EECS101 Discussion 5

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Binary SGM Image

- Compute the SGM image
  - $\text{SGM} = \left(\frac{\partial E}{\partial x}\right)^2 + \left(\frac{\partial E}{\partial y}\right)^2$
- Use a threshold to isolate edges in the SGM image
- Edge Map E(x,y)

Hough Transform

- Equation of line

  $x\sin(\theta) - y\cos(\theta) + \rho = 0,\ x, y \in R$

  $y = [\sin(\theta)/\cos(\theta)]x + \rho/\cos(\theta)$

- Hough transform for line

  $x\sin(\theta) - y\cos(\theta) + \rho = 0, \theta \in [0, \pi), \rho \in R$

  $\rho = -x\sin(\theta) + y\cos(\theta)$

- Pixels on the edges satisfy the equation. In other words, given (x,y), use the equation to solve for (θ, ρ)

Hough Transform

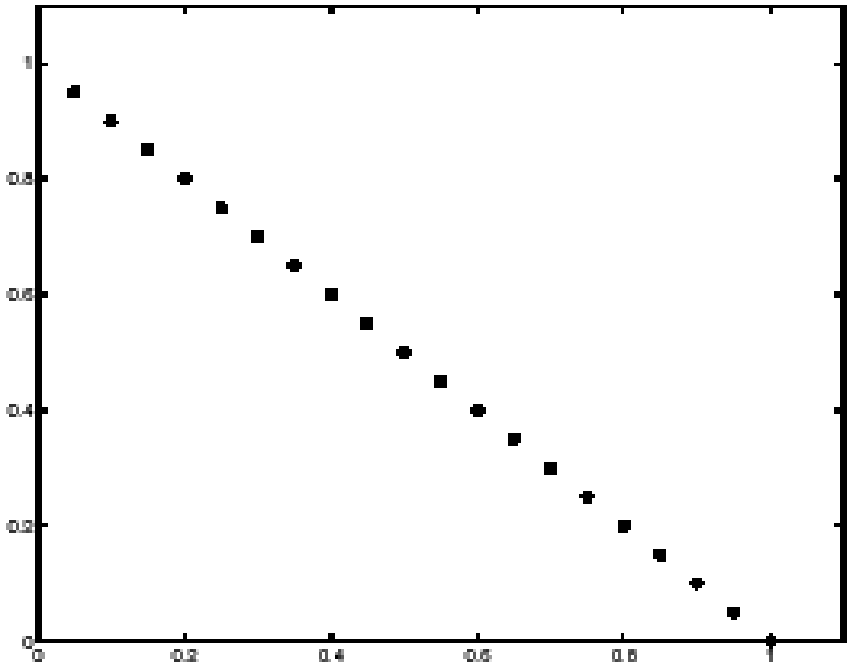
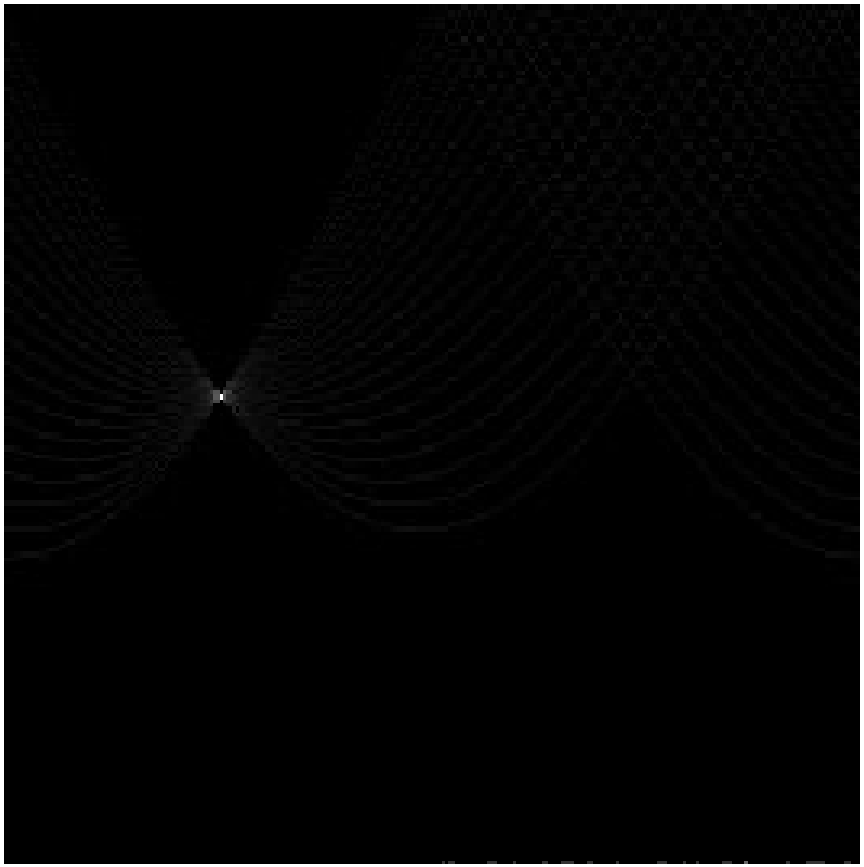


