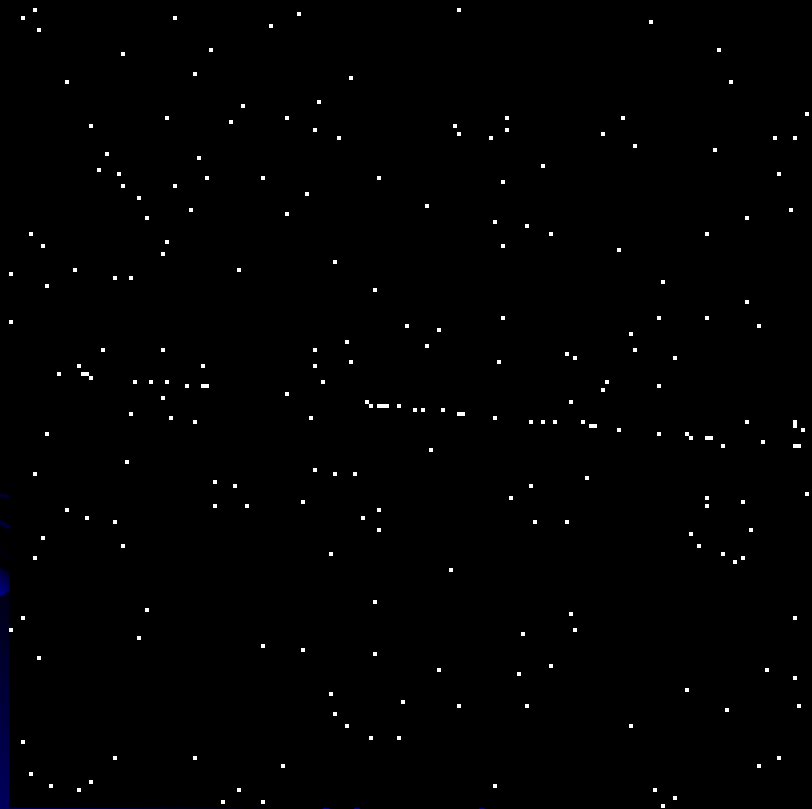# CSSE463: Image Recognition   Day 25

- ## This week
  - Today: Finding lines and circles using the Hough transform
  - Tomorrow: Applications of PCA
  - Weds night: k-means lab due.
  - Thursday: template matching for object recognition
 - Sunday night (new): project plans and prelim work due

- ## Questions?

Finding lines in real images

- Input: set of edge points
- Output: the equation of a line containing them
- Methods:
  - Least-squares (if you know which points belong to the line…)
  - Hough transform (today)

Hough transform

- Idea (Forsyth and Ponce, ch 15):
  - Represent a line using parameters
  - Each point in the image casts a vote for all lines of which it could be part.
 - Only the true line receives lots of votes
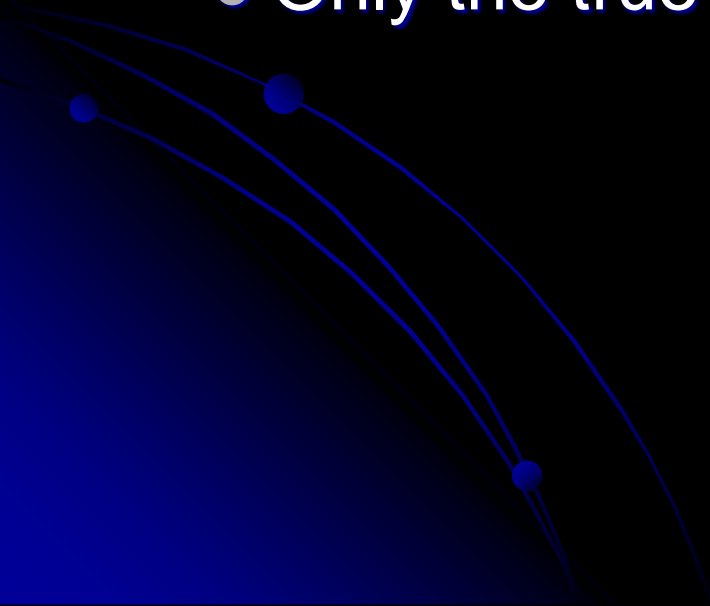
Parametric Equation of a Line

