New Technique of Edge Detection based on FIS

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Abstract— Edge detection of images is an important aspect in the field of image processing. Edges can be detected from the images by using various derivative edge detection methods, such as Sobel operator, Prewitt operator, Roberts operator, Laplacian operators and Canny operators .With these different approaches the edges are detected but somehow false edges are also detected or some important edges are missed due to the presence of noise. Therefore a new technique of artificial intelligence called fuzzy inference system is used in order to reduce these types of effects.. This paper presents a novel edge detection algorithm based on fuzzy inference system.The proposed approach uses a 3x3 sliding window with eight inputs and the center pixel as the output . ,then the pixel values of window are subjected to various fuzzy rules designed . Based on these set of rules the output of fuzzy is decided whether that particular pixel is an edge or not .Moreover the developed algorithm is compared with sobel ,prewitt etc to find the respective mean square error and peak signal to noise ratio of images containing noise.

Index Terms— Image processing, Fuzzy logic, Fuzzy image processing, MATLAB, Edge detection, fuzzy rules, noise

I. INTRODUCTION

Edge detectors have been an essential part of many computer vision systems and in this modern era these are of great importance. The edge detection process serves to simplify the analysis of images by drastically reducing the amount of data to be processed, while at the same time preserving useful structural information about object boundaries. There is certainly a great deal of diversity in the applications of edge detection, but it is felt that many applications share a common set of requirements. These requirements yield an abstract edge detection problem, the solution of which can be applied in any of the original problem domains[7]. Edge pixels are defined as locations in an image where there is a significant variation in gray level (or intensity level of color) pixels. The process of edge detection reduces an image to its edge details that appear as the outlines of image objects that are often used in subsequent image analysis operations for feature detection and object recognition [3]. Earlier edge detection methods, such as Sobel, Prewitt and Robert were used that are based on the calculation of the intensity gradient magnitude at each image pixel. In these algorithms, the gradient value is compared to the threshold value and a pixel location is classified as an edge if the value of the gradient is higher than a threshold. Gradient based edge detectors have a major drawback of being very sensitive to noise[2].In order to counter noise problems Canny proposed an approach to edge detection in which the image is convolved with the first order derivatives of Gaussian filter for smoothing in the local gradient direction followed by edge detection and thresholding [7]. Edge detection represents an extremely important step facilitating higher-level image analysis and therefore remains an area of active research, with new approaches continually being developed. Comparison of edge detection approaches and an assessment of their performance may be found in [8].The goal of the edge detection is to locate the pixels in the image that corresponds to edges of the objects seen in the image. An idea to solve the problem of edge detection by using fuzzy image processing and as well as the comparisons of the results with traditional methods of edge detection is the main consideration of this work. [5, 6]. Fuzzy Sets is a set without a crisp, clearly defined boundary. It can contain elements with only a partial degree of membership .Membership Functions (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 255 i.e. black and white for input and edge and non-edge for output [9,10,11].A fuzzy relative pixel value algorithm for edge detection has been presented by Shashank Mathur and Anil Ahlawat,in which the relative pixel values in 3*3 pixel mask are checked for scanning of image using the windowing technique, 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[1]. Edge detection represents an extremely important step facilitating higher-level image analysis and therefore remains an area of active research, with new approaches continually being developed. Comparison of edge detection approaches and an assessment of their performance may be found in [12, 13]. In this paper, the 3*3 window mask is used alongwith the fuzzy logic rules based algorithm for the detection of image edges. Fuzzy Inference based system in MATLAB environment has been developed, which is capable of detecting edges of an image. The result has been compared with the standard algorithms.

A. Fuzzy Image Processing

The work of this paper is concerned with the development of fuzzy logic rules based algorithm for the detection of image edges. For applying fuzzy on an image in order to detect the edges, image preprocessing is done. Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. Fuzzy image processing has three main stages, shown in the figure 1.

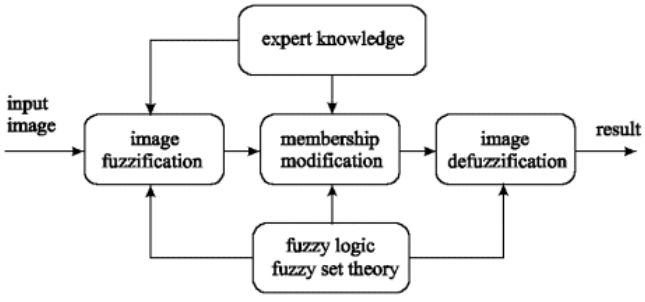

Fig. 1: The general structure of fuzzy image processing

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The fuzzification and defuzzification steps 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. 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.

