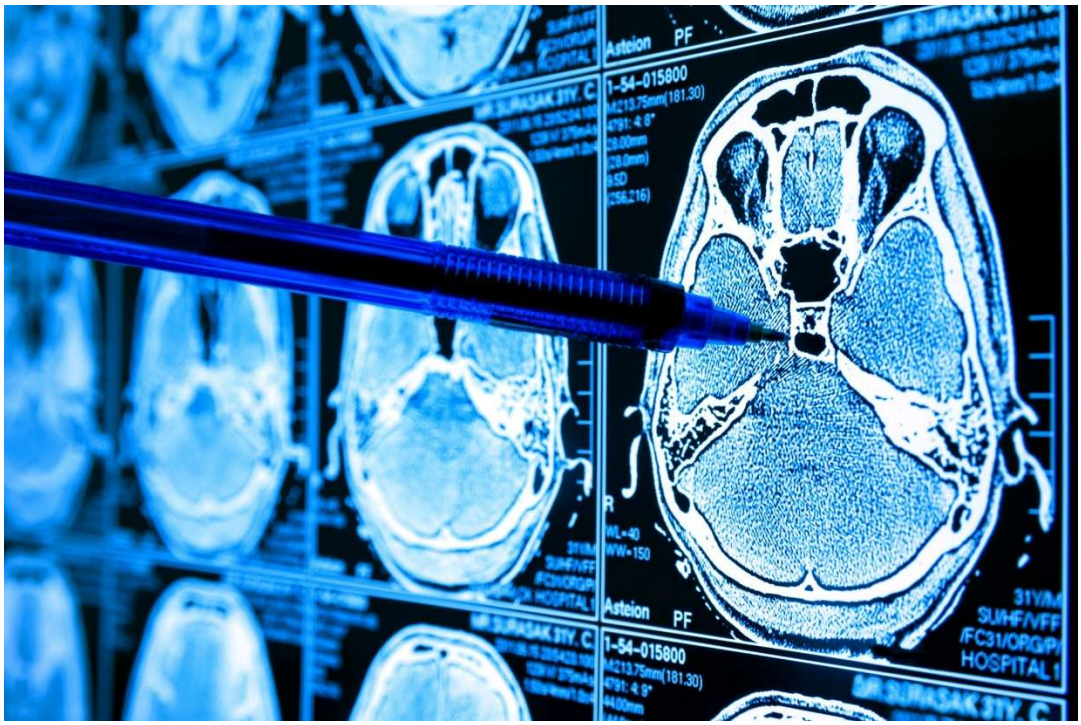
Image Segmentation

Image Segmentation is a crucial technique in digital image processing and computer vision. It refers to the process of dividing an image into multiple segments (sets of pixels) where each segment represents a region with similar attributes such as color, intensity, or texture.

The primary aim is to identify and separate objects or regions of interest in an image so that they can be analyzed independently or recognized more accurately.

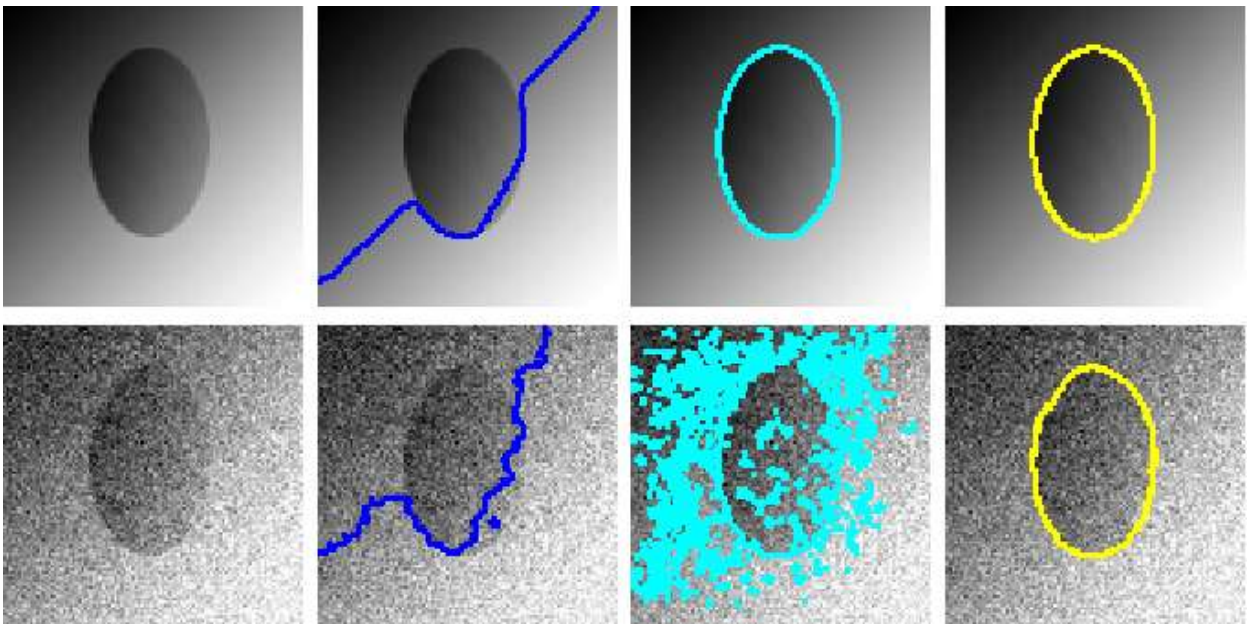
Think of it as the first step in understanding the contents of an image, much like how the human eye distinguishes objects from the background.

