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Shape Detector and Region of Interest Filtering : A Case Study

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Abstract: Image processing is becoming most popular domain in almost all filed of engineering and sciences. More specifically, image enhancement techniques are powerful in the field of medicine, industry automation, consumer electronics, computing science, etc. In this study, a particular shape is being detected from the input image using morphological algorithms. Erosion, dilation, erosion followed by dilation and dilation followed by erosion are the main morphological operations to enhance the input image. Shape detector work belongs to the category of image analysis which is an another useful tool which helps for pattern recognition, computer vision, image understanding, etc. Also an another task i.e., region of interest (ROI) filtering is being implemented to enhance the quality of the specific portion of the image. A simple two-dimensional convolution is applied as filtering to the region of interest. High-pass filters are applied to detect the edges of the image. Sobel, Roberts, Prewitt and Canny algorithms can also applied for the purpose of edge detection. Finally, the results are verified using Matlab software tool.

Key words: Image enhancement · Morphology · Region of Interest · Shape detector

INTRODUCTION

Signal and image processing field is used with every area of engineering and sciences. Researchers are working towards developing new algorithms for the betterment of image processing. Some algorithms are good at quality but at the cost of hardware complexity and cost. Some are above average quality with few hardware resources for the computation. So always there is a trade off between the quality and design complexity. Depends on the requirement, the choices are made and the algorithms will be further optimized to balance them [1].

Average filtering is useful to remove the noise from the input image; which also blurs the image. If the input is blurred, the image is enhanced by applying this kind of simple moving average filters in some applications like capturing snapshot while the cars are moving. If the noise added to the input image follows patterns of salt and pepper, then non-linear filters like median filters are used to remove them. Histogram equalization is an another approach through which the image enhancement would be achieved. Also point processing is a very useful technique for the betterment of the quality of the output processed image. Both linear and non-linear point operations can be done to improve the processing further [2].

Morphological operations are an another pertinent approach in the image enhancement field. More specifically, this kind of set theory based algorithms are much useful in pattern recognition. Erosion and the dilation are the most fundamental processes in morphology. A erosion process reduce the size of a particular pattern while the dilation enlarge it. Morphological noise filtering can also be achieved with the help of opening and closing. Hit-or-miss transform is an another morphology approach to detect a particular pattern from the input image [1, 3].

A main objective of this study is to detect a particular shape or a pattern using morphological image processing. The input image has both white circles and stick patterns, in which white circles are alone to be retained using dilation and erosion operations. Also the region of interest filtering is implemented with the help of simplest two-dimensional convolution approach by means of low-pass and high-pass filters. Finally, the resulting images are compared with the study requirements [4, 5].

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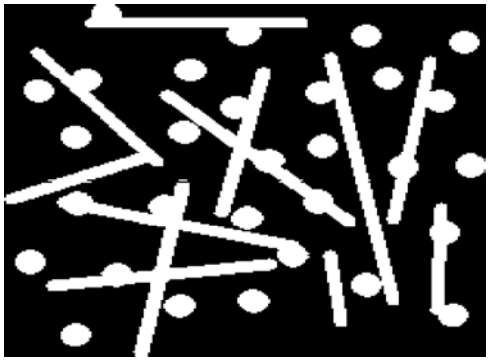

Fig. 1: Original image with circles and rectangles

Shape Detector: Morphological image processing is the best tool used for extracting or modifying information on the shape or structure of the objects within an image. Very often this would be applied to binary images and also this can be extended to gray scale images too. This is the different one from filtering in which the noise is filtered with the help of filter and the output image is obtained. But here, a kind of image analysis is performed to the given input image. For example, a classifier is used to convey the category of the objects in an image. In this study, a particular shape is being detected from the input image with the help of erosion and dilation morphological operations [1, 7].

Figure 1 shows the input image which contains circles and rectangle sticks. The objective is to detect the circles using opening by appropriate circular structuring element. Dilation is used to enlarge the pattern of interest while the erosion will shrink it. Closing is defined as dilation followed by erosion; the erosion followed by dilation is referred to as opening. Skeletonization is an another important operator is used to identify the center of the object or pattern [8].

Erosion and Dilation: Erosion is a process in which the structuring element is placed on the input image and if every pixel in a structuring element matches every pixel in the image region, the center pixel is replaced by 1. The size of the pattern is shrinking while the implementation of erosion process. If this process is repeated twice or thrice, the region of interesting pattern size will be minimized further.

Dilation is a process in which the structuring element is placed on the input image and if at least one pixel match with the structuring element, then the center pixel is replaced with the 1. If the dilation is required in all directions or horizontally and/or vertically, the structuring elements are chosen appropriately [9]. The size and the design of the structuring element play a vital role in the dilation process. Actually the original pattern size will be enlarged. Even to detect a boundary line of a object, this dilation could be useful. This is accomplished by dilating all directions and by subtracting the original image from the result [10].

