International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Edge Detection Approaches in the Taxonomy of Soft Computing-A Survey

Somya Saxena

Assistant Professor, Poornima Group of Institution, Jaipur, Rajasthan, India

Abstract: ***Vision is the process discovered from images related to the fact that what is there in the world and where it is. Problems related to the vision are tackled in the taxonomy of image processing under image segmentation. Edge detection is the process which deals with the images that contain noise, imprecise data, blur image. Basically edge detection is locating and identifying sharp discontinuities in the intensity of image. This paper contains a survey of techniques used in edge detection and makes a comparison between different edge detectors using neural network, fuzzy logic and neuro fuzzy system.***

Keywords: Edge Detection, Fuzzy Inference System, Neural network, Neuro Fuzzy System, Fuzzy logic

1. Introduction

Image Processing encompasses the process of acquiring the image of an area, pre-process that image and filter-out the individual characters and convert them in a form suitable for computer processing and then recognize them. Image processing undergo through some of the operations like Image Restoration, Image Enhancement, Image Compression and Image Segmentation. These processes refer to restore the corrupted image and then create the new noise free image which is clearer, alters the image to make better look and feel while compression is the process which removes repetition of data and represent in very few bits. The main focus of this paper is on image segmentation which refers to the process of subdividing the image [1].

Image segmentation refers to the process of segmenting a digital image into multiple homogeneous regions. These regions represent the part or an object of the entire scene. Edge detection plays a very important role with reference to image processing. It identifies the boundaries of object surfaces and the abrupt changes in the intensity of image. Edge detection is not only detect edges but also give a path for further research of image processing such as image segmentation, boundary detection, shape extraction, image tracking, image matching. This paper refers an analysis of some techniques which are used for edge detection and also a comparative study of conventional edge detectors and some recent edge detectors. [2]

From the last few years these components of soft computing gain attention. Fuzzy logic, neural network have diverted the attention of researchers towards them. Neuro-fuzzy concepts also gain importance due to the happy marriage of neural network and fuzzy logic. The fuzzy logic related approach deals the uncertainties and assigns crisp set to obtain most accurate solution. While neural network is used to drive meaningful data from the imprecise or incomplete data. The main potential of neural network is its design which is like a human brain. We can train this network by adjusting the synaptic weights of these neurons. On the other hand evolutionary computation also came into existence. Evolutionary computation technique is based on the principles of biological evolution such as genetic inheritance and natural selection. This technique continuously optimizes the problem and provides the solution.

Machine Learning is a subfield of AI which provides assistance to the persons dealing with computer applications like an expert system. This system is based on agents who learn from hypothetical examples [3]. There are mainly two ways gradient based and laplacian based to perform edge detection. If the edges are detected using derivatives then they focus on the continuous changes in function. First derivative and second derivative identifies the points on which image lie. On the other hand gradient vector has magnitude to provide strength and direction for the inclination of angles in the images. The gradient method detects the edges by looking for maximum and minimum in the first derivative of an image while Laplacian method locates zeros in the second derivative [4].

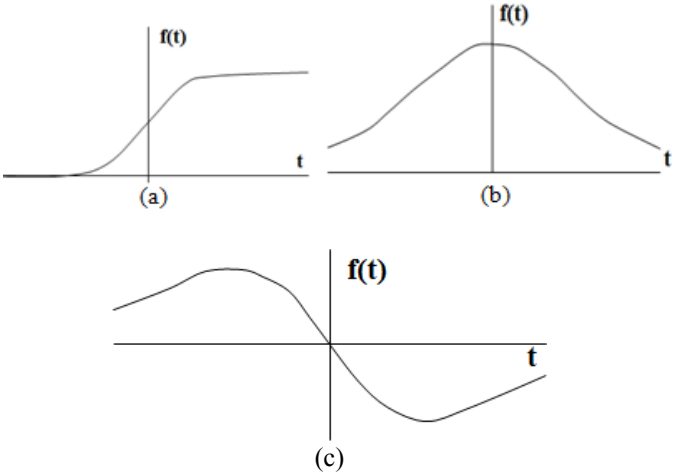

Figure 1: (a) Signal Applied to the edge detector (b) Gradient for first derivative Signal (c) Gradient for second derivative Signal [4]

2. Soft Computing Techniques for edge detection

2.1 Steps of Edge Detection

- **Smoothing:** suppress as much noise as possible, without destroying the true edges. This process also restores

images that are distorted due to some physical issues or due to low-vision [5].

