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Implementation Of Fuzzy Controller For Image Edge Detection

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Abstract— *Edges in images are pixels at which the intensity of an image function changes suddenly and edges are sets of connected edge pixels. Edge detectors have been an essential part of many computer vision systems and in this modern era these are of great importance. This paper proposed a fuzzy based image edge detection algorithm. The developed algorithm uses 3 by 3 mask windows with eight inputs pixels and the center pixel as the output. 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. The developed algorithm is compared with conventional edge detection algorithm like sobel, prewitt etc.*

Keywords— *FIS, Fuzzy logic, Edge detection.*

1. INTRODUCTION

The objects discrimination from their background is the crucial task in image processing. The extraction of an object from their background requires the detection of the edges forming that object. Edge detection in image processing has wide range of applications like image enhancement, recognition, morphing, restoration, registration, compression, retrieval and watermarking etc. Edge detection is a method or technique that detects the location of edges constituted by sudden changes in colour intensity or brightness of an image [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

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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 by 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.

2. PROPOSED METHOD

In this proposed method, eight inputs and one output are given to the fuzzy inference system. The eight inputs are the eight pixels of the 3 by 3 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.

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.

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.

The mask is slid over an area of the input continues to shift towards 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

ISSN 2348 – 7968

and the value of the pixels P1, P2, P3, P4, P6, P7 P8, and P9.

3. METHODOLGY USED

To accomplish the task of edge detection using fuzzy logic, step by step methodology is:

- The first step is determining the degree of membership of each input using membership functions.

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

- 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.
- Applying Implication Method.
- Aggregate resultant output FS for all fired rules are achieved by using MAX operator.
- Defuzzifying using the centroid method.

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. 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.

4. SIMULATION RESULTS

The implemented fuzzy based edge detection is tested with different images. The performance of the proposed system is compared with the existing edge detection algorithms. 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

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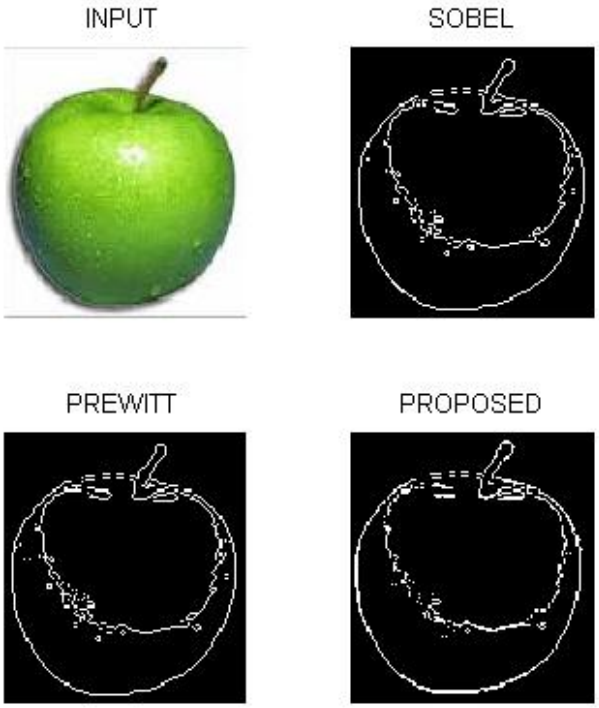
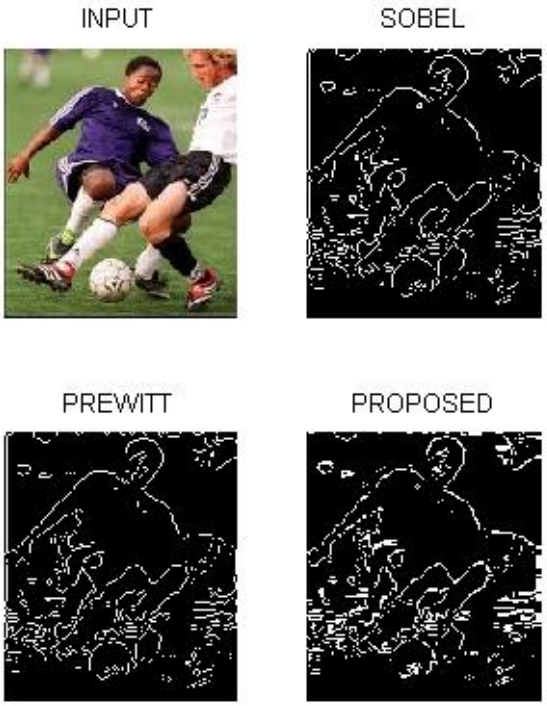
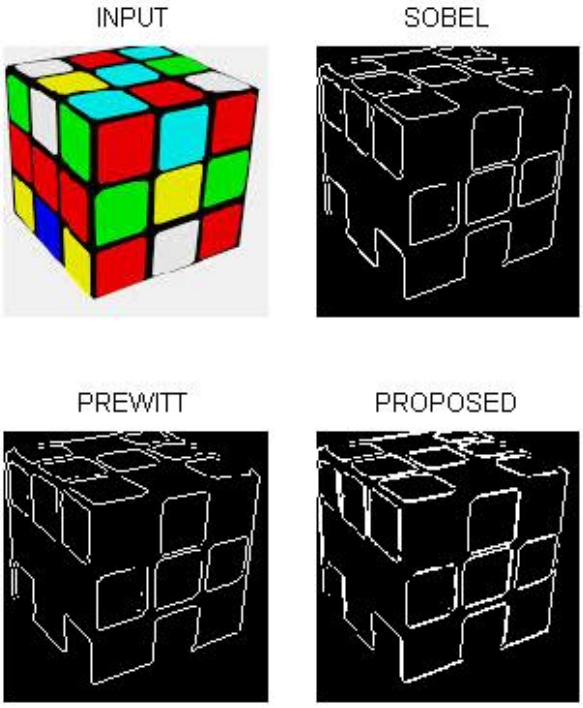
compared with Sobel and Prewitt approaches. It can be observed that the output that has been generated by the fuzzy method has found out the edges of the image more distinctly as compared to the ones that have been found out by the "Sobel" edge detection algorithm.



(a)



(b)



(c)

Fig1: (a- c): Results of proposed algorithm compared with Sobel and Prewitt.

Table 3: PSNR for different operators

ISSN 2348 – 7968

OPERATOR	APPLE	PLAYER	CUBE
SOBEL	49.5326	51.2804	50.3610
PREWITT	49.5626	51.3428	50.3900
PROPOSED	49.5649	51.4808	50.4258

Table 4: MSE for different operators

OPERATOR	APPLE	PLAYER	CUBE
SOBEL	0.7241	0.4842	0.5984
PREWITT	0.7192	0.4773	0.5944
PROPOSED	0.7188	0.4624	0.5895

6. CONCLUSION

In this paper, we develop, implement and test simple & small but a very efficient, fuzzy rule based edge detection algorithm. The performance of the proposed system is evaluated and compared with the various other existing edge detection algorithms. The results shows that the accuracy of the edge detection using proposed fuzzy algorithm outperform over the other algorithms

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