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Feature Extraction for Face Recognition using Edge Detection and Thresholding

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Abstract: ***Face recognition is first and foremost step in video surveillance applications which include human behavioral analysis, event detection, border security and ATM banking. Most of the time, it is very difficult to get good facial features from the particular image frame and it often requires sophisticated algorithm for face identification and recognition. Robust face detection system is still a more challenging job because of complex environments including illumination changes, background clutter and occlusions. This article presents a novel feature extraction algorithm for face recognition using edge detection and thresholding. Initially, the incoming image is preprocessed to smoothen the image features and it is converted in to grayscale image to reduce the computational complexity of post processing steps. In feature extraction step, the image is completely iterated throughout the spatial coordinates and the edges are detected using thresholding technique. The optimum threshold for global thresholding is identified by calculating the maximum between-class variance in the given image. The extracted edge features are invariant under scale and illumination changes and thus it ensures the robust binary mask for face identification. Finally, the foreground features are obtained using morphological operations and the face is highlighted in subsequent incoming image frames. The proposed method can be deployed in public places such as malls, ATM centers and airports for security applications. Experimental results clearly indicate that the proposed approach works well under complex situations.***

Keywords: Thresholding, face detection, complex background, morphological operations.

I. INTRODUCTION

In recent years, tremendous research works are being carried out in the field of computer vision. The idea of using physical attributes such as face, fingerprints, voiceprints or any of several other characteristics to human behavioral analysis has a lot of appeal. Any trait of human beings that is unique and sufficiently stable can serve as a distinguishing measure for verifying, recognizing or classifying them. Face is one such attribute of human beings that clearly distinguishes different individuals.

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In fact, face is the attribute that is most commonly used by human visual system to identify people. This local feature serves as robust cue at developing computational systems for automatic face recognition. Robust face detection involves more challenges including poor resolution, cluttered faces, blurring, occlusion and pose changes which degrades the performance of face recognition system [1]. Automatic face recognition is a process of identifying a test face image with one of the faces stored in a prepared face database. Real world images need not necessarily contain isolated faces that can directly serve as inputs to face recognition system. Hence, there is a need to isolate or segment facial regions to be fed to a face recognition system.

II. RELATED WORKS

Kumar et al. presented a detailed survey of face recognition methods and discussed the pros and cons of each methods for gender and age classification [2]. Petajan et al presented a work in which all local facial features are extracted individually and later clustered for face recognition [3]. However, all parameters of local features need to be tuned for better performance. Yoo et al. followed a nonparametric approach for face tracking. In this approach, skin color regions are localized without explicit model of foreground region and this method is computational expensive [4]. In skin color based approach, skin color intensity is more likely to change due to illumination variation [5]. Some of the researchers use Euler number for localizing the human face in the given image frame [6]. Most of the researchers consider foreground features for object detection and usually ignores the background features which leads to poor performance. Stauffer et al. used Mixture of Gaussians (MoG) for background modeling in object detection process [7]. Jung et al. improved the system performance by updating the co-occurrence of background pixels [8]. Adaptive thresholding is incorporated by McHugh et al. for object detection along with co-occurrence of pixels to improve system performance [9]. From the detailed study, it is inferred that robust technique for face recognition is still need to be devised for good performance under complex environments. In addition to that, local features such as color, texture, edges and fusion of one another can improve the results of face recognition system. Color features are best suited for dealing with rotations and scaling variations. But, it is helpless under poor illumination and rapid lighting variations. This problem will be eradicated by using texture features and texture features are good supplement for object detection. Besides that texture features are not work well for smooth surfaces.

III. SYSTEM OVERVIEW

The proposed method cope up with the challenges associated with face identification and recognition by extracting the edge features of the foreground (face). These edge features are good enough to deal with illumination conditions and scaling, rotation and cluttered environments. The overview of proposed methodology is given in Fig. 1. The proposed system involves three stages of operations such as preprocessing, edge feature extraction and target localization.

