Dam Construction

Dam construction is based on binary images, which are members of 2-D integer space Z^2. The simplest way to construct dams separating sets of binary points is to use morphological dilation.

The basics of how to construct dams using dilation are illustrated in Fig. Figure (a) shows portions of two catchment basins at flooding step *n* - 1 and Fig. (b) shows the result at the next flooding step, *n.* The water has spilled from one basin to the other and, therefore, a dam must be built to keep this from happening. In order to be consistent with notation to be introduced shortly,

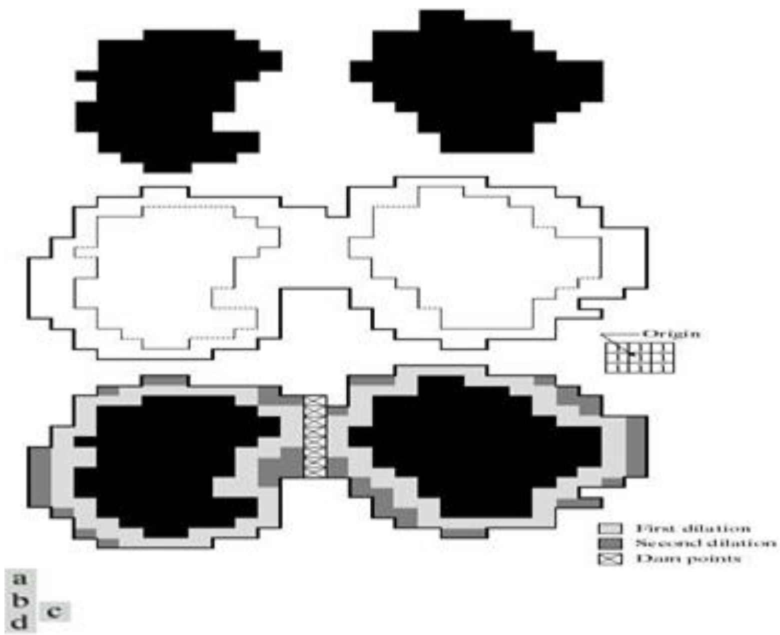

FIGURE 4.5.1(a) Two partially flooded catchment basins at stage of flooding. (b) Flooding at stage showing that water has spilled between basins. (c) Structuring element used for dilation. (d) Result of dilation and dam construction.)

(Source: Rafael C. Gonzalez, Richard E. Woods, ‗Digital Image Processing', Pearson, Third Edition, 2010 - Page-773)

let *M1* and M_2 denote the sets of coordinates of points in two regional minima. Then let the set of coordinates of points in the *catchment basin* associated with these two minima at stage *n* - 1 of flooding be denoted by and respectively.

These are the two black regions shown in Fig. (a). Suppose that each of the connected components in Fig.(a) is dilated by the structuring element shown in Fig. (c), subject to two conditions:

(1) The dilation has to be constrained to *q* (this means that the center of the structuring element can be located only at points in *q* during dilation),and

(2) The dilation cannot be performed on points that would cause the sets being dilated to merge (become a single connected component).

Figure (d) shows that a first dilation pass (in light gray) expanded the boundary of each original connected component. Note that condition (1) was satisfied by every point during dilation, and condition (2) did not apply to any point during the dilation process; thus the boundary of each region was expanded uniformly.

In the second dilation (shown in medium gray), several points failed condition (1) while meeting condition (2), resulting in the broken perimeter shown in the figure. It also is evident that the only points in *q* that satisfy the two conditions under consideration describe the one-pixel-thick connected path shown crossed-hatched in Fig. (d). This path constitutes the desired separating dam at stage *n* of flooding. Construction of the dam at this level of flooding is completed by setting all the points in the path just determined to a value greater than the maximum gray-level value of the image. The height of all dams is generally set at 1 plus the maximum allowed value in the image. This will prevent water from crossing over the part of the completed dam as the level of flooding is increased. It is important to note that dams built by this procedure, which are the desired segmentation boundaries, are connected components. In other words, this method eliminates the problems of broken segmentation lines,

Although the procedure just described is based on a simple example, the method used for more complex situations is exactly the same, including the use of the 3

X 3 symmetric structuring elements shown in Fig.(c).

1. At each step of the algorithm, the binary image in obtained in the following manner
   1. Initially, the set of pixels with minimum gray level are 1, others0.
   2. In each subsequent step, we flood the 3D topography from below and the pixels covered by the rising water are 1s and others 0s. M1,M2:

– Sets of coordinates of points in the two regional minima 2.$C_{n-1}(M_1)$, $C_{n-1}(M_2)$-

– Sets of coordinates ofpointsinthecatchmentbasinsassociatedwithM1M2at stage n-1 of flooding (catchment basins up to the flooding level)

3. C [n-1] - Union of $C_{n-1}(M_1)$,$C_{n-1}(M_2)$

4. At flooding step n-1, there are two connected components. At flooding step n, there is only one connected component
   – This indicates that the water between the two catchment basins has merged at flooding step n
   – Use "q" to denote the single connected component

5.Steps - Repeatedly dilate Cn-1(M1), Cn-1(M2) by the 3×3 structuring element shown, subject to the following condition

• Constrained to q (center of the structuring element can not go beyond q during dilation

6.The dam is constructed by the points on which the dilation would cause the sets being dilated to merge.

-Resulting one-pixel thick connected path

7. Setting the gray level at each point in the resultant path to a value greater than the maximum gray value of the image. Usuallymax+1