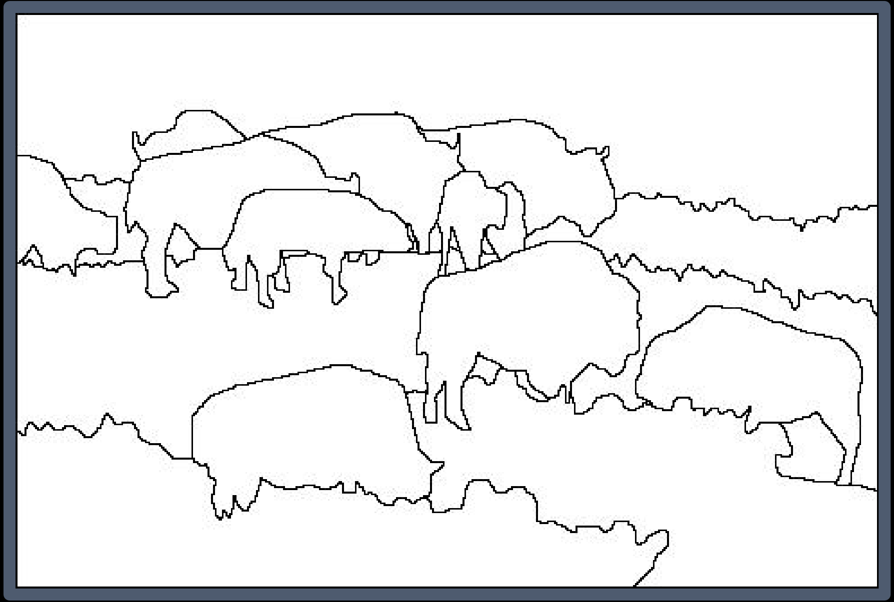
CS4495/6495
Introduction to Computer Vision

9A-L2 *Segmentation*

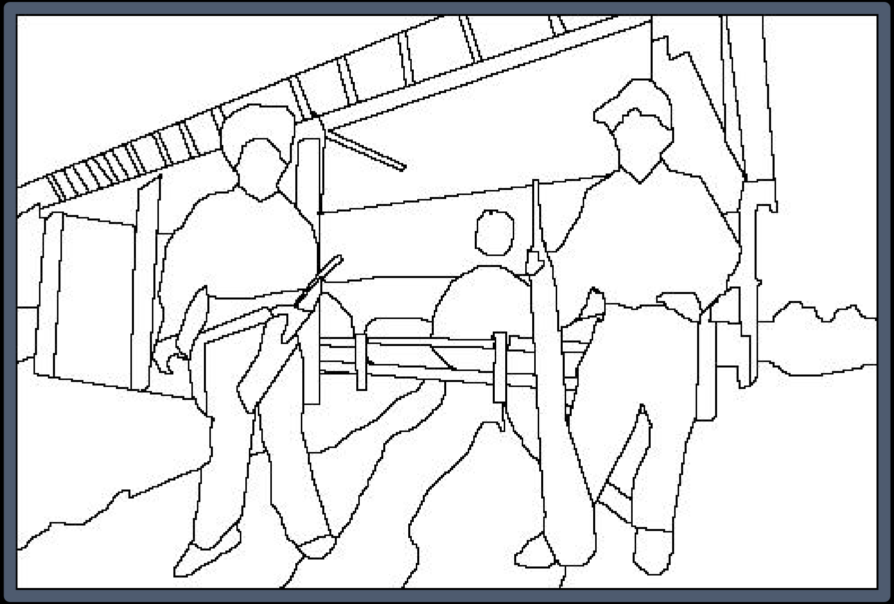
Slides by Tucker Hermans

Segmentation of Coherent Regions



Berkeley segmentation database:
www.eecs.berkeley.edu/Research/Projects/CS/vision/grouping/segbench/

Segmentation of Coherent Regions



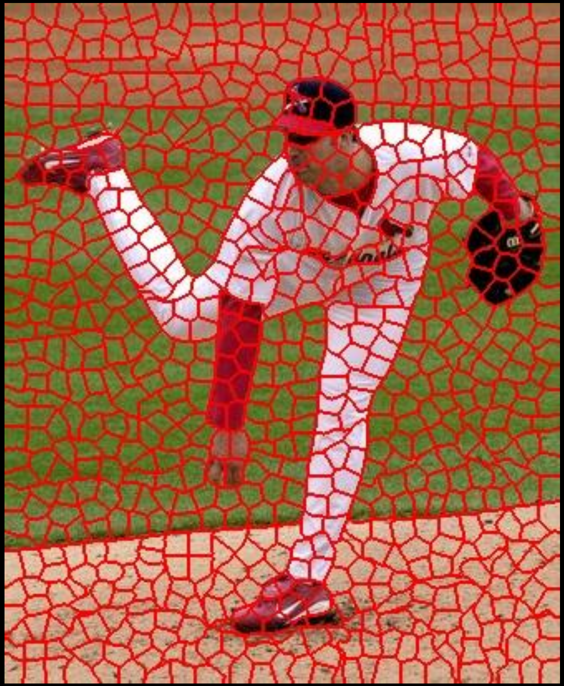
Berkeley segmentation database:
www.eecs.berkeley.edu/Research/Projects/CS/vision/grouping/segbench/

