# Comparison Based Edge Detection for Bone Fracture Detection

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***Abstract--Edge recognition is significant topic in image analysis and medical applications. For edge detection in medical areas numerous operators are used to find crack in fracture detection. To find exploration of image we are spread over operator mask to image. Sobel and Prewitt operator used dimension mask of 3x3 which consist of horizontal and vertical matrices. I expand mask to 5x5 and 7x7 for Bone Fracture detection. I implemented edge detection algorithm based on fuzzy interference system, which use these masks for detecting edge with various fuzzy rules designed. Comparison is done with sobel and prewitt operators for PSNR, MSE, Average Difference and Structural content parameters.***

***Keywords- Fuzzy logic, First Derivative Operators, Edge Detection, MATLAB, PSNR, MSE.***

## I. INTRODUCTION

Edge detection is the modern concept in medical applications like Brain tumor detection, MR and X-ray images [2]. This method is concentrating on pixel intensity alterations. Therefore, the edge detection has a significant important in the field of digital image processing for various applications like tracking, boundary detection and feature extraction [5] .There are number of derivative operators such as Sobel, Prewitt, Canny, Robert[1]. The goal of edge detectors is to find the exact location and best way to represent the edges in the images. This includes stages to be performed on image to achieve required result. Expansion of mask to higher order is efficient because lower masks are more sensitive to noise. So it is necessary to remove different noises form resultant images to get thinkable output. The best way to apply is to compare the result based on different performance parameters like PSNR, MSE, Average difference and Structural Content etc.

Here, I used fuzzy rules based edge detection techniques [12] to find crack in medical image. Fuzzy Sets contains components with degree of membership functions. Membership function defines range from which input is plotted to membership value between 0 and 1. In Fuzzy logic technique using mask we compared the pixel value with the neighbor pixel according to fuzzy rules conditions. In this paper, 3x3, 5x5 and 7x7 masks are used for fracture recognition in bone medical image . Expansion of higher mask provides capability to remove noise efficiently. This fuzzy based technique is implemented in Mat-lab. Fuzzy includes procedures, collection of information about process on image, segments and stages to perform edge detection of image. First we define value for each input using membership functions. Then inputs are fuzzified in which operators are applied on images to achieve result and we got output according designed fuzzy rules between 0 and 1.It is possible to find the maximum and minimum possible value using fuzzy inference system.

Noise in the image reduces the computational efficiency of the operators for providing best optimum result and it also affects the quality of the images. Fuzzy logic technique with higher mask provides good representation for bone fracture detection.

We can design lists of rules with fuzzy sets and apply for detection of edges on different applications which make it complex. In which we decide some threshold value or pixel value on basis of that we can say that particular pixel is edge or not. Fuzzy inference system also provides good result with the addition of salt and pepper noise [4]. Average difference and Structural content results give this method more important compare to Sobel and Prewitt operator with higher mask operation.

## II. SOBEL OPERATOR

I got Vertical and Horizontal direction masks for 3x3 Sobel operator as [15]:

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

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

Fig.1 vertical and horizontal direction 3x3 masks

I got Vertical and Horizontal direction masks for 5x5 Sobel as:

| | | | | |
|---|---|---|---|---|
| -5 | -4 | 0 | 4 | 5 |
| -8 | -10 | 0 | 10 | 8 |
| -10 | -20 | 0 | 20 | 10 |
| -8 | -10 | 0 | 10 | 8 |
| -5 | -4 | 0 | 4 | 5 |

| | | | | |
|---|---|---|---|---|
| 5 | 8 | 10 | 8 | 5 |
| 4 | 10 | 20 | 10 | 4 |
| 0 | 0 | 0 | 0 | 0 |
| -4 | -10 | -20 | -10 | -4 |
| -5 | -8 | -10 | -8 | -5 |

Fig.2 vertical and horizontal direction 5x5 masks

I got Vertical and Horizontal direction masks for 7x7 Sobel as:

| | | | | | | |
|---|---|---|---|---|---|---|
| -5 | -4.6 | -3 | 0 | 3 | 4.6 | 5 |
| -6.9 | -7.5 | -6 | 0 | 6 | 7.5 | 6.9 |
| -9 | -12 | -15 | 0 | 15 | 12 | 9 |
| -10 | -15 | -30 | 0 | 30 | 15 | 10 |
| -9 | -12 | -15 | 0 | 15 | 12 | 9 |
| -6.9 | -7.5 | -6 | 0 | 6 | 7.5 | 6.9 |
| -5 | -4.6 | -3 | 0 | 3 | 4.6 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 6.9 | 9 | 10 | 9 | 6.9 | 5 |
| 4.6 | 7.5 | 12 | 15 | 12 | 7.5 | 4.6 |
| 3 | 6 | 15 | 30 | 15 | 6 | 3 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| -3 | -6 | -15 | -30 | -15 | -6 | -3 |
| -4.6 | -7.5 | -12 | -15 | -12 | -7.5 | -4.6 |
| -5 | -6.9 | -9 | -10 | -9 | -6.9 | -5 |

