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A new Morphological Approach for Noise Removal cum Edge Detection

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Abstract

Edge detection is an important aspect in image processing. When a noisy image is presented for edge detection, the noise creates problem in the process of edge detection using conventional methods. One of the disadvantages of the conventional methods is that the noise is not removed automatically. The present paper proposes a novel approach for noise removal cum edge detection for both gray scale and binary images using morphological operations. Two images consisting of noise are processed and the effectiveness of the proposed approach is experimentally demonstrated. The results demonstrate that the proposed filter cum edge detector approach overcomes the deficiency of conventional methods and efficiently removes the noise and detects the edges.

Key words: Mathematical morphology, Structuring element, edge detection, morphological residue detector, noise, morphological gradient.

1. Introduction

Edges play an important role in image processing hence their detection is very important. The result of the final processed image depends on how effectively the edges have been extracted. The function of edge detection is to identify the boundaries of homogeneous regions in an image based on properties such as intensity and texture. Some early conventional methods for edge detection are Sobel algorithm, Prewitt algorithm and Laplacian of Gaussian operator. But they belong to high pass filtering methods, which are not effective for noisy images because noise and edge belong to the scope of high frequency. In real world applications, images contain object boundaries, object shadows and noise. Therefore, it may be difficult to distinguish the exact edge from noise or trivial geometric features. Many edge detection algorithms have been developed based on computation of the intensity gradient vector, which, in general, is sensitive to noise in the image.

Another approach is to study the statistical distribution of intensity values. The idea is to examine the distribution of intensity values of neighbourhood of a given pixel and determine if the pixel is to be classified as an edge. Although there exist some works, less attention has been paid to statistical approaches than the gradient methods in image processing. As the performance of classic edge detectors degrades with noise, edge detection using morphological operators is studied.

In this paper, a new morphological approach for noise removal cum edge detection is introduced for both binary and gray scale images. For detecting edges in an image efficiently, first the noise is to be removed. Noise in binary images is of two colours, black and white. The noise in gray scale images manifests itself as light elements on a dark background and as dark elements on the light region. Noise is removed using morphological operations and further morphological operations are applied on this image to extract the edges.

2. Basic Operations of Mathematical Morphology

Mathematical morphology is based on set theory which can be used to process and analyse the images. It provides an alternative approach to image processing based on shape concept stemmed from set theory. In mathematical morphology images are treated as sets, and morphological transformations which derived from Minkowski addition and subtraction are defined to extract features in images. The image which will be processed by mathematical morphology theory must be changed into set and represented as matrix.

Structuring Elements are used in morphological theory, which are also represented as matrices. Structuring element is a characteristic of certain structure and features to measure the shape of an image and is used to carry out other image processing operations. The shape and size of the structuring element (SE) plays crucial role in image processing and is therefore chosen according to the condition of the image and demand of processing.

The basic mathematical morphological operations namely dilation, erosion, opening, closing are used for detecting, modifying, manipulating the features present in the image based on their shape. In the following, some basic mathematical morphological operations of gray-scale images are introduced.

Let I (x, y) denote a gray-scale two dimensional image, SE denote structuring element. Dilation of a gray-scale image I(x, y), by a gray-scale structuring element SE (a, b) is denoted by

$$(I \oplus SE)(x, y) = \max\{I(x-a, y-b) + SE(a,b)\} \quad (1)$$

Erosion of a gray-scale image $I(x, y)$ by a gray-scale structuring element SE(a, b) is denoted by

$$(I \ominus SE)(x, y) = \min\{I(x+a, y+b) - SE(a,b)\} \quad (2)$$

Opening and closing of gray-scale image $I(x, y)$ by gray-scale structuring element SE(a,b) are denoted respectively by

$$I \circ SE = (I \ominus SE) \oplus SE \quad (3)$$

$$I \bullet SE = (I \oplus SE) \ominus SE \quad (4)$$

Erosion basically decreases the gray-scale value of an image by applying shrinking transformation, while dilation increases the gray-scale value of the image by applying expanding transformation. But both of them are sensitive to the image edge whose gray-scale value changes obviously. Erosion filters the inner image while dilation filters the outer image. Opening is erosion followed by dilation and closing is dilation followed by erosion. Opening generally smoothes the contour of an image, breaks narrow gaps. As opposed to opening, closing tends to fuse narrow breaks, eliminates small holes, and fills gaps in the contours.