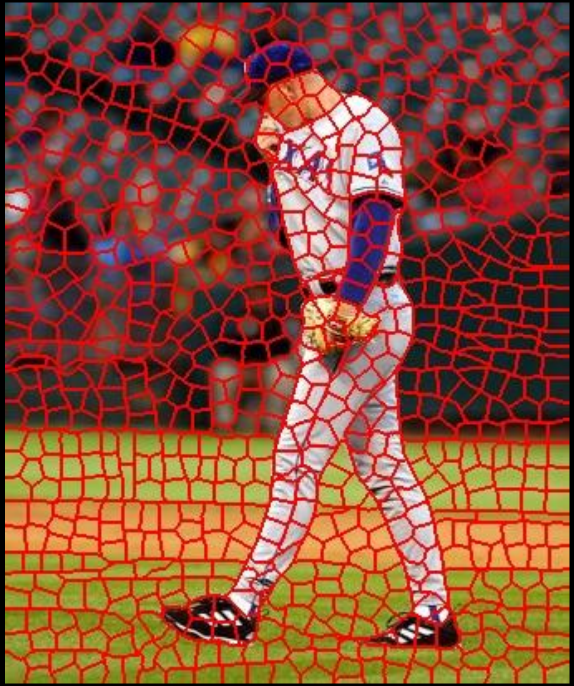
Figure-Ground Segmentation

- Separate the foreground object (figure) from the background (ground)

Grouping of Similar Neighbors

"Superpixels"





Slide by Svetlana Lazebnik

Extensions Beyond Single Images

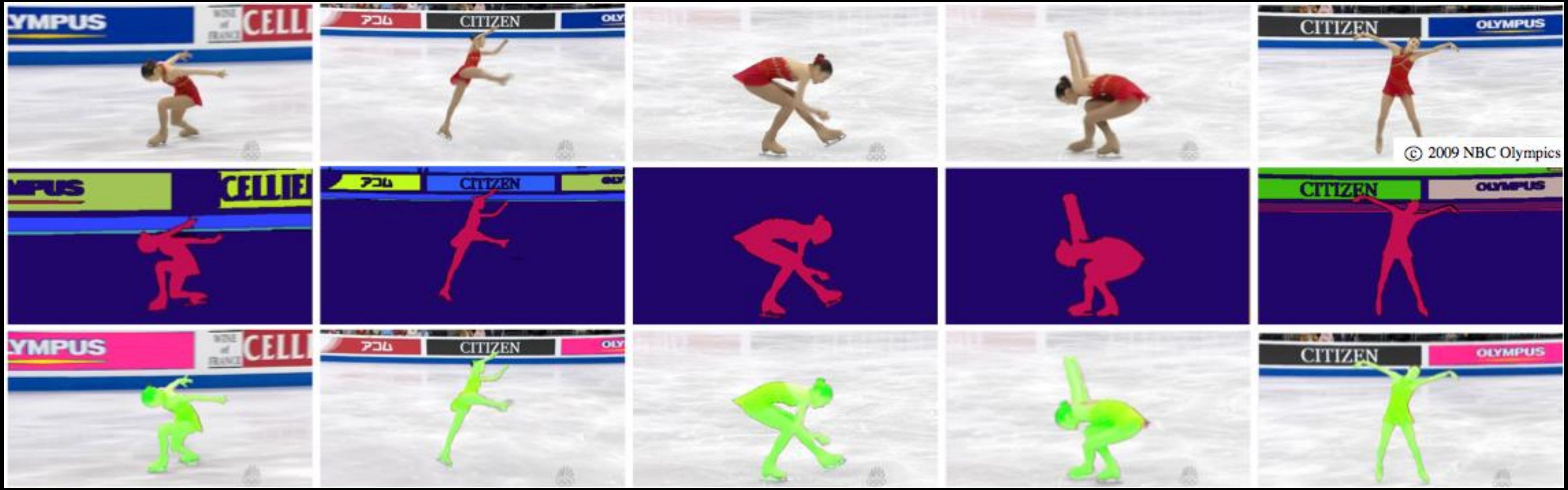
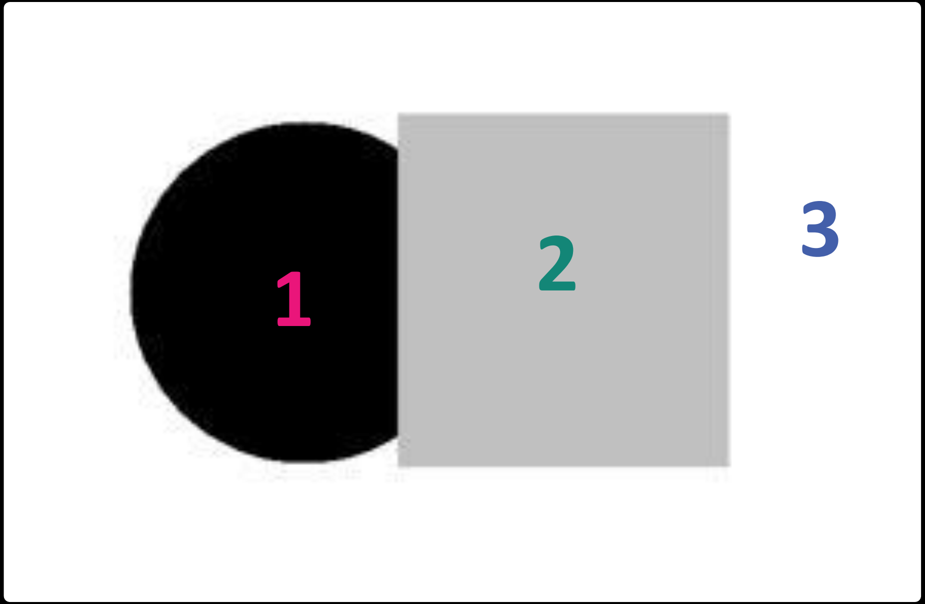
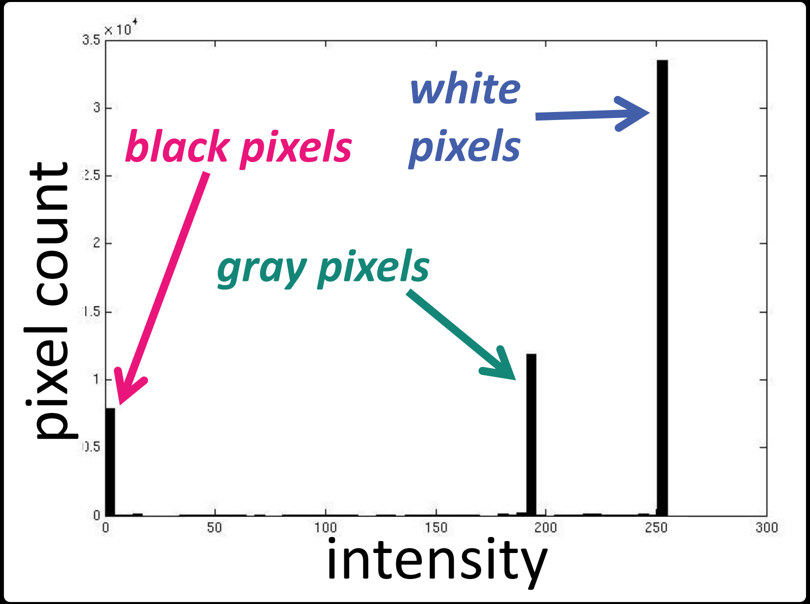