Fig.3 vertical and horizontal direction 7x7 masks

## III. PREWITT OPERATOR

In Prewitt operator [5]-[7]-[9], Kernel is based on the contrast difference, so the directional derivate that estimate vector G was defined as [15]:

G = Density Difference, so we got

G=$(c-g)\cdot[1,1]+(a-i)\cdot[-1,1]+(f-d)\cdot[1,0]+(b-h)\cdot[0,1]$

I got Vertical and Horizontal direction masks for 3x3 Prewitt as:

| | | |
|---|---|---|
| -1 | 0 | 1 |
| -1 | 0 | 1 |
| -1 | 0 | 1 |

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 0 | 0 | 0 |
| -1 | -1 | -1 |

Fig.4 vertical and horizontal direction 3x3 masks

I got Vertical and Horizontal masks for 5x5 Prewitt as:

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

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

Fig.5 vertical and horizontal direction5x5 masks

I got Vertical and Horizontal masks for 7x7 Prewitt operator from above equation as:

| | | | | | | |
|---|---|---|---|---|---|---|
| -3 | -2 | -1 | 0 | 1 | 2 | 3 |
| -3 | -2 | -1 | 0 | 1 | 2 | 3 |
| -3 | -2 | -1 | 0 | 1 | 2 | 3 |
| -3 | -2 | -1 | 0 | 1 | 2 | 3 |
| -3 | -2 | -1 | 0 | 1 | 2 | 3 |
| -3 | -2 | -1 | 0 | 1 | 2 | 3 |
| -3 | -2 | -1 | 0 | 1 | 2 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| -2 | -2 | -2 | -2 | -2 | -2 | -2 |
| -3 | -3 | -3 | -3 | -3 | -3 | -3 |

Fig.6 vertical and horizontal direction 7x7 masks

## IV. FUZZY INFERENCE SYSTEM

In fuzzy logic, we defined set of elements which is called universe of discourse [12]. Fuzzy logic and fuzzy set theory provide most important part for implementation of fuzzy rules for edge detection of image. In fuzzy logic, gradient value is compared with the threshold value and if gradient value is higher than threshold, then it assigned as an edge. The fuzzy technique includes decision making behavior for detecting edges in the images. We can define different rules for edge detection using fuzzy logic that why fuzzy is active research area for image analysis.

The Fuzzy Set 'B' is defined by equation as,

$$B=\{(z,\ \mu_B(z)|\ z\epsilon Z)\}$$

Where 'z' is elements in the set 'Z'. $\mu_B(z)$ is the membership functions of fuzzy set 'B'. The value of 'z' implemented into membership whose values between 0 and 1[2]. A Fuzzy set B in Z is characterized by a membership function $\mu_B(z)$ that associated with each element of Z a real number in the interval [0, 1]. The value of $\mu_B(z)$ at z represents the grade of membership of z in B. The nearer the value of $\mu_B(z)$ is to unity, higher the membership grade of z in B and conversely when the value of $\mu_B(z)$ is close to zero.

