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Edge Detection using Morphological Operator: A New Approach

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Abstract— Edges are regions of interest where there is a sudden change in intensity. These features play an important role in object identification methods commonly used for many applications in computer vision and pattern recognition. This paper presents methods for edge detection using morphological operator. Morphological edge detector heavily relies on the choice of the structuring element (SE) and the results will vary from one SE to other. Therefore, the novel approach is used to find the SE from the image itself using freeman chain code, which is then followed by the Morphological Gradient method to detect edges. The proposed method is very simple, efficient and fast. An experimental result on various images shows all the prominent edges efficiently.

Keywords— Edge Detection, Morphological Operator, Chain Code

I. INTRODUCTION

Edges are the changes or discontinuities of intensity in an image. Edges typically occur on the boundary between two different regions in an image. The goal of edge detection is to produce a line drawing of a scene from an image of that scene. Important features can be extracted from the edges of an image like corners, lines, curves. These features are used by higher-level computer vision algorithms for many applications. Classical methods of edge detection involve convolving the image with an operator which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. Early conventional edge detectors such as Sobel, Prewitt and Laplacian of Gaussian operator are not effective for noisy images [1]. There are an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Variables involved in the selection of an edge detection operator include Edge orientation, Noise environment and Edge structure. The geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be optimized to look for horizontal, vertical, or diagonal edges. Edge detection is difficult in noisy images, since both the noise and the edges contain high frequency content. The operator needs to be chosen in such a way that they are responsive to such a gradual change. So, there are problems of false edge detection, missing true edges, edge localization, high computational time and problems due to noise etc. Canny edge detection algorithm removes noise to some extent but does not give perfect edge in all the cases. Morphological edge detectors here plays a important role in case of noisy images but these detectors requires the selection of the SE which is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one. The smaller the size of SE, lesser is the noise removing capacity and more the ability to detect fine edges. By using large SE, more amount of noise is reduced likewise thickness of edges increases causing smearing of closely spaced edges. Therefore, the main objective is to dynamically select a SE and then detect edges using Morphological gradient method.

II. RELATED WORK

Early edge detector includes Soble, Perwitt, Canny edge detector fails to work well with the noisy image. In order to overcome these disadvantage many author have explored morphological operators for edge detection. Aslam et al [2] have suggested morphological edge detector where Rod shaped with flat top SE is used for edge detection. They have also used the SE of different size and concluded that if the size of the SEs were too small it fails to remove the noise and if the size of the SE increases thicker edge were obtained, causing smearing of edges. This smearing of edges were controlled using multi directional morphological edge detectors. Chanda et al. [3] have also proposed morphological edge detection methods using multi-scale approach for detecting edges of various fineness under noisy condition based on the theory of mathematical morphology. The proposed detector has better noise immunity and orientation and positional response compared to most of the conventional morphologic edge detectors. Rama Bai et al. [4] have proposed a novel approach for noise removal cum edge detection for both gray scale and binary images using morphological operations - erosion and dilation.

Most of the authors have used fixed size and fixed shape SE for applying morphological operators on images, these SEs works very well with one type of images but fails completely for other type of images. Larger the size of the SE there will be high noise removal but produces thicker images, smaller the size of SE less will be the noise removal but produces thin edges. Similarly, square shaped SE are chose to detect straight lines and round SE is chosen for detecting circular features. The appropriate shape and size of SE to get the desired edges of the image is difficult to obtain.

Limited work has been carried out in past to generate dynamic SE that will suit for all the types of the images. Lee et al. [5] have proposed a new morphological edge detector using amoebas, dynamic SEs which adapts their shapes to image contours. The proposed methods have less sensitivity to noise while detecting more details of image than other morphological edge detectors with a fixed SE. Mahesh Kumar et al. [6] have suggested a novel mathematical morphological edge detection algorithm based on multi shape structure, is proposed to detect the edge of lungs CT image with salt-and-pepper noise. The proposed work aims at generating SE dynamically from the image itself using chain code for morphological edge detector.