Image segmentation: Toy example



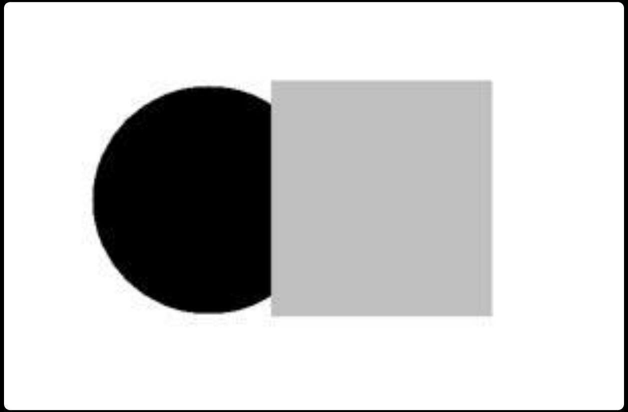
Input image

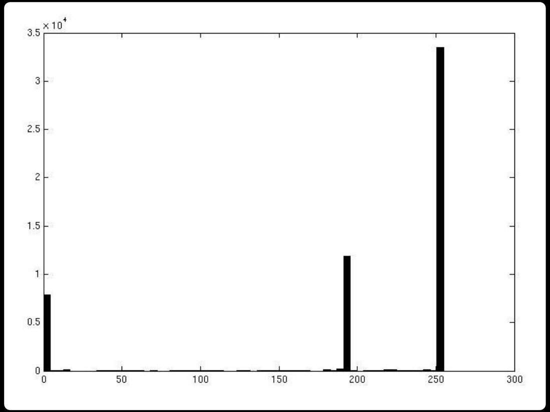


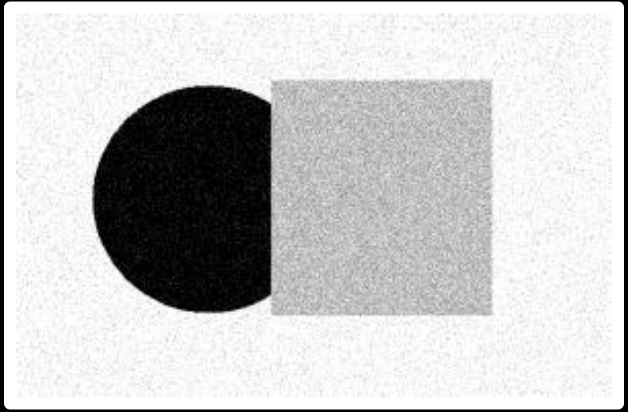
Intensity histogram

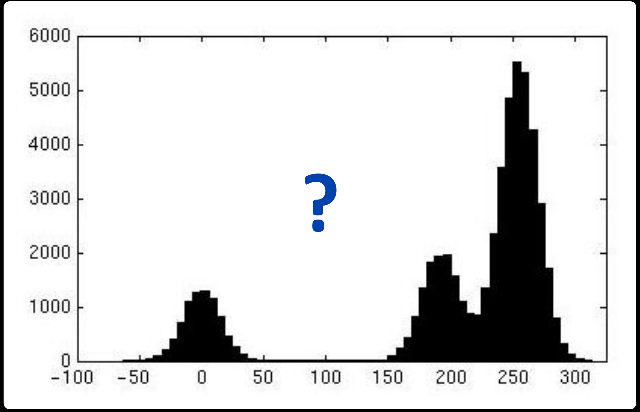
Kristen Grauman

Noisy Images

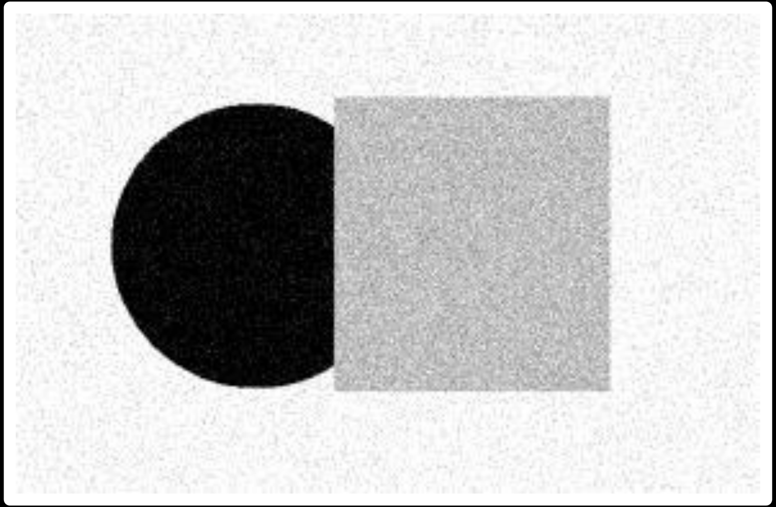


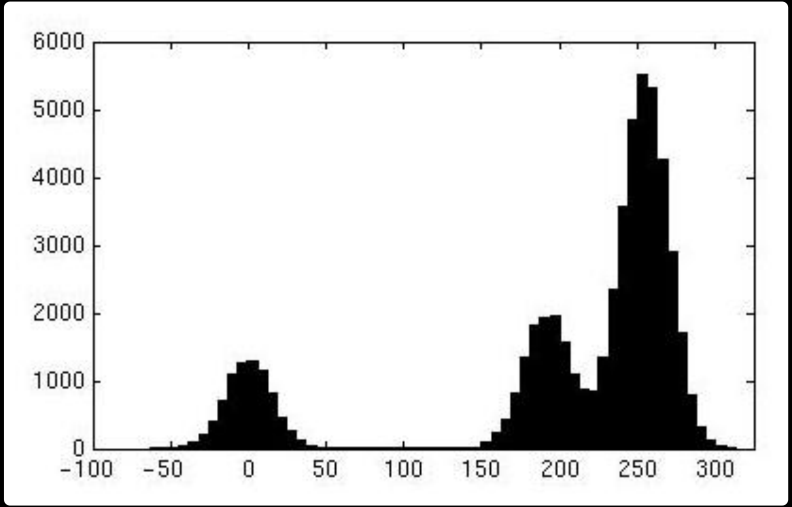






Noisy Images





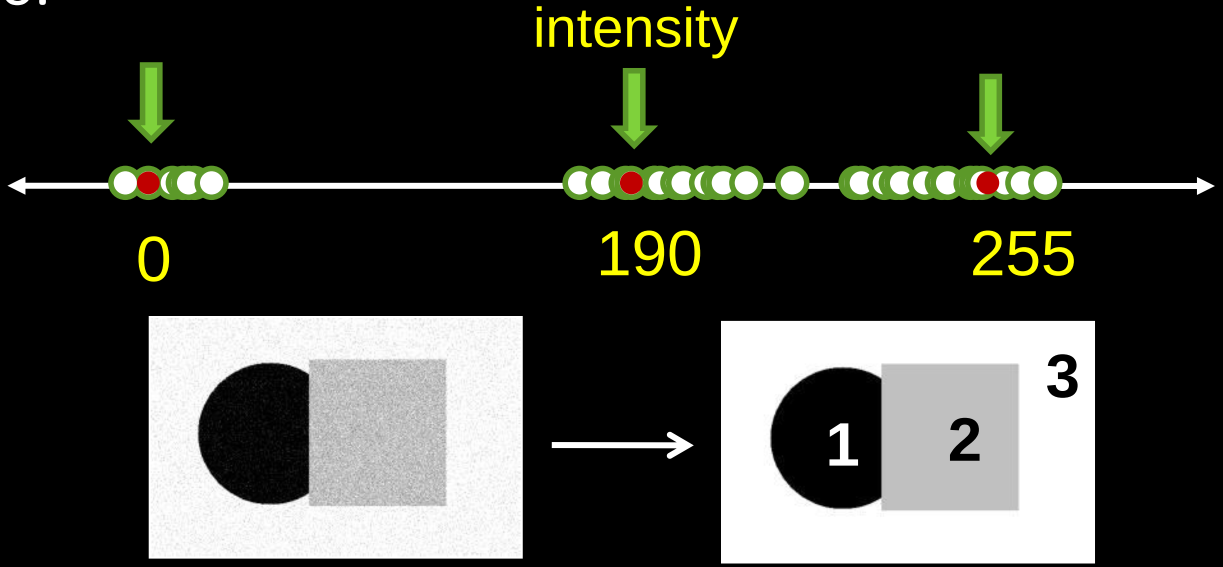
How to determine the three main intensities that define our groups?

- We need to *cluster*.

Kristen Grauman

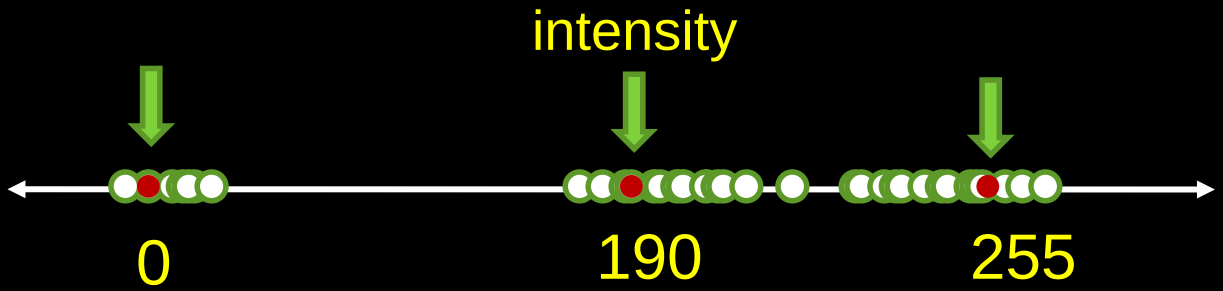
Clustering

