EFFECTIVE ALGORITHM FOR IMPLEMENTING EDGE DETECTION USING ADAPTIVE BILATERAL FILTERING BASED FUZZY NEURAL NETWORKS FOR IMAGES

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Abstract---. The fundamental problem of image processing is to reduce noise from a digital color image. The problem here is to develop a filter that removes noise and also sharpens the edges simultaneously. So we have to design a filter first of all which uses a better method for sharpening without halo and secondly it should be able to remove noise effectively. It can employ conventional filters for noise removal, which work efficiently in smooth regions but blurring of the image takes place especially at the edges. A lot of effort is put in designing a noise removal by preserving the edges. Bilateral filter adopts low pass Gaussian filter for both domain and range filter. The domain low pass Gaussian filter gives higher weight to pixels that are spatially close to center pixel. The range low pass Gaussian filter gives higher weight to pixels that are similar to center pixel in gray value. By combining domain filter and range filter we can produce bilateral filter which will reduce noise and enhances the sharpness. Gaussian filter that is oriented along the edge will do the averaging along the edges and reduce in gradient direction. For this reason bilateral filter can smooth the noise and preserve the edge details.

In terms of image sharpening unsharp mask (USM) has certain disadvantages First It sharpens the image by adding halo(undershoot and overshoot). Second it amplifies the noise information present in the image instead of suppressing the noise and reduce the quality of image. To reduce the first problem we have several slope restoration algorithms. Those algorithms modify the edge information normally or horizontally or vertically i.e in ID only. The ABF will restore the edge slope, without need to locate edge normal's. So ABF with neural networks is efficient to implement. This will produce clean, crisp edges. To reduce the noise levels in an image. It uses Gaussian low pass filter which will remove the noise.

Keywords---HFCM,FNN,ABF,Bilateral filter,Weighted support vector machines, Edge detection, Gradients, Image processing.

1. INTRODUCTION

A new way to detect edges by using the hybrid fuzzy cognitive map based on fuzzy neural network. The decision needed in this case is between the pixel is part of an edge or the pixel is not part of an edge. In order to obtain this decision we must extract the information from the images since the entire image is not useful as the input to the hybrid fuzzy cognitive map based on fuzzy neural network (HFCM).

In order to obtain this decision we must extract the information needed from the images. In this work a vector is formed for each pixel given the difference between this one and the pixels in a 3 x 3 neighborhood around it. This way a components vector such as entropy, gradient and variance are calculated at each pixel except for the border of the image, because in this case the differences cannot be calculated. This vector is used as input to the HFCM both in the training process and when we use the trained HFCM over real images.

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2. Preliminaries

2.1 PROPOSED ALGORITHM

The algorithm proposed is implemented in Matlab. Its implementation is discussed in detail below:

- **Step 1**: The first and the foremost part of the algorithm is image acquisition. The image is obtained from various sources. Images acquired can be of any format and orientation.
- **Step 2:** Obtained image has to undergo various modifications such that it is suitable for performing the operations on them. Image is cropped to the necessary dimensions such that it is a square image. Cropped image is then converted to gray scale image such 3-dimensional images is converted into 2-dimensional images.
- **Step 3:** Resulting 2-dimensional image might be a noisy image. Image is then filtered to remove the unwanted noise. Various filtering techniques were applied in the image. Spatial filters, frequency domain filters and adaptive filters were applied on the image, since periodic noise was predominant compared to other noise present in the image. Frequency domain filters were singled out. Butterworth filter in band pass type proved to be most efficient filter. The threshold of the filter is dynamically chosen by the filter based on the image. threshold varies from image to image depending on the image intensity, major factor deciding the threshold of the image is the variation of intensity between the foreground and the background image.
- **Step 4:** The final process in the algorithm is edge detection, once the image is filtered, a pure sample from which crack has to be detected is obtained. The edge detection algorithm is applied on the sample.

