Segmentation

Segmentation

- Divide image into parts that (might) represent objects or areas in the real world
  - Complete segmentation
  - Partial segmentation

Segmentation

Segmentation

Segmentation

Complete segmentation

- Result is a set of disjoint regions corresponding uniquely with objects in the image
- $R = \bigcup_{i=1}^{S} R_i,\ R_i \cap R_j \neq \emptyset,\ i \neq j$

Partial segmentation

- Regions do not correspond directly with image objects

Segmentation methods

- Global knowledge (histogram of image features)
- Edge-based
  - Hough transform
- Region-based
  - Split & merge

Thresholding

- Transformation of input image f to an output (segmented) binary image g

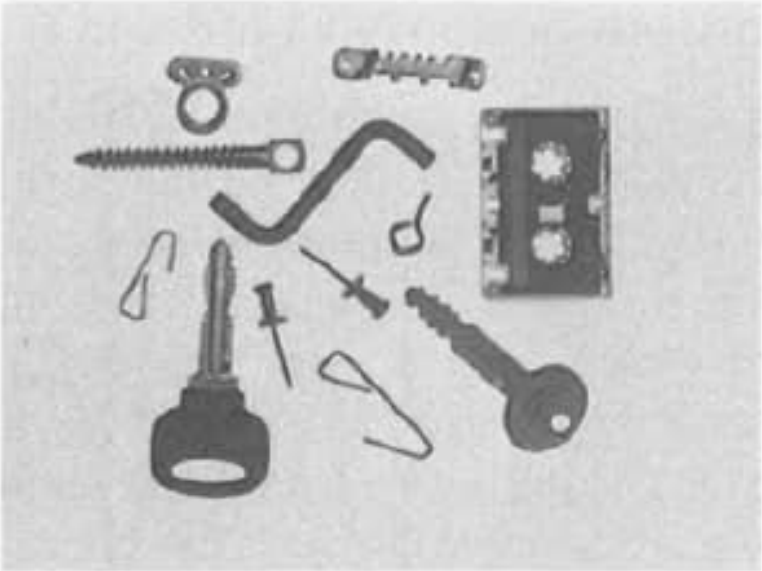
$$g(i,j) = \begin{cases} 1 & \text{for } f(i,j) \geq T \\ 0 & \text{for } f(i,j) < T \end{cases}$$

- Number T is threshold.

Thresholding

Good for segmenting images with properties

- Objects in image do not touch each other
- Grey-levels of objects are clearly distinct from grey-levels of background.



Thresholding – variations

Adaptive thresholding

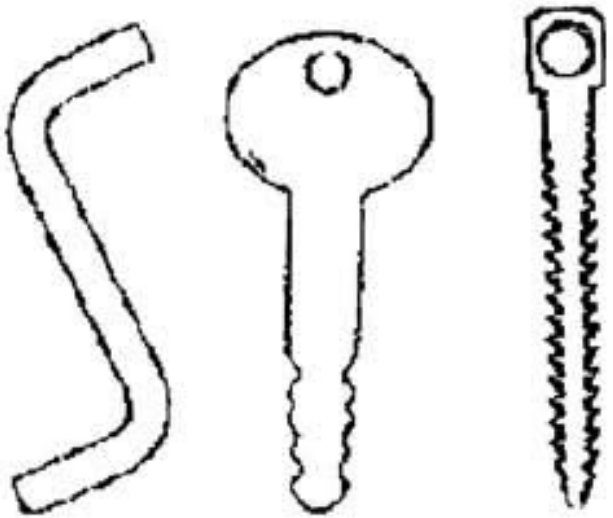
- Threshold value varies over the image as a function of local image characteristics.
- E.g. divide the image into subimages and determine threshold for each subimage independently (interpolate if threshold cannot be determined)

Thresholding – variations

Band thresholding

- Segment an image into regions of pixels with grey-levels from a set D and background

$$g(i,j) = \begin{cases} 1 & \text{for } f(i,j) \in D, \\ 0 & \text{otherwise.} \end{cases}$$



Thresholding–variations

Band thresholding

- Good for segmenting objects with particular range of grey-levels in the image.
- E.g. cell segmentations
  - particular grey-level interval represents cytoplasma
  - background is lighter
  - cell kernel darker

Thresholding–variations

Multiple thresholding

- Segment image into smaller number of grey-levels according to chosen sets of grey-levels in the image.

$$g(i,j) = \begin{cases} 1 & \text{for } f(i,j) \in D_1, \\ 2 & \text{for } f(i,j) \in D_2, \\ 3 & \text{for } f(i,j) \in D_3, \\ \dots & \\ n & \text{for } f(i,j) \in D_n, \\ 0 & \text{otherwise.} \end{cases}$$

Thresholding–variations

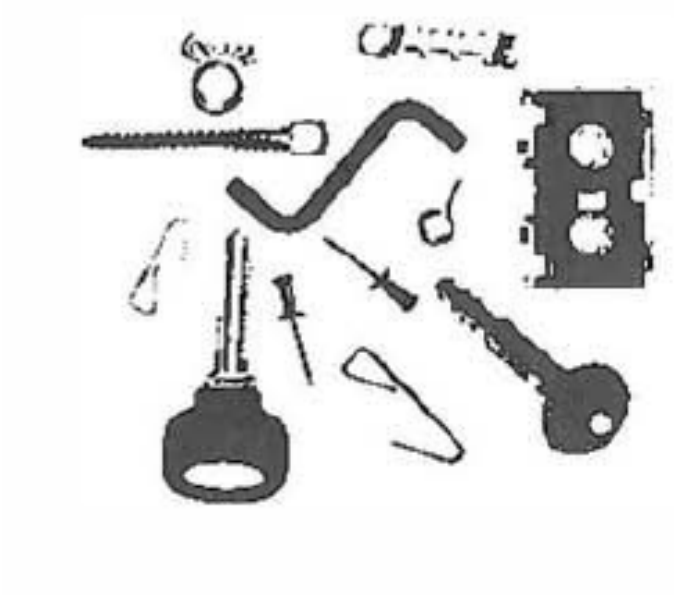
Semi-thresholding

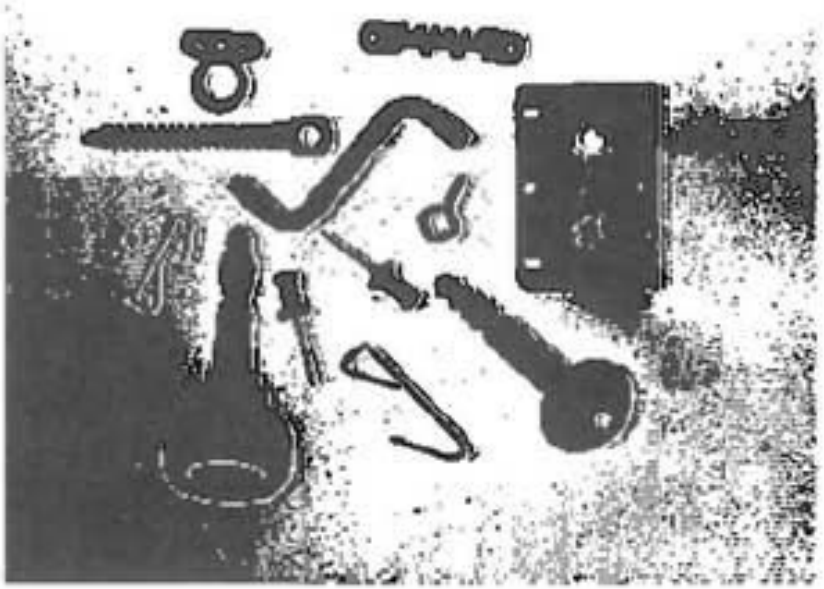
- Leaves grey-levels in an image intact if their value is at least threshold value.

$$g(i,j) = \begin{cases} f(i,j) & \text{for } f(i,j) \geq T, \\ 0 & \text{otherwise.} \end{cases}$$

