Edge Detection

Detection of discontinuities

Discontinuities such as isolated points, thin lines and edges in the image can be detected by using similar masks as in the low- and high-pass filtering. The absolute value of the weighted sum given by equation (2.7) indicates how strongly that particular pixel corresponds to the property described by the mask; the greater the absolute value, the stronger the response.

1. Point detection

The mask for detecting *isolated points* is given in the Figure. A point can be defined to be isolated I if the response by the masking exceeds a predefined threshold:

-1	-1	-1
-1	8	-1
-1	-1	-1

Figure4.1.1: Mask detecting isolated points.

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition , 2010.-Page-312)

2. Line Detection

- Line detection is identical to point detection.
- Instead of one mask, four different masks must be used to cover the four primary directions namely, horizontal, vertical and two diagonals.
- Thus lines are detected using the following masks

-1	-1	-1
2	2	2
-1	-1	-1

-1	-1	2
-1	2	-1
2	-1	-1

-1	2	-1
-1	2	-1
-1	2	-1

2	-1	-1
-1	2	-1
-1	-1	2

Figure 4.1.2 Masks for line detection

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition , 2010.-Page-699)

- Horizontal mask will result with max response when a line passed through the middle row of the mask with a constant background.
- Thus a similar idea is used with other masks.
- The preferred direction of each mask is weighted with a larger coefficient (i.e.,2) than other possible directions.
- Consider the following diagrams:

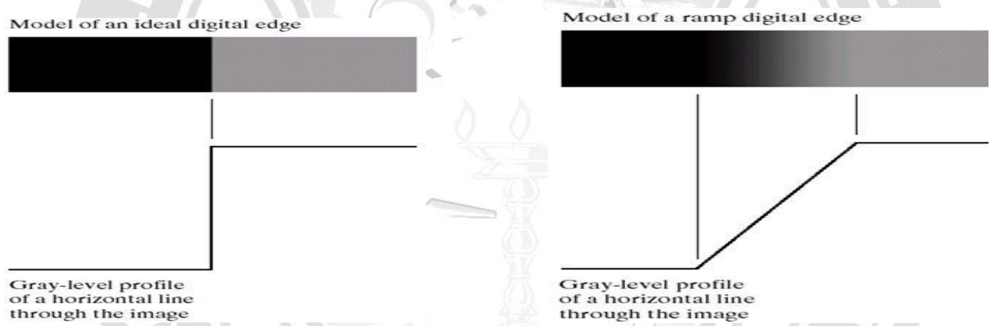

Fig4.1.3: Model of an Ideal digital edge , Model of an Ramp digital edge.

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition , 2010.-Page-312)

.

THICK EDGE:

- The slope of the ramp is inversely proportional to the degree of blurring in the edge.
- We no longer have a thin (one pixel thick) path.
- Instead, an edge point now is any point contained in the ramp, and an edge would then be a set of such points that are connected.
- The thickness is determined by the length of the ramp.
- The length is determined by the slope, which is in turn determined by the

degree of blurring.

- **Blurred edges tend to be thick and sharp edges tend to be thin**

Steps for Line detection:

- Apply every masks on the image
- let R1, R2, R3, R4 denotes the response of the horizontal, +45 degree, vertical and - 45 degree masks, respectively.
- if, at a certain point in the image $|R_i| > |R_j|$,
- for all j□i, that point is said to be more likely associated with a line in the direction of mask i.
- Alternatively, to detect all lines in an image in the direction defined by a given mask, just run the mask through the image and threshold the absolute value of the result.
- The points that are left are the strongest responses, which, for lines one pixel thick, correspond closest to the direction defined by the mask.

2.Edge Detection

- The most important operation to detect discontinuities is *edgedetection*.
- **Edge detection is used for detecting discontinuities in gray level. First and second order digital derivatives are implemented to detect the edges in an image.**
- Edge is defined as the boundary between two regions with relatively distinct gray- level properties.
- An edge is a set of connected pixels that lie on the boundary between two regions.
- Approaches for implementing edge detection

first-order derivative (Gradient operator)

Second-order derivative (Laplacian operator)

Detection of discontinuities

Discontinuities such as isolated points, thin lines and edges in the image can be detected by using similar masks as in the low- and high-pass filtering. The absolute value of the weighted sum given by equation (2.7) indicates how strongly that particular pixel corresponds to the property described by the mask; the greater the absolute value, the stronger the response.

EROSION AND DILATION IN MORPHOLOGICAL PROCESSING.

These operations are fundamental to morphological processing.

Erosion:

With ***A*** and ***B*** as sets in Z^2, the erosion of ***A*** by ***B,*** denoted ***A Ɵ B,*** is defined as

$$A \ominus B = \{z \mid (B)_z \subseteq A\}$$

In words, this equation indicates that the erosion of **A** by **B** is the set of all points **z** such that **B,** translated by **z,** is contained in **A.** In the following discussion, set **B** is assumed to be a structuring element. The statement that **B** has to be contained in **A** is equivalent to **B** not sharing any common elements with the background; we can express erosion in the following equivalent form:

$$A \ominus B = \{z \mid (B)_z \cap A^c = \emptyset\}$$

where, A^c is the complement of ***A*** and Ø is the empty set.