- Represent a line using 2 parameters
- $y = mx + b$?
  - Problem?
- $Ax + By + C = 0$?
  - 3 parameters; but A, B, and C are related…we only need 2
- ρ and θ
  - ρ is distance from line to origin
  - Θ is the angle the distance segment makes with x-axis
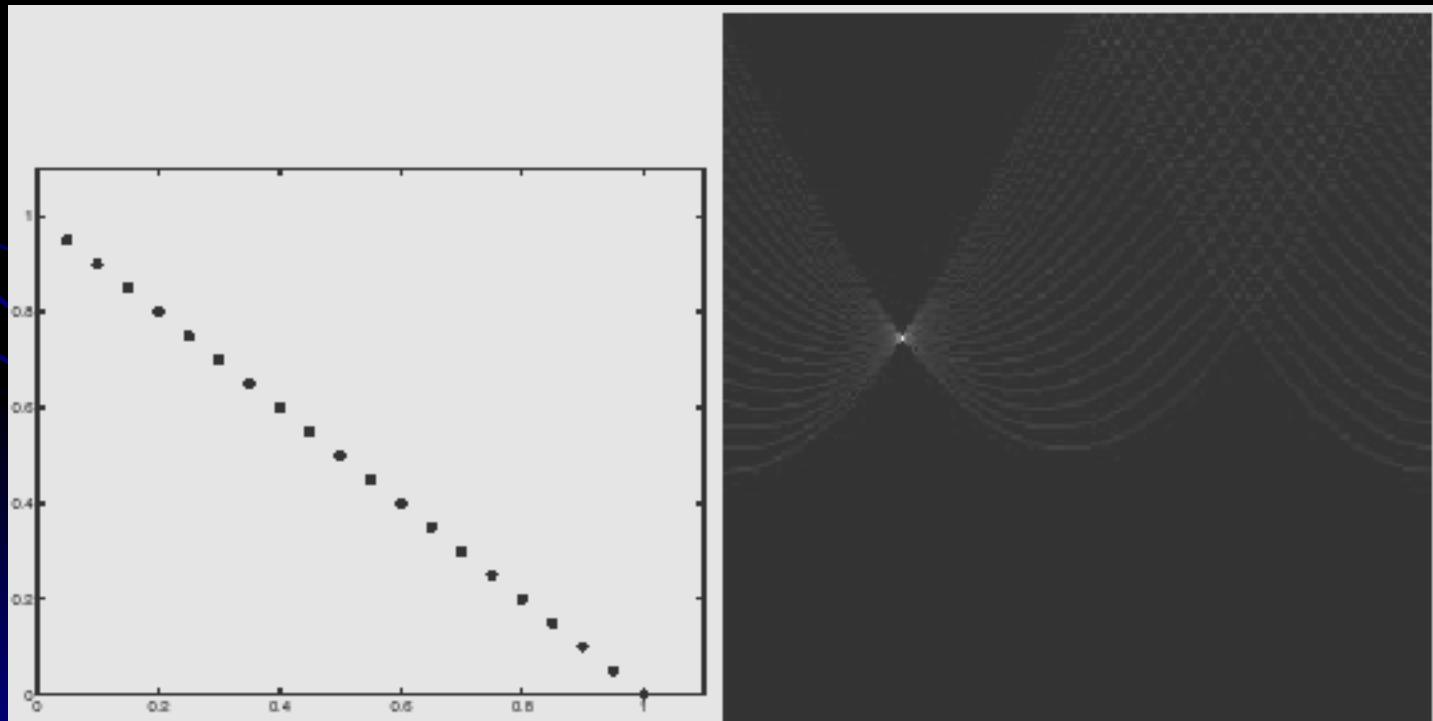 - $x \cos\theta + y \sin\theta = \rho$

Voting

- Each point in image votes for all lines of which it could be part.

