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A RECENT APPROACH TO IMAGE EDGE DETECTION BY THE IMPLEMENTATION OF RULE BASED FUZZY LOGIC

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ABSTRACT
Image processing is any form of information processing for which both the input and output are images, such as photographs or frames of video. Most image processing techniques involve treating the image as a two-dimensional matrix. A few decades ago, image processing was done largely in the analog domain, chiefly by optical devices. There is also much massively parallel architecture that has been developed for the purpose.

I.   INTRODUCTION

1.1 Digital Image Processing
Image processing is any form of information processing for which both the input and output are images, such as photographs or frames of video. Most image processing techniques involve treating the image as a two-dimensional matrix. A few decades ago, image processing was done largely in the analog domain, chiefly by optical devices. These optical methods are still essential to applications such as holography because they are inherently parallel; however, due to the significant increase in computer speed, these techniques are increasingly being replaced by digital image processing methods. Digital image processing techniques are generally more versatile, reliable, and accurate; they have the additional benefit of being easier to implement than their analog counterparts. Specialized hardware is still used for digital image processing: computer architectures based on pipelining have been the most commercially successful. [R.Gonzalez, et al. 2002] There is also much massively parallel architecture that has been developed for the purpose. Today, hardware solutions are commonly used in video processing systems. However, commercial image processing tasks are more commonly done by software running on conventional personal computers.

1.1.1 A Digital Image and Its Types
In Fig 1.1 A digital **i**mageis defined as two dimensional function of f(x, y), where x, y are spatial co-ordinates. Amplitude of any pair co-ordinates of x, y is called the intensity or gray level of image at that point.
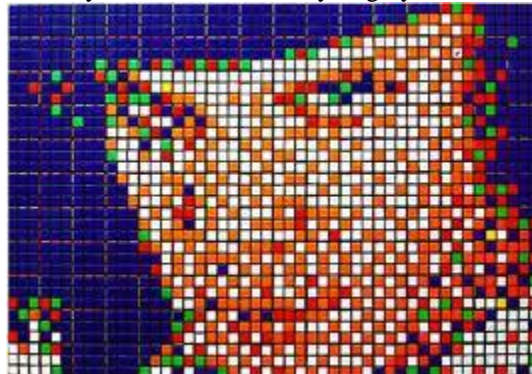

Fig 1.1 Digital image

The useful paradigm in determining an image type is to consider three types of computerized processors-low, mid and high level. Low-level processors involve primitive operations such as image processing to reduce noise, contrast enhancement and sharpening. They are characterized by the fact that both its input and outputs are images. Mid level processing of images involves tasks such as segmentation-(partitioning image into regions or objects).It characterized by the fact that its inputs are 195images but its output are attributes extracted from those images. High level involves "making sense" of an ensemble of recognized object as an image analysis and performs cognitive functions normally associated with vision [R.Gonzalez, et al. 2002]

The basic data structure of image is the array, an ordered set of real or complex elements. Matlab stores most images as two-dimensional arrays (i.e., matrices), in which each element of the matrix corresponds to a single pixel in the displayed image. (Pixel is derived from picture element and usually denotes a single dot on a computer display.)
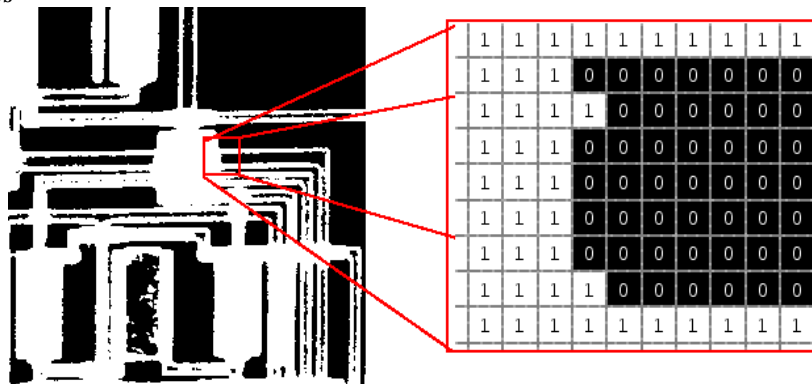
1.1.2 Binary Images

