Edge Detection Technique Using Hybrid Fuzzy logic Method

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***ABSTRACT*-Edge detection is an important element in image processing, since edges detection is to identify the boundaries of homogeneous regions in an image based on properties such as intensity and texture. Many edge detection algorithms have been developed based on computation of the intensity gradient vector, which, in general, is sensitive to noise in the image. In order to suppress the noise, the operator based on fuzzy technique is introduced. This paper uses a very simple but efficient fuzzy logic based algorithm to detect the edges of an input image by scanning it throughout using a 2x2 pixel window and 3x3 window .The results of the implemented algorithm have been compared with the standard edge detection algorithm such as 'Sobel', 'Prewitt'.**

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***Keywords*-Fuzzy logic, Edge detection, digital image processing, feature extraction, electronic vision, computer vision, comparison**

I. INTRODUCTION

Edges in a digital image provide important information about the objects contained within the image since they constitute the boundaries between the objects in the image. Edge detection is a frequently performed operation in many image processing applications because it is usually the first operation that is performed before other image processing tasks such as image segmentation, boundary detection, object recognition and classification, image registration, and so on. Consequently, the success of these subsequent image processing tasks is strictly dependent on the performance of the edge detection operation. Today the images can come from different modalities beyond normal gray-scale and colour photographs, such as infrared, X-ray, as well as the new generation of hyper-spectral satellite data sets. Usage of specific

Linear time-invariant (LTI) filter is the most common procedure applied to the edge detection problem, and the one which results in the least computational effort. In the case of first-order filters, an edge is interpreted as an abrupt variation in gray level between two neighbour pixels. The goal in this case is to determine in which points in the image the first derivative of the gray level as a function of position is of high magnitude. By applying the threshold to the new output image, edges in arbitrary directions are detected. In other ways the output of the edge detection filter is the input of the polygonal approximation technique to extract features which to be measured, [1]

The classic operators work well in circumstances where the area of the image under study is of high contrast. In fact, classic operators work very well with in regions of an image that can be simply converted into a binary image by simple thresholding. To be definite as to the failings of classic operators: classic edge detector tends to give poor results for labelling edge pixels, when an edge, although definite, represents only a smallish grayscale jump. Yet often such edges are clearly visible to the human eye. Recent research has concerned using neural Fuzzy Feature to develop edge detectors, after training on a relatively small set of proto-type edges, in sample images classifiable by classic edge detectors. This work was pioneered by Bezdek et al [2] who trained a neural net to give the same fuzzy output as a normalized Sobel Operator. However, work by the writer and collaborators have shown that training NN classifiers to crisp values is a more effective variant of Bezdek's scheme.

