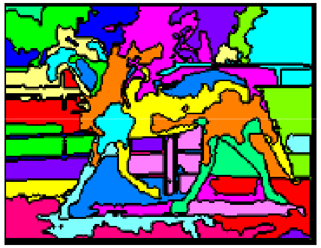
Image Segmentation

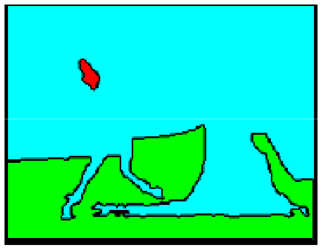
Image Segmentation

- Goal: Group pixels into meaningful or perceptually similar regions

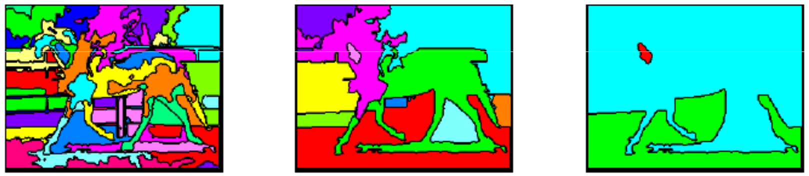
Types of Segmentations



Oversegmentation



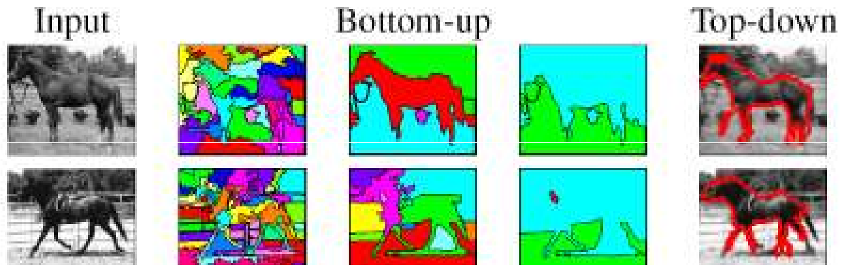
Undersegmentation



Multiple Segmentations

Segmentation Methods

- **Bottom-up**: Group pixels with similar features, relying mainly on continuity principles.
- **Top-down**: Use prior knowledge about an object such as its possible shape, color, or texture, to guide the segmentation

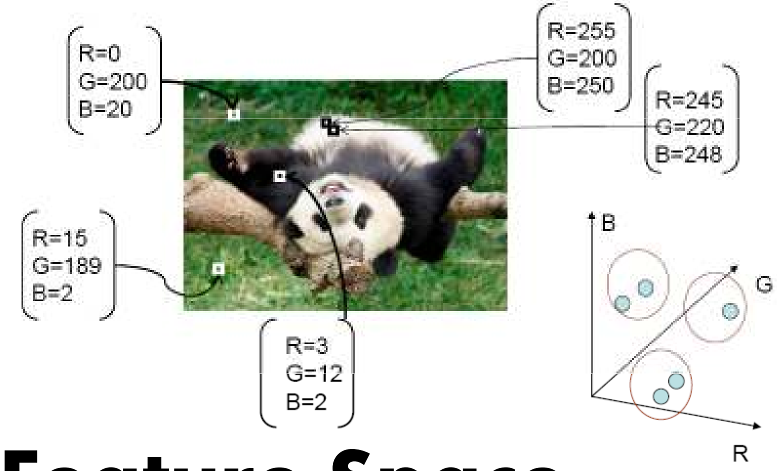


[Levin and Weiss 2006]

Segmentation Methods

- Bottom-up Approaches
  - Clustering
    - K-means
    - Mean-shift
  - Boundary
    - Watershed
  - Graph-Based
    - Felzenszwalb and Huttenlocher
      http://www.cs.brown.edu/~pff/segment/
- Top-down Approaches
  - Deformable Templates
  - Active Shape Models
  - Active Contours (Snake)

Segmentation by Clustering



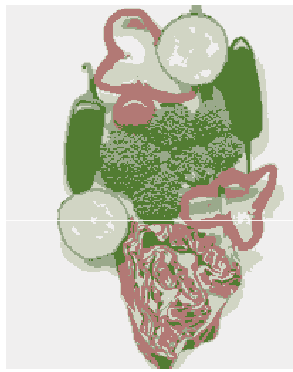
Feature Space

Source: K. Grauman

K-means Clustering

1. Choose the number of cluster K
2. Initialize the centers of every cluster
3. Assign each sample to nearest center → They will belong to the same cluster
4. Find mean of the samples that belong to the same cluster → Use mean as new centers for that cluster
5. Repeat 3 and 4 until the centers are converged

