FUZZY LOGIC BASED NOVEL METHOD OF FACE DETECTION

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Abstract - The paper proposes the implementation of new face detection methods for still colored images. The face detection is performed by combining skin detection methods with template matching. The skin detection is performed using YCbCr method and template matching is performed in edge detected image and template image. The edge detection is performed using novel fuzzy edge detection method which is used to detect the edges of an image without determining the threshold value. The novel method begins by scanning an image using 2*2 floating mask. The algorithm has 4 inputs which can be “black” or “white” and 2 outputs which can be “edge” or “black” and having sixteen rules. The MSE and PSNR value from this method is compared with other classical edge detection methods and an existing fuzzy method which shows that novel edge detection method have less MSE value and more PSNR value than these methods which mean better results.

Keywords - Edge Detection, Face Detection, Fuzzy edge detection, Fuzzy Logic, Skin detection, YCbCr model.

I. INTRODUCTION

Digital image processing is a subset of the electronic domain where the image is transformed into an array of small integers. These small arrays of integers are known as pixels. Edges in images refers to sharp discontinuities in the intensity and contrast of one pixel to next pixel which can bring major variations in the quality of the picture. Edge detection [15] of an image considerably trims down the data and sort out worthless information, whereas keeping the important structural properties of an image intact. Fuzzy logic [2] corresponds to a powerful problem solving methodology using a mathematical framework to deal with the improbability of information. Fuzzy image processing is using fuzzy logic for understanding, representation and processing the images, their segments and features as fuzzy sets. The representation and processing of the images and their segments most importantly depend on the technique of fuzzy logic that is going to be used and secondly on the nature and type of the problem to be solved. This research problem deals with Fuzzy inference system (FIS) which represents greater robustness to blurred image. Further tuning of the weights associated with the fuzzy inference rules is still necessary to reduce even more inclusion in the output image of pixels not belonging to edges.

The results from fuzzy edge detection method [27] compared with other edge detection methods [4] like Sobel [3], Robert, Prewitt, Canny and LoG. The results show that the results from fuzzy edge detection are better than other edge detection methods in terms of MSE and PSNR values. The fuzzy edge detection is further used in face detection as template matching. The fuzzy edge detection detects fine edges and thus helps in template matching to find faces from still images. The face detection is an important area in the field of security. This better method leads to better security.

II. LITERATURE REVIEW

Nagendram, Divya, Bharadwaj and Dharanija [5] survey the theory of edge detection for image segmentation using soft computing approach based on the Fuzzy logic. A novel FIS method based on fuzzy logic reasoning strategy is proposed for edge detection in digital images without determining the threshold value or need a training algorithm. The proposed approach begins by segmenting the images into regions using floating 3x3 binary matrixes. A direct fuzzy inference system mapped a range of values distinct from each other in the floating matrix to detect the edge. In future, modification of fuzzy rules can produce better results. Further tuning of the weights associated with the fuzzy inference rules is still necessary to reduce even more inclusion in the output image of pixels not belonging to edges.

Jayachandran, Dhanasekaran, Perumal and Sudarson [6] describe a novel fuzzy inference system sub detector is proposed it is developed based on the fuzzy inference rules. This FIS method is used to detect of edges in digital images corrupted by impulse noise. It effectively detects the edges of noise images without determining the threshold value. The proposed approach begins by segmenting the images into regions using floating 3x3 binary matrixes. The edge pixels are mapped to a range of values distinct from each other. The robustness of the proposed method results for different
captured images is compared to those obtained with the linear Sobel operator. It has given a permanent effect in the lines smoothness and straightness for the straight lines and good roundness for the curved lines. At the same time, the corners get sharper and can be defined easily. One past drawback of this type of algorithm was that they required extensive computation.

Kaushal and Raina [7] describe a face detection technique based on Gabor Wavelet Transform (GWT) and Artificial Neural Network (ANN). Gabor filters can serve as excellent band-pass filters for one-dimensional signals (e.g. speech). A complex Gabor filter is defined as the product of a Gaussian kernel time a complex sinusoid. An artificial neural network (ANN) is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. The technique extracts the features of the image by using Gabor filter and train the network with the help of feed forward neural network. This method is inspired by eigenfaces and elastic bunch matching method. In the procedure of face detection, firstly a database is made for faces and non-faces, and network is trained for this database. Then the features are extracted with the help of Gabor filter. The rectangles are drawn on the faces. But the technique may detect the false negative and false positive. Where the false negative=number of missed faces/total number of actual faces and false positive= number of incorrect detected faces/total number of actual faces. As this technique is using Gabor wavelet thus this method is robust to illumination, which is the main problem of eigenfaces approach.

