# Edge Detection Using Fuzzy Approach Involving Automatic Threshold Generation

Nishchal Gyan Upadhyay, Kamlesh Lakhwani

**Abstract:** Edge detection is one of the most important techniques in image processing. In spite of 20 years of research, the need for general edge detector is still felt. The key uncertainty in the edge detection algorithm is Threshold decision. To deal with uncertainty of information, soft computing approach is a good mathematical framework. In this work, we used fuzzy logic for Automatic Thresholding and generated threshold is used with different methods for edge detection. The results obtained from the proposed method are found to be comparable to those from many well known edge detector. However, the values of the input parameters providing the appreciable results in the proposed detector.

**Index terms:** Automatic Thresholding, Edge Detection, Fuzzy System, Fuzzification, Histogram, Hull, Pixel Count

## 1. INTRODUCTION

Edge detection is a very important low-level image processing operation, which is used in various higher level tasks such as motion and feature analysis, understanding, since last two decades researchers have done extensive study on the performance of different edge detection algorithms by checking them with different images. They observed that the performance of the well known edge detectors, like Canny, Sobel, Iverson etc, Depends critically on the choice of the input parameters. They have also reported striking improvement of the performance of some of the edge detectors, especially Canny's, when the choice of the input parameters is done adaptively, instead of using some fixed default values. A problem very commonly faced by detectors is the choice of threshold values, which are often chosen on heuristic basis. Prewitt's, Roberts', Sobel's operators, and zero-crossing edge detectors use thresholds which are generally selected without any precise objective guideline. In the MATLAB version of Canny's edge detector the default value of upper threshold is suggested to be 75th percentile of the gradient strength. In general, thresholding techniques can be approximately classified into six categories: histogram shape-based, clustering-based, and entropy-based, image attribute-based, spatial-based and local characteristics-based approaches. Histogram shape-based approaches analyze the shape properties of the image gray level histogram to find the threshold for the object and background separation, such as the peaks, valleys and curvatures of the histogram.


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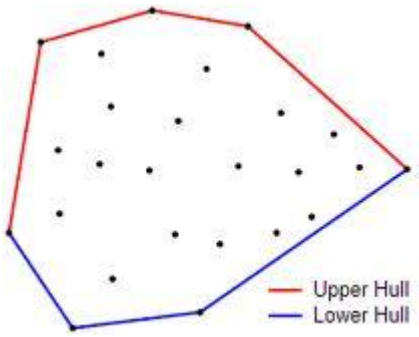
Clustering based approaches use certain algorithms, such as mean-square or fuzzy clustering, to group the image points into two clusters according to their gray values. Entropy-based approaches exploit the entropy of the gray level distribution in an image for thresholding, such as maximization of the entropy of the threshold image or minimization of the cross-entropy between the original image and the output binary image. Image attribute-based approaches determine the threshold by searching some attribute quality or measure of similarity between the original and the binary type images, such as gray level moments, edge coincidence etc. Spatial methods select the threshold by using not only gray value distribution but also the spatial relationship of pixels in a neighborhood, for example, in the form of correlation functions or co-occurrence probabilities.

## 2. AUTOMATIC EDGE THRESHOLDING USING FUZZY LOGIC

Before we start understanding automatic thresholding we should know what Convex Hull is.

### 2.1 Convex Hull

The convex hull of a set X of points in the Euclidean plane is the smallest convex set that contains X. For instance, when X is a bounded subset of the plane, the convex hull may be visualized as the shape formed by a rubber band stretched around X. Formally, the convex hull may be defined as the intersection of all convex sets containing X or as the set of all convex combinations of points in X. With the latter definition, convex hulls may be extended from Euclidean spaces to arbitrary real vector spaces; they may also be generalized further, to oriented matroids. The algorithmic problem of finding the convex hull of a finite set of points in the plane or in low-dimensional Euclidean spaces is one of the fundamental problems of computational geometry. Now coming back to automatic edge detection, we determine multiple edge thresholds for an input image, where the image is divided into multiple groups based on intensity histogram of an image. For each group there will be different threshold.




