Comparative Analysis of Edge Detection Algorithms Based on Content Based Image Retrieval With Heterogeneous Images

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Abstract **- Heterogeneous image database having various types of visual features. Nowadays, Content Based Image Retrieval system is mostly handling unlabelled images and also heterogeneous images. Still feature extraction process is an important issue of CBIR system, because it is the initial and most essential step of CBIR system. Traditional CBIR system works with low level feature's that is colour and texture. The next level visual feature's such as middle and high are shape and semantic. In this paper, we explained about CBIR system and compared the first order, second order and Gaussian edge detection methods with fuzzy logic. The proposed work gives a brief knowledge on edge detection algorithms and also states the merits and demerits for better understanding. The Fuzzy inference pixel system based edge detection algorithm performs well when compare to other methods.**

Keywords: Fuzzy Logic, CBIR, Heterogeneous images, Edge Detection Techniques, Image segmentation

I. INTRODUCTION

An image is an array, or a matrix, of square pixels (picture elements) arranged in columns and rows [1]. The feature means characteristics of an object that is feature is a significant piece of information extracted from an image which provides a more detailed understanding of the image. Feature extraction has referred that dimensionality reduction of that object. It plays an important role in image processing. In image processing features can be classified into three types that are low, middle and high. *Low level* features are colour, texture and *middle level* feature is shape and *a high level feature* is a semantic gap of objects [2]. Feature vector is used to store the extracted features as a matrix format in a database for processing [4]. CBIR system of image retrieval is invented by T. Kato in 1992. CBIR working by using features of the content of the image is known as Content-Based Image Retrieval (CBIR). Nowadays it is classified into many types such as colour based image retrieval, texture based image retrieval, shape based image retrieval and semantic based image retrieval. Thus the above types of image retrievals are come under CBIR types of retrievals. The image retrieval system acts as a classifier to divide the images in the image database into three classes are relevant, irrelevant and unlabelled images.

An edge is a sharp change in intensity of an image [8]. Edge detection process detects outlines of an object and boundaries between objects and the background in the image. An edge-detection filter can also be used to improve the appearance of blurred or anti-aliased video streams. The basic edge-detection operator is a matrix area gradient operation that determines the level of variance between different pixels. The edge-detection operator is calculated by forming a matrix centered on a pixel chosen as the center of the matrix area. If the value of this matrix area is above a given threshold, then the middle pixel is classified as an edge [6]. The main steps in edge detection are smoothening, thresholding, differentiation and localization [5]. Gradient-based edge detectors are Roberts, Prewitt, Sobel operators and band-pass filters such as Canny. Gradient operators, Laplacian operators and Zero-crossing operators are used for edge detection. The gradient operators compute some quantity related to the magnitude of the slope of the underlying image gray tone intensity surface of which the observed image pixel values are noisy discretized sample. The Laplacian operators compute some quantity related to the Laplacian of the underlying image gray tone intensity surface. The zero-crossing operators determine whether or not the digital Laplacian or the estimated second direction derivative has a zero-crossing within the pixel [7].

The fuzzy relative pixel value algorithm has been developed with the knowledge of vision analysis with low or no illumination, thus making this method optimized for application requiring such methods [6]. The method helps us to detect edges in an image in all cases due to the subjection of pixel values to an algorithm involving a host of fuzzy conditions for edges associated with an image. The purpose of this paper is to present a new methodology for image edge detection which is undoubtedly one of the most important operations related to low level computer vision, in particular within the area of feature extraction with the plethora of techniques, each

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based on a new methodology, having been published. The method described here uses a fuzzy based logic model with the help of which high performance is achieved along with simplicity in resulting model [7]. Fuzzy logic helps to deal with problems with imprecise and vague information and thus helps to create a model for image edge detection as presented here displaying the accuracy of fuzzy methods in digital image processing [8] ,[9]. The section II of this paper is trying to explain various existing edge detection algorithms with heterogeneous image. Section III is presenting the fuzzy relative pixel value algorithm for detecting edge in an image. Section IV is comparative analysis of edge detection methods of CBIR system. Finally the conclusion of the paper is included.

A. Content Based Image Retrieval

Content Based Image Retrieval (CBIR) is a technique used for extracting similar images from an image database. Content based means search analysis based on the contents of an image. Content refers to the colour, texture, shape or any other information. The feature descriptors of the content can be obtained from the image itself [3].