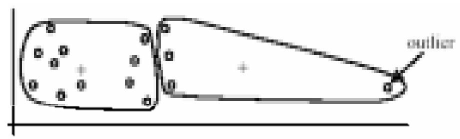
K-means Clustering Using Intensity or Color alone

Image	Clusters on Intensity	Clusters on Color
		

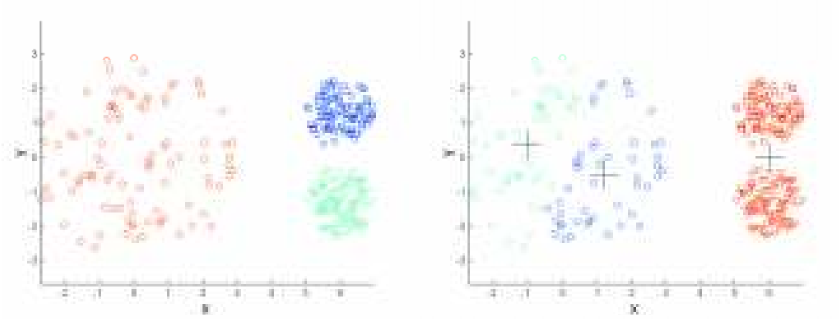
K-means Pros and Cons

- Pros
  - Simple and fast
  - Easy to implement

- Cons
  - Need to choose K
  - Sensitive to outliers
  - Sensitive to initial condition



K-means Pros and Cons



Original Points

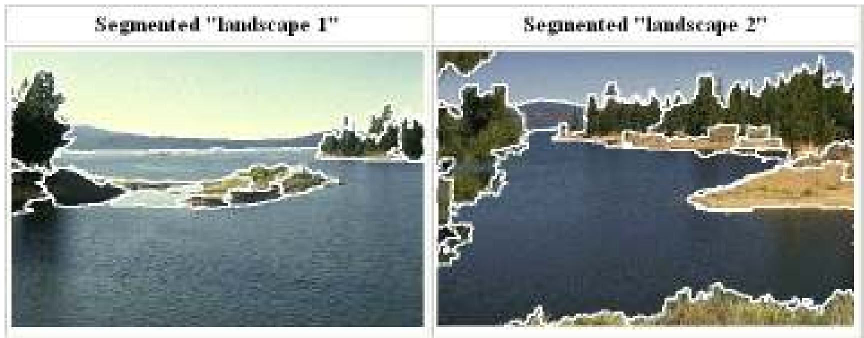
K-means (3 Clusters)

http://www.cs.uvm.edu/~xwu/kdd/Slides/Kmeans-ICDM06.pdf

Mean shift Segmentation

D. Comaniciu and P. Meer, Mean Shift: A Robust Approach toward Feature Space Analysis, PAMI 2002.

- Versatile technique for clustering-based segmentation

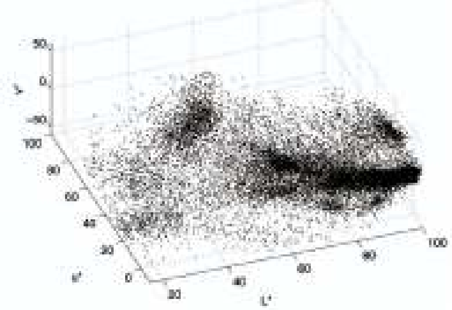


Mean-shift Algorithm

- Try to find *modes* of this non-parametric density

image

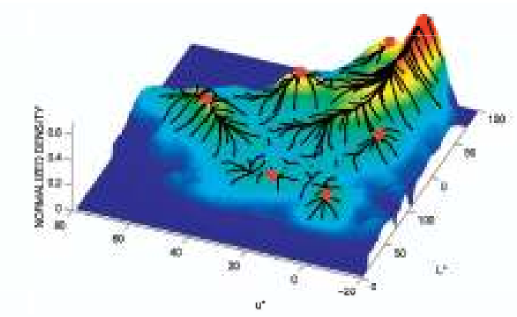
Feature space
(L*u*v* color values)



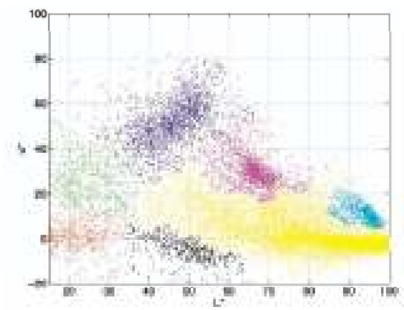
http://img.my.csdn.net/uploads/201210/05/1349427627_8823.png