II. PROPOSED METHOD

In this proposed method eight inputs and one output is given to the fuzzy inference system. The eight inputs are the eight pixels of the 3x3 masking window.For inputs and output ,the triangular membership function is used. Two fuzzy sets are used for the input -Black & White and three fuzzy sets are used for the output- Black, Edge & White.

A. Fuzzy sets and fuzzy membership functions

The fuzzy sets are created to represent each variable's intensities; these sets are associated to the linguistic variables 'black' and 'white' for input and 'black', 'edge' and 'white' for output. The adopted membership functions for the fuzzy sets associated to the input and output are triangular, as shown in figures (3) and (4).

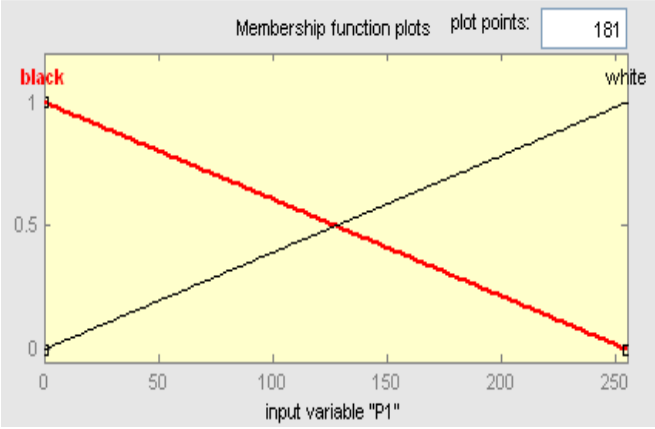


Fig. 3: Membership functions of the fuzzy sets associated to the input

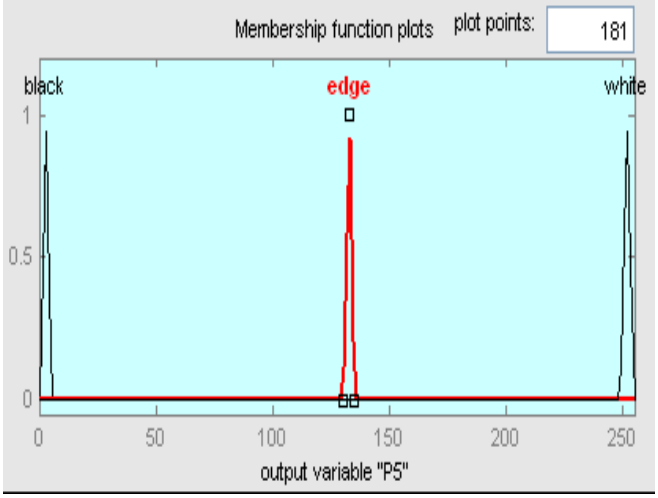


Fig. 4: Membership functions of the fuzzy sets associated to the output

The functions adopted to implement the "and" and "or" operations are the minimum and maximum functions, respectively.

Table 1. Fuzzy Sets for Input & Output

Two fuzzy sets used for input		
Name	**Range**	**MF Type**
Black	[0 0 255]	Triangular
White	[0 255 255]	Triangular
Three fuzzy sets used for output		
Name	**Range**	**MF Type**
Black	[0 3 5]	Triangular
Edge	[130 133 135]	Triangular
White	[249 252 255]	Triangular

The Mamdani method is chosen as the defuzzification procedure, which means that the fuzzy sets obtained by applying each inference rule to the input data are joined through the add function; the output of the system is then computed using weighted average method of the resulting membership function. The values of the three membership functions of the output are designed to separate the values of the edges regions and non edges regions of the image.