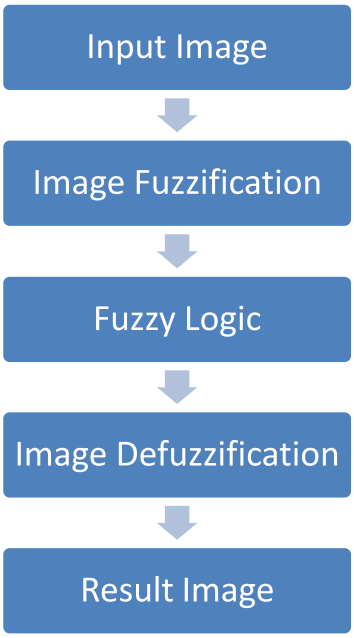

Figure 1. Basic Block Diagram

A. Jayachandran, R. Dhanasekaran, T. Sudarson Rama Perumal proposed 3×3 window technique for scanning the image. In their technique they used only 8 rules for detecting the edge[3]. Shashank Mathur and Anil Ahlawat, presented a fuzzy relative pixel value algorithm in which 3*3 pixels mask for scanning of image using the windowing technique was used, which was 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. However their technique was not rule based [4].Yinghua Li, Bingqi Liu, and Bin Zhou presented Fuzzy technology in which they firstly set the image fuzzy characteristic plane of original image, secondly preceded the fuzzy enhancement, and then detected the edge by Sobel differential arithmetic[5]. Yasar Becerikli1 and Tayfun proposed that fuzzy rules based algorithm is more flexible in handling thickness of edges in the final image [6].Cristiano Jacques Miosso, Adolfo Bauchspiess presented that First-order linear filters constitute the algorithms most widely applied to edge detection in digital images but they don't allow good results to be obtained from images where the contrast varies a lot, due to non-uniform lighting, as it happens during acquisition of most part of natural images[7].Dong-Su Kim, Wang-Heon Lee, In-So Kweon, Presented an edge magnitude and direction scheme that uses 3 x3 ideal binary pixel patterns and described a lookup table. They concluded that their algorithm didn't require any manual online threshold adjustment and was more suitable to the dynamic environment[8].

The most important factor decreasing the performance of edge detection is the noise. Unfortunately, digital images are certainly degraded by noise during image acquisition and/or transmission due to a number of imperfections encountered in imaging processes and/or communication channels. Most edge detection operators are based on the assumption that images contain large homogeneous regions separated by clear boundaries. However, this assumption loses its validity if the image is corrupted by noise. There- fore, majority of the edge detection operators require a pre- filtering of the noisy image by using an appropriate noise filter before edge detection is performed. In this case, how- ever, the performance of the edge detection operation be- comes strictly dependent on the performance of the noise filter. Moreover, the complexity of the system and the processing time are considerably increased.

A. Fuzzy Image Processing

Fuzzy image processing has three main stages: image fuzzification, modification of membership values, and, if necessary, image defuzzification. The fuzzification and defuzzification steps are due to the fact that we do not possess fuzzy hardware. Therefore, the coding of image data (fuzzification) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques. The main power of fuzzy image processing is in the middle step (modification of membership values). After the image data are transformed from gray-level plane to the membership plane (fuzzification), appropriate fuzzy techniques modify the membership values. This can be a fuzzy clustering, a fuzzy rule-based approach, a fuzzy integration approach and so on, [9].

B. Advantages of Fuzzy Image Processing

Fuzzy image processing is important to represent uncertainty in data. Some of the main benefits of fuzzy image processing are listed as below:

• Fuzzy techniques are powerful tools for knowledge representation and processing
• Fuzzy techniques can manage the vagueness and ambiguity efficiently.
• Fuzzy logic is tolerant of imprecise data.
• Fuzzy logic is conceptually easy to understand. The mathematical concepts behind fuzzy reasoning are very simple. What makes fuzzy nice is the "naturalness" of its approach and not

its far-reaching complexity. In many image processing applications, expert knowledge is used to overcome the difficulties (e.g. object recognition, scene analysis). Fuzzy set theory and fuzzy logic offer powerful tools to represent and process human knowledge in form of fuzzy if-then rules. On the other side, many difficulties in image processing arise because the data/tasks/results are uncertain. This uncertainty, however, is not always due to the randomness but to the ambiguity and vagueness. Beside randomness which can be managed by probability theory, imperfection in the image processing can be distinguished into three types as follows:

- Grayness ambiguity
- Geometrical fuzziness
- Vague (complex/ill-defined) knowledge

These problems are fuzzy in the nature.

C. Fuzzy Sets and Fuzzy Membership Functions

The system implementation was carried out considering that the input image and the output image obtained after defuzzification are both 8-bit quantized; this way, their gray levels are always between 0 and 255. The fuzzy sets were created to represent each variable's intensities; these sets were associated to the linguistic variables "Black", Edge and "white".

II. FIS SYSTEM DESIGN

In order to detect the edge in the image, a fuzzy inference system has been designed which take different pixel value as inputs, fuzzified these input i.e. convert it into fuzzy plane and then using some predefined rule mark the considered pixel as edge, Black, White. Mandani method is chosen as the defuzzification method and the output of the system is calculated as the centroid of the resulting membership functions.Block diagram of proposed method is shown in Fig.2.