Axnick and Karl and Ng [8] explain fast face recognition for access control with a small database with speed and accuracy. There are mainly two types of approaches for fast face recognition (i) Geometric (ii) Holistic. The geometric technique is that where measurements are made such as the distance between the eyes and shapes of lines connecting facial features. In holistic method, the entire image segment is reduced to few key values, and these values are compared with some stored images (key values). This paper includes a technique in which the first step is to detect/localize a face by background subtraction and eye localization. In the second step, the feature extraction is done by finding eye, nose & mouth parameter. In the third step, the face is recognized by considering by Euclidean points of the face. The accuracy of this technique for 2D color images is 97% with one-second processing time per face and for 3D images is 100%. However, the current 3D scans require that the subject stay still for 0.4 seconds while an eye safe laser scans them.

Barbu [9] explains the technique for face recognition, which uses two-dimensional Gabor filtering and supervised classification. The Gabor filter represents a band-pass linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function. The Gabor filter is applied to image and concatenated into a three-dimensional feature vector. Then the distance between different features is used by squaring Euclidean metric. The next stage is feature vector classification. This method uses a supervised classification technique for these Gabor filters-based 3D feature vector. The supervised classifier used in this technique is a minimum average distance classifier. The last step is verification procedure that consists in either confirming or invalidating a facial identification result. The result of this process is identified faces. A high face recognition rate, of approximately 90%, has been reached by this recognition system in the experiments involving hundreds frontal images.

Jemaa and Khanfir [10] represent a technique for face detection and recognition of color images. The face detection technique is based on skin color information and fuzzy classification. The skin information is extracted using YCbCr model and further improved using IF-Then rules of fuzzy classification. A new algorithm is proposed in order to detect automatically face features (eyes, mouth and nose) and extract their corresponding geometrical points. The geometric points: distance between eyes, width and height of the nose, the difference between the nose and mouth, etc. are extracted. These fiducial points are described by sets of wavelet components, which are used for recognition. To achieve the face recognition, it uses neural networks and studies its performances for different inputs. It compares the two types of features used for recognition: geometric distances and Gabor coefficients which can be used either independently or jointly. This comparison shows that Gabor coefficients are more powerful than geometric distances. It also shows with experimental results how the importance recognition ratio makes the system an effective tool for automatic face detection and recognition. The best result is given by this method is 99.98% for faces with different rotation and lighting conditions.

Tripathi, Sharma and Sharma [11] present a method for face detection which combines the skin color detector and template matching method. The skin color is detected using YCbCr model. In this model, Y represents luminance information and Cb,Cr represents chrominance factors. The skin and non-skin areas can be easily detected by using this model. After detecting skin area the next task is to detect face and non-face areas from that skin area. As the skin area contains both the face and non-face areas. This is done with the help of template matching. This method detects faces and removes non-faces more accurately. In this method, eigen faces are used as a template. For this, edge detection is applied to image with the help of Sobel Edge Detection, which helps in more accurate face detection. This method improves face detection process by reducing no. of false positives.

Chandrappa, Ravishankar and Babu [12] describe a face detection technique. This paper proposes a novel technique for detecting faces in color images using skin color model algorithms combined with skin likely-hood, skin Segmentation, Morphological operation and Template matching. Color images with skin color in the chromatic and pure color space YCrCb, which separates luminance and chrominance components. A Gaussian probability density is estimated from skin samples, collected from different ethnic groups, via the maximum-likelihood criterion. Adaptive thresholding for segmentation to localize the faces within the detected skin regions is also used. Then, mathematical morphological operators are used to remove noisy regions and fill holes in the skin-color region, so we can extract candidate human face regions. This system achieves high detection accuracy, high detection speed and reduces the false detecting rate.
Yulong and Qi [13] suggested an approach in which abstract template is constructed for extracting facial information from images. Different from the traditional template, which only includes color or gradient information in pixel level, abstract templates synthesize texture, shape and scale information of the objects with relative parameters. This parameterized model can be used to describe the object to be recognized together with a measure of how like it fits the image data. Three kinds of abstract templates are proposed in eye, eye pair, and face texture detection separately for face detection. After applying the abstract template, the parameters computed can be used for object description and recognition.

