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Region Growing

Team 3

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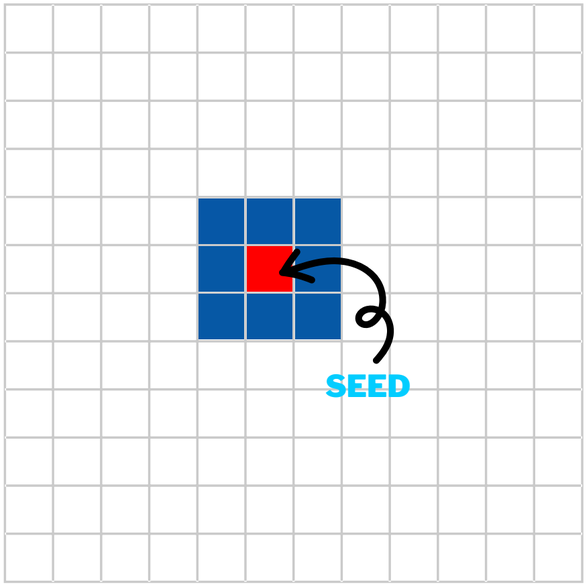

What is Region Growing?

Region growing is a image segmentation technique. in this technique, regions recursively grow if similarity criteria is matched, one pixel is compared with its neighbours. This method has proven useful in numerous fields- including medicine, satellite image analysis, and microscopy- due to its adaptability to various types of images and objectives

About Region Growing

The pixel can be either a cluster of one or more. An initial **pixel**, known as seed pixel is chosen randomly. The **size** of the region grows as the neighbouring pixels are added to the cluster of seed pixels. Those that meet the similarity criterion join the same region. The process continues recursively, extending to new neighbors that also share these attributes.

When the growth of one region **stops**, we choose another **seed pixel** which does not belong to any other region yet and repeat the same process until all pixels belong to some region.

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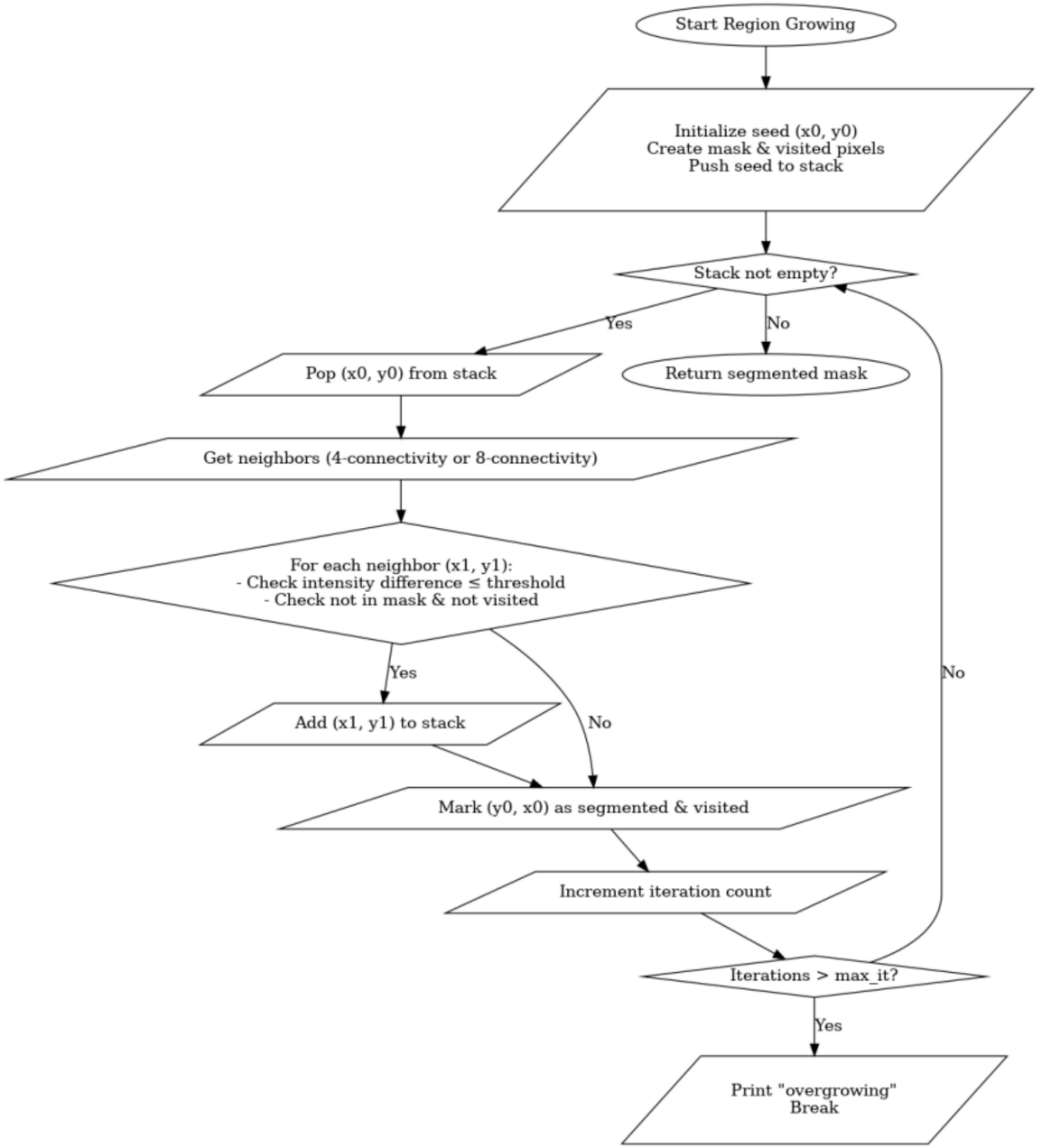
How It Works



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How It Works N4

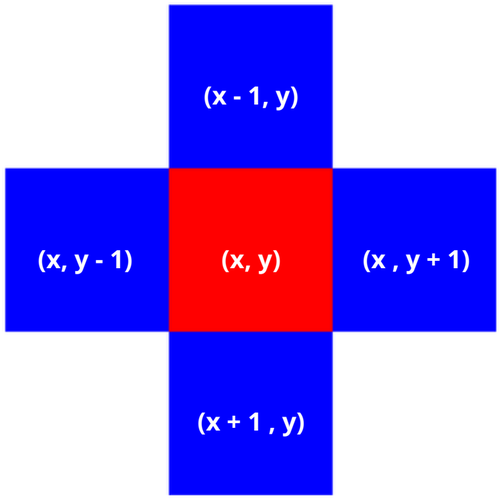
Top-down

The top-down approach starts with predefined seed pixels and grows regions until all pixels belong to a region.