Mean-shift Algorithm

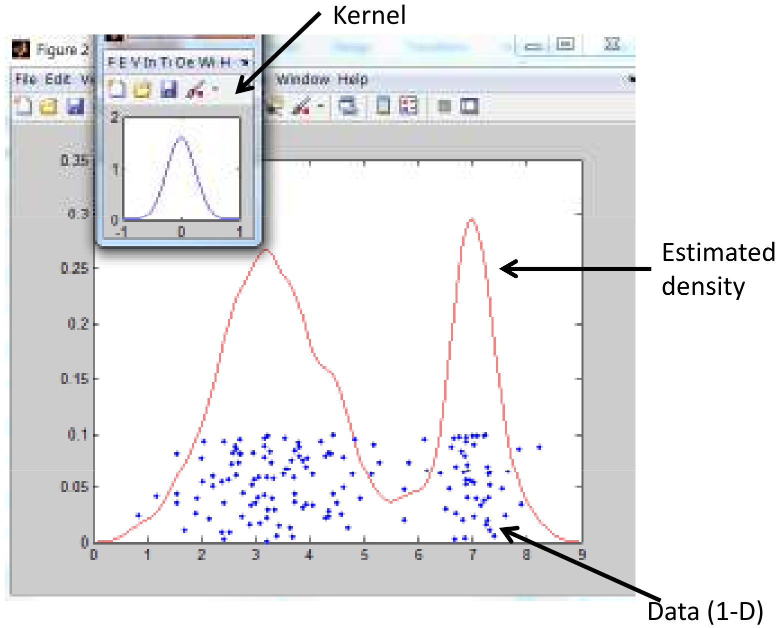
- Try to find *modes* of this non-parametric density

