IMAGE SEGMENTATION USING CONTEMPORARY FUZZY LOGIC

Dr.E.N.Ganesh
Professor, ECE Dept, Saveetha Engineering College
Thandalam,Chennai
Enganesh50@gmail.com

Abstract: **Digital Image Processing is a versatile cost effective method utilized in many areas with various technologies. In this paper a novel method for an application of digital image processing is developed in edge detection utilizing the contemporary Fuzzy logic, a key concept of artificial intelligence ,where Fuzzy relative value pixel algorithm are involved to increase the efficiency and the outcome of the expected result .It helps in finding and highlighting all the edges associated with an image by checking the relative pixel values and thus provides an algorithm to abridge the concepts of digital image processing and artificial intelligence. Exhaustive scanning of an image using the windowing technique takes place 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. After the testing of fuzzy conditions the appropriate values are allocated to the pixels in the window under testing to provide an image highlighted with all the associated edges.**

Keywords: Fuzzy logic, Digital image processing, Edge detection, Feature extraction

1. INTRODUCTION

Several methods have been proposed for the image edge-detection which is the method of marking points in a digital image where luminous intensity changes sharply for which different type of methodology have been implemented in various applications like traffic speed estimation [1], image compression [2], and classification of images [3]. Most of the traditional edge-detection algorithms in image processing typically convolute a filter operator and the input image, and then map overlapping input image regions to output signals which leads to considerable loss in edge detection [4]; however there is no such loss in the fuzzy based method described here. Research has clearly demonstrated that methods involving Gaussian filtering suffer from problems such at edge displacement, vanishing edges and false edges [5]. Another problem faced by few methods like the anisotropic diffusion lies in obtaining the locations of semantically meaningful edges at coarse scales generated by convoluting images with Gaussian kernels [6]. Methods that involve simple scan line approach are not able to detect all the edges due to limitation of the methodology to trace only the horizontal and vertical neighbors [7] of a point.

The method described does not implement any thresholding unlike few published methods [8] which helps to detect each and every edge associated with the image but introduces fuzzy logic which derives its origin from approximate reasoning for highlighting all the edges associated with an image. The fuzzy relative pixel value algorithm has been developed with the knowledge of vision analysis with low or no illumination [9], thus making this method optimized for application requiring such methods. The method helps us to detect edges in an image in all cases due to subjection of pixel values to an algorithm involving 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 an area of feature extraction with plethora of techniques, each 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 [10]. 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 [11] displaying the accuracy of fuzzy methods in digital image processing [12]. *A very important role is played in image analysis by what are termed feature points, pixels that are identified as having a special property. Feature points include edge pixels as determined by the well-known classic edge detectors of PreWitt, Sobel, Marr, and Canny [17:21]. Recently there has been much revived interest [22, 23] in feature points determined by "corner" operators such as the Plessey, and interesting point operators such as that introduced by Moravec. [24, 25] Classical operators identify a pixel as a particular class of feature point by carrying out some series of operations within a window centered on the pixel under scrutiny. 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 within 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 labeling edge pixels, when an edge, although definite, represents only a small gray-scale jump. Yet often such edges are clearly visible to the human eye.

1A. Fuzzy Image Processing

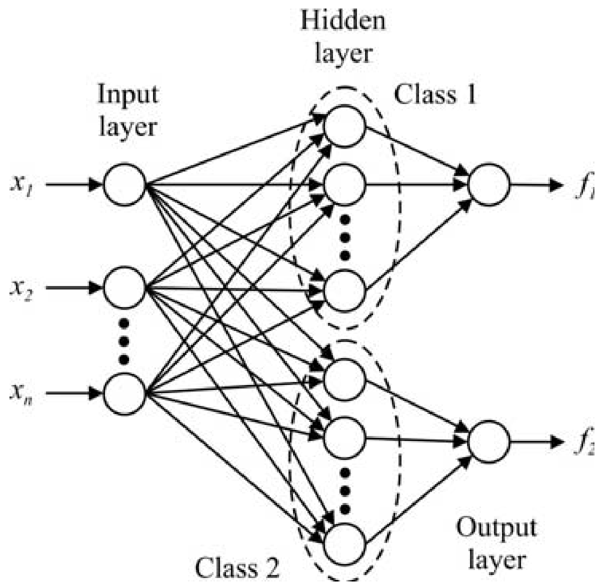
Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on the selected fuzzy technique and on the problem to be solved. Fuzzy image processing has three main stages: image fuzzification, modification of membership values, and if necessary, image defuzzification as shown in Fig. 2. 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 [29].

