A NOBEL HYBRID APPROACH FOR EDGE DETECTION

Palvi Rani[1], Poonam Tanwar[2]

[1]School of Computer Science Engineering, Lingaya's University,Faridabad
`palvi.okaya@gmail.com`
[2]Assit Prof School of Computer Science Engineering, Lingaya's University,Faridabad
`Poonam.tanwar@rediffmail.com`

ABSTRACT

The objective of this paper is to present the hybrid approach for edge detection. Under this technique, edge detection is performed in two phase. In first phase, Canny Algorithm is applied for image smoothing and in second phase neural network is to detecting actual edges. Neural network is a wonderful tool for edge detection. As it is a non-linear network with built-in thresholding capability. Neural Network can be trained with back propagation technique using few training patterns but the most important and difficult part is to identify the correct and proper training set.

KEYWORDS

Edge Detection, Neural Network, Canny Algorithm, Gaussian Filter

1. INTRODUCTION

Today edge detection is a very important area in the field of image processing and computer vision. Edge defines the boundaries of regions in the image. Edges also play an important role for image segmentation and object recognition. Boundaries of an image represents useful feature with small set of data. In computer vision, edge detection is used in bio metric machines, X-Ray, Shopping Malls, Satellite images etc. the automated visual inspection is done. Currently many applications like Identification wheat fields, image manipulation for movies, registered cars identification details using plate numbers, optical character reorganization are commonly used.

1.1 EDGE DETECTION

Edge detection is the process to detect the important features of image. Here, features mean the properties of image like discontinuities in physical and geometric characteristics of image or abrupt variation in the intensity of image. The quality of edges is affected by the presence of objects in similar illumination, noise and density of edges [12]. The variation in characteristics can leads to the variation in gray level of image. Edge detection represents an important step for facilitating higher level image analysis and therefore remains an area of research with new approaches is continually being developed [9].

1.2 CANNY ALGORITHM

Canny Edge Detection is one of the commonly used edge detection algorithm. It was developed in 1985 then it became popular because of its good localization and better response in noisy

conditions. Canny Edge Detection algorithm is a multistage process used to detect the edges of the image.

1. Canny edge detector uses the first derivative of Gaussian to reduce the noise in image and produces a blur image.
2. The edge can be in any direction horizontally, vertically or diagonally, so the edge detector operator returns the first derivative in horizontal direction (Gx) and vertical direction (Gy). Edge direction is identified by
Q=arctan (Gy/Gx)
$G=Ö Gx^2+Gy^2$ [1]
3. From the given values of image gradient, the direction of edge is calculated by comparing the gradient value with its local maxima. This step is also called as non-maximum suppression because it gives a wide range of edges including thin edges.
4. Once the gradient values have been computed, thresholding is performed. The total number of edge points depends on the value of threshold. Large the value of threshold produce small number of edges. Small the value of threshold produce large number of edges.
5. After applying the threshold, edge thinning is performed to remove the false edges that are shown in image. It removes all the unwanted edge pixels.

1.3 NEURAL NETWORK

Neural Network is an attempt of modelling processing capabilities of data to extract the useful information. Artificial Neural Network is based on biological neural having dendrites, axon and synapse. In past few years, it is getting more interest due to fast computation and learning behaviour. Same like biological network, input data is present to the nodes of the neural network and synapses is represented by weight. The actual knowledge of the network is stored in weights. The activation function is applied on the net summation of input and weight. Bias is also added to the net summation before applying the activation function. As it refers to some stored energy of the node. Data is classified after applying the function. During the learning process weights are modified depend on the error comes.

$$O = f\left(\Sigma_{i=0 \text{ to } n} w_i x\right) \quad [13]$$

There are mainly two types of neural network feed forward and feedback. As there are number of layers in to the network, so in feed forward network generates output and if the output is not correct, back propagation method is used to modify the weight. In case of feedback network the output of the network is passed as input to network.