Image space



Votes

Horizontal axis is θ, vertical is ρ.

Credit: S. Narasimhan with CMU

Hough Transform

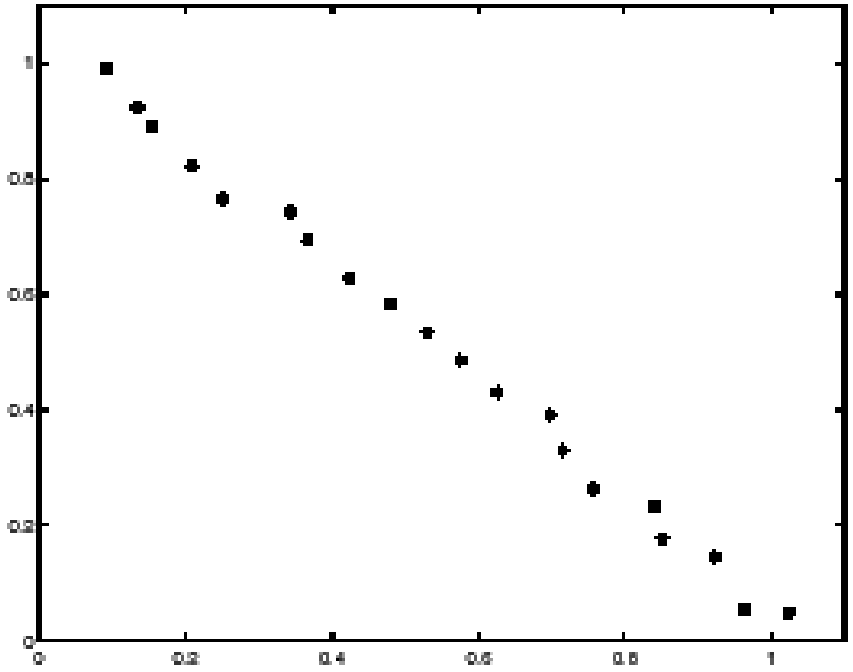
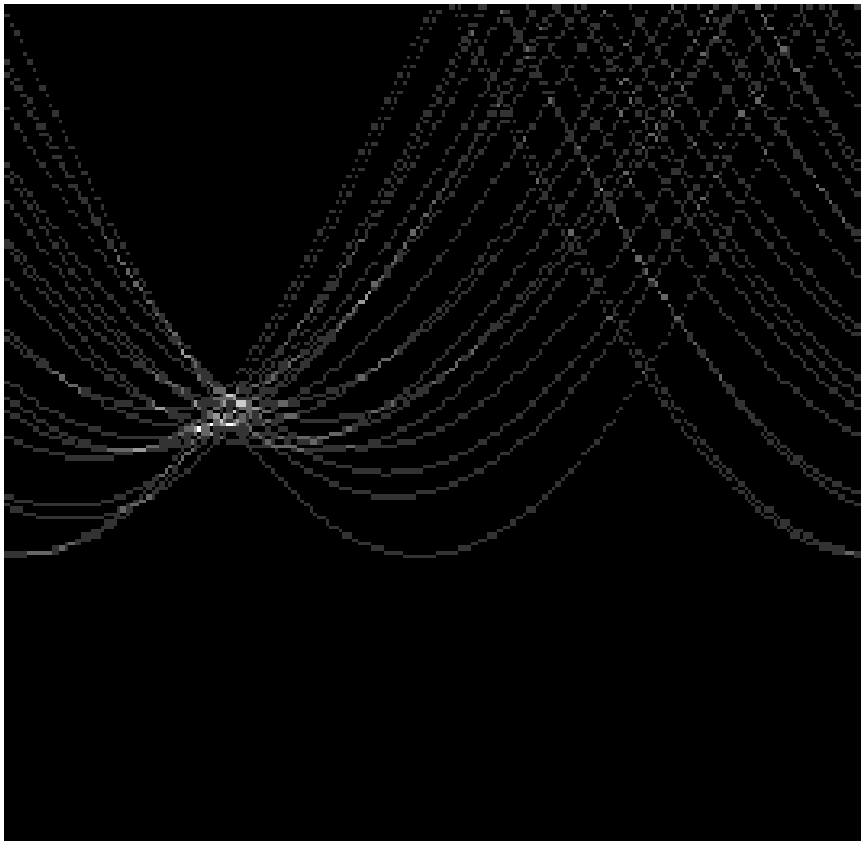