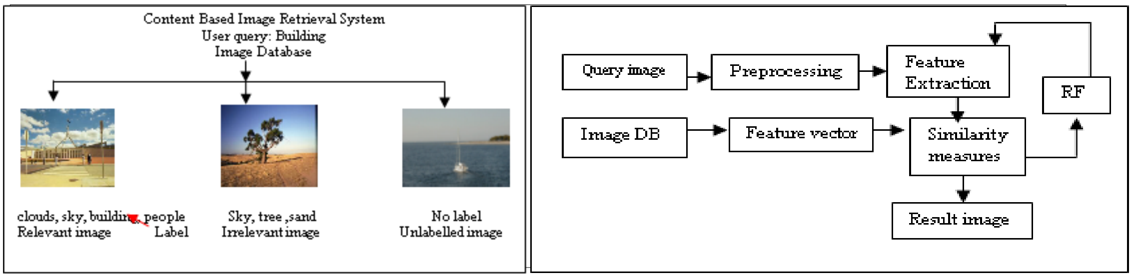

Figure 1. (a) Example of CBIR system; (b) Basic Diagram of CBIR system.

II. EDGE DETECTION METHODS

Edge detection methods are classified into three types such as first derivatives, second derivatives and Gaussian edge detector.

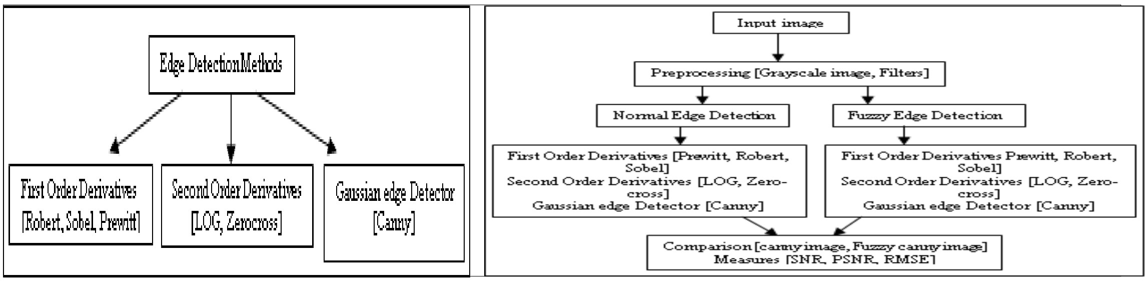

Figure 2. (a) Edge Detection Methods; (b) System Architecture

A. Robert Edge Detector

The calculation of the gradient magnitude of an image is obtained by the partial derivatives G_x and G_y at every pixel location. The simplest way to implement the first order partial derivative is by using the Roberts cross gradient operator.

$$G_x = f(i, j) - f(i+1, j+1) \quad G_y = f(i+1, j) - f(i, j+1) \tag{1}$$

The above partial derivatives can be implemented by approximating them to two 2x2 masks. The Roberts operator masks are:

+1	0
0	-1

G_x

0	+1
-1	0

G_y

These filters have been the shortest support, thus the position of the edges is more accurate, but the problem with the short support of the filters is its vulnerability to noise. It also produces a very weak response to genuine edges unless they are very sharp.

B. Prewitt Edge detector

The Prewitt edge detector is a much better operator than Roberts's operator. This operator having a 3 x 3 masks deals better with the effect of noise. An approach using the masks of size 3 x 3 is given below, the arrangement of pixels about the pixels [i, j]. Partial derivatives of the Prewitt operator are calculated as

A0	a1	A2
A7	[i, j]	A3
A6	a5	a4

G_x = (a6 +ca5+ a4) – (a0+ca1+ a2)

G_y = (a2 +ca3+ a4) – (a0+ca7+ a6) (2)

The constant c implies the emphasis given in pixels closer to the centre of the mask. G_x and G_y are the approximation at [i, j]. Setting c=1, the Prewitt operator is obtained. Therefore the Prewitt masks are as follows

-1	-1	-1
0	0	0
1	1	1

G_x

-1	0	1
-1	0	1
1	0	1

G_y

These masks have longer support. They differentiate in one direction and average in the other direction, so the edge detector is less vulnerable to noise.