3. The New Approach for Noise Removal cum Edge Detection

In the proposed method, closing then followed by opening is performed using an appropriate Structuring Element (SE) on the image to be processed. Again closing operation is performed on the resultant image. This removes the noise from the image and hence is used to pre-process the image. The choosing of structuring element is a key factor in morphological image processing. The size and shape of the structuring element decide the final results of detected edges and de-noising in both binary and gray scale images.
Three methods are proposed to detect edges in the image.

Method 1: The edge of the image is detected by the following process. The edge of an image *I* which is denoted by E (*I*) is defined as the difference set of the dilation domain of *I* and the domain of *I*.

It can be depicted by the following equation

$$\{[(I \bullet SE) \circ SE] \bullet SE\} \oplus SE - \{[(I \bullet SE) \circ SE] \bullet SE\} \quad (5)$$

Method 2: The edge of the image can also be detected by the following process. The edge of an image *I* which is denoted by E (*I*) is defined as the difference set of the domain of *I* and the eroded domain of *I*.

It can be depicted by the following equation

$$\{[(I \bullet SE) \circ SE] \bullet SE\} - \{[(I \bullet SE) \circ SE] \bullet SE\} \ominus SE \quad (6)$$

Method 3: The edge of the image can also be detected by the following process. The edge of an image *I* which is denoted by E (*I*) is defined as the difference set of the dilated domain of *I* and the eroded domain of *I*.

It can be depicted as follows

$$\{[(I \bullet SE) \circ SE] \bullet SE\} \oplus SE - \{[(I \bullet SE) \circ SE] \bullet SE\} \ominus SE \quad (7)$$

4. Experimental Results and Conclusions

The proposed methods are applied on two images, a binary image with salt and pepper noise as shown in Fig.2 and a gray scale image with salt and pepper noise as shown in Fig.3. The structuring element used in all the methods is a 3x3 window as in Fig.1. As it is already brought out in previous sections that selection of an appropriate structuring element is very important step which has large bearing on the results that are produced.

0	1	0
1	1	1
0	1	0

Fig.1

Fig.2

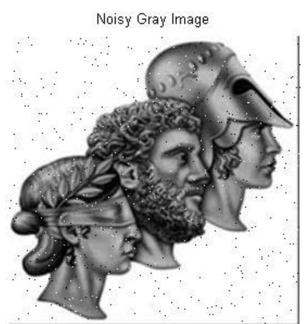

Fig.3

The results obtained using proposed ***Method-1*** are shown below in Fig.4 and Fig.5.

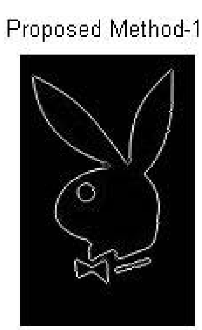

Fig.4 Fig.5

The results obtained using proposed ***Method-2*** are shown below in Fig.6 and Fig.7.

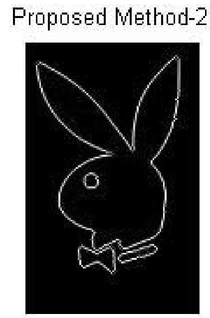

Fig.6 Fig.7

The results obtained using proposed ***Method-3*** are shown below in Fig.8 and Fig.9.

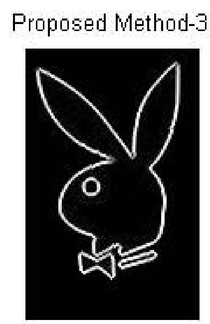

Fig.8 Fig.9

It could be seen from the above results that noise is completely removed from the images and edges are extracted.

In ***Method-1,*** edges are thinner and some interior edges are not detected effectively in gray scale image. In ***Method-2,*** the edges are a little thicker and more number of edges could be seen. ***Method-3*** outperforms previous two methods, edges are more continuous and almost all edges could be extracted.

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