- Goal: choose three "centers" as the representative intensities, and label every pixel according to which of these centers it is nearest to.



Clustering

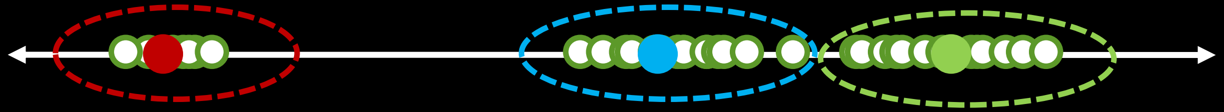
- Best cluster centers are those that minimize SSD between all points and their nearest cluster center c_i:



$$SSD = \sum_{\text{cluster } C_i} \sum_{p \in C_i} \left\| p_j - c_i \right\|$$

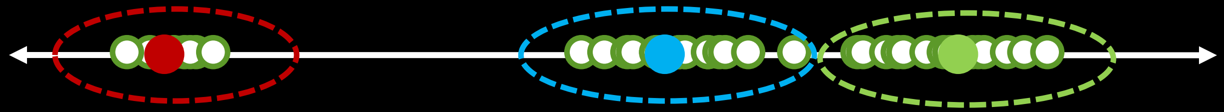
Clustering

- With this objective, it is a "chicken and egg" problem:
  - Q: If we knew c_i's, how would we determine which points to associate with each cluster center?
  - A: for each point p, choose closest c_i