Image segmentation does exactly this—breaks down a complex image into simpler, meaningful parts.



Region-Based Segmentation

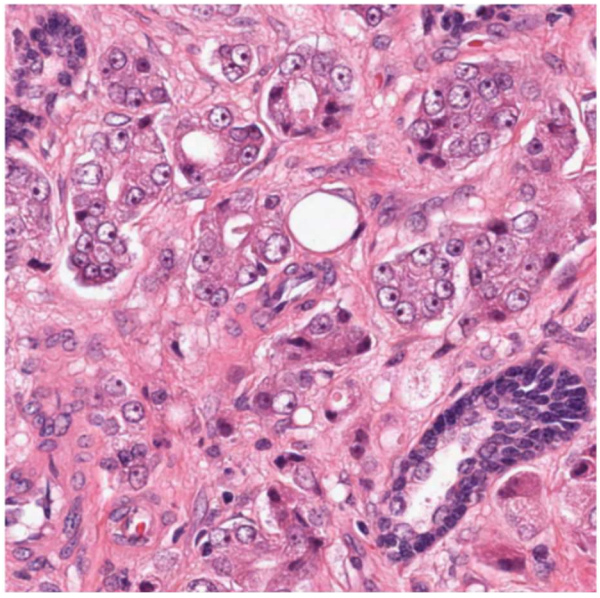
Region-based segmentation groups neighboring pixels into larger regions based on similarity criteria, like intensity, color, or texture. It begins with a seed pixel and grows the region by checking nearby pixels for similarity.