Shape Detector Using Opening: Figure 2 shows the circular structuring element B, which used for binary opening to detect the circles. A process of erosion followed by dilation is applied for this task.

$$B = \begin{bmatrix} 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 \end{bmatrix}$$

Fig. 2: Circular structuring element for opening

The opening operation as erosion followed by the dilation using structuring element B is implemented as in Equation 1. Erosion output fit the circular pattern and the size of the circles are reduced. Also the rectangle stick objects are eliminated since this pattern is completely different from the circular structuring element. The dilation process is applied to enlarge the pattern of circles.

$$Y = (A \square B) \oplus B \quad (1)$$

Figure 3 shows only the portion of circles as expected, which is the result after erosion. Since the size of the circled patterns are reduced, to acquire the correct result the dilation is applied on this result.

Figure 4 shows the result of dilation after erosion. In spatial domain filtering, averaging filters are used to blur the image and to remove the high frequency noise contents in the image. But these filters are not good in the filtering of salt and pepper noise. A non-linear filter like median filter would be used to remove this kind of impulsive noise from the image. In spatial domain filtering to remove the salt and pepper noise with media filters, the larger size kernels are not appropriate since the median value deviates from the desired pixel. Morphological operations are not linear and are useful to remove the salt and pepper noise.

Fig. 3: Detection of circles using erosion

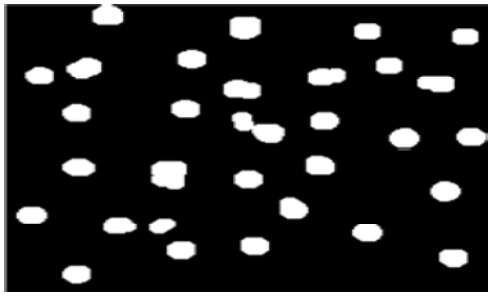

Fig. 4: Dilation process result of detected patterns with enlarged size

Internal and External Boundary Detection: Erosion and dilation can be also used for the boundary detection applications. The internal boundary detection is achieved by subtracting the erosion result from the original text image [1, 10]. The external boundary detection is achieved by subtracting the original text image from the dilation result; the equations are as follows,

Internal boundary: $A - (A \square B)$
External boundary: $(A \oplus B) - A$

The applied structuring element B is as follows,

$$B = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

Figure 5 shows the input text image and figure 6 shows the corresponding internal and external boundary detection resulting images.

Hit-or-miss Transform: Hit-or-miss transform is a powerful tool for finding shapes in the images. Both erosion and dilation operations are normally used in morphological algorithms; but only erosion term is used with hit-or-miss transform for finding the pattern in a given image. The procedure to detect a particular pattern is as flows:

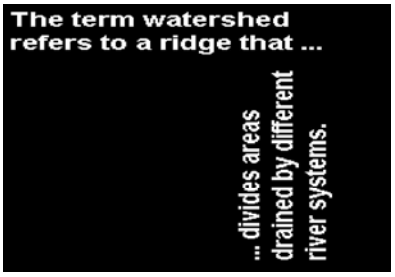

Fig. 5: The text image used for the internal and external boundary detection

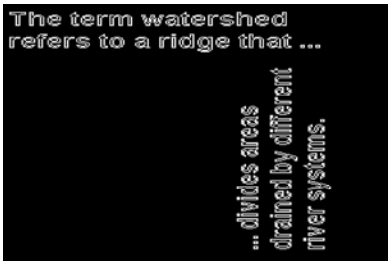

Fig. 6(a): Internal boundary

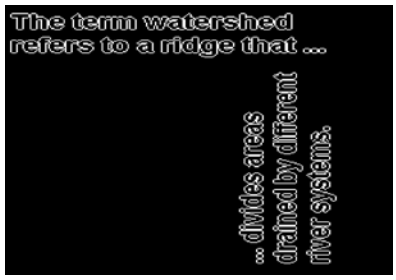

Fig. 6(b): External boundary

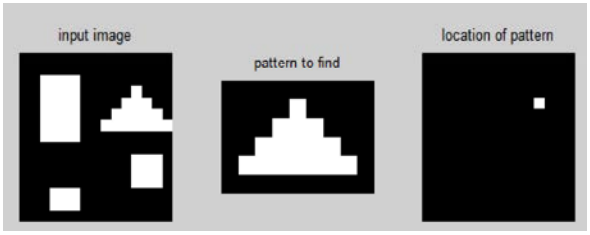

Fig. 7: Pattern detection using hit-or-miss transform

- The erosion process is applied to the input image A with structuring element B, which is a 3x3 with all ones.
- Then, pattern which is to be detected can act as an another structuring element. The complement of A is eroded with this new structuring element.
- The final result is obtained from the intersection of the above two results.