Bottom-up

The bottom-up approach selects seeds only from objects of interest and grows regions based on similarity criteria.

N4 Connectivity Representation



How It Works N8

The _N8 function finds the 8-connected neighbors of a pixel (x0,y0) in a 2D image of size M×N.
Unlike 4-connectivity (N4), which only considers horizontal and vertical neighbors, N8 includes diagonal neighbors as well.

Top-left

(x - 1, y - 1)

Top-right

(x - 1, y + 1)

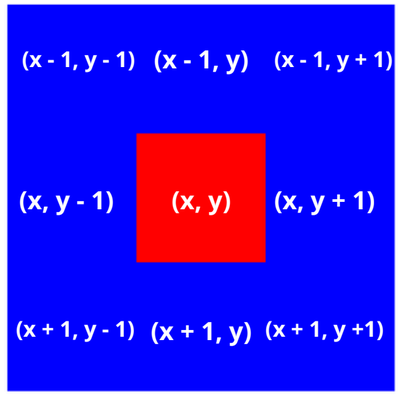
Bottom-left

(x + 1, y - 1)

Bottom-right

(x + 1, y + 1)

N8 Connectivity Representation



Similarity

$$\text{Similarity}(P, Q) = |I(P) - I(Q)|$$

Overgrowth

Occurs when too many pixels are included in the segmented region.
This happens when the **threshold is too high**, allowing the algorithm to include pixels that shouldn't belong to the region.

Adequate Growth

Occurs when the segmented region correctly follows the boundaries of the object.
This means the **threshold is well-tuned**, allowing the region to grow naturally while respecting edges.

Over-segmentation

Occurs when segmentation stops too early, creating many small regions.
This happens when the **threshold is too low**, preventing the algorithm from expanding properly.

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Advantages

01

Scalability

It can handle large datasets efficiently, making it suitable for real-time or high-throughput applications.

02

No fixed shape assumption

Unlike some segmentation methods, which assume the shape or structure, region growing can segment objects with irregular shapes.

03

Parameter tuning and initialization

Region growing does not need initialization as the head start of the algorithm, such as a threshold value or number of clusters, rather, region growing algorithms have parameters that can be adjusted to fine-tune the segmentation results according to specific requirements.

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Disadvantages

01

Dependence on seed point

Different choices of seed points can produce different segmentations, making results less deterministic if the seed selection process is not standardized.

02

High Computational Cost

Region Growing algorithms require significant computational resources, especially with large, high-resolution images or multiple seed points. Because the algorithm checks each neighboring pixel recursively, processing complexity increases rapidly with image size and the number of regions.

03

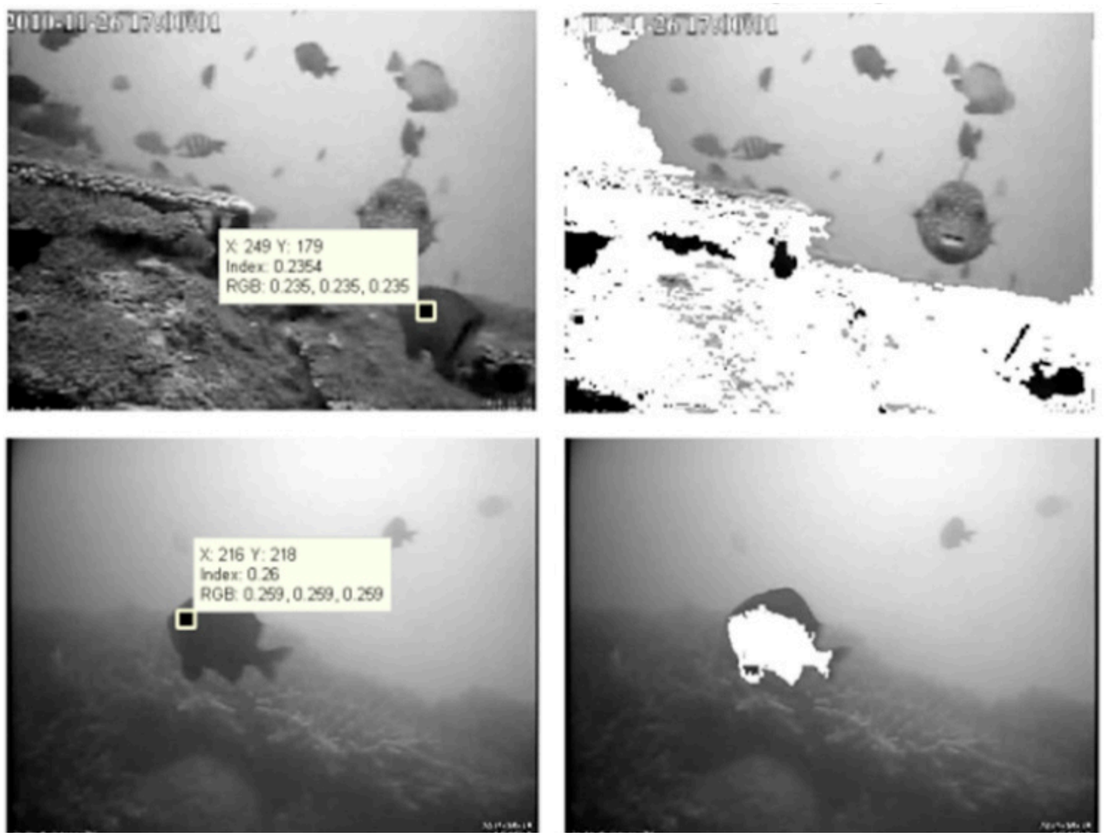
Noise and Grayscale Unevenness

Region Growing assumes that pixels within a region have consistent characteristics. However, real-world images often present grayscale unevenness or abrupt variations, complicating segmentation tasks.

04

Difficulty with Complex and Overlapping Objects

Region Growing struggles significantly when objects in an image have subtle or indistinct boundaries, or when multiple regions have similar intensity profiles.



Top: Background and object have similar colors and texture.
Bottom: Inaccurate positioning of the seed.

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Limitations

01

Assumes uniform intensity:

The algorithm works best when regions have consistent pixel values, and struggles with areas that have varying intensities.

