Challenges in Image Segmentation

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4 Tightly Coupled Problems

Image Segmentation, Object Detection, Visual Saliency and 3D Scene Layout

Why Image Segmentation Is Difficult?

- What is a good number of segments?
  - What is the purpose of the segmentation?
    - Visual-saliency-based segmentation may be more meaningful
    - Object-recognition-based segmentation may be more relevant
- Human uses 3D information to segment (e.g., occlusion) while computers have only 2D image information
- Human uses semantics to group pixels while computers are very weak in semantic understanding

Simplest Cases

- Blue Screen Technology


BoscoTech

Image Segmentation Types

- Interactive segmentation (with human assistance)

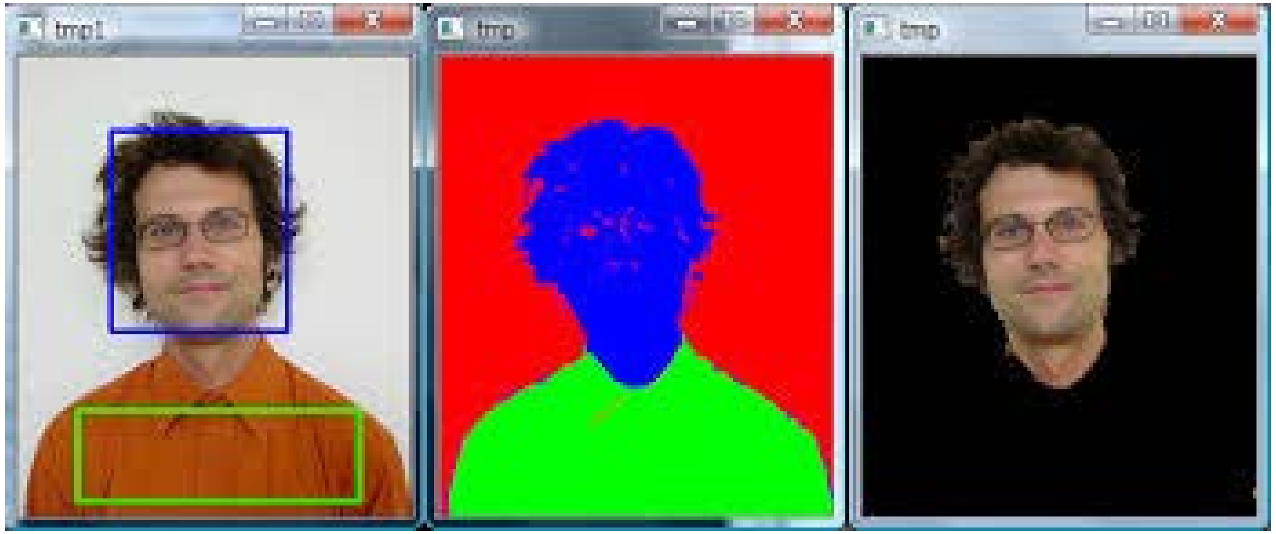
https://www.youtube.com/watch?v=aOqOwM-Qbtg

- Automatic segmentation

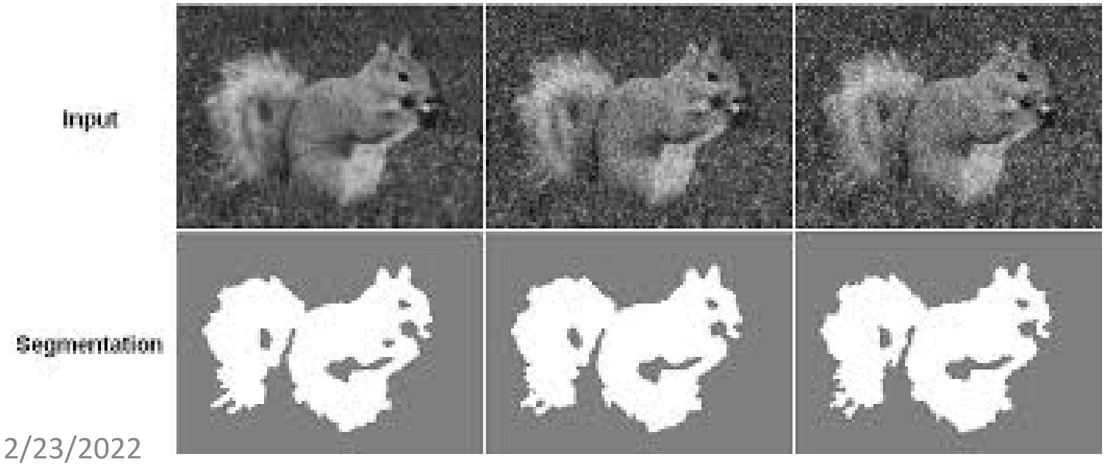
Without human assistance

Image Segmentation Tasks

- From Two Groups (Foreground and Background) to Multiple Groups



- From Gray-Scale Images to Color Images



Several Ideas

- Contour detection (contour serves as a separator)
  - Active contour
- Region growing
  - Watershed
- Graph-based
  - Pixels are nodes, their similarity is defined by an edge value
    - Very similar -> small edge value
    - Very different -> large edge value
    - How to define similarities? mostly related to color (could be others)
- Superpixel methods