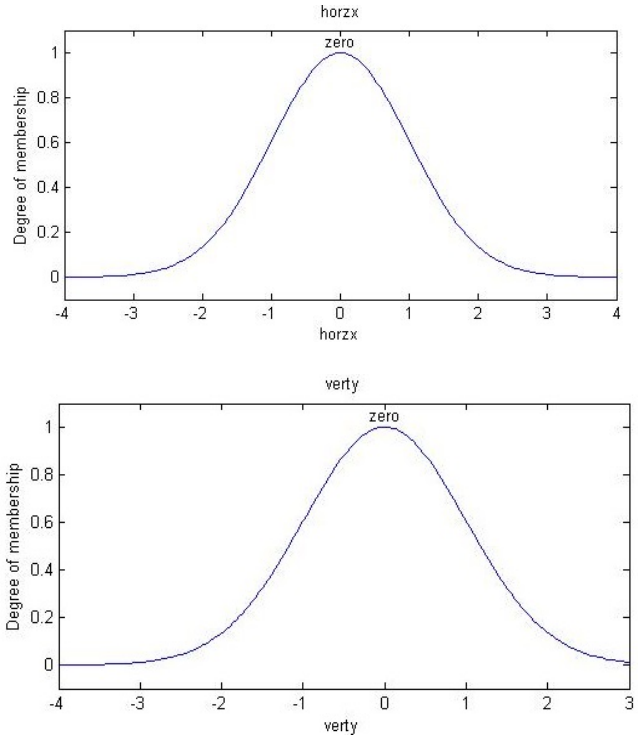



Fig 7 Membership functions of the fuzzy sets Zero

With fuzzy sets, we can say that all z for which $\mu_B(z)$ = 1 are complete member of the set and all z for which $\mu_B(z)$ = 1 are not member of the set.

The fuzzy sets are used to represent every variables value and assign black and white according to fuzzy rules. The functions are implemented to find max and min functions. In this method, mask is slide over entire row until it reaches to end of the row. This process is continued till full image is scanned. During scanning of the image through mask output is generated by FIS based on fuzzy rules and value of the neighbor pixels.

In this FIS method, an input medical bone fracture image has been taken. Normalization has been implemented on input image matrix, in which each value of the pixel has been divided by the largest value of pixel in the image matrix such its value between 0 and 1[3]. Here I considered membership function as shown in fig 7, in which if horizontal value is zero and vertical value is zero then Iout is white and if horizontal value is not zero or vertical value is not zero then Iout is black. These rules are applied for lower as well as higher mask for detecting edges in the image. Higher mask provide efficient edge detection of fracture in medical images as compared to lower mask. The results are better compared to sobel and prewitt operators with higher mask which gives advantage of using fuzzy inference system for edge detection in medical images.

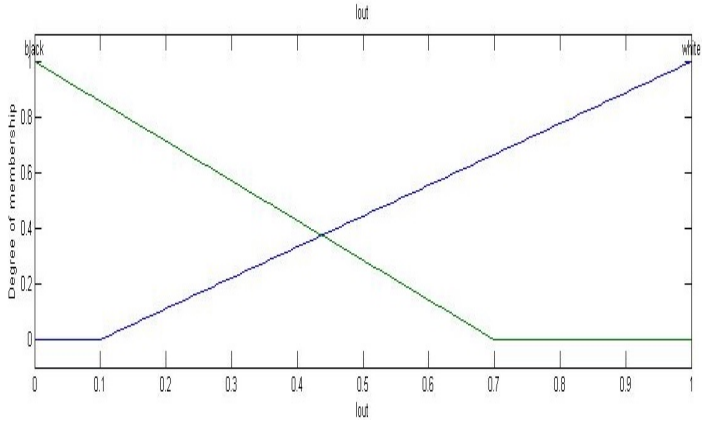



Fig 8 Membership functions of the fuzzy sets White and Black

## V. NOISE AND PARAMETERS

Noise is considered as unwanted information in the image. One of the most common is salt-and-pepper noise. This noise considers for which a certain amount of the pixels in the image are either black or white. Salt and Pepper noise sneaks into

images in conditions where rapid transients take place [4]. Here, One Medical Image is corrupted by salt and pepper noise and results are compared based on selected parameters with Sobel and Prewitt operators.

A. Mean Square Error

MSE defines the difference of pixels between original image and edge detected image

$$\text{MSE} = \frac{\sum_{m,n}[X_1(m,n) - X_2(m,n)]^2}{m*n}$$

Where $X_1$ is original image; $X_2$ is resultant image; m and n are rows and columns of the image.