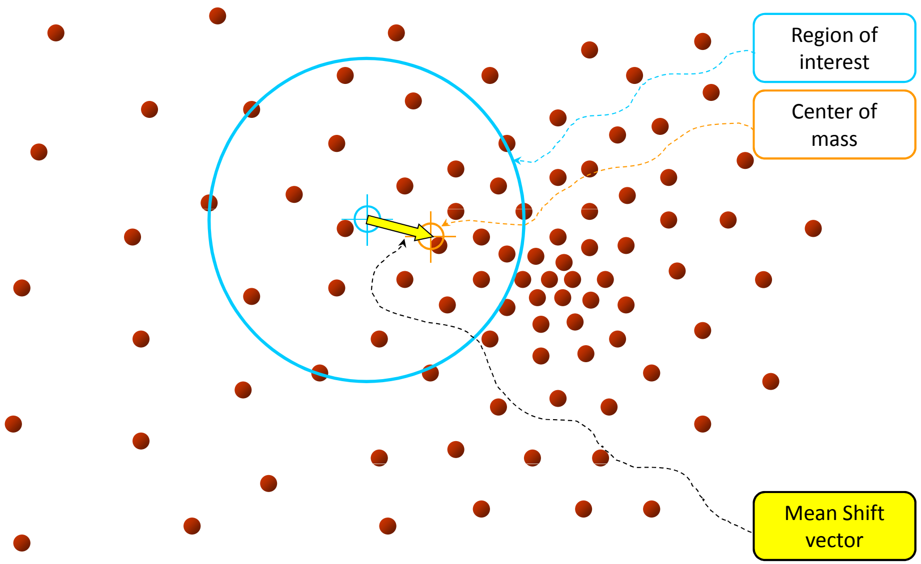


Density

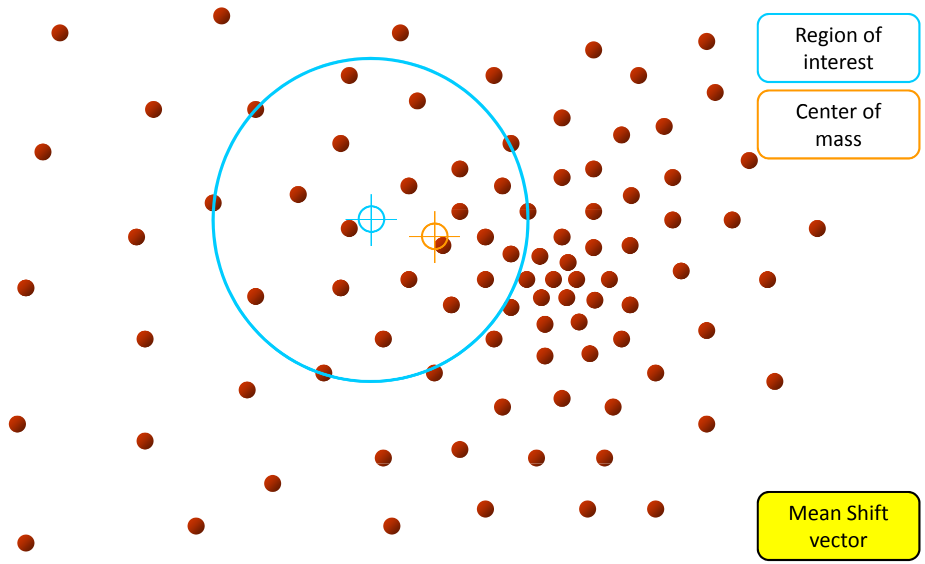


Cluster





Slide by Y. Ukrainitz & B. Sarel



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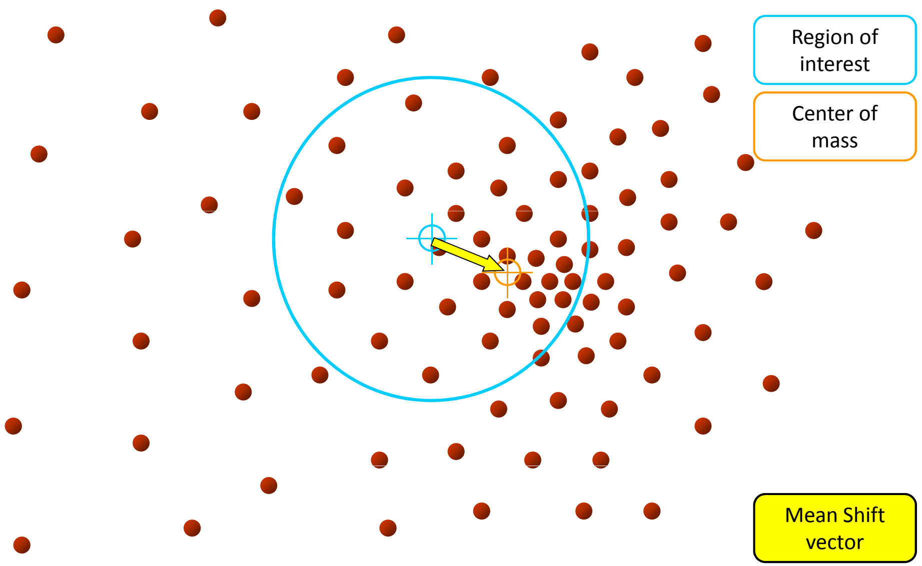

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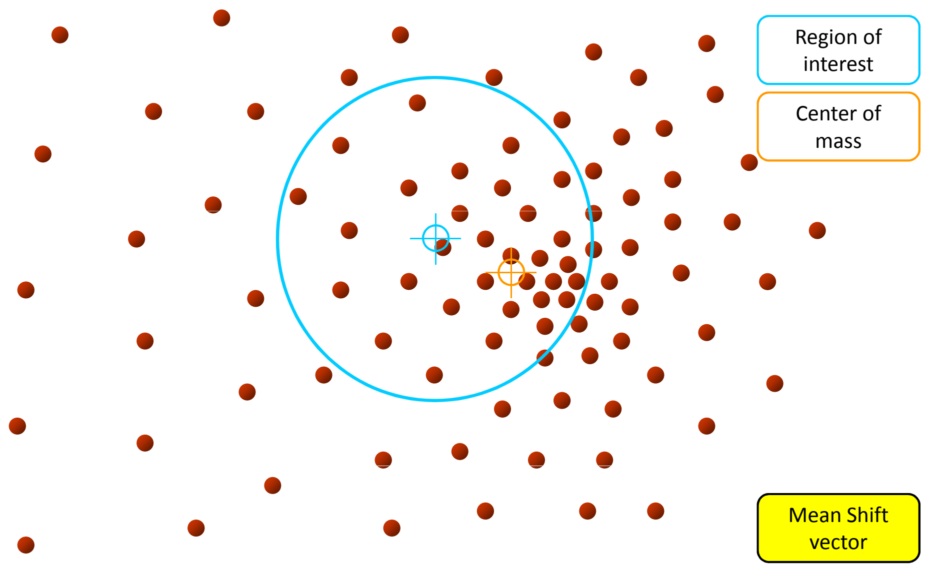