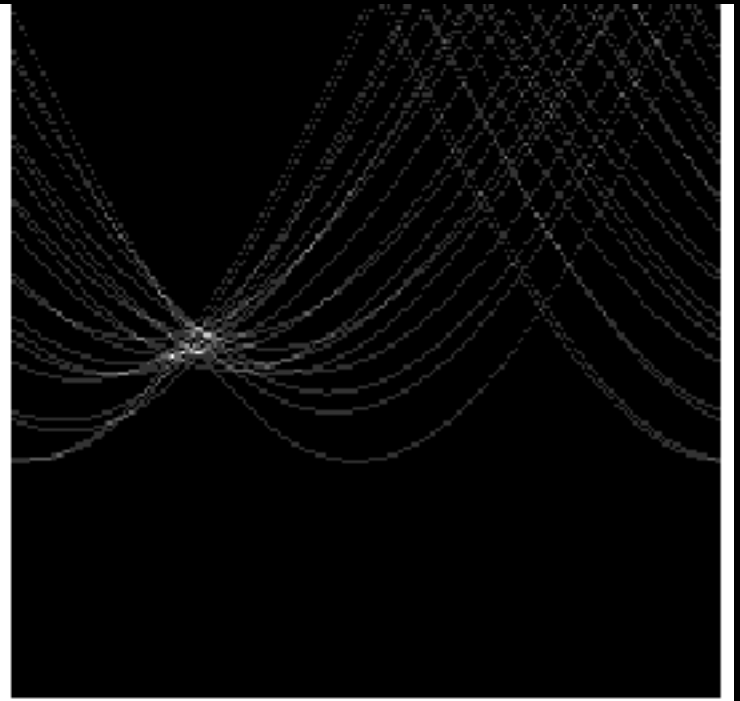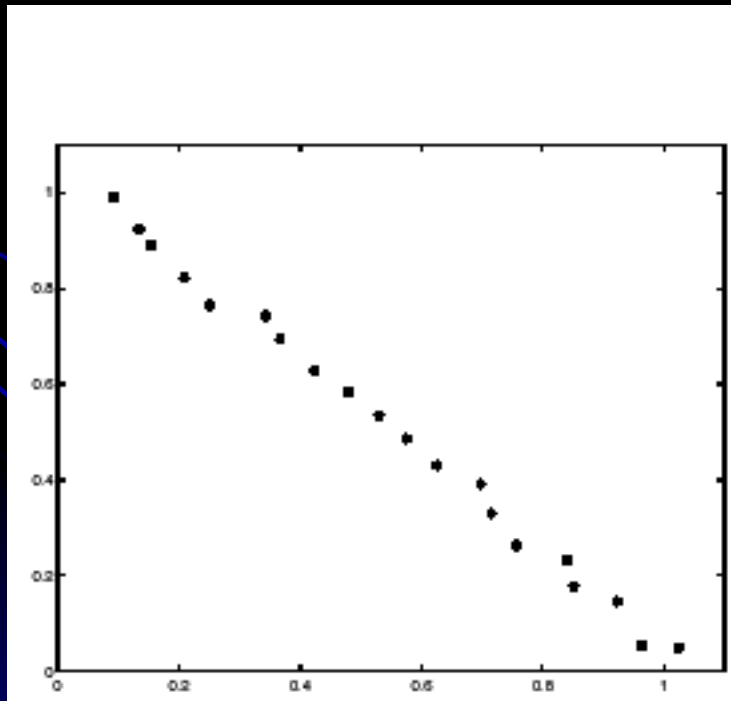- Only "true" line receives lots of votes.