Thresholding

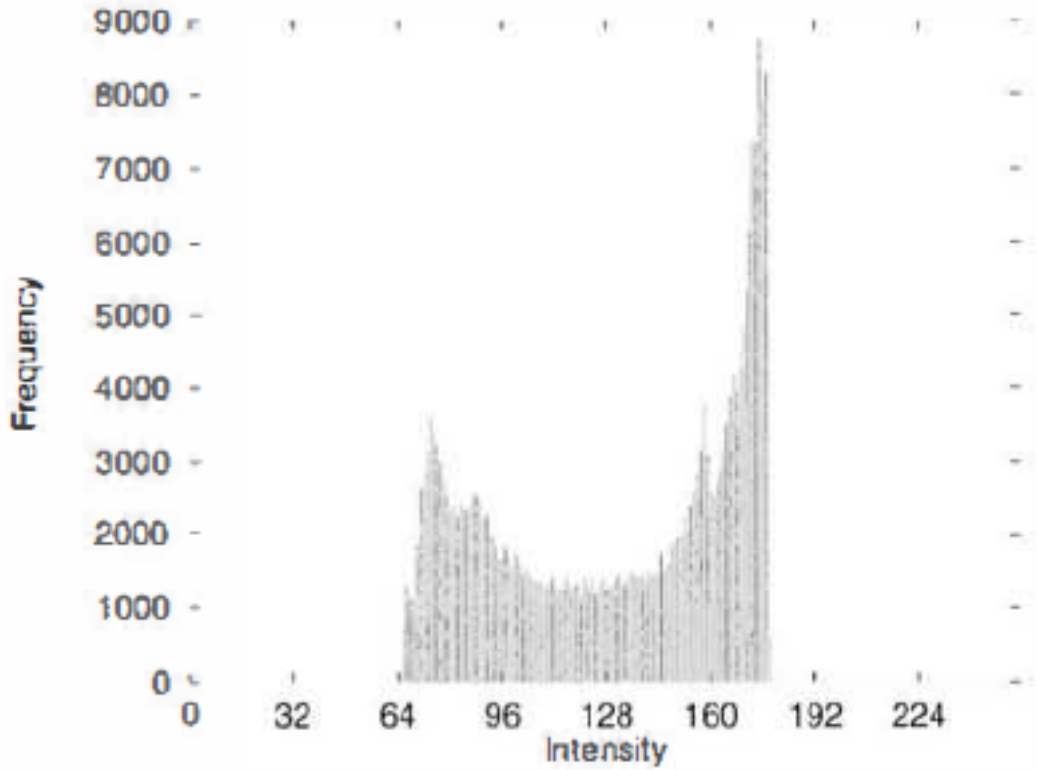
What threshold value to choose?





Threshold detection methods

- Histogram based – histogram shape analysis
- Assumption: Objects in the image consists of pixels with similar grey-levels, background grey-levels differ from objects grey-levels – bi-modal histogram



Threshold detection methods

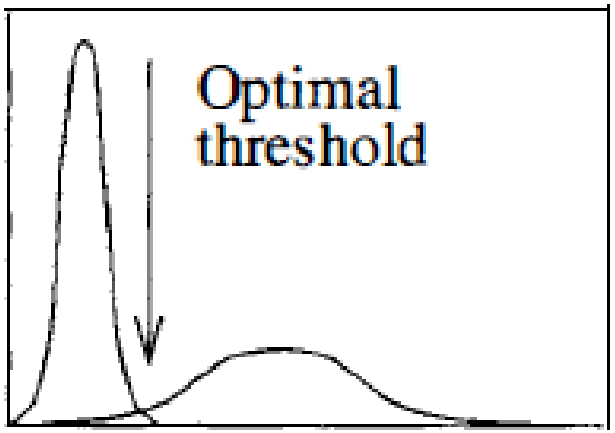
- Two peaks usually represent objects and background grey-levels.
- Intuitively, threshold is minimal grey-level value between two peaks
- Variation for multimodal histogram is evident.

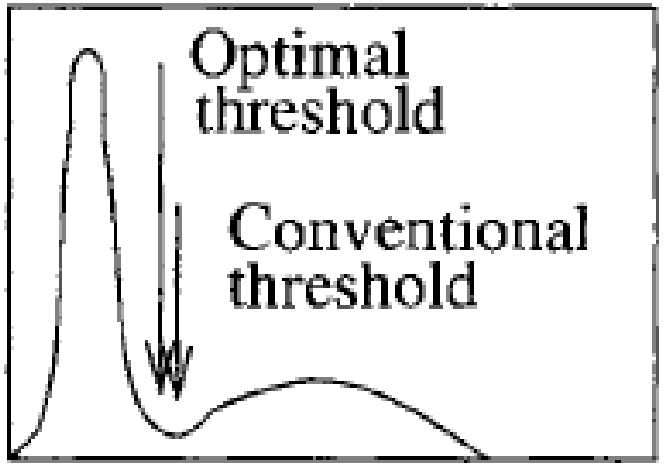
Threshold detection methods

Optimal thresholding

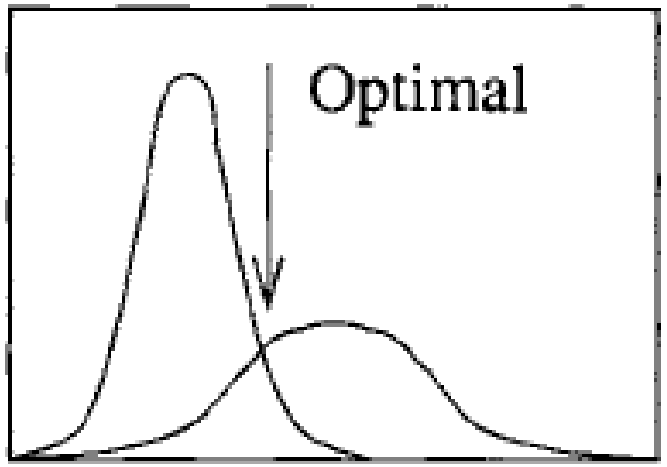
- Approximation of histogram using weighted sum of probability densities with normal distribution.
- Threshold equals to closest grey-level corresponding to minimum probability between maxima of two or more normal distributions.
- Minimal error segmentation

