COL783: Digital Image Processing

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Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments (regions)

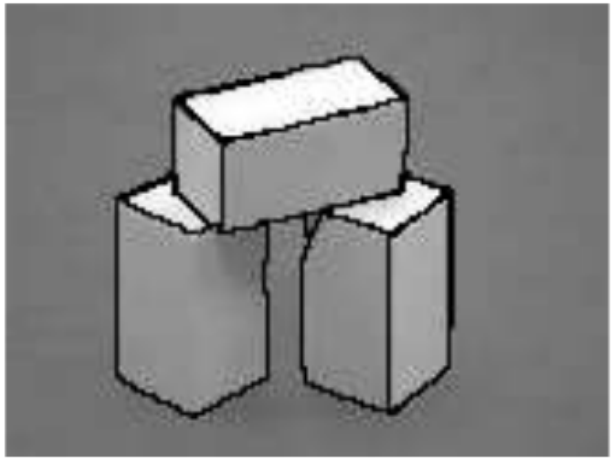


Image Segmentation

Edge Detection

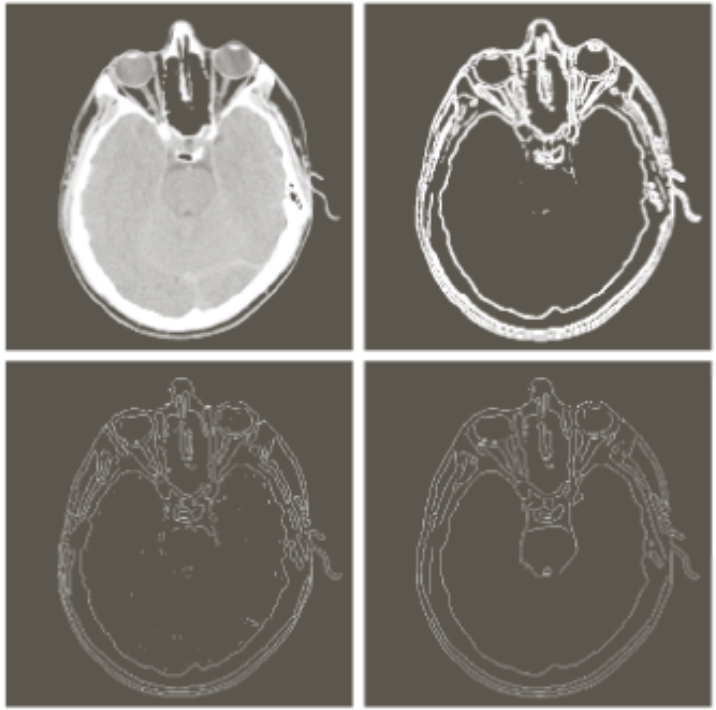


Image Segmentation

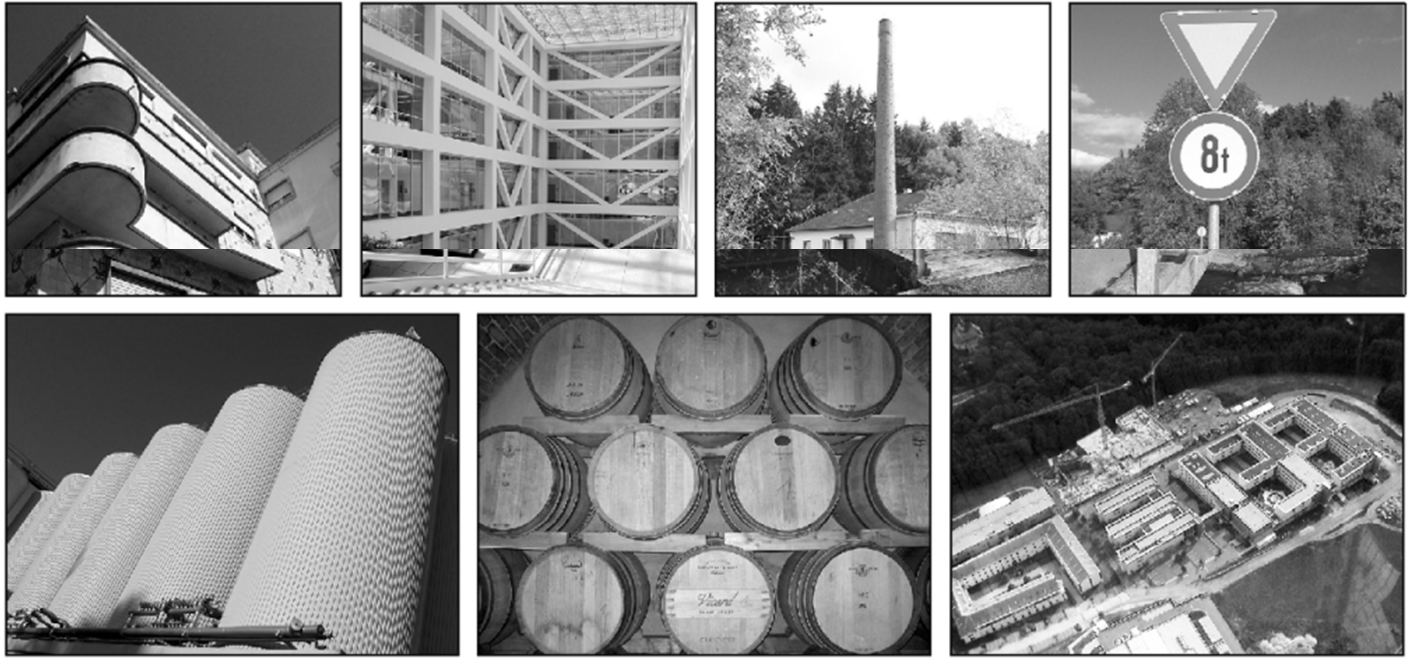
Hough Transform

Detection of simple geometric shapes:

Lines

Circles

Ellipses