III. MORPHOLOGICAL OPERATOR DEFINITION [8]

- **Erosion:** The erosion of a set X by a structuring element B is denoted by $E_B(X)$ and is defined as the locus of points x, such that B is included in X when its origin is placed at x:

$$E_B(X) = \{x \mid Bx \subseteq X\}$$

- **Dilation:** The dilation of a set X by a structuring element B is denoted by $D_B(X)$ and is defined as the locus of points x such that B hits X when its origin coincides with x:

$$D_B(X) = \{x \mid Bx \cap X \neq \emptyset\}$$

- **Morphological Gradient:**
- Morphological gradient is the arithmetic difference between the dilation and the erosion with the elementary structuring element B:

$$P_B(X)=E_B(X) - D_B(X)$$

IV. METHODOLOGY USED

The problem faced in the various methods for detection of edges using morphological operator is the selection structural element, usually the shape and size of the structuring element are chosen by trial and error method. The proposed methodology comprises of following steps (Schematic diagram is shown in figure 1):

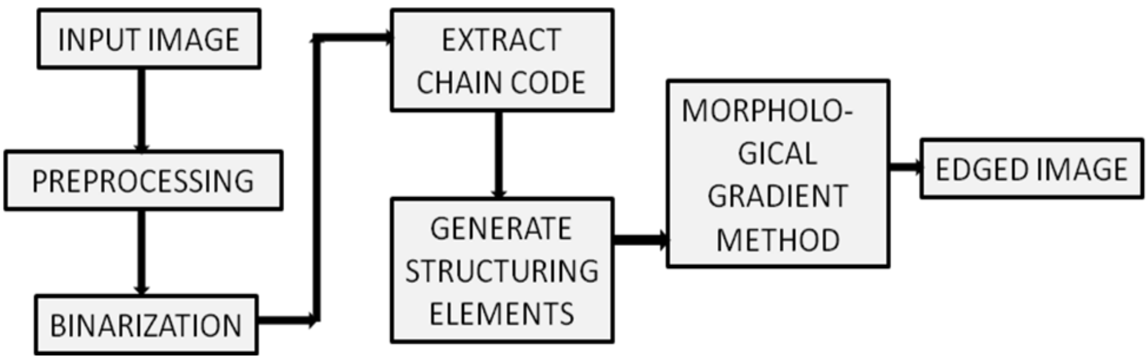


FIGURE 1: SCHEMATIC DIAGRAM REPRESENTING THE PROPOSED METHODOLOGY.

i. ***Preprocessing:***
This step comprises of cleaning an image using median filter to reduce noise if any. Median filter is used to remove salt and pepper noise. It is followed by converting color image to gray scale images.

ii. ***Binirization:***
This step is used mainly to identify the various regions in an image. Global thresholding is used to binarize the input image.

iii. ***Extract chain code:***
Freeman Chain code is used to obtain the chain code for the input image. Chain codes are used to represent a boundary by a connected sequence of straight line segments of specified length and direction. Typically this representation is based on 4- or 8- connectivity of the segments. The direction of each segment is coded by using a numbering scheme shown in Figs. 2(a) and 2(b).

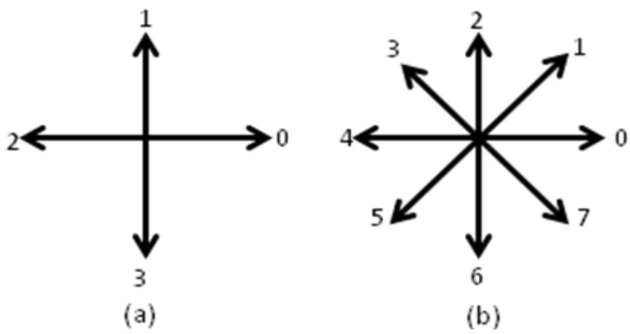


Fig. 2 Freeman Chain code using (a) 4- connectivity and (b) 8- connectivity

The chain code of a boundary depends on the starting point. However, the code can be normalized with respect to the starting point by treating it as a circular sequence of direction numbers and redefining the starting point so that the resulting sequence of numbers forms an integer of minimum magnitude.

iv. ***Generate Structuring elements:*** The chain code obtained is used to extract the structural element from the chain code dynamically. Methods used to built SEs are given below:

a. ***Method 1:***
- Extract Freeman Chain code from the binary image.
- Declare a 3x3 mask representing the 8-connected Freeman Chain code.
- Calculate the difference between adjacent values of Freeman Chain code
- If difference is positive then update the same structuring element with value 1 in the same position w.r.t the 3x3 mask.
- Else create a new SE and insert the value 1 in the same position w.r.t the 3x3 mask.
- Repeat the process till the end of the Freeman chain code.
- Combine all the resulting SE into one.

b. ***Method 2:***
- Extraction of Freeman Chain code from the binary image.
- Declare a 3x3 mask representing the 8-connected Freeman Chain code.
- Create a structuring element.
- Compare each element of Freeman Chain code with the position of 3x3 mask.
- Insert 1 in the SE at the position where the values of 3x3 mask and Freeman Chain code match.
- Repeat the process till the end of the Freeman chain code.