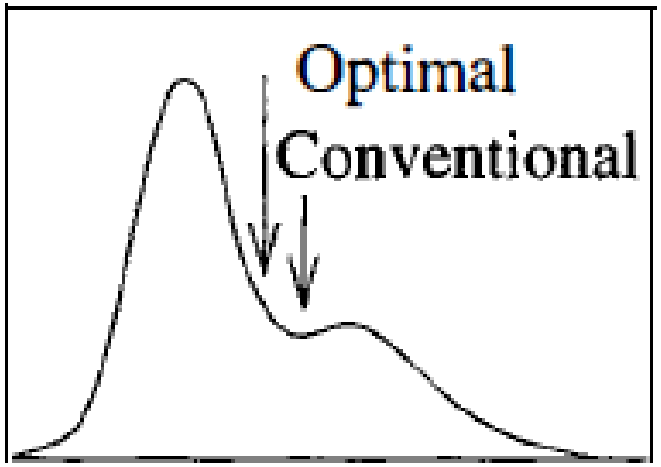
Optimal thresholding



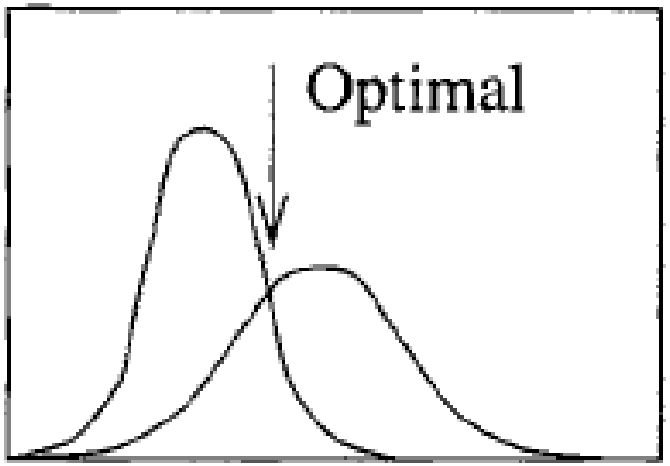


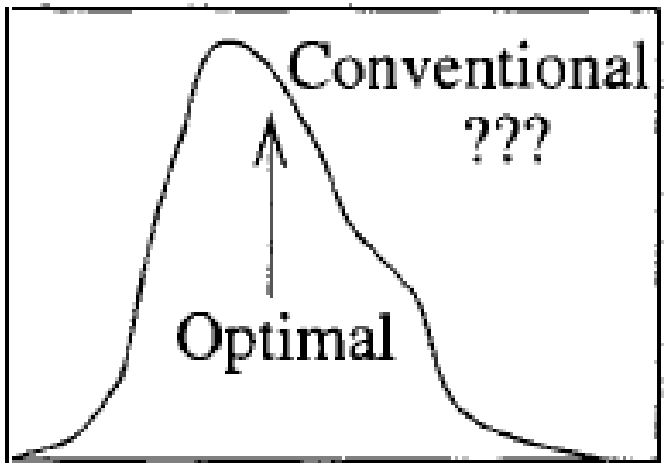
Optimal thresholding





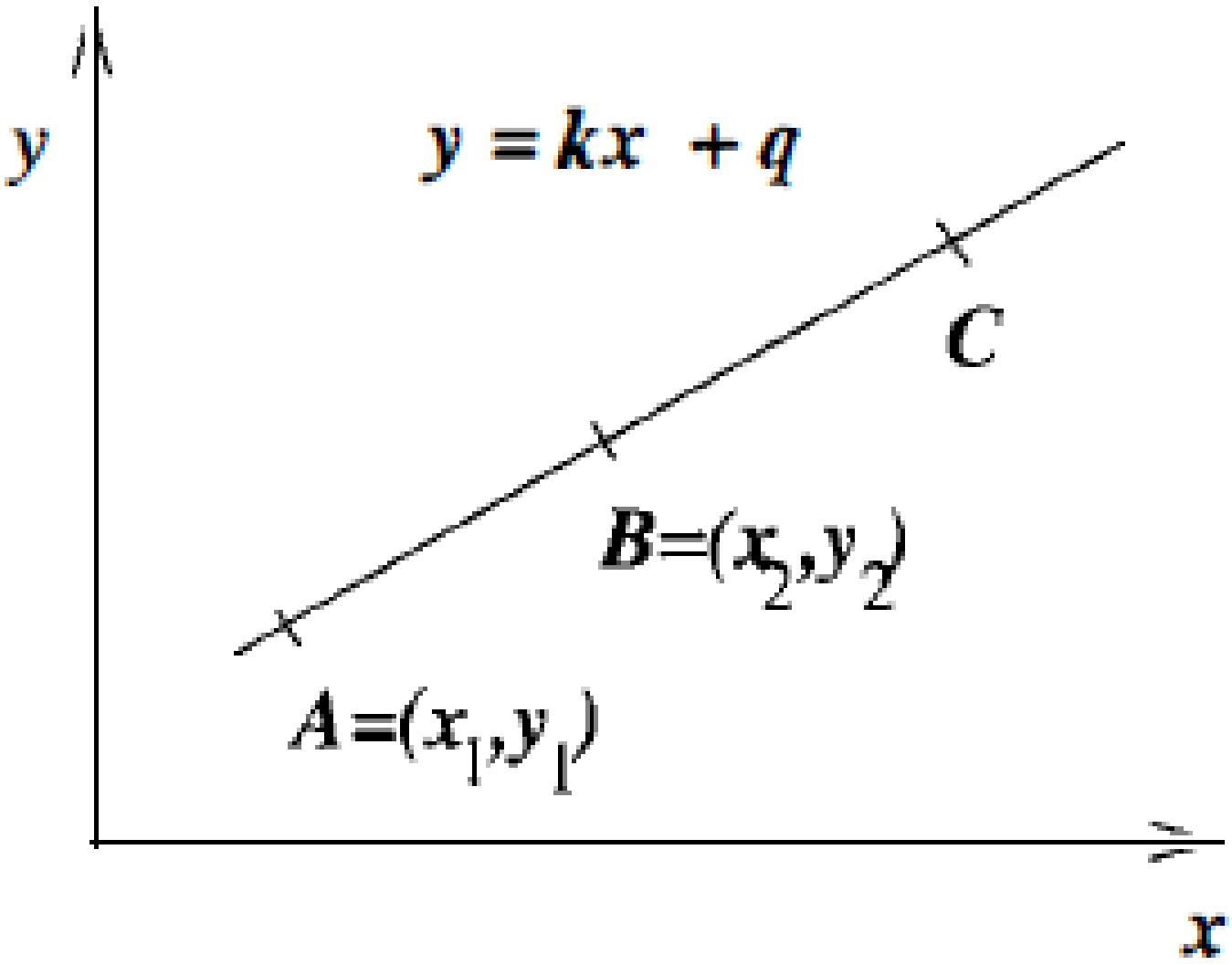
Optimal thresholding





Edge-based segmentation – Hough transform

- Idea: How to find straight line in image



Hough transform

- Line in xy plane is given by equation

$$y = kx + q$$

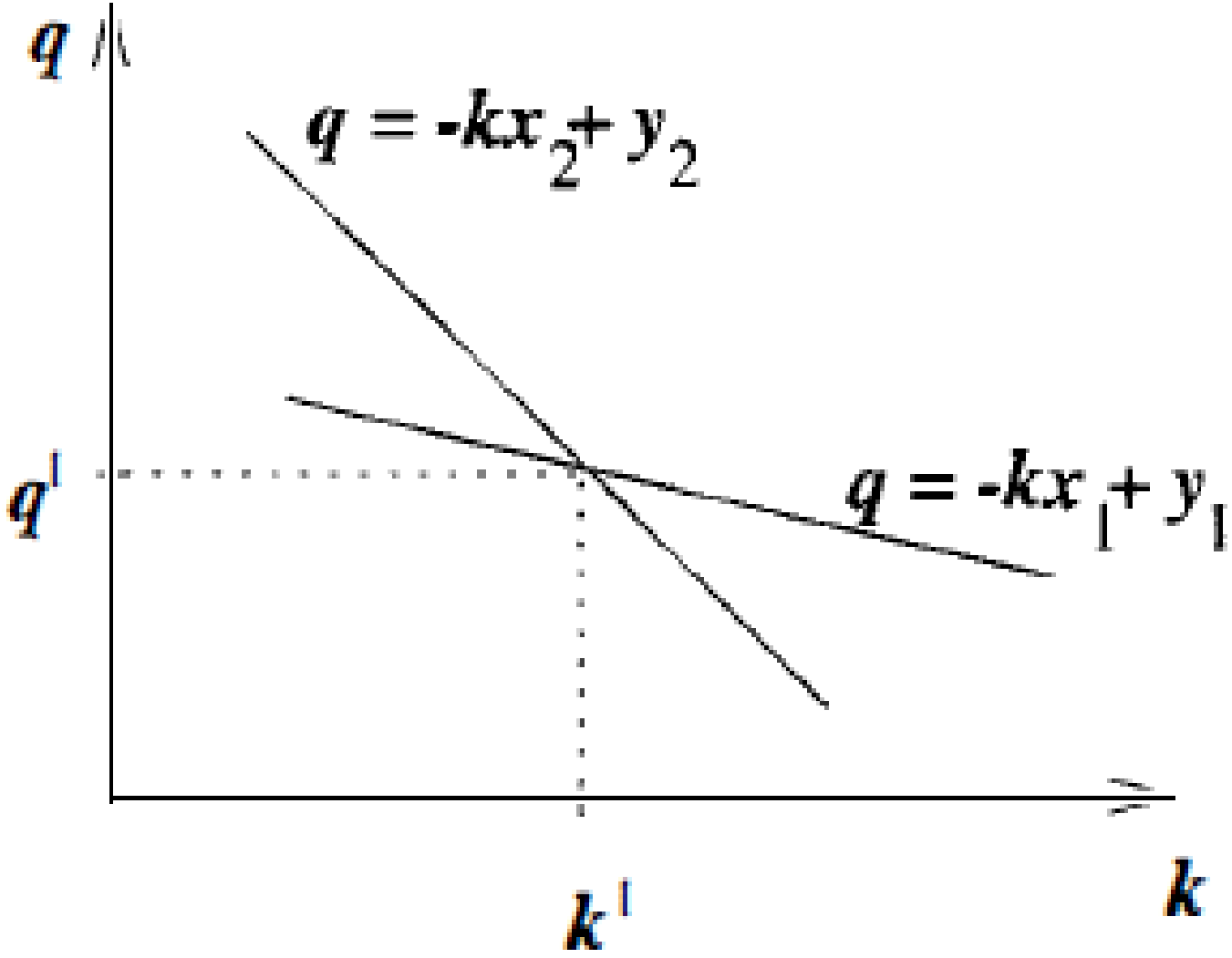
- $A = (x_1, y_1)$ is point of the line iff it fulfills the equation of the line

$$y_1 = kx_1 + q$$

- For given x_1, y_1 the equation $y_1 = kx_1 + q$ is equation of line in kq plane, $q = -x_1 k + y_1$.
- Line $q = -x_1 k + y_1$ in kq plane represents all lines through point (x_1, y_1).