This entire process is applied and the results are shown in Figure 7.

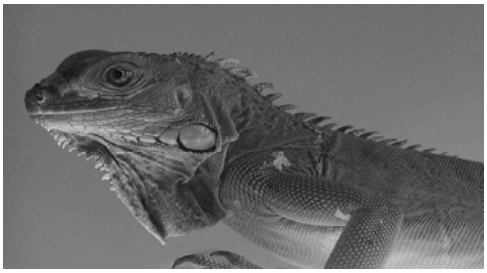

Fig. 8: Region of interest in Iguana image

Region of Interest Filtering: Spatial filtering is the easiest technique for the region of interest from the input image. Figure 8 shows the iguana image in which spatial filtering techniques are applied with the region of interest as face of the object. Portion of the object is retained while the remaining is blurred with the lowpass filter. The input image has the size of 461x664 in which row 60 to 200 and column 15 to 255 is the region of interest.

Figure 9 shows the convolution masks used for edge detection. All types of edge detection algorithms can also be implemented. Even unsharp msking can be implemented with the help of morphological operations. Still high-boost filtering, internal boundary and external boundary detection also can be applied to the ROI of the image. Figure 10 shows the blurring effect applied to the non-ROI portion; which will show the clear region of interest portion only. Figure 11 shows the high-pass filter output to the ROI portion.

(a) $\begin{bmatrix} 4 & 0 & -4 \\ 4 & 0 & 4 \\ 4 & 0 & -4 \end{bmatrix}$

(b) $\begin{bmatrix} 0 & 8 & 0 \\ 4 & 0 & -4 \\ 0 & -8 & 0 \end{bmatrix}$

Fig. 9: Convolutions masks used for edge detection

Fig. 10: Blurring effect applied to non-ROI portion

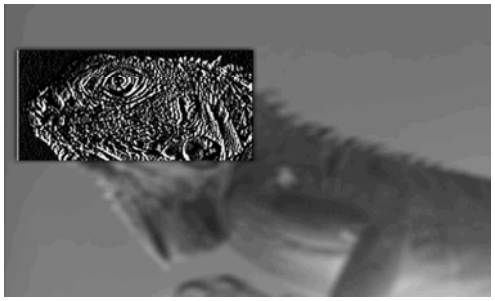

Fig. 11: Highpass filtering effect to the ROI portion

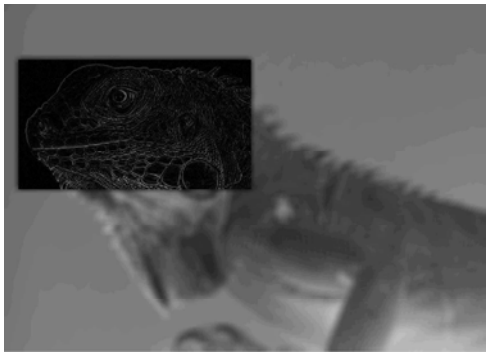

Fig. 12: Internal boundary detection of region of interest portion

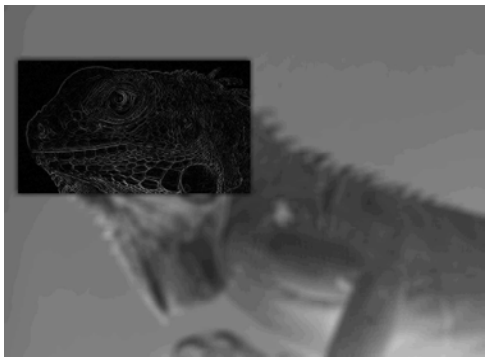

Fig. 13: External boundary detection of region of interest portion

Internal boundary detection is found by applying the erosion output to the ROI portion and subtracting the result from the ROI portion. This output is obtained as in Figure 12. Similarly, the external boundary detection can be achieved by subtracting the ROI portion from the dilation result. Figure 13 shows the external boundary detection using this concept.

RESULTS AND CONCLUSIONS

Morphological image processing is an effective tool for image enhancement and as well as image analysis. Erosion and dilation are the most fundamental operations

are being used for the task of detecting the shape in this study. The white circles are detected perfectly from the input image which contains both the circles and rectangle sticks. Opening and closing are operators to enhance further the image. Also region of interest filtering is implemented by applying lowpass and highpass filters along with internal and external boundary detection results. Hit-or-miss transform is used to detect a particular pattern from the input image. Further, Laplacian and Gaussian filtering can be implemented too to enhance the results better.Shape detection, highpass filtering, internal and external boundaries are very crucial to indentify the type of the object from the image. Pattern recognition can also be achieved using the frequency domain approach. Finger print recognition and classification and human face recognition are some of the most popular applications out of pattern recognition.

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