EMORY
UNIVERSITY
SCHOOL OF
MEDICINE

Department of
Biomedical Informatics

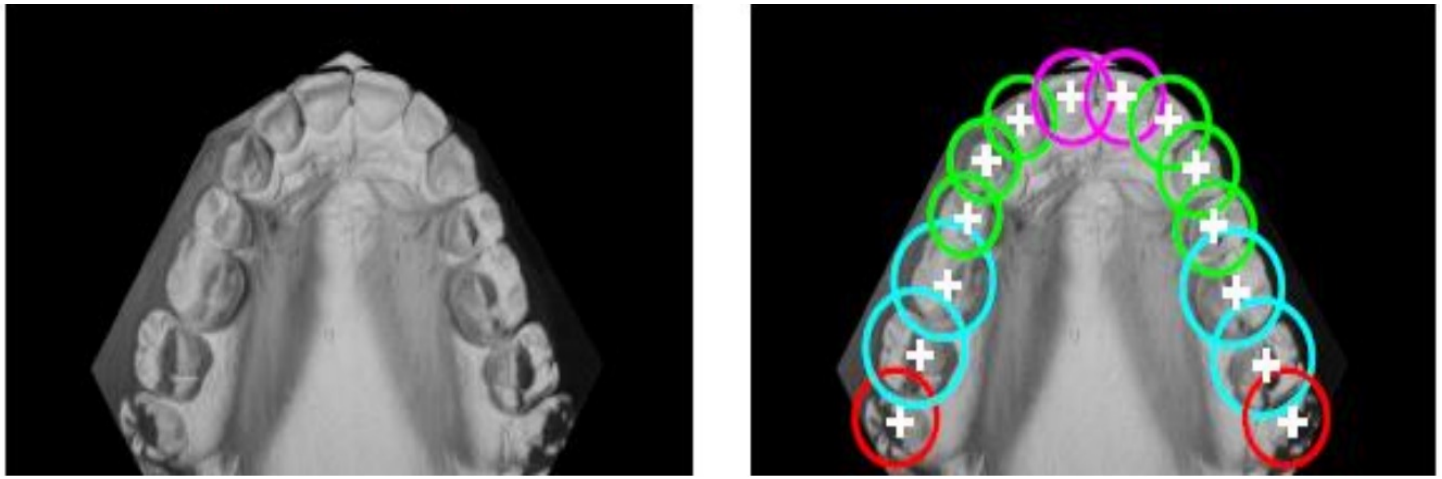
Alphanumerics Lab Meeting

Hough Transform

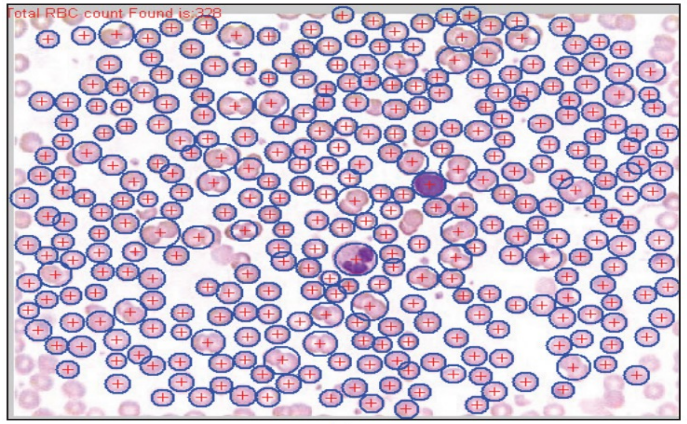
Seyedeh Somayyeh Mousavi

November 11th, 2022

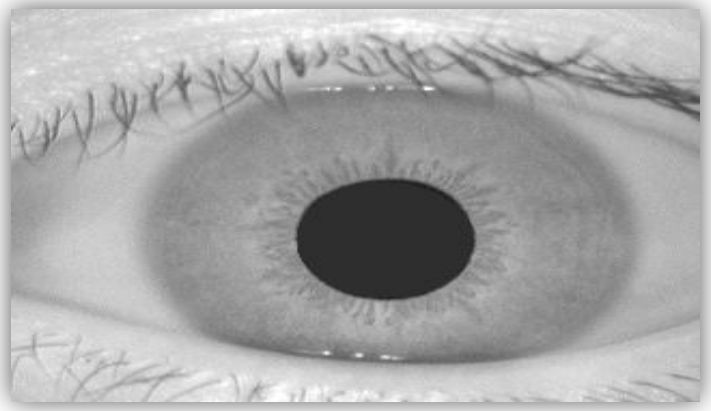
Application of Hough Transform



The Orthodontic Plaster Cast Image Segmentation



Automatic red blood cell counting



Eye Tracking