1B. 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". The adopted membership functions for the fuzzy sets associated to the input and to the output were triangles, as The functions adopted to implement the "and" and "or" operations were the minimum and maximum functions, respectively. The Mamdani method was chosen as the defuzzification procedure, where the fuzzy sets obtained by applying each inference rule to the input data were joined through the add function; the output of the system was then computed as the lom of the resulting membership function. The values of the three memberships function of the output are designed to separate the values of the blacks, whites and edges of the image.

2. The Fuzzy Classifier Architecture

A fuzzy classifier is a system that accepts as input vectors containing attributes or fuzzy truths that allow fuzzy attributes to belong to different membership functions. The output of the classifier is represented by fuzzy truths for the membership functions corresponding to the input vector. The class attributed to an input vector is the one whose truth value, given by the membership functions, is the greatest. For an input vector to belong to only one class, the highest truth value must beat by far the following truth value. The architecture of a fuzzy classifier for only two classes is presented in Figure 5.



2. METHODOLOGY

The algorithm described below is based on the subjection of a set of nine pixels, part of a 3x3 window of an image to a set of fuzzy conditions which helps to highlight all the edges that are associated with an image. The fuzzy conditions help in testing 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.

3. 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 central pixel having values (2, 2). After the initialization, the pixel values are subjected to the fuzzy conditions for edge existence shown in Fig.1. (a-h). 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 now 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 (refer to flowchart shown in Fig.4.). In this manner the window shifts and checks all the pixels in one horizontal line then increments to check the next vertical location.

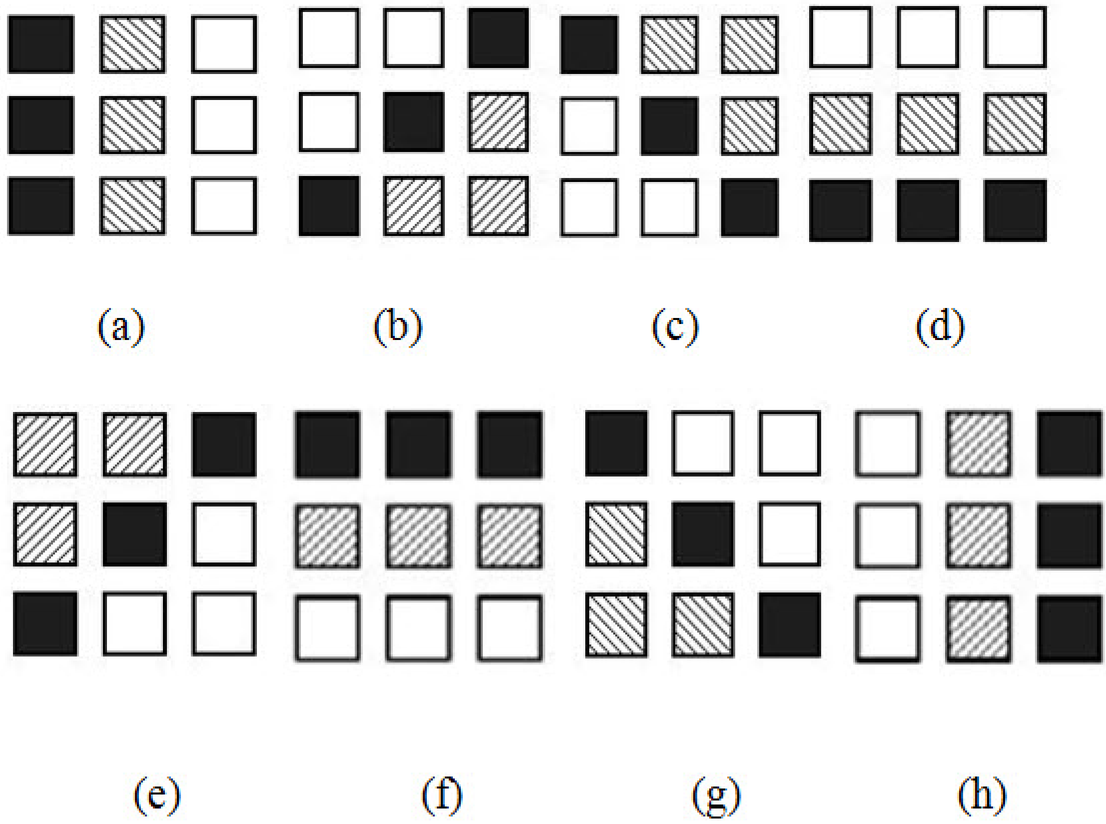


Fig 1(a-h). Fuzzy conditions have been displayed.