02

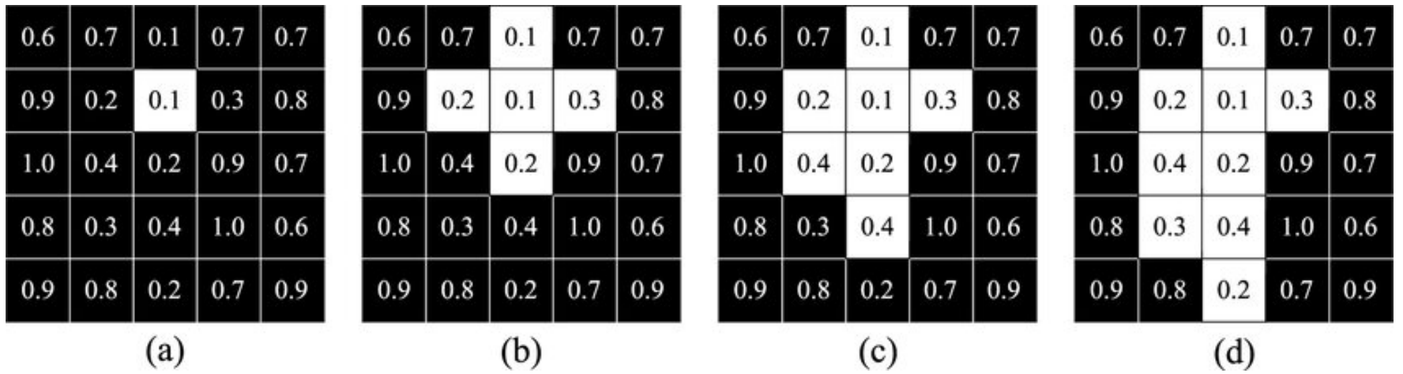
Challenges with textured regions

It may not perform well on areas with rapid, patterned intensity changes, like textured surfaces.

03

Issues with subtle differences

If the object and background have similar pixel values, the algorithm may fail to accurately segment them.



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Applications
Medical Imaging

01

Blood Circulation Analysis

Diagnosis of vascular diseases and assessment of organ perfusion issues.

02

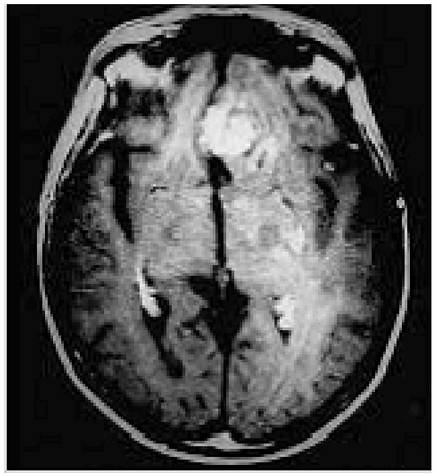
Cancer Detection & Treatment

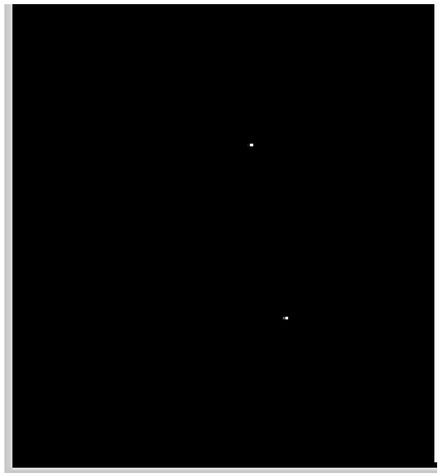
Identifying and delineating tumors in MRI or CT scans, supporting therapy planning.

03

Neurological Applications

Tracks cerebral blood flow for conditions like Alzheimer’s and brain injuries.





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Applications

Satellite Imaging

01

Urban & Population Studies

racking city expansion, infrastructure development, and population density.

02

Environmental Monitoring

Detecting deforestation, wildfires, and climate-related changes.