Superpixel Methods

- Superpixel algorithms group pixels into perceptually meaningful regions while respecting potential object contours, and thereby can replace the rigid pixel grid structure

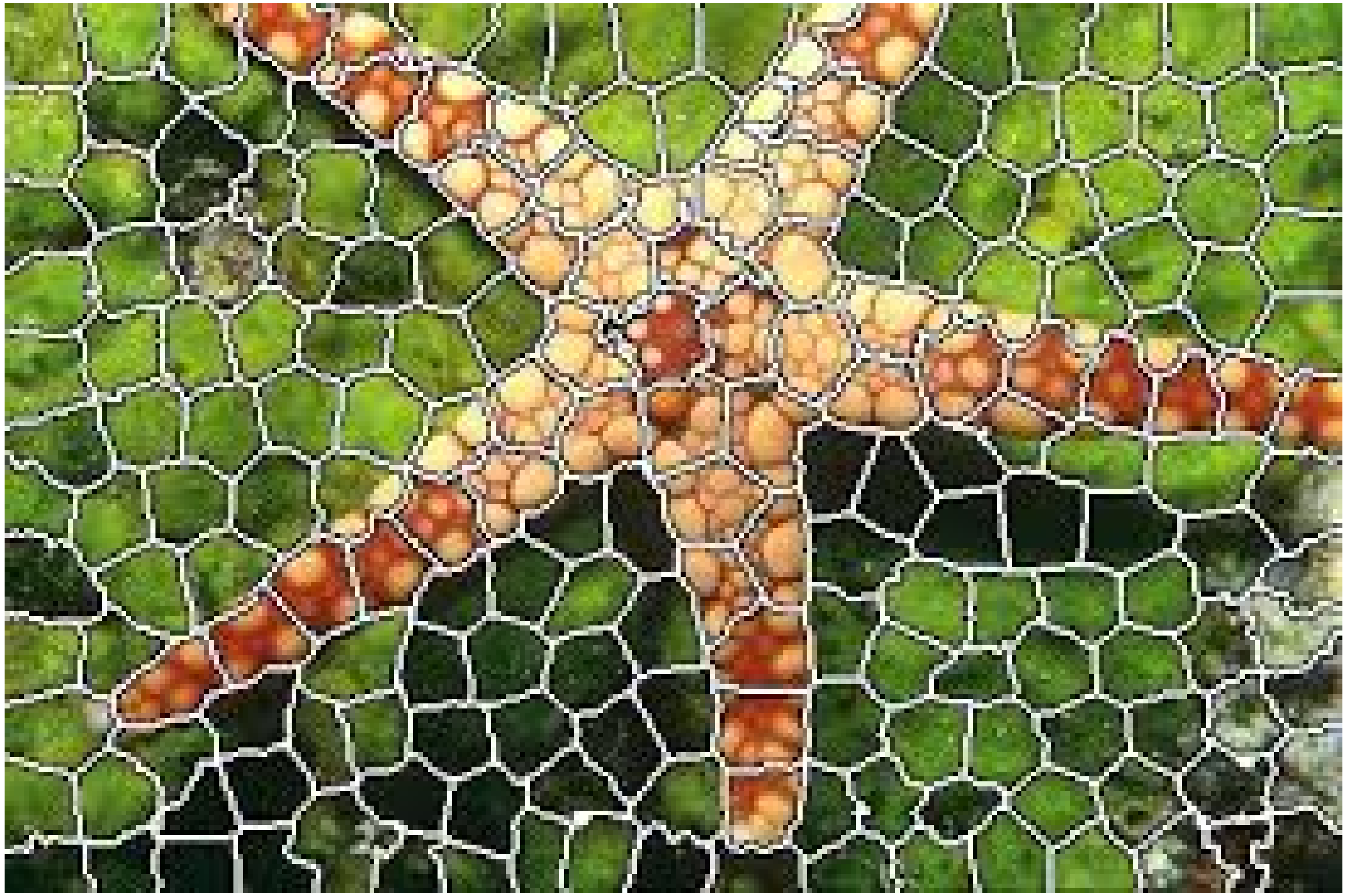
- Due to the reduced complexity, superpixels were popular for various unsupervised computer vision applications
  - Examples: multiclass object segmentation, depth estimation, human pose estimation, and object localization.

