A Novel Method for Implementation of Edge Detection based on proposed FGCMT- Edge Detection Method

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Abstract: In image processing for the most part widespread preprocessing step is edge detection. The image edges are viewed like a form of primary information that can be extracted by means of applying detectors with one of a kind methodology. The wide segmentation algorithm can't effectively extract vital aspect statistics of digital image. So, we can use the advantages of edge detection algorithm to solve the problem of extract aspect statistics of digital image i.e., light conditions and environmental factors that lead to the low-performance. The algorithms for edge detection are Sobel operator, Laplacian of Gaussian Operator, Robert Operator and Prewitt Operator. The issues of edge detection methodologies with recognize to noise, performance, processing time, etc. In this paper, proposed the new edge detection strategy which detects the sharp edges as well as right edges. The difference of the consequence with sizeable aspect detectors suggests that the new edge detection algorithm is able to detecting exquisite vital factors within the variety of classes of trendy images.

Keywords: Robert edge detector, Prewitt edge detector, Sobel edge detector, Canny edge detector, Filtering, Gradient, Classification and Multi-level Thresholding

I.INTRODUCTION

One of the most necessary and fundamental step in any digital image processing device is Detection of the Edge. It is because of the reality that, edges detection simplifies assessment of pix by means of way of particularly decreasing the quantity of data to be process through filtering undesirable information, mean while maintaining the fundamental structural data of an image. Various facet detection strategies are on hand such as Robert edge detector, Sobel part detector, Prewitt edge detector, Canny area detector, Gaussian Laplacian, etc. Among these, Canny area detection algorithm is most considerably used in industries, as it is instead overall performance oriented and gives low error bit rate[1][2]. The Canny area detector has a most effective performance, so that it was once commonly used in more than a few applications. Comparison of additional algorithms of edge detection is the complexity of the computation concerned and the latency is high. This is because of the actuality the algorithm of canny edge is groundwork on frame-level statistics, making it unsuitable for real time applications. [3].

The proposed algorithm combines necessary methods and multilevel threshold calculation to clear up the above-mentioned troubles in current schemes. Elementary techniques are employed at filtering, gradient magnitude and orientation calculation. Multilevel threshold calculation calculates the excessive and low values of threshold primarily base on the block statistic [4][5]. The proposed algorithm reduces the runtime complexity and finds the well-built edge pixel. The consequences of the implementation are compared to the special consequences of aspect detection method such as Canny, Sobel, and Prewitt operator. Output of proposed method is used to obtain better segmentation result.

II. EDGE DETECTION METHODOLOGY

Detection of the edge is to identify for situate of mathematical techniques at which the intention for figuring out elements within a digital image which brightness of image changes sharply or, more formally, have discontinuity. The factors at which the brightness of image adjustments sharply is usually equipped into a set of curved line segments tenured edges [6]. Here, exclusive methods for detection of edge such as:

1. Canny Edge Detector

The edge detector of Canny [7] is broadly viewed like the algorithm of trendy facet detection in photo process. Canny noticed that aspect detection trouble like a problem of signal processing optimization, therefore developed a goal feature is to optimize. [8]. Discussion of Canny region detector steps is given as:

- Smoothing is image blurring to eliminate noise.
- Method of finding gradients potential the edges must be noticeable place the image gradients has magnitudes in large.
- In no most suppression, only local maxima be supposed to noticeable like edges.
- Double thresholding ability Potential edges are decided.
- In tracking of the edge through edges of final, hysteresis are determining by means of suppressing every edges i.e. no longer linked to extremely (strong) positive edge.

2. Prewitt Edge Detector

For detecting horizontal and vertical image edges by prewitt operator [9]. Prewitt output image edges are the image edges similar to the 4-band image. Image of the X gradient is 1st band image and the Y gradient is 2nd band image are calculated through the way of difficulty among the kernels of Prewitt. Every person pixel values of the 3rd and 4th band images are the magnitude and orientation of the gradient

respectively. If the threshold value is higher than the magnitude of the gradient of a given pixel, then the fourth bands pixel values of the output picture is put to the default values.