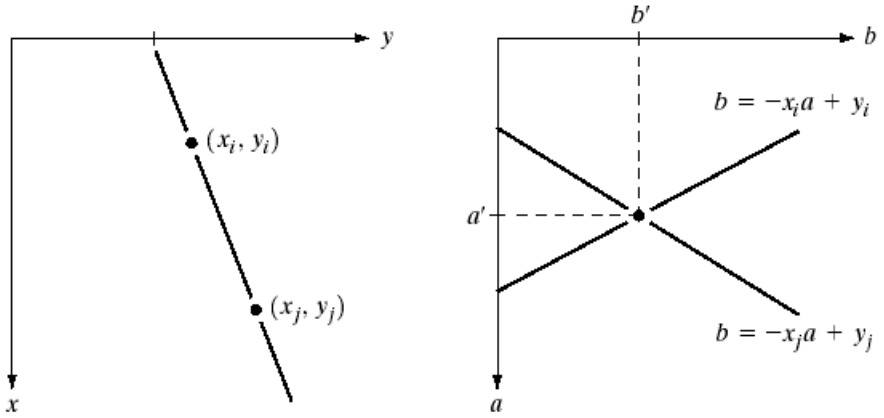


Source: https://web.cs.wpi.edu/~emmanuel/courses/cs545/S14/slides/lecture06.pdf

Image Segmentation

Hough Transform

Lines



a b

FIGURE 10.17 (a) xy-plane. (b) Parameter space.

Image Segmentation

Hough Transform

Lines

FIGURE 10.18 Subdivision of the parameter plane for use in the Hough transform.

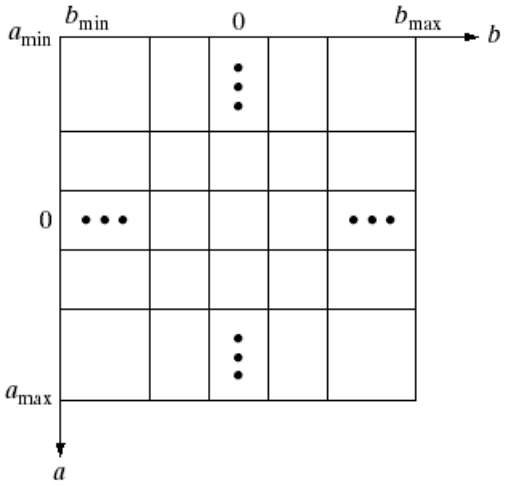
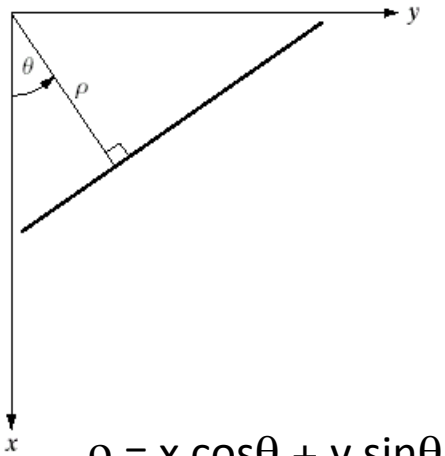