2. SURVEY OF EDGE DETECTION

The lots of techniques have already been developed in this area. All are discussed below:

2.1 FIRST-ORDER IMAGE GRADIENT

First-order image gradient is one of the oldest and commonly used techniques. It gives directional change in intensity or colour of image. Gradient value is compared with the threshold to decide given pixel is an edge or not. Sobel, Prewitt and Robert operators are used. The convolution kernels used in x and y direction are given for all the operators.
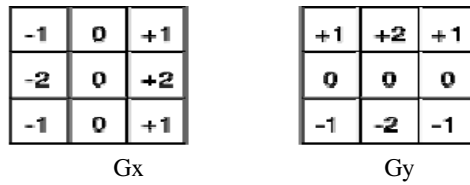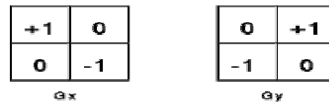
Figure1. Sobel Operator [1]
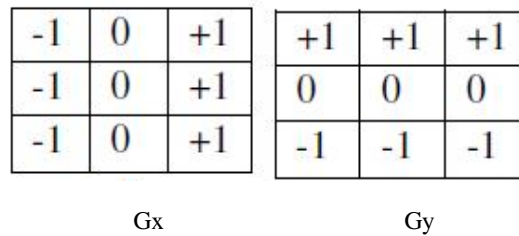

Figure2. Robert Operator [1]

Figure3. Prewitt Operator [1]

2.2 SECOND ORDER IMAGE GRADIENT

Second order image gradient method also known as Laplacian image gradient is used to find the edges. Because it has been seen that first-order image gradient sometimes gives false edges. When the first-order image gradient is maximum second order derivative is zero [1].

2.3 LAPLACIAN OF GAUSSIANS METHOD

Laplacian of Gaussians Method is some advancement in Laplacian image gradient. In this, firstly image smoothing is performed to remove the noise from image. For this, Gaussian Filter is applied and again second order image gradient method is applied to find the edges. Three commonly used convolution kernels are given below:
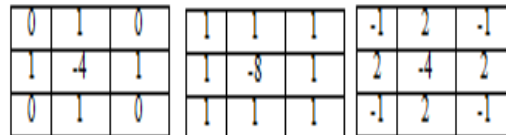

Figure4. Convolution Matrix for Second Order Image Gradient [1]

2.4 CANNY ALGORITHM

Canny is a multi-step edge detection Algorithm developed in 1985 and since a popular approach for detecting the edges. The steps followed in Canny Algorithm are explained below:

1. Uses Gaussian filter to smooth the image. A convolution matrix is used to remove the noisy effects from image.
2. Sobel Operator is used as a first order image gradient to detect the actual edges.
3. Edge thinning is performed to sharpen the edges.
4. Double thresholding is performed to remove the false edges from the image.

For thinning the edges search is carried out to find the local maxima in gradient direction. If the rounded angle is zero degree the point will considered as an edge if its intensity is greater than the intensities of north and south direction [11].

2.5 FUZZY BASED ALGORITHM

In few recent years fuzzy technology is also playing an important in image processing specially in edge detection.

1. Abdullah A. Alshennawy and Ayman A. Aly proposed an algorithm based on fuzzy of segmenting the image into regions of 3*3 binary matrixes. A fuzzy inference system is used which compares the values from each other in floating matrix to detect edges. The whole process is the combination 3 steps. Fuzzification, processing of membership values and Defuzzification is performed to change the crisp input to fuzzy input and Defuzzification is performed to again change the fuzzy result into crisp output. The main power of algorithm lies in middle step of the whole process. Image data transformed to the membership plan, fuzzy techniques are applied to modify the membership values. This can be done through fuzzy rule based approach, fuzzy clustering etc.

2. Aborisade and D.O. also presented a technique on fuzzy in which Sobel Operator, Gaussian Filter and Mean Filter is applied on image. A set of fuzzy rules are applied on the values that are get from these operators to detect edges. Steps of techniques are as follows:

A. An input image is pre-process to remove a band of spatial frequencies and to locate in edges in gray level image. For each pixel in the image edge strength value is calculated with three (3) 3×3 linear spatial filters i.e. low-pass, high-pass and edge enhancement filters (Sobel) through spatial convolution process. In carrying out a 3×3 kernel convolution, nine convolution coefficients called the convolution mask are defined.
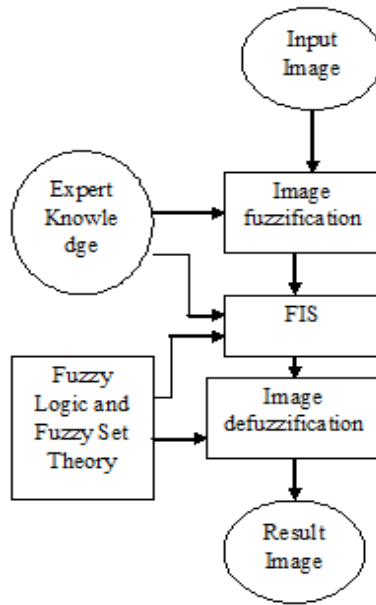
Figure5. Structure of fuzzy image processing [4]

B. Each pixel in the input image is evaluated with its eight neighbours, using each of the three masks to produce edge strength value. The equation used for the calculation of edginess values between the centre pixel and the neighbourhood pixels of the three (3) masks using spatial convolution process.

C. In the proposed edge detection Gaussian membership functions are used. To apply these functions, each of the edge strength values of g, Hp, Lp and O are mapped into fuzzy domain between 0 and 1, relative to the normalized gray levels between 0 and 100, using Gaussian membership functions given as

$$\mu_{mn} = G(x_{mn}) = e^{[-(x_{max} - x_{mn})^i / 2\sigma^i]} \qquad [4]$$

A set of fuzzy rules are given to decide an edge or not.

2.6 NEURAL NETWORK BASED ALGORITHMS

1. In the field of image processing, Neural Network is gaining interest from last few years. For edge detection also neural network plays a very important role. John Terry and Duc Vu give both supervised and unsupervised approaches to detect edges given below:

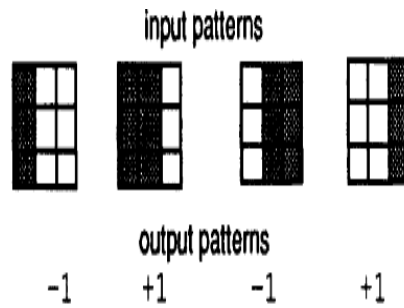   A. Supervised- Train the network with a given set of data sets which can be an edge.

Figure6. Patterns [6]

B. Unsupervised- Create input layer with 5 inputs and subtract central pixel from all the neighbour four pixels and thresholding is done at output layer.
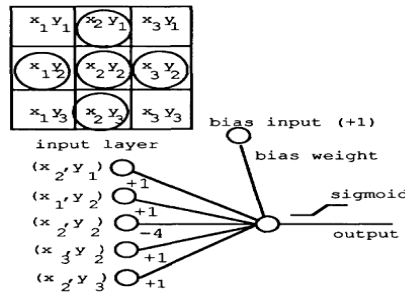

Figure7. Unsupervised Method [6]

2. Md. Shoib Bhuiyan, Akira, Sato and Fujimoto has created an algorithm only for finding edges in illumination change. Each pixel having 3 neurons- one gives pixel intensity, second gives discontinuities in horizontal direction and other gives in vertical direction. Set of coefficients as energy function is used to determine the edges.

3. HamedMehrara and Mohammad Zahedinejad given a technique in which the Original image is first converted into binary image (1 for white and 0 for black) using global thresholding. The 2*2 pixel window is used to create the training sets. Almost 16 training patterns are created. This pixel window when overlap on actual image gives 2*2 output window result. We get 4 different pixel windows results for each pixel in widow and all those are multiplied to get the final result.
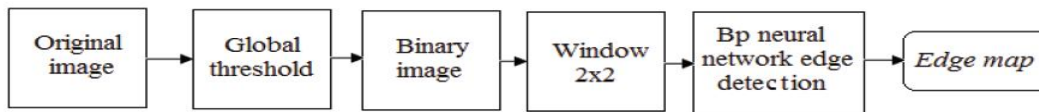

Figure8. NN Edge Detection Technique [8]

2.7 HYBRID APPROACH OF NEURO-FUZZY

Various algorithms based on hybrid Neuro-Fuzzy Techniques are also being designed.

1. One of the algorithms discussed by C.Sriramakrishnan and A. Shanmugam is given below:

  i.   One the given input image Sobel and Laplacian is applied.