3. Sobel Edge Detector

Execute a 2-Dimension image spatial gradient dimension and highlights sections of spatial soaring frequency with the purpose of communicate to edges by the sobel operator [9][10]. Usually this operator is used to detect the expected fixed magnitude of gradient at enter grayscale image of every point. The sobel operator [11] contains of 3 × 3 density kernels pair. These kernels are intended to react according to the walking horizontally and vertically relative edges to the grid pixel, one kernel for every two perpendicular orientations. To the enter image the kernels can be apply separately, to generate gradient measurements issue separately in every orientation which have been named as G_x for horizontal gradient and G_y for vertical gradient. These G_x values and G_y values mixed collectively in the direction of locate the absolute gradient magnitude at every point and the gradient orientation.

III. PROPOSED FGCMT- EDGE DETECTION METHODOLOGY

In general the aspect finding methods contain multi step method for instance preprocessing, cleaning of noise, coefficients thresholding, smoothing and post processing. The proposed algorithm two Filtering, Gradient, Classification and Multi-Level Thresholding (FGCMT) combines fundamental techniques and multilevel threshold calculation to resolve the above-mentioned problems in current schemes. Elementary techniques are employed at filtering, gradient magnitude and orientation calculation. Multilevel threshold calculation calculates the small as well as excessive threshold values are totally based on the block statistic. The proposed algorithm reduces the runtime complexity and finds the sturdy edge pixel.

In the proposed algorithm, size P×P of an original image is separated into L×L non-overlapping blocks, every non-overlapping block dimension is P×P by means of n-bits each. The facet detection of every non-overlapping block effects in the blocking artifact. In order to dispose of artifacts of the blocking, block of non-overlapping are prolonged through unique alongside left, right, bottom and top pixel boundaries. These extended blocks of non-overlapping are called overlapping blocks. The dimension of overlapping block is k×k where, k = p + 2.

The proposed algorithm as the first step applies the filter, after making use of filter; the proposed method follows the steps, Filtering Image the usage of Impulse Filter, finding the gradient magnitude and gradient orientation, Classification and Multi-Level Thresholding. Initially, the enter image is smoothened using impulse filter. If core generates the noise filtered image. The aspect of noise free images is extracted via gradients. The noise filter, gradient magnitude and orientation are calculated for every block the use of elementary techniques. The computed gradient magnitude is used to classify every pixel in the block as uniform, texture, and edge.

Phase I: Filtering Image using Impulse Filter

No imaging technique is free of noise, but noise is a whole lot greater frequent where edges are defected. The noise presence in an image blurs the content of the image, hides essential features of an image, disgraces the high- image quality and will have the object visibility impact with the aid of giving undesirable appearance.

To mark the location of these noisy image pixels, formed a binary noise mask B (i, j) and applied on noisy image to separate the noisy and noise free pixels.

$$B(i,j) = \begin{cases} 0 & I(i,j) = I \\ 1 & otherwise \end{cases} \quad (1)$$

Where, B (i, j) =0 stand for noisy pixels, B (i, j) =1 stand for noise-free pixels and I (i, j) stand for the pixel at location (i, j) with intensity I. The proposed filter uses a square window start with the size of (2R+1) X (2R+1) with R=1 initially and place over the binary mask in excess of the noisy image. The filtering window will be extended by R=2 while the current window has no noise-free pixel. This process is required to be frequent generally for noise densities greater than 50% until in any case five noise-free pixels be there in the selected window. In selected square filtering window, a set of fuzzy is formed from pixel intensity of this window called the information source values and they are represented through a membership function that provides the association degree for every element of this set. Hanman-Anirban entropy function [12] takes the form of the information measure of an image on making the following substitution:

$$H_g = \sum_{I_{ije}} \frac{\left|I_{ij} - I_{ref}\right|^2}{2f^2_{h(ref)}} = \sum I_{ij}\mu^g_{ij} \quad (2)$$