Kherchaoui and Algeria Houacine [14] described a face detection method based on combining both a statistical model of skin color and geometrical face characteristics. The system presented is organized in two parts. The first one consists in skin color detection by a statistical method, based on a Gaussian mixture model in the chromatic CbCr color space. The second part is devoted to processing detected skin regions to select those corresponding to the faces. A skin region is considered as a face candidate if it verifies a set of geometrical constraints. And then, a template matching is applied to reach the final decision depending on the degree of similarity between the template used and the region under analysis. Both skin detection part, and whole face detection system were tested on face databases.

Maini and Aggarwal [15] describe edge detection techniques. The techniques canny, LoG (Laplacian of Gaussian), Robert, Prewitt and Sobel’s methods described. According to the paper, a canny method (Canny, 1986) performs much better than other methods. Canny yields thin lines for its edge using non-maximal suppression. Canny also utilizes hysteresis with a threshold. It also describes that edge detection is used in the matching process. Thus, it is very important that we should choose the best edge detector for good results. Also this is the first step of object recognition like face recognition.

Sao and Yegnanarayana [16] represent face verification method, which uses two classes, i.e. interclass variation and intra class variation. Interclass variation is the variation between two persons, and intra class variation is the variation of the same person because of pose, illumination and expression. The intra class variation is the main problem in face verification. This method uses template matching based approach, which is performed using edginess based representation of a face image. The no. of results obtained by template matching on face images are combined with the help of auto associative –neural network (AANN) model based classifier. The AANN model is used to capture the distribution of the false class images and does not require many reference images of the true class. The result shows that the proposed method is promising alternate to other methods in pose and illumination variation.

Tan, Chan, Pratheepan and Condell [17] proposed a novel human skin detection approach that combines a smoothed 2D histogram and Gaussian model, for automatic human skin detection in a color image(s). In this approach, an eye detector is used to refine the skin model for a specific person. The proposed approach reduces computational costs as no training is required, and it improves the accuracy of skin detection despite wide variation in ethnicity and illumination. This is the first method to employ fusion strategies for this purpose. Qualitative and quantitative results on three standard public data sets and a comparison with state-of-the-art methods have shown the effectiveness and robustness of the proposed approach.

Wang and Ji [18] suggest that in the face detection, mostly often used features are selected from a large set (e.g. Haar wavelets). Generally, Haar wavelets only represent the local geometric feature. When applying those features to profile faces and eyes with irregular geometric patterns, the classifier accuracy is low in the later training stages, only near 50%. In this paper, instead of brute-force searching the large feature set, it proposes to statistically learn the discriminant features for object detection. Besides applying Fisher discriminant analysis (FDA) in AdaBoost, further propose the recursive nonparametric discriminant analysis (RNDA) to handle more general cases. Those discriminant analysis features are not constrained with geometric shape and can provide better accuracy. The compact size of a feature set allows selecting a near optimal subset of features and constructing the probabilistic classifiers by greedy searching. The proposed methods are applied to multi-view face and eye detection and achieve good accuracy.

Hadid, Pietikainen and Ahonen [19] introduced a novel discriminative feature space which is efficient not only for face detection but also for recognition. The face representation is based on local binary patterns (LBP) and consists of encoding both local and global facial characteristics into a compact feature histogram. The proposed representation is invariant with respect to monotonic gray scale transformations and can be derived in a single scan through the image. Considering the derived feature space, a second-degree polynomial kernel SVM classifier was trained to detect frontal faces in grayscale images. Experimental results using several complex images show that the proposed approach performs favorably compared to the state-of-the-art methods. Additionally, experiments with detecting and recognizing low-resolution faces from video sequences were carried out, demonstrating that the same facial representation can be efficiently used for both detection and recognition. The proposed method also provides better results than LDA and PCA.

Li, Yao, Lv, Chen and Zhang [20] propose a method to overcome deficiencies of skin segmentation and calculate much of template matching. The paper presents a method of face detection based on skin segmentation and template matching. In the study of threshold in skin segmentation, the paper presents an adaptive threshold based on the amount of pixels and presents a search method of mirror image. In the study of template matching, the paper presents arithmetic of template matching on grid weight.

Marius, Pennathur and Rose [21] use a method, which follows one similar to a rejection scheme algorithm [22]. The first step is to reject regions in the image those are not faces based on color thresholding and skin segmentation. The next step is to use binary image processing to create clearer delineations in these regions. Template matching with both training image faces and eigenfaces using the Sirovich-Kirby, [23] method is used to detect faces from the non-faces, and also used to find the position of faces from images.

### III. METHODOLOGY OF WORK

The system takes still colored image as input for face identification. The skin color information is firstly fetched
after that features of face got extracted by some appropriate methods and then faces are detected from the image. The system also has the feature of filtering images so that better feature extraction can be done. The size of image can also be changed according to requirement before extracting the features of the image. The work is implemented using MATLAB 7.6.