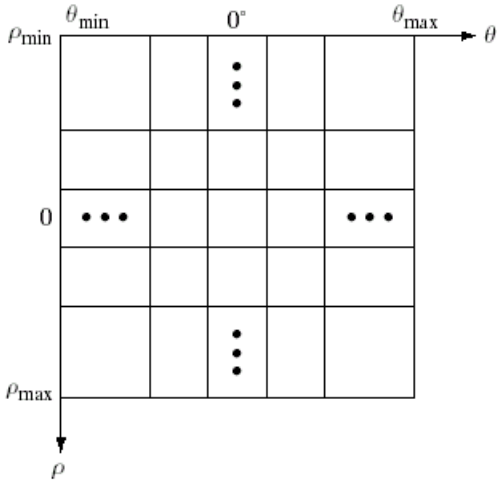
Image Segmentation

Hough Transform

Lines



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



a b

FIGURE 10.19 (a) Normal representation of a line. (b) Subdivision of the $\rho\theta$-plane into cells.

Image Segmentation

Hough Transform

Lines

Apply edge operator to image f(x,y), and compute gradient magnitude M(x,y) at each pixel.

Build the accumulator array A:

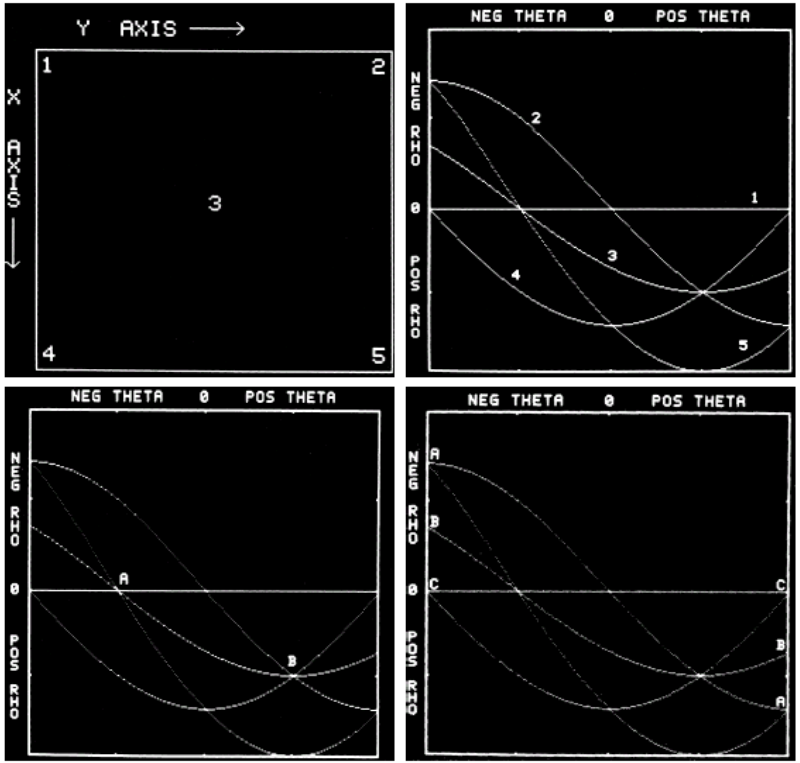
```
for each edge pixel M(x,y)
    if ( M(x,y) > threshold )
      for each quantized value of θ
          compute: ρ = x cosθ + y sinθ

          increment: A[ρ][θ]++
```

Search accumulator array for maxima, corresponding to lines in the image.