C. Sobel Edge Detector

The Sobel edge detector is very much similar to the Prewitt edge detector. The difference between the both is that the weight of the central coefficient is 2 in the Sobel operator. The partial derivatives of the Sobel operator are calculated as

G_x = (a6 +2a5+ a4) – (a0+2a1+ a2) G_y = (a2 +2a3+ a4) – (a0+2a7+ a6) (3)

Therefore the Sobel masks are:

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

G_x

-1	0	1
-2	0	2
1	0	1

G_y

Although the Prewitt masks are easier to implement than Sobel masks, the latter has better noise suppression characteristics.

D. LOG Operator

The two partial derivative approximations for the Laplacian for a 3 x 3 region are given as

G_x = 4(a8) - (a1+ a3+ a5+ a7)

G_y = 8(a8) - (a0+a1+ a2+ a3+ a4+ a5+ a6+ a7) (4)

The masks for implementing these two equations are as follows

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

-1	-1	-1
-1	8	-1
-1	-1	-1

The above partial derivative equations are isotropic for rotation increments of 900 and 450, respectively.

E. Zero-crossing

Edge detection is done by convolving an image with the Laplacian at a given scale and marks the points where the result have zero value, which is called the zero-crossings. These points should be checked to ensure that the gradient magnitude is large.

0	0	0
0	0	0
0	0	0

F. Canny

Canny technique is a very important method to find edges by isolating noise from the image before finding edges of the image, without affecting the features of the edges in the image and then applying the tendency to find the edges and the critical value for threshold. The algorithmic steps for canny edge detection technique are followed:

1. Convolve image f (r, c) with a Gaussian function to get smooth image f (r, c). f (r, c)=f(r,c)*G(r,c,6)
2. Apply first difference gradient operator to compute edge strength, then edge magnitude and direction are obtained as before.
3. Apply non-maximal or critical suppression of the gradient magnitude.
4. Apply threshold of the non-maximal suppression image.

TABLE I. MERITS AND DEMERITS OF EDGE DETECTION METHODS

Operators	**Merits**	**Demerits**
First derivative and gradient operators (Robert, Prewitt and Sobel)	Simple calculation to detect the edges and their orientations	Inaccurate detection sensitivity in case of noise
Second derivative and Laplacian operator (LOG)	It finds the correct places of edges and testing wider area around the pixel	It cannot find the orientation of an edge because of using the Laplacian filter
Zero Crossing (Laplacian second directional derivative) [8]	Detection of edges and their orientations, Having fixed characteristics in all directions.	Sensitivity to noise, Re-responding to some of existing images.
Gaussian edge detectors (Canny, Shen Castan and Boie-Cox) [7]	Probability for finding error rate and localization. Also, it is symmetric along the edge and reduces the noise by smoothing the image. So it performs, the better detection in noisy condition	Complex computing

III. THE FUZZY RELATIVE PIXEL VALUE ALGORITHM

The Algorithm begins with reading an MxN image. The first set of nine pixels of a 3x3 window is chosen with the central pixel having values (2, 2). After the initialization, the pixel values are subjected to the fuzzy conditions for edge existence shown in Figure 3. (a-i). After the subjection of the pixel values to the fuzzy conditions the algorithm generates an intermediate image. It is checked whether all pixels have been checked or not. If not then first the horizontal coordinate pixels are checked. If all horizontal pixels have been checked the vertical pixels are checked else the horizontal pixel is incremented to retrieve the next set of pixels of a window. In this manner the window shifts and checks all the pixels in one horizontal line, then increments to check the next vertical location.

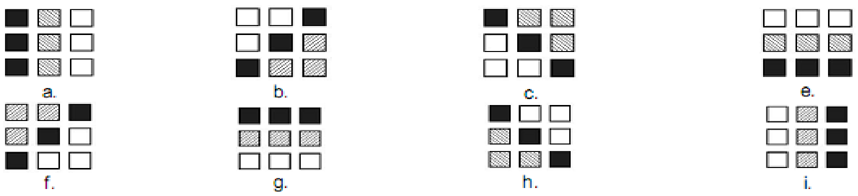

Figure 3 (a-i). Fuzzy conditions have been displayed

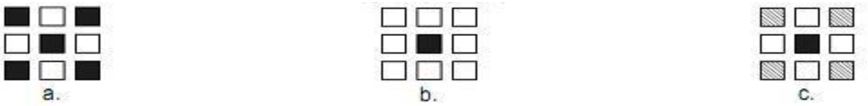

Figure 4. (a, b) Type of unwanted edge pixels (c) Fuzzy condition for removal of unwanted edge pixels

Legend: Pixel Checked Edge pixel Unchecked Pixel

After edge highlighting image is subjected to another set of condition with the help of which the unwanted parts of the output image of the type shown in Figure 4. (a-b) are removed to generate an image which contains only the edges associated with the input image.

