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# A FUZZY FILTERING MODEL FOR CONTOUR DETECTION

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***Abstract***
***Contour detection is the basic property of image processing. Fuzzy Filtering technique is proposed to generate thick edges in two dimensional gray images. Fuzzy logic is applied to extract value for an image and is used for object contour detection. Fuzzy based pixel selection can reduce the drawbacks of conventional methods(Prewitt, Robert). In the traditional methods, filter mask is used for all kinds of images. It may succeed in one kind of image but fail in another one. In this frame work the threshold parameter values are obtained from the fuzzy histogram of the input image. The Fuzzy inference method selects the complete information about the border of the object and the resultant image has less impulse noise and the contrast of the edge is increased. The extracted object contour is thicker than the existing methods. The performance of the algorithm is tested with Peak Signal Noise Ratio(PSNR) and Complex Wavelet Structural Similarity Metrics(CWSSIM).***

***Keywords:***
***Contour Detection, Threshold, Histogram, Fuzzy Filtering, Fuzzy Logic***

## 1. INTRODUCTION

Fuzzy based edge detection is the most important application of image processing. Histogram Equalization modeling is a non-linear contrast enhancement method, the histogram of the input image is reassembled to produce a uniform population density set of the image. Fuzzy inference based image enhancement requires appropriate reasoning process of histogram data to generate a new image [17]. While detecting the edges of an image, the noises which are present in the image array are reduced and the quality of the image increases. The edge detection principle is based on slope operators, filter template, zero crossing in first and second derivative etc[3]. In images, edges are identified by sudden changes of the object contour where a significant difference occurs in the gray-level value of an image[7],[11]. The aim of edge detection is to determine the smooth border of an image in the presence of noises (Salt and Pepper, Gaussian). A filter mask is generated for the gray scale image for finding the gradient changes of the input image. Edge detection algorithm determines the shapes in a particular gradient manner and to draw a resultant bitmap image where edges are in white on black background. The presence of a high gradient variation, indicating a sudden intensity transitions for the discontinuities of the edges[12],[14]. The change would be normally maintain at the border of the image and their neighboring domain of the pixel intensities. Filter scheme would be provide equal enhancement or generation of edges irrespective of their orientation [16]. Robert, Prewitt and Sobel gradient methods use Filter matrix convolved with the input image. The convolution based operator is often processed for image enhancement and it uses a mask to process the image [2]. Prewitt edge detection method has good effect on many kinds of images and it will fail, if one image has some noises and blur. Sobel, Robert and Prewitt methods have two drawbacks,

- The extracted borders from the image are not very clear and small gradient changes may not be detected.
- Threshold selection is difficult from filter mask.

Sobel method is not applicable for finding the thick edges with small luminescence changes of the neighboring pixels. Russo Fuzzy inferences for edge without being deceived by salt and pepper noise [15]. The results were better than Prewit, Robert and Sobel methods, especially in the occurrence of impulse noises. This paper presents a Fuzzy inference method which can generate the thick edges from an image in different neighboring domain. The threshold parameters are adaptively adjusted by the Fuzzy inference rules. Fuzzy Reasoning method can smooth the edges efficiently and remove the unwanted pixels (noise) from the image.

## 2. FUZZY LOGIC MODELING FOR IMAGE ENHACEMENT

Contrast Enhancement methods can be categorized into two classes[7]. The first one is based on modifying the frequency transfer of an image and is called Transform pixel domain. The other one is Spatial transform. Histogram Equalization modification of gray values are also used for image enhancement[4],[6]. In Fuzzy based inference modeling of image enhancement, fuzzy sets are formed with IF-THEN-ELSE fuzzy inference rules[10]. The fuzzy reasoning gives directives much similar to human reasoning for the decision. An image can be considered as a matrix of fuzzy skeleton set [8] with membership values that represents the image property in the range 0(low) to 1(high). Different statistical filtering values attempted to improve the contrast of the image[8],[9]. Edges are generally difficult to identify with their neighboring pixel values. There are obvious different gray level intensity between two neighboring regions, and the possibility of the pixel on an edge would be high. In Sobel and Prewitt methods the edges are inspected by calculating the gradient value of the neighboring pixels[7],[13]. In the fuzzy inference method the threshold values are playing the major role similar to the spatial methods for edge identification. In practical edge detection method, edges are often identified by computing the gradient value with filter template. The fuzzy filtering rules are involved to fix the exact pixel for edges on the image domain.