Simple Linear Iterative Clustering (SLIC)

- Cluster pixels in the five-dimensional color and pixel coordinate space (e.g., r,g,b,x,y)
- Initialization
  - Begin with a collection of K cluster centers initialized at an equally sampled regular grid on the image of N pixels
  - For each cluster, you define for a localized window 2S x 2S centered at the cluster center, where S=N/K−−−−√ is the roughly the space between the seed cluster centers
- Iteration
  - Check whether the pixel within the 2S x 2S local window should be assigned to the cluster center or not (by comparing the distance in 5D space to the cluster center)
  - Once you loop through all the clusters, you can update the cluster center by averaging over the cluster members. Iterate the pixel-to-cluster assignment process till convergence or maximum iterations reached

SLIC Superpixel Method

- Simple Linear Iterative Clustering (SLIC)



SLIC Superpixel Method

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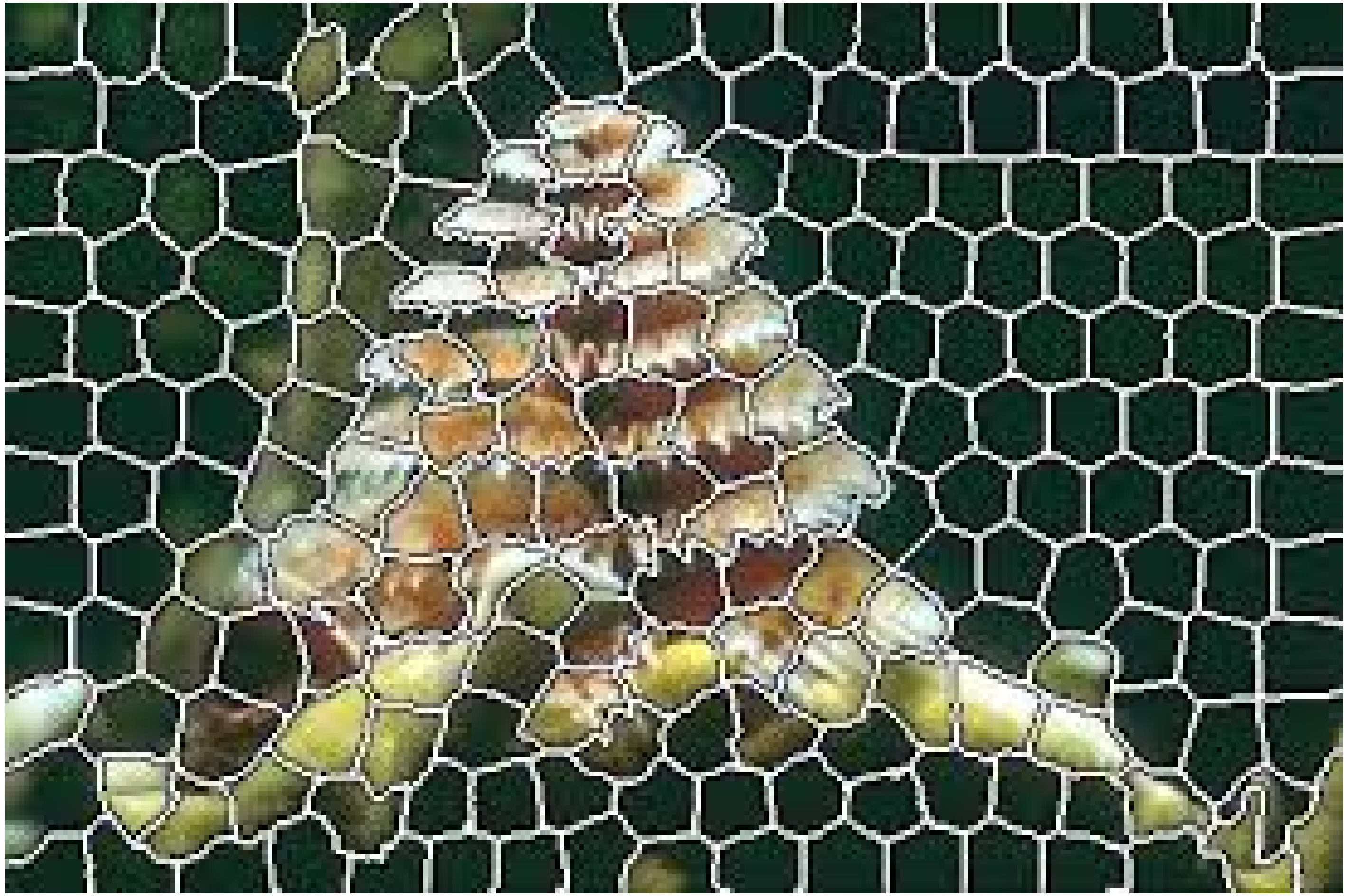