Image space



Votes

Credit: S. Narasimhan with CMU

Hough Transform

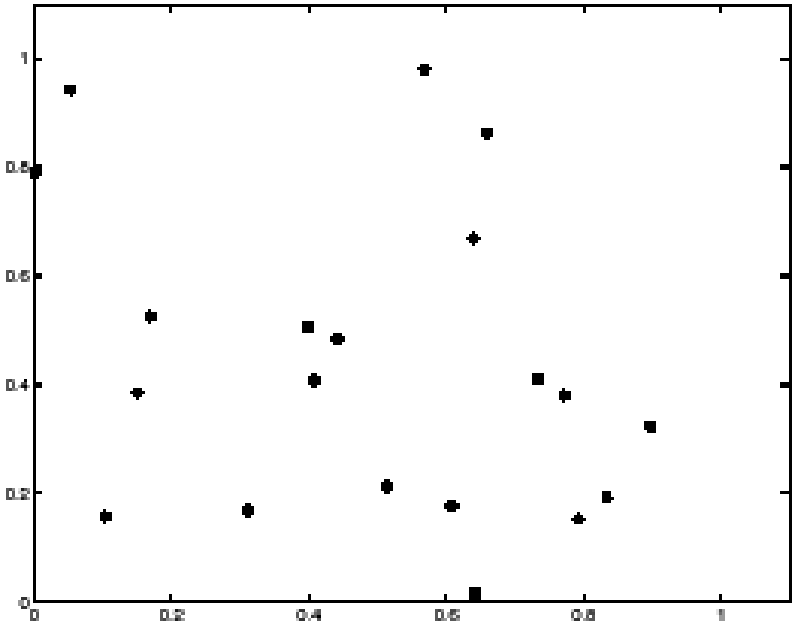
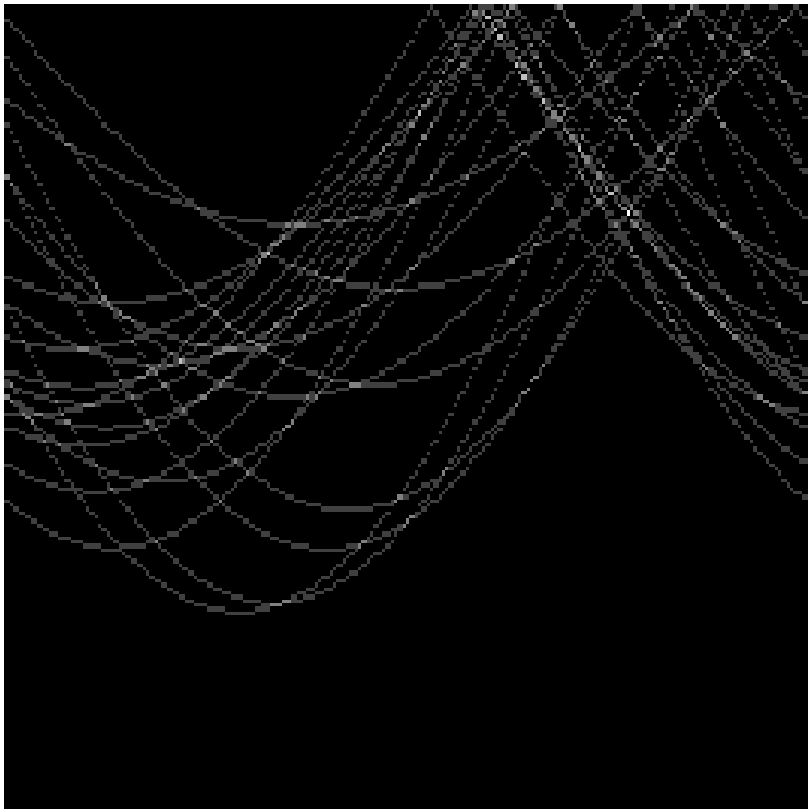