2.2 FOUR STEPS OF EDGE DETECTION

Formulation of the edge detection problem as a problem of cost minimization. Their edge estimator is defined to be the edge configuration that minimizes a cost function, defined as a weighted average of the following five cost factors: edge curvature, dissimilarity of the regions separated by the edges, number of edge pixels, fragmentation of the edges, and edge thickness.

- (1) Smoothing: suppress as much noise as possible, without destroying the true edges.
- (2) Enhancement: apply a filter to enhance the quality of the edges in the image sharpening.
- (3) Detection: determine which edge pixels should be discarded as noise and which should be retained usually, thresholding provides the criterion used for detection.
- (4) Localization: determine the exact location of an edge sub-pixel resolution might be required for some applications, that is, estimate the location of an edge to better than the spacing between pixels. Edge thinning and linking are usually required in this step.

The Gaussian filtering is combined with Laplacian to break down the image where the intensity varies to detect the edges effectively. It uses linear interpolation to determine the sub pixel location of the edge .The digital implementation of the Laplacian function is made using the mask given inbelowfigure.

0	-1	0
-1	4	-1
0	-1	0

Fig.2. Gaussian mask for Intensity Variation

3 Preservation of Image Structure

In this research, the proposed edge detection system consists of two major phases such as edge detection and analysis of edge detector results using WSVM classification method. The proposed flow diagram is shown in the figure 1.

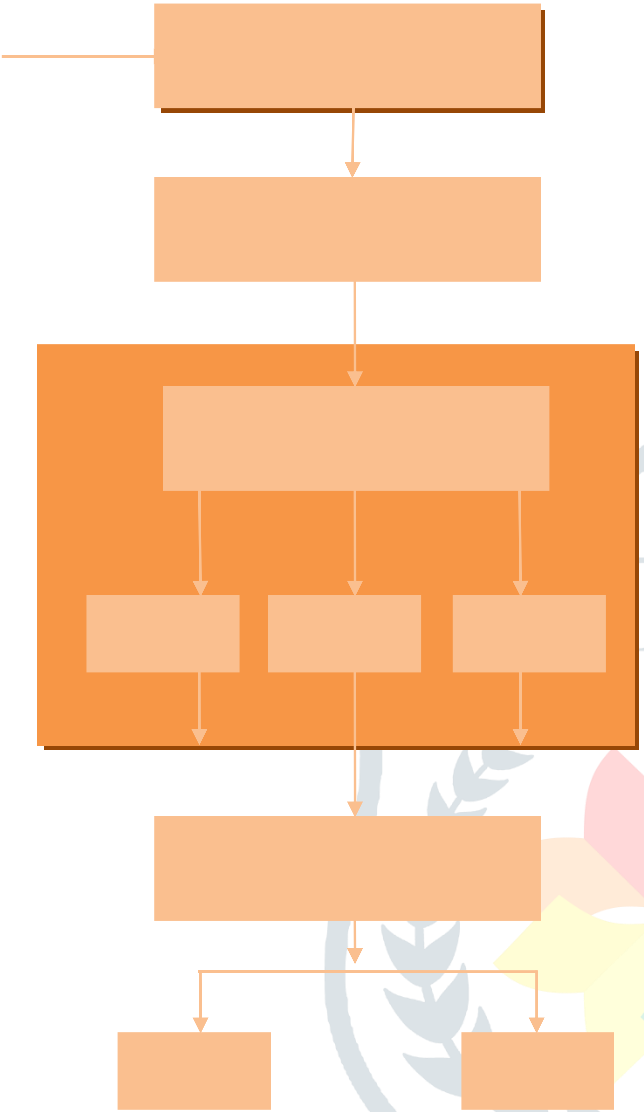

Figure 1 proposed flow diagram

In order to perform edge detection process initially the images are converted into pixels and formation of matrix for those pixels values,

3.1Features selected for each image

In this section, will describe the three important features for image pixels to analysis edge detection results.

