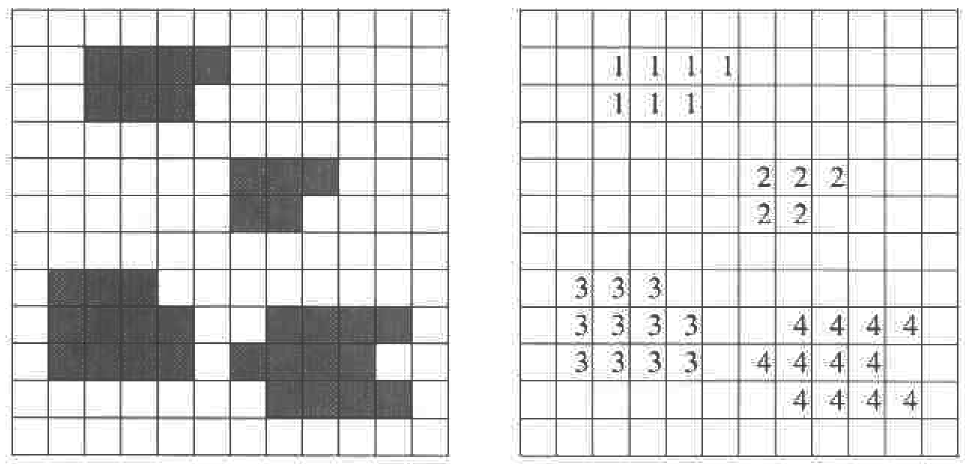
Region Representations

• Array Representation

- The most basic representation for regions is to use an array of the same size as the original image with entries that indicate the region to which a pixel belongs.



• Hierarchical Representation

- Hierarchical representations of images (or regions) allows represetation at multiple resolutions.

- In many applications, one can compute properties of images (or regions) first at a low resolution and then perform additional computations over a selected area of the image at a higher resolution.