03

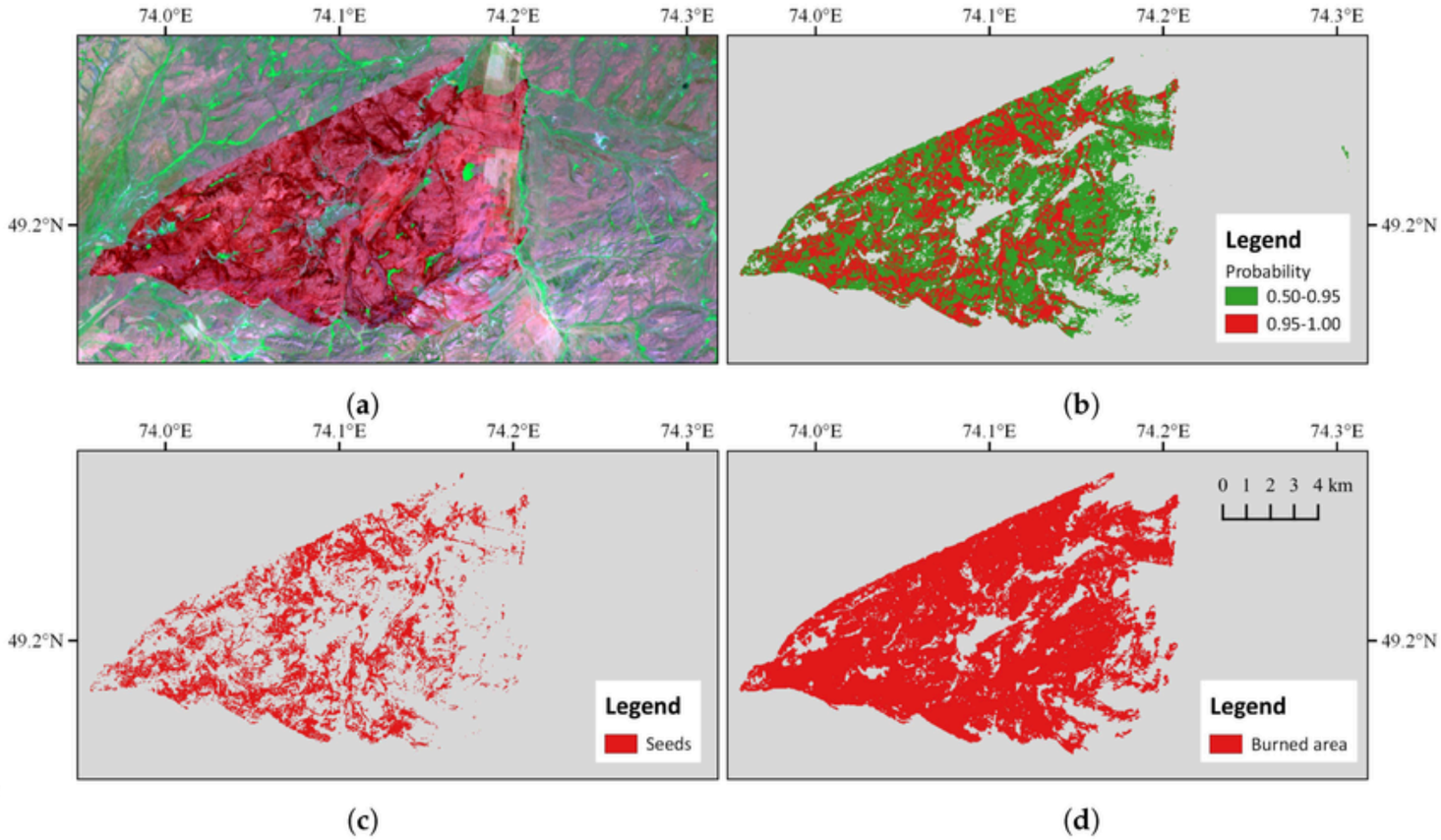
Military & Security

Monitoring unauthorized activities, heat signatures, and potentially suspicious movements.

04

Agriculture & Vegetation Analysis

Assessing crop health and irrigation levels to improve resource management.



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Applications

Microscopic Image

01

Cell & Nuclei Segmentation

Helps in medical diagnostics by detecting individual cells.

02

Tissue Classification

Differentiating tissue types in histopathology studies.

03

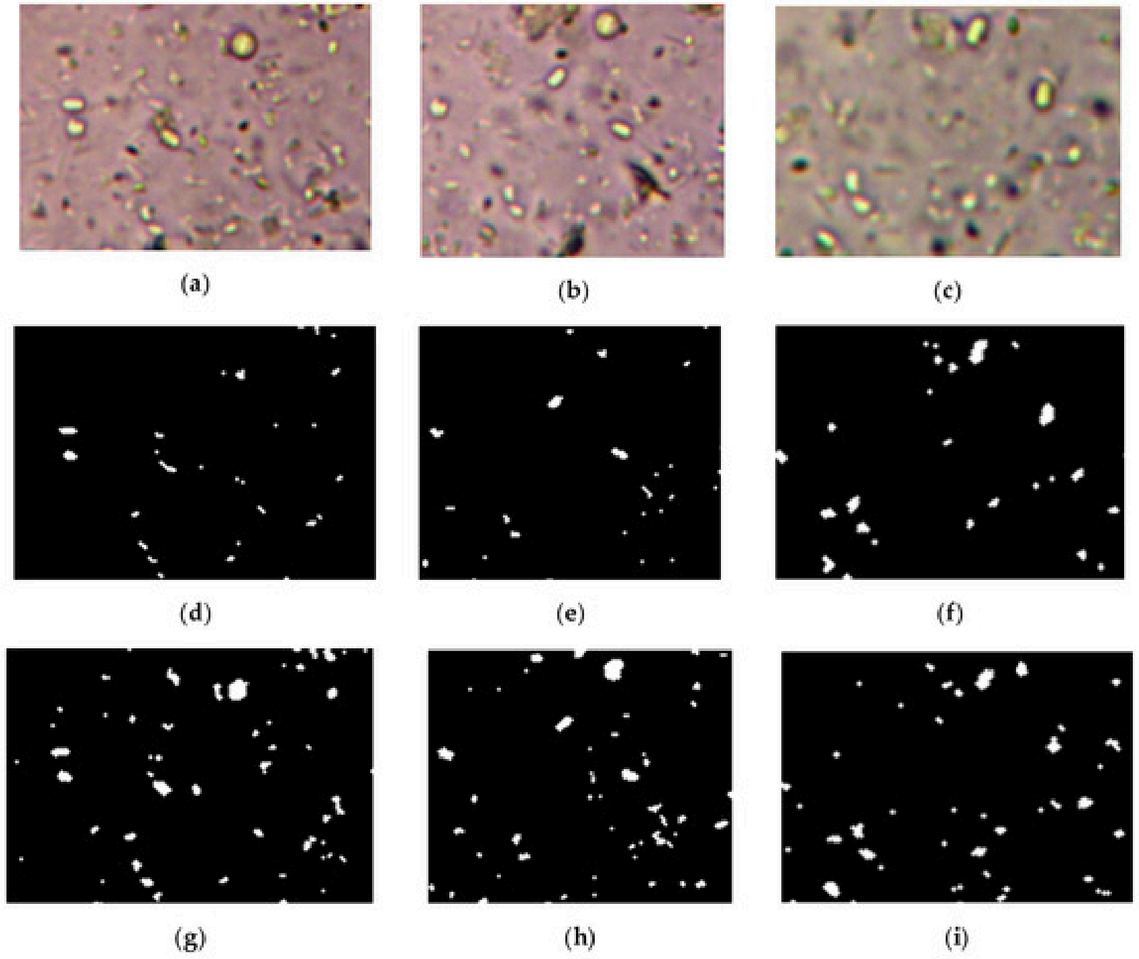
Bacteria & Microorganism Detection

Identifies bacterial colonies in microbiology.

04

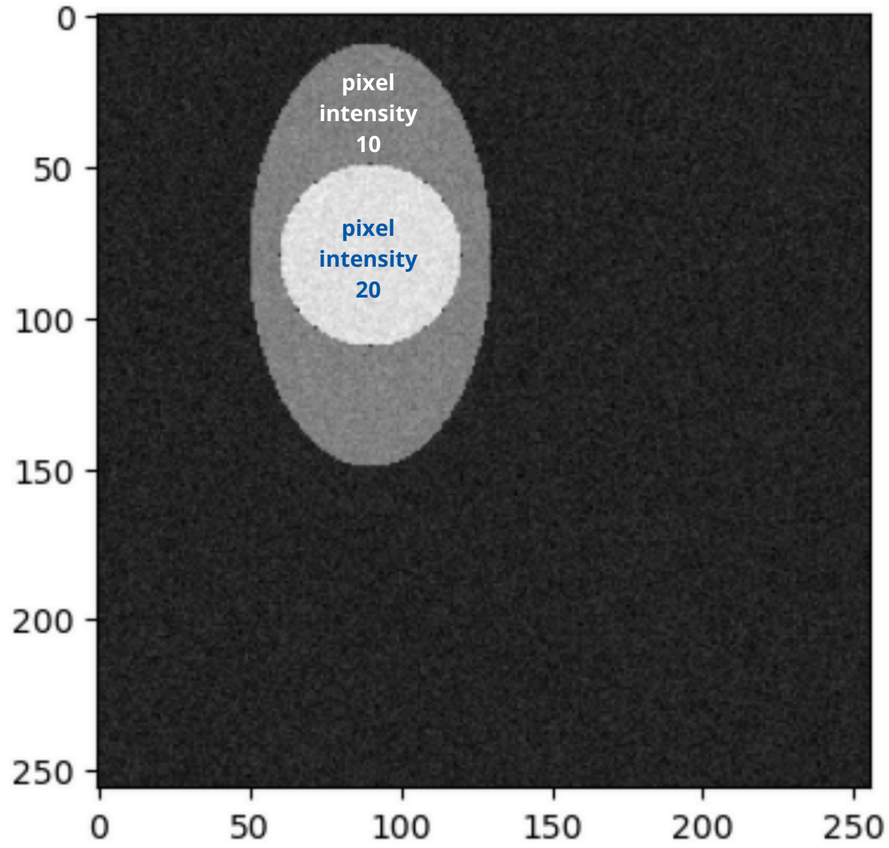
Blood Sample Analysis

Segments red and white blood cells for hematology studies.