P1	P2	P2
P4	P5	P6
P7	P6	P9

Fig. 5: 3x3 matrix representation

The mask is slid over an area of the input continues to shift towads 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 slide 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, P4, P6, P7 P8, and P9. To accomplish the task of edge detection using fuzzy logic,the step by step methodology is followed as described under:

a) Fuzzifying Inputs: The first step is determining the degree of membership of each input using membership functions.

b) Applying Fuzzy Operators: After inputs have been fuzzified, if the antecedent of a rule has more than one part, the fuzzy t-norms operator is applied to obtain the result.

c) Applying Implication Method: Implication method is the process of determining the output of each fuzzy rule's consequent. Before applying this , care must be taken of the rule's weight which is a number between 0 and 1.

d) Aggregating All Outputs: Aggregate resultant output FS for all fired rules is achieved by using MAX operator (s-norm)

Table 2: Fuzzy Rule Matrix

Fuzzy Inputs								Fuzzy Output
P1	P2	P3	P4	P6	P7	P8	P9	P5
W	W	W	W	W	B	B	B	E
B	B	B	W	W	W	W	W	E
B	W	W	B	W	B	W	W	E
W	W	B	W	B	W	W	B	E
B	B	W	B	W	B	W	W	E
W	W	B	W	B	W	B	B	E
B	W	W	B	W	B	B	W	E
W	B	B	W	B	W	W	B	E
B	B	B	B	W	W	W	W	E
W	W	W	B	W	B	B	B	E
B	B	B	W	B	W	W	W	E
W	W	W	W	B	B	B	B	E
B	B	B	B	B	W	W	W	E
B	B	W	B	W	B	B	W	E
W	W	W	B	B	B	B	B	E
W	B	B	W	B	W	B	B	E
B	W	W	B	W	W	W	W	E
W	W	W	B	W	B	W	W	E
W	W	W	W	W	B	B	W	E
B	B	W	W	W	W	W	W	E
W	W	W	W	W	W	B	B	E
W	W	W	W	B	W	W	B	E
W	W	B	W	B	W	W	W	E
W	B	B	W	W	W	W	W	E
W	B	B	W	B	W	W	W	E
W	W	W	W	B	W	B	B	E
B	B	W	B	W	W	W	W	E
W	W	W	B	W	B	B	W	E

e) Defuzzifying: It is desirous that the output is a single number ,so the output fuzzy set of aggregation process is converted into a single number using the centroid method.

B. Fuzzy Inference Rules:

The inference rules depend on the weights of the neighbor gray level pixels, if the neighbor's weights are degree of blacks or degree of whites. The powerful of these rules is the ability to extract all edges in the processed image directly. This study is assaying all the pixels of the processed image by studying the situation of each neighbor of each pixel. The condition of each pixel is decided by using the floating 3x3 mask which can be scanning the all grays. In this location, some of the desired rules are explained. value. We have defined two fuzzy sets Black (B) and White(W) for eight fuzzy input variables *P1,P2,P3 P4, P6, P7,P8* and P9 and three fuzzy sets Black (B) **,**Edge (E) and White(W) for output variable P5 representing the image after the edges have been detected over the universe of discourse U = [0 ,....., G - I] (G = 256). The fuzzy rules for this fuzzy edge detection algorithm are shown in table 2.

III. IMAGE NOISE

Noise is any undesired information that contaminates an image. Noise appears in image from various sources. The digital image acquisition process, which converts an optical image into a continuous electrical signal which is then sampled, is primary process by which noise appears in digital image. There are several ways through which noise can be introduced into an image, depending on how the image is created.One of the most common type of noise is salt and pepper noise. This type contains random occurrences of both black and white intensity values, and often caused by threshold of noise image.The PSNR and MSE of images corrupted by salt and pepper noise is calculated by the developed algorithm and then compared with other techniques .

