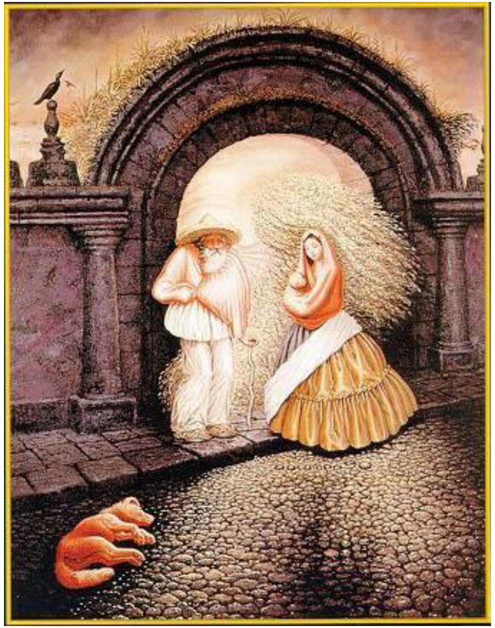
Image Segmentation

Outline

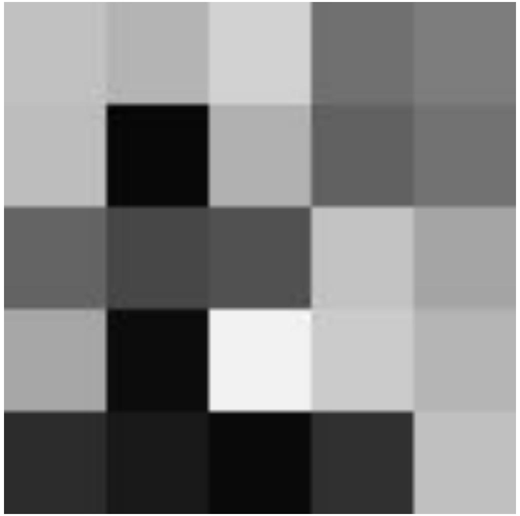
- Thresholding
- K-Means Clustering
- Mean-Shift Clustering



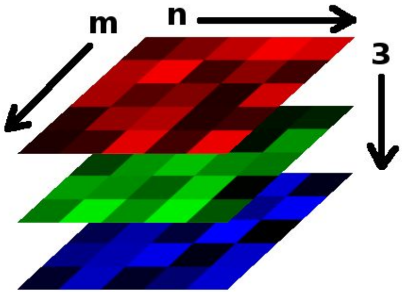
Acknowledgement :
Images in the slides were taken from UCF CVRC and CS131, Stanford University.

Images are matrix.

Values in matrix = how much light



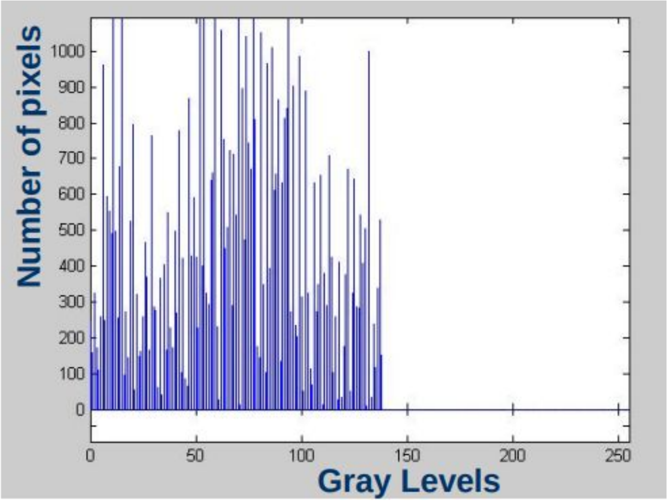
$$\begin{bmatrix} 193 & 180 & 210 & 112 & 125 \\ 189 & 8 & 177 & 97 & 114 \\ 100 & 71 & 81 & 195 & 165 \\ 167 & 12 & 242 & 203 & 181 \\ 44 & 25 & 9 & 48 & 192 \end{bmatrix}$$




```
Image = cv2.imread(FileName, Flag)
```

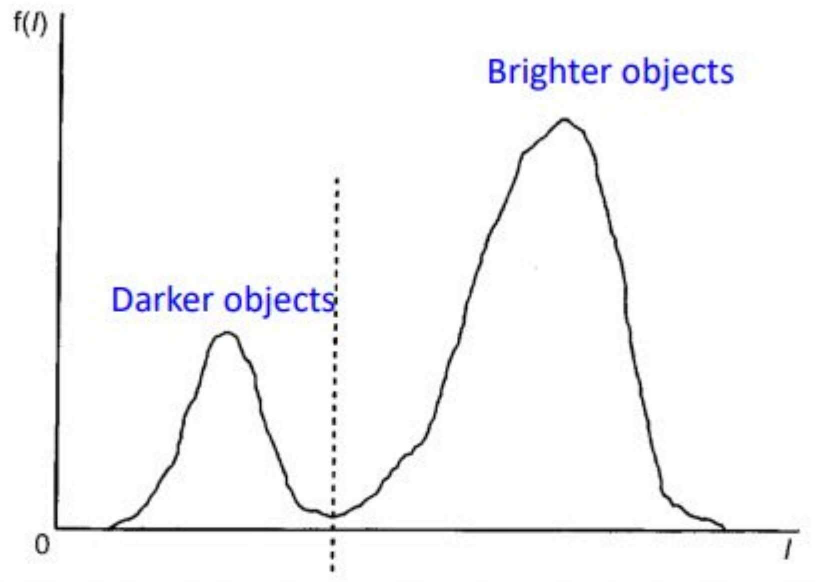
Histogram

- Histogram captures the distribution of gray levels in the image.
- How frequently each gray level occurs in the image




0
256
Count: 10192
Mean: 133.711
StdDev: 55.391
Min: 9
Max: 255
Mode: 178 (180)
0
256
Count: 10192
Mean: 104.637
StdDev: 89.862
Min: 11
Max: 254
Mode: 23 (440)

Thresholding



Threshold Value

> Peak on the left of the histogram corresponds to dark objects.

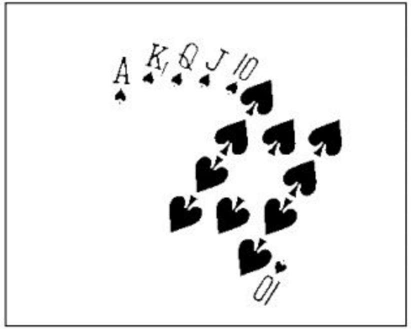
> Peak on the right of the histogram corresponds to brighter objects

DIFFICULTIES

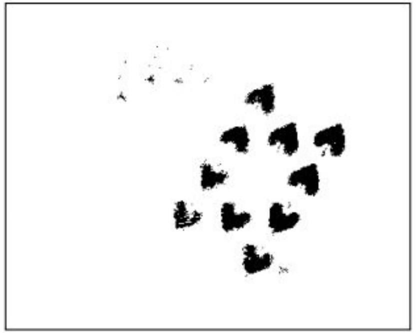
1. The valley may be so broad that it is difficult to locate a significant minimum
2. Number of minima due to type of details in the image
3. Noise
4. No visible valley
5. Histogram may be multi-moda

Threshold Value

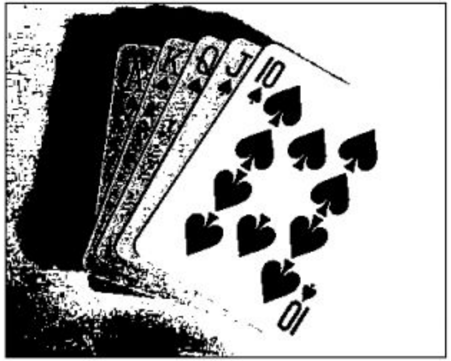
Original Image



Thresholded Image



Threshold Too Low



Threshold Too High

- Otsu’s
- Adaptive Thresholding
- Niblack’s
- Sauvola’s
- Triangle Binarization

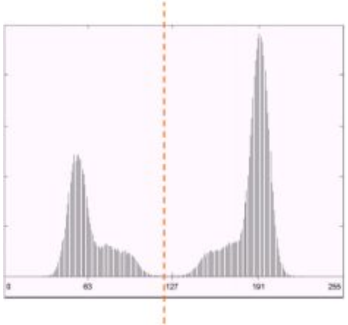
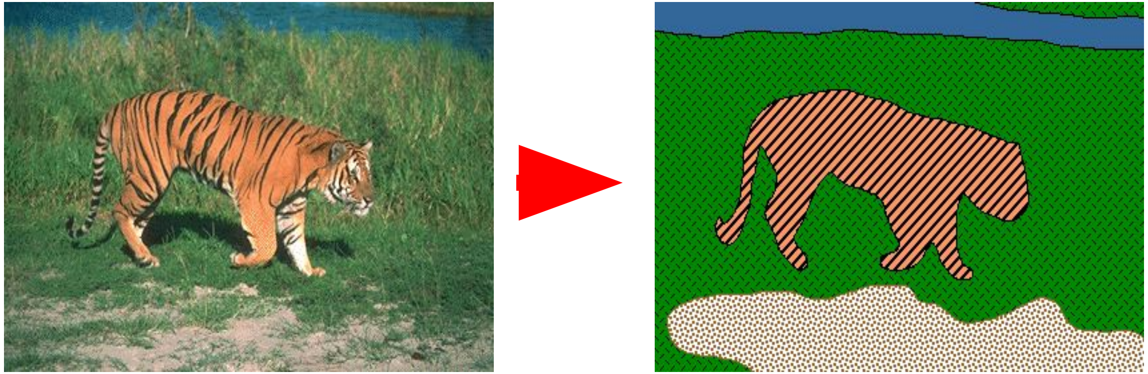


