Segmentation - Split and Merge

Objectives

- Learn segmentation techniques using the Split and merge method.
- Watershed technique.
- Region methods: splitting, merging.
- Graph-based segmentation.
- Probabilistic aggregation.

What are different?

- Threshold: single threshold is rarely sufficient for the whole image because of lighting and intra-object statistical variations
- Using recursively splitting the whole image into pieces based on region statistics or, conversely, merging pixels and regions together in a hierarchical fashion.
- It is also possible to combine both splitting and merging by starting with a medium-grain segmentation and then allowing both merging and splitting operations.

Split and merge Segmentation

- Algorithm:
  - Define the criterion to be used for homogeneity
  - Split the image into equal size regions
  - Calculate homogeneity for each region
  - If the region is homogeneous, then merge it with neighbors
  - The process is repeated until all regions pass the homogeneity test

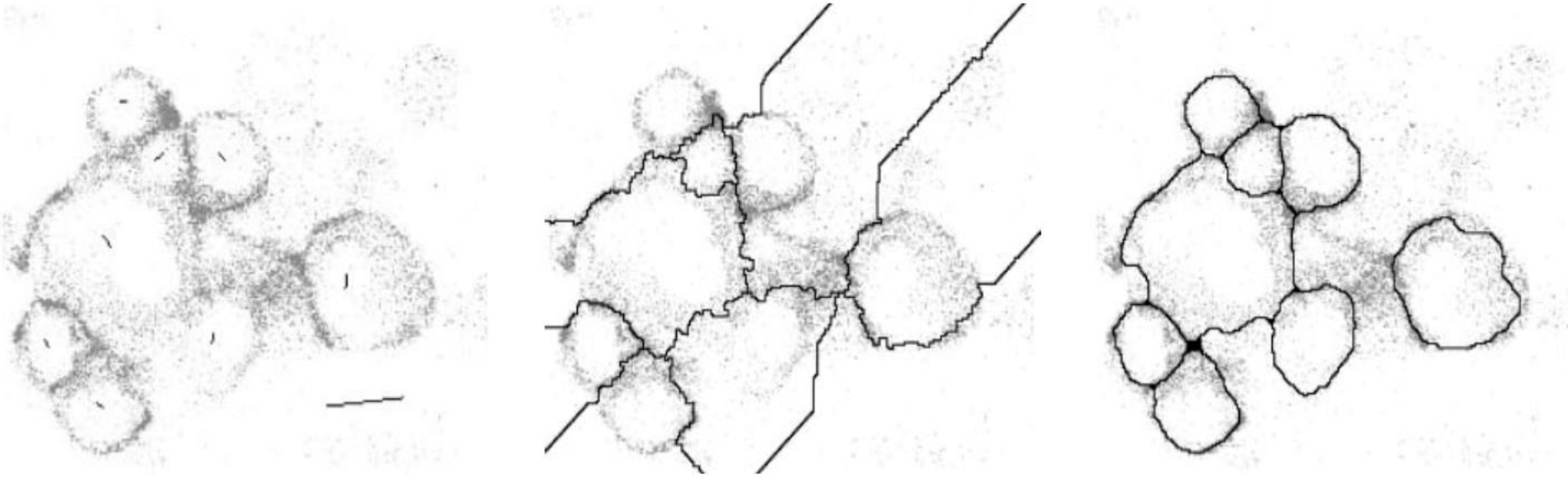
Watershed

- A watershed is a transformation defined on a grayscale image.
- The name refers metaphorically to a geological watershed, or drainage divide, which separates adjacent drainage basins.
- The watershed transformation treats the image it operates upon like a topographic map, with the brightness of each point representing its height, and finds the lines that run along the tops of ridges.

Watershed

- To understand the watershed, one can think of an image as a surface:
  - The bright pixels represent mountaintops
  - The dark pixels valleys
- The surface is punctured in some of the valleys, and then slowly submerged into a water bath
- The water will pour in each puncture and start to fill the valleys
- However, the water from different punctures is not allowed to mix, and therefore the dams need to be built at the points of first contact
- These dams are the boundaries of the water basins, and also the boundaries of image objects