## 3. FUZZY REGIONS IDENTIFICATION OF AN IMAGE

Fuzzy edge regions are identified from the fuzzy histogram of the input image. The two regions are, the pixel value of high difference in gray level with its surrounding ones belongs to fuzzy contour region and the low difference gray level values belong to fuzzy smooth regions[17]. The histogram is constructed from the differences in gray level intensity of every pixel with its surrounding pixels from the fuzzy set. The histogram of the input image Δ(x,y) is constructed from the following equation.

$$\Delta(x,y) = \max(\Delta(x,y)) - \Delta(x+i, y+i) \quad (1)$$

where, Δ is the expected histogram for the pixel at location (x,y). The typical fuzzy edge regions (thick) are given below,

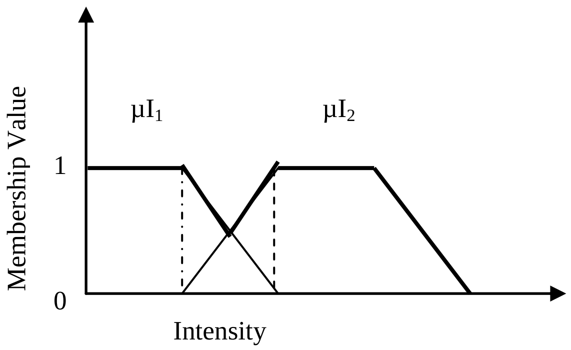



Fig.1. Typical Fuzzy Image Regions

There are two fuzzy edges generated: Fuzzy Edge Smooth Region ($\mu I_1$) and Thick Fuzzy Edge Region ($\mu I_2$). Two threshold values LEV (Low Edge value) and HEV (High Edge value) are used for smooth edge region and LTR (Low Threshold Region) and HTR (High Threshold Region) are used for thick fuzzy object contour. The threshold values may be different according to the input images. If the edge is smooth the difference between pixels is very less luminescence. The threshold parameter values for different gray images are given below,

Table.1. Threshold Parameter Values

| Image | LEV | LTR | HEV | HTR |
|---|---|---|---|---|
| **Lena** | 16 | 58 | 95 | 36 |
| **Mineral** | 25 | 93 | 132 | 42 |
| **Rice** | 18 | 38 | 48 | 42 |

## 4. FUZZY INFERENCES FOR CONTOUR DETECTION

Fuzzy inference filtering model is proposed for detecting the edge with less computation rules. The fuzzy computation can be rejected if the fuzzy membership function is having no significant value at the inference findings. Smooth Edge Region (SER) is generated with the parameters LEV and HEV. The hypothetical histogram specification for the different threshold parameters are specified in the following diagram.

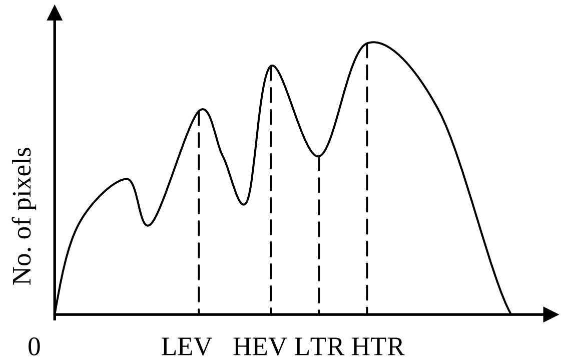



Fig.2. Hypothetical Image Histogram

Low edge value and high edge value are used to put the pixel occurring in the smooth region either in low state(black) or high state(white). The smooth edge region and thick edge regions are constructed from the following Eqs. (2) and (3).