Hough transform

- kq plane



Hough transform

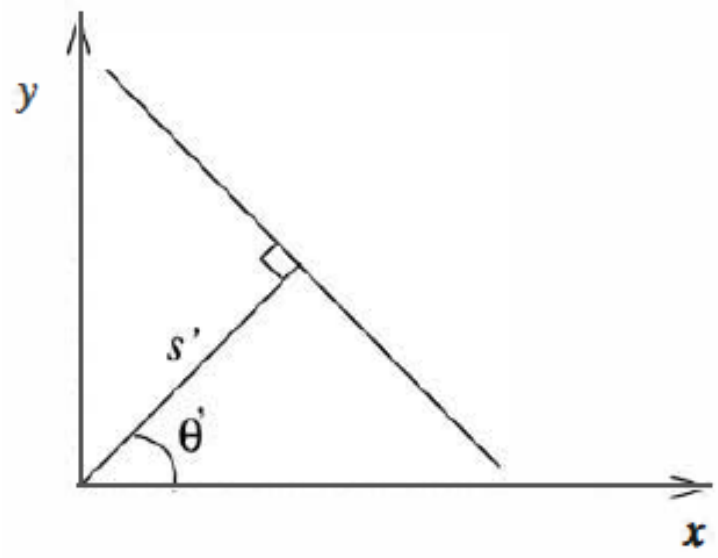
- Intersection of two lines in kq plane gives a point, which represents line in xy plane containing both points
- If set of points lies on a line the Hough transform for these points gives set of lines that intersects at one point in kq plane.
- This point represents the line on which lies the set of points.

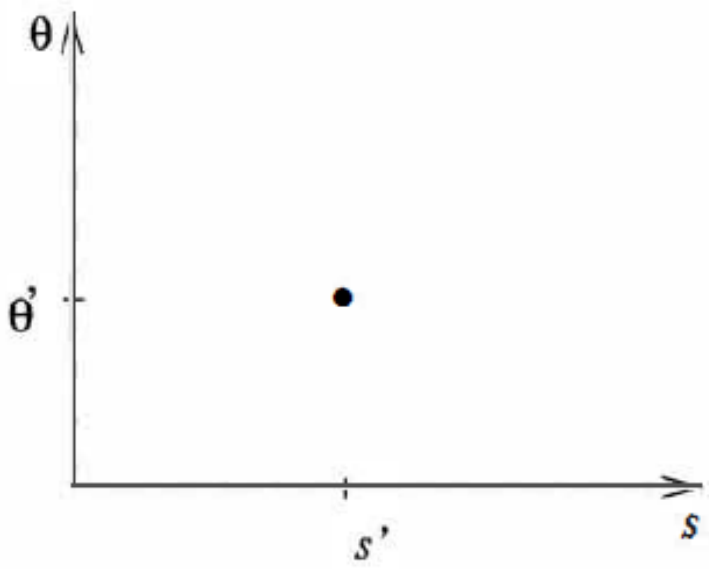
Hough transform

- For actual line searching, equation of a line is

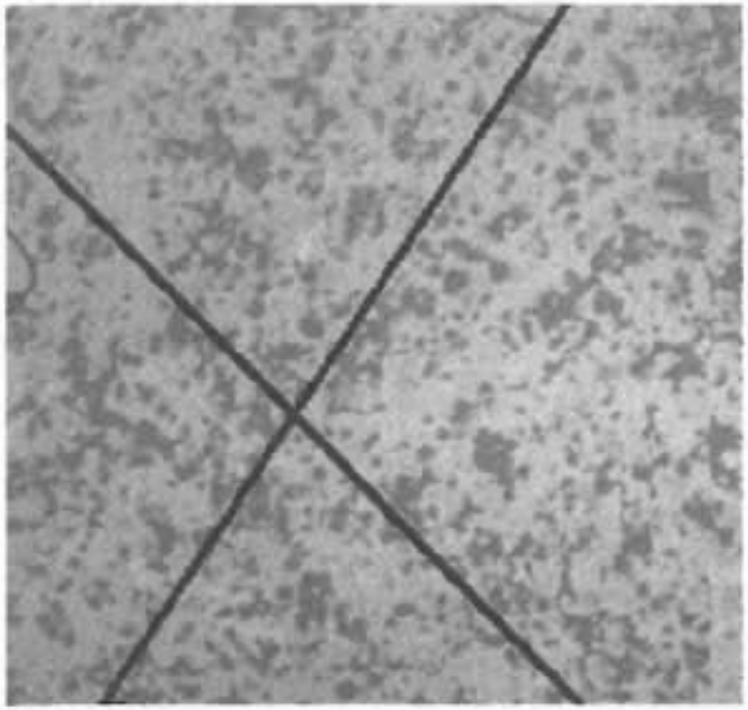
$$s = x\cos\theta + y\sin\theta$$

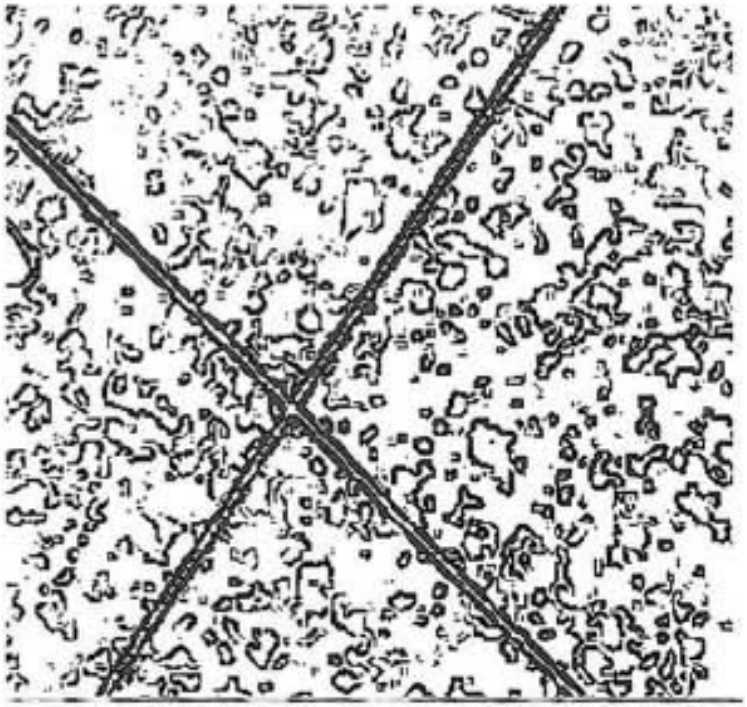
- Parametric space is then plane $s\theta$