Watershed



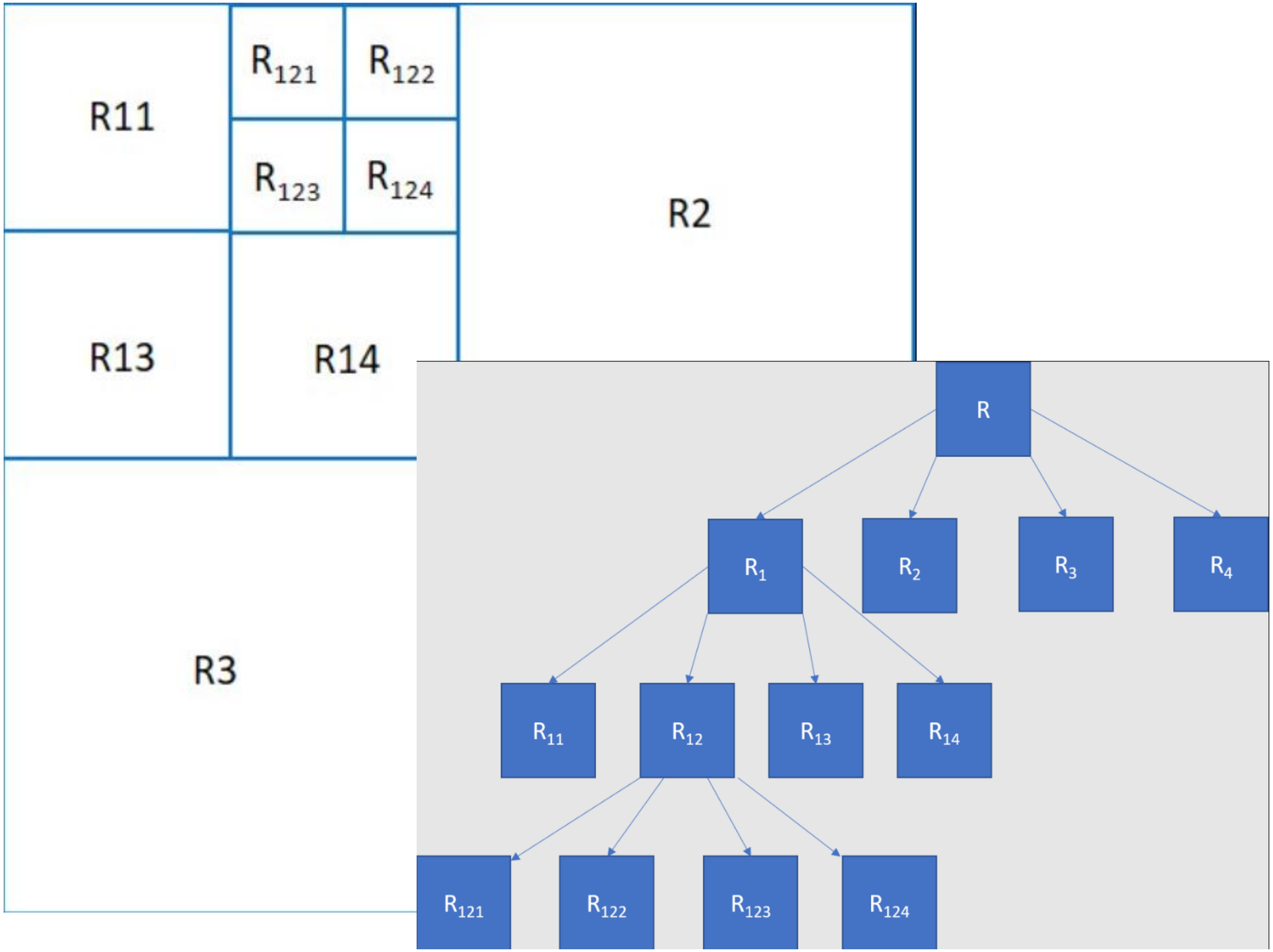
(a) (b) (c)

Watershed

Region Splitting

- Region Splitting: The basic idea of region splitting is to break the image into a set of disjoint regions which are coherent within themselves
- Region Splitting process:
  - Initially take the image as a whole to be the area of interest.
  - Look at the area of interest and decide if all pixels contained in the region satisfy some similarity constraint.
  - If TRUE then the area of interest corresponds to a region in the image.
  - If FALSE split the area of interest (usually into four equal sub-areas) and consider each of the sub-areas as the area of interest in turn.
  - This process continues until no further splitting occurs. In the worst case this happens when the areas are just one pixel in size.