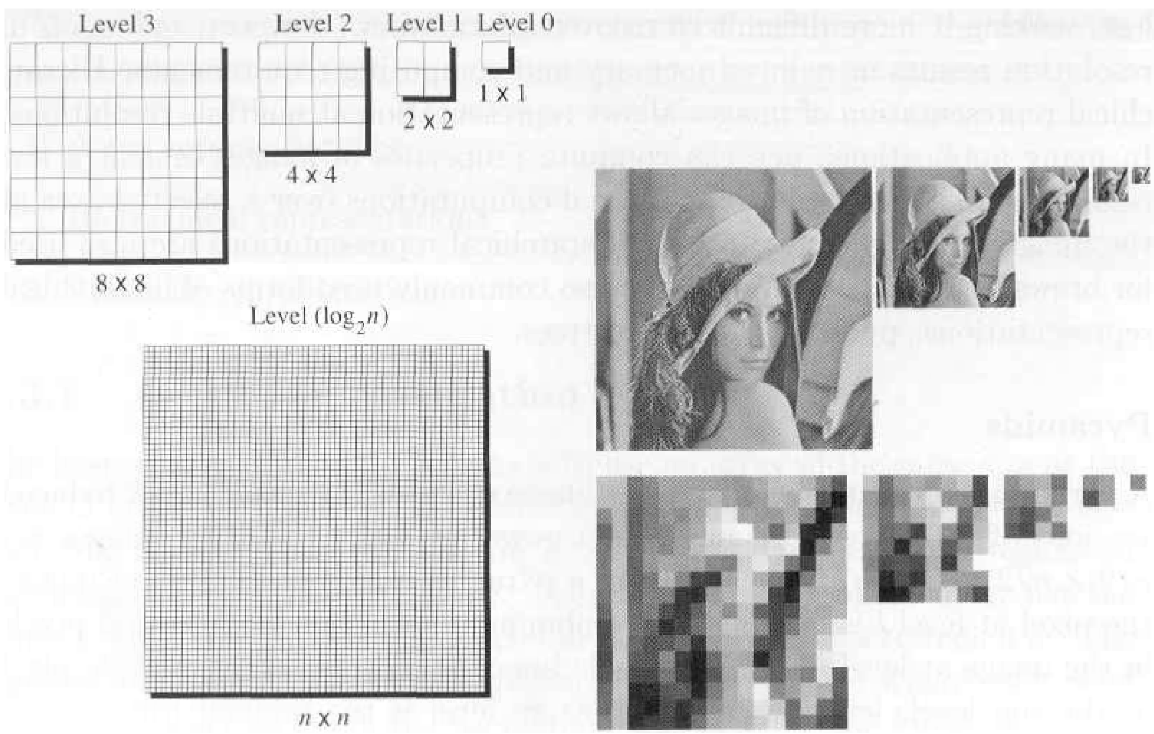
Pyramids

* A pyramid representation of an n x n image contains the image and k reduced versions of the image.

* Assuming n is a power of 2, the other images are

$$n/2 \text{ x } n/2, \ \ n/4 \text{ x } n/4, \ \ldots, 1 \text{ x } 1$$

* A pixel at level l is obtained by combining information from several pixels in the image at level $l+1$ (e.g., averaging).



<u>Quad Trees</u>

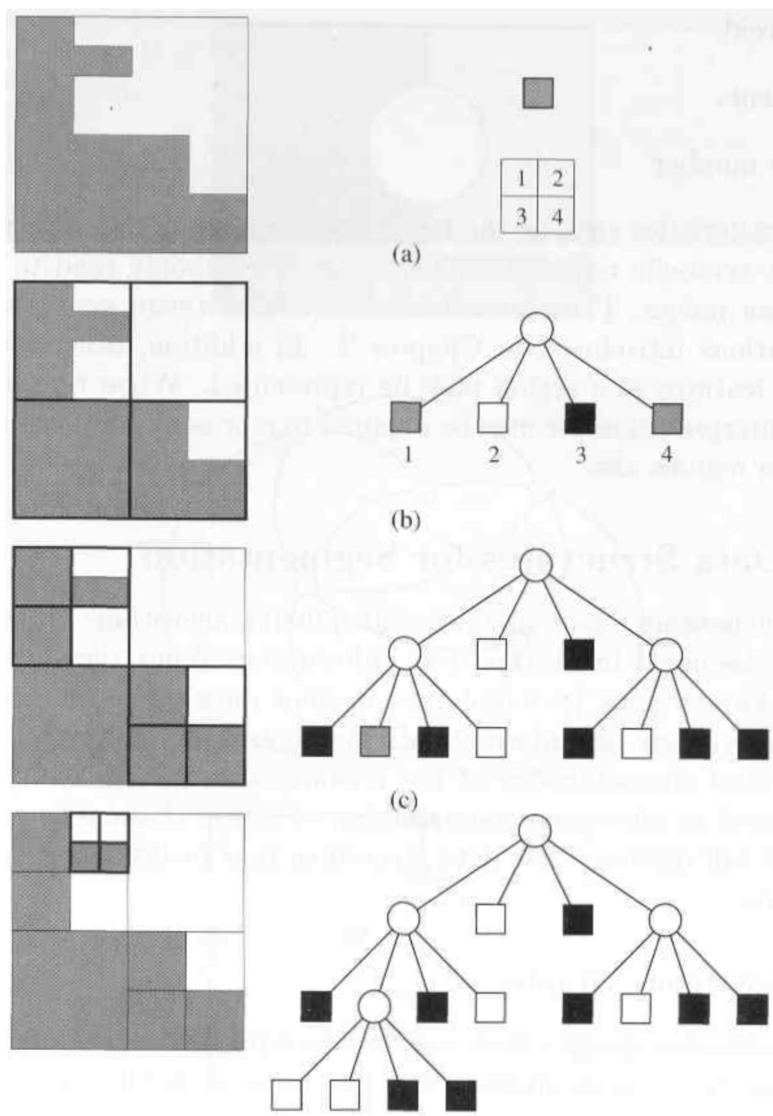
* It is built by recursive splitting of an image (binary).