Clustering

- With this objective, it is a “chicken and egg” problem:
  - Q: If we knew the cluster memberships, how do we get the centers?
  - A: choose c_i to be the mean of all points in the cluster



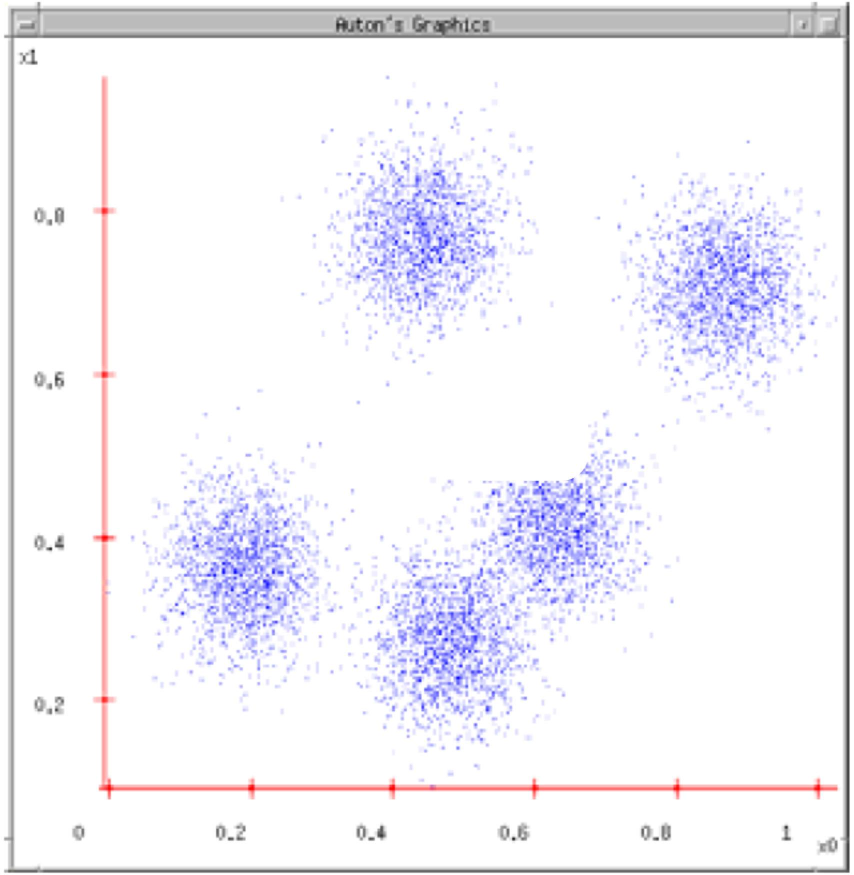
K-means clustering: Algorithm

1. Randomly initialize cluster centers $c_1, \ldots, c_K$
2. Determine points in each cluster:
   - For each point p, find the closest c_i; put p into cluster i
3. Given points in each cluster, solve for c_i:
   - Set c_i to be the mean of points in cluster i
4. If any c_i has changed, repeat Step 2