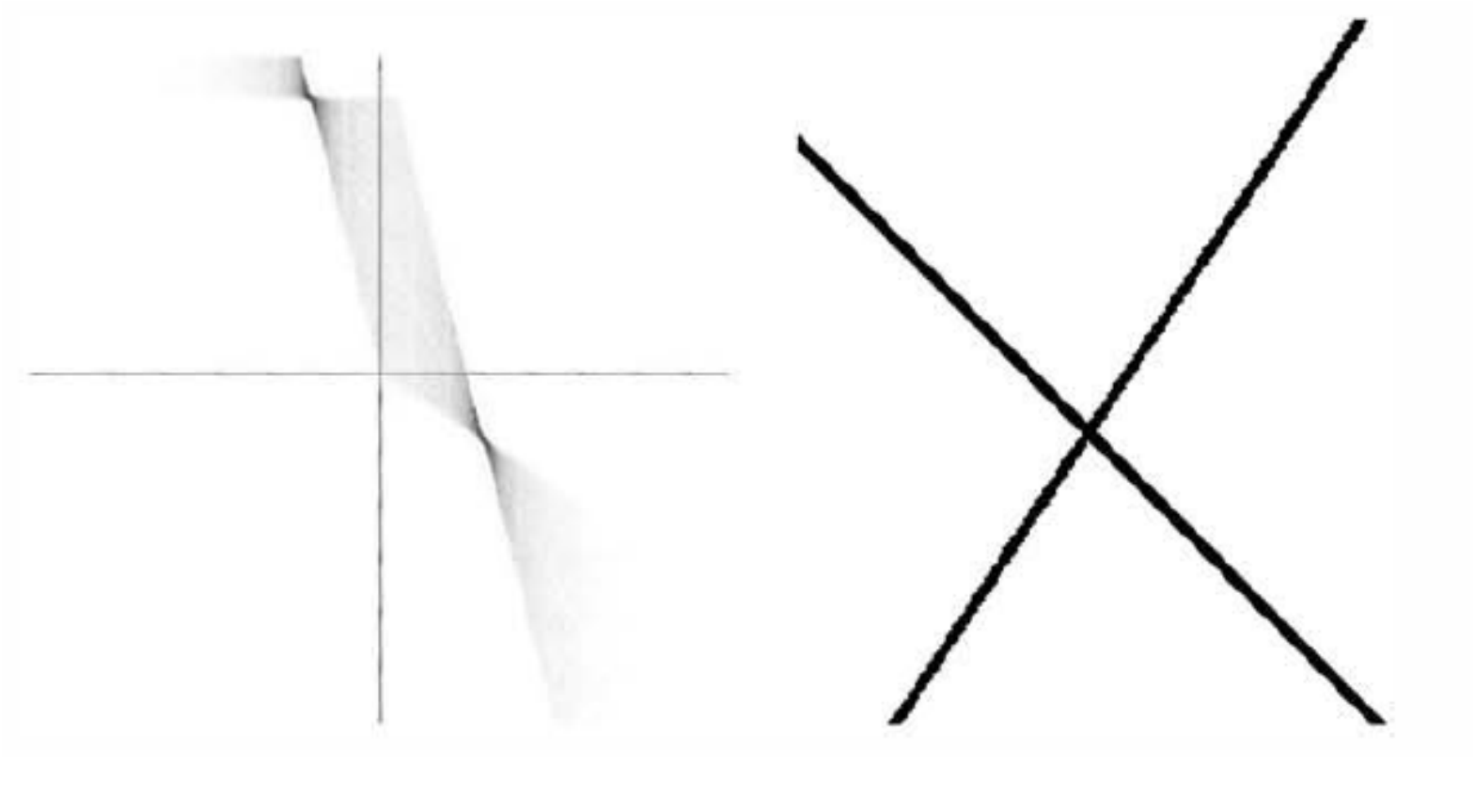


Hough transform





Hough transform

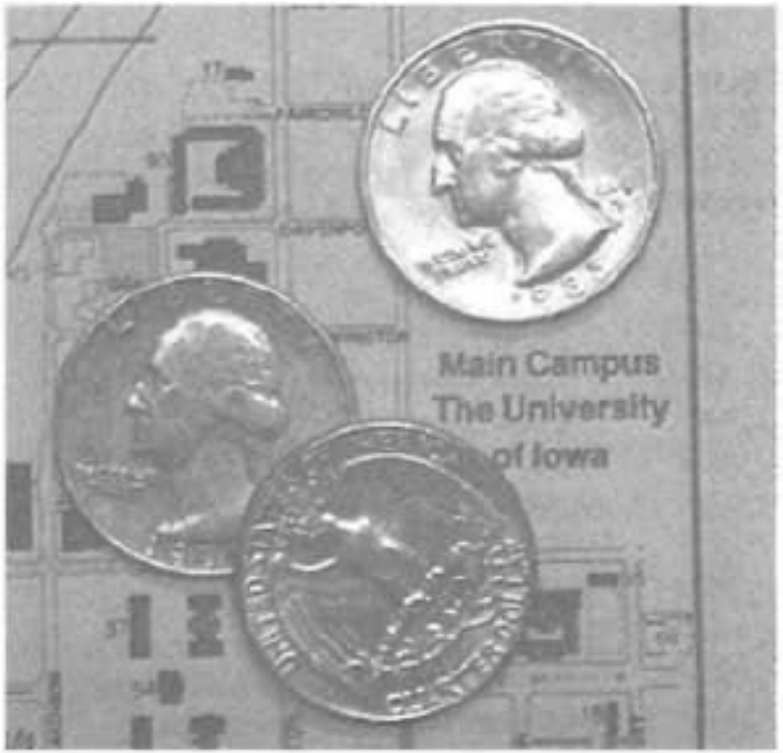


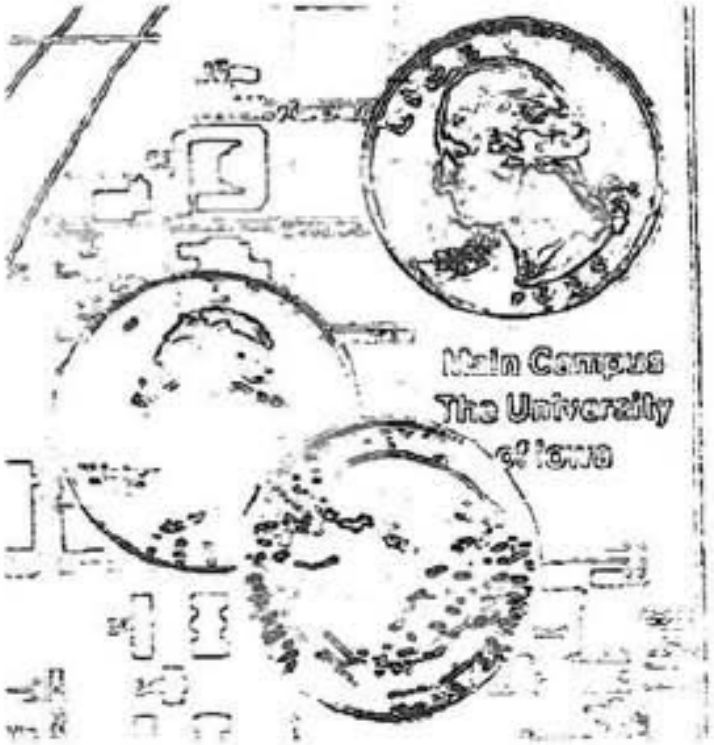
Hough transform

- Can be used to search for circles or any curve with known analytic expression.
- For circle the equation is