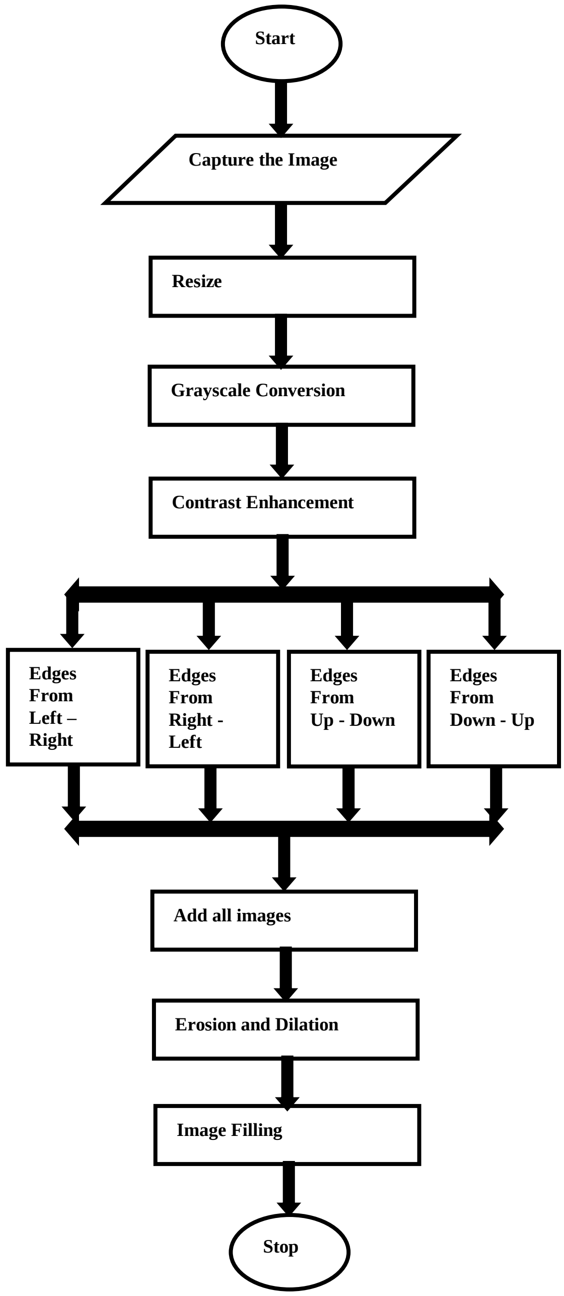

Fig. 1.Overview of proposed method

A. Preprocessing

Pre-processing step involves image capturing, resizing, color space conversion and contrast improvement. The color image is captured by the camera and the image is stored in the JPEG format. RGB color space is predominantly influenced by intensity variation and thus the proposed system employs grayscale conversion as preprocessing step for face detection. In addition, the RGB image is converted into grayscale image and resized to reduce the computational complexity. Moreover, the gray scale image retains most of the image features with acceptable loss of color details. Further, image may be degraded while capturing due to aperture effects and irregular illuminations. Now, the contrast of the grayscale image has to be enhanced in order to improve the quality of post processing. The preprocessed image undergoes the post processing for edge detection.

B. Feature Extraction Using Edge Detection

In this feature extraction step, the image is completely iterated throughout the spatial coordinates and the edges are detected using thresholding technique. Initially, the optimum threshold is identified for maximum between-class variance by trial and error method. Then, the difference between the neighboring pixels is compared with optimum threshold. If the difference is greater than the threshold then it is marked as logic '1' else it is marked as logic '0's.

Fig. 2.Original image frame

Fig.2 illustrates the original image frame. Let p_{ij} be the pixel being processed and s_{ij} be the processed pixel. Let 'T' be the optimum threshold. Then, the four edge outputs are obtained (see Fig.3) by iterating left to right, iterating right to left, iterating up to down and iterating down to up according to eq. (1)–(4). Now, these four images are added together to get the final edge detected image as shown in Fig.4.

