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Classification and Analysis of Morphological Edge Detectors

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Keywords : edge detector, de-noising capacity, orientation, mathematical morphology, edge accuracy.

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CLASSIFICATION AND ANALYSISOF MORPHOLOGICAL EDGE DETECTORS

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Classification and Analysis of Morphological Edge Detectors

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I. Introduction

Images when subjected to discontinuities in its physical features such as surface illumination, shadows, geometry and intensity levels causes distortion at its outline called edges. These edges represent vital information which needs to be detected and extracted to construct the original image. This process of detection of the edges and restoring the edges is called as edge detection. In the field of image processing edge detection is a key step in the preprocessing of a computer vision system. Due to this significance impact, edge detection plays a pivotal role, as its results affect the final performance of image processing directly.

Edge detectors employ various operators to perform edge detection. Traditional operators such as spatial differential operators or template matching operators were used widely to detect edges. Differential operators include Sobel edge operator. Template matching operators include Prewitt, Kirsch, Robinson three level and five level edge operators. The performance of these operators degrades with noise. Marr, Hildreth and Canny operators were developed with an inbuilt noise smoothening mechanism to overcome degradation due to noise.

Canny operator, though still exists, lags when compared to the advanced edge detectors using morphological approach.

Mathematical morphology technique is used for the analysis and processing of geometrical structures, based on set theory, lattice theory, topology and random functions. Features such as low noise sensitivity, low cost and easy computation makes morphology theory as most advanced technique in edge detection.

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Initially morphology dealt with binary images with basic operations of *dilation* and *erosion*. Based on these two compound operations *opening* and *closings* are defined. These operations when performed on single structural element becomes very sensitive to noise hence it is applied using multi structural elements.

Mathematical morphology as a significant sub-branch of nonlinear filtering theory has abandoned conventional mathematical modelling and analytical standpoint. It overcame the defect of high sensitivity to noise in traditional edge detection and could probe ideal edges located in the images. Hence the study of various morphology edge detectors gives us an in-depth understanding into the edge detection mechanism.

II. Edge Detectors

a) Morphologic Edge Detectors

Morphologic transformations form binary image to gray scale image. The morphological operations, *dilation (enlarges the image)* and *erosion (shrinks the image),* work with two images, the original image and a template called structuring element. Each structuring element has a particular shape which controls the parameters of the operation. A simple method of performing gray scale edge detection in morphology is to take the difference between an image and its erosion/dilation image generated by a structuring element. Rod shaped with flat top structuring element is popularly used for edge detection.

Dilation and Erosion Residue edge detectors are used in this method to perform edge detection. *Dilation residue edge detector*[1] provides edge strength to the side having low value. *Erosion residue edge detector* provides edge strength to the side having high value. These biased detectors are thus sensitive to noise.

b) Blur-Minimum Edge Detector

Dilation and Erosion operators are biased when they are applied for edge detection individually as seen above. To develop an unbiased edge operator, dilation and erosion operators are combined. The resultant combined operator is known as *blur-minimum edge detector*[3]. This is a good detector of ramp edge and is less sensitive to noise.

This cannot detect ideal step edges. Emphasizing this defection which can be controlled by pre smoothing with simple mean filter. This increases the performance of edge detection, as it converts the step edge into ramp edge and reduces the noise in the image.

This detector lacks in localization sensitivity and produces thick edges, likewise edges are discontinuous in nature.

c) Multi-Scale Morphology Edge Detector

Iterative opening and closing operations are able to filter the noise and make the image smooth. As the size of the noise patterns in the image vary significantly, using one structuring element will not be able to remove the noise effectively.

In multi scale morphologic edge detector, structuring elements of different sizes are used to extract features at different scales. The smaller the size of structuring element, lesser is the noise removing capacity and more the ability to detect fine edges. By using large structuring element, more amount of noise is reduced likewise thickness of edges increases causing smearing of closely spaced edges.