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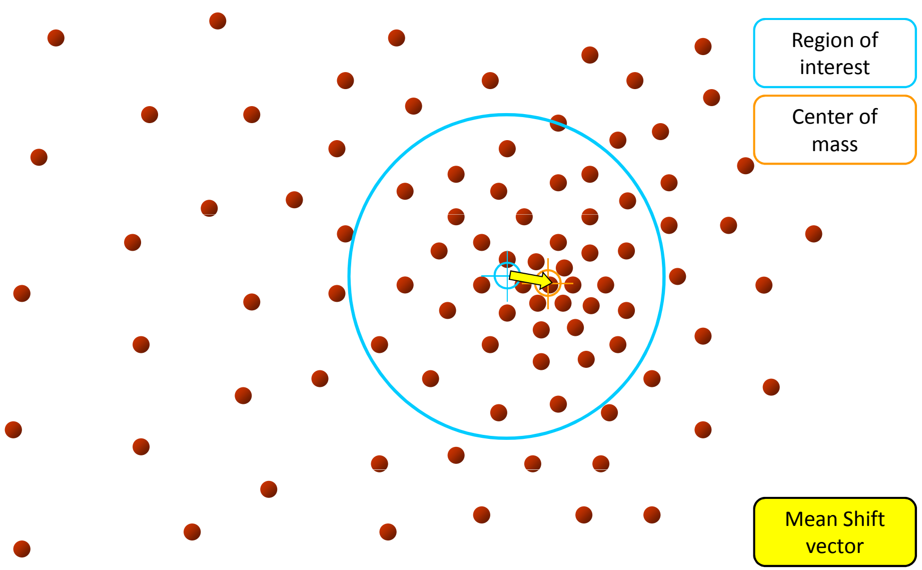

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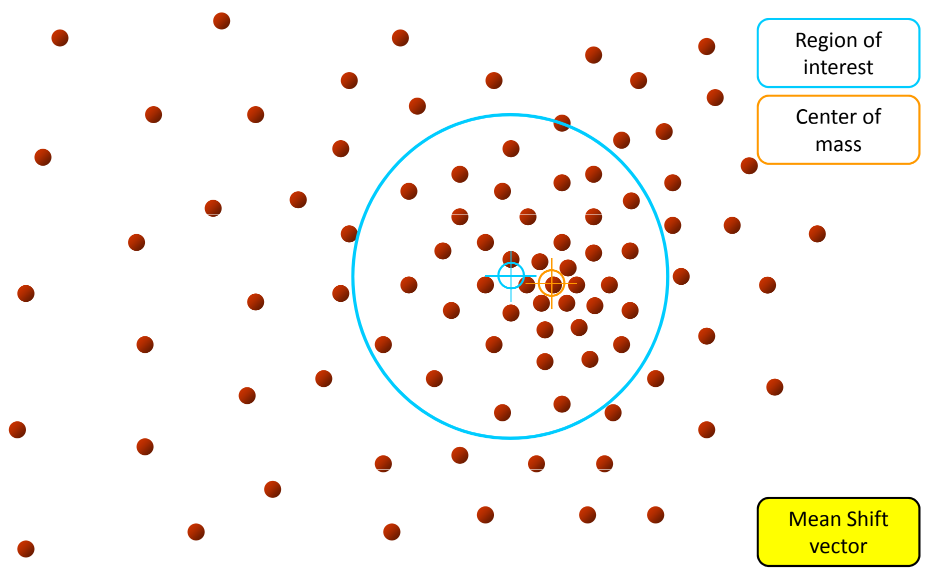
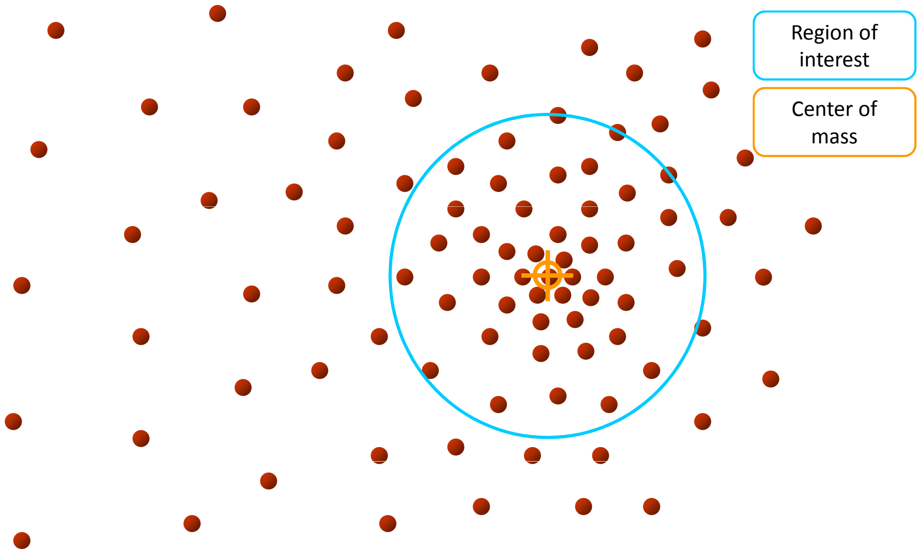