Fig 1.2 Binary Image

In Fig 1.2 binary image, also known as a bi-level image, each pixel assumes one of only two discrete values: 1 or 0. A binary image is stored as a logical array. The Fig 1.2 shows a binary image with a close-up view of some of the pixel values.
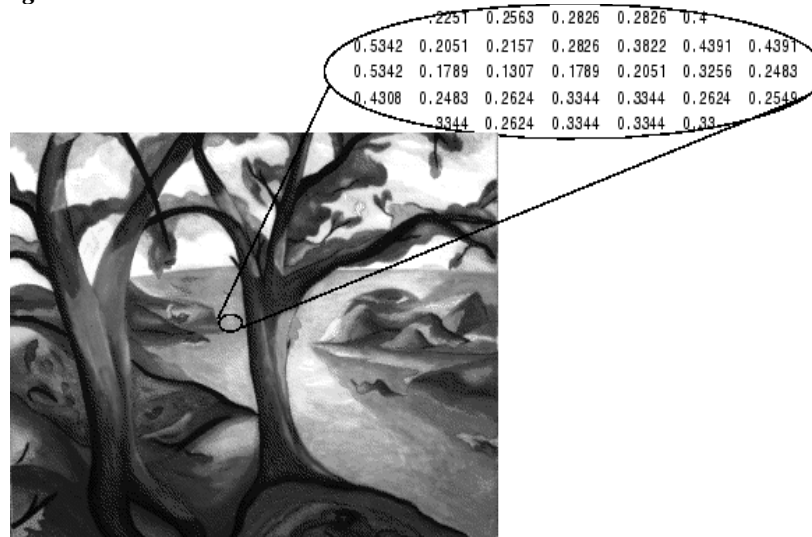
1.1.3 Gray Scale Image

Fig 1.3 Gray Scale Image

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In Fig 1.3 An intensity image, also known as a grayscale image, is a data matrix, M, whose values represent intensities within some range. MATLAB stores an intensity image as an individual matrix, with each element of the matrix corresponding to one image pixel. The matrix can be of class uint8, uint16, int16, single, or double. While intensity images are rarely saved with a color map, MATLAB uses a color map to display them. For a matrix of class single or double, using the default grayscale colormap, the intensity 0 represents black and the intensity 1 represents white. [Thompson Clay M, et al. 1995]

1.2 Image Coordinates Systems

The most convenient method for expressing locations in an image is to use pixel coordinates. In this coordinate system, the image is treated as a grid of discrete elements, ordered from top to bottom and left to right[R.Gonzalez, et al. 2002, Thompson Clay M, et al.1995]

1.2.1   The Pixel Coordinate System

In Fig 1.4 pixel coordinates, the first component r (the row) increases downward, while the second component c (the column) increases to the right. Pixel coordinates are integer values and range between 1 and the length of the row or column. There is a one-to-one correspondence between pixel coordinates and the coordinates MATLAB uses for matrix subscripting. This correspondence makes the relationship between an image's data matrix and the way the image is displayed easy to understand. For example, the data for the pixel in the fifth row, second column is stored in the matrix element (5, 2). In the pixel coordinate system, a pixel is treated as a discrete unit, uniquely identified by a single coordinate pair, such as (5, 2). From this perspective, a location such as (5.3, 2.2) is not meaningful.
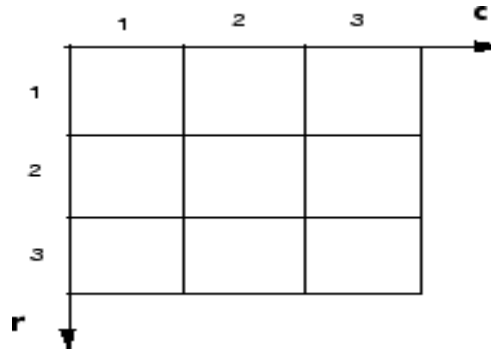