IV. EXPERIMENTS

The proposed system was tested with different images, its performance being compared to that of the Robert, Prewitt, Sobel, Zero-cross, Log and Canny operators and the proposed FIPS method. The firing orders associated with each fuzzy pixel rule were tuned to obtain good results while extracting edges of the image shown in figure 5, where we used this image as comparative model for the classical Robert, Prewitt, Sobel, Zero-cross, Log and Canny operators and the FIPS method. The original image is shown in part of figure 5. The edge detection based on Robert, Prewitt, Sobel, Zero cross, Log and Canny operators using the image processing toolbox in MATLAB is illustrated at the part 2. The white pixels on the map indicate there are edges, thus will be preserved from smoothing. There is obviously some noise left on the edge map and some of the edges are corrupted. By applying the new FIPS on the image to detect its edges, it is found that the modified version of edge map has less noise and less edge corruption as shown on the image of figure 3. (h). for the segmentation task, a thin edge is better because we only want to preserve the edge rather than the details in the neighbourhood. The values of the edge map are normalized to the interval of 0 and 1 to represent the edginess membership values.

The fuzzy relative pixel value algorithm for image edge detection was tested for various images and the outputs were compared to the existing edge detection algorithms and it was observed that the outputs of this algorithm provide much more distinct marked edges and thus have better visual appearance than the ones that are being used. The sample output shown below in figure 5., compares the Robert, Prewitt, Sobel, Zero-cross, Log and Canny algorithms and the fuzzy relative pixel value algorithm. It can be observed that the output that has been generated by the fuzzy method has found out the edges of the image more distinctly as compared to the ones that have been found out by the “Canny” edge detection algorithm. Thus the Fuzzy relative pixel value algorithm provides better edge detection and has an exhaustive set of fuzzy conditions which helps to extract the edges with a very high efficiency.

The proposed fuzzy relative pixel value algorithm for image edge detection was tested for various images. The performance of these t image edge detection techniques are analysed and discussed. The noise level is measured by the standard deviation of the image:

$$\sigma = sqrt((1/N)\sum(b_i - b)^2), i = 1,2,3,\ldots,N \quad (5)$$

Where b is the mean gray level value of the original image and b_i is the gray level value of the surrounding region and N is the total number of pixel in the image. The **RMSE**, **SNR, and PSNR** are provided in the following table.

TABLE II. STATISTICAL MEASUREMENTS

Statistical Measurements	Formulas
MSE	$\frac{\sum(f(i,j) - F(i,j))^2}{MN}$
RMSE	$\sqrt{\frac{\sum(f(i,j) - F(i,j))^2}{MN}}$
SNR	$10\log_{10}\frac{\sigma^2}{\sigma_e^2}$
PSNR	$20\log_{10}\frac{255}{RMSE}$

Where $f(i, j)$ is original image, F (i, j) is enhanced image, σ^2 is variance of original image and σ_e^2 is variance of enhanced image. If the value of RMSE is low and the values of SNR and PSNR are larger than the enhancement approach is better.