A. Window mask

The two fuzzy inference systems are used in this paper. One FIS system takes 4 inputs from 2×2 windows and another takes 8 inputs from 3×3 windows.

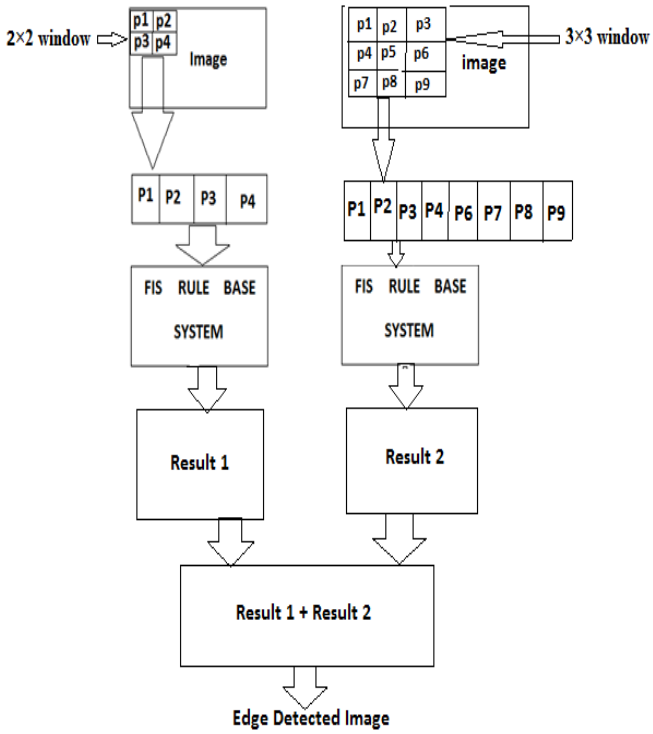

Fig 2 Block diagram of fuzzy system

III. ALGORITHM

The algorithm is based on the subjection of a set of four pixels, part of a 2x2 window of an image to a set of fuzzy conditions which help to highlight all the edges that are associated with an image. The fuzzy conditions help to test the relative values of pixels which can be present in case of presence on an edge. So the relative pixel values are instrumental in extracting all the edges associated to an image. The image is said to have an edge if the intensity variation in between the adjacent pixels is large. This task is accomplished with the help of sixteen rules. The mask used for scanning image is shown in Fig 3.

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P1(i,j)	P2(i,j+1)
P3(i+1,j)	P4(i+1,j+1)

Fig3. 2×2 Mask used for scanning

P1(I,J)	P2(I,J+1)	P3(I,J+2)
P4(I+1,J)	P5(I+1,J+1)	P6(I+1,J+2)
P7(I+2,J)	P8(I+2,J+1)	P9(I+2,J+2)

Fig4. 3×3 mask used for scanning

The mask is slid over an area of the input image, changes that P4 pixel's value and then shifts one pixel to the right and continues to the right until it reaches the end of a row. It then starts at the beginning of the next row & process continues till the whole image is scanned. When this mask is made to slid over the image, the output is generated by the fuzzy inference system based upon the rules and the value of the pixels P1, P2, P3 and P4. After this 3×3 window is used in the same manner. Again window is slided over the whole image, the output is generated by the fuzzy inference system based upon the rules and values of pixels P1, P2, P3, P4, P6, P7, P8, P9.

a) Crisp inputs for P1, P2, and P3 & P4 are fuzzified into various FS, having conventional crisp membership functions i.e. Black & White.

b) Firing strength is calculated using fuzzy t-norms operators (MIN or PRODUCT) on MFs.

c) Fuzzy rules are fired for each crisp input.

d) Aggregate resultant output FS for all fired rules are achieved by using MAX operator (s-norm).

e) De-fuzzification is performed using the Centroid method.

f) Crisp Output P4_out is the pixel value of the output image i.e. one containing the Edges, Black and White regions.Above steps are applied again for 3×3 windows.