![Methodology of Work Diagram](image1)

**Fig. 1 Methodology of Work**

1. The input of face detector is any still colored image taken from the user. It may in any format like .JPG, .Bmp etc.
2. The input image can be resized according to requirement. The preferred size of the image is 200*200 pixels.
3. After resizing image, skin detection is done for finding skin areas. It is performed using the YCbCr skin detection model.
4. The output of skin detection is used as input for template matching. In template matching firstly edge detection is performed using fuzzy edge detection. Then template matching of this image is performed with template image.
5. The output is shown with blue mark on face on original image which represent the detected face.

**A. Skin detection**

The skin detection is performed with YCbCr color space. A YCbCr space segment the image into two components: luminosity component and color components. HSV space divides the image into the three components which are hue, saturation and color value. The advantage of converting the image to the YCbCr domain is that the effect of luminosity can be removed during image processing. In the RGB domain, each component of the picture i.e. red, green and blue has a different brightness. In the YCbCr domain, whole information about the brightness is given by the Y component were as the Cb (blue) and Cr (red) components are independent of the luminosity. The main advantage of using YCbCr space is that Cb and Cr components tell whether a pixel is part of the skin or not [1]. Color is represented by luma (Y component) which constructed as a weighted sum of the RGB values and Cb and Cr components are formed by subtracting Y from RGB red and blue components.

\[
Y = 0.299 R + 0.587 G + 0.114 B
\]

\[
C_r = R - Y
\]

\[
C_b = B - Y
\]

**B. Edge detection**

Fuzzy logic is used to perform the edge detection on an image. The algorithm is based on the selection of a set of four pixels of the image. The 2x2 window of an image is used to set of fuzzy conditions to highlight all the edges that are associated with an image. The image is said to have an edge if there is large variation in intensity between the adjacent pixels. This task of edge detection is accomplished with the help of sixteen fuzzy inference rules.

The mask used for scanning image is shown below in Fig. 2 which uses four pixels P1, P2, P3 and P4. The input to these pixels can be black or white, and the output can be black or edge.

![2x2 Mask used for finding edges](image2)

**Fig. 2 2x2 Mask used for finding edges**

**C. Fuzzy Inference Rules**

The fuzzy inference rules are defined in such a way that the FIS can detect edges of the image and reject the non-edge pixels. For example, the first rule is for pixels that are not part of edge, i.e. for black output and the rest of the rules are in edge pixels.

![Rules of Fuzzy Inference System](image3)

**Fig. 3 Rules of Fuzzy Inference System**

**IV. RESULTS**

Testing of an algorithm is done by giving the input of different images to check whether all the required outputs are generated and are in the desired and proper format for different environment. The best result is obtained from our algorithm as compare to other edge detectors. The algorithm is tested for images from GTVA database. Digital image as input is given and the edges of that image are produced. Results are shown as below:

**A. Result of Fuzzy Edge Detection**
The Fig. 4 shows the original image. The Fig. 5 shows the actual result after applying the fuzzy edge detection method.

B. Result of Face Detection
The result of face detection is shown for two images. The result is implemented with three parameters which are MSE, PSNR and time elapsed (e).

1) Case-I
The stepwise result of the face detection algorithm for image shown in Fig. 4, is shown by Fig. 6 (a) to Fig. 6 (g). The algorithm provides a good result for still colored images having frontal faces. The algorithm will, firstly, find skin area and then perform template matching for skin detected image, to find a face from the input image.
Fig. 6 (f) Template Image

Fig. 6 (g) Detected Face after applying novel method

The output is shown with the detected face, marked on the original image. The blue mark is indicating face in the original image.

The performance is compared based on the parameters Mean Square Error (MSE), Peak Signal-to-Noise Ratio (PSNR) and Computational time. To higher the value of PSNR, better the quality of output image. MSE indicates the average difference of the pixels throughout the image. A higher MSE indicates a greater difference between the original and processed image. The elapsed time indicates the time taken by algorithm to find the edges of input image. The Table I,II and III shows the value of MSE (Mean Square Error), PSNR (Peak Signal to Noise Ratio) and Elapsed Time (e) for different edge detection methods for Fig. 6 (a).