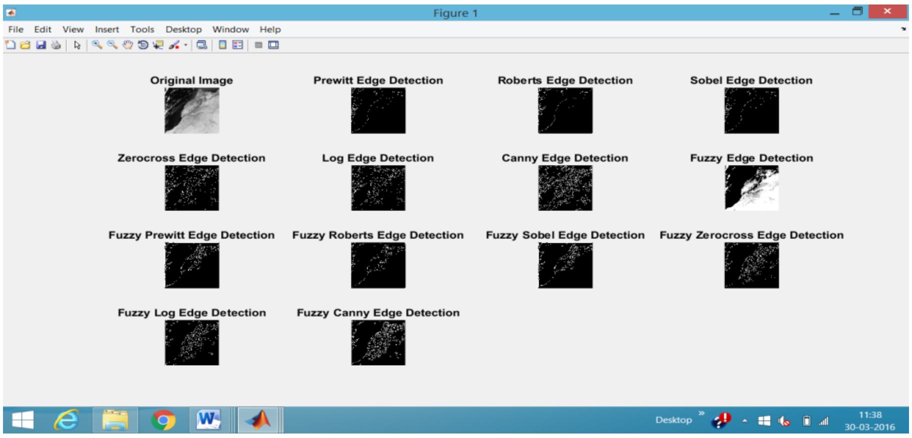

Figure 5. Satellite image Edge Detection Result

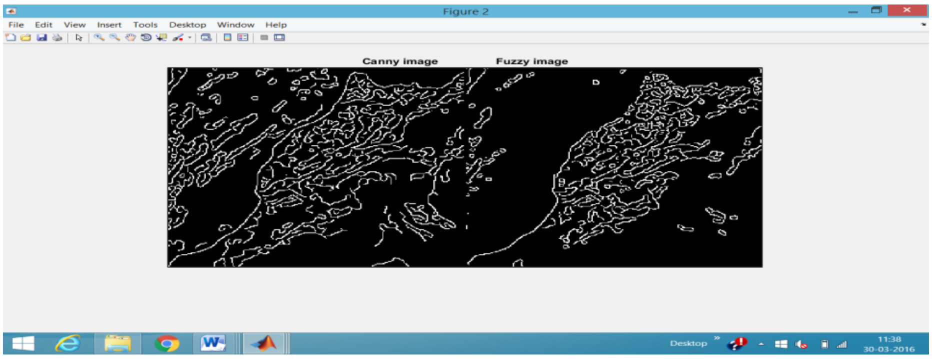

Figure 6. Comparison of Canny and Fuzzy image

The below Table III shows the measurement values of existing edge detection algorithms such as RMSE, SNR and PSNR. These values comparing the proposed method statistical measurement is more accurate than existing methods. The pictorial representations are given in figure 7.

TABLE III. OVERALL PERFORMANCE OF EDGE DETECTION METHODS

Filenames	Image1(Satellite)			Image2(Natural)			Image3(Medical)			Image4(Standard)		
Measures , Operators	***SNR***	***PSNR***	***RMSE***	***SNR***	***PSNR***	***RMSE***	***SNR***	***PSNR***	***RMSE***	***SNR***	***PSNR***	***RMSE***
Prewitt	8.07	2.10	0.78	2.22	2.87	0.71	8.81	4.53	0.59	14.38	2.87	0.71
Roberts	6.21	2.08	0.78	2.53	2.89	0.71	8.13	4.53	0.59	13.19	2.86	0.71
Sobel	8.09	2.10	0.78	2.38	2.87	0.71	8.74	4.53	0.59	14.02	2.87	0.71
Zero-cross	7.43	2.21	0.77	0.80	3.00	0.70	6.66	4.59	0.58	12.65	3.10	0.69
Log	7.43	2.21	0.77	0.80	3.00	0.70	6.66	4.59	0.58	12.65	3.10	0.69
Canny	6.22	2.35	0.76	0.06	2.84	0.72	6.90	4.67	0.58	9.50	3.03	0.70
Fuzzy Prewitt	6.26	2.19	0.77	0.60	2.91	0.71	10.59	4.39	0.60	9.68	2.94	0.71
Fuzzy Roberts	7.96	2.13	0.78	0.08	2.70	0.73	10.76	4.36	0.60	11.10	2.75	0.72
Fuzzy Sobel	6.38	2.19	0.77	0.62	2.92	0.71	10.66	4.38	0.60	9.40	2.94	0.71
Fuzzy Zero-cross	5.84	2.41	0.75	1.30	3.20	0.69	11.60	4.62	0.58	7.45	3.27	0.68
Fuzzy Log	5.84	2.41	0.75	1.30	3.20	0.69	11.60	4.62	0.58	7.45	3.27	0.68
Fuzzy Canny	3.27	2.53	0.74	0.22	3.25	0.68	9.45	4.40	0.60	5.80	3.29	0.68