V. SIMULATION RESULTS

Fig5.a

Fig5.b

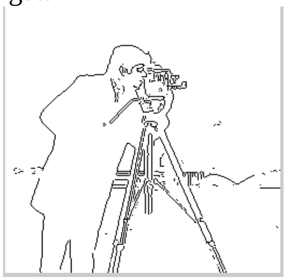

Fig5.c

Fig5.d

Fig5.e

Fig5.f

Fig.5 (a) cameraman image
(b) Sobel operator (c) prewitt operator (d) 2×2 window (e) 3×3 window **(f) 2×2and3×3window combined (Proposed Method)**

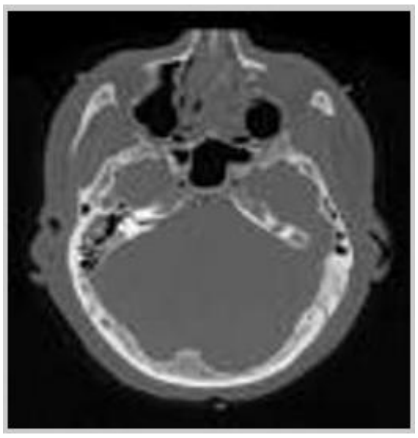

Fig 6.a

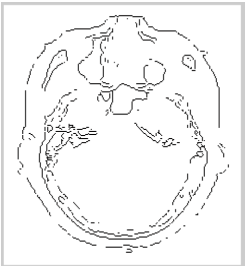

Fig 6.b

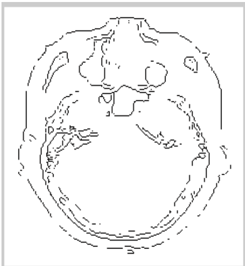

Fig.6.c

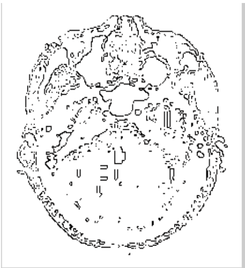

Fig 6.d

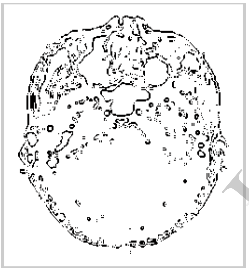

Fig 6.e

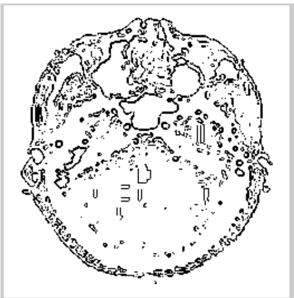

Fig 6.f

Fig 6(a) Brain image (b) sobel operator(c)prewitt operator(d)2×2 window (e)3×3 window **(f)2×2 and3×3 window combined(Proposed Method)**

In this paper two images of cameraman and brain are shown. In result we can see that our proposed method result showing good result then other traditional method like sobel operator and priwitt operator.

VI. CONCLUSIONS

In this paper, emphasis has been to develop a very simple & small but a very efficient, fuzzy rule based edge detection algorithm to abridge the concepts of artificial intelligence and digital image processing. The algorithm and associated GUI has been developed in MATLAB environment. Comparisons were made with the various other edge detection algorithms that have already been developed. Displayed results have shown the accuracy of the edge detection using our fuzzy rule based algorithm over the other algorithms. Sample output have been shown to make the readers understand the accuracy of the algorithm. Thus developed algorithm exhibits tremendous scope of application in various areas of digital image processing.

VII. FUTURE SCOPE

a) To optimize the FLS, by fusion of other intelligent techniques like GA, ANN, PSO and / or ACO etc.

b) Presently, edge thickness is more than desirable. One can improve it by optimization of various fuzzy parameters.

c) The size of mask can be increased from 2x2 and 3x3 to 4x4 and accordingly more rules can be set and results can be compared w.r.t. mask size.

d) In our technique, the image is first to be converted into gray image. This limitation can be eliminated and algorithm can be applied directly to color images, and the detection would then become significantly more complex.

VIII. REFERENCES

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