Image space



Votes

Suggestions and hints

$$xsin(\theta) - ycos(\theta) + \rho = 0, \theta \in [0, \pi), \rho \in R$$
$$\rho = -xsin(\theta) + ycos(\theta)$$

- Quantize (ρ, θ) parameter
  - θ: [0, 180), step=1 or smaller
  - ρ: based on image size
  - ρ might be negative, how to use it as index?
    - Rescale ρ to keep it positive,
    - $\rho' = a\rho + b,\ s.t. \rho' \geq 0$

Suggestions and hints

$$xsin(\theta) - ycos(\theta) + \rho = 0, \theta \in [0, \pi), \rho \in R$$
$$\rho = -xsin(\theta) + ycos(\theta)$$

- Radians and Degrees
  - Trigonometric Functions provided with <math.h> in C
  - The measurement of C is Radians
  - 180° is equal π rad.
  - $\cos\left(60 \times \left(\frac{pi}{180}\right)\right) = \frac{1}{2}$

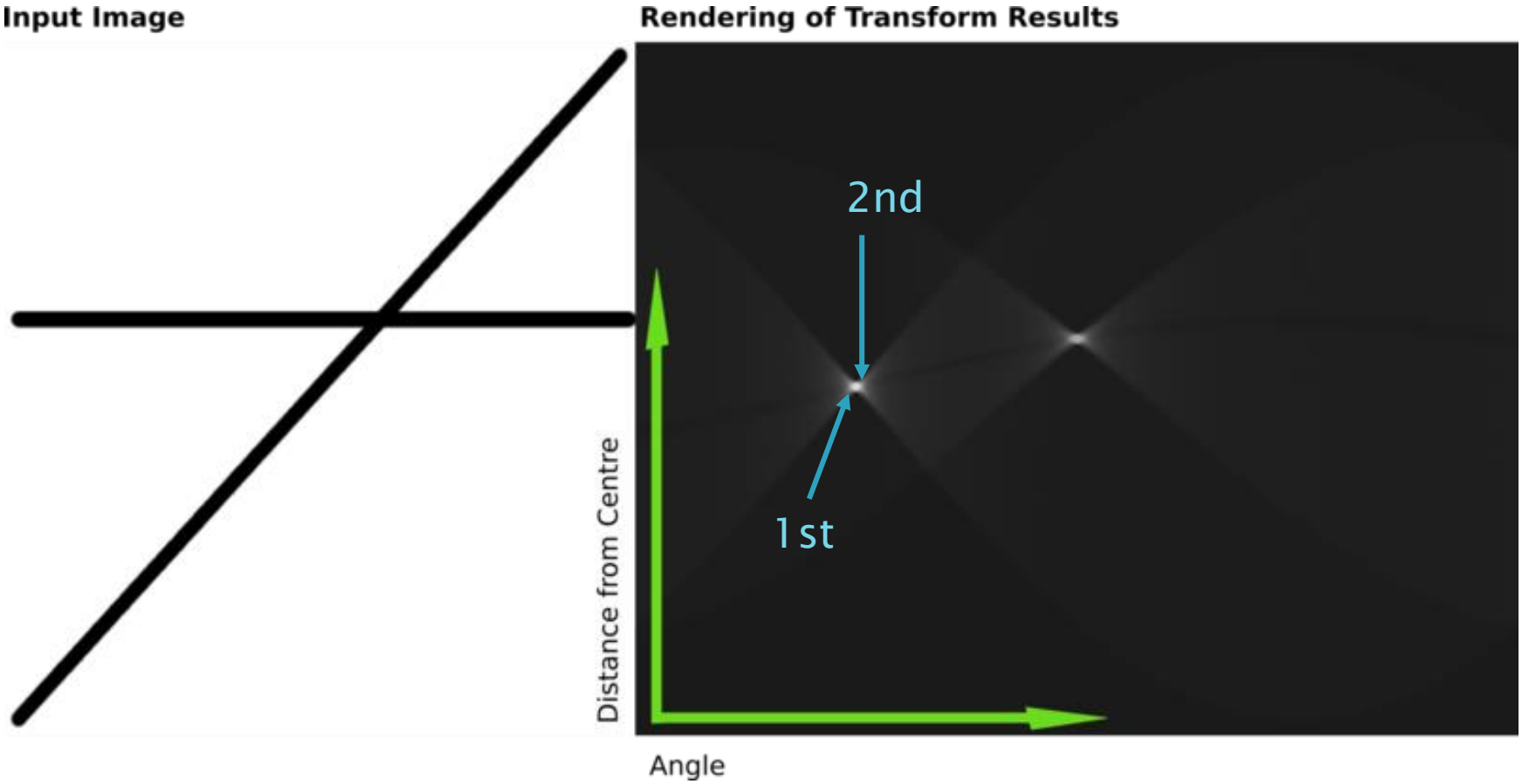
Suggestions and hints

- Initialize accumulate function A(ρ, θ) to zero for each bucket in (ρ, θ) space
- For each edge pixel in the edge map, compute ρ, θ corresponding to the edge from its position & direction. Set A(ρ, θ) = A(ρ, θ) + 1 for computed (ρ, θ)

Reconstruct an Image from the Voting Array

- Find local maxima in A(θ, ρ) corresponding to detected lines in image
  - The voting array is noisy because of small numbers. Use threshold to eliminate noise.
  - Find 3 local maxima corresponding to 3 lines.
    - hough_threshold = min{3 local maxima}

Hough Transform



How to avoid that the most two bright pixels indicate the same line?

Think about their distance

Reconstruct an Image from the Voting Array

- Reconstruction from the array
  - Three pairs of (θ, ρ)
  - Draw three lines using the line equation.

$$x\sin(\theta) - y\cos(\theta) + \rho = 0, \qquad x, y \in R$$

  - Given (θ, ρ), find out all the (x,y) that satisfy the equation and assign them value 255.
  - Remember you have rescaled ρ, transfer it back.

