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Edge Detection Using Soft Computing in Matlab

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Abstract:- Edge detection is a primary operation of most of the image processing applications such as image detection, boundary detection, image classification, image registration. Edge detection filters out less important information and preserve the structural properties of image.The Proposed technique uses ANFIS edge detector for edge detection on digital images. It involves a neuro fuzzy system with the learning capability of neural network and the advantages of rule-based fuzzy system. This work follows hybrid algorithm to resolve the edge detection issues with the help of least square method and gradient descent method.

Keywords:- Edge Detection, ANFIS, Neural Network, Fuzzy Logic, Hybrid Algorithm.

1. Introduction

Computer Vision has gain great amount of attention in the area of research and development. Many applications based on this concept such as computer-aided diagnosis of medical images, estimation of crop growth, image manipulation used in film industry, inspection tasks in many industrial plants, with the help of possible methods of data processing [1]. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. This is an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Edge detection is categorized into two categories of to perform edge detection namely Gradient, Laplacian [2]. There are many ways to perform edge detection. However, the most may be grouped into three categories, gradient (Approximations of the first derivative), Laplacian (Zero crossing detectors) and Image approximation algorithms. Edge detectors based on gradient concept are the Roberts [3], Prewit and Sobel [4] show the effect of these filters on the sensing images. The major drawback of such an operator in segmentation is the fact that determining the actual location of the edge, slope turn over's point, is difficult. A.A. Alshennawy et al. [5] have proposed a novel method based on fuzzy logic reasoning for edge detection in digital images without determining the threshold value.

2. Proposed Algorithm:-

2.1 Learning Algorithm of ANFIS

The task of the learning algorithm for this architecture is to tune all the modifiable parameters, namely $\{a_i, b_i, c_i\}$ and $\{p_i, q_i, r_i\}$, to make the ANFIS output match the training data. When the premise parameters a_i, b_i and c_i of the membership function are fixed, the output of the ANFIS model can be written as:

$$f = \frac{w_1}{w_1 + w_2} f_{1+\frac{w_2}{w_1+w_1}} f_2 \qquad (2.1)$$

After rearrangement and submission of if- then –else rules the output can be expressed as:

$$f_1 = (\overline{w_1}x)p_1 + (\overline{w_1}x)q_1 + (\overline{w_1}x)r_1 + (\overline{w_2}x)p_2 + (\overline{w_2}x)q_2 + (\overline{w_2}x)r_2 \qquad (2.3)$$

which is a linear combination of the modifiable consequent parameters p_1, q_1, r_1, p_2, q_2 and r_2. The least squares method can be used to identify the optimal values of these parameters easily. When the premise parameters are not fixed, the search space becomes larger and the convergence of the training becomes slower. A hybrid algorithm combining the least squares method and the gradient descent method is adopted to solve this problem. The hybrid algorithm is composed of a forward and a backward pass. Table 2.1 summarizes the activities in each pass.

Table 2.1 Two passes in the hybrid learning procedure for ANFIS

	Forward pass	Backward pass
Premise parameters	Fixed	Gradient descent
Consequent parameters	Least-squares estimator	Fixed
Signals	Node outputs	Error signals

2.2 Adaptive Neuro-Fuzzy Model for Edge detection

A novel neuro-fuzzy model proposed in this work for Edge detection. Adaptive neuro fuzzy inference system (ANFIS) combines the advantages of fuzzy logic and neural networks. Fig. 2.2 displays a high level diagram of the proposed ANFIS.