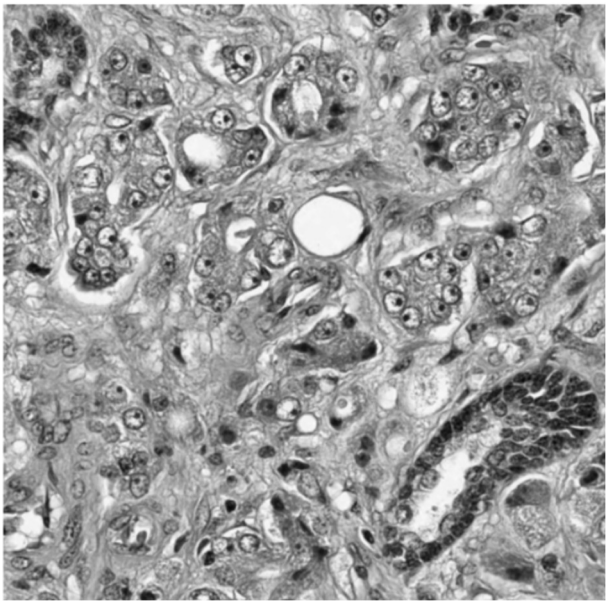


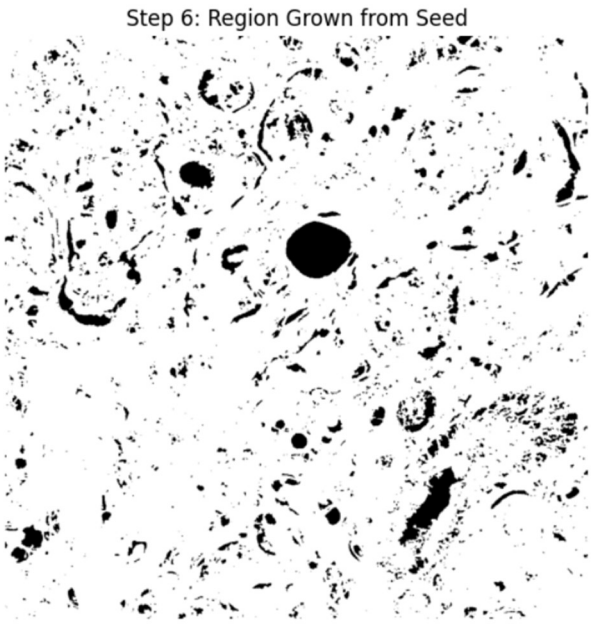
Key Points on Region-Based Segmentation

- **Goal:** Partition an image into regions where pixels within each region are similar according to some criteria.
- **Criteria for similarity:** Pixel intensity, color, texture, or other statistical properties.
- **Region Growing:**
  - Starts from one or more seed points.
  - Adds neighboring pixels that are similar to the seed.
  - Continues until no more pixels satisfy the similarity condition.
- **Region Splitting and Merging:**
  - The image is initially considered as a single large region.
  - It is recursively split into smaller regions if they are not homogeneous.
  - Adjacent regions that are similar are merged back.
- **Advantages:**
  - Produces connected regions.

    - Simple and intuitive.
    - Can handle noisy images better than edge detection in some cases.
- **Limitations:**
    - Sensitive to the choice of seed points in region growing.
    - Over-segmentation or under-segmentation may occur if similarity thresholds are not well chosen.
    - Computationally intensive for large images







Watershed Algorithm

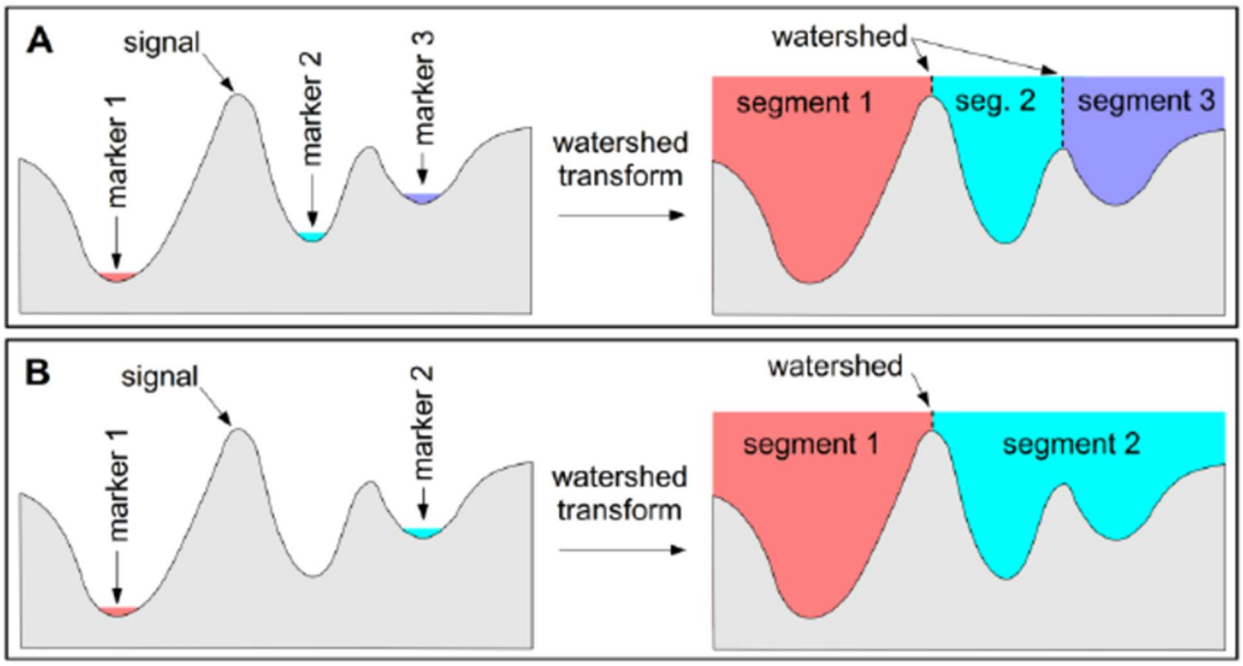
Imagine a grayscale image as a topographic surface:

- Bright pixels = peaks (high elevation)
- Dark pixels = valleys (low elevation)

The Watershed algorithm "**floods**" this topographic surface from the valleys (local minima). As water levels rise, the water fills the valleys. When water from different basins is about to merge, a dam (boundary) is built. These dams represent the segment borders.

The Watershed algorithm is especially useful when:

- You have **overlapping objects** (e.g., cells in microscopy)
- You want to separate **connected components** based on gradient or shape


A
signal
marker 1
marker 2
marker 3
watershed transform
watershed
segment 1
seg. 2
segment 3
B
signal
marker 1
marker 2
watershed transform
watershed
segment 1
segment 2