The fuzzifier f_h is taken from Hanmandlu et al. [15] given by:

$$f^2_{h(ref)} = \frac{\sum_{i=1}^{W}\sum_{j=1}^{W}(I_{ref} - I_{ij})^4}{\sum_{i=1}^{W}\sum_{j=1}^{W}(I_{ref} - I_{ij})^2} \quad (3)$$

Where μ^g_{ij} is a Gaussian membership function I(i, j) represents the values of the information source. Information source value I(i, j) are the values of intensity of an image in the range 0 - 255. Here we have taken $I_{ref} = I_{avg}$. For the calculation of entropy, an image is divided into small filtering windows.

To calculate the trimmed median, selected window pixels are set in either the descending order or ascending order and gray levels pixels 0 and 255 are removed. The remaining pixels median is called as trimmed median M_{ij}. Median worded as Difference Measure (D).

$$D = abs(I - M_{ij}) \quad (4)$$

Fuzzify Difference Measure μ(D) by using the Gaussian membership function (GMF)

$$\mu(D) = e^{-\left(\frac{(D-Davg)^2}{2f_h^2}\right)} \quad (5)$$

Here D_{avg} stands for average value of the difference measure (D). GMF indicates that membership μ(D) of Difference Measure (D) is close to 1 if the deviation from the median is less or the difference between average value of D and D is minimum. The effective information (EI) denoted by H_k is the sum of information values in the k^{th} window [12].

$$H_k = \sum \mu(D) * D \quad (6)$$

This EI gives the actual weighting factor to be applied to the median for correct the central pixel which is given by the following switching criterion.

$$y = \begin{cases} \frac{\sum \mu(D)*D}{\sum \mu(D)} & EI < T \\ M & \text{otherwise} \end{cases} \quad (7)$$

Where T represents the threshold which is in use as half of the maximum difference measure (≅ 255). EI represents the effective information. It use the pixels intensities window are close enough, i.e. $EI < T$, then the noisy pixel is changed with the local information given by above Equation. Otherwise If $EI > T$, then the noisy pixel is changed by the trimmed median value.

Filtering Algorithm:

- Step 1: Read the noisy image
- Step 2: Choose a 3X3 window with center pixel I(i, j)
- Step 3: If 0 < I(i, j)<255 (check for Noisy pixel) then Go to step 11.
- Step 4: Otherwise, Count the number (N) of noisy pixels within the Chosen window
- Step 5 :If N>5 and I^S window size<9X9
- Step 6:Calculate the difference measure all pixels from trimmed median
- Step 7:Formulate GMF for difference measure and calculate the EI in the selected window
- Step 8: If EI (Effective Information) <T then Replace the center pixel by weighted information.
- Step 9: Otherwise, replace the center pixel by median of all non noisy pixels. Then go to step 11.
- Step 10: Otherwise, Increase window size to one level. Then go to step 4.
- Step 11: Obtain the denoised image

Phase II: Gradient Magnitude and Orientation

The **image gradient** is basically used for edge detection in image processing. Phase one produce the noise filtered image. The edge of noise free images is extracted by gradients.

Strength of an edge pixel has been found using gradient magnitude. The magnitude of a single pixel is computed using below Equations.

Horizontal and vertical directions gradient is denoted by $f_x(x,y)$ and $f_y(x,y)$ respectively. For each pixel(x,y), the gradient is computed by convolving the images with the gradient mask. The gradients $f_x(x,y)$ and $f_y(x,y)$ is computed using the below Equations are 8.1 & 8.2

$$f_x(x,y) = f(x+1,y) - f(x-1,y) \quad (8.1)$$

$$f_y(x,y) = f(x,y+1) - f(x,y-1) \quad (8.2)$$

The magnitude and orientation of every pixel is computed using 8.1, 8.2 and 9 Equations respectively. The magnitude and the orientation define the strength and direction of the edge at every pixel respectively.