Pixel Features

The pixel value of every image information is obtained by comparing with its neighboring pixel features. Every pixel value features information comparison can be done by extracting $3\times\mathbf{3}\ 3\times\mathbf{3}$ matrix of neighboring features. For every one of the $pixel\ [x,y], pixel\ [x,y],$ it's neighborhood matrix contains $9\ pixels: [x - 1;\ y - 1]; \dots; [x+1;\ y+1]$ $9\ pixels: [x - 1;\ y - 1]; \dots; [x+1;\ y+1]$. To extract pixels values of features such as variance, entropy, and gradient, in this use a $3\times\mathbf{3}\ 3\times\mathbf{3}$ matrix of neighboring features. Based on this selected attributes only decides whether the selected pixels corresponds to edge and non-edge features or not. The color intensity level of each pixels $[x,y][x,y]$ that corresponds to grayscale images is represented as $f(x,y)$ $f(x,y)$ and it ranges starts from $0\ to\ 255$.

Variance

Variance is one of the usual metric that consists of information about pixels values .If the variance value is low it indicates only a small amount of changes occurs in grayness value and if the variance values are high it indicates that large amount of changes occurs in grayness value. A pixel which corresponds to high variance is used in this work to measure the edge detection values. The mean $\mu(x,y)\mu(x,y)$ value of each pixel $[x,y][x,y]$ is computed as:

$$\mu(x,y) = \left({}^{1}/_{9}\right) \sum_{i,j=-1}^{1} f(x+i, y+i)$$

$$var(x,y) = \left({}^{1}/_{9}\right) \sum_{i,j=-1}^{1} \left(f(x+i, y+i) - \mu(x,y)\right)^{2}$$

Entropy

From information theory if the value of entropy is less, it achieves high information gain ratio and rate of intensity level for each pixels is also high with larger dispersion. So the pixels with better entropy values are considered as an edge pixel [11] and remaining becomes non edge features. The entropy of each pixels $[x;\ y][x;\ y]$ is computed as:

$$entropy(x,y) = -\sum_{i=x-1}^{x+1}\sum_{j=y-1}^{y+1} p_{ij}\log p_{ij}$$

Where

$$p_{xy} = \frac{f(x,y)}{\sum_{i=x-1}^{x+1}\sum_{j=y-1}^{y+1} f(i,j)}$$

Gradient

The scales of the gradient tell concerning how rapidly the image is varying, whereas the direction value of gradient tell about the direction in which the image is changing most rapidly. In this work use Sobel method [4] to measure the gradient value of image. The gradient value $G(x,y)\ \ G(x,y)$ of each pixel $[x,y][x,y]$ is computed as:

where $G_X(x,y)\, G_X(x,y)$ represents the mask value in X X direction and $G_Y(x,y)\, G_Y(x,y)$ represents the mask value in Y Y direction correspondingly.

3.2Edge detection using classification

Our proposed edge detection methods takes less time to complete the process, since instead of consideration of image as input, in this work initially we extract feature from images and it considered as input to the training process. It improves the edge detection results with less execution time.

. The predefined threshold value of each feature is calculated using some of the existing methods, for variance use an Otsu's threshold calculation .For entropy feature use an image based entropy measure to calculate threshold value for each entropy feature. For gradient feature, gradient based threshold calculation is used for calculating the threshold. Once the threshold calculation is completed then group those feature into edge and non-edge feature separately based on the two class's namely positive and negative class. The positive class is represented as $p_1^+\, p_1^+$ and the negative class is represented as $p_1^-\, p_1^-$.