Automatic segmentation of cervical soft tissue from MR images

Hough Transform	Seyedeh Somayyeh Mousavi	11/11/2022

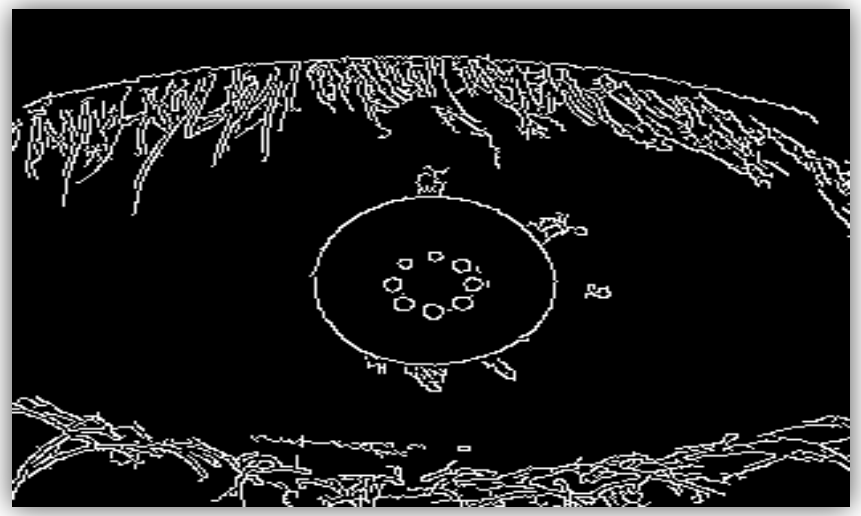
Overview

- Introduction
- Hough Line Transform
- Hough Circle Transform
- Example

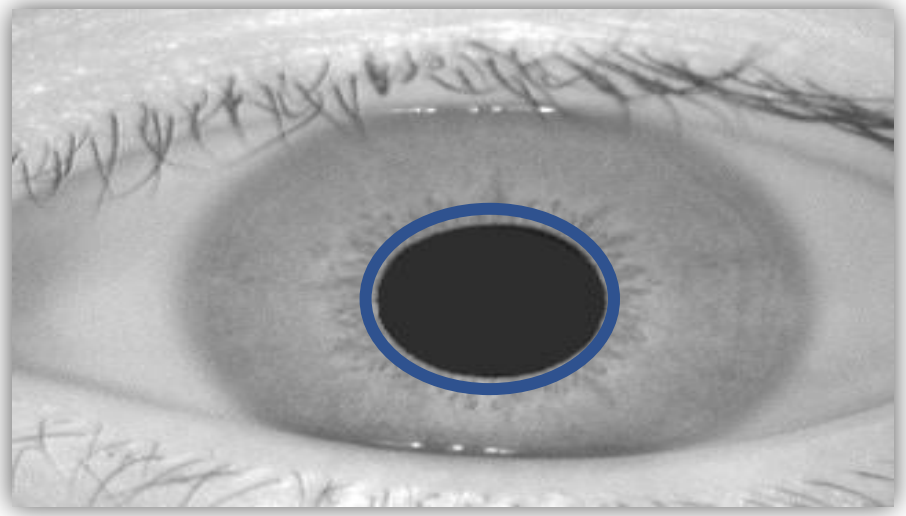
Introduction

Edges vs Boundaries

Edges
– Local intensity discontinuities
– Points
– Not dependent on models



Boundaries
– Extensive
– Composed of many points
