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A New Programming and Mathematical Approach to Improve the Edge Detection of Brighter Images

Kalyan Kumar Jena*

Department of Computer Science Engineering & Application,
Indira Gandhi Institute of Technology, Sarang, Odisha, India

Abstract—Edge Detection is a widely used technique in image processing for edge detection of different Gray-scale and color image. In this paper a new method for edge detection of images is presented. This method is based on the concept of construction of interval-valued fuzzy relation .This method would be helpful in examining various brighter images. To compare the results, we also examine the result of some traditional methods of edge detection. Finally, this method is applied to images and the results are compared.

Keywords--- Interval-valued Fuzzy Relation , Image Processing , Edge Detection

I. INTRODUCTION

Edge detection has became serious challenge to image processing research personnel .Generally, the edges are representation of the discontinuities of image intensity function .There could be various reason such as lighting conditions ,object geometry , type of material surface texture etc , as well as their mutual interaction , for discontinuities.

Edge detection algorithm is essentially a process of detection of this discontinues in an image. But the process of edge localization is quite complex in case of gray level or intensity image. There are different operators used to perform edge detection.The widely used operators such as Sobel , Prewitt, Roberts, Canny and Laplacain are sensitive to noises and their anti-noise performances are poor[2]. Fuzzy techniques have always been utilized as one of the modern methods in different processes. This paper mainly used sobel, prewitt, Robert and Canny operators to do edge detection on bitmap images and compare the results with the results of upper constructor with Laplacian method which is based on fuzzy systems[1]. It has been proved that the effect by using this fuzzy method to do edge detection is very good and it can highlight almost all the edges associated with an image[10].This method detects the edges in high illumination areas.

II. EDGE DETECTION CONCEPT

The objective of edge detection is to mark the points in an image at which the luminous intensity changes sharply. Sharp changes in image properties usually reflect important events and changes in properties of the world. These include discontinuities in depth, discontinuities in surface orientation, changes in material properties and Variations in scene illumination. Edge detection is a research field within image processing and computer vision, in particular within the area of feature extraction. There are many methods for edge detection [4].Edge detection of an image reduces significantly the amount of data and filters out information that may be regarded as less relevant, preserving the important structural properties of an image.Edge pixel or edge elements are detected by taking derivative followed by thresholding and they occasionally incorporate noise cleaning scheme .Two dimensional derivative are computed by means of what we call is edge mask. Edges may be viewpoint dependent - these are edges that may change as the viewpoint changes, and typically reflect the geometry of the scene, objects occluding one another and so on.

Edges may be viewpoint independent - these generally reflect properties of the viewed objects such as surface markings and surface shape. A typical edge might be the border between a block of red color and a block of yellow; in contrast a line can be a small number of pixels of a different color on an otherwise unchanging background. There will be one edge on each side of the line. Edges play quite an important role in many applications of image processing. .

Taking an edge to be a change in intensity taking place over a number of pixels, edge detection algorithms generally compute a derivative of this intensity change. To simplify matters, we can consider the detection of an edge in one dimension. In this instance, our data can be a single line of pixel intensities. The edge detection methods that have been published mainly differ in the types of smoothing filters that are applied and the way the measures of edge strength are computed[3]. As many edge detection methods rely on the computation of image gradients, they also differ in the types of filters used for computing gradient estimates in the x- and y-directions.

III. SOBEL OPERATOR

The Sobel operator[5] performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input gray scale image[7].In theory at least, the operator consists of a pair of 3×3 convolution kernels as shown in Figure 1. One kernel is simply the other rotated by 90°. This is very similar to the Roberts Cross operator.

$$\begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \qquad \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}$$

G_X **G_Y**

Fig. 1 Sobel operator mask

IV. PREWITT OPERATOR

The Prewitt operator[5] is used in image processing, particularly within edge detection algorithms. Technically, it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Prewitt operator is either the corresponding gradient vector or the norm of this vector. The Prewitt operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. On the other hand, the gradient approximation which it produces is relatively crude, in particular for high frequency variations in the image. The Prewitt operator is named for Judith Prewitt.

Mathematically, the operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical. If we define $\mathbf{A}$ as the source image, and **Gx** and **Gy** are two images which at each point contain the horizontal and vertical derivative approximations, the latter are computed as:

$$G_{X=} \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix}$$

$$G_{Y=} \begin{bmatrix} +1 & +1 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$$

Fig. 2 Prewitt Operator Mask

V. ROBERT OPERATOR

It can also detect the edges by using the following mask:

+1	0
0	-1

Gx

0	+1
-1	0

Gy

Fig. 3 Robert Operator Mask

VI. CANNY OPERATOR

The Canny operator was designed to be an optimal edge detector according to particular criteria.The operator works in a multi-stage process.First of all the image is smoothed by Gaussian convolution.Then a simple 2-D first derivative operator is applied to the smoothed image to highlight regions of the image with high first spatial derivative. Edges give rise to ridges in the gradient magnitude image.

Step 1

- Noise is filtered out – usually a Gaussian filter is used
- Width is chosen carefully

Step 2

- Edge strength is found out by taking the gradient of the image
- A Roberts mask or a Sobel mask can be used

Step 3

- Find the edge direction

$$\theta = \tan^{-1}\left(\frac{Gy}{Gx}\right)$$

Step 4

- Resolve edge direction

Step 5

- Non-maxima suppression – trace along the edge direction and suppress any pixel value not considered to be an edge. Gives a thin line of edge

Step 6

- Use double / hysterisis thresholding to eliminate streaking

VII. UPPER CONSTRUCOR WITH LAPLACIAN METHOD

The *upper constructor* is a generalization of the tn-processing

A t-norm T: $[0, 1]^2 \rightarrow [0, 1]$ is an associative, commutative, increasing function, such that, T(0, x) = x for all x ∈ [0, 1].