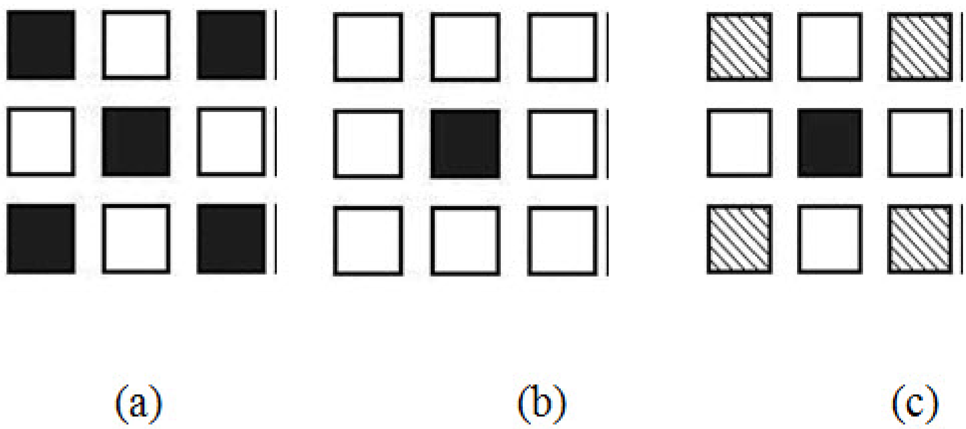
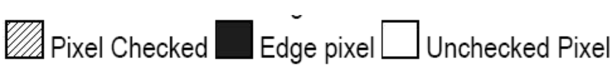


Fig 2. (a, b) Type of unwanted edge pixels (c) Fuzzy condition for removal of unwanted edge pixels.

Legend:



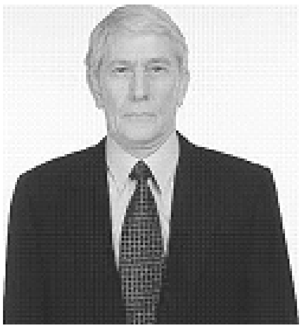
After the edge highlighting image is subjected to another set of conditions with the help of which the unwanted parts of the output image of type shown in Fig.2.(a-b) are removed to generate an image which contains only the edges associated with the input image. Let us now consider the case of the fuzzy condition displayed in Fig.1.(g) for an input image A and an output image B of size MxN pixels respectively we have the following set of conditions that are implemented to detect the edges pixel values.

Input: *An image A of MxN pixels*
Output: An image B of MxN pixels
Edge Detection (A, B)
For I←2 to M-1
For J←2to N-1
If A (I-1, J)>A (I-1, J+1)
Then If A (I-1, J-1)>A (I, J)
Then If A (I, J-1)>A (I+1, J-1)
Then
B (I-1, J+1) ←0
B (I, J) ←0
B (I+1, J-1) ←0
End For
End For
For I←2 to M-1
For J←2to N-1
If B(I-1,J)=255& B(I,J)=0& B(I+1,J)=255& B(I,J- 1)=255
Then B (I, J) ←255
End For
End For

We can observe in the above algorithm written for a particular fuzzy condition that the nesting of statements is done in a manner that only the edge associated pixels are granted black pixel values. The application of fuzzy conditions on the image helps to highlight all the edges associated with it but do leave unnecessary pixel values which only distort the edge values. To eliminate these unwanted edge pixels, another fuzzy condition is implemented to enhance the working of the fuzzy relative pixel value algorithm. With the help of these set of conditions the algorithm is able to eliminate all the noisy pixels and filters out the edges to provide us with a clean output image with all the distinct edges associated with that image.

4. EXPERIMENTAL RESULTS

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 provides much more distinct marked edges and thus have better visual appearance than the ones that are being used. The sample output is shown below in Fig.5. (a-c) compares the “Sobel” Edge detection algorithm 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 “sobel” 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.



(a)Input Image (b) Intermediate Image

(b) Output Image

a. Input Image b. Sobel algorithm

c. Fuzzy relative pixel value algorithm

Fig 5 (a-c). Comparison of Fuzzy relative pixel value algorithm and Sobel edge detection algorithm.