Fig. 1.4 Pixel Coordinate System

1.2.2   The Spatial Coordinate System

In Fig 1.5 coordinate system corresponds closely to the pixel coordinate system in many ways. For example, the spatial coordinates of the center point of any pixel are identical to the pixel coordinates for that pixel. There are some important differences, however. In pixel coordinates, the upper left corner of an image is (1, 1), while in spatial coordinates, this location by default is (0.5, 0.5). This difference is due to the pixel coordinate system's being discrete, while the spatial coordinate system is continuous. Also, the upper left corner is always (1, 1) in pixel coordinates, but you can specify a non default origin for the spatial coordinate system. Another potentially confusing difference is largely a matter of convention: the order of the horizontal and vertical components is reversed in the notation for these two systems. The spatial coordinates are expressed as (x, y).
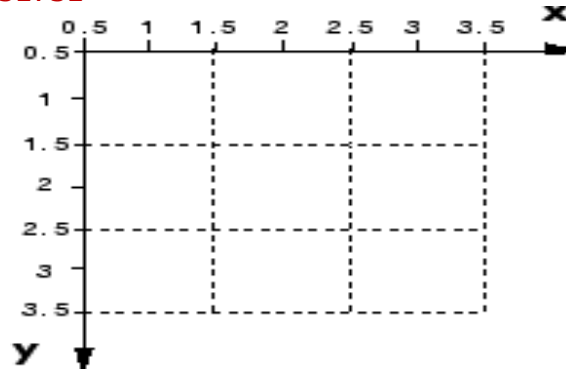
Fig 1.5 Spatial Coordinate System

II.   PROBLEM FORMULATION

In the image processing and computer vision, edge detection treats the localization of significant variations of gray level image and the identification of physical and geometrical properties of object of the scene. Edge detection is difficult issue. Many difficulties come from the complex contents like noise, varying contrast in an image, orientation sensitivity. Traditional edge detection techniques, such as Robert, Sobel, Prewitt and canny are widely used. All these techniques are studied and compared with the technique developed by fuzzy rule based classifier approach. It is found that most of existing techniques are very sensitive to noise and do not give satisfactory results in low contrast areas.

A fuzzy theory based edge detector avoids these problems and is a better method for edge detection and noise filtering than the traditional methods. Edge detection using fuzzy logic provides an alternative approach to detect edges .Fig 3.1 shows the basic building blocks of the system developed in this research work.
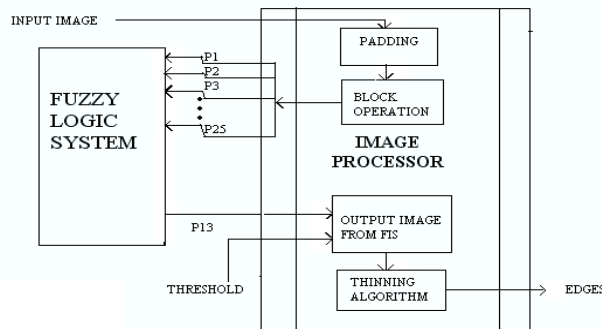

Fig 3.1 Basic Building Blocks of Proposed System

III.   OBJECTIVES OF PROPOSED WORK

The objective of the research work is development of conventional fuzzy logic based model in MATLAB environment for edge detection of an image by using rule based approach. The model is developed as simulator that account for detection of edges of any image that converts the image into gray levels ranging from 0 to 255. The developed model is anticipated to have the following capabilities:

- Should be able to accept different images that can be colored or gray images.
- Should have feature to compare the FIS output image with traditional techniques.

Methodology

To accomplish the task of edge detection using fuzzy logic, the step by step methodology is followed is described as under

- Study and comparison of various traditional techniques..
- Advantages and disadvantages of fuzzy logic are then analyzed.
- Based upon analysis, fuzzy inference system is designed and a rule base is developed for fuzzy inference system in MATLAB.
- A program is developed to use FIS in MATLAB.
- Then work is done to reduce the noise present in the output image.
- Results achieved after the execution of program are compared with earlier outputs by using quantative and qualitative approaches.

IV.   RESULTS AND DISCUSSIONS

Quantative comparison

Following tables show the quantative comparison between traditional and fuzzy edge detectors based on various parameters that discussed earlier in chapter 1.Theses tables are created by using two different test images i.e.; test image 1 and test image 2.