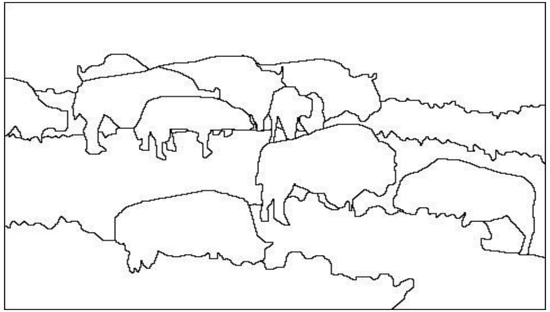
Image Segmentation

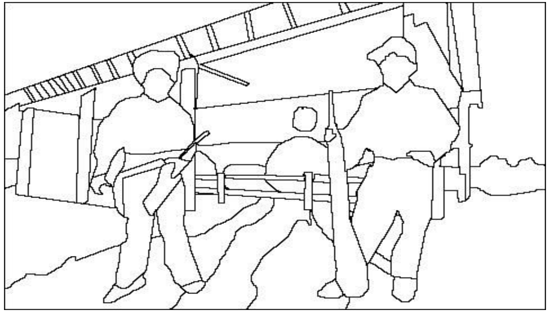
- Goal: identify groups of pixels that go together
- Thresholding is the simplest image segmentation