Image Segmentation

Hough Transform

Lines



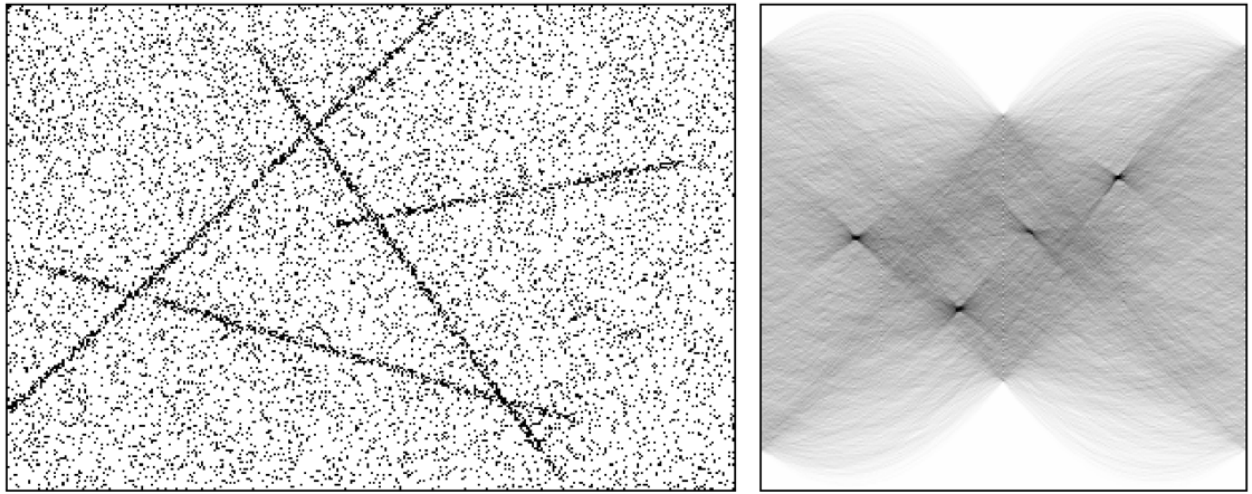
a b
c d

FIGURE 10.20 Illustration of the Hough transform. (Courtesy of Mr. D. R. Cate, Texas Instruments, Inc.)

Image Segmentation

Hough Transform

Lines



(a) (b)

Source: https://web.cs.wpi.edu/~emmanuel/courses/cs545/S14/slides/lecture06.pdf

Image Segmentation

Hough Transform

Circles

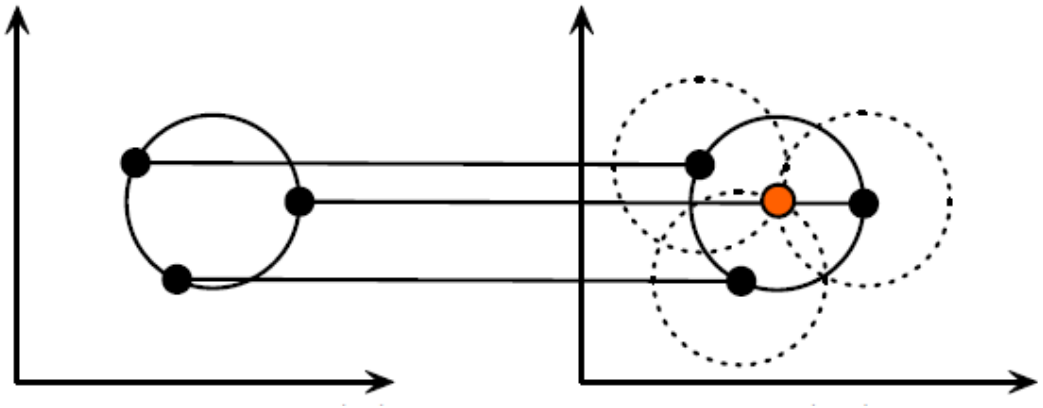


Image Segmentation

Hough Transform

Circles

Apply edge operator to image f(x,y), and compute gradient magnitude M(x,y) at each pixel.

Build the accumulator array A:

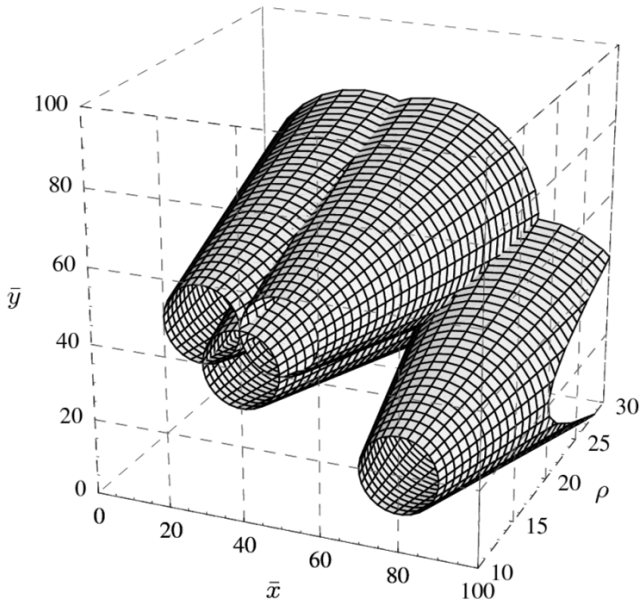
```
for each edge pixel M(x,y)
    if ( M(x,y) > threshold )
      for each quantized value of θ
         compute: xc = x – R * cosθ
                  yc = y – R * sinθ
         increment: A[xc][yc]++
```

Search accumulator array for maxima, corresponding to circle centers in the image.