### 2.2 Fuzzy System

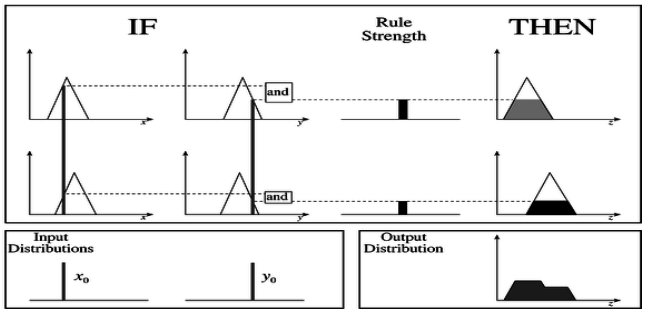
For solving the problem of knowledge based, the system is called as Fuzzy system. Now we frame, a set of fuzzy rules based on knowledge of the MRI image characterization. These rules are based on the basis of IF THEN ELSE condition. Every rule is applied sequentially and is explained later. The Fuzzy system contains four components such as fuzzifier, fuzzy interface, fuzzy knowledge base, and defuzzifier. The Fuzzifier component is used to change the input into linguistic format. After the fuzzification, the fuzzy interface machine applies the fuzzy rules taken from fuzzy knowledge base, in sequential order. In the defuzzification process, the fuzzy data is converted into a crisp data.

### 2.3 Fuzzy Interference System

A fuzzy inference system (FIS) is a system that uses fuzzy set theory to map inputs (features in the case of fuzzy classification) to outputs (classes in the case of fuzzy classification). Two FISs will be discussed here, the Mamdani and the Sugeno.

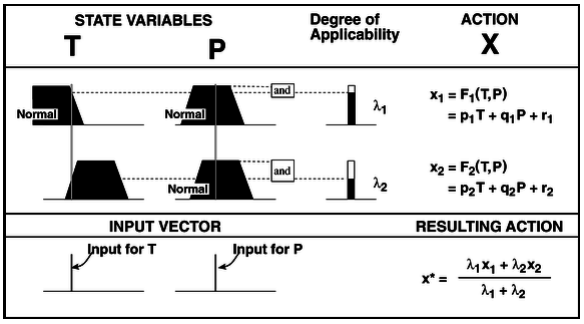
#### 2.3.1 FIS (MAMDANI)

1. First determining a set of fuzzy rules.
2. Using the input membership functions, Fuzzification of input is done.
3. Combining the Fuzzifier inputs according to the fuzzy rules to establish rule strength.
4. Finding the consequence of the rule by combining the rule strength and the output membership function,




#### 2.3.2 FIS (Sugeno)

The primary difference is that the output consequence is not computed by clipping an output membership function at the rule strength. In fact, in the Sugeno FIS there is no output membership function at all. One of the large problems with the Sugeno FIS is that there is no good intuitive method for determining the coefficients, p, q, and r. Also, the Sugeno has only crisp outputs which may not be what is desired in a given HCI application.




## 3. METHODOLOGY

Now that we know terms like Convex Hull, Fuzzy System we can further proceeds to understand the methodology.

### 3.1 Algorithm for automatic edge detection

The step-by-step methodology to be followed for detecting edges using fuzzy theory.

a) A thorough analysis of various edge detection techniques will be done.
b) Advantages and disadvantages of using Fuzzy logic will be analyzed.
c) Based upon above analysis a program will be developed using Matlab.

### Basic steps involved:

Following images will help us understanding the algorithm in a better way:

**Figure1**

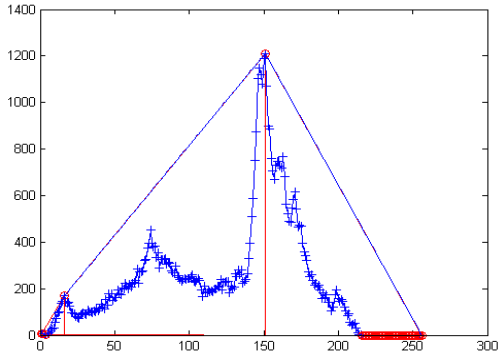
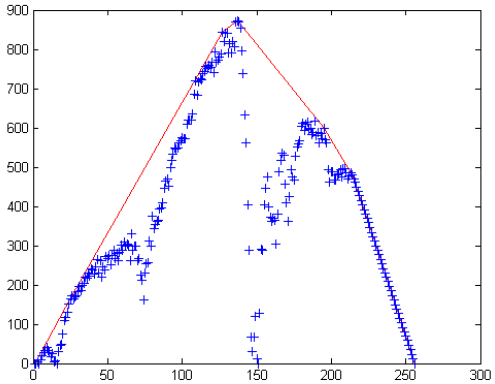



**Figure2**




**Step I:** In step I, clusters the pixels into groups where the pixel

intensities of each group belong to the interval defined by the two consecutive strong valleys on the intensity histogram of the image based on Figure 1 and Figure 2.The convex hull algorithm is used to find peak and valleys from histogram of the image.