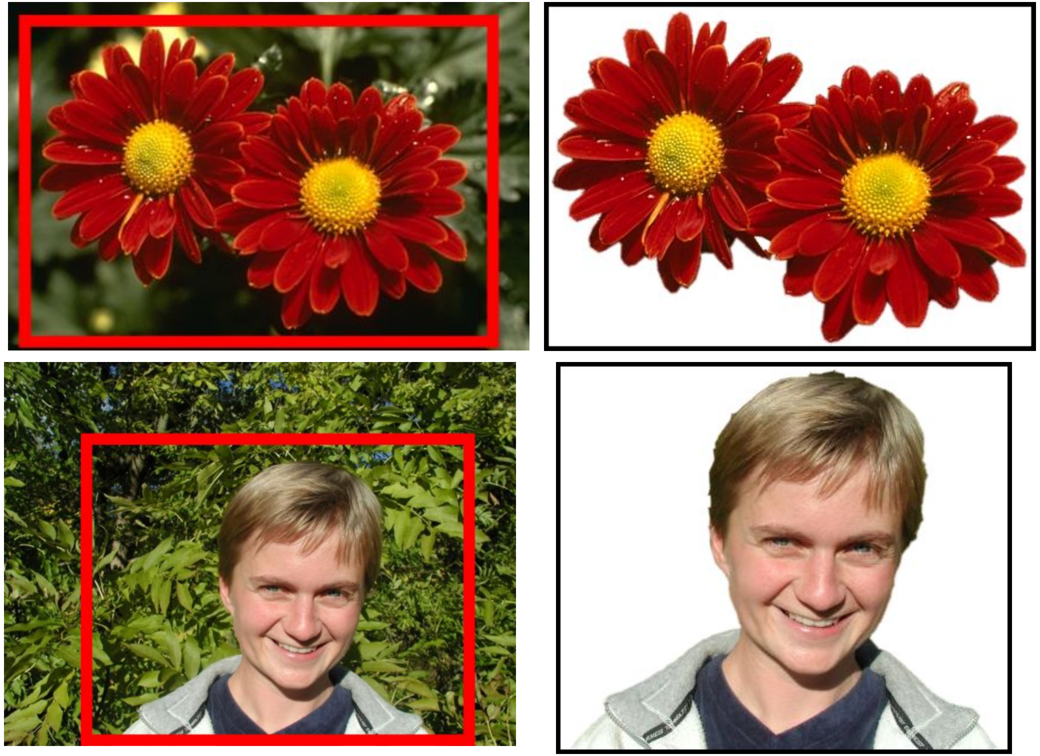
Segmentation by Human

Image | Human segmentation





Segmentation as a result



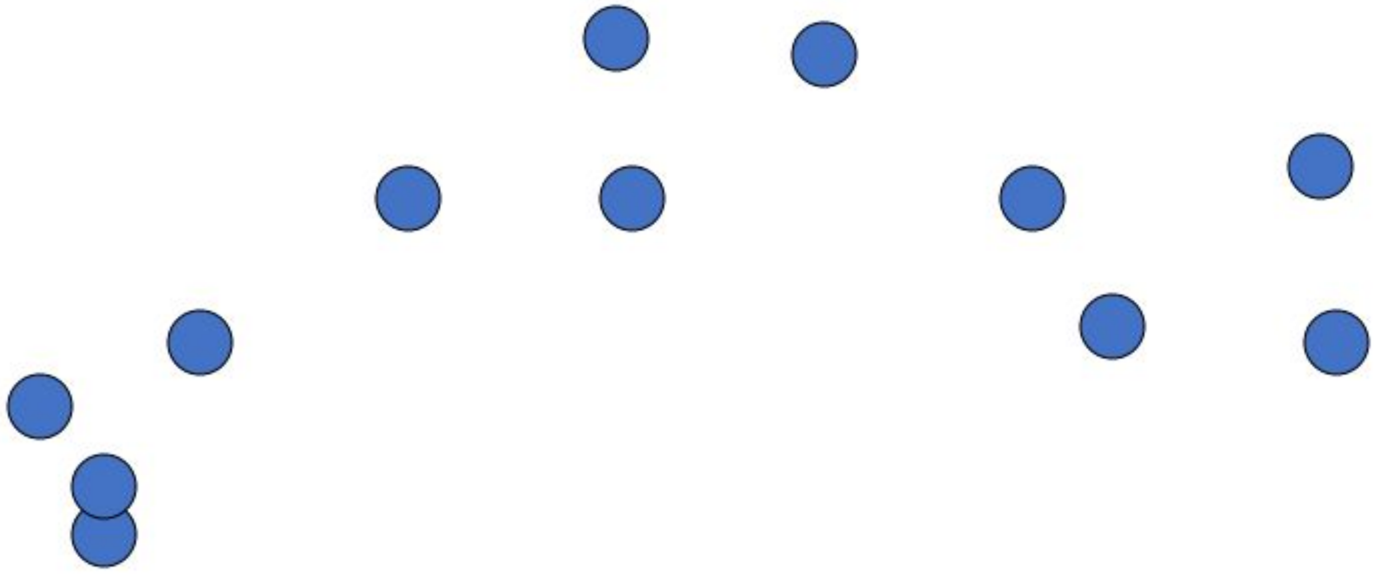
Rother et al. 2004

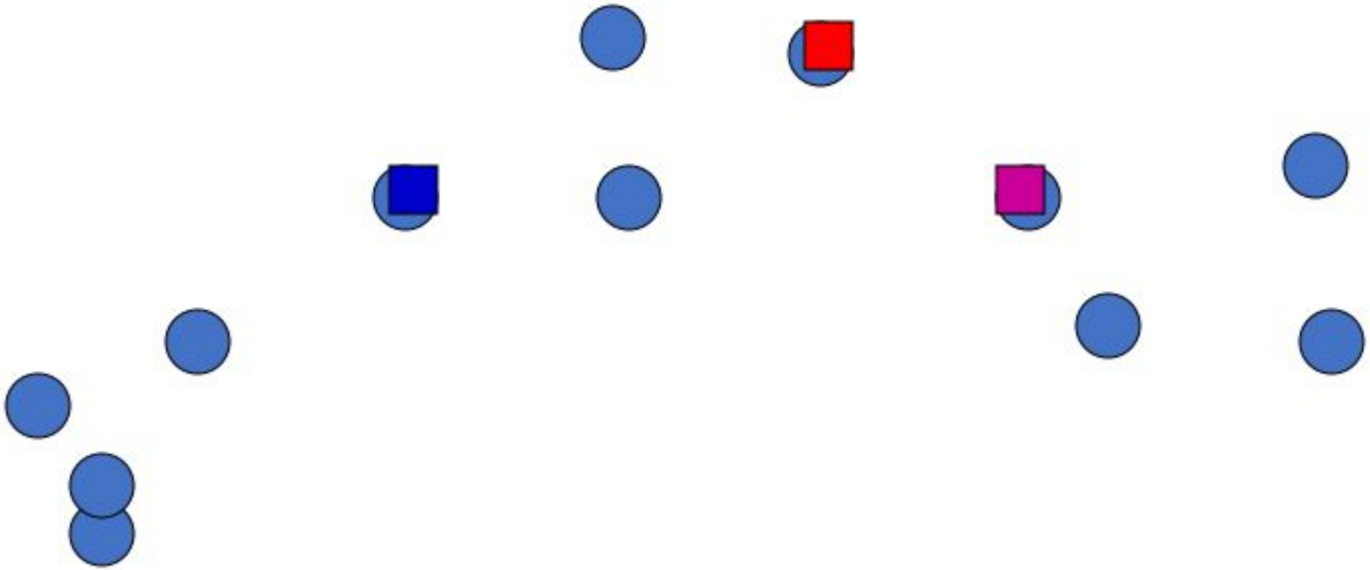
Visual Similarity can be based on

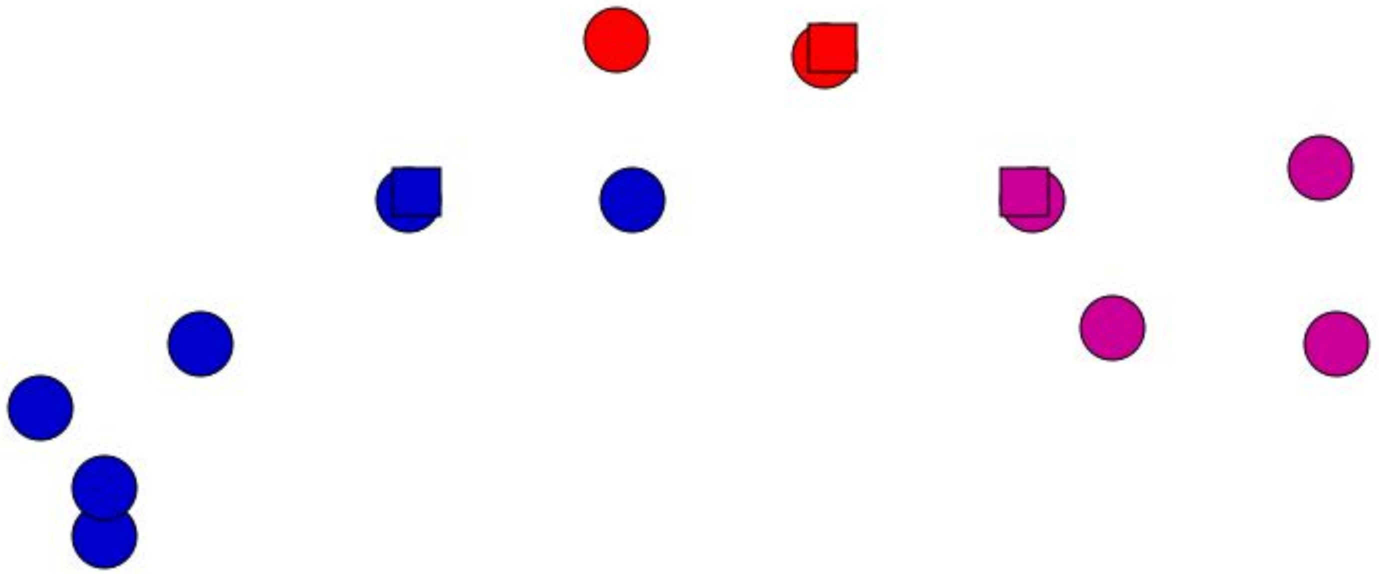
- Brightness
- Color
- Position …. ….

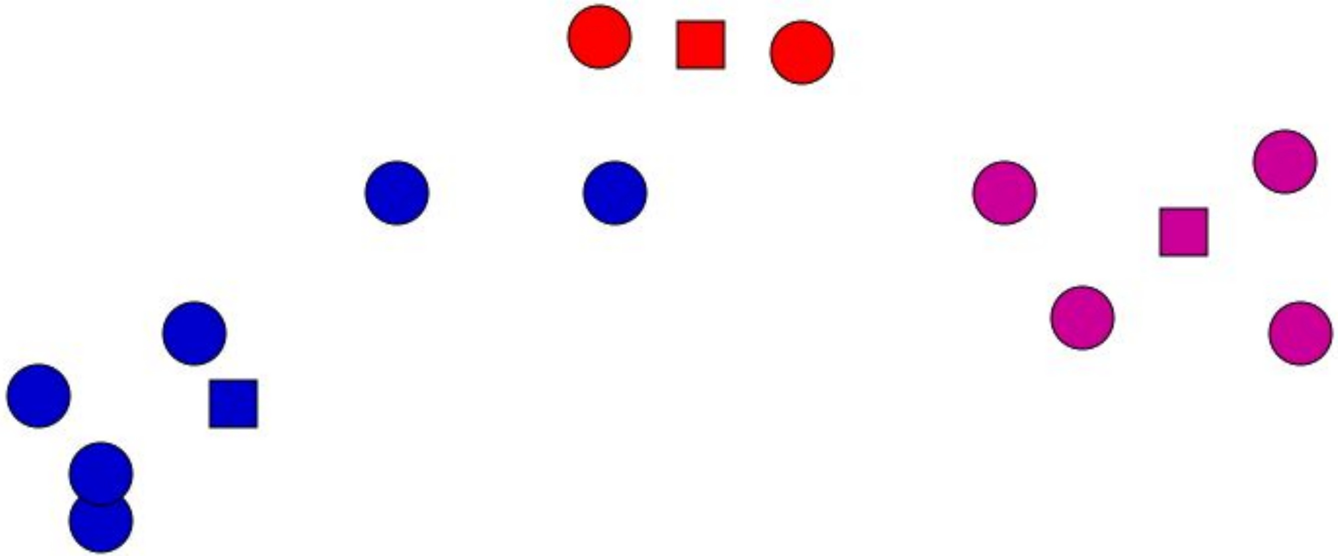
K-means

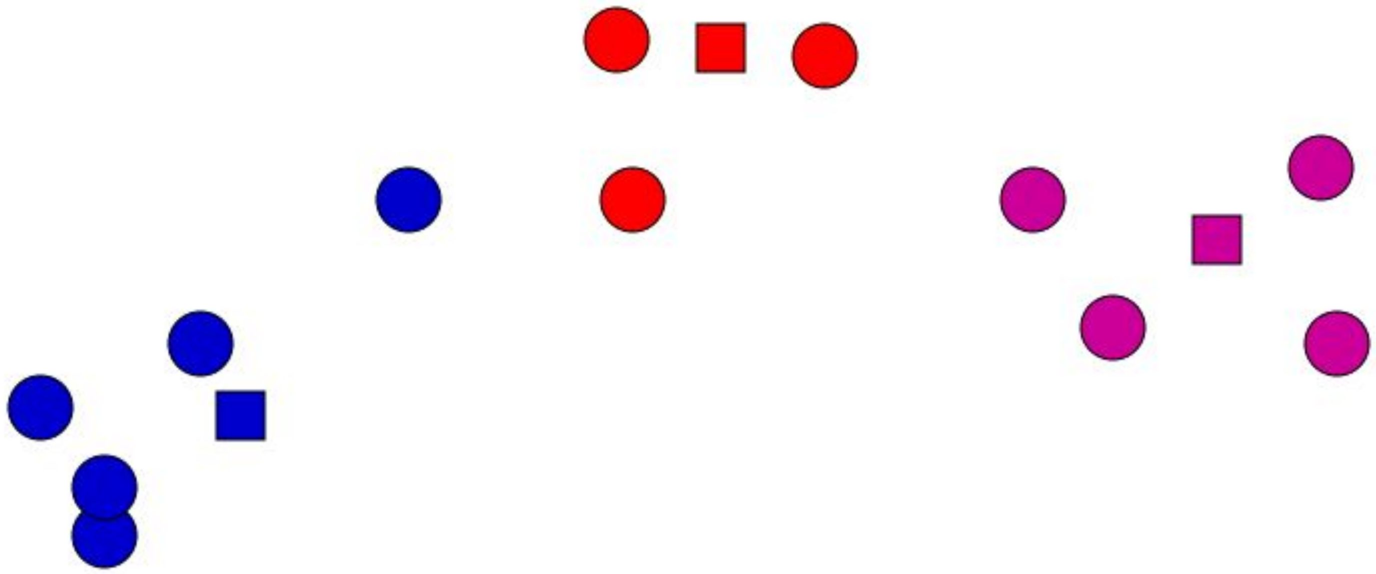
- Most well-known and popular **clustering** algorithm:
- Start with some initial **cluster** centers
- Iterate:
    - Assign/cluster each example to closest center
    - Recalculate centers as the mean of the points in a cluster