Region Splitting

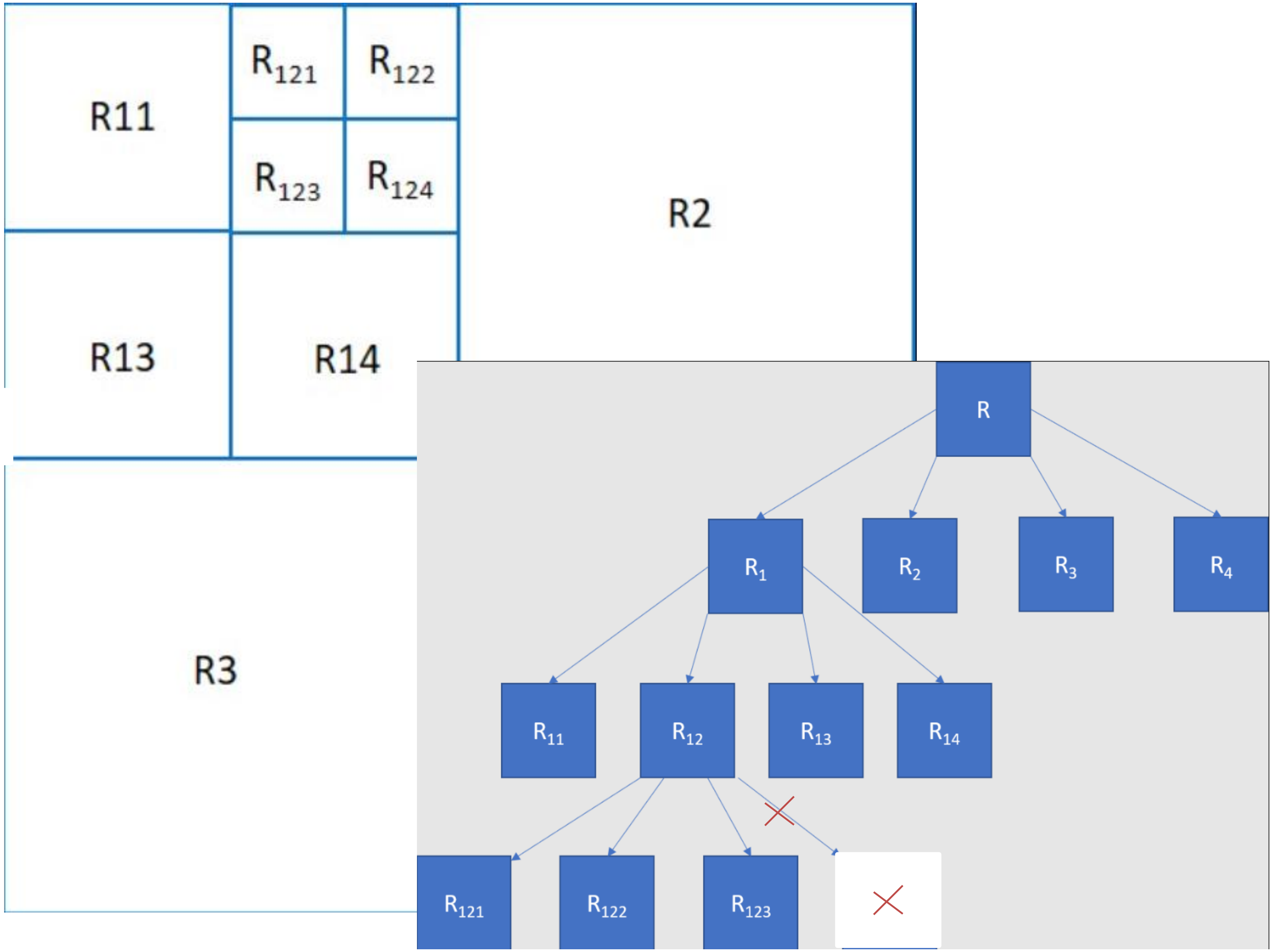


Region Splitting is enough?

- Region splitting only: the final segmentation would probably contain many neighboring regions that have identical or similar properties.
- A merging process is used after each split which compares adjacent regions and merges them if necessary