$$\mu I_1 = \frac{LEV - S(x,y)}{HEV} \quad (2)$$

$$\mu I_2 = \frac{LTR - S(x,y)}{HTR} \quad (3)$$

where, LEV and LTR are the threshold values which are determined from the following algorithm.

```
Lowthresholdvalue(c,t,h)
{
  k = 0, i = 1;
  do
    {
      if( ( Σ_{i=o}^{k} [i*h(i)] > c*t )
        {
        i  = o;
        return k;
         }
         else
         {
           k = k++;
           i++;
          }
        } while(i<= 255);
  }
```

Similarly the high threshold values (HTR and HEV) are determined from the following routine.

```
Highthresholdvalue(d,t,h)
        {
          L =255, i = 0;
          do
```

{

if( $\left( \sum_{i=1}^{255} [i * h(i)] > d * t \right)$

{

return L;

}

else

{

L = L--;

}

} while(i<= 255);

}

where, t is the gradient value from the gradient matrix S(x,y) of the input image I(x,y) and h is the histogram of the gray scale intensity values while c and d are the two constant values initially set to 0.3 and 0.7 respectively.

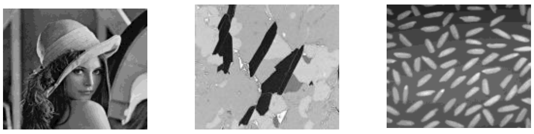
The thick edge of R(x,y) is calculated by the following fuzzy inference rules,

$$R(x,y) = \begin{cases} 255 & \mu I_1 >= \text{HTR} \\ 0 & \mu I_2 >= \text{LTR} \\ S(x,y) \max(\mu I_1, \mu I_2) & \end{cases} \quad (4)$$

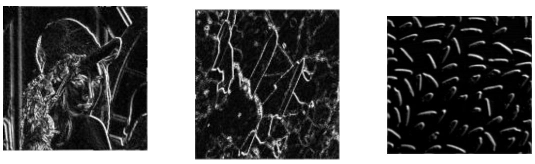
where, $\mu I_1$ is the smooth object region and $\mu I_2$ is the thick ramp edge region and S(x,y) is the gradient value of the input image. The value of $\mu I_1$ and $\mu I_2$ is assigned in the interval $0<=\mu<=1$. When $\mu I_1$ is 0 indicates dark black and when $\mu I_1 = 1$ bright. A set consisting of all $\mu I_1$ and $\mu I_2$ is called the fuzzy property plane of the input image with histogram analysis.

## 5. EXPERIMENTAL RESULTS

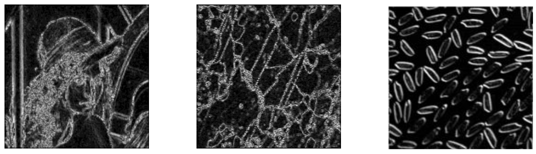
In this section, we demonstrate the results of the proposed fuzzy reasoning method through different images (Lena, Mineral and Rice). The original images of Lena, mineral and rice are given in Figs.3(a), 3(b) and 3(c) respectively. And its corresponding Sobel method images are given in Figs.4(a),4(b) and 4(c). Prewitt and Robert images are given in Fig.(5) and (6). The exact edges are not identified by these methods. In Fig.(7) the proposed Fuzzy inference method of thick edge image is given. Here the impulse noises are reduced and the ramp edges are clearly identified. The histogram of the Lena, Mineral and Rice images are given in Figs.8(a), 8(b) and 8(c) respectively.