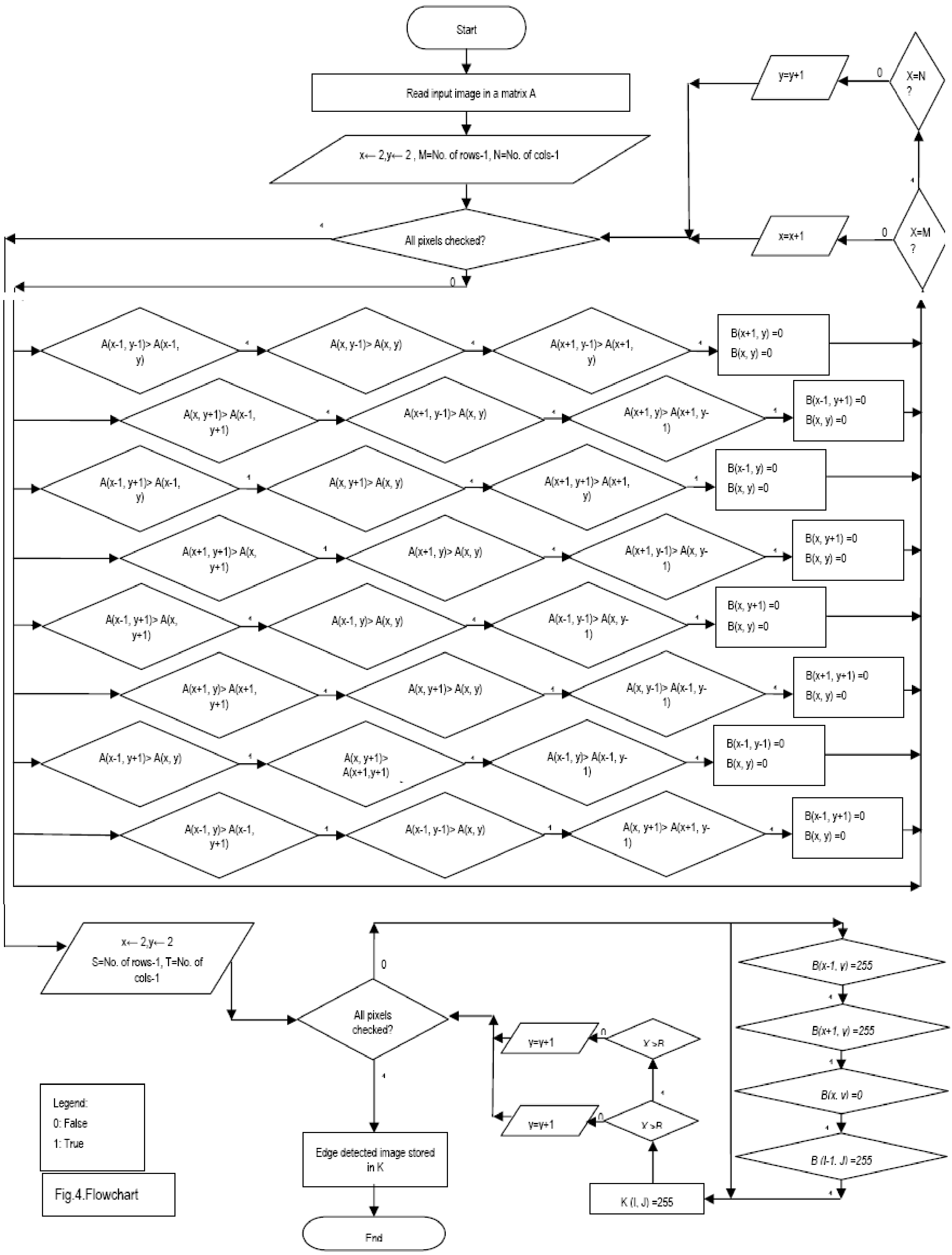


Fig 3: Flow Chart

6. CONCLUSION

In this paper, the algorithm to find the edges associated with an image had been introduced which has been instrumental in bridging the concepts of artificial intelligence and digital image processing. Comparisons were made amongst the various other edge-detection algorithms that have already been developed and displayed. The accuracy of the edge-detection using the fuzzy relative pixel value algorithm over the other algorithms has tremendous scope of application in various areas of digital image processing. The image edge-detection using fuzzy relative pixel value algorithm has been successful in obtaining the edges that are present in an image after the implementation and execution of the algorithms with various sets of images. Sample outputs have been shown to make the readers understand the accuracy of the algorithm and the display that the algorithm can find image edges even in case of minor pixel value gradients.

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