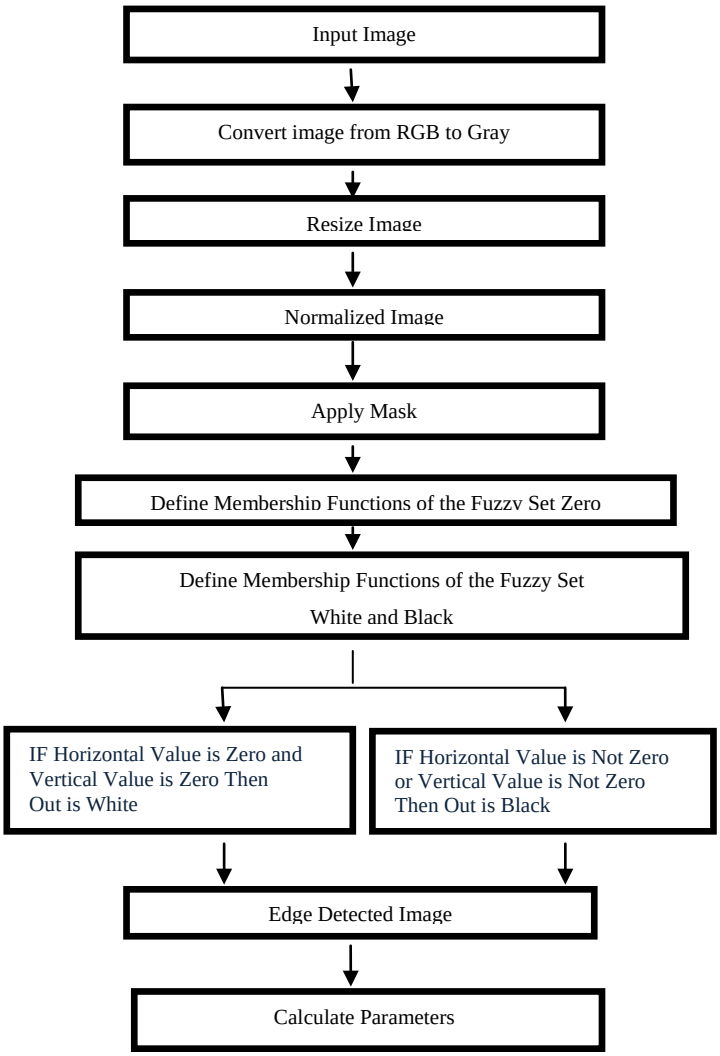



Fig 9 Flowchart of Fuzzy Inference System

B. Peak Signal to Noise Ratio

Peak signal-to-noise ratio is ratio between the power of a signal to the power of noise in the image. The PSNR calculated in decibel (dB).The PSNR measured based on the MSE by,

$$\text{PSNR} = 10\, log_{10}\left[\frac{R^2}{MSE}\right]$$

C. Average Difference

In order to achieve low noisy images Average Difference value should be low. This parameter is calculated from equation as:

$$\text{Average Diff.} = \frac{\sum_{j=1}^{m}\sum_{i=1}^{n}[X_1(m,n) - X_2(m,n)]}{m*n}$$

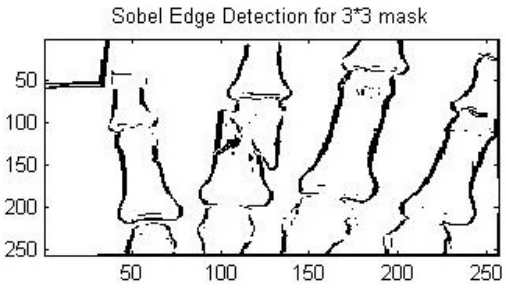
D. Structural Content

Structural Content parameter value should be high for edge detected image to know structural information of the image.

$$\text{Structural Content} = \frac{\sum_{j=1}^{m}\sum_{i=1}^{n}[X_1(m,n)]^2}{\sum_{j=1}^{m}\sum_{i=1}^{n}[X_2(m,n)]^2}$$