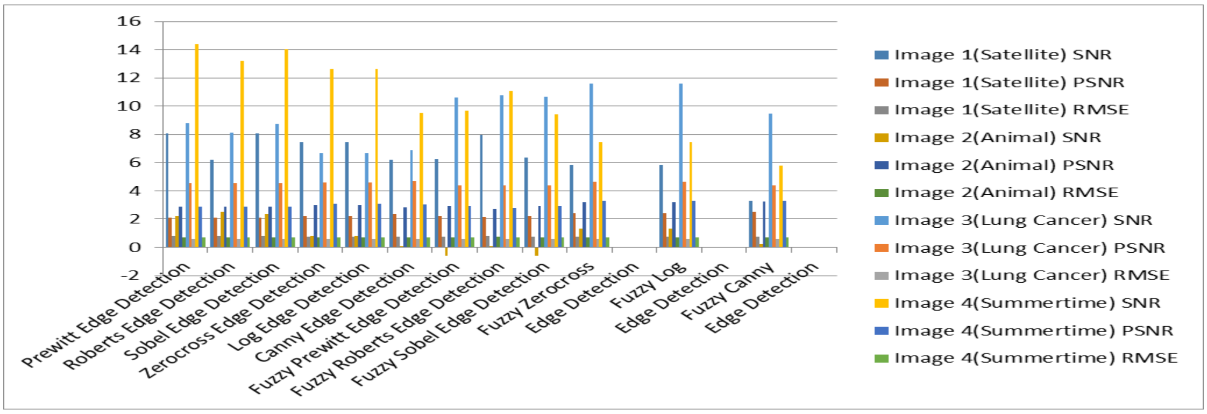

Figure 7. Over All Performance Analysis Graph

V. CONCLUSION

In this paper, a fuzzy based new edge detection algorithm is proposed. Based on the first order derivatives and second order derivatives and gaussion edge detection methods are computed at each pixel, and are used as fuzzy system input. Experimental results show the higher quality and superiority of the extracted edges compared to the other methods in the literature such as Sobel, Robert, Prewitt, Zero-cross, and Log and canny. To achieve good result, some parameters and thresholds are experimentally set. Automatically determining these values needs to further researches. Improving fuzzy system performance by the ways such as using different kind of input, different fuzzy membership functions and rules also need to be investigated in future works.

REFERENCES

[1] https://www.spacetelescope.org/static/projects/fits_liberator/image_processing.pdf.

[2] T. Dharani, I. Laurence Aroquiaraj, “CONTENT BASED IMAGE RETRIEVAL SYSTEM with MODIFIED KNN ALGORITHM”, International Journal of Innovations in Scientific and Engineering Research (IJISER), Vol. 1 Issue 1 Jan 2014.

[3] T. Dharani, I. Laurence Aroquiaraj, “AN APPRAISAL OF CONTENT BASED IMAGE RETRIEVAL BY MEANS OF UNLABELLED IMAGES”, International Journal of Advanced Research in Biology Engineering Science and Technology, Vol. 2, Special Issue 10, March 2016.

[4] T. Dharani, I. Laurence Aroquiaraj, “Content Based Image Retrieval System using Feature Classification with Modified KNN Algorithm”, International Journal of Computer Trends and Technology (IJCTT) – volume 4 Issue 7–July 2013.

[5] V. Mageshwari, Dr. I. Laurence Aroquiaraj and T. Dharani, “A Resourceful Comparison of First Order Edge Detections Using Grayscale Intensities”, Imperial Journal of Interdisciplinary Research (IJIR) Vol-2, Issue-5, 2016.

[6] Hong Shan Neoh Asher Hazanchuk**, “**Adaptive Edge Detection for Real-Time Video Processing using FPGAs**”**, An embedded soft processor refers to a reconfigurable processor which resides on the FPGA fabric, Altera Corporation, 2005.

[7] Mohamed Roushdy, “Comparative Study of Edge Detection Algorithms Applying on the Grayscale Noisy Image Using Morphological Filter”, GVIP Journal, Volume 6, Issue 4, December, 2006.

[8] Vandana Mittal, “Edge Detection Technique Using Fuzzy Logic”, MAY 2008.

[9] Shashank Mathur, Anil Ahlawat, “APPLICATION OF FUZZY LOGIC ON IMAGE EDGE DETECTION”, Intelligent Technologies and Applications, July 2008.