Region Splitting and Merging

R123

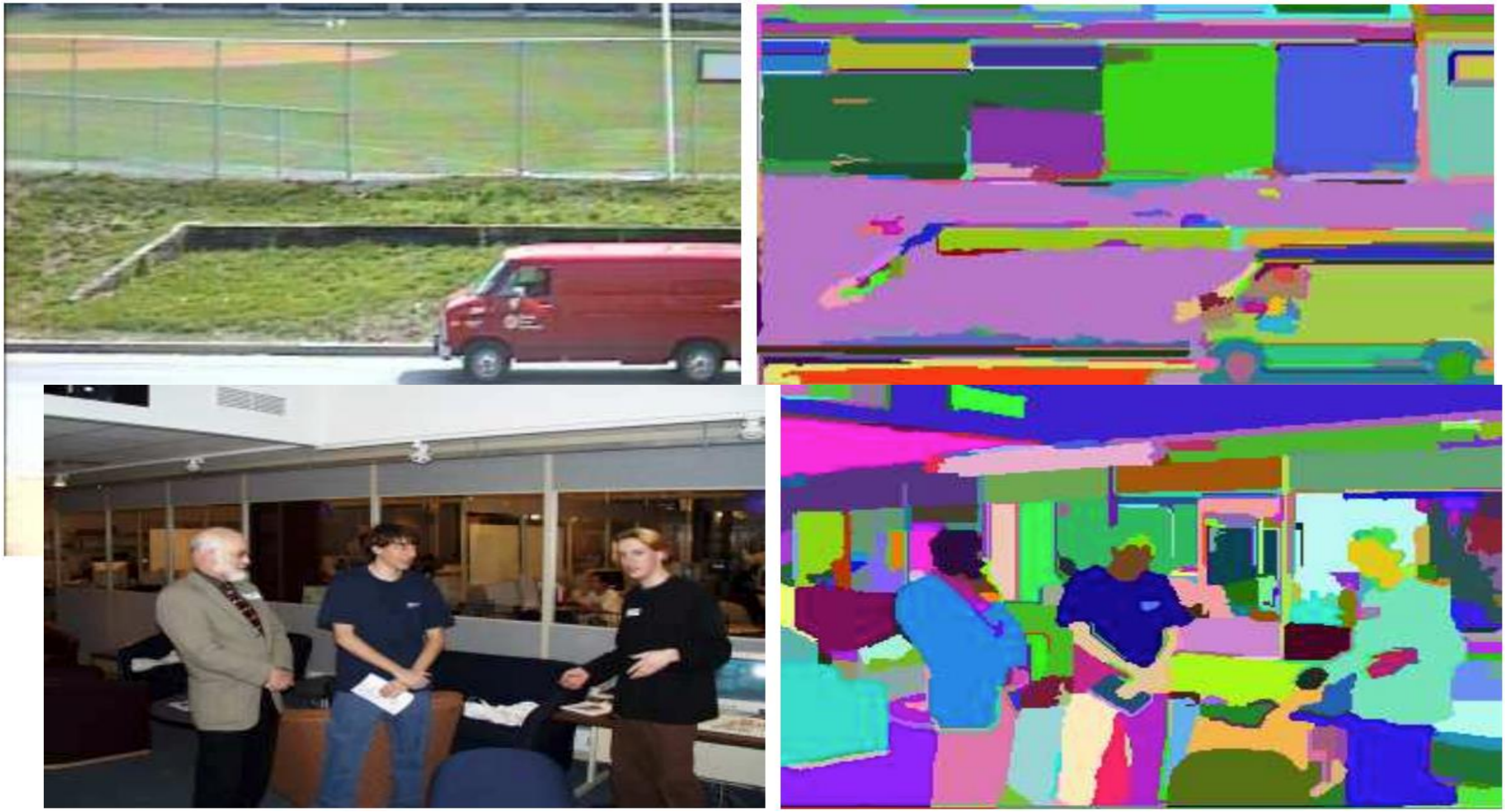


Graph-based Segmentation

The input is a graph $G = (V, E)$, with n vertices and m edges. The output is a segmentation of V into components $S = (C_1, \ldots, C_r)$.

0. Sort E into $\pi = (o_1, \ldots, o_m)$, by non-decreasing edge weight.
1. Start with a segmentation S^0, where each vertex v_i is in its own component.
2. Repeat step 3 for $q = 1, \ldots, m$.
3. Construct S^q given S^{q-1} as follows. Let v_i and v_j denote the vertices connected by the q-th edge in the ordering, i.e., $o_q = (v_i, v_j)$. If v_i and v_j are in disjoint components of S^{q-1} and $w(o_q)$ is small compared to the internal difference of both those components, then merge the two components otherwise do nothing. More formally, let C_i^{q-1} be the component of S^{q-1} containing v_i and C_j^{q-1} the component containing v_j. If $C_i^{q-1} \neq C_j^{q-1}$ and $w(o_q) \leq MInt(C_i^{q-1}, C_j^{q-1})$ then S^q is obtained from S^{q-1} by merging C_i^{q-1} and C_j^{q-1}. Otherwise $S^q = S^{q-1}$.
4. Return $S = S^m$.

Graph-based Segmentation



Probabilistic Aggregation

- Probabilistic merging algorithm based on two cues, namely gray-level similarity and texture similarity.
- The gray-level similarity between regions Ri and Rj is based on the minimal external difference from other neighboring regions

$$\sigma_{local}^{+} = \min(\Delta_i^{+}, \Delta_j^{+})$$

- This is compared to the average intensity difference:

$$\sigma_{local}^{-} = \frac{\Delta_i^{-} + \Delta_j^{-}}{2}$$

Probabilistic Aggregation

- The texture similarity is defined using relative differences between histogram bins of simple oriented Sobel filter responses. The pairwise statistics σ+ and σ− are used to compute the likelihoods pij that two regions should be merged

Summary

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