Table 3. MSE for Different Operators

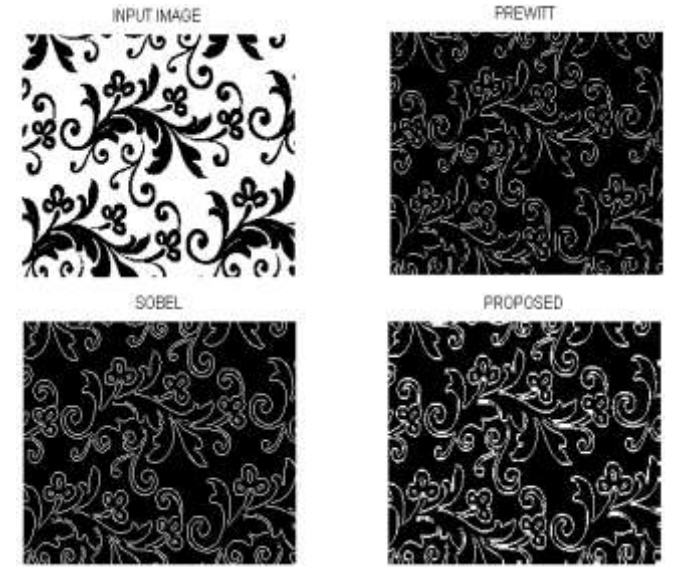
OPERATOR	BASE	HOUSE	LENA	BABON
SOBEL	0.6424	0.4837	0.5213	0.5294
PREWITT	0.6398	0.4843	0.5208	0.5296
PROPOSED	0.6103	0.4641	0.5030	0.4975

Table 4. PSNR for Different Operators

OPERATOR	BASE	HOUSE	LENA	BABON
SOBEL	50.0527	51.2848	50.9598	50.8928
PREWITT	50.0702	51.2797	50.9641	50.8912
PROPOSED	50.2751	51.4651	51.1148	51.1627

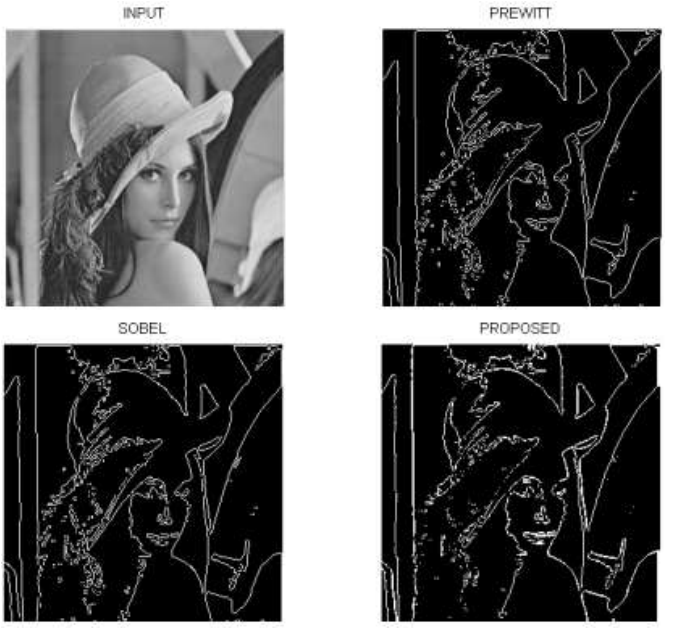
IV. SIMULATION RESULTS

The proposed system was tested with different images, its performance being compared 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 standard existing. Moreover, it is visible from Table (3) &(4) that the method proposed in this paper has high PSNR as well as lower MSE as compared with Sobel and Prewitt approaches. 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 "Sobel" edge detection algorithm.

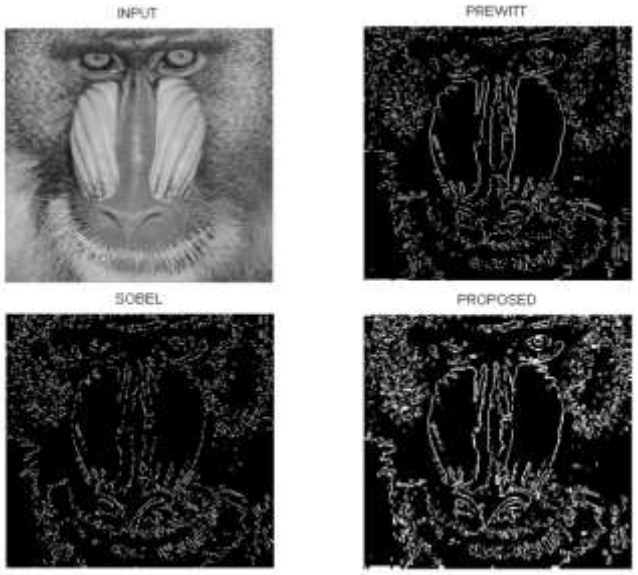


(a)

(b)



(c)



(d)

Fig. 6: (a), (b), (c), (d) Results of our algorithm compared with Sobel and Prewitt with input images of base, house, lena and babon

Also table (5) & (6) gives a brief comparison of images corrupted with salt and pepper noise thus showing that the developed algorithm has high PSNR than other methods. Thus the Fuzzy rule based system provides better edge detection and has an exhaustive set of fuzzy conditions which helps to extract the edges with a very high efficiency.