– May be dependent on models

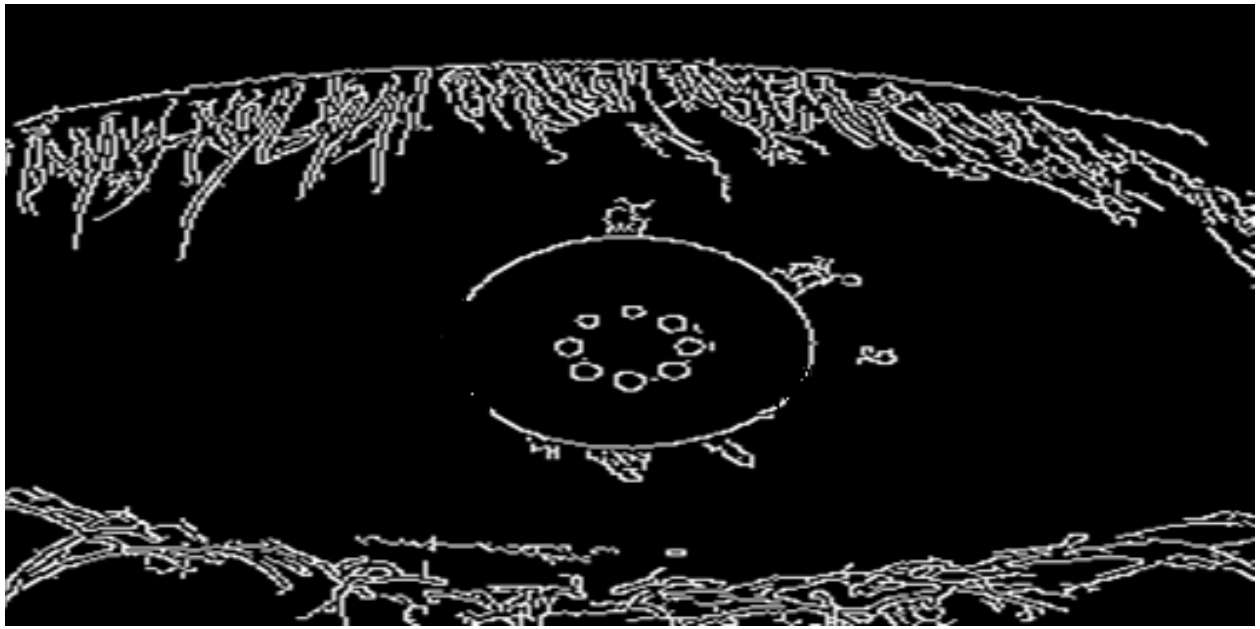


Adjusted from Prof. William Hoff slide

Introduction

Difficulties of Fitting Approaches

1. Extraneous data
2. Noise
3. Incomplete data

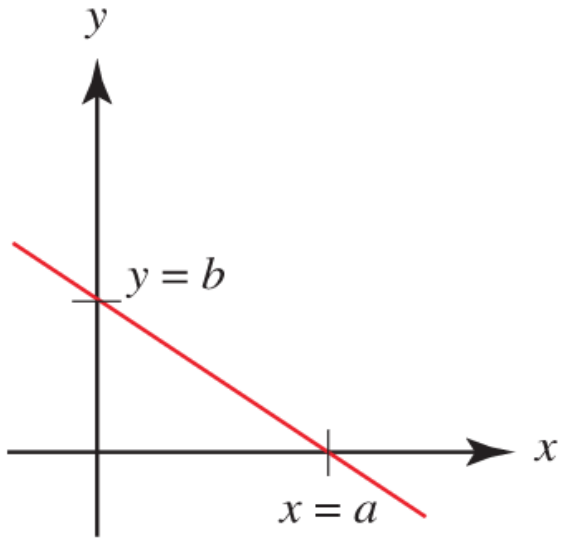


Solution: Hough Transform Function

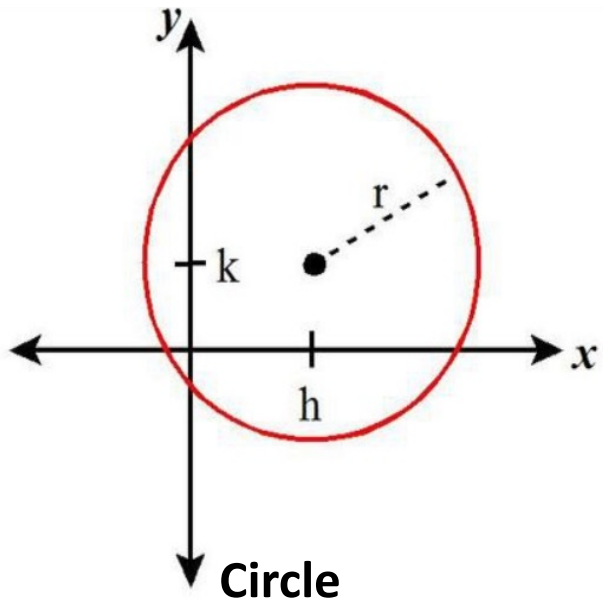
Introduction

Equation: $y = mx + c$ $(x-h)^2+(y-k)^2=r^2$ $1 = \frac{x^2}{a^2} + \frac{y^2}{b^2}$