Left-to- right:

$$s_{ij} = \begin{cases} 1 & \text{for } \left(p_{ij} - p_{i(j+1)}\right) > T \\ 0 & \text{otherwise} \end{cases} \quad ; \mathrm{i} = 0 \text{ to } M, j = 0 \text{ to } N \tag{1}$$

Right -to- right:

$$s_{ij} = \begin{cases} 1 & \text{for } \left(p_{ij} - p_{i(j-1)}\right) > T \\ 0 & \text{otherwise} \end{cases} \quad ; \mathrm{i} = 0 \text{ to } M, \ j = N \text{ to } 0 \tag{2}$$

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Top –to- bottom:

$$s_{ij} = \begin{cases} 1 & \text{for } \left(p_{ij} - p_{(i+1)j}\right) > T \\ 0 & \text{otherwise} \end{cases} \quad ; i = 0 \text{ to } M, j = 0 \text{ to } N \tag{3}$$

Bottom-to- top

$$s_{ij} = \begin{cases} 1 & \text{for } \left(p_{ij} - p_{(i-1)j}\right) > T \\ 0 & \text{otherwise} \end{cases} \quad ; i = M \text{ to } 0, \; j = 0 \text{ to } N \tag{4}$$

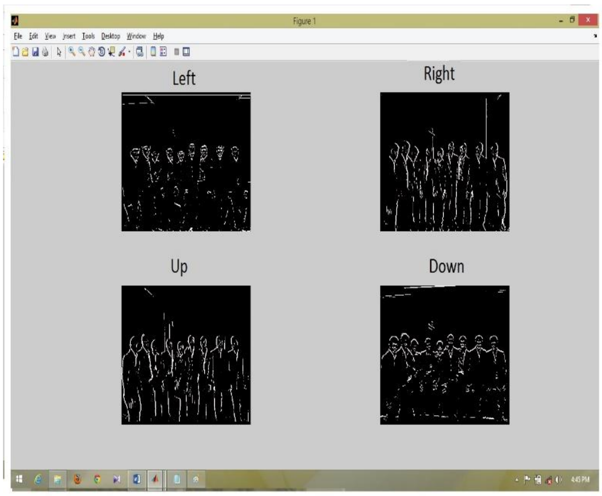

Fig. 3.Four edge detection results

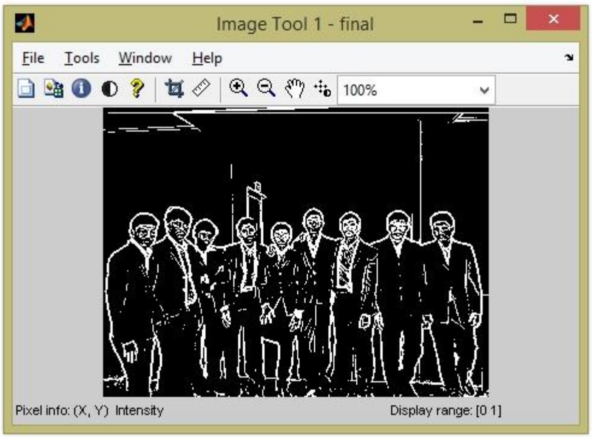

Fig. 4.Final edge detection result

C. Target Localization

In this phase, the target features are identified and localized by two processes such as component labeling and morphological operations. The component labeling is binary processing in which all connected components are labelled as a foreground regions. Each connected component is assigned with a unique label and other parts of the image are considered as background. This process retains the foreground details and it ensures the correct target location. The face image obtained in the edge detection process contain non-face regions and these regions must be confined as background regions. The removal of non-face regions from the obtained edge features is proceeded by morphological processes such as dilation and erosion. At first, image opening is done in two steps namely erosion and dilation. This erosion process get rid of small and tinny inaccessible noise-like regions that have very low probability of representing a face. Dilation reserves the regions that are unconcerned during erosion. Hence, the image opening ensures feasible binary mask for face detection. At the end, image closing operation is done to improve the results. Image closing is carried out by dilation followed by erosion. Here, dilation preserves small parts of face regions and erosion of close operation take out the unwanted parts of the face regions that are generated during the image opening process. Fig. 5 shows the result of morphological operations.