### TABLE I

<table>
<thead>
<tr>
<th>Method</th>
<th>M.S.E.</th>
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<tbody>
<tr>
<td>Sobel</td>
<td>0.0469</td>
</tr>
<tr>
<td>Prewitt</td>
<td>0.0466</td>
</tr>
<tr>
<td>Robert</td>
<td>0.0307</td>
</tr>
<tr>
<td>Canny</td>
<td>0.0625</td>
</tr>
<tr>
<td>LoG</td>
<td>0.0486</td>
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<td>An Existing Fuzzy Method</td>
<td>0.1127</td>
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<td>Novel Fuzzy Method</td>
<td>0.0254</td>
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### TABLE II

<table>
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<th>Method</th>
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<tr>
<td>Sobel</td>
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<td>Prewitt</td>
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<tr>
<td>Robert</td>
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<tr>
<td>Canny</td>
<td>0.3281</td>
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<tr>
<td>LoG</td>
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<td>An Existing Fuzzy Method</td>
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<tr>
<td>Novel Fuzzy Method</td>
<td>23.0313</td>
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The results from tables show that MSE in novel fuzzy algorithm is less than Sobel, Prewitt, Canny, LoG, Robert and an existing fuzzy method. Similarly, PSNR of Novel Fuzzy Method is more than these methods. But the time elapsed by fuzzy method is more than other methods but better than existing fuzzy method.

![M.S.E.](image1)

![PSNR](image2)

The output is shown with the detected face, marked on the original image. The blue mark is indicating face in the original image.
The results of the graph show that MSE in fuzzy algorithm is less than Sobel, Prewitt, Canny, LoG, Robert and an existing fuzzy method. Similarly, PSNR of Novel Fuzzy Method is more than other classical and existing fuzzy method.

2) Case-II

The stepwise result of the face detection algorithm is shown by Fig. 9 (a) to Fig. 9 (h). The algorithm provides the best results for still colored images having frontal faces. The algorithm will, firstly, find skin area and then perform template matching for skin detected image, to find a face from the input image.
The Table IV, V and VI shows the value of MSE (Mean Square Error), PSNR (Peak Signal to Noise Ratio) and Elapsed Time (e) for different edge detection methods for Fig. 9 (a).

**TABLE IV VALUE OF MSE**

<table>
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<td>Robert</td>
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<td>Canny</td>
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<td>LoG</td>
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<td>0.1201</td>
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**TABLE V VALUE OF PSNR**

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<td>Canny</td>
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<td>LoG</td>
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<td>47.3369</td>
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<td>53.7891</td>
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**TABLE VI VALUE OF TIME ELASPED**

<table>
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<th>Time Elapsed e (s)</th>
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<td>Robert</td>
<td>0.1250</td>
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<tr>
<td>Canny</td>
<td>0.2969</td>
</tr>
<tr>
<td>LoG</td>
<td>0.1719</td>
</tr>
</tbody>
</table>

The results from tables show that MSE in novel fuzzy algorithm is less than Sobel, Prewitt, Canny, LoG, Robert and an existing fuzzy method. Lower the value of MSE means better results for fuzzy method. Similarly, PSNR of Novel Fuzzy Method is more than these methods. Higher the value of PSNR for fuzzy edge detection means better results. But the time elapsed by the fuzzy edge detection method is more than other classical methods because of more computation but better than existing fuzzy method.

The results of the graph show that MSE in fuzzy algorithm is less than Sobel, Prewitt, Canny, LoG, Robert and an existing fuzzy method. Similarly, PSNR of Novel Fuzzy Method is more than other classical and existing fuzzy method.

**V. CONCLUSION**

The system takes still colored image as input for face detection. This is implemented with the help of template matching and skin color detector. The skin color method is combined with a template matching method for better results. The method performs template matching using edge detection. The face detection is performed using different classical edge detection methods like Sobel, Prewitt, Canny, Robert and LoG and an existing fuzzy method. A novel method using fuzzy logic designed for better edge detection. Thus, in this method the novel algorithm designed, which improve edge detection under different environments. The novel edge detection method is used with skin detection to detect faces from still images. The MSE and PSNR value of
this method is compared with other classical edge detection methods and an existing fuzzy method which shows that novel edge detection method have less MSE value and more PSNR value which mean better results. The result also concludes that the FIS implemented in this method presents greater robustness to distorted image and lightning variations.

VI. FUTURE SCOPE
This technique is used to find fine edges using fuzzy logic. In future, modification in fuzzy rules and tuning in weights associated with these rules may lead to better results. Also face detection done in proposed method is for still images. This can further extend in the future for 3D images, i.e. videos and the detection will become significantly more complex. The work is for face detection, which is a key step of face recognition. Thus, it can be further extended to face recognition. The computation time taken by novel method is more than classical methods. Thus, in future, by changing some rules of fuzzy logic, time can be reduced.

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