- **Enhancement:** apply a filter to amplify the perceptual features quality of the edges in the image.
- **Detection:** determine which edge pixels should be discarded as noise and which should be retained.
- **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.

2.2 Conventional Edge Detectors

These edge detection methods are also used to make a comparison from recent edge detectors.

1) Sobel Operator

The Sobel operator is a 3X3 gradient edge detector performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. One kernel is used to mask over the input image and then shift one pixel to the right and obtain the edges [4].

-1	0	+1
-2	0	+2
-1	0	+1

(a)

+1	+2	+1
0	0	0
-1	-2	-1

(b)

P_1	P_2	P_3
P_4	P_5	P_6
P_7	P_8	P_9

(c)

Figure 2: (a) (b) Sobel convolution kernel towards x and y direction (c) Pseudo- convolution kernel for approximate magnitude

An approximate magnitude and angle of orientation is calculated using

$$|G_x| = |G_x| + |G_y| \quad (2.1)$$

$$\tan^{-1}\left(G_y / G_x\right) \quad (2.2)$$

The approximate magnitude is calculated using

$$|G| = |(P_1 + 2\times P_2 + P_3) - (P_7 + 2\times P_8 + P_9)| + |(P_3 + 2\times P_6 + P_9) - (P_1 + 2\times P_4 + P_7)| \quad (2.3)$$

2) Canny Operator

The Edge Detector is basically used for step edges and follows these steps to detect edges. a) Smoothing b) Finding gradients c) Non-maximum suppression d) Double thresholding e) Edge tracking by hysteresis. The kernels for x and y direction are same as for sobel operator and magnitude and gradient can be calculated using equation (2.1) and (2.2). Canny saw the edge detection as an optimization problem and follow three criteria's good detection, good localization, and minimum response. [6]

3) Roberts Operator

The Roberts Cross operator performs a simple, computation on grayscale images, 2-D spatial gradient measurement on an image and then highlights regions of high spatial frequency which often correspond to edges. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The gradient magnitude for Roberts's operator and angle of orientation can be calculated from equation (2.1) and (2.2). We can compute the approximate gradient magnitude using the kernel from equation (2.3).

$$|G| = |P_1 - P_4| + |P_2 - P_3| \quad (2.3)$$

+1	0
0	-1

(a)

0	+1
-1	0

(b)

P_1	P_2
P_3	P_4

(c)

Figure 3: (a) (b) - Roberts convolution kernels towards x and y direction (c) Pseudo-convolution kernel used to compute approximate magnitude. [2]

4) Prewitt Operator

Prewitt edge detector detects edges with their orientation and provides simplicity. These masks are used to detect edges in horizontal and vertical direction. The process which is obtained by Prewitt is time consuming but it provides maximum response. This edge detector is gradient based and has 3x3 neighborhoods. This operator is limited to eight possible orientations and these eight mask are calculated and the largest module is selected [2].

-1	0	+1
-1	0	+1
-1	0	+1

(a)

+1	+1	+1
0	0	0
-1	-1	-1

(b)

Figure 4: Prewitt Masks

3. Different Approaches of Edge Detection

Edge detection follows a number of approaches some of which are based on (a) Neural Network (b) Fuzzy logic based (c) Neuro- Fuzzy based.