Table5: MSE comparison of various images corrupted by salt and pepper noise

OPERATOR	BASE	HOUSE	LENA	BABON
SOBEL	0.6389	0.4851	0.5214	0.5286
PREWITT	0.6350	0.4832	0.5199	0.5293
PROPOSED	0.6085	0.4655	0.5029	0.4981

Table6: PSNR comparison of various images corrupted by salt and pepper noise

OPERATOR	BASE	HOUSE	LENA	BABON
SOBEL	50.0812	51.2631	50.9658	50.8975
PREWITT	50.1037	51.2729	50.9713	50.8949
PROPOSED	50.2809	51.4608	51.1122	51.1542

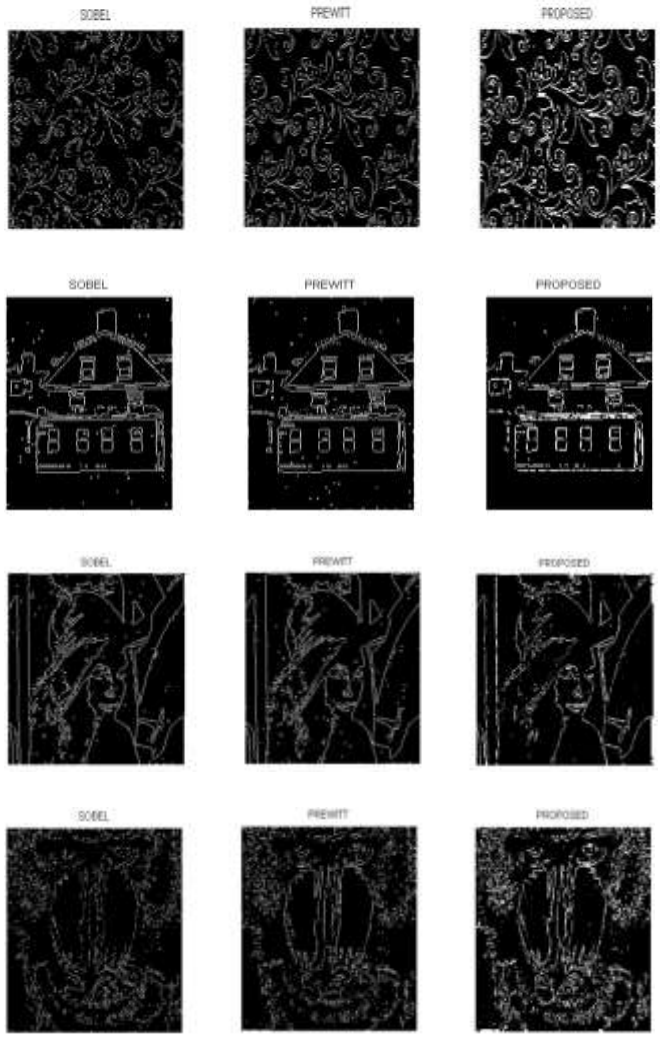


Fig. 7: Results of our algorithm compared with Sobel and Prewitt corrupted with salt and pepper noise

V. CONCLUSION

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. Comparisons were made with the various other existing edge detection algorithms The results displayed have shown the accuracy of the edge detection using the fuzzy rule based algorithm over the other algorithms. The fuzzy rule based algorithm has been successful in obtaining the edges that are present in an image after the its implementation and execution with various sets of images using a scanning window of 3x3.Thus developed algorithm exhibits tremendous scope of application in various areas of digital image processing.

VI. FUTURE SCOPE

The technique applied in this paper can be optimized by the fusion of other intelligent methods like Artificial Neural Network, Genetic Algorithm etc. Different parameters can be varied in order to improve the edges.Moreover the size of the mask can be increased and accordingly more rules can be set and results can be compared with respect to the mask size.

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