$$mag(x,y) = \sqrt{f_x(x,y)^2 + f_y(x,y)^2} \quad (9)$$

The direction of pixel edge be calculated by using gradient orientation. The direction of a pixel $\theta(x,y)$ is given in below Equation 10.

$$\theta(x,y) = arctan\left[\frac{f_y(x,y)}{f_x(x,y)}\right] \quad (10)$$

The direction of each pixel lies between 0° and 180°. In the proposed algorithm, the directions are spaced consistently and separated into four areas, such as 0°, 60°, 120°, and 180°. To find area for (x, y), modify $\theta(x,y)$ as $tan\theta(x,y)$ and a specific area is defined between the two angle values. For generality purpose, gradient orientation calculation algorithm can be rewritten as follows:

$$tan\theta(x,y) = \left[\frac{f_y(x,y)}{f_x(x,y)}\right] \quad (11)$$

Further block classification and multilevel threshold calculations have been performed based on gradient magnitude, direction and are in the next phase.

Phase III: Pixel and Block Classification

Block classification method utilize the local block statistics for labeling the type as strong edge block, medium edge, texture and edge. This method is executed in two stages namely, block classification and pixel classification.

Pixel classification, Pixel classification is executed by using the local mean of four pixels gradient magnitude. The gradient magnitude of nine pixels is extracted using 3×3 mask or window. The local mean value is calculated using,

$$mean = \frac{1}{4}\sum_{i=1}^{9} mag_i(x,y) \quad (12)$$

Where, $mag_i(x,y)$ represent the gradient magnitude of a pixel (x, y). The pixel present in the center of the mask is classified as uniform, texture, and edge. This classification is done by comparing local mean values of uniform and edge with the threshold values of uniform and edge.

Block Classification, The blocks of an image are classified as smooth, strong edge, medium edge and texture. This classification is executed based on the total number of edge pixels in the block of an image. Number of edge pixels is described in percentage (P_1). P_1 is the percentage of pixels.

Based on P_1, the block type are, Smooth (P_1=0), texture ($0<P_1\leq 0.05$), medium edge ($0.05<P_1\leq 0.15$), strong edge (otherwise). The value of P_1 for each block type is learnt from sample natural images.

Phase IV: Multi-Level Thresholding

The performance of edge detection algorithm depends on the values of threshold. Hence, it is essential that the threshold values must be calculated precisely. Otsu's method is one of the best methods of the threshold selection with equality and shape measures. Traditional method needs more computational time, and work well for a bi-level thresholding problem, while the number of threshold level increases, complexity of the thresholding problem also increase. Multilevel thresholding have more than two threshold level to divide blocks into different clusters and find the maximum inter-class variance between these cluster and minimum intra-class variance within any cluster.

In multi-level OTSU thresholding method, Blocks B segmented into N classes. Multi-level OTSU proceeds an array (A) contains the cluster indices (from 1 to N) of every point. It denoted as OTSU (I, N).In case if N is not defined then it assume 2 by default. Syntax [A, Sep] = OTSU (...) proceeds the value (Sep) of the reparability criterion in the range [0 1]. The zero values are assigned to non-finite pixels and less than the N values, where one is attained only with N-valued arrays. The gradient values aid to divide two different thresholds.

In multi-level thresholding, different stage threshold level 3 and level 4 are computed and get the best one, then got the output image edge. The segmentation is then bringing out on the image component that attains most of the energy.

The OTSU method, thoroughly look for the threshold to diminish the intraclass variance, defined as a weighted sum of variances of two classes-

$$\sigma_w^2(t) = W_1(t)\sigma_1^1(t) + W_2(t)\sigma_2^2(t) \quad (13)$$

Weight w_i is the probability of two classes divided by a threshold t and σ_i^2 of these classes variances. The OTSU indicates that reducing the intra-class variance is the similar as maximizing inter-class variance:

$$\sigma_b^2(t) = \sigma^2(t) - \sigma_w^2(t) = W_1(t)W_2(t)[\mu_1(t) + \mu_2(t)]^2 \quad (14)$$