3.1 Neural Network

Neural network a set of neurons works like human brain or a kind of expert system to process incomplete information obtained by perception. Hamed Mehrara et al. [7] have proposed a new edge detection technique based on the BP neural network. Edge patterns of binary images subdivided into 16 possible types of visual patterns. After training the pre-defined edge patterns, the BP neural network is applied to correspond any type of edges with its related visual pattern. It will also resolve the problem of convergence if the BP neural network performs edge detection then it needs heavy training.

3.2 Fuzzy Logic Based

Fuzzy logic follows different situations for communicating with edge detection such as it create membership functions to identify degree of indistinct or vague data. Fuzzy logic

also works on if-then rules and it is helpful to detect edges from neighborhood. A. Jayachandran et al. [8] presents a research on edge detection based on Fuzzy information system in digital images without any idea about their threshold value. This work uses the FIS method based on the fuzzy logic reasoning strategy and then approach segments the image by 3x3 binary matrix. This work aims to identify the points on which the first derivative of the gray level image as a function of position is of high magnitude and then threshold detects a new output edge through which edges are detected. Shashank Mathur et al. [9] have implemented the fuzzy relative pixel value algorithms and help to find all the highlighted edges.Exhaustive scanning of an image using the windowing technique takes place which is subjected to a set of fuzzy conditions for the comparison of pixel values with adjacent pixels to check the pixel magnitude gradient in the window. After the testing of fuzzy conditions the appropriate values are allocated to the pixels in the window under testing to provide an image highlighted with all the associated edges.

3.3 Neuro- Fuzzy Based Approach

NF Systems are often represented as multilayer feed forward network. This combination adopt the ability of neural network from the examples and the capability of fuzzy logic to model the uncertainty and imprecision. This integration also provides ANFIS (Adaptive Neuro Fuzzy Inference System) which consolidate Artificial Neural network with Fuzzy Inference System. Basically ANFIS removes the need of manual optimization and fuzzy system parameters and neural network automatically tune the system parameters.

4. Fuzzy Inference System

FIS an expert system, defines a non-linear mapping of input data values into single output using fuzzy rules. FIS split itself into Mamdani fuzzy models, Sugeno fuzzy model. Both of these works on fuzzy if- then rules but Sugeno contains the fuzzy sets with function of input variable and reduce the number of rules tried by Mamdani model.

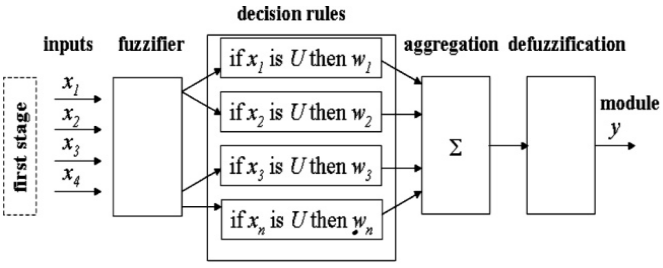

Figure 5: Implementation of FIS

Lei Zhang et al. [10] have presented a novel first order Sugeno model based adaptive neuro-fuzzy inference system (ANFIS) with 4-input and 1-output for edge detection in digital images. The internal parameters of the proposed ANFIS edge detector are optimized by training using very simple artificial images. In [11] a first order Sugeno FIS have been proposed with 8-input and 1-output. Each input has 2 triangular functions and one constant membership function with 256 rules. This work follows the hybrid algorithm in collaboration with least square method and the gradient descent method. H. Farahanirad et al. [12] presents a hybrid edge detection algorithm for dealing with noise sensitive situations like Salt and Pepper noise. The Proposed edge detector uses a combination of four neural network, neuro-fuzzy network, and adaptive median filter for providing robustness in noise.