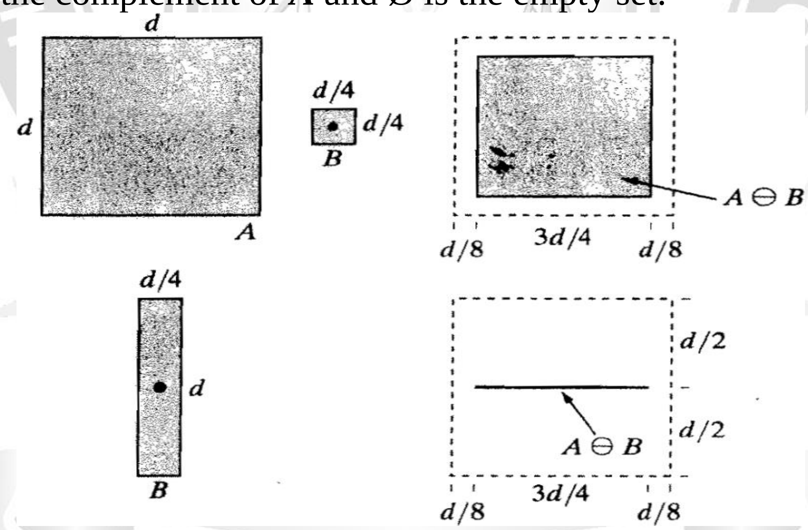

Fig4.1.4: a) Set (b) Square structuring element, (c) Erosion of by shown shaded. (d) Elongated structuring element. (e) Erosion of by using this element. The dotted border in (c) and (e) is the boundary of set A, shown only for reference.

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition, 2010.-Page-634)

The elements of ***A*** and ***B*** are shown shaded and the background is white. The solid boundary in Fig. (c) is the limit beyond which further displacements of the origin of ***B*** would cause the structuring element to cease being completely contained in ***A.***

Thus, the locus of points (locations of the origin of ***B)*** within (and including) this boundary, constitutes the erosion of ***A*** by ***B.*** We show the erosion shaded in Fig. (c).The boundary of set ***A*** is shown dashed in Figs. (c) and (e) only as a reference; it is not part of the erosion operation. Figure (d) shows an elongated structuring element, and Fig. (e) shows the erosion of ***A*** by this element. Note that the original set was eroded to a line. However, these equations have the distinct advantage over other formulations in that they are more intuitive when the structuring element *B* is viewed as a spatial mask

Thus erosion shrinks or thins objects in a binary image. In fact, we can view erosion as a ***morphological filtering*** operation in which image details smaller than the structuring element are filtered (re-moved) from the image

(i) Dilation

However, the preceding definitions have a distinct advantage over other formulations in that they are more intuitive when the structuring element ***B*** is viewed as a convolution mask. The basic process of flipping (rotating) ***B*** about its origin and then successively displacing it so that it slides over set (image) ***A*** is analogous to spatial convolution. Keep in mind, however, that dilation is based on set operations and therefore is a nonlinear operation, whereas convolution is a linear operation. Unlike erosion, which is a shrinking or thinning operation, dilation "grows" or "thickens" objects in a binary image. The specific manner and extent of this thickening is controlled by the shape of the structuring element used.

In the following Figure (b) shows a structuring element (in this case ***B* = *B*** because the SE is symmetric about its origin). The dashed line in Fig. (c) shows the original set for reference, and the solid line shows the limit beyond which any further displacements of the origin of ***B*** by ***z*** would cause the intersection of ***B*** and ***A*** to be empty. Therefore, all points on and inside this boundary constitute the dilation of ***A*** by ***B.*** Figure (d) shows a structuring element designed to achieve more dilation vertically than horizontally, and Fig. (e) shows the dilation achieved with this element

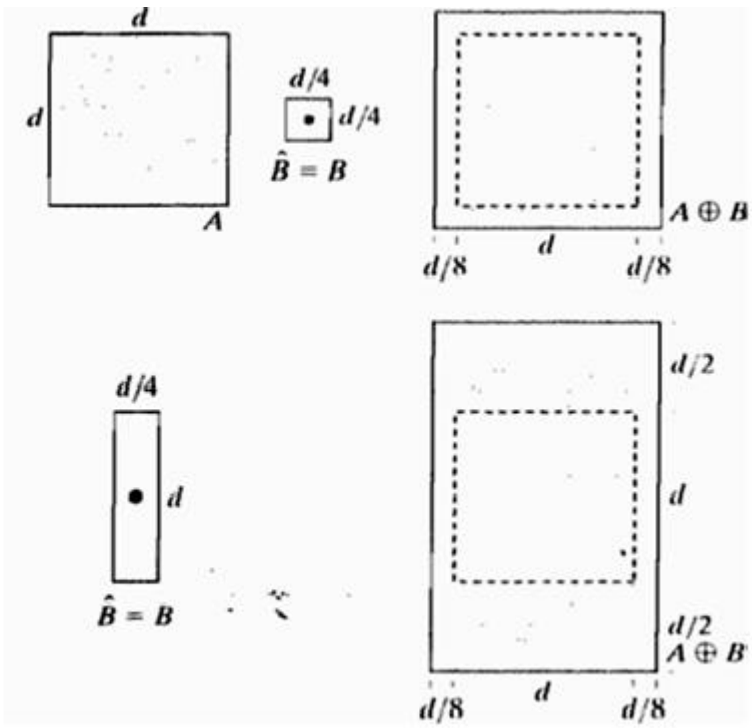

FIG:4.1.5 (a) Set (b) Square structuring element (the dot denotes the origin). (c) Dilation of by shown shaded. (d) Elongated structuring element. (e) Dilation of using this element. The dotted border in (c) and (e) is the boundary of set shown only for reference.

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition, 2010.-Page-634)