Steve Seitz

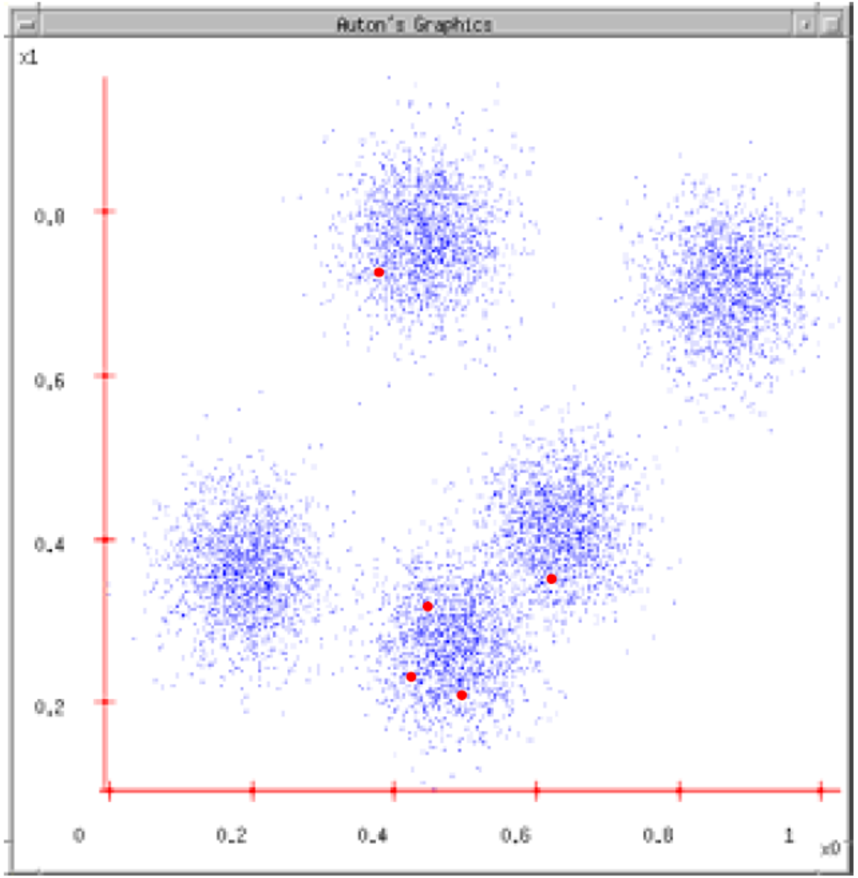
K-means

1. Ask user how many clusters they'd like. *(e.g. k=5)*



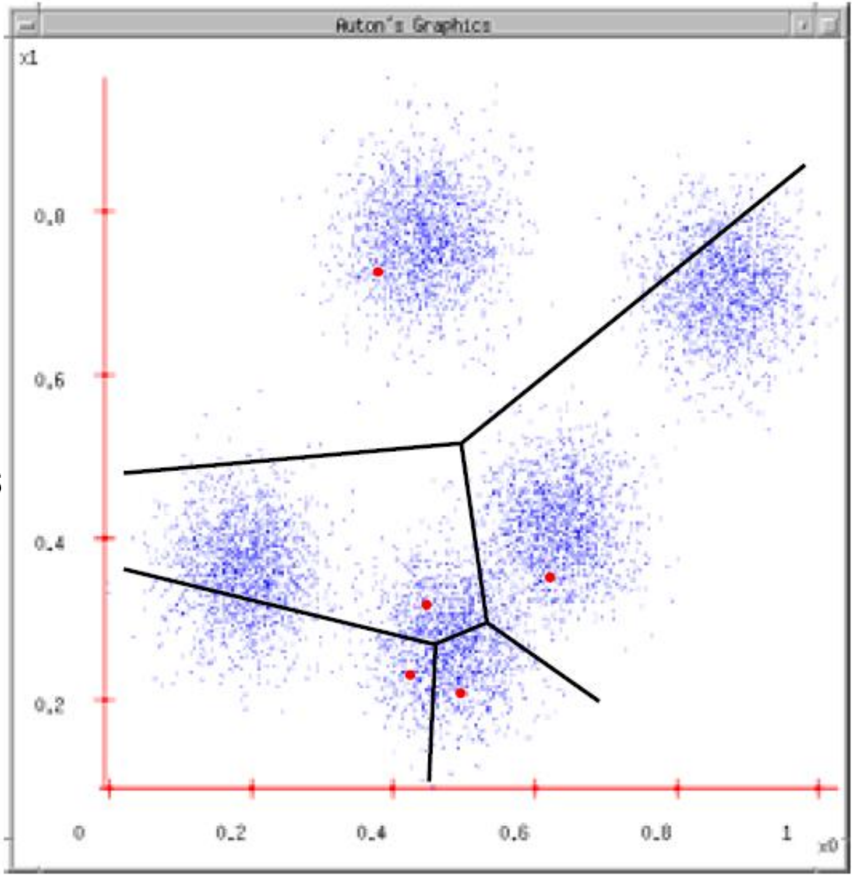
K-means

1. Ask user how many clusters they'd like. *(e.g. k=5)*
2. Randomly guess k cluster Center locations



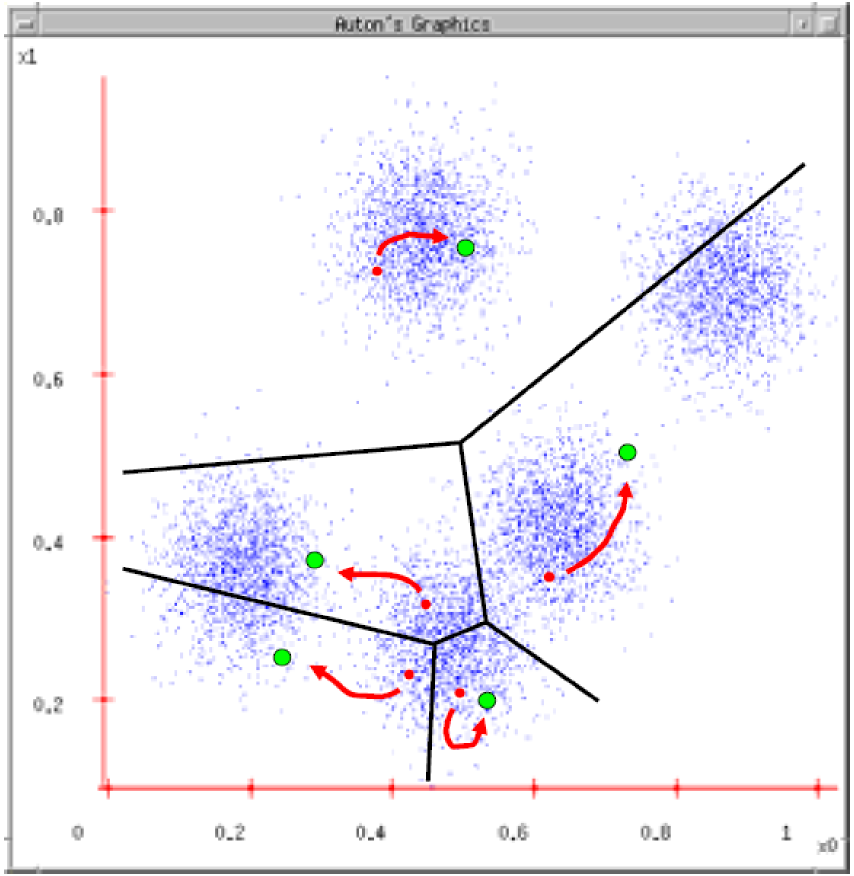
K-means

1. Ask user how many clusters they'd like. *(e.g. k=5)*
2. Randomly guess k cluster Center locations
3. Each datapoint finds out which Center it's closest to.