Which is showed in conditions of class probabilities w_i and class means μ_i. The class probability $W_1(t)$ be calculated as of the histogram as t:

$$W_1(t) = \sum_0^t p(i) \quad (15)$$

even as the class mean $\mu_1(t)$ is:

$$\mu_1(t) = \sum_0^t \frac{p(i)x(i)}{W_1} \quad (16)$$

Where is the middle value of the i^{th} histogram b_{in}. Likewise, $W_2(t)$ can calculate easily and μ_2 on the histogram right-hand side for bins greater than t. The class means and class probabilities can be calculated iteratively. This proposal capitulates an effectual image segmentation results.

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

Edge detection distinguishes the edges, object boundaries of the original image. To evaluate detected edges, proposed scheme is applied to various standard color and grayscale test images despoiled with impulse and gaussian noise, and compared with other existing edge detection algorithms using MATLAB R2011b. All tests were done on an Intel R CoreTMi7-3770K CPU at 4GHz, Windows 10 Professional OS and 8GB RAM. The efficiency of the proposed algorithms is estimated with the aid of various edge detection parameters. Evaluation of the performance is conceded out on this research by using a variety of objective analysis methods. From the figure (1), (2), (3) and (4) clearly shows that the results of the proposed edge detector will be the visually pleasing one. Moreover, it is a time consuming method and has a low computational complexity.



Figure 1: The result of Canny Edge Detector



Figure 2:The result of Prewitt Edge Detector

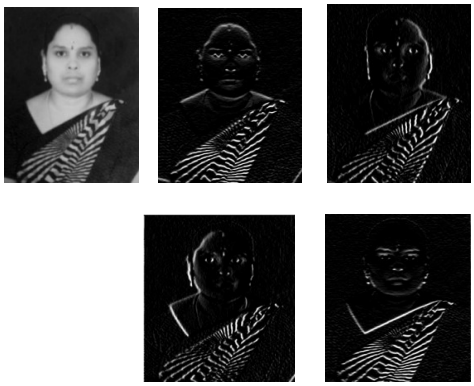


Figure 3: The result of Sobel Edge Detector





Figure 4: The result of FGCMT of Edge Detector

Peak Signal to Noise Ratio (PSNR)

PSNR is the ratio of highest possible power signal to the degrading noise power that concerns the faithfulness of its demonstration. The PSNR generally showed in provisions of the decibel scale (dB). Peak Signal to Noise Ratio is worn to appraise the detection quality of the image edge. The formula to compute the PSNR value is shown in below equation.

$$PSNR = 10log_{10}(\frac{R^2}{MSE}) \quad (17)$$

Where, MSE represent the Mean Square Error and R represents the input image data maximal variation. R^2 is 255 while it have an 8-bit unsigned integer data type.

Figure 5 illustrate computed PSNR values result by concerning proposed scheme, Prewitt, Sobel as well as Canny method for the different images despoiled by impulse noise and Gaussian noise. From Figure it is examined that the proposed method attains higher PSNR values in most of the cases and completed that demised image quality will be high. The proposed method outperforms well even if images despoiled with high density noise.

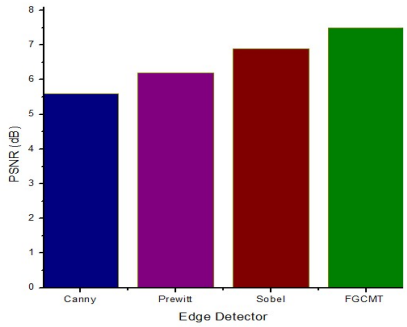


Figure 5: Shows the Calculation of PSNR values

Structural Similarity Index (SSIM)

The SSIM is a full reference metric which is used to measure the resemblance between the two images. The SSIM index can be sighted as a quantitative measure between two images such that one of the images is of perfect quality. It is based on the calculation of three terms: Luminance comparison l, Contrast Comparison c and Structure comparison. The overall index is multiplicative combination of these 3 terms:

$$SSIM = [l(I_o, I_r)]^{\alpha}.[c(I_o, I_r)]^{\beta}.[s(I_o, I_r)]^{\gamma} \quad (18)$$

Where $\alpha = \beta = \gamma = 1$ for equal significance of three terms.