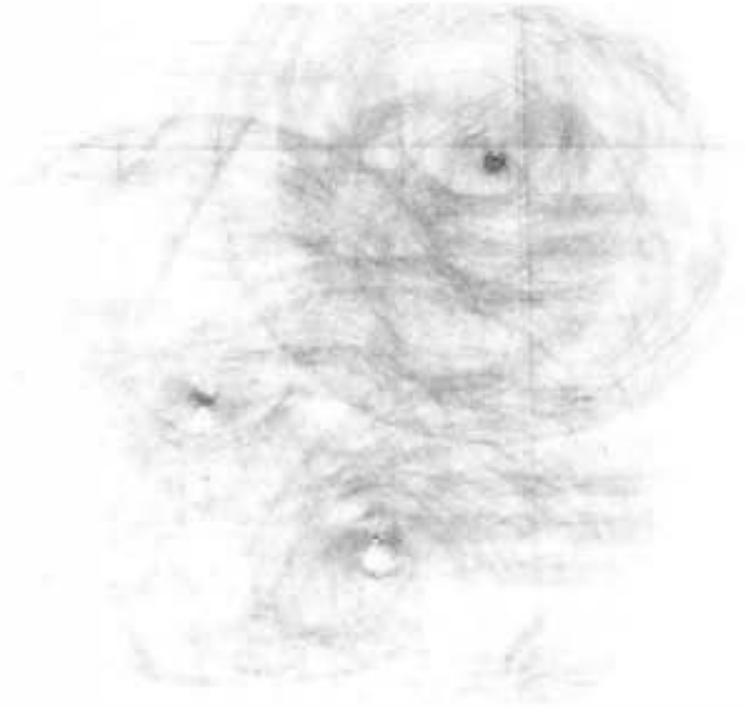
$$(x-a)^2 + (y-b)^2 = r^2$$

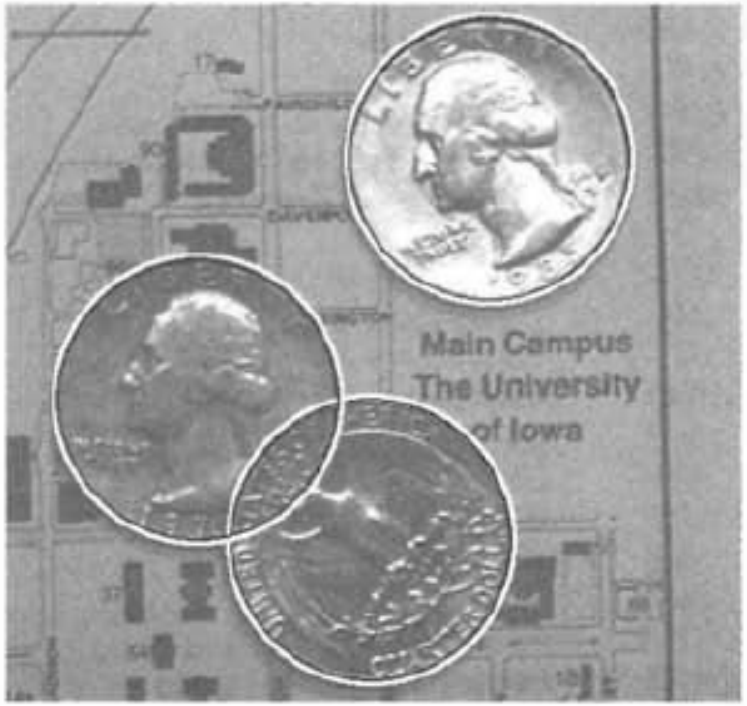
Hough transform



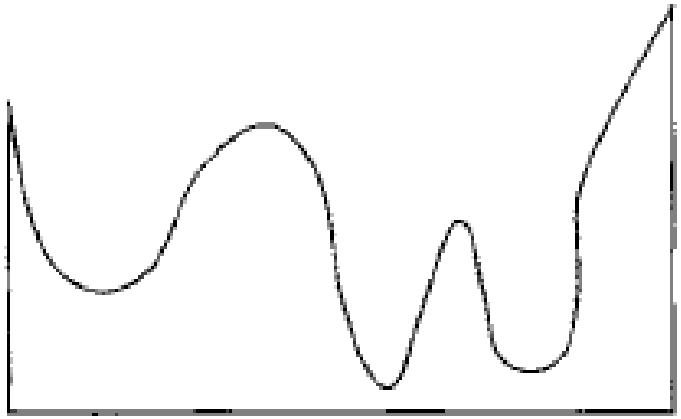


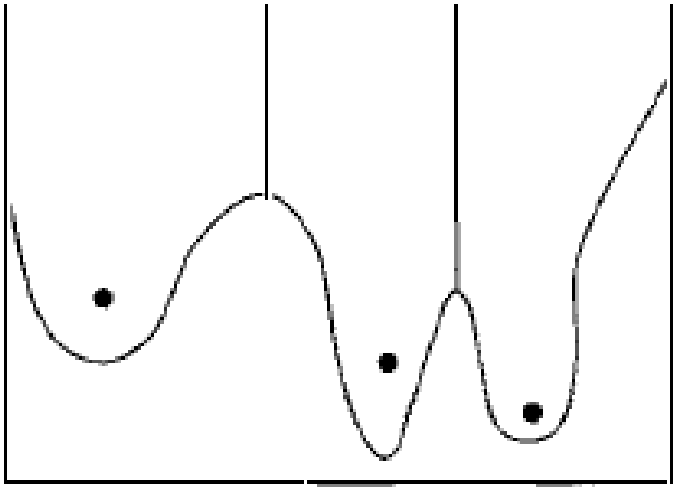
Hough transform



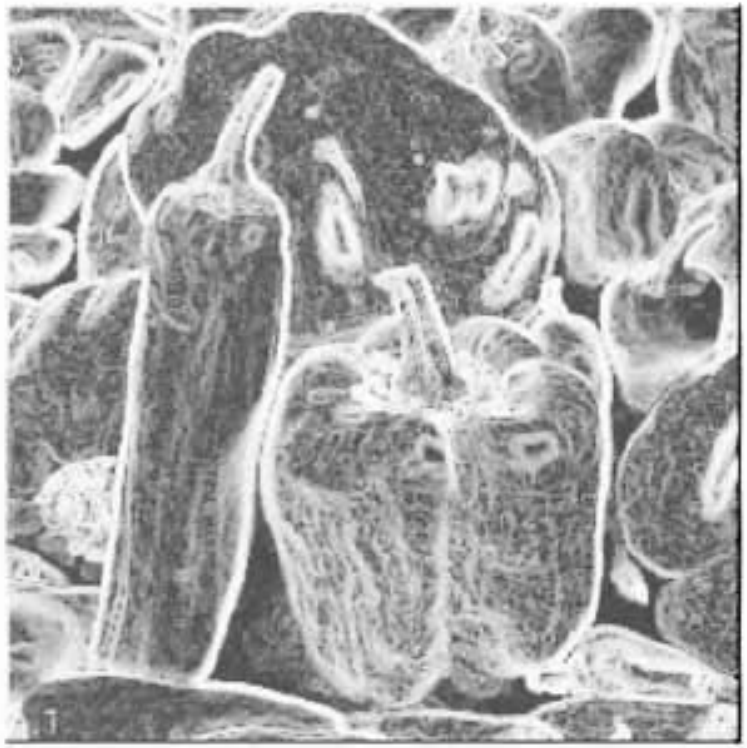


Watershed segmentation

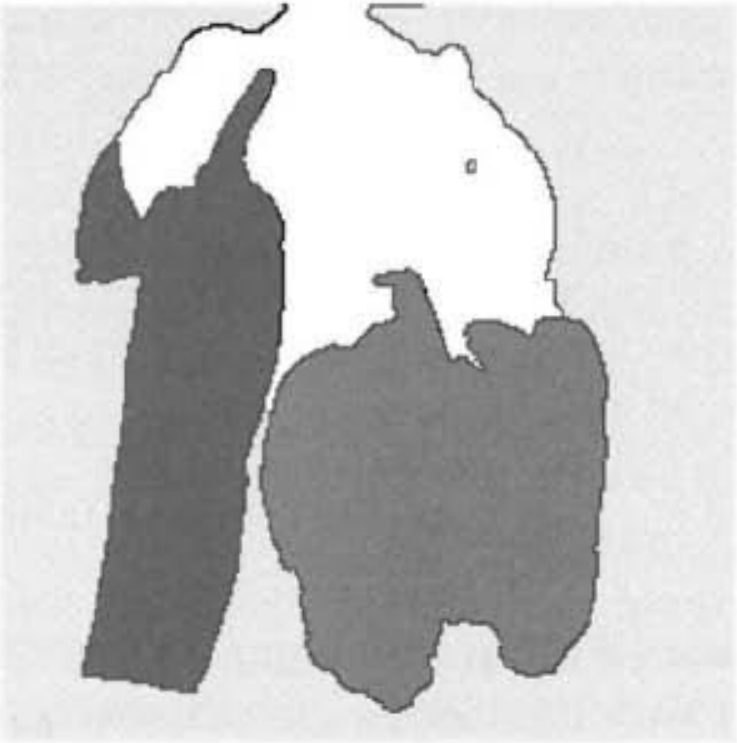




