3 to 0.85 for 6 test images consists of prominent moles with corresponding NCC values. No ranges of threshold values are neglected since there is an equal probability of detection and failure in each range. If a face image contains more than two or three moles which are prominent enough, then threshold values are adjusted manually so that all prominent moles are recorded without rejection.


(1) (2)

(3) (4)

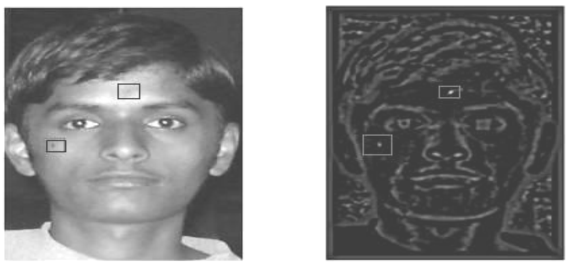



(5) (6)

Fig 6: Test images of 1 to 6


image 4 (d) NCC of the test image 4

(a) (b)



(c) (d)

Fig 7: (a) Test image 5 (b) NCC of the test image 5 (c) Test

TABLE 2: THE DETECTION/FAILURE OF MOLE FOR VARIOUS TEMPLATE SIZES.

Test Image Number	Template sizes used for NCC matching							
	9 to 15		16 to 21		22 to 27		28 to 33	
1	Mole 1	Mole 2	Mole 1	Mole 2	Mole 1	Mole 2	Mole 1	Mole 2
2	0.4277	0.5256	0.3103	0.3951	0.2271	0.2880	0.1917	0.1927
3	0.3344	-	0.1341	-	Failed	-	Failed	-
4	0.8032	0.3668	Failed	0.4478	Failed	Failed	Failed	Failed
5	0.5434	-	0.3431	-	Failed	-	Failed	-

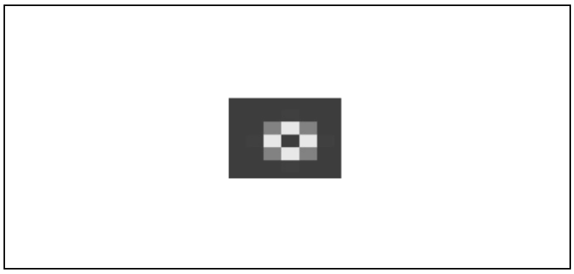
TABLE 3: THE DETECTION\FAILURE OF MOLE FOR VARIOUS RANGES OF NCC THRESHOLD VALUES

Test Image Number	Threshold Values (NCC Coefficients)			NCC value of the prominent mole in the test image
	0.3 to 0.49	0.5 to 0.64	0.65 to 0.85	
1	Detected	Failed	Failed	0.4107
2	Detected	Failed	Failed	0.3990
3	Failed	Failed	Detected	0.9132
4	Failed	Detected	Failed	0.6114
5	Failed	Failed	Detected	0.8379
6	Detected	Failed	Failed	0.5748

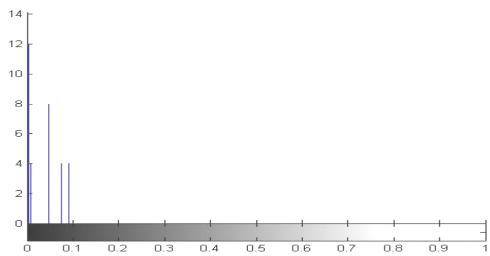
Figure 9 shows complement of Gaussian template and its corresponding histogram. The complement of Gaussian template has smooth variation from center to the outer area and the histogram gives gradual variation in intensity, which is an advantage compared to LOG template.

The NCC value of test images 5 and 6 with LOG template is shown in the Figures 10(a) and 10(c) has less intensity values. The NCC values of test images 5 and 6 with complement of Gaussian template is as shown in the figures 10(b) and 10(d) has improved intensity values.

Figure 8 shows LOG template and its histogram. The texture variation of the mole is centrally dark and decreases gradually towards the end. The disadvantages of LOG template is a sudden variation from center to the outer area as shown in the Figure 8(a) and the histogram of LOG template gives random variation in intensity as shown in the Figure 8(b).