Slide by Y. Ukrainitz & B. Sarel



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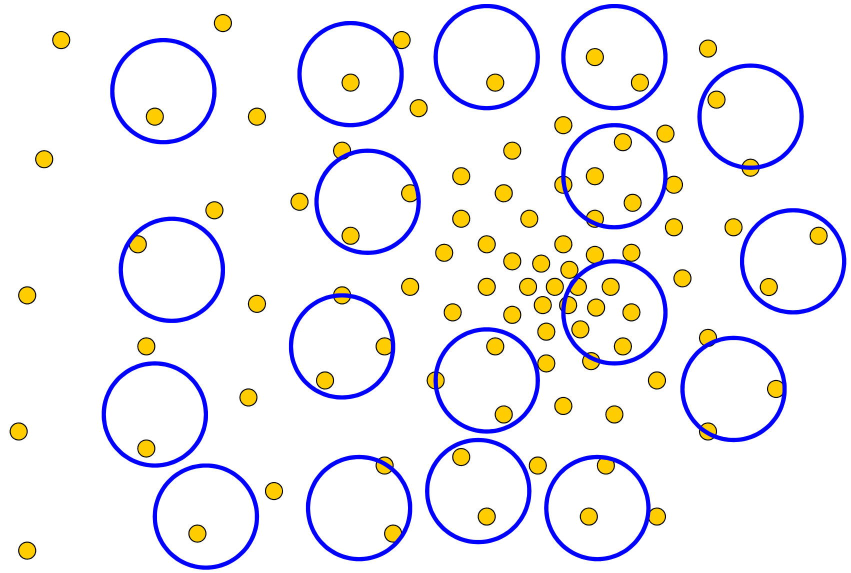
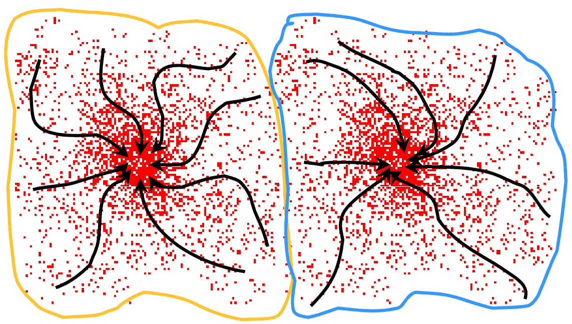
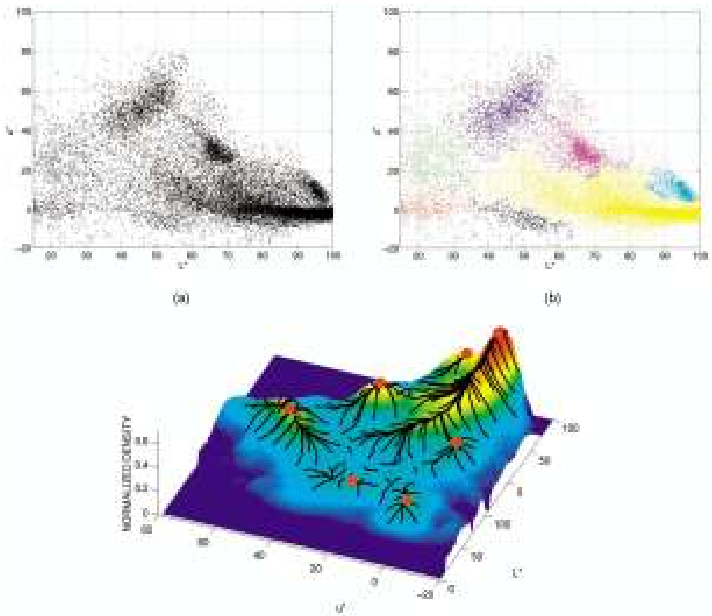


Attraction Basin

- Attraction basin: the region for which all trajectories lead to the same mode
- Cluster: all data points in the attraction basin of a mode