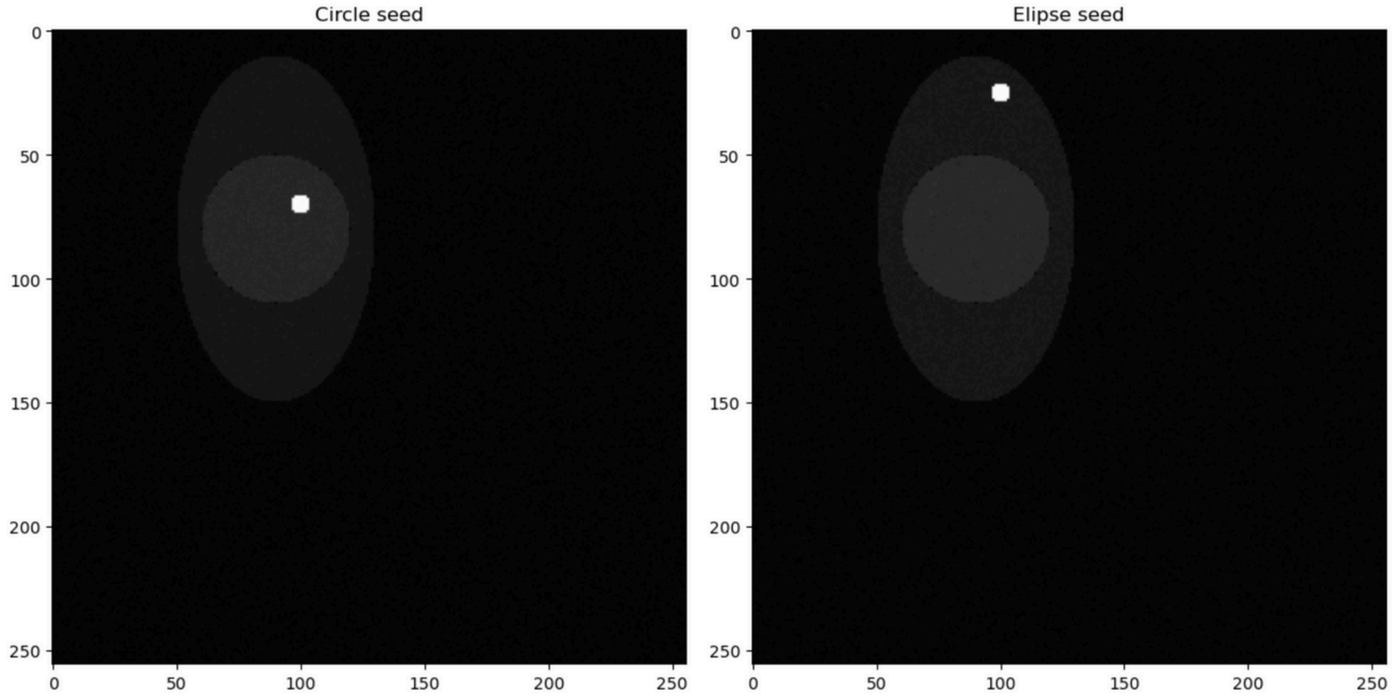
Create an ellipse and circle region

```
# Create a coordinate grid (256x256) using meshgrid
xx, yy = np.meshgrid(np.arange(256), np.arange(256))
# Initialize a blank grayscale image (256x256) filled with zeros
img = np.zeros((256, 256))

# Define a circular region centered at (90, 80) with a radius of 30 pixels
rr0 = (xx-90)**2 + (yy-80)**2
# Assign pixel intensity 20 to this circular region
img[rr0 < 30**2] = 20.0

# Define an elliptical region surrounding the circular region
# The equation represents an ellipse centered at (90, 80) with axes (40, 70)
rr1 = (xx-90)**2/40**2 + (yy-80)**2/70**2

# Assign intensity 10 to the contiguous elliptical region outside the initial circle
# The condition ensures the pixels belong to the elliptical region but not the inner circle
img[(rr0 > 30.0**2)*(rr1 < 1.0)] = 10.0

# Apply Gaussian noise to the image using a predefined function
img = regionGrowing.gaussian_noise(image=img, sigma=1)

plot_images([img], figsize=(4,8), hideAxis=False)
# plt.imshow(img, cmap="gray")
```



Define seeds

```
# using a sedd
circle_seed = (100, 70)
ellipse_seed = (100, 25)

# draw a circle around the seed
circle_flag =  regionGrowing.set_seed(image=img, seed=circle_seed, seed_size=4)
ellipse_flag =  regionGrowing.set_seed(image=img, seed=ellipse_seed, seed_size=4)

labels = ["Circle seed", "Elipse seed"]

plot_images([circle_flag, ellipse_flag], labels, hideAxis=False)
```