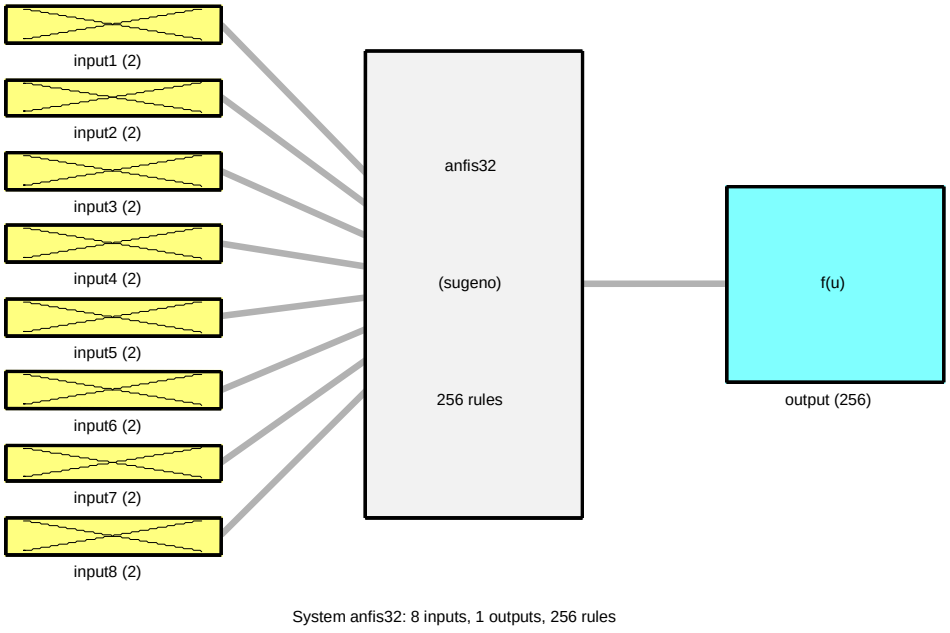

Fig. 2.2: Diagram of the proposed ANFIS

Adaptive neuro fuzzy system is created that makes use of the Sugeno FIS structure as shown in Fig. 2.2. Eventually, a training data set that contains the desired input/output data pairs of the targeted system is modeled. The Proposed training data set which are in the matrix form are presented to ANFIS for training (estimating) membership function parameters. They fully represent the features of the data that the trained FIS intends to model.

2.2.1 ANFIS Training Set

The most difficult part of any ANFIS training problem is defining the proper training set. A simple method is recommended for the edge detection training problem. Training of ANFIS can be accomplished by preparing a dataset as shown in Fig. 2.5. The designed ANFIS system is given eight inputs and generates one output. The Eight inputs are the eight pixel values (p1, p2, p3, p4, p6, p7, p8, p9) of the window mask used as shown in Fig. 2.3. Take an image object to be learned and slide it from point to point across all locations of a window which will be the input window to the pattern detection network. When the whole binary image is scanned by the input pixel window, we obtain the edges.

P1	P2	P3
P4	**P5**	P6
P7	P8	P9

Fig. 2.3 : Floating 3x3 pixel window mask

2.2.2 Proposed ANFIS

The proposed ANFIS detector is a first-order Sugeno type fuzzy inference system with 8-inputs and 1-output. Each input has 2 triangular type membership functions and the output has a constant membership function which take 256 rules.

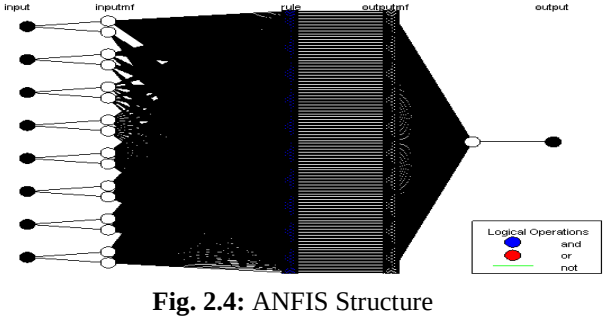

Fig. 2.4: ANFIS Structure

The no of output membership functions are 256 and there is only one output. This is because ANFIS does not allow any rule sharing. There are two options available for designing a FIS in the ANFIS editor. They are [A] Grid partition method and [B] subtractive clustering method. In this proposed work grid partition method is used. Hybrid algorithm is used for training the model. Fig.-2.4 shows the ANFIS structure. The edge patterns in binary images are classified into 32 categories, as shown in Fig. 2.5, and then train the ANFIS on these patterns. Information about the anfis structure is shown in the Table 2.3. The blank elements in each 3x3window indicate white (pixels value: 1s) in binary images, whereas the dark elements indicate black (pixels value: 0s).

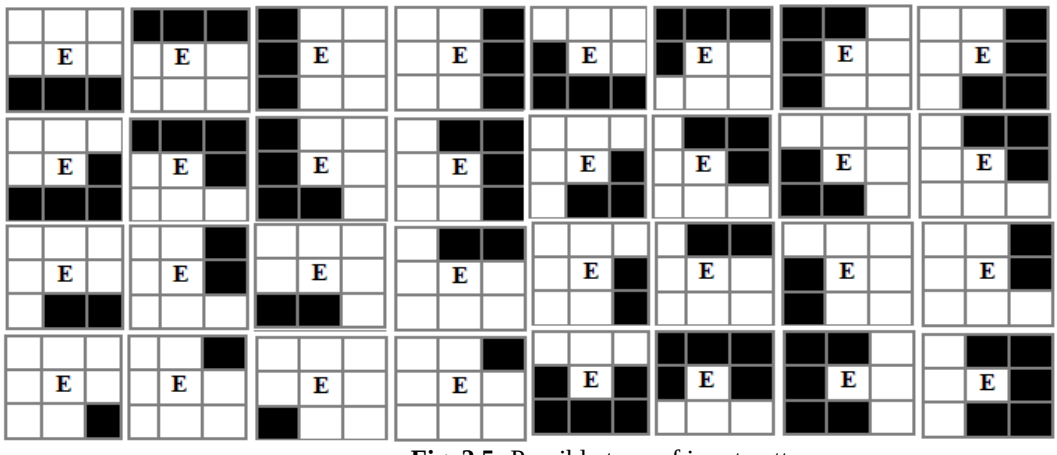

Fig. 2.5 : Possible type of input patterns

Table 2.2
ANFIS information (triangular membership function)

Learning Algorithm	Hybrid
Number of nodes	555
Number of linear parameters	256
Number of nonlinear parameters	48
Total number of parameters	304
Number of training data pairs	32
Number of checking data pairs	0
Number of fuzzy rules	256
No. of Epoch's	100

3 Implementation Results:-

The experiment has been performed in MATLAB 2011a [11]. ANFIS editor from Fuzzy logic toolbox has been used to design the proposed ANFIS edge detector. Using a given input/output data set, the toolbox function anfis constructs a fuzzy inference system (FIS) whose membership function parameters are tuned (adjusted) using hybrid algorithm (combination of back propagation algorithm with a least squares type of method). This allows our ANFIS systems to learn from the data we are modeling.

