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 representation 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 $n \times n$ image contains the image and $k$ reduced versions of the image.

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

$$\frac{n}{2} \times \frac{n}{2}, \frac{n}{4} \times \frac{n}{4}, ..., 1 \times 1$$

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

* 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 \(d[(u, v), (i, j)] = 1\)
• **Medial Axis** (or skeleton)

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

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

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.

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

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

- The skeleton is very sensitive to noise.