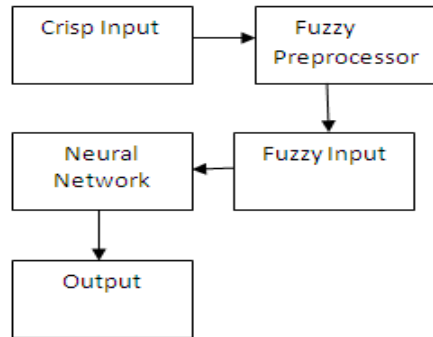 ii.   Fuzzy rules are applied on the output we gain from these operators.

Figure9. Hybrid Edge Detection Technique-1 [9]

  iii.   In neural network, input layer consists of gradient direction and hidden layer consists of fuzzy data.

  iv.   Both are used to train the network.

2. Another Algorithm on Hybrid Neuro-Fuzzy is presented by Suryakant and Renu Dhir. The technique used by them as follows:

i. Gray level image converted into binary image (0 or 1) using global thresholding.

ii. This is applied as input into ANFIS where a set of training patterns uses 3*3 window mask to train the network.
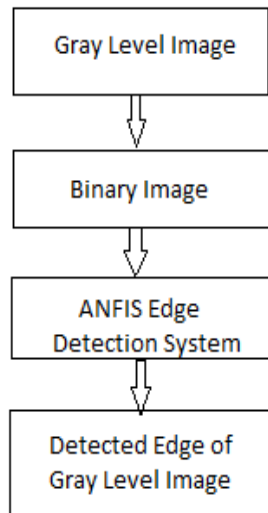

Figure10. Hybrid Edge Detection Technique-2 [10]

3. Another Algorithm is discussed by Lei Jhang, Mei Xiao, Jian Ma and Hongxon Song. The approach is to construct an ANFIS using fuzzy Inference System whose membership function values are adjusted by Back propagation method. The steps followed under this approach are discussed below:

33

i. A FIS with first order Sugeno type system having 4 inputs and 1 output.
ii. Edge Intensity is normalized to [0,L-1]. L is number of gray levels.
iii. Pixels are divided into two type of sets S0 and S1.
3*3 mask of image pixel is taken, if there is large distance between S0 and S1, it is considered as an edge.
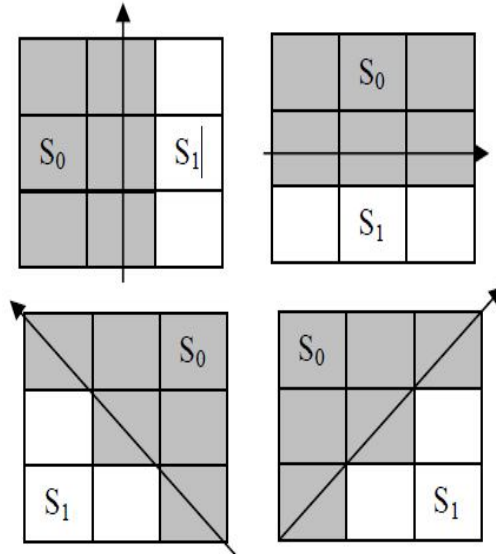

Figure11. Edges in direction 1, 2, 3 and 4   [19]

The comparison of various edge detection techniques is given in Table1 of annexure 1.

3. PROPOSED WORK

As Canny is popular with giving good results based on image smoothing and Neural Network is popular with its high tolerance, speed and accuracy. From studying the advantages of both Canny Algorithm and Neural Network, architecture is proposed. The architecture has various modules which are discussed below:

3.1 USER INTERFACE

User Interface is a space through which human interacts with the machine. Users submit the queries and get their results on a user interface system. As in this case, an input to the system is an image submitted through the front end of user interface and after processing result is displayed to user.

3.2 INPUT IMAGE

A 2D image is given to system as an input. Any type of image black and white or colour could be submitted as canny's will be applied to change normal image into gray level image.