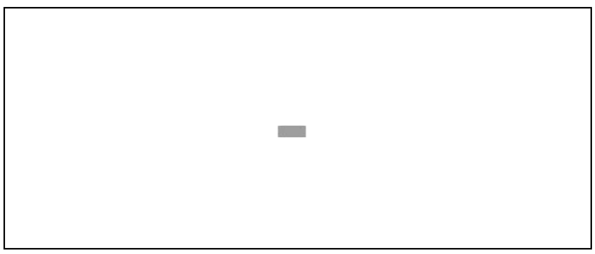


(a)

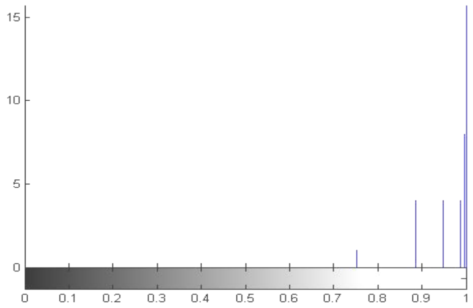


(b)

Fig 8: (a) LOG template (b) Histogram image of the LOG template



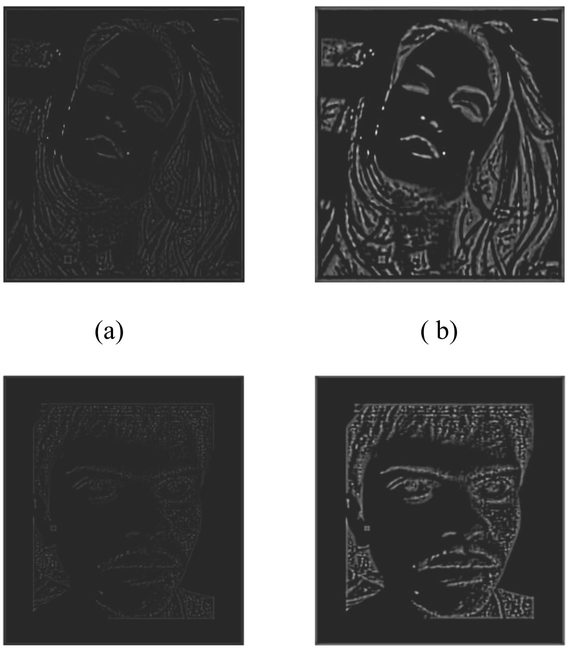
(a)



(b)

Fig 9: (a) Complement of Gaussian template (b) Histogram image of the complement of Gaussian template.

Table 4 gives the comparison of NCC values for existing algorithm Skin Detail Analysis for Face Recognition (SDAFR) using LOG template mask [16] and the proposed algorithm TBMDFR using complement of Gaussian template for 6 images with percentage of increase in NCC values. NCC values of TBMDFR are better when compared to SDAFR which indicates that the identifying the valid mole is better, hence face recognition of the proposed algorithm is improved compared to the existing algorithm..



(a) (b)

(c) (d)

Fig 10: (a) and (c) NCC of test images 5 and 6 using LOG template, (b) and (d) NCC of test images 5 and 6 using complement of Gaussian template.

TABLE 4: NCC VALUES OF SDAFR AND TBMDFR

Test image number	NCC value for SDAFR	NCC value for TBMDFR	% increase in NCC values
1	0.1926	0.4107	113.23
2	0.3634	0.3990	9.7963
3	0.4328	0.9132	110.99
4	0.1714	0.6114	256.70
5	0.3993	0.8379	109.84
6	0.1274	0.5748	351.17

VI. CONCLUSION

The proposed algorithm TBMDFR uses the face image with minimum of one mole for personnel identification. The illumination compensation using homomorphic filtering is performed for clear visibility of the mole. NCC matching with complement of Gaussian template is used to detect the mole with its intensity value and position with predefined NCC threshold values. Validation of the mole is determined by comparing the co-ordinates of the detected moles with the Grab-Cut segmented image and the mole present in the skin region is accepted as a valid mole. The NCC values of TBMDFR are more compared to existing SDAFR algorithm; hence the proposed algorithm is better in face recognition with minimum of one mole.

REFERENCES

[1] Yuri Y Boykov and M. P. Jolly, "Interactive Graph Cuts for Optimal Boundary and Region Segmentation of Objects in N-D images," Proceedings of International Conference on Computer Vision, Vancouver, Canada vol. 1, pp. 105–112, July 2001.

[2] T. F. Cootes, G. J. Edwards, and C. J. Taylor, "Active Appearance Models," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 23 pp. 681–695, January 2001.

[3] Volker Blanz and T. Vetter, "A Morphable Model for the Synthesis of 3D Faces," Proceedings of Computer Graphics and Interactive Techniques, SIGGRAPH, pp. 187–194, 1999.

[4] K. N. Walker, T. F. Cootes, and C. J. Taylor, "Locating Salient Object Features," Proceedings of British Machine Vision Conference, vol. 2, pp. 557–566, 1998.