Slide by Y. Ukrainitz & B. Sarel



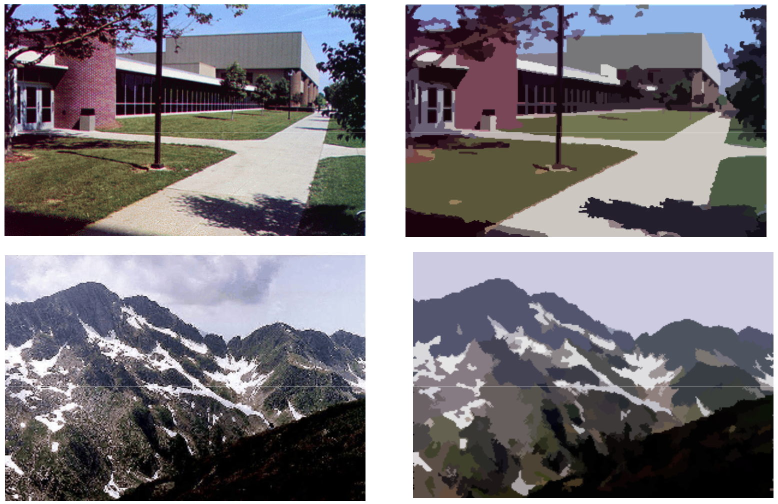
Mean-Shift Clustering

- The mean shift algorithm seeks ***modes*** of the given set of points
  1. Choose kernel and bandwidth
  2. For each point:
     a) Center a window on that point
     b) Compute the mean of the data in the search window
     c) Center the search window at the new mean location
     d) Repeat b) ,c) until convergence
  3. Assign points that lead to nearby modes to the same cluster

Segmentation by Mean Shift

- Compute features for each pixel (color, gradients, texture, etc); also store each pixel's position
- Set kernel size for features K_f and position K_s
- Initialize windows at individual pixel locations
- Perform mean shift for each window until convergence
- Merge modes that are within width of K_f and K_s

Mean-Shift Clustering



http://www.caip.rutgers.edu/~comanici/MSPAMI/msPamiResults.html

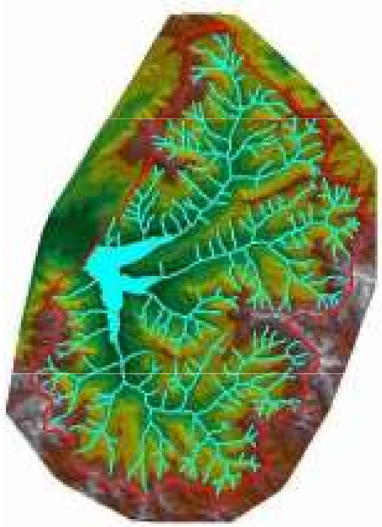
Mean-Shift Clustering

http://www.caip.rutgers.edu/~comanici/MSPAMI/msPamiResults.html

Mean Shift Pros and Cons

- Pros
  - Good general-purpose segmentation
  - Flexible in number and shape of regions
  - Robust to outliers
- Cons
  - Have to choose kernel size in advance
  - Not suitable for high-dimensional features
- When to use it
  - Oversegmentation
  - Multiple segmentations
  - Tracking, clustering, filtering applications
    - D. Comaniciu, V. Ramesh, P. Meer: *Real-Time Tracking of Non-Rigid Objects using Mean Shift*, *Best Paper Award*, IEEE Conf. Computer Vision and Pattern Recognition (CVPR'00), Hilton Head Island, South Carolina, Vol. 2, 142-149, 2000