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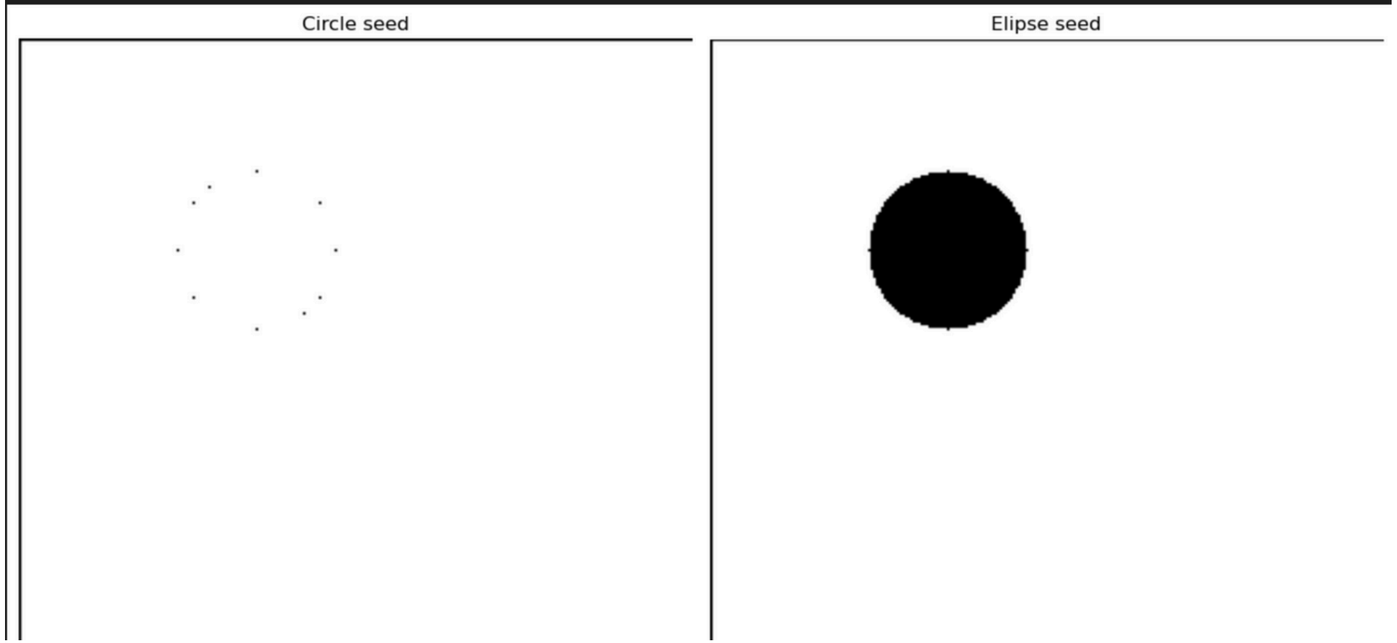
Region overgrowth detected

```
circle_mask = regionGrowing(seed=circle_seed, image=img, threshold=8)
elipse_mask = regionGrowing(seed=ellipse_seed, image=img, threshold=6)

plot_images([circle_mask, elipse_mask], labels)
```

✓ 1.3s Python

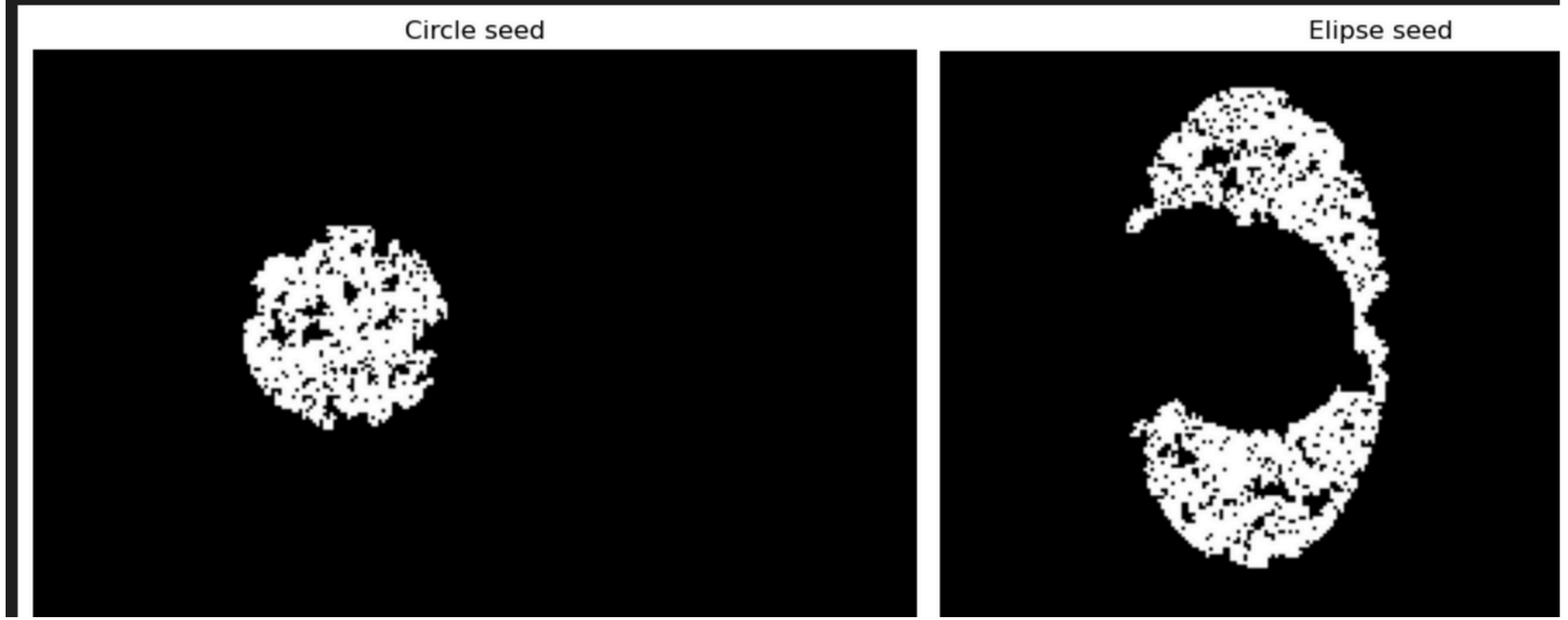


Oversegmentation

```
circle_mask = regionGrowing(seed=circle_seed, image=img, threshold=1)
elipse_mask = regionGrowing(seed=ellipse_seed, image=img, threshold=1)

plot_images([circle_mask, elipse_mask], labels)
```

✓ 0.2s



Adequate growth

```python
circle_mask = regionGrowing(seed=circle_seed, image=img, threshold=4)
elipse_mask = regionGrowing(seed=ellipse_seed, image=img, threshold=4)

plot_images([circle_mask, elipse_mask], labels)
```