3.3 ANNY'S GAUSSIAN ALGORITHM

Gaussian smoothing uses a convolution operator to smooth the image. In convolution process, the image is blurred to remove the noisy effects from image and image being smooth.
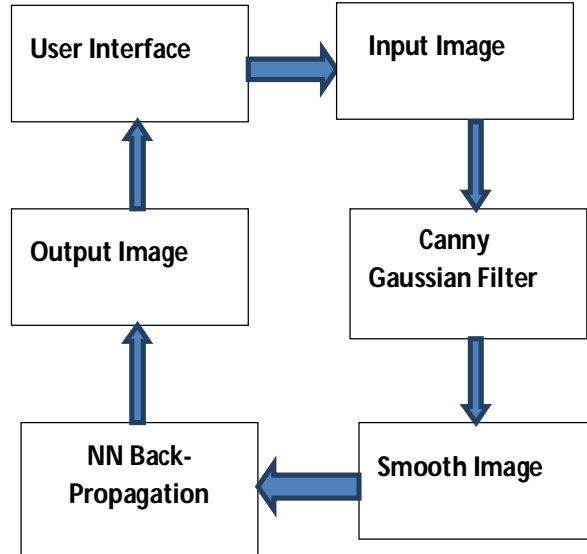
Figure12. Proposed Edge Detection Architecture

3.4 SMOOTH IMAGE

After the process of Gaussian filter, the resulting image will be the smooth image with very less noise data. Smoothed image passed as input to actual neural network system to detect the final edges.

3.5 NN BACK PROPAGATION

Neural Network's back propagation technique is one of the popular techniques that mainly used for classification process. In the process of back propagation, a convolution matrix will be generated, a knowledge that actually generates the edge from gray level image.

3.6 OUTPUT IMAGE

After the process of NN back propagation, the actual edged image will produced as output and presented to the user.
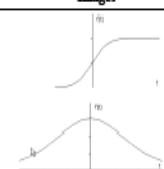
4. CONCLUSIONS
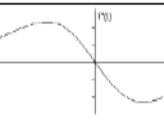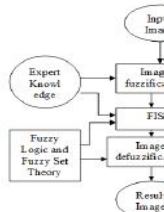
Many algorithms are used to solve the problem of edge detection. But all of them having some disadvantages in form of speed of computation or reliability. Neural Network has the capability of work in environment of high tolerance and gives good results with great accuracy. Gaussian filter in addition to it remove noise at large extent. So, if they both used in combined approach can give better results as compared to other techniques. The purpose of this approach is to combine the advantages of neural network and canny techniques.

REFERENCES

[1] PinakiPratim Acharjy, Ritaban Das & Dibyendu Ghoshal, (2012) "Study on Image Edge Detection Using the Gradients", International Journal of Scientific and Research Publications, Vol 2.
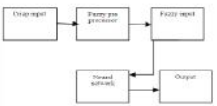
[2] Raman Main & Dr.Himansu Aggarwal, (2010) "Study and Comparison of Various Image Edge Detection Techniques", International Journal of Image Processing (IJIP), Vol 3, Issue 1.

[3] Sara Sharifzadeh & Hamid Hassanpour, (2008) "Edge Detection Techniques: Evaluations and Comparisons", International Journal of Image Processing (IJIP), Vol 3, Issue 3, pp 1507-1520.

[4] Abdallah A. Alshennawy & Ayman A. Aly, (2009) "Edge Detection in Digital Images using Fuzzy Logic Technique", International Journal of Electrical and Computer Engineering, pp. 4-7.

[5] Aborisade & D.O., (2010) "Fuzzy Logic Based Digital Image Edge Detection",Global Journal of Computer Science and Technology, Vol. 10, Issue 14, version 1,pp. 78.

[6] P.John Terry & Duc Vu, (1993) "Edge Detection using Neural Network", Signal System and Computers.

[7] Md. Shoib Bhuiyan, Akira, Sato & Fujimoto, (1993) "Edge Detection by Neural Network with a Line Process", International Joint Conference in Neural Networks.

[8] Hamed Mehrara & Mohammad Zahedinejad, (2011) "Quad-pixel edge detection using neural network", Journal of Advances in Computer Research, pp.47-54.

[9] C.Sriramakrishnan & A. Shanmugam, (2012) "An fuzzy Neural approach for Medical Image Retrieval" ,Journal of Computer Science, pp. 1809-1813.