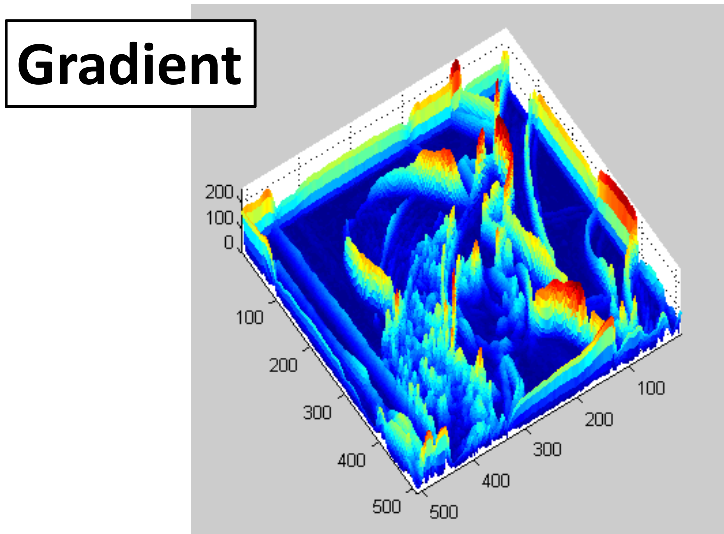
Watershed Algorithm



Watershed Segmentation

Image Gradient Watershed Boundaries

Watershed Segmentation

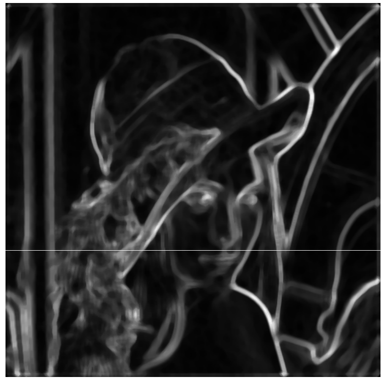


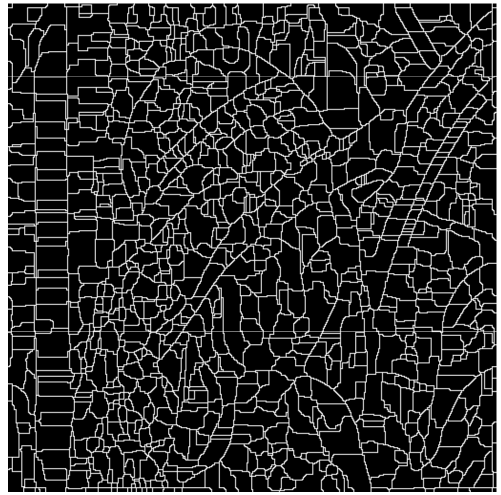
Watershed Segmentation

1. Choose **local minima** as region seeds
2. Add neighbors to *priority queue*, sorted by value
3. Take top priority pixel from queue
    1. If all labeled neighbors have same label, assign that label to pixel
    2. Add all non-marked neighbors to queue
4. Repeat step 3 until finished (all remaining pixels in queue are on the boundary)

Meyer 1991

Use Gaussian or median filter to reduce number of regions

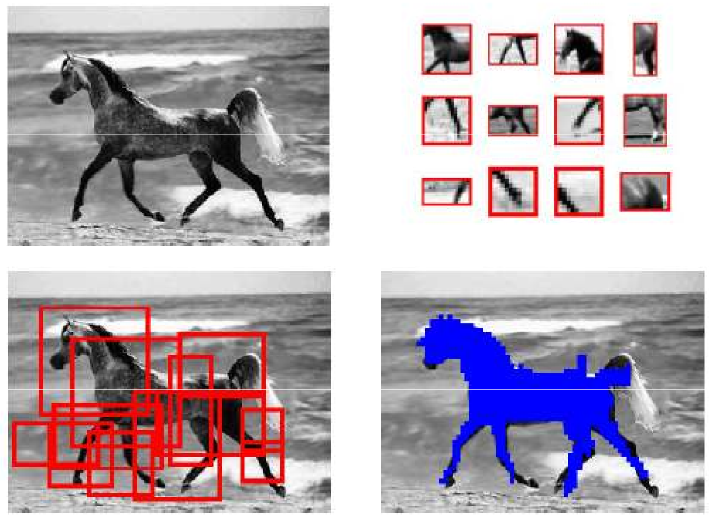




Watershed Pros and Cons

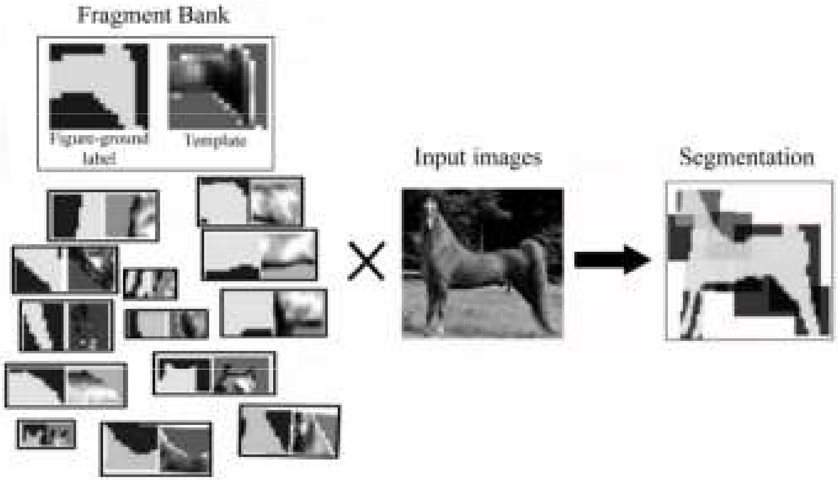
- Pros
    - Fast
    - Preserves boundaries
- Cons
    - Only as good as the soft boundaries
    - Not easy to get variety of regions for multiple segmentations
- Usage
    - Use as a starting point for hierarchical segmentation

Class-Specific Top-Down Segmentation



Eran Borenstein, et al.

Class-Specific Top-Down Segmentation



Eran Borenstein, et al.