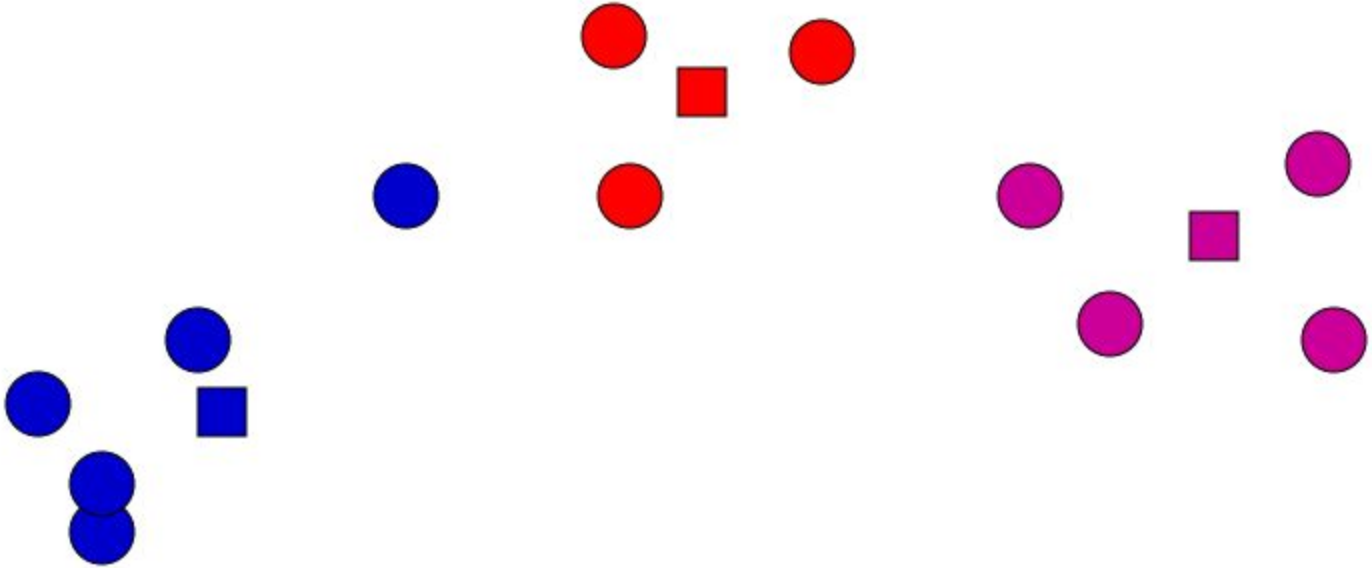


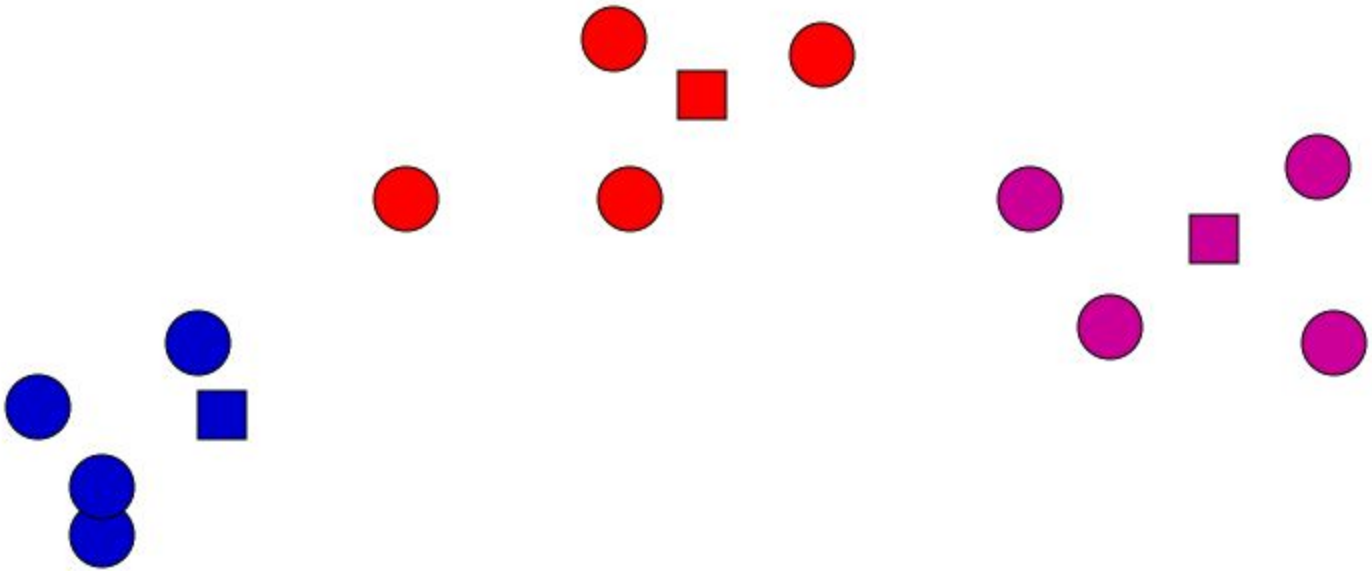


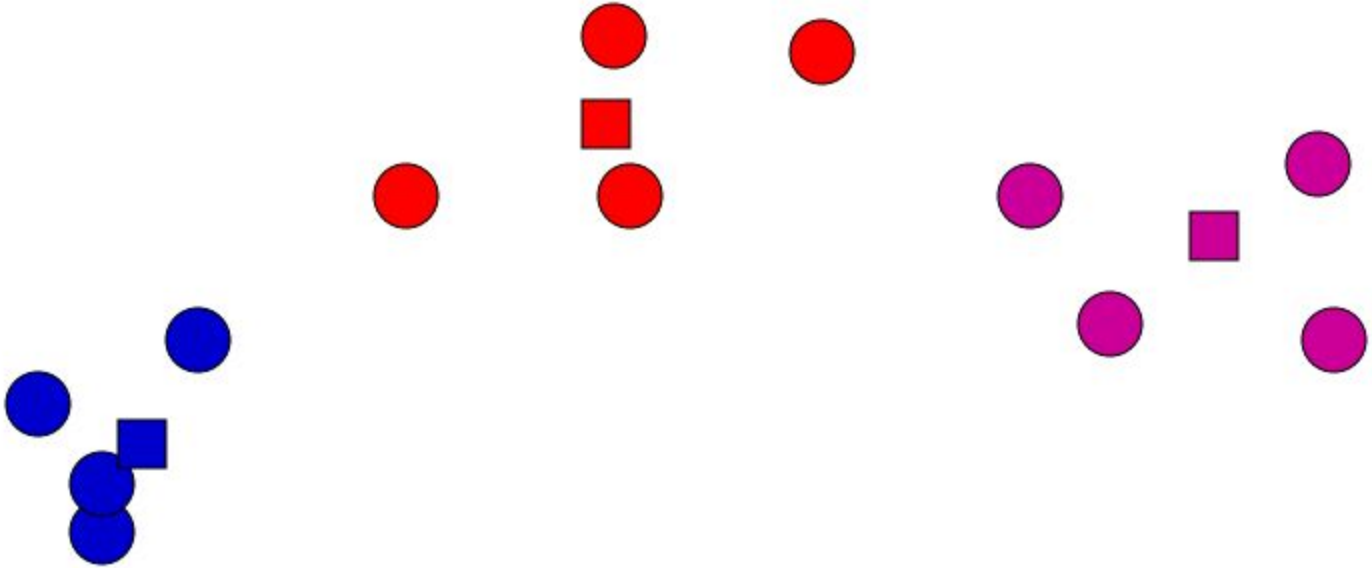


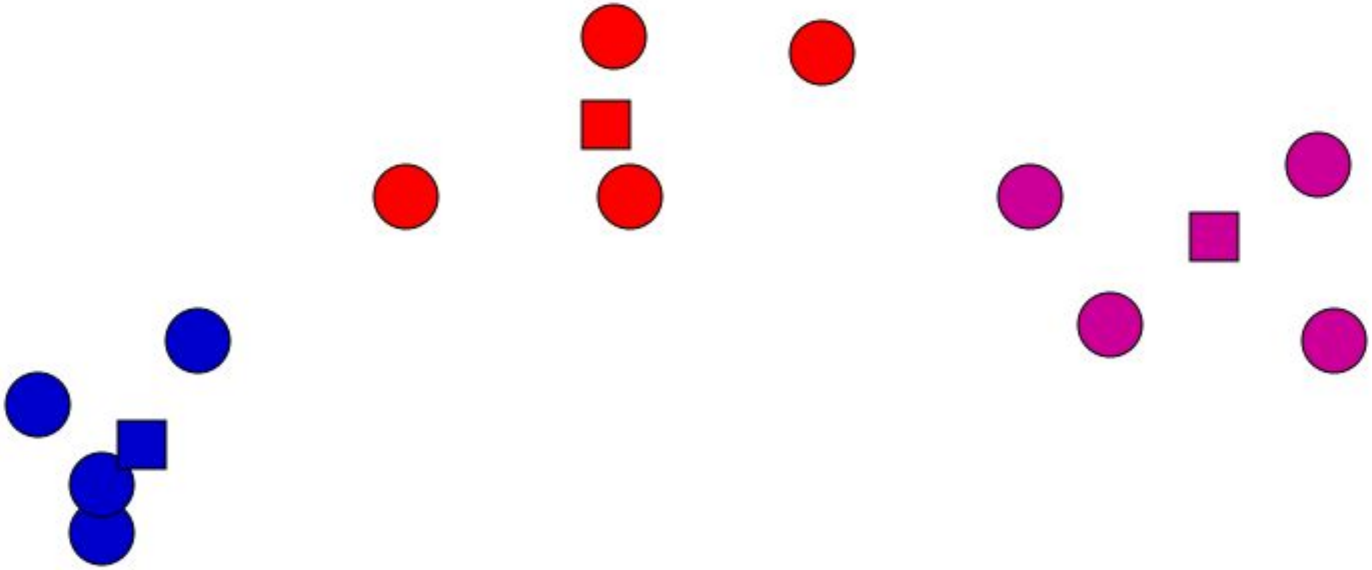












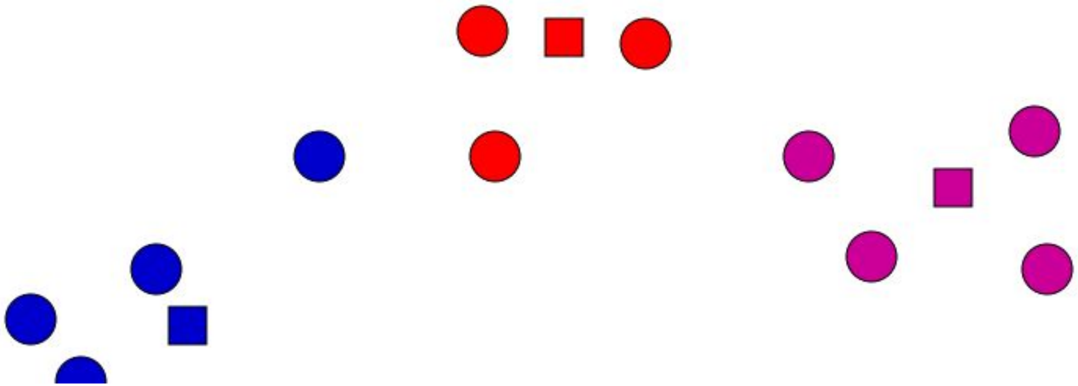
Iterate:

- **Assign/cluster each example to closest center**

  iterate over each point:

  - get **distance** to each cluster center
  - assign to closest center (hard cluster)