**Step II:** Using fuzzy reasoning process determine the edge thresholds for each pixels group. We have used three statistics of a pixel group in determining the inputs of fuzzy reasoning process: mode, mean of edge magnitude and pixel count. Mode is most repeated value in group. Pixel count is the number of pixels in a group.

**Step III:** Apply these inputs of a group to FIS system. Fuzzy rule is comprised of 18 rules. Membership function we used are experimentally chosen and denoted by "S", "M" and "L" representing "small", "medium" and "large".

**Step IV:** A crisp output is determined using the output membership functions. According to the total number of pixels groups in an input image, we selectively use one of the two outputs in the rule: OUT1 and OUT2 .If the total number of pixel group is larger than 2, OUT 1 are chosen otherwise Out2. Finally we determine the edge threshold

For z=1~ (number of group)

thr[z]=mode[z]+β[z]

Where,

thr[z] is the threshold for zth group mode[z] is the mode of edge magnitude of zth group. B[z] is the fuzzy reasoning output for zth group.

| Rule no | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| In 1 | S | S | S | S | S | S | M | M | M | M | M | M | L | L | L | L | L | L |
| In 2 | S | S | M | M | L | L | S | S | M | M | L | L | S | S | M | M | L | L |
| In 3 | S | L | S | L | S | L | S | L | S | L | S | L | S | L | S | L | S | L |
| OUT 1 | M | M(S) | M | M | M | M | M | M | M | L | M | L | M | L | M | L | L | L |
| OUT 2 | L | L | M | L | M | M | L | L | L | L | L | L | L | L | L | L | L | L |

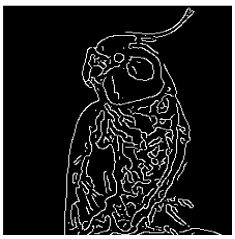
## 4. RESULT

Result analysis of an image with various edge detection techniques. Fig. 4.1 Following are the details:

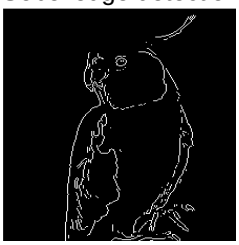
a) Original Image
b) The result obtained using Sobel edge detection method
c) The result obtained using canny edge detection method
d) The result using Fuzzy based automatic threshold method

a) Original Image

b) Sobel edge detection



c) Canny Edge Detection



d) Fuzzy based Image

So let's begin with comparing all the above images which are obtained using different edge detection methods. Fig. 1 shows the original image. Fig.2 shows the image obtained using Sobel edge detection method. Fig 3 shows the result obtained using canny edge detection and the 4th image shows the resulting image using Fuzzy based automatic threshold method for edge detection. So it can be seen clearly that last image that is fuzzy based image is clearer and easy to understand in comparison to other edge detection method as it shows sufficient no. of edges needed to understand an image. No more any less. Canny shows extra no. of edges which is not a good indication for understanding an image and Sobel image is lacking sufficient no. of edges, which makes Fuzzy based detected image the worthy of being called the better edge detection technique than others.

## 5. CONCLUSION

As we can see from the above displayed results that Sobel edge detection based image shows better results but it can be even improved to better. Canny edge detection based image show more number of images than the actual need which makes the image even more complicated to understand whereas, Fuzzy Thresholding based results are way better than that of other edge detection techniques like Canny and Sobel.

## 6. FUTURE WORK

It can be used for multiple Face Detection Techniques, suppose there are two images held very close that it is very difficult to find that there is more than one image present. Normal methods can't judge the no. of images, but using this method the edge detection is so accurate that one can differentiate easily that there are more than one image is present.

## 7. ACKNOWLEDGEMENT

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