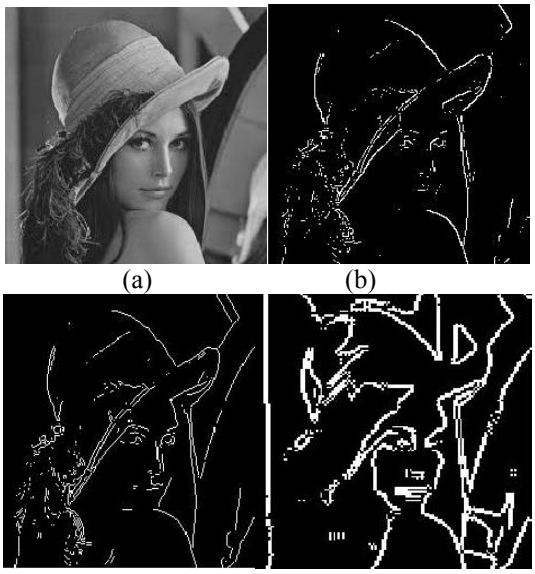

Figure 6: (a) original image (b) roberts method (c) sobel method (d) neuro fuzzy method

5. Conclusion

This paper mainly focuses on the study of various conventional edge detectors and also the approaches for edge detection. This study also gives a comparison between conventional edge detectors and neuro-fuzzy based edge detectors. We show neuro-fuzzy edge detectors on a natural image and its results are compared with conventional edge detectors.

References

[1] Veni Jain, "A New Fast Fuzzy Edge Detector" In Proceeding of "M.Tech thesis Department of IT Delhi Technological university".
[2] N. Senthilkumaran, R. Rajesh, "Edge Detection Techniques for Image Segmentation- A survey of Soft Computing Approaches" In Proceeding of "International Journal of Recent Trends in Engineering", Vol. 1, No. 2, May 2009.
[3] H.A. Aboulenien, P. De Wilde, "Neural Network Learning in a Travel reservation domain" In Proceedings of " Recent advances in artificial Neural Networks Design and Applications".
[4] Samta Gupta, Susmita Ghosh Mazumdar, "Sobel Edge Detection Algorithm", In Proceedings of "International Journal of Computer Science and Management Research" Vol 2, Issue 2, Feb-2013.
[5] M. Egmont-Petersen, D. de Ridder, H. Handels, "Image Processing with neural networks- a review", In Proceedings of "Pattern Recognition Society. Published by Elsevier Science Ltd" 2002.
[6] John Canny "A computational approach to edge detection" Pattern Analysis and Machine Intelligence,

In Proceedings of "IEEE Transactions on, PAMI"-8(6):679–698, Nov. 1986.

[7] Hamed Mehrara , Mohammad Zahedinejad and Ali Pourmohammad "Novel Edge Detection Using BP Neural Network Based on Threshold Binarization" In Proceedings of Second International Conference on Computer and Electrical Engineering, pp:408-412, 2009.

[8] Jayachandran, Dr. R. Dhanashakeran, O. Sugel Anand, J.H.M. Ajitha, "Fuzzy Information System based Digital Image Segmentation by Edge Detection", In Proceedings of the IEEE, ISBN 978-1-4244-5967-4/10, 2010.

[9] Shashank Mathur, Anil Ahlawat "Intelligent Information and Engineering Systems" In Proceedings of "International Conference on Intelligent Information and Engineering Systems" INFOS, Varna, Bulgaria, 2008.

[10] Lei Zhang, Mei Xiao, Jian Ma, Hongxun Song, "Edge Detection by Adaptive Neuro Fuzzy Inference System" In Proceedings of IEEE, 2009.

[11] Somya Saxena, Sunil Kumar, Vijay Kumar Sharma, " Edge Detection Using Soft Computing in Matlab", In Proceedings of International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3,Issue 6, pp. 758-761, June 2013.

[12] H. Farahanirad, J. Shanbehzadeh, M. M. Pedram, A.Sarrafzadeh, "A Hybrid Edge Detection Algorithm for Salt and-Pepper Noise", In Proceedings of the International MultiConference of Engineers and Computer Scientists Vol. 1, ISBN: 978-988-18210-3-4, March 2011.