SLIC Superpixel Method

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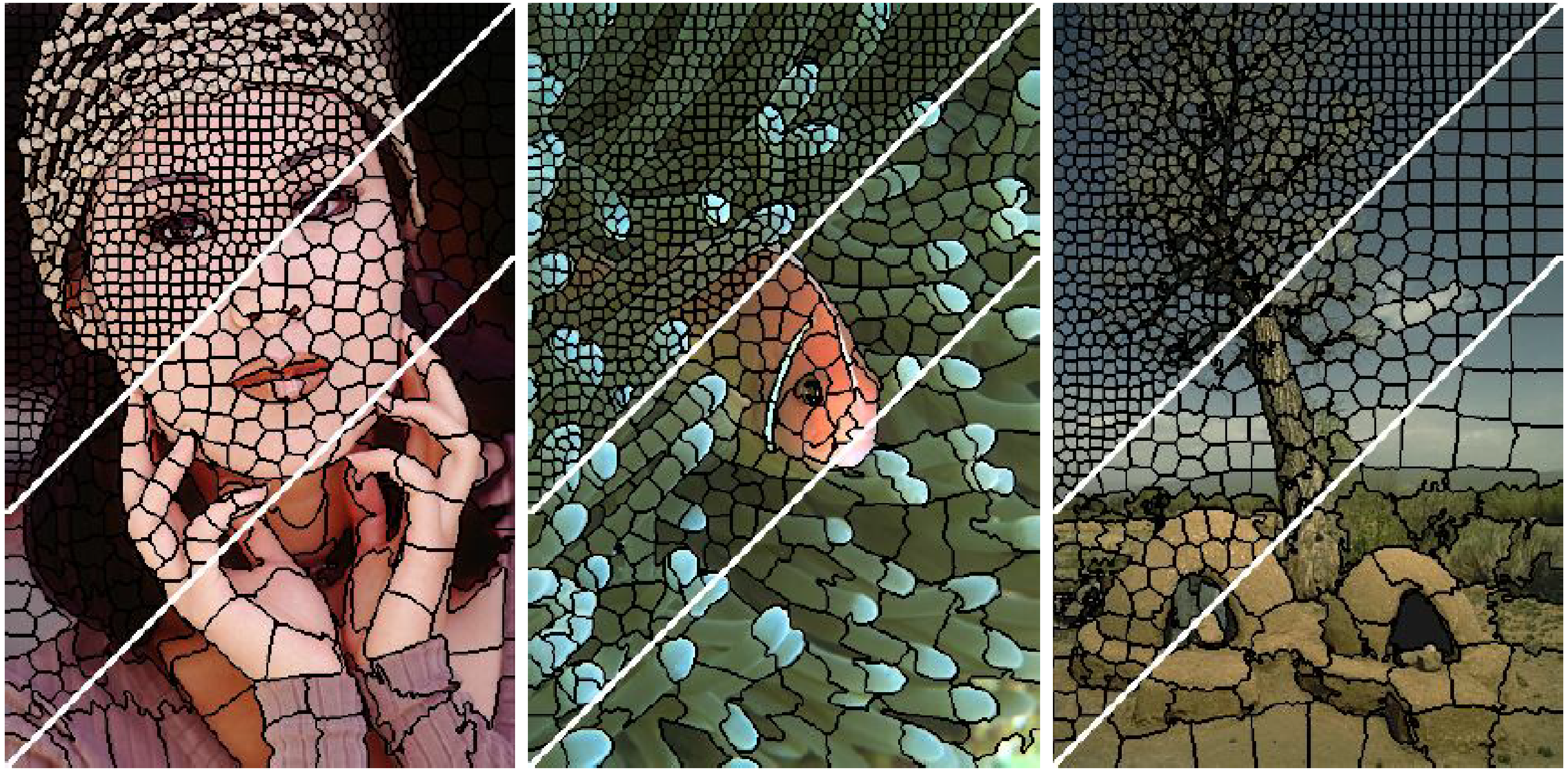

Fig. 1. Image segmented using our algorithm into superpixels of (approximate) size 64, 256, and 1024 pixels. The superpixels are compact, uniform in size, and adhere well to region boundaries.

Recent Trend: Supervised Image Segmentation

- PASCAL VOC Image Segmentation Dataset (2005-2012)
- Homepage: http://host.robots.ox.ac.uk/pascal/VOC/
- 20 Object Classes + 1 Background Class

20 Semantic Classes in PASCAL VOC

aeroplane, bicycle, bird, boat, bottle, bus, car, cat, chair, cow, diningtable, dog, horse, motorbike, person, potted plant, sheep, sofa, train, and tv/monitor.

Pascal VOC Image Segmentation Datasets (1)

Pascal VOC Image Segmentation Datasets (2)

Semantic Segmentation versus Instance Segmentation

Instance Segmentation | Semantic Segmentation

Image | Object | Class

More Examples