3.3Detection Method

Based on the above mentioned definitions the pixels of each images is labeled as either positive class or negative class with dark and bright region. The pixel values are clustered using KPCM to generate weight value automatically for each pixel in HFCM classification process. The positively labeled edge pixels are grouped into $p_1^+\, p_1^+$ and negative non edge pixels are grouped into $p_1^-\, p_1^-$. In classification algorithm the possibility of the positive and negative class (edges) is represented as $(y_i = 1)(y_i = 1)$ & $(y_i = -1)(y_i = -1)$ be denoted by $W_i^+ = p_i^+$ $W_i^+ = p_i^+$ and $W_i^- = p_i^-$ $W_i^- = p_i^-$ after the completion of weight values estimation, correspondingly. (Here W_i^+ W_i^+ denote the weights values of data points that correspond to positive class and W− denote the weights values of data points that correspond to negative class.) .Finally the classification result are achieved in efficient manner when compare to SVM and WSVM methods.

4.EXPERIMENTAL RESULTS

In order to measure the results of proposed HFCM-FNN basased edge detection method and existing SVM,WSVM based is simulated using MATLAB to different set of images. It shows that the proposed HFCM-FNN based edge detection methods provide more edge detection results when compare to existing edge detection algorithms such SVM, WSVM algorithm. The edge detection methods results are analyzed using the parameters like MSE and PSNR.

PEAK SIGNAL TO NOISE RATIO (PSNR)

Peak signal to noise ratio is defined as the ratio among the utmost possible outcomes results and corrupted noise results of the image. The $PSNR$ $PSNR$ value for each image is calculated by using following formula,

$$PSNR = 10\log_{10}\left(\frac{MAX_i^2}{MSE}\right)$$

MEAN SQUARE ERROR (MSE)

Mean square error (MSE) is defined as the distinction among an estimator results and the true value of the original images results are computed as,

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

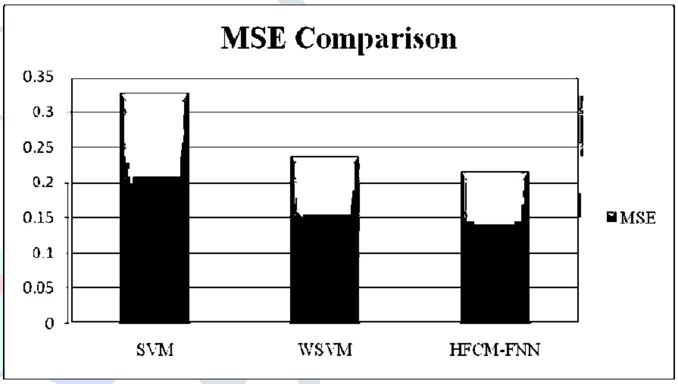

Figure 2 : Comparison of MSE

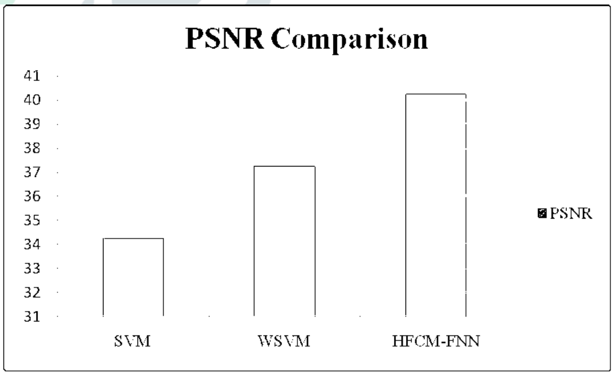

Fig.4.27. Comparison of PSNR of various edge detection methods with HFCM-

Figure 3 : Comparison of PSNR

Figure 2 and 3 shows that the graphical representation results of comparison of MSE and PSNR between proposed HFCM method and existing methodologies such as SVM,WSVM. If the value of MSE is less it shows that proposed HFCM have high edge detection results than existing methods .The PSNR value of proposed HFCM is high than the existing edge detection algorithms such as clustering, SVM. The values of PSNR and MSE are tabulated in Table 1.