- Recalculate centers as the mean of the points in a cluster



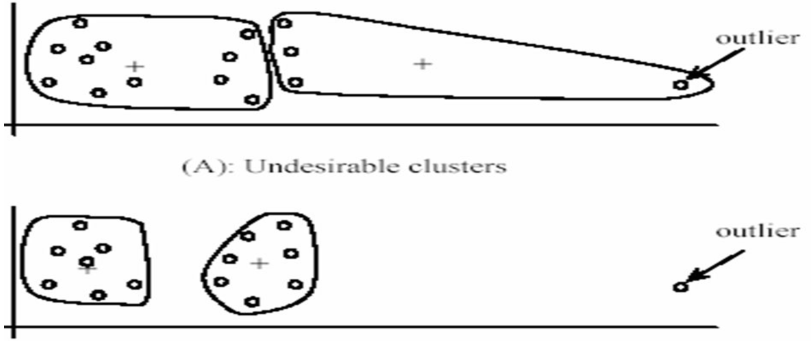
K-means: pros and cons

Pros

- Simple, fast to compute
- Converges to local minimum of within-cluster squared error

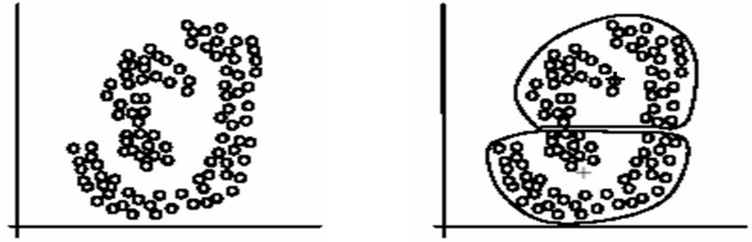
Cons/issues

- Setting k?
- Sensitive to initial centers
- Sensitive to outliers
- Detects spherical clusters
- Assuming means can be computed



(A): Undesirable clusters

(B): Ideal clusters



(A): Two natural clusters

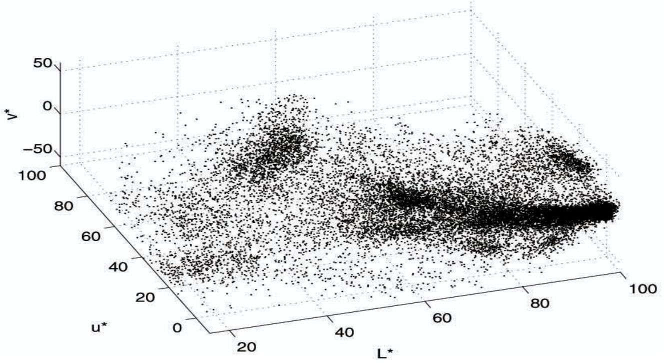
(B): *k*-means clusters

Mean shift algorithm

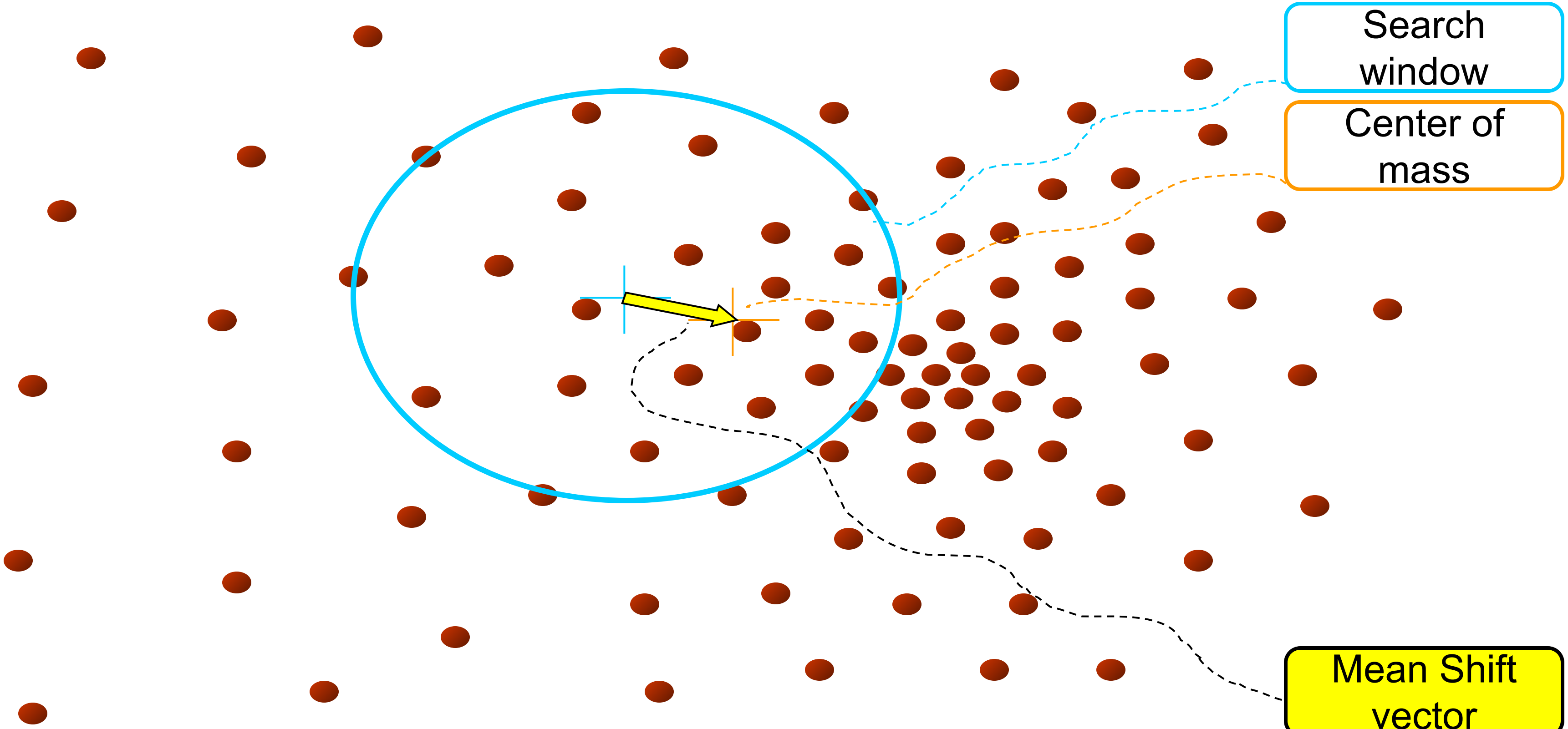
- The mean shift algorithm seeks *modes* or local maxima of density in the feature space