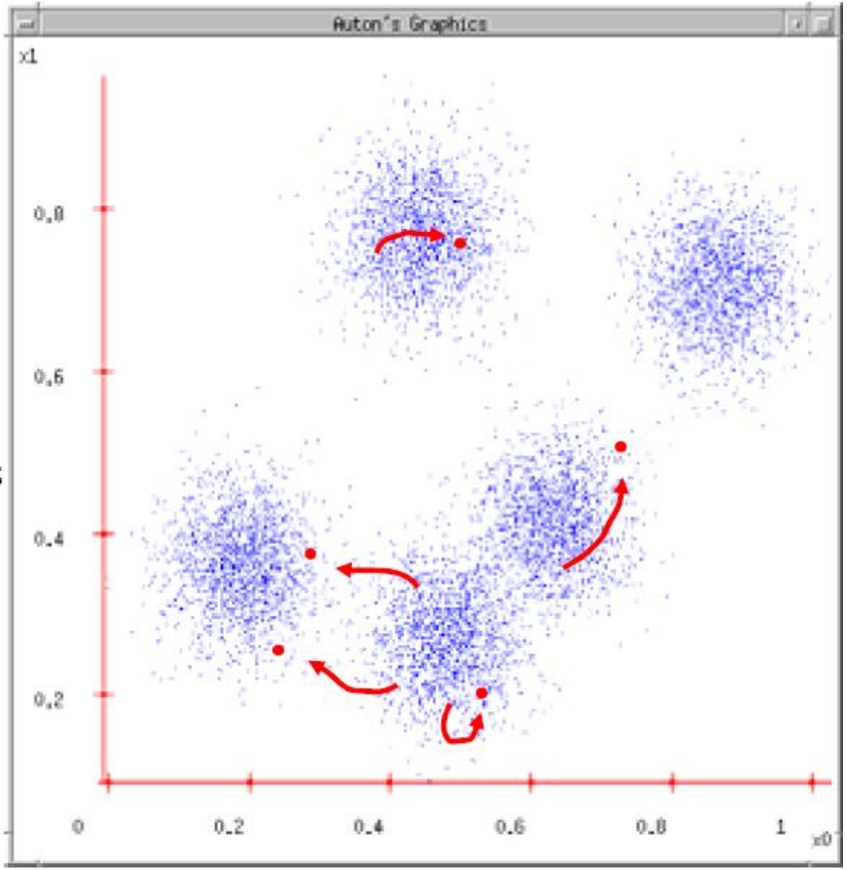
K-means

1. Ask user how many clusters they'd like. *(e.g. k=5)*
2. Randomly guess k cluster Center locations
3. Each datapoint finds out which Center it's closest to.
4. Each Center finds the centroid of the points it owns…



K-means

1. Ask user how many clusters they'd like. *(e.g. k=5)*
2. Randomly guess k cluster Center locations
3. Each datapoint finds out which Center it's closest to.
4. Each Center finds the centroid of the points it owns…
5. …and jumps there
6. …Repeat until terminated!



Segmentation as clustering

Depending on what we choose as the *feature space*, we can group pixels in different ways.

Grouping pixels based on **intensity** similarity

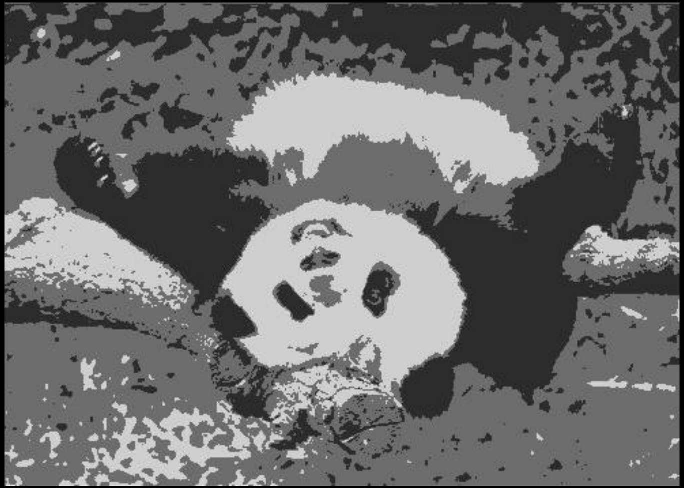
Feature space: intensity value (1-d)

Kristen Grauman

Number of Clusters

K=2

K=3

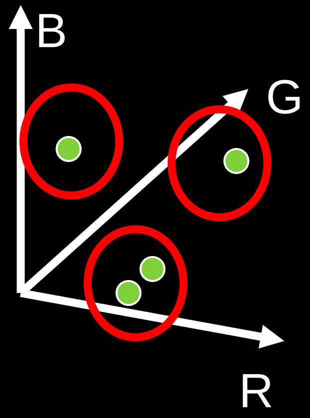


Can be thought of as *quantization* of the feature space; segmentation label map

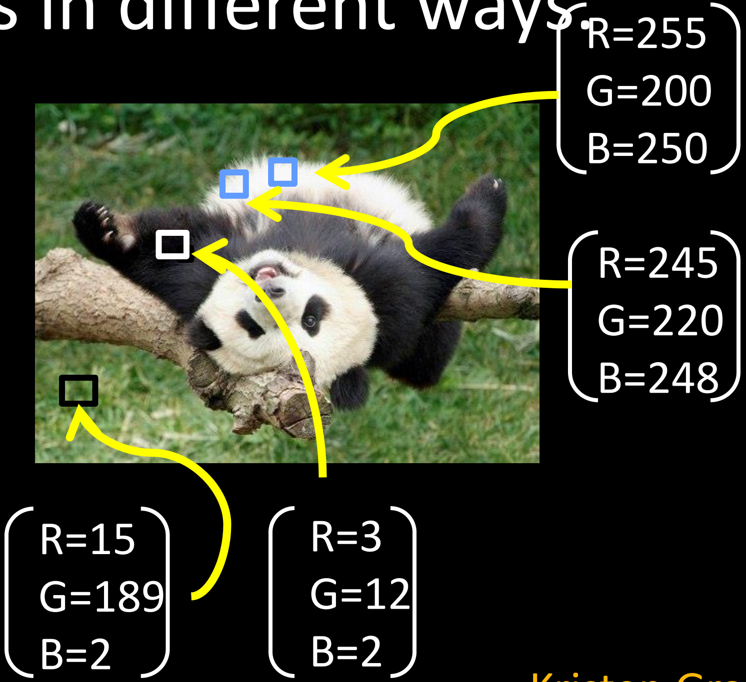
Segmentation as clustering

Depending on what we choose as the *feature space*, we can group pixels in different ways.