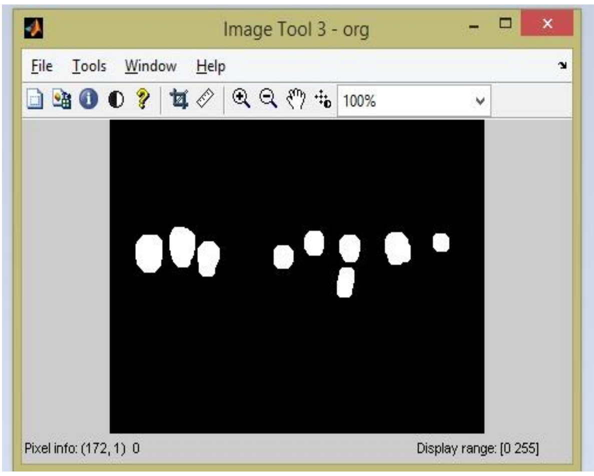

Fig. 5.Morphological operation results

The smoothing filter is used to find the oval shaped face region in an image. The binary mask is mapped with the original image frame and the face regions are highlighted with green color to showcase the face regions. The final face detection result of original image frame is shown in Fig.6.

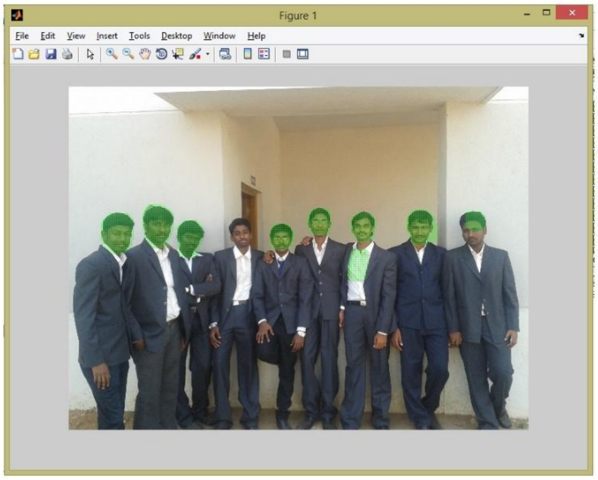

Fig. 6.Face detection results

IV. RESULTS AND DISCUSSION

Experiment is carried out in the system environment using MATLAB. R2010a. An image processing tool box is used to implement the proposed algorithm and different performance metrics are used to validate the results. These metrics include success rate, false alarm rate (*FA*), precision (*P*) and accuracy (*A*). The success rate [10] measures the successful face detections among the total number of faces in the given image frame. If the detected part matches at least 50 percent of the face region, it is then considered as successful detection.

The precision, false alarm rate and accuracy are calculated based on the constraints [11]-[13] such as true positives (T^p), false positives (F^p), true negatives (T^n) and false negatives (F^n). If the face is identified as face in the given image, then it is termed as true positive. Conversely, if face is present in the given image and it is identified as non-face, then it is termed as false negative. Similarly, if non-face regions are detected as non-face regions in the given image, it is then referred as true negatives. Furthermore, if non-face regions are identified as face regions, then it is said that false positives. Precision dictates the number of true positives among the total detections and false alarm rate gives the count of failure detections.

$$P = \frac{T^p}{T^p + F^p} \quad (5)$$

$$FA = \frac{F^p}{T^p + F^p} \quad (6)$$

$$A = \frac{T^p + T^n}{T^p + F^p + T^n + F^n} \quad (7)$$

Table- I: Quantitative analysis of proposed method

Sequence	Metrics			
	Precision	*Accuracy*	*False alarm rate*	*Success rate*
Face Occ	*0.821*	*0.87*	*0.179*	*0.8667*
james2.av	*0.836*	*0.845*	*0.164*	*0.8833*
mushiake1.av	*0.8752*	*0.8560*	*0.1440*	*0.8978*
Own sequence	*0.9046*	*0.8745*	*0.106*	*0.9022*

Experiment was carried out for different challenging image sequences to validate its robustness. Fig. 7-10 give the quantitative analysis of proposed system in terms of performance metrics. Table I dictates the values of surveillance metrics of proposed approach. From the results, it is inferred that the proposed approach done good job almost for all image sequences created by our own compared to all other publically available sequences. For good performance, the values of precision, accuracy and success rate must be high and false alarm rate should be very low. From Table. 1, it is observed that, the performance of proposed approach is appreciable in terms of low false alarm rate, high precision, accuracy and success rate.