A t-norm T is called idempotent if T(x, x) = x for all x ∈ [0, 1].

The four basic *t*-norms are as follows

1. The maximum $T_M(x,y)=\max(x,y)$.
2. The probabilistic sum $T_P(x, y) = x+y-x.y$
3. The Łukasiewicz t-norm
   $T_L(x, y) = \min(x + y , 1)$.
4. $T_{nM}(x, y) = \max(x, y)$, *if x +y < 1*
   1, otherwise.

- Let R ∈ F(X × Y) be an FR. Consider two t-conorms T1 and T2 and two values n,m ∈ N such that n ≤ P −1/2 , and m ≤ Q−1/2 .We define the upper constructor associated with T1 , T2 , n, and m in the following way:
- $L^{n,m}$T1 ,T2 : F(X x Y) →F(X x Y) given by
  $L^{n,m}$T1 ,T2 [R](x, y) =
  $T_1^{m,n}(T_2(R(x-i, y-j), R(x,y)))$
  i=-n
  J=-m
  for all (x,y)∈(X,Y)

The Algorithm begins with reading an M x N image. The first set of nine pixels of a 3x3 window are chosen with central pixel having values (2,2) i.e for each pixel(i,j) we are taking the 8 neighbourhood of (i,j).After the initialization, the pixel values are initially marked as edge pixel after an observation to the 8 neighbourhood. After the subjection of the pixel values the algorithm generates an intermediate image using a construction method stated below. 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. In this manner the window shifts and checks all the pixels in one horizontal line then increments to check the next vertical location.

After edge highlighting image is subjected to another set of condition with the help of which the unwanted parts of the output image of type 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. For an input image A and an output image B of size M x N pixels respectively we have the following set of conditions that are implemented to detect the edges pixel values.

Input*:* An image A of M x N pixels (Phase 1)

Output*:* An image B of M x N pixels

```
Initial Edge Detection (A, B) using Max Construction
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) is maximum and highlighted as edge initially.
  End For
End For
```

In the above algorithm Max construction [1] is used but not after fuzzification as after fuzzification the membership values would become fractions that can't be stored in unsigned char. Hence the same technique of max construction is used but on true picture and taking into consideration 8-nbd of a pixel (i,j).

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 and initially min valued edge pixels are given white value. These pixels are initially marked as edge.

Input: An image B of size MxN (Phase 2.)

Output: Edge image of size MxN

We now use Laplacian operator[3] on the intermediate image to get the edge image. And In this way whatever image is being constructed is compared with edges found on same image by other existing techniques.

Laplacian operator is

$$\begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 2 & 1 & 0 \\ 1 & 2 & -16 & 2 & 1 \\ 0 & 1 & 2 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

Fig. 4 Laplacian Operator Mask which is stored in a 5x5 array.

VIII. EXPERIMENTAL RESULTS AND ANALYSIS

First, use the traditional edge detection operators (include Sobel operator, Prewitt operator, Robert operator and Canny Operator) to do edge detection. Then use the max constructor with laplacian operator[1] which is based on fuzzy systems to do the edge detection.

Traditional edge detection operators are used for edge detection, and the results are showed in Figure 5,6,7,8,9:

Fig..5 The original image

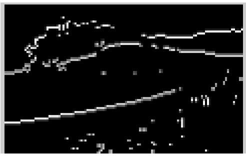

Fig. 6 Edge detection using sobel operator

Fig. 7 Edge detection using Prewitt operator

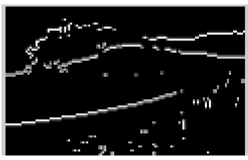

Fig. 8 Edge detection using Robert operator

Fig. 9 Edge detection using Canny operator

we are performed edge detection using sobel,prewitt,Robert and Canny edge detection methods and outputs are displayed for the corresponding input images which are shown in the Figure 5, 6,7,8,9. Though some portions of edges are clearly visible but some of the higher intensity areas are not so clearly visible. In order to overcome this defect, the paper combines Laplacian operator and max construction method, see in Figure 10:

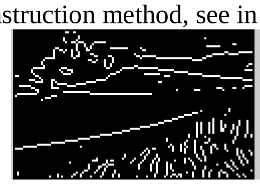

Fig. 10 Edge detection using Upper Constructor with laplacian operator

Figure 10 shows the output of max construction with laplacian operator. The laplacian operator essentially act as a band pass filter because of its differential and smoothing behavior

Again the Laplacian is separable which make computation very efficient. Therefore, it plays a certain role in smoothing the image and max construction helps in detecting the edges in higher illumination areas.

IX. CONCLUSION

In this paper, the method to find the edges associated with an image had been implemented .Comparison were made amongst the various other edge detection algorithms that have already been developed and displayed the accuracy of the edge detection using Upper constructor with laplacian method. Upper constructor with laplacian method detects the edges of the image with higher contrast in a very effective manner which provides better results as compared to all the traditional edge detection operators.

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AUTHOR PROFILE

Kalyan Kumar Jena B.Tech(CSE),M.Tech(CSE.),Ph.D.(Continuing) Asst. Prof., Dept. Of Computer Science Engg. & App. Indira Gandhi Institute Of Technology,Sarang,Odisha,India Research Area: Image Processing (Edge Detection)