* Every node of the tree corresponds to a subregion.

* Three types of nodes: white, black, and gray.

* White/Black nodes correspond to white/black regions (no further splitting).

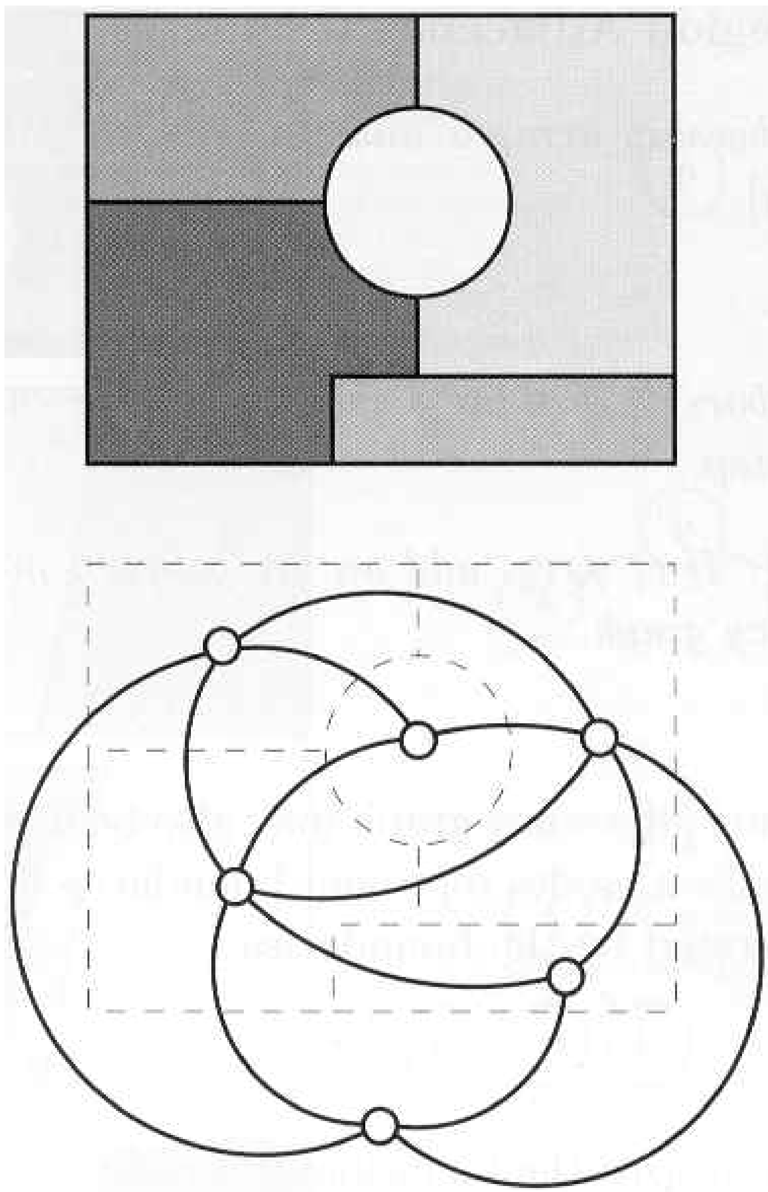
* Gray nodes correspond to regions containing both black and white pixels (further splitting is required).



• **Region adjacency graph (RAG)**

- Represents regions and relationships among them in an image.

- Nodes represent regions, arcs represent common boundary.



• **Distance Transform** (for skeleton computation)

- Compute the minimum distance between a pixel of a region and the background.