- Demo
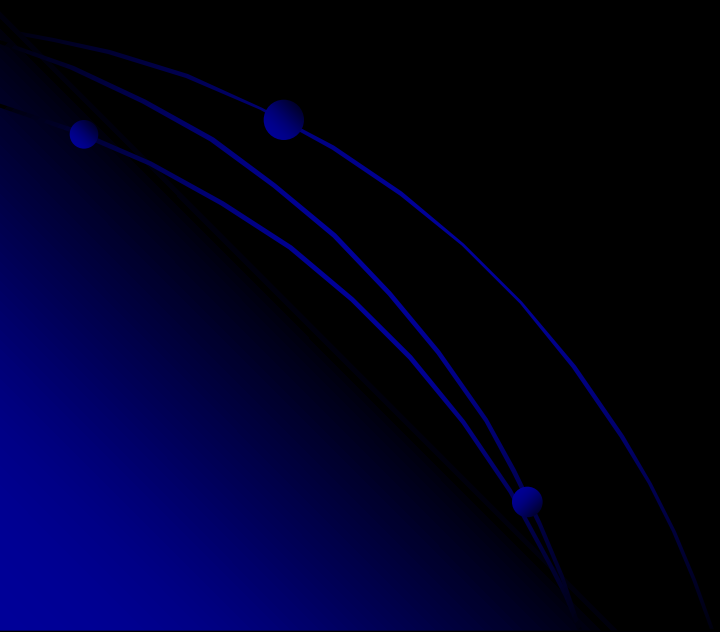
Perfect line

- Notice sharp peak in voting space
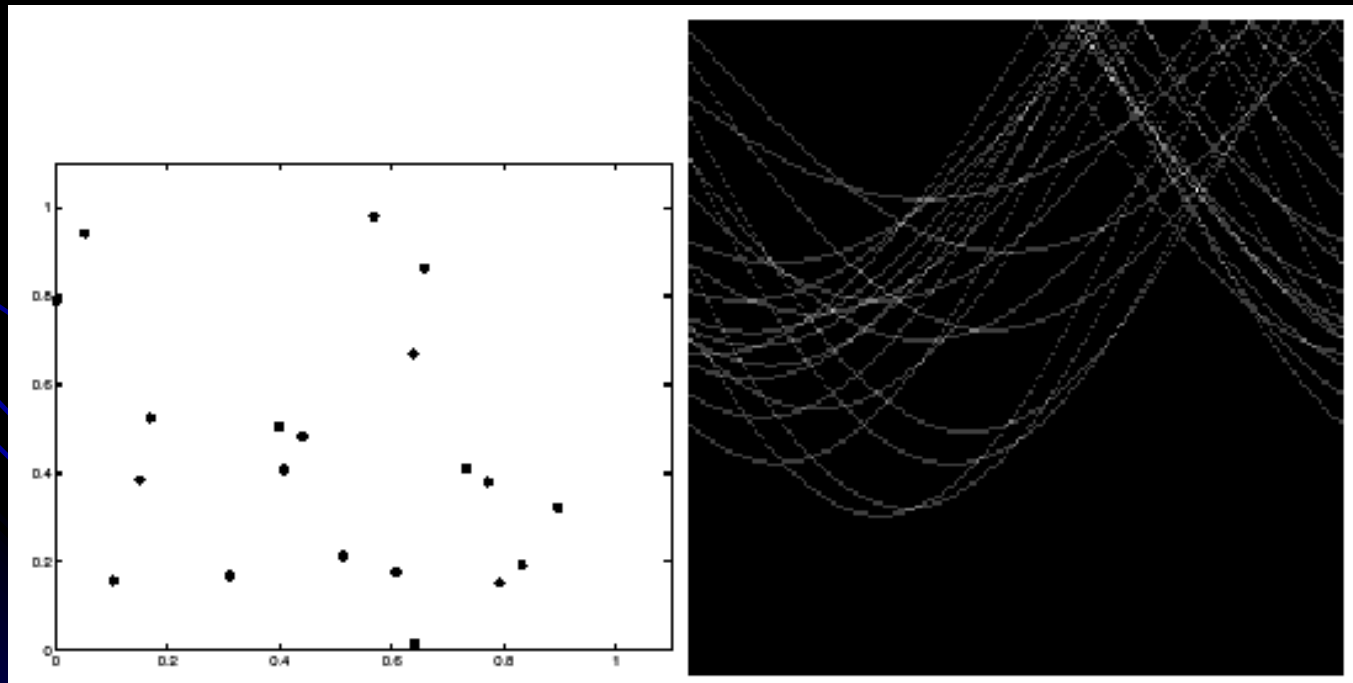- (next 3 images from Forsyth and Ponce, ch 15)

Approximate line

- Notice the broader peak. Can we detect it?
- Could use a coarser quantization?
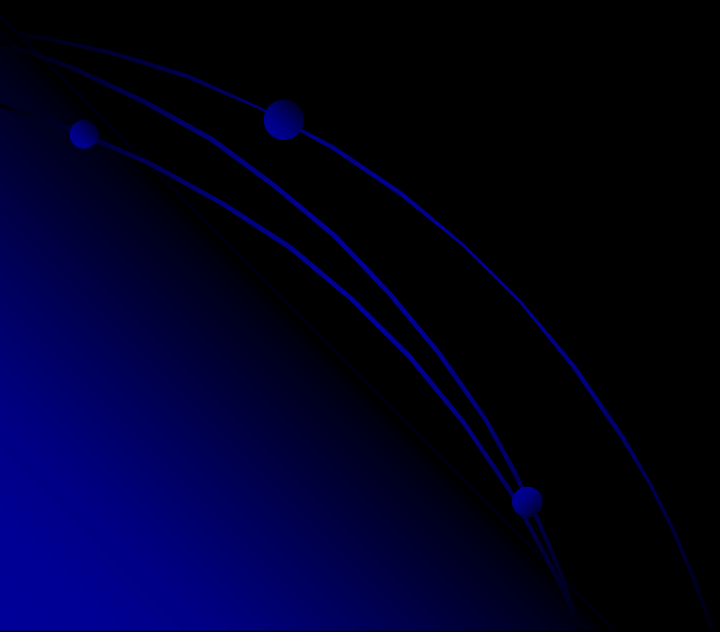- Accumulator array: bin size? Range?