[10] Suryakant & Renu Dhir, (2012) "Novel Edge Detection Using Adaptive Neuro-Fuzzy Inference System", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 2, Issue 5.

[11] Emesto Damiani & Jechang Jeong , "Multimedia Techniques for Device and Ambient Intelligence".

[12] EhsanNadarnejat, (2008) "Edge Detection Techniques: Evaluations and comparison", Applied Mathematical Sciences, Vol 2,pp. 1507-1520.

[13] JacekM.Zurada, (2003) "Introduction to Neural Networks".

[14] Yuko Roodt, Willem Visser & Willem A. Clark, (2012) "Image Processing in GPU: Implementing the Canny Edge Detection Algorithm".

[15] Suryakant & Neetu Khushwaha, (2012) "Edge Detection Using Fuzzy Logic in Matlab",International Journal of Advanced Research in Computer Science and Software Engineering, Vol 2, Issue 2.

[16] Begol Mosle & Maghooli Keivaan, (2011) "Improving Digital Image Edge Detection by Fuzzy Systems" ,World Academy of Science, Engineering and Technology.

[17] Atif Bin Mansoor, Ajmal S Mian & Shoib A Khan,"Fuzzy Morphology for Edge Detection and Segmentation".

[18] Paul Viola & Michael Jones, (2001) "Rapid Object Detection Using a Boosted Cascade of Simple Features",Accepted Conference on Computer Vision and Pattern Recognition.

[19] Lei Jhang, Mei Xiao, Jian Ma & Hongxon Son, (2009) "A Novel Edge Detection Method based on Adaptive Neuro Fuzzy Inference System",Intelligent, Information, Control and Communication Technology for Agricultural engineering.

[20] Yasar Beserikli & tayfoon M. Karan, (2005) "A New Fuzzy Approach for Edge Detection"Springer Verlag Berlin Heidelberg, pp. 943-951.

[21] Abdullah Gubbi & Mohammad Fazel Azeem, "Type-2 Fuzzy Logic for edge Detection of Gray Scale Images", www.intechopen.com

ANNEXURE1

Table1. Comparison of various Edge Detection Techniques

SNo	Technique	Paper	Author	Year	Algorithm	Images	Application	Advantages	Disadvantages	Ref.
1	First Order Image Gradient	A Study on Image Edge Detection Using the Gradients	i. Pinaki Pratim Acharjya ii. Ritaban Das iii. Dibyendu Ghoshal	2012	i. Sobel Method ii. Prewitt Method		i. Character Recoginization ii. Pattern Recognization	i. Simple ii. Detection of edges and their orientations	i. Sensitive to noise ii. Inaccurate Results	[1]
2	Second Order Image Gradient- Zero-crossing	A Study on Image Edge Detection Using the Gradients	i. Pinaki Pratim Acharjya ii. Ritaban Das iii. Dibyendu Ghoshal	2012	Laplacian Gradient Method		i. Character Recoginization ii. Pattern Recognization	i. Detection of edges and their orientations. ii. Having fixed characteristics in all directions	i. Responding to some of the existing edges ii. Sensitivity to noise	[1]
3	Laplacian of Gaussian- smoothed	Study and Comparison of Various Image Edge Detection Techniques	i. Raman Maini ii. Dr. Himansu Aggarwal	2010	i.Gaussian filter is applied to smooth the image ii. Laplacian Gradient Method is used to detect edges		i. Character Recoginization ii. Pattern Recognization	Finding the correct places of edges, Testing wider area around the pixel	i. Malfunctioning at the corners, curves where the gray level intensity function varies.	[2]
4	Canny Algorithm	Edge Detection Techniques: Evaluations and Comparisons	i. Sara Sharifzadeh ii. Hamid Hassanpour	2008	i. Uses Gaussian filter to smooth the image ii.Sobel Operator for image gradient iii. Edge thinning is performed iv. Double threshlding is performed.	-> For thinning the edges search is carried out to find the local maxima in gradient direction. -> If the rounded angle is zero degree the point will considered as an edge if its intensity is greater than the intensities of north and south direction.[11]	i.Remote Sensing ii. optical character recognition iii. computer-aided diagnosis of medical images	i. Good localization and response. ii.Better detection specially in noise conditions	i. Complex Computation ii. Time Consuming	[3]
5	a. Fuzzy	a. Edge Detection in Digital Images using Fuzzy Logic Technique	i. Abdallah A. Alshennawy ii. and Ayman A. Aly	2009	i. Applying Sobel Operaot on original Image to convert image in gray level ii. Gradient image is tranfered in number of classes as black, white depend on the thresholding iii. Fuzzy rules are applied to detect edges ii. Defuzzification is performed to convert in actual image		i. Human Analysis of images ii. computer-aided diagnosis of medical image	Edges are clear and smooth	i. Large number of computations ii. Fuzzy rules needs to properly defind and clear. iii. Noise Issue	[4]
6	b. Fuzzy	b. Fuzzy Logic Based Digital Image Edge Detection	i. Aborisade ii. D.O.	2010	i. Sobel Operator, Gaussian Filter and Mean Filter is apllied on image. ii. Depend on the values we get from these methods, a set of fuzzy rules are defined to detect the edges.		i. Human Analysis of images ii. computer-aided diagnosis of medical image	Edges are clear and smooth	i. Fuzzy rules are extremly large due to the three different operators we applying. ii. Sensitive to noise	[5]
7	Neural Network	a. Edge Detection using Neural Network	i. P.John Terry ii. Duc Vu	1993	i. Supervised- Train the network with a given set of data sets which can be an edge ii. Unsupervised Create input layer with 5 inputs and subtract central pixel from all the neighbour four pixels and thresholding is done at output layer.		i. mammography images ii. Simple Image Validation	Fault Tolerance High Speed	Noisy images	[6]
8	Neural Network	b. Edge Detection by Neural Network with a Line Process	i.Md. ShoibBhuiyam ii. Akira iii. Sato iv. Fujimoto	1993	Each pixel having 3 neurons- one gives pixel intensity, second gives discontinuities in horizontal direction and other gives in vertical direction. Set of coefficients as energy function are used to determine the edges.			Detect correctly edges even in non uniform image contrast	Noisy results	[7]