Performance Evaluation Metrics

- **Number of Edge:-**determine the number of edge detected by any edge detection technique.
- **Mean Square Error:-**In statistics, the mean square error (MSE) is one way to evaluate the difference between an estimator and the true value of the quantity being estimated. MSE measures the average of the square of the "error," with the error being the amount by which the estimator differs from the quantity to be estimated.
- **Peak Signal-to-Noise Ratio:-**Computes the peak signal-to-noise ratio, between two images. This ratio is often used as a quality measurement between the original and edge detected image. The higher the PSNR, the better the quality of the compressed, or reconstructed image.

Results

The proposed ANFIS edge detector was simulated using MATLAB on different images, its performance are compared to that of the Sobel and Roberts operators. In first example, cameraman image is processed and compared.

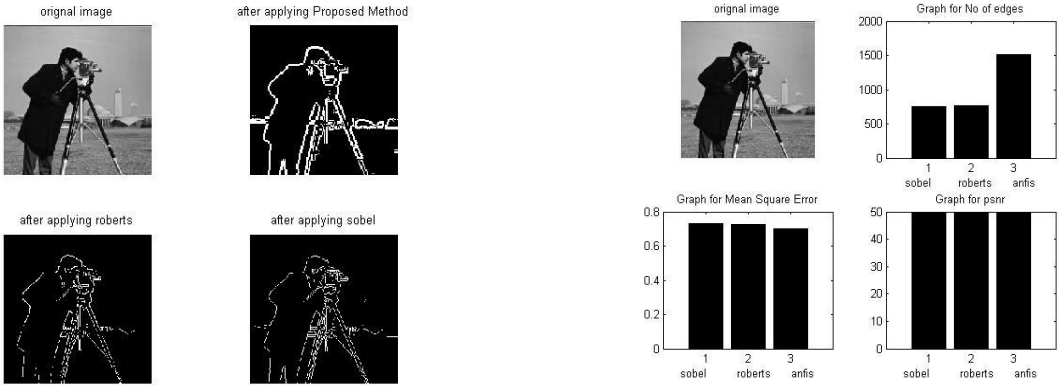

Fig 3.1 Original CameraMan Image, Edge Detected by Proposed Method, Roberts Method, Sobel Method

Fig. 3.2 Results obtained from Proposed method is compared with Sobel and Roberts Method

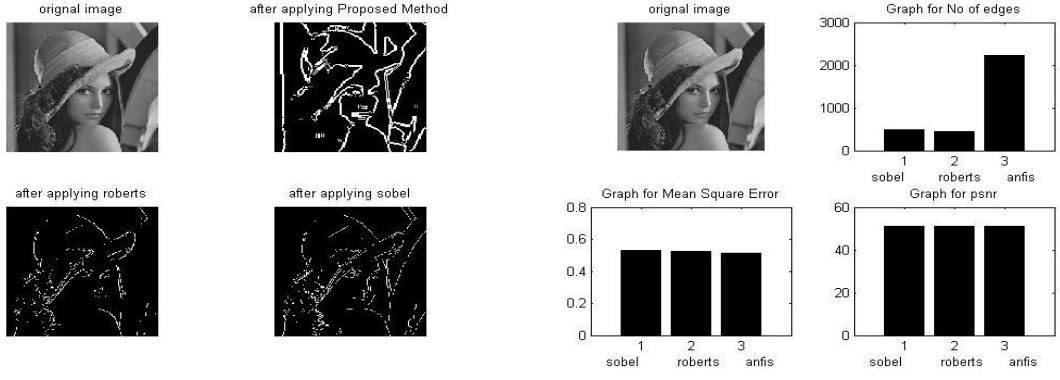

Fig. 3.3: Original lena image, edge detected by proposed method, Roberts and Sobel method

Fig. 3.4: Results obtained of proposed method is compared with Sobel and Roberts method

4 Conclusion & Future Work

The proposed neuro-fuzzy method identifies more fine edges as compared to the gradient based (sobel and Robert) method. The results show that application of ANFIS method to the edge detection is a feasible approach to address the problem of uncertainty and vagueness present in an image. The proposed technique is to find more fine edges using ANFIS edge detector. In future, modification of training set to reduce even more inclusion in the output image of pixels not belonging to edges which can produce better result.

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