TABLE 1 : PERFORMANCE COMPARISON RESULTS

Methodology	MSE	PSNR	Number of edges detected
SVM	0.3259	34.258	989
WSVM	0.2369	37.259	2045
HFCM-FNN	0.2145	40.256	3125

Table5.14 Increase in Number of Edges Detected (percentage)

Methodology	SVM	WSVM
HFCM-FNN	21.36%	10.8%

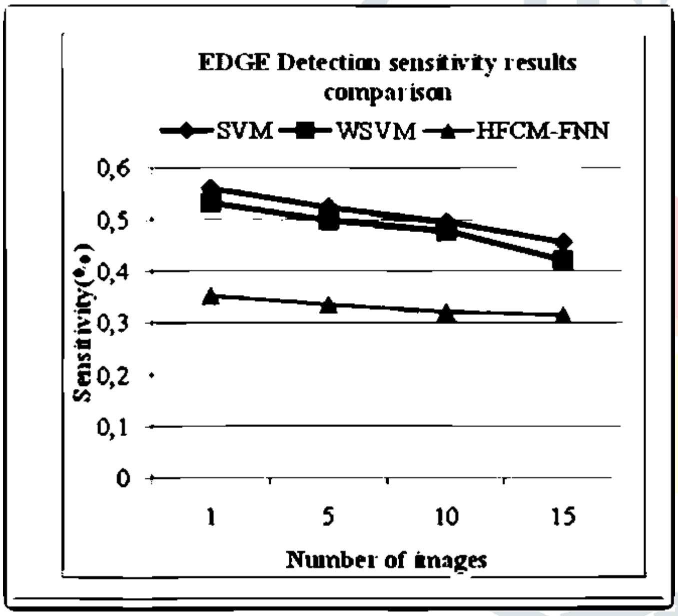

Figure 4: Comparison results for number of edges detection

Figure 4 shows that the graphical representation results for number of edges correctly detected among existing SVM,WSVM classification and proposed HFCM-FNN classification methods. The number of edges detected value is high for proposed HFCM edge detection method than existing edge detection algorithms such as SVM and WSVM.

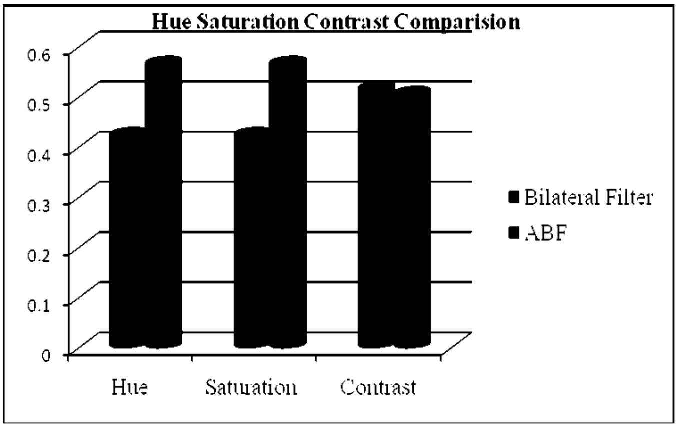

Figure 5: Graph indicating hue, saturation and contrast values for —Einsten

Figure 5 shows that the graphical representation results of Bilateral filter and ABF. The proposed HFCM algorithms have high edge detection accuracy than SVM ,WSVM algorithm.

5.CONCLUSION

The performance of the proposed novel method for edge detection which operates ABF along with the hybrid fuzzy cognitive map based fuzzy neural network (HFCM-FNN) is compared with other algorithms such as SVM, and WSVM. Experimental results show the ability and high performance of proposed method. On the basis of experimental perception, the number of edges detected is 21.36% more than that of SVM and 10.8% more than that of WSVM of edge maps of various grayscale images it is proved that the proposed method is able to detect highest edge pixels in noise free images as well as in case of noisy images. Also it gives smooth and thin edges without distorting the shape of images. The MSE performance of HFCM-FNN is significantly decreased by 0.11% than SVM and 0.02% less than WSVM. The PSNR comparison shows that HFCM-FNN shows significantly increased by 5.99% than SVM and 2.99% increased than WSVM.

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