Python

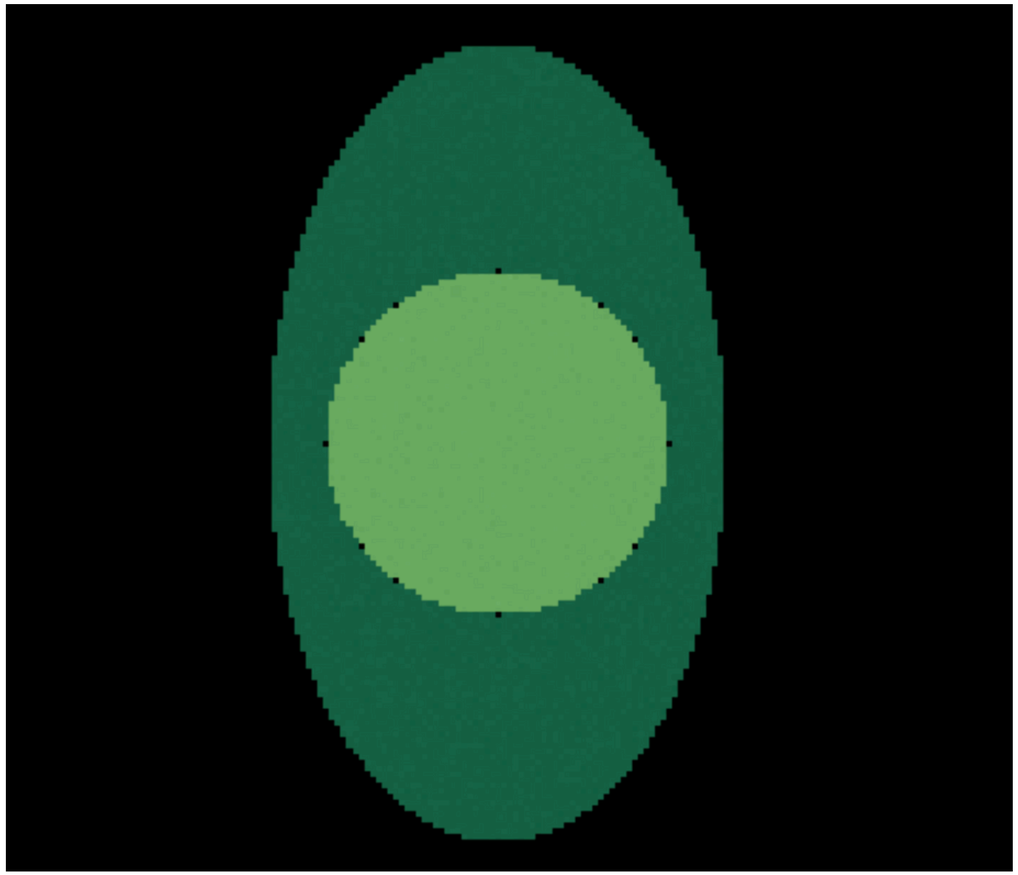
Region growing

```
# Convert grayscale image to 3-channel (RGB) by stacking it three times
img_rgb = np.stack([img] * 3, axis=-1)  # Shape becomes (H, W, 3)

# Normalize values to [0, 255] and convert to uint8
img_rgb = np.clip(img_rgb, 0, 255).astype(np.uint8)

masks = [circle_mask, elipse_mask]

ellipse_circle = regionGrowing.plot_region_growing(image=img_rgb, masks=masks)
plot_images([ellipse_circle])
```



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Region growing Applied in medical imaging

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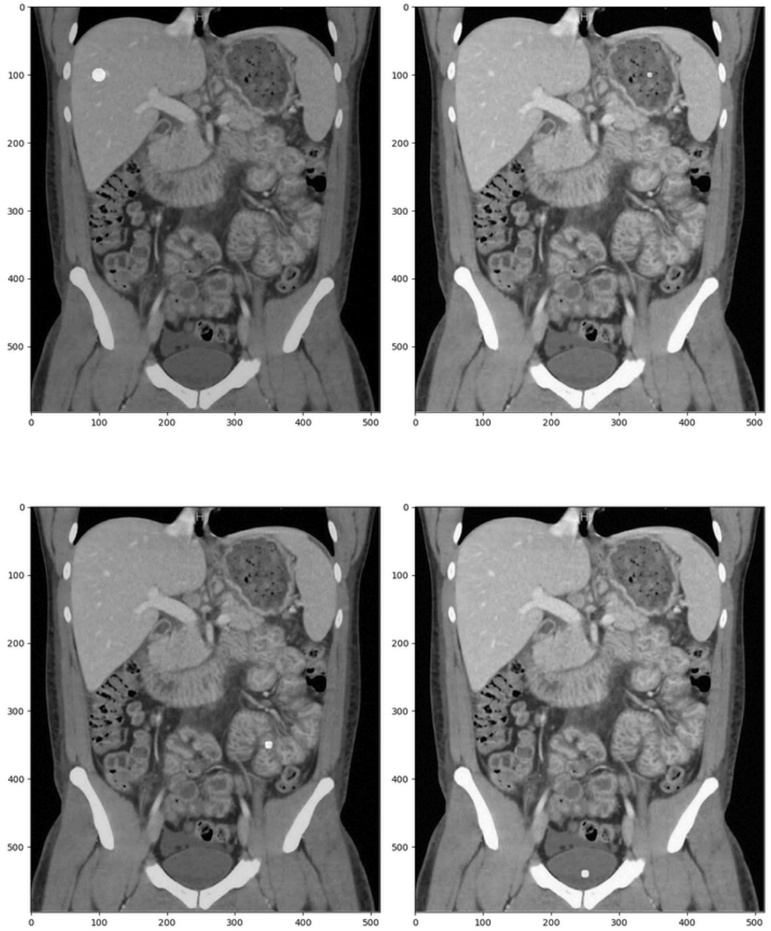
Region growing

seeds:

- (100, 100)
- (345,100)
- (350, 350)
- (250,540)



```
corps_seed = (100, 100)
corps_seed2 = (345,100)
corps_seed3 = (350, 350)
corps_seed4 = (250,540)

seed_img1 = regionGrowing.set_seed(gray_corps_image, corps_seed, 10)
seed_img2 = regionGrowing.set_seed(gray_corps_image, corps_seed2, 4)
seed_img3 = regionGrowing.set_seed(gray_corps_image, corps_seed3, 6)
seed_img4 = regionGrowing.set_seed(gray_corps_image, corps_seed4, 6)

plot_images([seed_img1, seed_img2, seed_img3, seed_img4], hideAxis=False, figsize=(12,16), ncols=2, nrows=2)
```