image

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

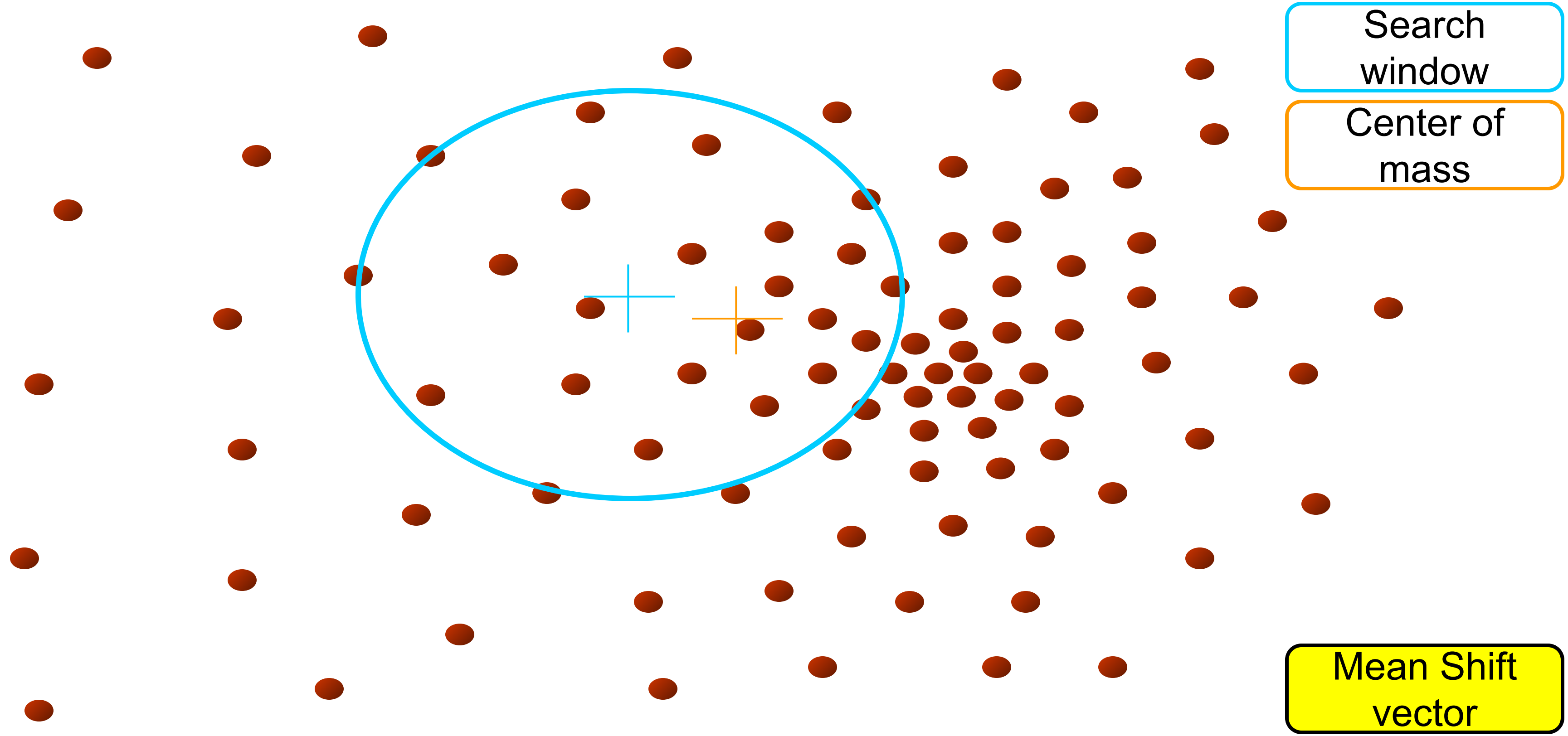


Mean shift



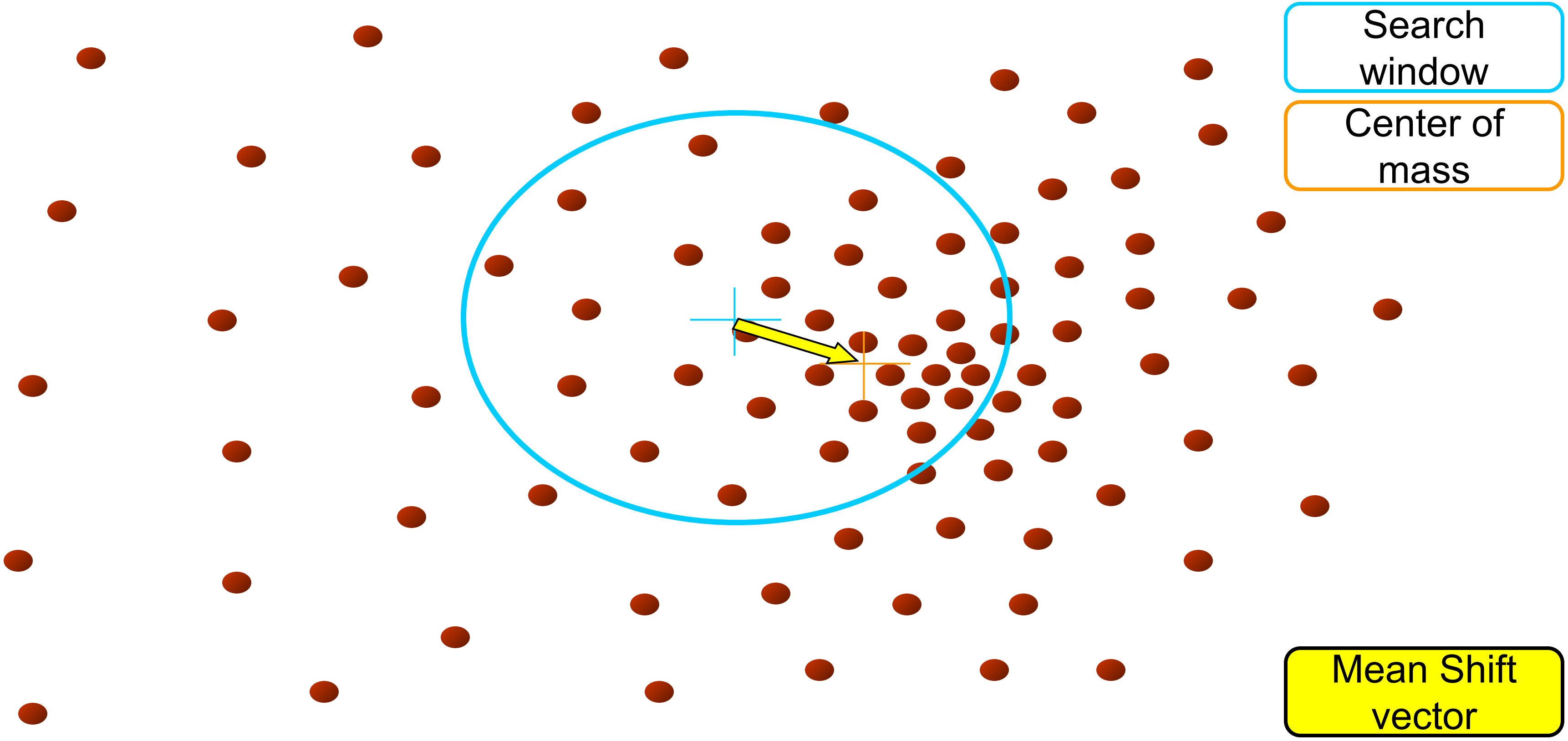
Slide by Y. Ukrainitz & B. Sarel

Mean shift



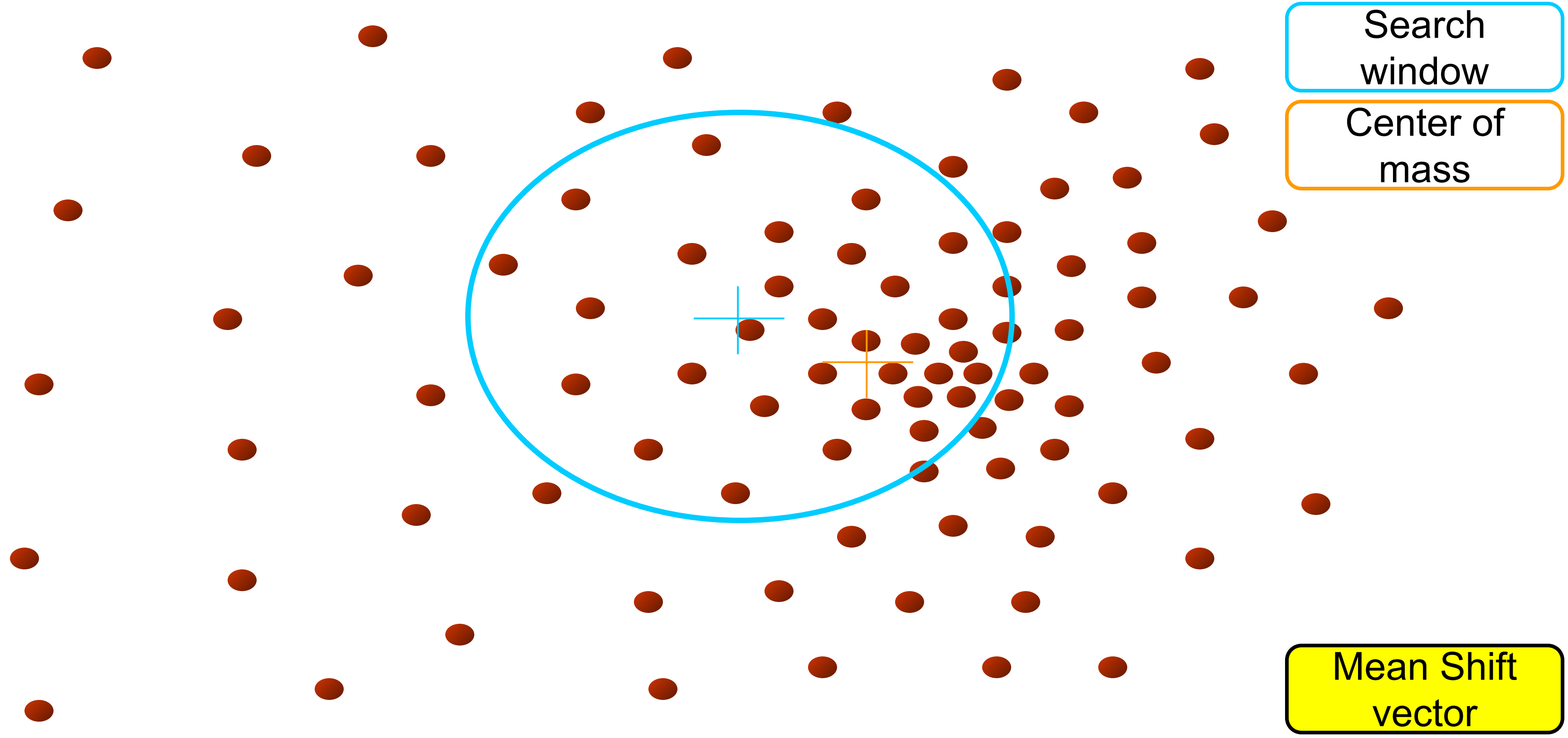
Slide by Y. Ukrainitz & B. Sarel

Mean shift



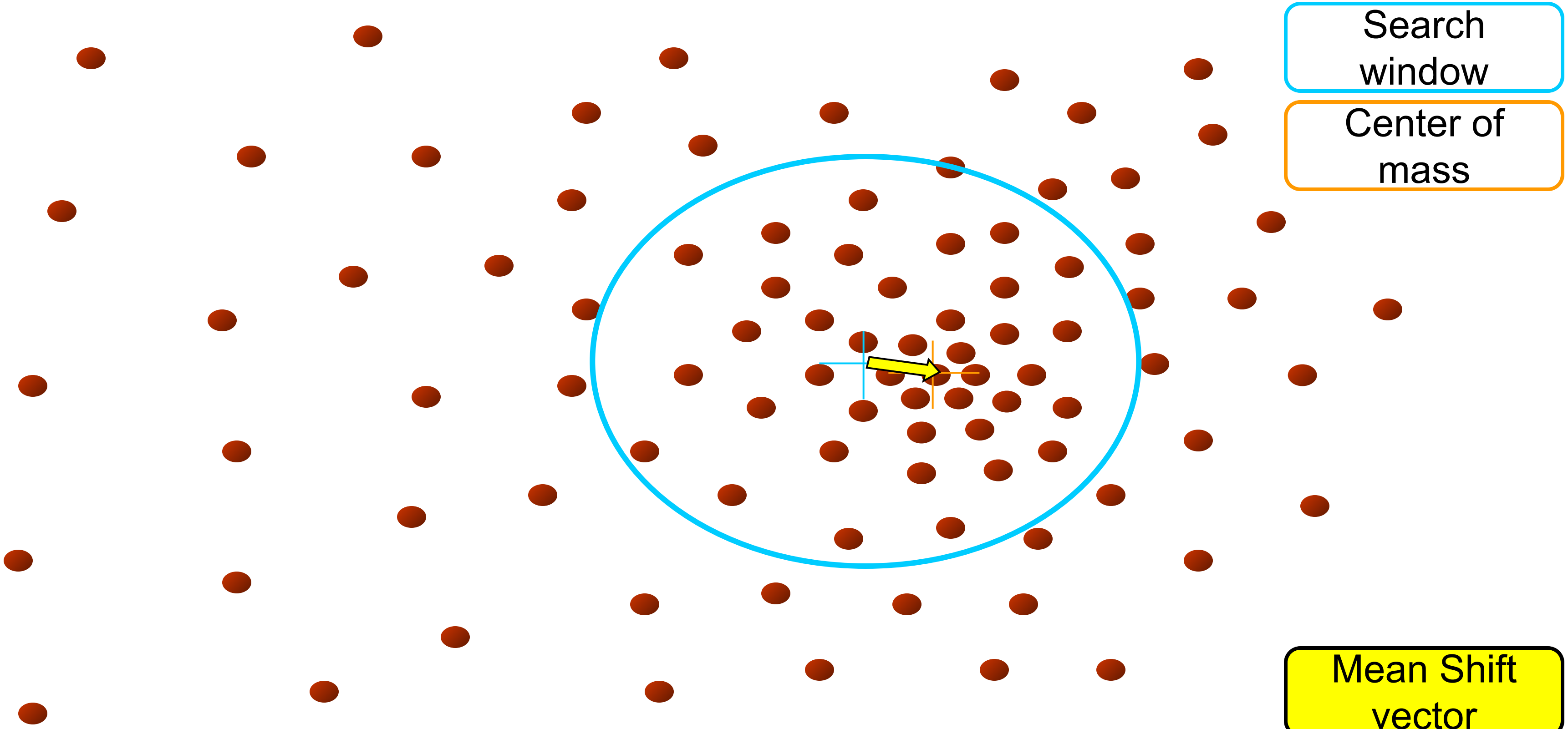
Slide by Y. Ukrainitz & B. Sarel

Mean shift



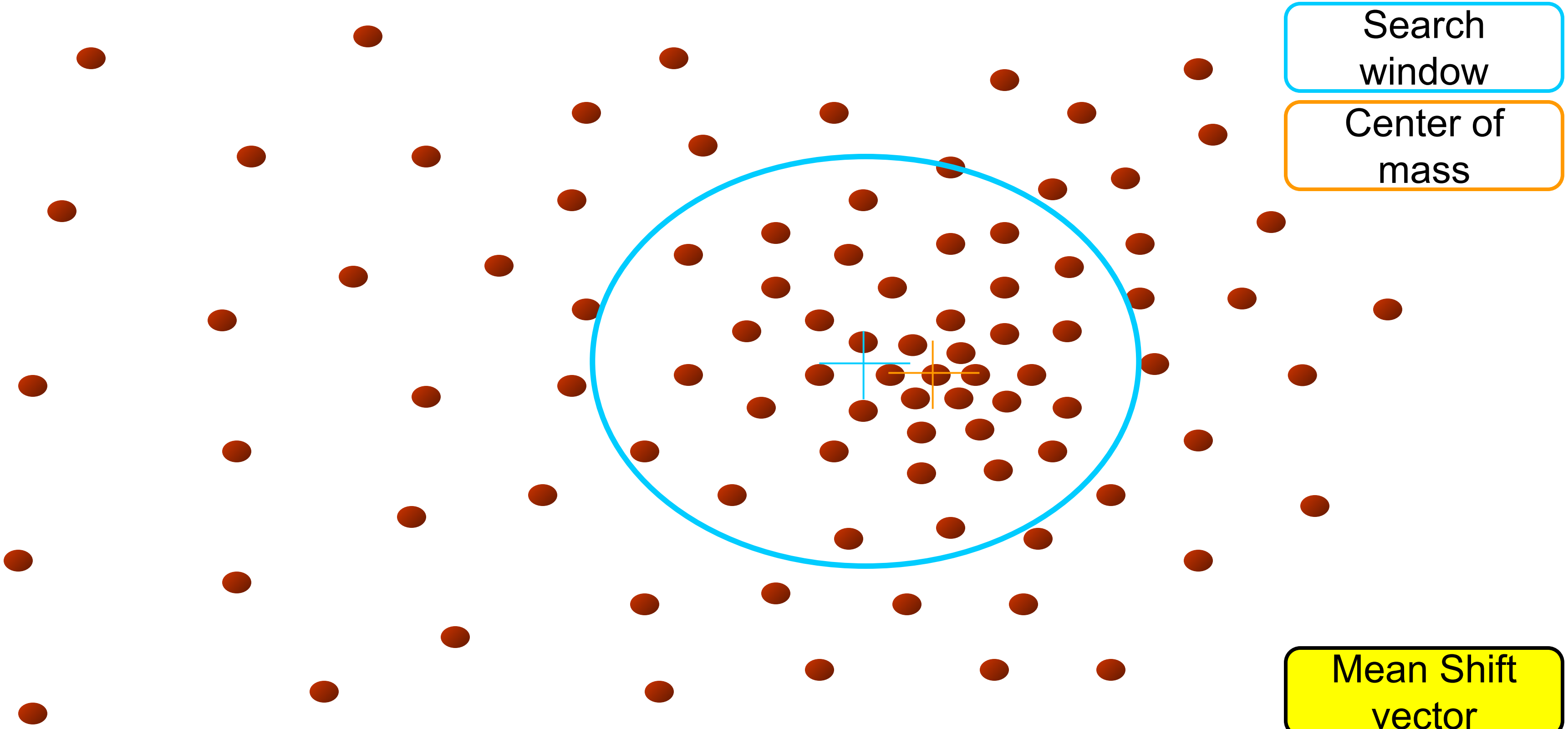
Slide by Y. Ukrainitz & B. Sarel

Mean shift



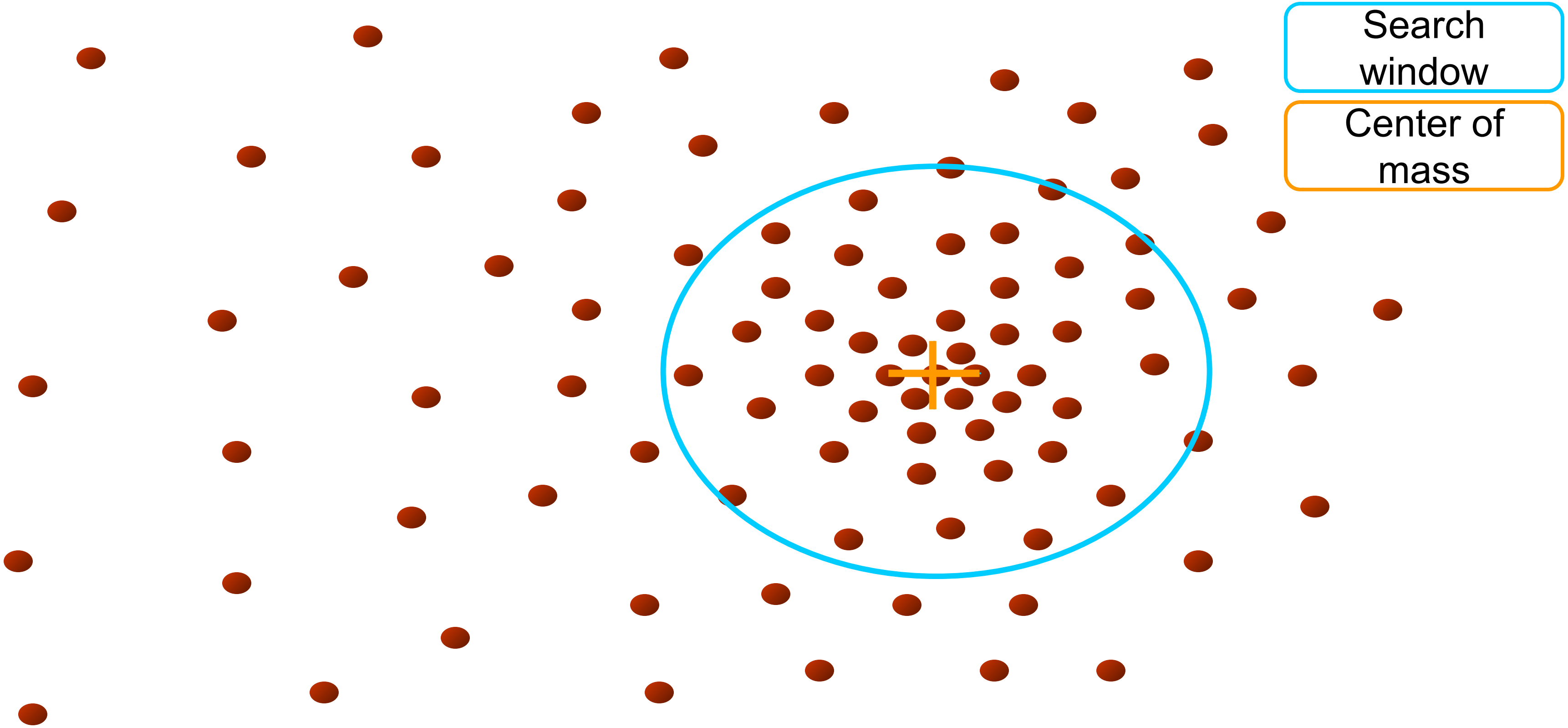
Slide by Y. Ukrainitz & B. Sarel

Mean shift