In Fig. below shows the original image of shapes. With the prewitt edge detector the resulted edges are broken. But with the fuzzy edge detector, it shows the dark and clear edges.
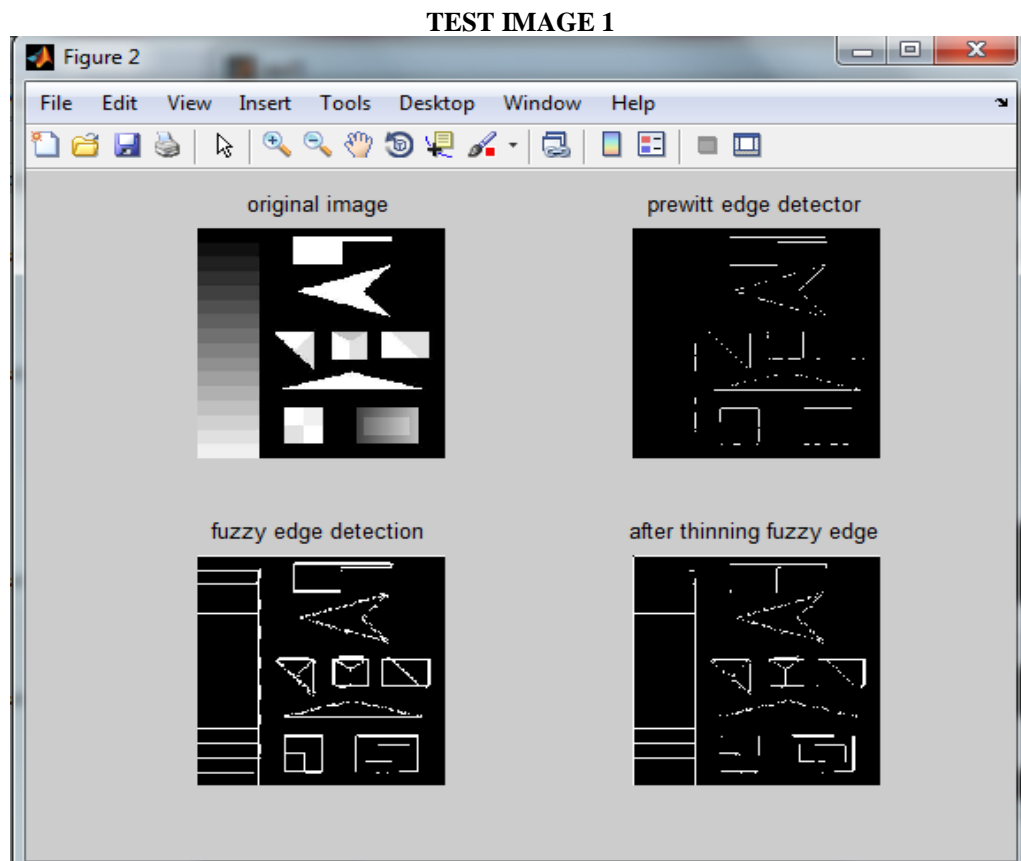
TEST IMAGE 1

FIGURE SHOWS THE OUTPUT FROM IMAGE OF DIFFERENT SHAPES COMPARED WITH PREWITT OPERATOR

Test image 1 is detected by too many edge detectors and metrics being calculated. With all different detectors, results are different. It is calculated by SOBEL, CANNY, PREWITT, FUZZY 2 x 2 and FUZZY 5 X 5 and the results are given below in Table.

TABLE 5.1

Metrics	SOBEL	CANNY	PREWITT	FUZZY 2*2	FUZZY 5*5
TP	2506	2623	2497	4201	4655
FN	1071	550	1070	1016	0883
FP	1430	2275	1427	2503	2772
IMP	0.1390	0.0797	0.1391	0.0861	0.0584
MCER	0.0405	0.0457	0.0404	0.0569	0.0752
NSR	3.5080	2.4409	3.4924	5.4060	6.3196
Distance	1.3495	1.1813	1.3488	1.3045	1.2956
Mean Width	1.2369	2.1587	1.2356	1.9965	1.9565
PCO	0.3629	0.1175	0.3622	0.1876	0.0664
PFA	0.7793	0.7107	0.7785	0.8448	0.8641
PND	0.5897	0.1718	0.5837	0.3429	0.2023

The above discussed procedure is repeated for different input images and result obtained after simulation using MATLAB coding are shown.

V.   CONCLUSIONS

In this research, emphasis has been to develop a very simple and small but a very efficient, fuzzy rule based edge detection algorithm to abridge the concepts of Artificial Intelligence (AI) and Digital image processing. The algorithm and the associated GUI have been developed in the MATLAB environment. Comparisons are made with various other edge detection algorithms that have already been developed. Displayed results have been shown the accuracy of the edge detection use the fuzzy rule based algorithm over the other algorithms. The fuzzy rule based classifier has been successful in obtaining the edges that are present in an image after implementation and the execution with various sets of images. Sample output has been shown to make readers understand the accuracy of the algoritm. thus developed algorithm exhibits tremendous scope of application in the various areas of digital image processing such as biometrics.

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