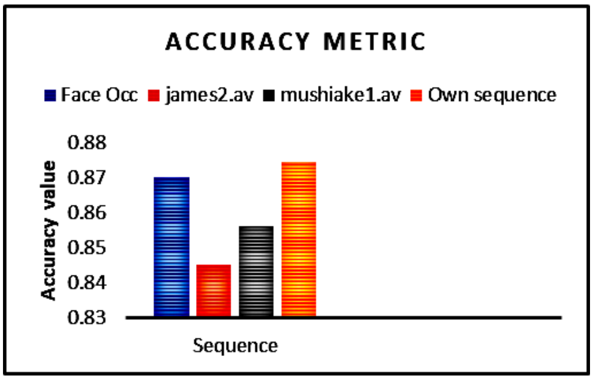

Fig. 7.Plot of Accuracy

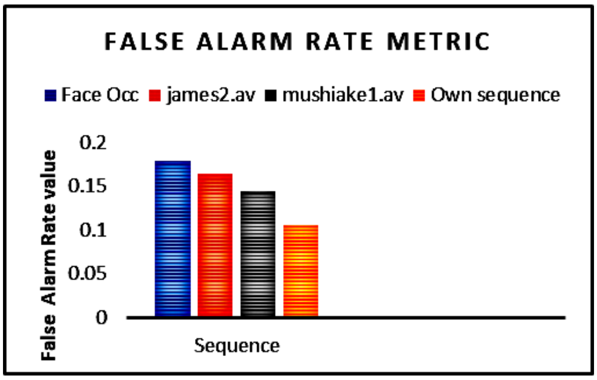

Fig. 8. Plot of False alarm rate

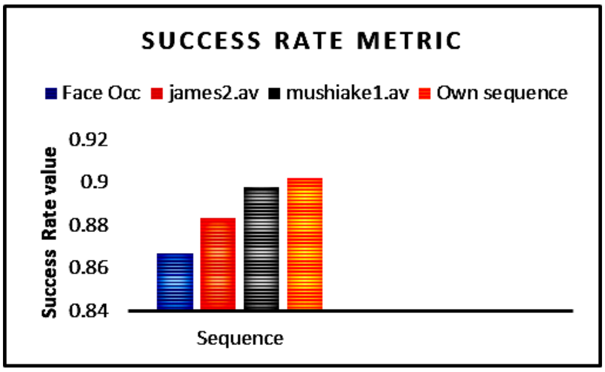

Fig. 9.Plot of success rate

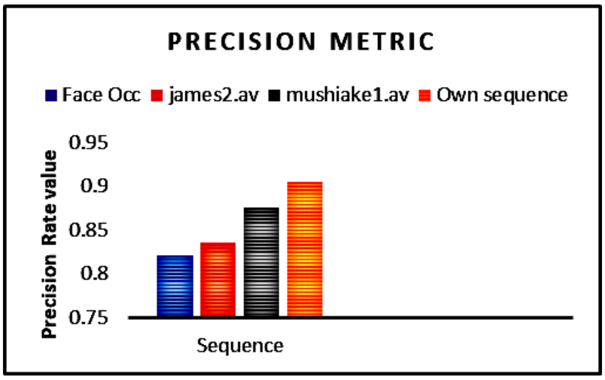

Fig. 10. Plot of precision

V. CONCLUSION AND FUTURE WORK

An efficient feature extraction using edge detection and thresholding is proposed for face recognition system. It is achieved in three steps such as preprocessing, feature extraction and morphological processing. In preprocessing, the RGB image is captured and it is converted into gray scale image. In feature extraction, edge features are obtained and binary mask is derived by morphological operations. Finally using mask processing, the face is detected for the given image frame. Experimental was carried out for different challenging sequences and the performance is tested based on surveillance metrics. The quantitative results clearly shows that the proposed approach outperforms in all sequences. However, the proposed method loses the color feature information because of the use of gray scale image and not able to handle the real time specifications In addition to that, the global thresholding may degrade the system performance under smooth surface region and rapid in-plane rotations.

The proposed method can further be extended in future by deriving separate explicit models for foreground and background regions. Then, a large dataset can be used for training phase with unsupervised learning for further improvements.

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