Edge maps, combination of different size structuring elements, helps in reducing the defects encountered by using larger size structuring element. True edge points are extracted from the combined edge map as follows:

1. Obtain edge strength maps using structuring elements of different scale.
2. Combine these edge strength maps.
3. Extract the edge points lying on the ridge of the edge strength surface using non-maximal suppression technique.

This detector performs better than other improved morphological detectors under noisy conditions. It is possible to obtain thin edges or object boundaries with multiscale operator which may not be detected with other morphological methods. This method can detect weak edge points lying next to strong edge points without any sacrifice of quality.

d) Alternative Sequential Filter Edge Detector

Alternating Sequential Filter (ASF) edge detector[4] basically an erosion residue edge detector uses a rod structuring element preceded by noise suppression. In this noise is suppressed by alternating application of opening and closing morphological filters.

This is used to detect weak edge points besides the strong edge point without quality degradation.

This edge detector cannot detect small and quick variations on gray level surface i.e., it is difficult to select a structuring element.

e) Multi-scale morphologic edge detector using edge tracking approach

Multi-scale morphologic gradient method's deficiency begins when there is a presence of large amount of noise in the image. This leads to the complexity in choosing the structural element. If we consider a small structural element, edges can be preserved whereas the noise cannot be eliminated. When big structural element is considered, though noise is removed, tiny edge characteristics are lost.

The edge of the actual object often possesses extremely high spatial continuity and exhibits good linearity[5]. Thus edge tracking algorithm is based on this property.

The technique used in this approach is a follows

i. *Extracting the morphological gradient*

In this method structural elements scale is selected based on the principle that *the geometric dimension of the edge must be larger than that of noise*. According to the dimensional difference between edge and noise, we can get a scale to preserve the edge and remove the noise by using pixel length count.

ii. *Tracking the morphologic edges*

To acquire the input image data, the scanning sequence can be divided into two, from top to bottom and from left to right as follows

Step 1 : Select a proper threshold value as tracking threshold value. If the pixel length exceeds threshold value, this set of pixels would be marked as edge.

Step 2 : Select a lower threshold value as tracking threshold value. If the tracking value is less than the tracking threshold value, this value is saved as mid value.

Step 3 : If the edge length (i.e. pixel count greater than tracking threshold) exceeds the mid value, the series of pixels initialized are classified as the sort of noise signal and their gray-level values are set to the background value. If the edge length is less than the mid value, the series of pixels initialized are classified as the sort of edge signals and their values are preserved.

iii. *Constructing the final edge image*

The capability of structuring element to remove the noise is weak if its size is small and the false edge detection probability is high. By contrast, the capability of structuring element to eliminate noise is high and it could extract the real edge thus we could increase the weights of big structuring elements properly and decrease the weights of small ones simultaneously.

All this process requires a high computational capability which increases the complexity. This complexity can be reduced using multi thread technology.

f) Multidirectional Structuring Element Morphological Edge Detector

The shape and size of the structuring elements determine the geometrical features in an image that are preserved or removed. Smaller the size of structuring element, lesser is the noise removing capacity and more the ability to detect edge details. By using large size structuring element one can remove more noise but at the same time the thickness of edge increases causing smearing of edges.

This smearing of edges can be controlled we can combine eight orientation structuring elements obtained with eight right angles transformation of original structuring element[6].

Once the structuring element is selected its different angles needs to be processed by morphological transformation for edge detection is as follows

1. The enhanced image has fine edge details for detecting edge.
2. Filtering the noise of the enhanced image.
3. Processing of the structural element by morphology transformation.

If the scale of structural element is selected properly, this method reduces the noise more efficiently compared to other methods. Edge detectors employing this method has more connectivity compared to other methods.

III. Conclusion

The analysis of the various morphological edge detection methods yields the results of their advantages and disadvantages. Of all the methods *Multidirectional structuring element morphological edge detector* is more suitable in reducing noise levels and in restoring the thin edges with critical information. Though *multi-scale morphology edge tracking approach* has all the attributes of a good edge detector, its complexity in computation acts as a hurdle against the robust use of it. Therefore by combining the two above said methods, we can improve the efficiency of edge detection even in noisy conditions also.

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