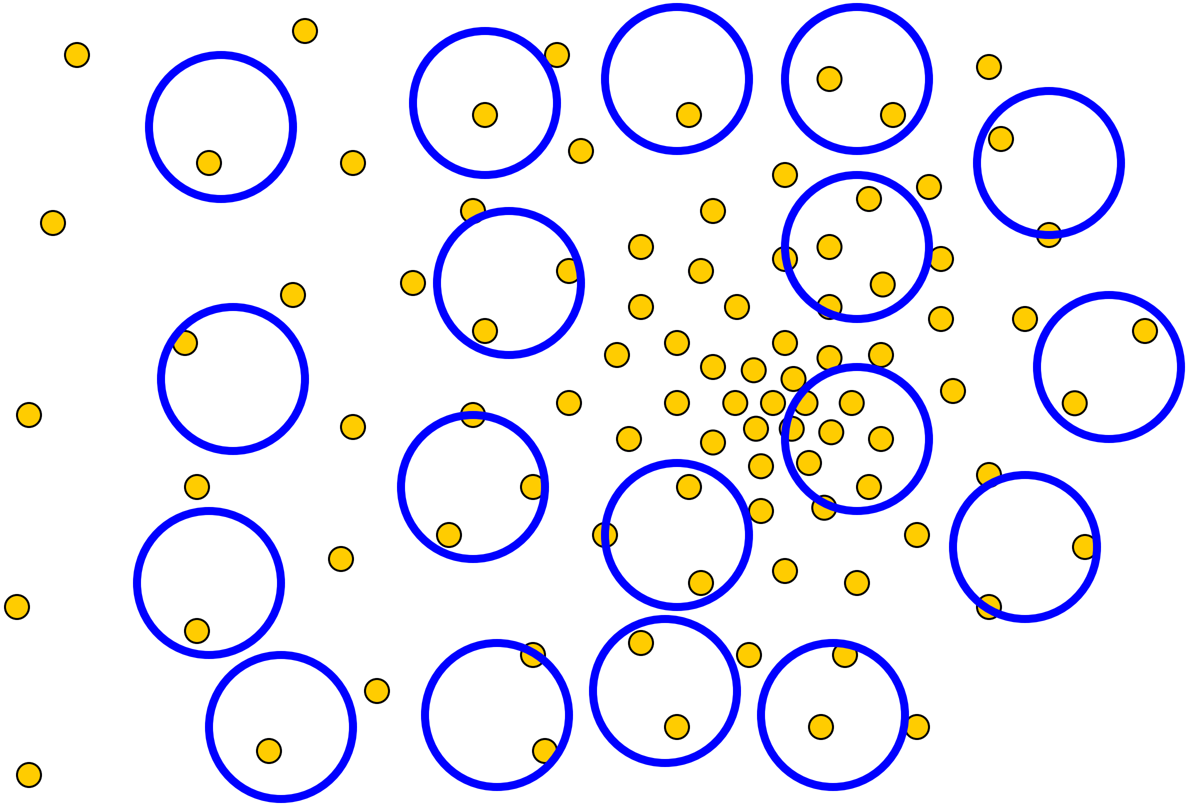
Slide by Y. Ukrainitz & B. Sarel

Mean shift



Slide by Y. Ukrainitz & B. Sarel

Real Modality Analysis

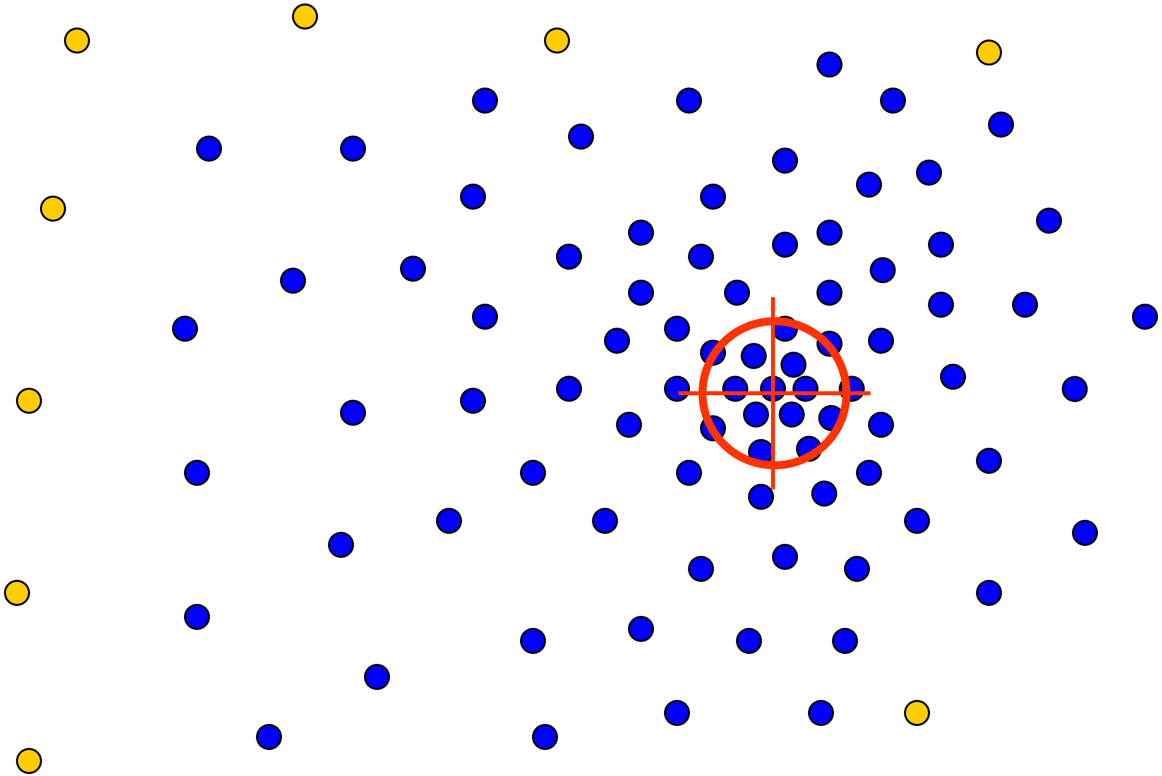


Tessellate the space with windows

Run the procedure in parallel

Slide by Y. Ukrainitz & B. Sarel

Real Modality Analysis

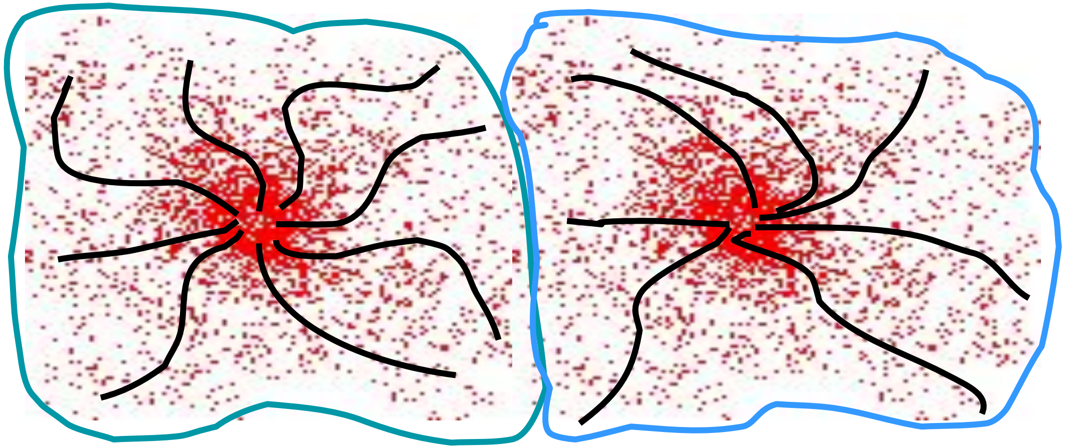


The blue data points were traversed by the windows towards the mode.

Slide by Y. Ukrainitz & B. Sarel

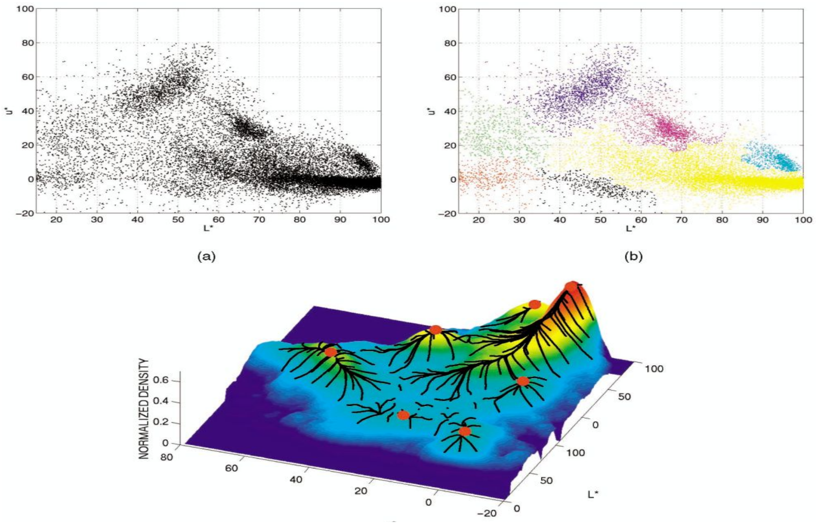
Mean shift clustering

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



Slide by Y. Ukrainitz & B. Sarel

- Find features (color, gradients, texture, etc)
- Initialize windows at individual feature points
- Perform mean shift for each window until convergence
- Merge windows that end up near the same “peak” or mode



Mean shift segmentation results




Mean shift

- <u>Pros</u>:
  - Does not assume shape on clusters
  - One parameter choice (window size)
  - Generic technique
  - Find multiple modes
- <u>Cons</u>:
  - Selection of window size
  - Does not scale well with dimension of feature space

Kristen Grauman

Q & A

Thank You !