[5] Volker Blanz and T.Vetter, "Face Recognition based on Fitting a 3D Morphable Model," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 25, no. 9, pp. 1063–1074, September 2003.

[6] Alexei A. Efros and Thomas K. Leung, "Texture Synthesis by Non-parametric Sampling," IEEE International Conference on Computer Vision, pp. 1033–1038, September 1999.

[7] Daniela Hall, B. Leibe, and B. Schiele, "Saliency of Interest Points under Scale Changes," Proceedings of British Machine Vision Conference, pp. 646-655, September 2002.

[8] Vladimir Vezhnevets, Vassili Sazonov and Alla Andreeva, "A Survey on Pixel-based Skin Color Detection Techniques," Proceedings of Graphicon, pp. 85-92, September 2003.

[9] Carsten Rother, V. Kolmogorov, and A. Blake, "Grab Cut: Interactive Foreground Extraction using Iterated Graph Cuts," Proceedings of ACM Transactions on Graphics, vol. 23, no. 3 pp. 309–314, August 2004.

[10] Behnam Karimi and Adam Krzyzak, "A Study on Significance of Color in Face Recognition using Several Eigenface Algorithms," Proceedings of Twentieth Canadian Conference on Electrical and Computer Science Engineering, pp. 1309-1312, April 2007.

[11] David S. Bolme, Michelle Strout, and J. Ross Beveridge, "FacePerf: Benchmarks for Face Recognition Algorithms," Proceedings of IEEE International Symposium on Workload Characterization (IISWC), pp. 114-119, September 2007.

[12] J. Sheeba Rani, D. Devaraj, R. Sukanesh, "A Novel Feature Extraction Technique for Face Recognition," Proceedings of International Conference on Computational Intelligence and Multimedia Applications, pp. 431-435, 2007.

[13] Scott Von Duhn, Lijun Yin, Myung Jin Ko, and Terry Hung, "Multiple-View Face Tracking For Modeling and Analysis based on Non-Cooperative Video Imagery," IEEE Conference on Computer Vision and Pattern Recognition (CVPR'07), pp. 1-8, June 2007.

[14] Wen Gao, Bo Cao, Shiguang Shan, Xilin Chen, Delong Zhou, Xiaohua Zhang, and Debin Zhao, "The CAS-PEAL Large-Scale Chinese Face Database and Baseline Evaluations," IEEE Transactions on Systems, Man, and Cybernetics-part A: Systems and Humans, vol. 38, no. 1, pp. 149-161, January 2008.

[15] Kui Jia and Shaogang Gong, "Generalized Face Super-Resolution," IEEE Transactions on Image Processing, vol. 17, no. 6, pp. 873-886, June 2008.

[16] Jean-Sebastien Pierrard and Thomas Vetter, "Skin Detail Analysis for Face Recognition," Proceedings of International Conference on Computer Vision and Pattern Recognition (CVPR'07), pp. 1-8, June 2007.

[17] Lijun Yin, Xiaozhou Wei, Yisun, Jun Wang, Mathew J. Rosato, "A 3D Facial Expression Database for Facial Behavior Research," Proceedings of the Seventh International Conference on Automatic Face and Gesture Recognition (FGR2006), pp. 211-216, April 2006.

[18] Stan Z. Li, Rufeng Chu, Shencai liao and Lun Zhang, "Illumination Invariant Face Recognition using Near-Infrared Images," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 29, no. 4, pp. 627-639, April 2007.

[19] Shahrin Azuan Nazeer, Nazrruddin Omar and Marzuki Khalid, "Face Recognition System using Artificial Neural Networks Approach," IEEE-ICSCN, pp. 420-425, February 2007.

[20] Anil K. Jain and Unsang park, "Facial marks: Soft Biometric for Face Recognition," to be published in IEEE International Conference on Image Processing, Cairo, November 2009.

[21] Kailash J.Karande and sanjay N. Talwar, " Independent Component Analysis of Edge Information for Face Recognition,' international Journal of Image Processing, vol. 3, issue 3, pp. 120-130, 2009.

[22] T. Zhang, Y. Y. Tang, B. Fang, Z. Shang and X. Liu, "Face Recognition Under Varying Illumination Using Gradientfaces," IEEE Transaction on Image Processing, vol. 18, no.11, pp. 2599-2606, November 2009.

[23] Virendra.P. Vishwakarma, Sujata.Pandey, and M. N. Gupta, "An Illumination Invariant Accurate Face Recognition with Down Scaling of DCT Coefficients," Journal of Computing and Information Technology, vol 18, no1, 2010.

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