For the test image given below the SE generated using method 1 and 2 are

Test Images	Method1				Method2
	SE1	SE2	SE3	combined	SE
	0 0 0 0 1 1 0 1 0	0 1 0 0 1 1 0 0 0	0 1 0 0 1 0 0 0 0	0 1 0 0 1 1 0 1 0	1 1 1 1 1

Fig. 3 SEs obtained using method 1 and 2.

Depending upon the input images the various SEs generated dynamically are shown below in Figure 4.

	1	
1	**1**	**1**
	1	

	1	
1		**1**
	1	

	1	**1**
1	**1**	**1**
1	**1**	

1	**1**	**1**
1		**1**
1	**1**	**1**

Fig. 4 SEs obtained using a chain code method

v. ***Edge Detection:*** Final step is to use this dynamic SEs to extract edges in an image using morphological gradient method.

V. RESULTS AND DISCUSSIONS

The results shown in Table 1 shows that Morphological edge detection outperforms Canny Edge Detector. It gives continuous edge and it also filters out the noise present in the input image. Canny operator detects all the edges, though it is consider as the most efficient edge detector as the continuity of the edges are maintained but it also considers the noise as the part of the object. Morphological edge detector suppresses the noise effectively but may give gives poor edge detection due to the wrong choice of SEs. Therefore, the approach discuss in this paper generates SEs dynamically from the input image using chain code method. The visual analysis shows that the proposed method gives the smooth edges compare to canny edge detector in addition it also removes the noise.

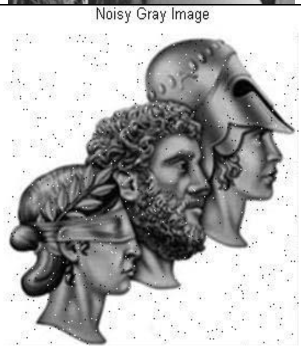
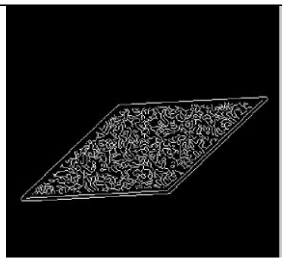
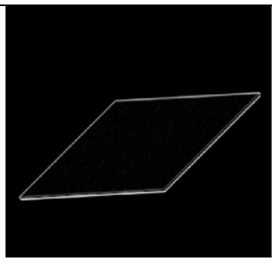
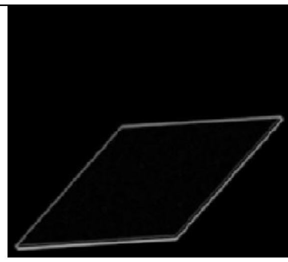
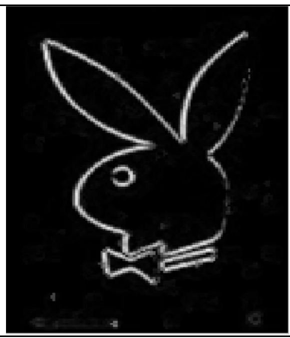
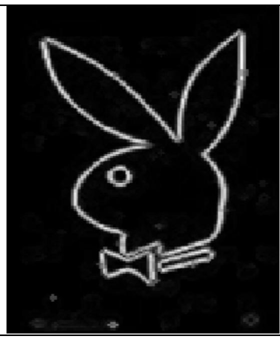
Input Image	Canny Edge Detection	Morphological Edge Detection using dynamic SEs (Method 1)	Morphological Edge Detection using dynamic SEs (Method 2)
			
			
			
			

TABLE 1.
COMPARISON OF CANNY AND MORPHOLOGICAL EDGE DETECTOR.

VI. CONCLUSION

In this paper, a new approach to generate SEs dynamically form the input image is proposed for morphological edge detector. Results of morphological operator will differ with the choice of SEs, therefore, an attempt has been made to extract chain code of the input image which is used to generate SE dynamically. The proposed algorithms shows better result compare to traditional edge detector and also helps to remove the noise contained in an image.

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