Watershed segmentation



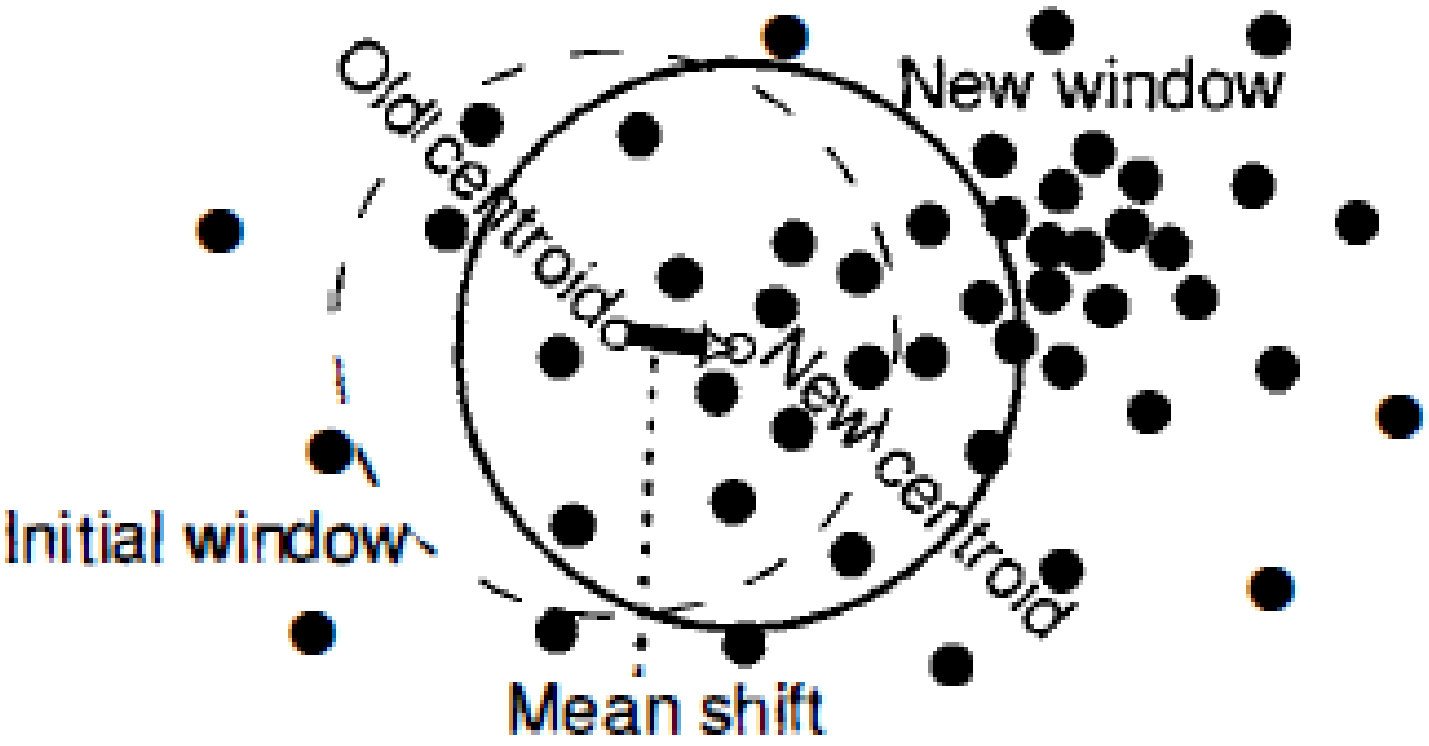
Watershed segmentation



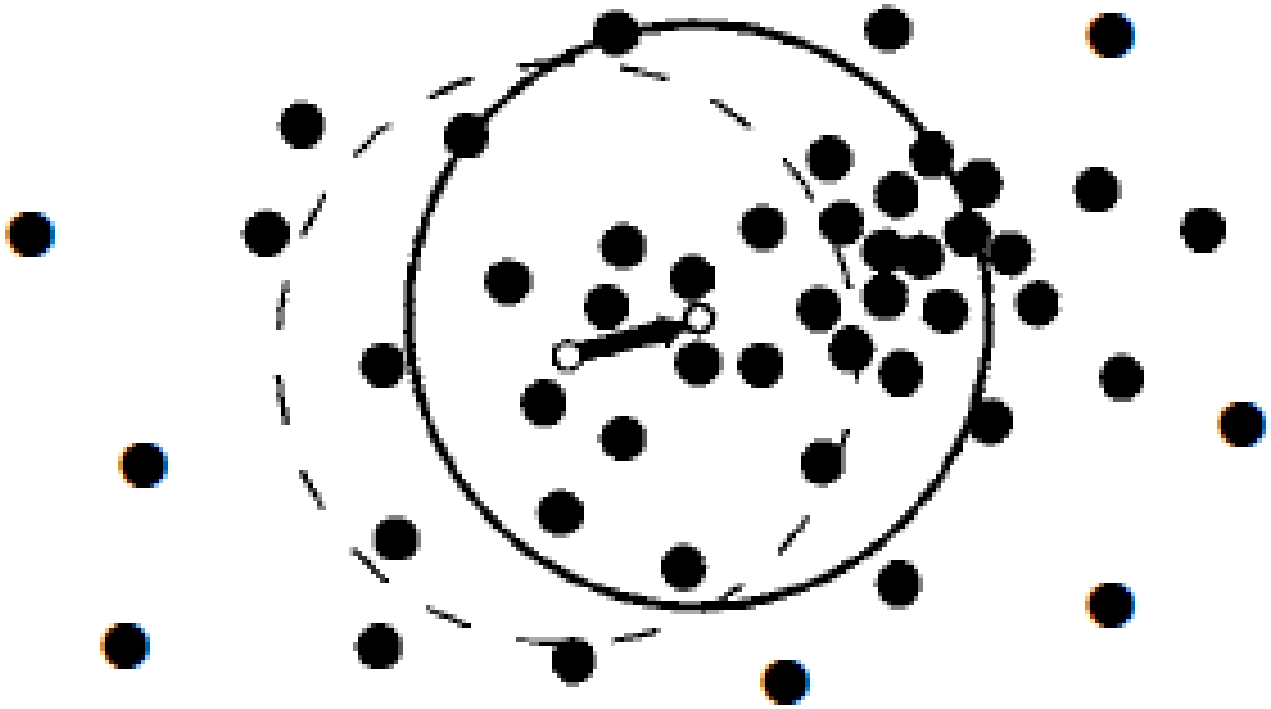
Mean shift segmentation

- Clustering of feature space
- E.g. in color images, feature space is RGB space, feature is color of pixel.
- Feature space is more densely populated at the area corresponding to the significant feature