Grouping pixels based on **color** similarity



Feature space: color value (3-d)



Kristen Grauman

Segmentation as clustering

K-means clustering based on intensity or color is essentially vector quantization of the image attributes

Image

Intensity-based clusters

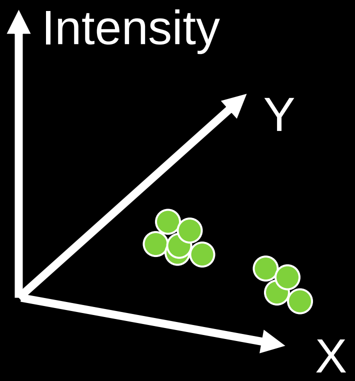
Color-based clusters

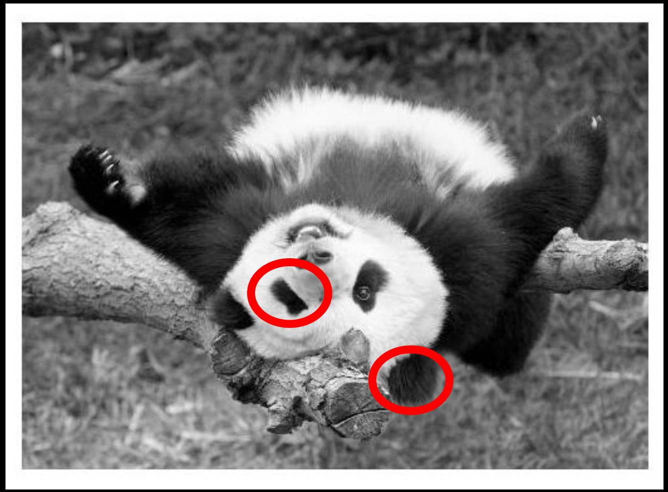
Svetlana Lazebnik

Segmentation as clustering

Depending on what we choose as the *feature space*, we can group pixels in different ways.

Grouping pixels based on
intensity+position similarity

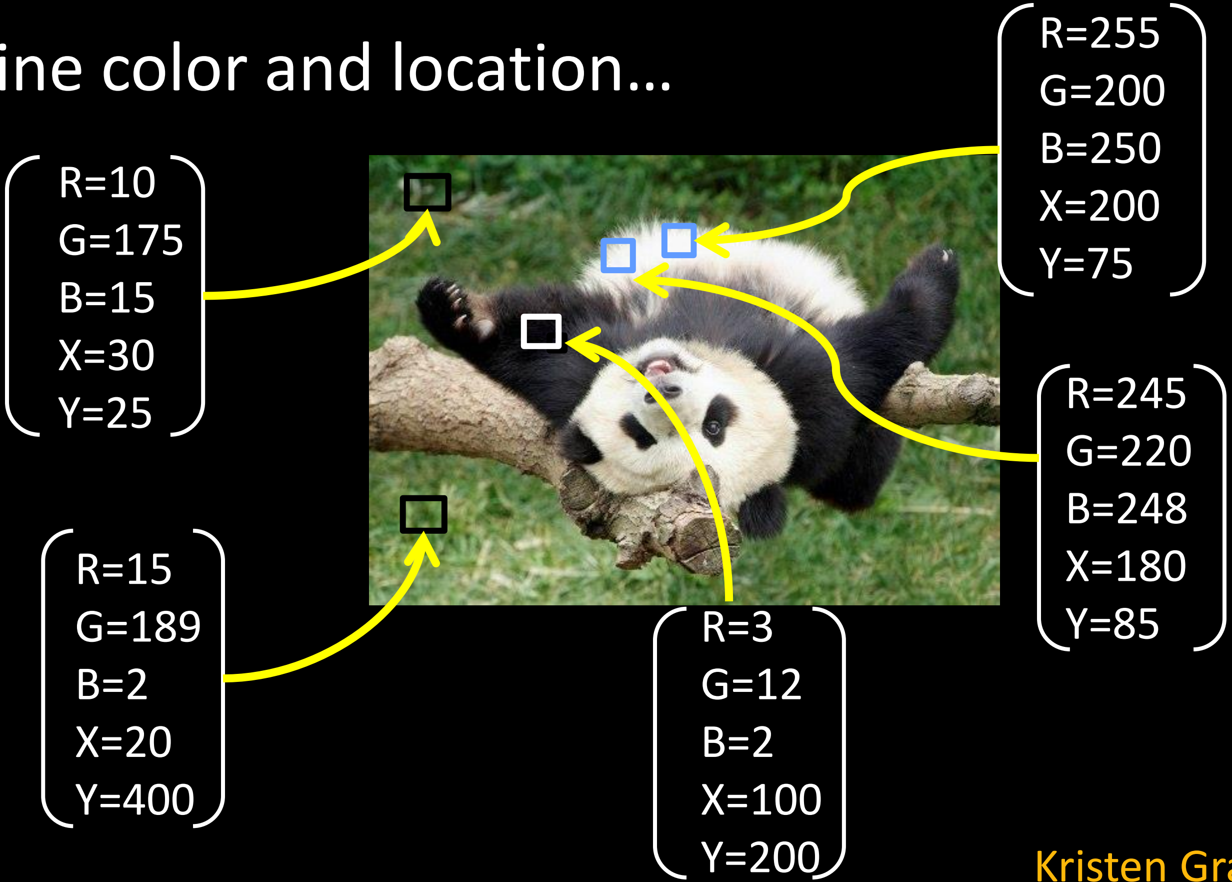




Kristen Grauman

Segmentation as clustering

- Can combine color and location…



Kristen Grauman

K-Means for segmentation

- Pros
  - Very simple method
  - Converges to a local minimum of the error function

Svetlana Lazebnik

K-Means for segmentation

- Cons
  - Memory-intensive
  - Need to pick K
  - Sensitive to initialization
  - Sensitive to outliers
  - Only finds “spherical” clusters