9	Neural Network	c. Quad-pixel edge detection using neural network	i.HamedMehrara ii. Mohammad Zahedinejad	2011	Uses 2*2 pixel window and create 16 training sets and train the networks to detect edges on the basis of it.			Good Results.	Time requied to trained the network	[8]
10	Hybrid-Neuro Fuzzy	a. An fuzzy Neural approach for Medical Image Retrieval	i.C. Sriramakrishnan ii.A. Shanmugam	2012	i. One the given input image sobel and laplacian is applied. ii. Fuzzy rules are applied on the output we gain from these operators. Iii. In neural network, input layer consists of gradient direction and hidden layer consists fuzzy data. iv. Both are used to trained the network.		Used to find the Tumors in medical images.	Provides good accuracy around 90%.	i. The number of fuzzy rules are large. ii. Training Time can be large.	[9]
11	Hybrid-Neuro Fuzzy	b. Novel Edge Detection Using Adaptive Neuro-Fuzzy Inference System	i. Suryakant ii. Renu Dhir	2012	i.Gray level image converted into binary image(0 or 1) using global thresholding. ii. This is applied as input into ANFIS where a set of training patterns uses 3*3 window mask to train the network.		Character Recognition	Easy as compared to other neuro-fuzzy algorithm	i. Not detetct correct edges. ii. Image noise rduces its computation power	[10]

Authors

Pallavi Rani

Pallavi Rani received her B.Tech in Computer Science & Engg from Maharishi Dayanand University Haryana. Pursuing M.Tech in Computer Science & Engg from Lingaya's University , Haryana. She has 3 year's of teaching experience. Her area of interest includes Theory of computation, Java, Artificial intelligence.

Poonam Tanwar

Poonam Tanwar received her B.Tech, M.Tech degree in Computer Science & Engg from Maharishi Dayanand University Haryana. Pursuing P.hd From Uttarakhand Technical University Dehradun(UTU). She has over 10 years of experience in teaching. Currently she is Assit Professor At Lingaya's University, Faridabad, Haryana, India. She has 20 papers to his credit. Her area of Interest includes artificial intelligence, Computer graphics, Theory of computation & Soft Computing. She is member of IEEE.