Image Segmentation

Hough Transform

Circles



3D parameter space:
$\bar{x}, \bar{y} = 0 \ldots 100$
$\rho = 10 \ldots 30$

Image points $\boldsymbol{p}_k$:
$\boldsymbol{p}_1 = (30, 50)$
$\boldsymbol{p}_2 = (50, 50)$
$\boldsymbol{p}_3 = (40, 40)$
$\boldsymbol{p}_4 = (80, 20)$

Source: https://web.cs.wpi.edu/~emmanuel/courses/cs545/S14/slides/lecture06.pdf

Image Segmentation

Hough Transform

Circles

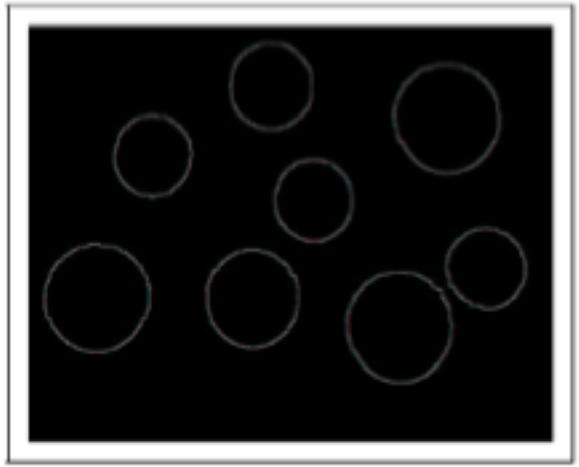
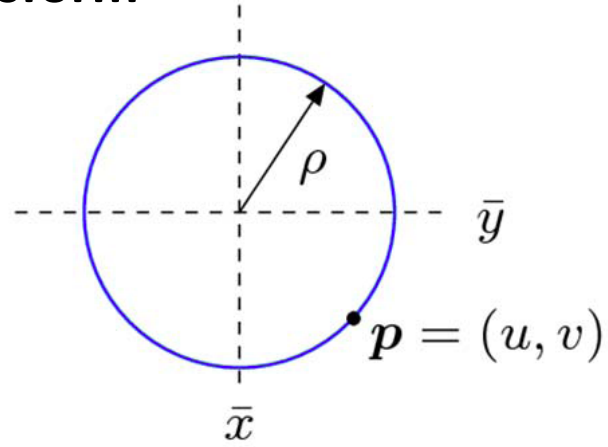
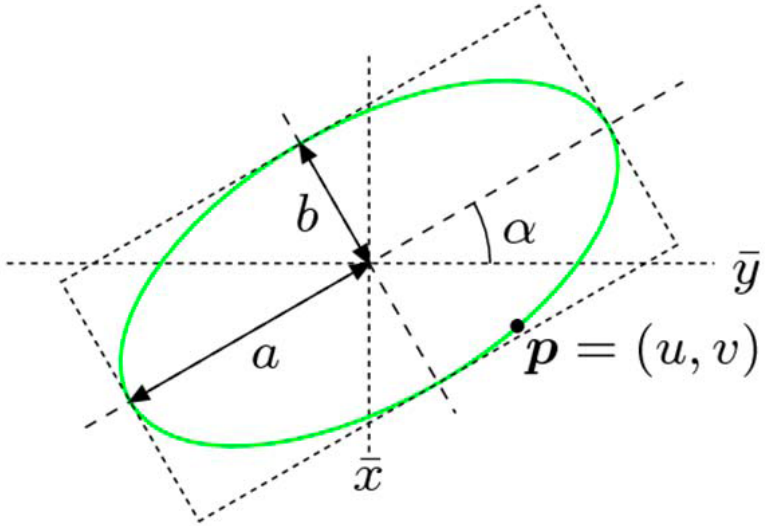


Image Segmentation

Hough Transform

Ellipses





- Ellipse requires 5 parameters

where $(\bar{x}, \bar{y})$ are coordinates of center, (r_a, r_b) are 2 radii and α is orientation of principal axis

Image Segmentation

Generalized Hough Transform (GHT)