

MORPHOLOGIC EDGE DETECTION WITH MULTI-SCALE APPROACH

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ABSTRACT

In this paper we present a new morphologic edge detection method using multi-scale approach for detecting edges of various fineness under noisy condition. Comparative study reveals its superiority over other morphologic edge detectors.

1 Introduction

Edges in an image are formed due to variations of some of the physical properties, like surface illumination and shadows, geometry (orientation and depth) and reflectance of objects in the scene. Hence one can say that edge points represent some important features in a scene. The performance of almost all the conventional edge operators degrades with noise. To overcome this problem, recently some new edge detectors were proposed [1, 2], which have in built noise smoothing mechanism. However, performance of most of the edge detectors improve if multi-scale approach is adopted where information available at various scales are integrated.

A new approach to image analysis was proposed using the theory of mathematical morphology [3] [4]. This approach is based on set theoretic concepts of shape. As the identification of objects and object features directly depend on their shape, mathematical morphology is becoming an obvious approach for various machine vision recognition processes. Initially morphology dealt with binary image only, and basic operation were dilation and erosion, also known as Minkowski addition and subtraction [5]. Natural extension of morphologic transformations from binary image processing to gray scale processing using max and min operations is done by Sternberg [6] and Haralick et.al. [7]. Lee et.al. [8] have used gray scale morphology for edge detection. In this paper we present a morphologic edge detection methods using multi-scale approach for detecting edges of various fineness under noisy condition and compare results with that of other morphologic edge detectors.

2 Morphologic edge detection

The morphologic operations work with *two* images, the original image to be processed and a template called structuring element. Each structuring element has a particular shape which controls parameters of

the operation. Most fundamental morphological operations are morphological *dilation* (\oplus) and morphological *erosion* (\ominus). Based on these, two compound operations known as *opening* and *closing* are defined. 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. This may be preceded by pre-processing or followed by postprocessing or both. The difference image is an image of edge strength. Most popularly used structuring element for edge detection is rod shaped with flat top. The edge strength image due to **dilation residue edge detector** is given by

$$G_d(r, c) = (f \oplus b)(r, c) - f(r, c) \quad (1)$$

The edge strength image due to **erosion residue edge detector** is given by

$$G_e(r, c) = f(r, c) - (f \ominus b)(r, c) \quad (2)$$

Where $f(r, c)$ image pixel at a point (r, c) . Both dilation residue edge detector and erosion residue edge detector are noise sensitive. Moreover these are biased in the sense that the former gives the edge strength to that side of an edge which has low value while the later gives to the high value side. A position unbiased operator can be obtained by the combination of these operators $G_d(r, c)$ and $G_e(r, c)$. Three such combinations are defined using pixelwise minimum, maximum and sum. They are denoted by $G_{min}(r, c)$, $G_{max}(r, c)$ and $G_{sum}(r, c)$, respectively and are defined as

$$G_{min}(r, c) = \min\{G_d(r, c), G_e(r, c)\} \quad (3)$$

$$G_{max}(r, c) = \max\{G_d(r, c), G_e(r, c)\} \quad (4)$$

$$G_{sum}(r, c) = G_d(r, c) + G_e(r, c) \quad (5)$$

G_{sum} results in thick edges and strength of detected edge is less than actual edge strength. $G_{min}(r, c)$ is less sensitive to noise but cannot detect ideal step edges. Minimum of dilation residue and erosion residue is a good detector of ramp edge and is less sensitive to noise, but it cannot detect step edge. So

pre smoothing with simple mean filter can improve its performance in two ways. Firstly by reducing the noise in the image and secondly, by converting step edges into ramp edges. The resultant combined operator is known as *blur-minimum edge detector* [8] which lacks in localization sensitivity and produces thick edges. To overcome these problems a new edge detector [9], known as *Alternating Sequential Filter (ASF) edge detector* was proposed. This is basically an erosion residue edge detector using a rod structuring element preceded by noise suppression. Here noise is suppressed by alternating application of opening and closing morphological filters.

3 Multi-scale morphologic edge detector

The proposed *Multi-scale Morphological edge detector* is able to differentiate these fine variations of gray level surface, and yet can remove noise. As the name implies this is based on multi scaling approach. Structuring elements of different sizes are used to extract features at different scale. The smaller the size of structuring element, lesser is the noise removing capacity and more the ability to detect fine edges. By using large size structuring element one can remove more noise but at the same time the thickness of edge increases causing smearing of closely spaced edges. Hence to overcome these problems one can combine judiciously different edge maps obtained with different size structuring elements. True edge points are extracted from this combined edge map. The following are the different steps involved.

1. Obtain edge strength maps using structuring elements of different size(scale). This is done using an improved dilation residue operator at different scale and the edge strength at scale n is given by

$$G_d^n(r, c) = \min \left\{ \begin{array}{l} \text{dilation}_{nD_{rod}}(r, c) - f(r, c), \\ \text{dilation}_{nD}(r, c) - f(r, c), \\ G_d^n(r, c) \end{array} \right\} \quad (6)$$

where $G_d^n(r, c)$ is defined as

$$G_d^n(r, c) = \max \left\{ \begin{array}{l} \text{dilation}_{nD_1}(r, c) - \text{dilation}_{nD_2}(r, c), \\ \text{dilation}_{nD_3}(r, c) - \text{dilation}_{nD_4}(r, c) \end{array} \right\}$$

Where $nD_{rod1}, nD_1, nD_2, nD_3, nD_4$ are the domains of the structuring elements.

2. Combine edge strength maps/images obtained in Step 1.
3. Extract the edge points lying on the ridge of the edge strength surface using non-maximal suppression technique.

4 Experimental results and Discussion

To show the relative performance of proposed multi-scale morphologic edge detector in comparison with that of other morphologic edge detectors, we have applied the edge detectors on the well known image e.g. Lena (size 256×256) with and without noise. It can be observed that proposed multi-scale morphological edge detector performs better than basic dilation residue and erosion residue edge detection methods under noisy conditions. The edges obtained by blur-minimum operator are not continuous and some edge points are missing. Multi-scale edge detector performs better than the other improved morphological detectors under noise conditions. It is possible to obtain thin edges or object boundaries with multi-scale operator which may not be detected with other morphological methods. This method detects weak edge points lying next to strong edge points without any sacrifice of quality. A detail performance study of this edge detector is available in [10].

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(a)



(b)



(c)



(d)



(e)



(f)

Figure 1: Illustrates the study of performance of edge detectors on real image. (a) Original noise-free image of Lena, edge map due to (b) Dilation residue edge detector, (c) Erosion residue edge detector, (d) Blur-minimum edge detector, (e) ASF edge detector, (f) Multi-scale morphologic edge detector.



(a)



(b)



(c)



(d)



(e)



(f)

Figure 2: Illustrates the study of performance of edge detectors on real image. (a) Noisy image of Lena (SNR=30), edge map due to (b) Dilation residue edge detector, (c) Erosion residue edge detector, (d) Blur-minimum edge detector, (e) ASF edge detector, (f) Multi-scale morphologic edge detector.