## VI. Simulation Results

Fig 10 Original Gray Medical Image



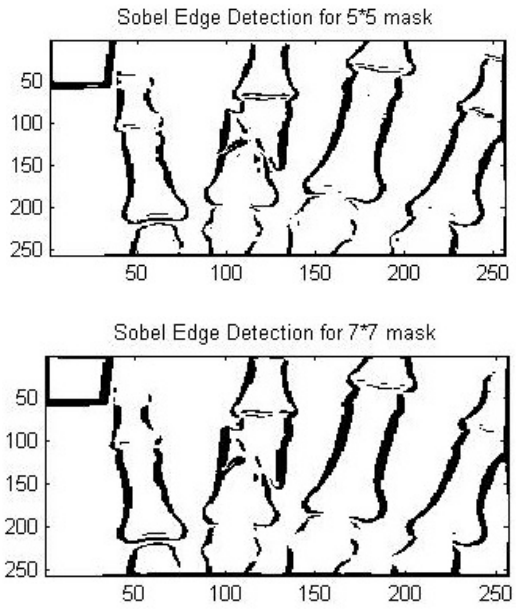



Fig 11 Results after Sobel masks

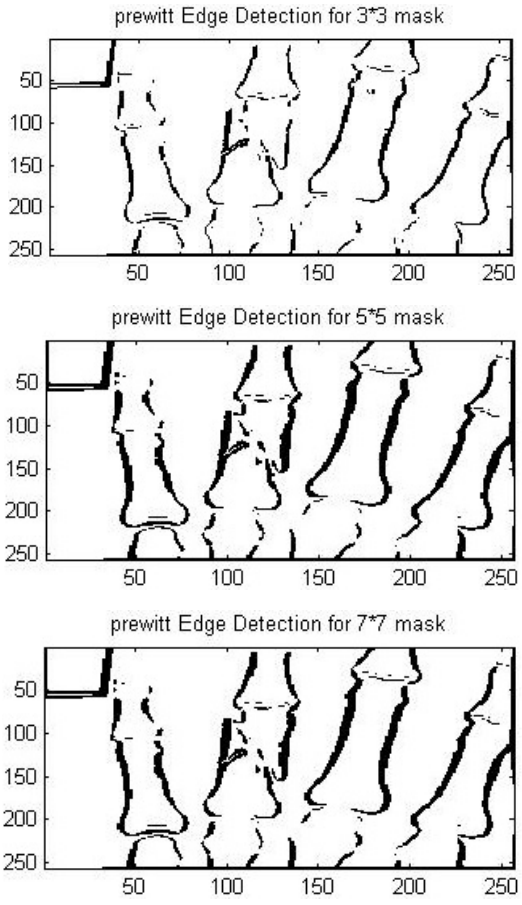



Fig 12 Results after Prewitt masks

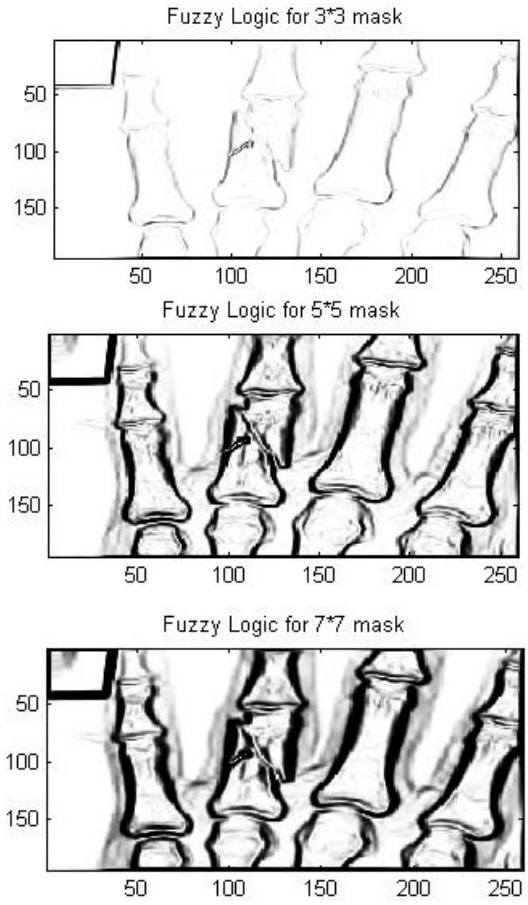



Fig 13 Results after Fuzzy Logic

## VII. Conclusion and Future Scope

In this work, medical bone image have been tested with different size of masks for three methods. From the results I concluded that fuzzy logic based edge detection provide better bone fracture detection with 7x7 higher mask. Fuzzy based edge detection algorithm also provides better result for comparison parameters. As par the results of images, higher mask provide more info compare to lower mask. I also achieve better results after the addition of Salt and Pepper noise.

| Method | PSNR (db.) | MSE | Average Difference | Structural Content |
|---|---|---|---|---|
| S 3x3 | 3.6561 | 28020 | 0.5 | 0.2682 |
| P 3x3 | 3.6641 | 27969 | 0.5191 | 0.2627 |
| F 3X3 | 6.178 | 15678 | 0.4038 | 33249 |
| S 5X5 | 3.6425 | 28108 | 0.4645 | 0.2791 |
| P 5X5 | 3.6555 | 28024 | 0.4665 | 0.2785 |

| | | | | |
|---|---|---|---|---|
| F 5X5 | 6.1717 | 15700 | 0.4042 | 41754 |
| S 7X7 | 3.6453 | 28090 | 0.45 | 0.2839 |
| P 7X7 | 3.6555 | 28024 | 0.4665 | 0.2785 |
| F 7X7 | 6.1696 | 15708 | 0.4043 | 46006 |

Table for Fuzzy, Sobel and Prewitt Method

In Future Scope, Using Different complex fuzzy rules we can perform different edge detection operations for achieving better results and performed edge detection on colour medical images and brain tumor applications. I implemented this work using mat-lab version 2013 and window 7.

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