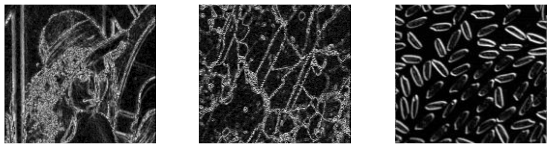
3a) Lena 3b) Mineral 3c) Rice



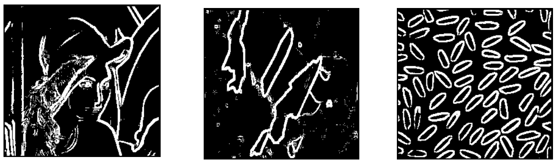
4a) Sobel image 4b) Sobel image 4c) Sobel image



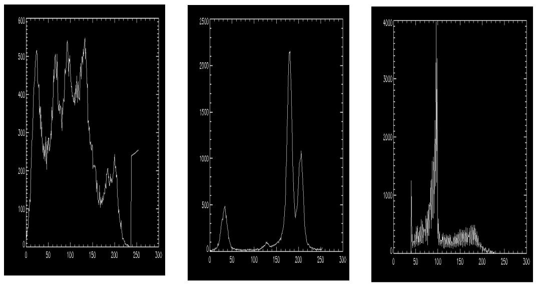
5a) Prewitt image 5b)Prewitt image 5c)Prewitt image



6a) Robert image 6b)Robert image 6c)Robert image



7a) Proposed Fuzzy image 7b) Fuzzy image 7c) Fuzzy image



8) Histogram of original images
a) Lena b) Mineral c) Rice

## 6. EVALUATION CRITERIA

There are two evaluation measures used for comparing the fuzzy based filtering method with the other methods. The PSNR value[5] is evaluated from the following Eqs. (5) and (6). The image metric is expressed in terms of visual decibels(dB).

$$MSE = \sum_{i=1}^{N} \sum_{j=1}^{M} I(i,j) - S(i,j) \quad (5)$$

$$PSNR = 10 \log_{10} (255)^2 / (MSE)^2 (dB) \quad (6)$$

The second evaluation measure is CWSSIM [1] and is found out from the equation given below:

$$CWSSIM(c_x, c_y) = \frac{2\left|\sum_{i=1}^{N} c_{x,i} * c_{y,i}\right| + k}{\sum_{i=1}^{N} |c_{x,i}|^2 + \sum_{i=0}^{N} |c_{y,i}|^2 + k} \quad (7)$$

where, k is a small positive constant and $c_x$, , $c_y$ are complex wavelet co-efficients that correspond to image patches x and y. $\mu x$ and $\mu y$ are the mean values of the image. The value $\sigma_x$ and $\sigma_y$ are the standard deviations of the resultant image. The results of PSNR and CWSSIM are tabulated in Table.2.

Table.2. Performance Comparison with PSNR and CWISS

| Image | Method | PSNR | CWISS |
|---|---|---|---|
| **Lena** | Sobel | 186.296 | 1.000 |
| | Prewitt | 28.062 | 0.535 |
| | Robert | 28.057 | 0.521 |
| | Fuzzy filter | 10.208 | 0.346 |
| **Mineral** | Sobel | 186.069 | 1.000 |
| | Prewitt | 27.612 | 0.297 |
| | Robert | 27.599 | 0.300 |
| | Fuzzy filter | 12.847 | 0.394 |
| **Rice** | Sobel | 186.296 | 1.000 |
| | Prewitt | 27.730 | 0.409 |
| | Robert | 27.738 | 0.425 |
| | Fuzzy filter | 8.776 | 0.655 |

## 7. CONCLUSION

Conventional object detection methods, Robert and Prewitt methods are not suitable with its convolution. In the Fuzzy inference based method the edges of the regions are thick with less complexity. In the proposed method the threshold parameter is decided for generating the thick edge value of the given image. In the boundary generated from the ordinary gradient based method, noises appear at the ramp edges of the resultant image. PSNR and CWSSIM produce computationally efficient result than the traditional algorithms. The blur is reduced at the thick corner of the edges. The proposed fuzzy based method solves the problem of narrow gray range values and it shows that the extracted edges are thick and have less impulsive noise in the object contours.

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