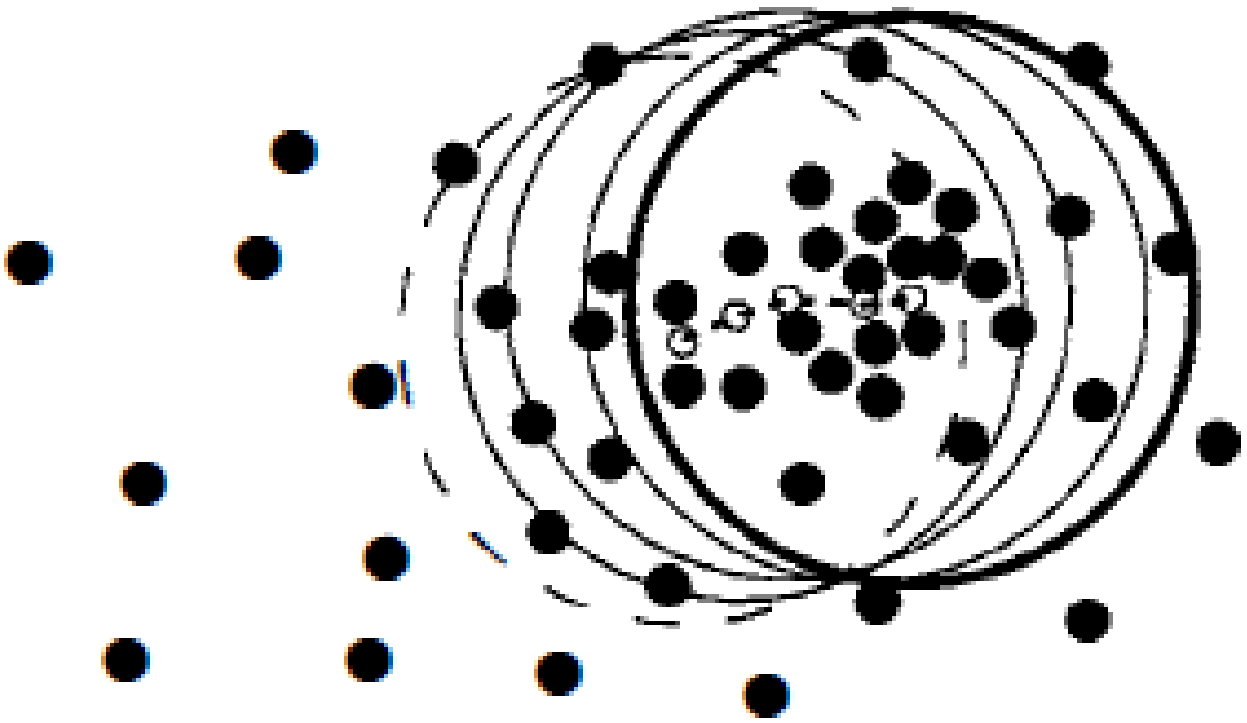
Mean shift segmentation



Mean shift segmentation



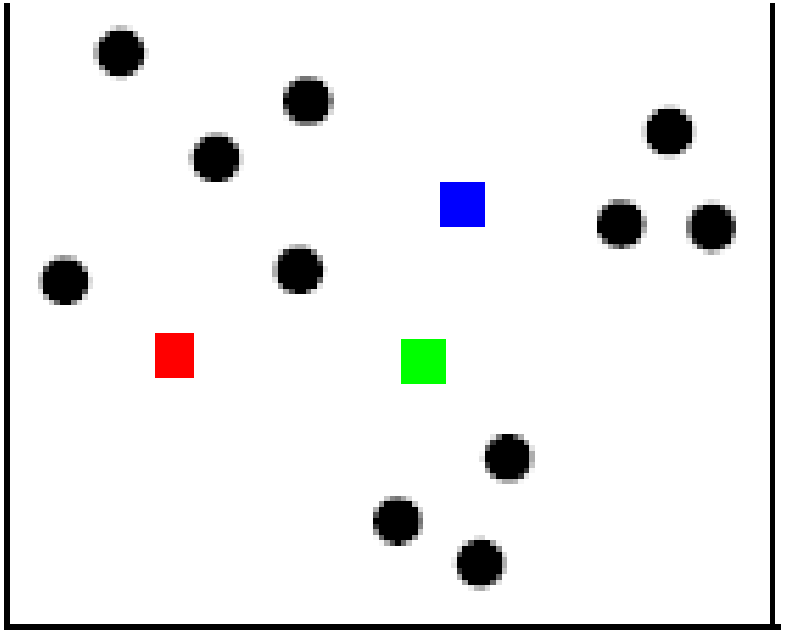
Mean shift segmentation



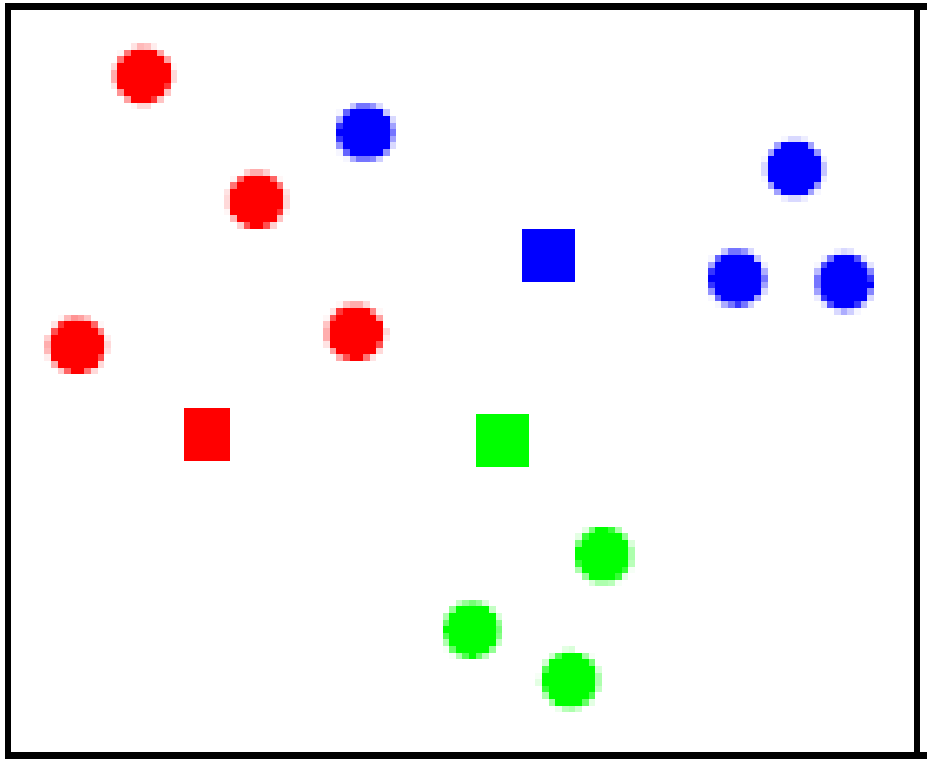
Mean shift segmentation

K-means segmentation

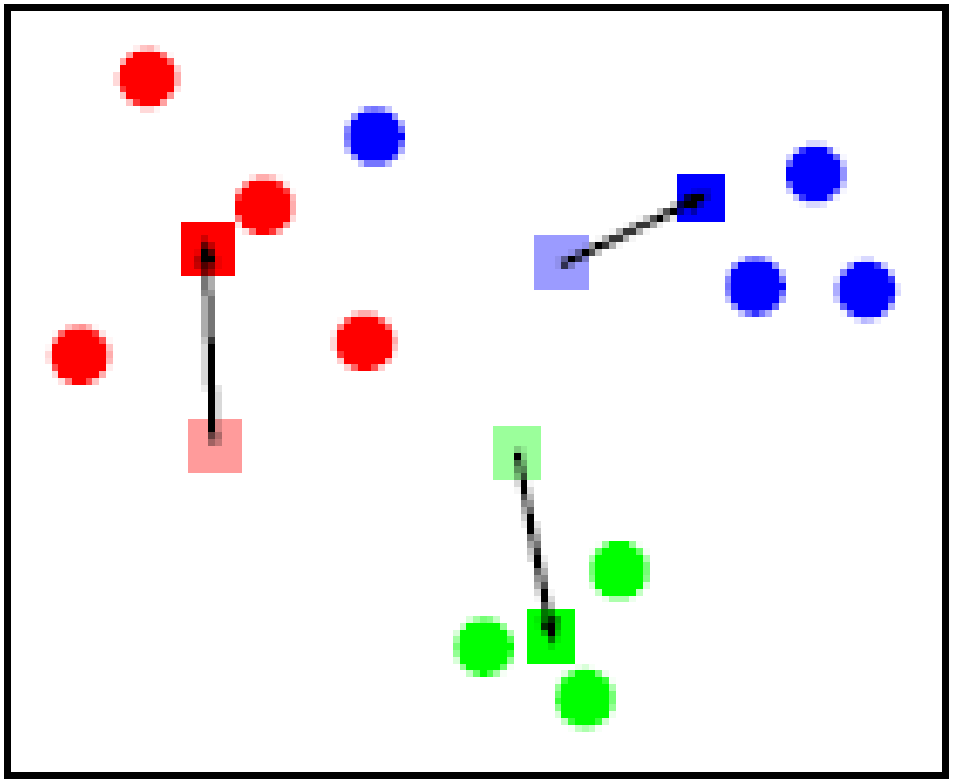
- Similar to mean shift
- Used if number of desired segments is known



K-means segmentation



K-means segmentation



K-means segmentation