- A parallel iterative algorithm to compute the distance transform is based on the following equations (uses 4-neighbors):

$$f^0[i][j] = 1$$

$$f^m[i][j] = 1 + min(f^{m-1}[u][v])$$

where (u, v) are all pixels satisfying $d[(u, v), (i, j)] = 1$

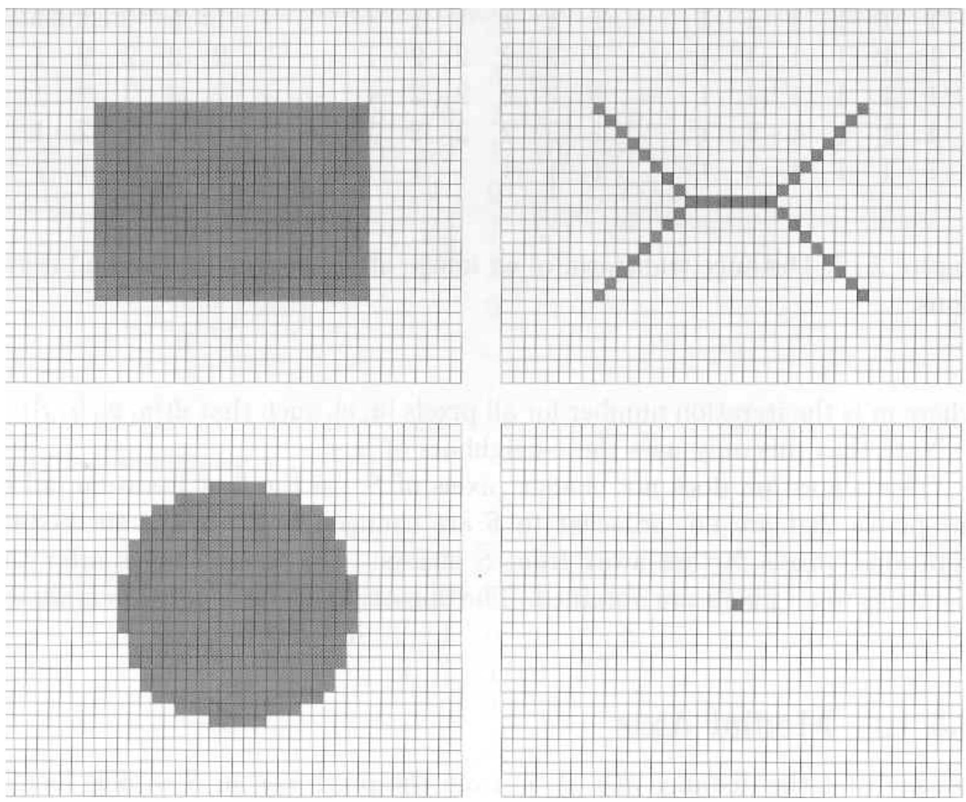
$$\begin{matrix} 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{matrix} \rightarrow \begin{matrix} 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 2 & 2 & 2 & 2 & 1 \\ 1 & 2 & 2 & 2 & 2 & 1 \\ 1 & 2 & 2 & 2 & 2 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{matrix} \rightarrow \begin{matrix} 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 2 & 2 & 2 & 2 & 1 \\ 1 & 2 & 3 & 3 & 2 & 1 \\ 1 & 2 & 2 & 2 & 2 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 \end{matrix}$$

• **Medial Axis** (or skeleton)

- The set of pixels $I(i, j)$ in S with distances from the background that are locally maximum, i.e.,

$$d((i, j), background) \geq d((u, v), background)$$

are called the *medial axis* or *skeleton* of S.



- The original region can be reconstructed from its skeleton and the distances of the skeleton pixels from the background.

$$f^m[i][j] = \begin{cases} max(0, max(f^{m-1}[u][v] - 1)) & \text{if } f^{m-1}[i][j] = 0 \\ f^{m-1}[i][j] & otherwise \end{cases}$$

where (u, v) are all pixels satisfying $d[(u, v), (i, j)] = 1$ (4-neighbors)

- The skeleton is very sensitive to noise.