From the definition of SSIM, if the two images I_o and I_r are equal then SSIM=1.

Figure 6 shows the graphs of the SSIM 5 images through different edge detectors. It is estimated from Figure2 proposed algorithm illustrates the highest SSIM index between all the edge detectors. These values show that the proposed edge detector is a best match by means of ground truth images.

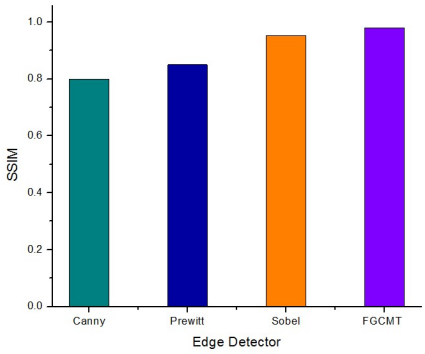


Figure 6: Shows the Calculation of SSIM values in different edge detectors

Figure of Merit (FOM)

The value of FOM is calculated to check the edges level conserved by concerned the appropriate edge detector subsequent to image de-noising. FOM value computed after obtaining the final color image edge. The Figure 3 of Merit (FOM) is an edge preserving measure and shown by below equation.

$$\mathrm{FOM} = 1/(\max\{\mathrm{N}, \mathrm{N_{ideal}}\} + \mathrm{d_i}\lambda$$

Figure 7 shows the histogram of figure of merit (FOM) which lies in the range for 100 test images comparing all four types of edge detectors. It is clear that the FOM value is better even though image is corrupted with higher density with proposed method compared to other methods.

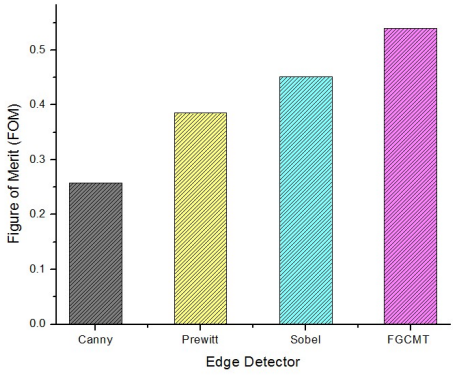


Figure 7: Graphical form for artificially added noisy image in Edge Detector using FOM

Processing Time

The edge detection schemes process concerned in detecting well and improved edges in lesser amount of time while contrast with other edge detection methods. Therefore processing time can be integrated as one of the parameter

for calculating the performance of the edge detection schemes.

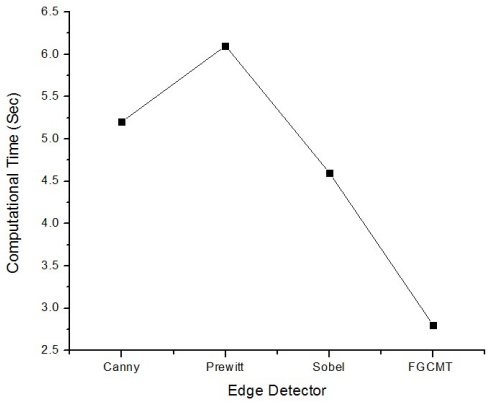


Figure 8: Time Complexity for Edge Detecting Method

V.CONCLUSION

This proposed detected edge from this technique is fed into the object recognizer for recognizing the objects efficiently. New method also experimented by means of most of fractured fragments and can entire surface segmentation and robustly extraction of edge feature lines. Experimental results illustrate that the proposed system can detect successfully and classify the face recognize with 98.2% accuracy. In future work, we will expand our database for added face identification and as training purpose use large number of data in classification. As we raise the training data, the accuracy rate and speed of system will be high.

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