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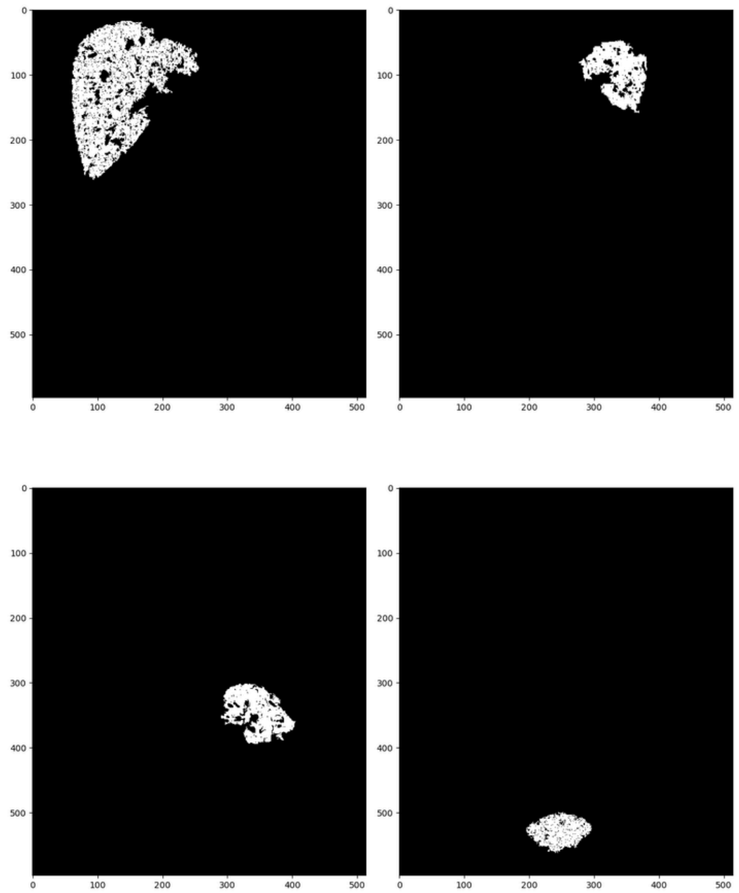
Region growing masks

```
corps_mask = regionGrowing(seed=corps_seed, image=gray_corps_image,
                           threshold=2, dist=8)
corps_organ_mask2 = regionGrowing(seed=corps_seed2, image=gray_corps_image,
                                  threshold= 5, dist=4)
corps_organ_mask3 = regionGrowing(seed=corps_seed3, image=gray_corps_image,
                                  threshold= 4, dist=8)
corps_organ_mask4 = regionGrowing(seed=corps_seed4, image=gray_corps_image,
                                  threshold= 2, dist=8)

plot_images([corps_mask, corps_organ_mask2, corps_organ_mask3, corps_organ_mask4],
            hideAxis=False, figsize=(12,16), ncols=2, nrows=2)
```

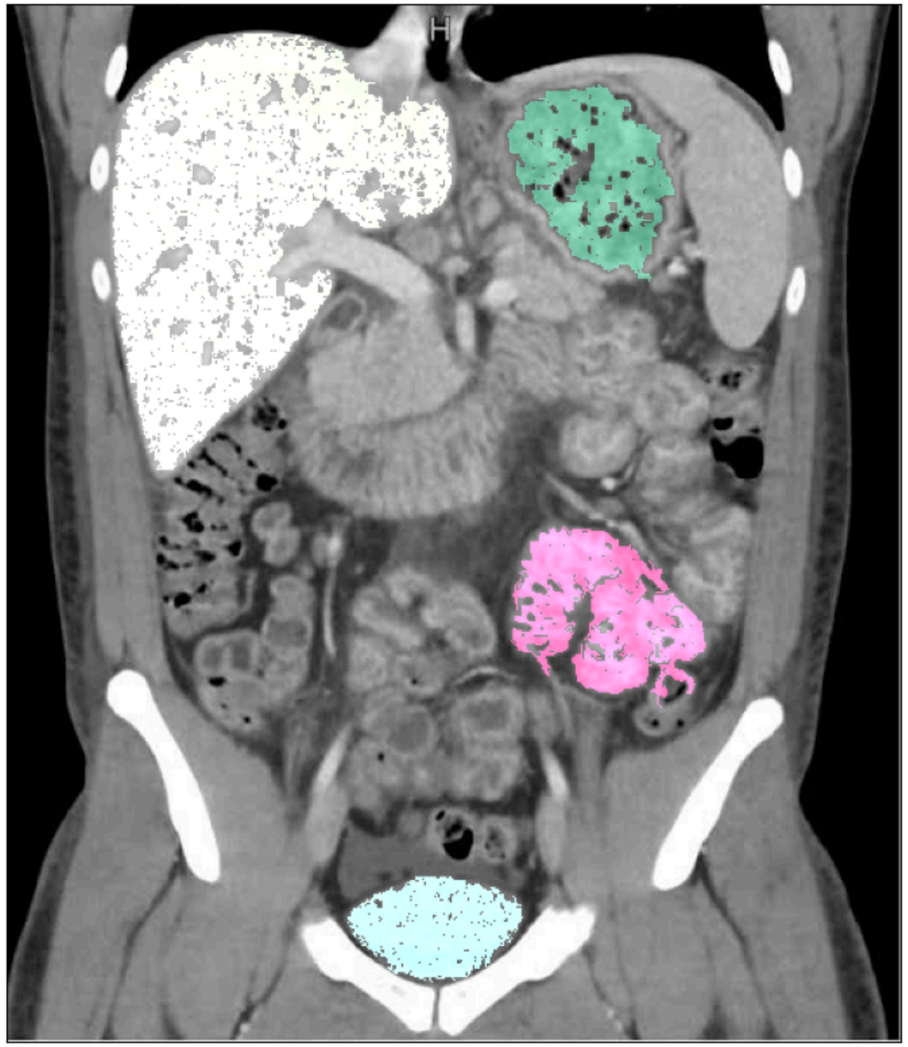


Region growing

```
masks = [corps_mask, corps_organ_mask2, corps_organ_mask3, corps_organ_mask4]

final_image = regionGrowing.plot_region_growing(image=corp_image, masks=masks)

plot_images([final_image], hideAxis=True)
```



Observations with similarity

Case	Threshold	Growth effect	Solution
Overgrowth	Too high	Region grows uncontrollably	Decrease `**threshold**`, limit **maximum iteration**
Adequate growth	Well-tuned	Region follows object boundaries	Keep **threshold** optimized
Oversegmentation	Too low	Region stops growing too early	Increase **threshold**, test with **N8**

Observations with neighbors

Feature	N4 connectivity	N8 Connectivity
Expansion type	More stricted	More flexible
Best for	Grid-based structures	Smooth region expansion

Observations with noise

Without noise reduction	With noise reduction
Region expands into noisy artifacts	Smoother segmentation with fewer errors
Overgrowth due to random intensity spikes	Controlled growth respecting object boundaries
Fragmented regions of threshold is too strict	Consistent segmentation with less randomness

References

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