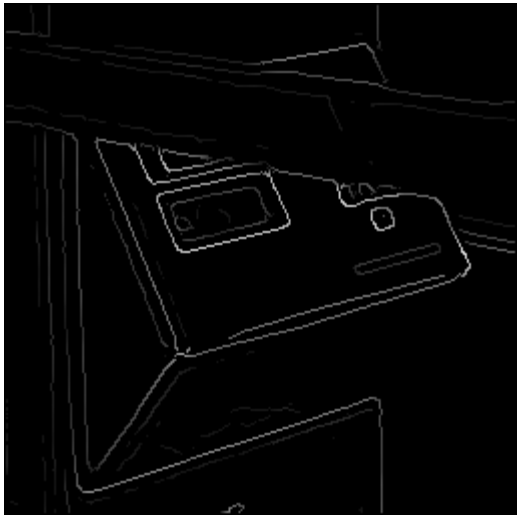
Suggestions and hints

- Assume that the (x, y) coordinate system origin is at the bottom left corner of the image where x increases going to the right and y increases going up.
- The index matrix never change.

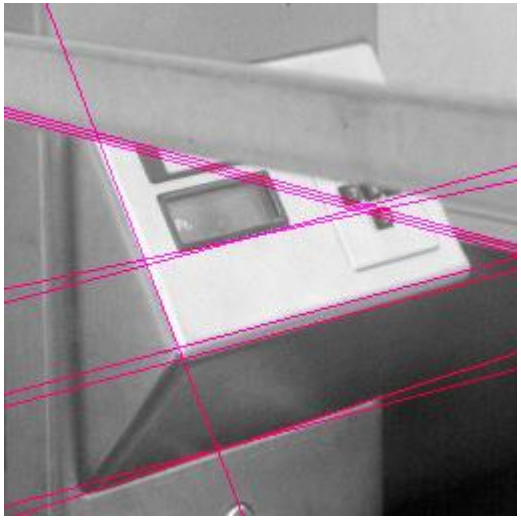
```
for (i = end of i; i > 0; i--)
      for ( j = 1; j < end of j; j++)
```

Hough Transform

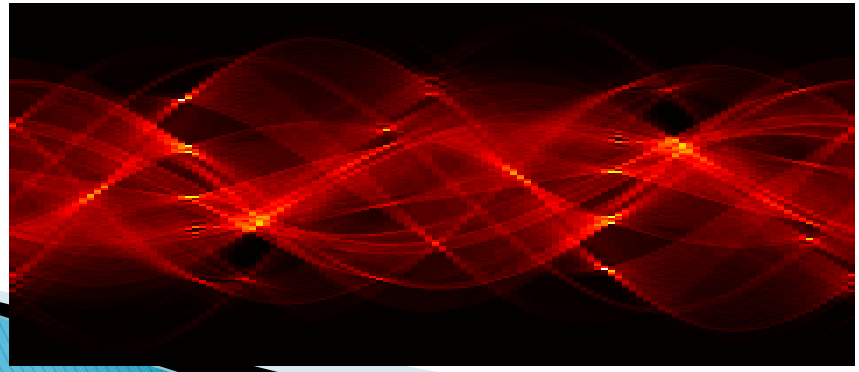
Original



Edge Detection



Found Lines



Votes

Suggestions and hints

- The workload of HW5 is heavy! Start your assignment as Earlier as possible.

Submission Guideline

4 images will be generated

- image-sgm.ras: SGM to original image
- image-binary.ras: Threshold SGM to original image
- image-voting_array.ras: Voting array, there should be lots of curves in the image.
- image-reconstructed_image.ras: Reconstructed image, there should be 3 lines.

Submission Guideline

- Demo:
  - 1. Show your working directory without any .ras files.
  - 2. Compile and run your program.
  - 3. Show the same working directory in step 1 with newly generated ras files.
  - 4. Display the images including SGM, binary, normalized voting array and reconstructed image and comments.

- Submit your program and write up to Canvas by Feb 27 midnight

Grading Criteria

- Total 100 points
  - 10 points for submitting a program
  - 20 points for demo
  - 22 points for the binary SGM image
  - 8 points for reporting each of the 3 pairs of (θ, ρ) and corresponding votes (totally 24 points)
  - 24 points for the reconstructed image