Random noise

- Votes spead all over the place: no line
- Too much noise creates "phantom lines"
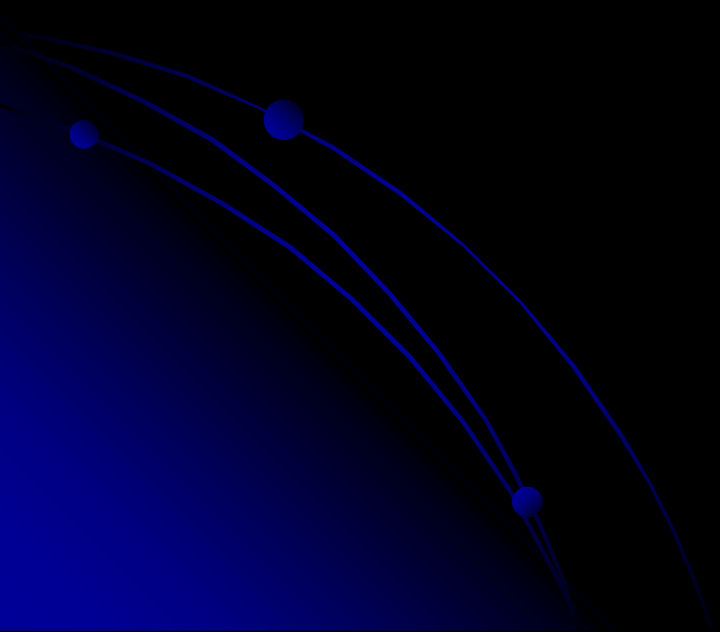 - Smoothing can help

Limitations

- Finding the right grid size in parameter space may be tricky
  - Trial and error

Matlab

- Run an edge detector first to find points that are voting

- [H, theta, rho] = hough(edgeImg);

- peaks = houghpeaks(H,nPeaks);

Generalizations

- Finding circles with fixed radius…
- Finding circles with arbitrary radius…
- Finding line segments
- Finding arbitrary shapes…
  - Ballard, Dana. 1981. Generalizing the Hough transform to detect arbitrary shapes. *Pattern Recognition*, 13(2):111-122.
  - Dana was a long-time member of Rochester's computer vision group.

My Circle Finder

- Demo

- Wouldn't this be a great lab?
  - Like Matlab's hough and houghpeaks (for lines), but from scratch
  - Easier would be to find circles of fixed radius
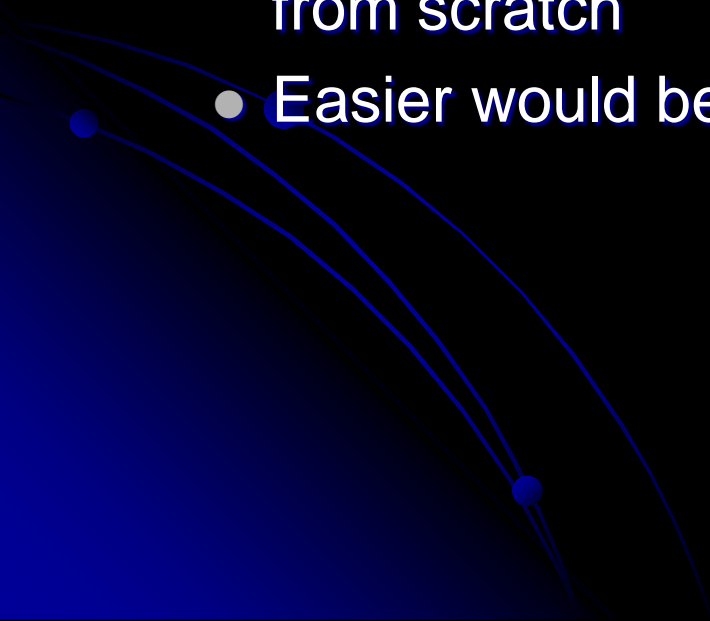
Reducing the number of votes

- Use the edge gradient information as well
    - Only need to cast votes for centers along the gradient
- Use partial curves. If you had a way of grouping relating points, you could use curvature.