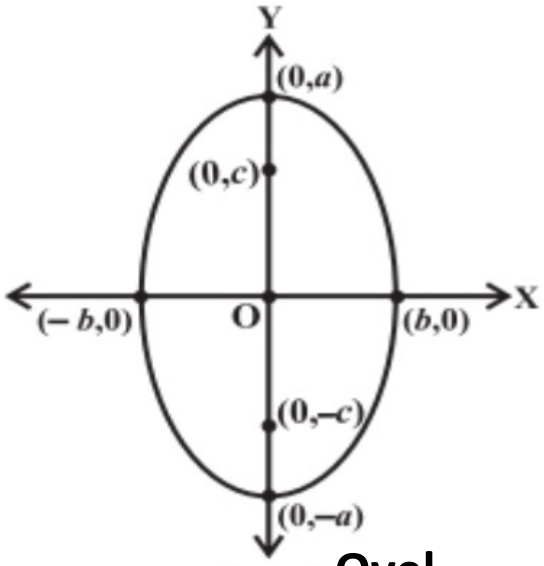
Parameters: m, c h, k, r a, b



Straight line



Circle

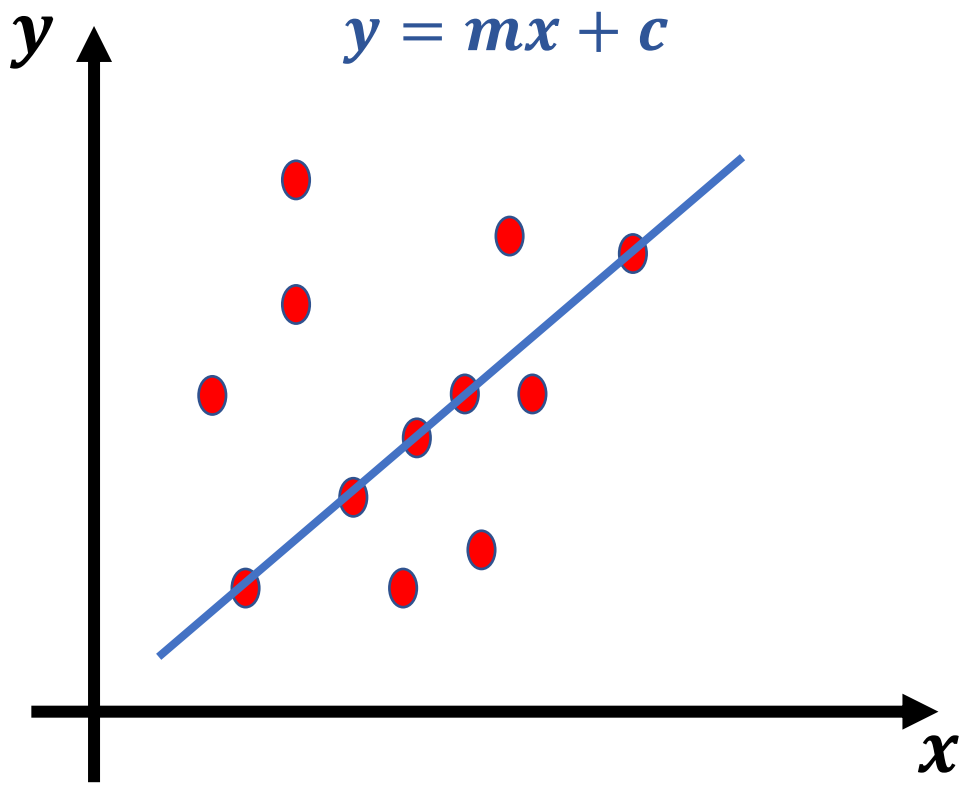


Ovel

Hough Line Transform

Edge points: (x_i, y_i)

$$y = mx + c$$

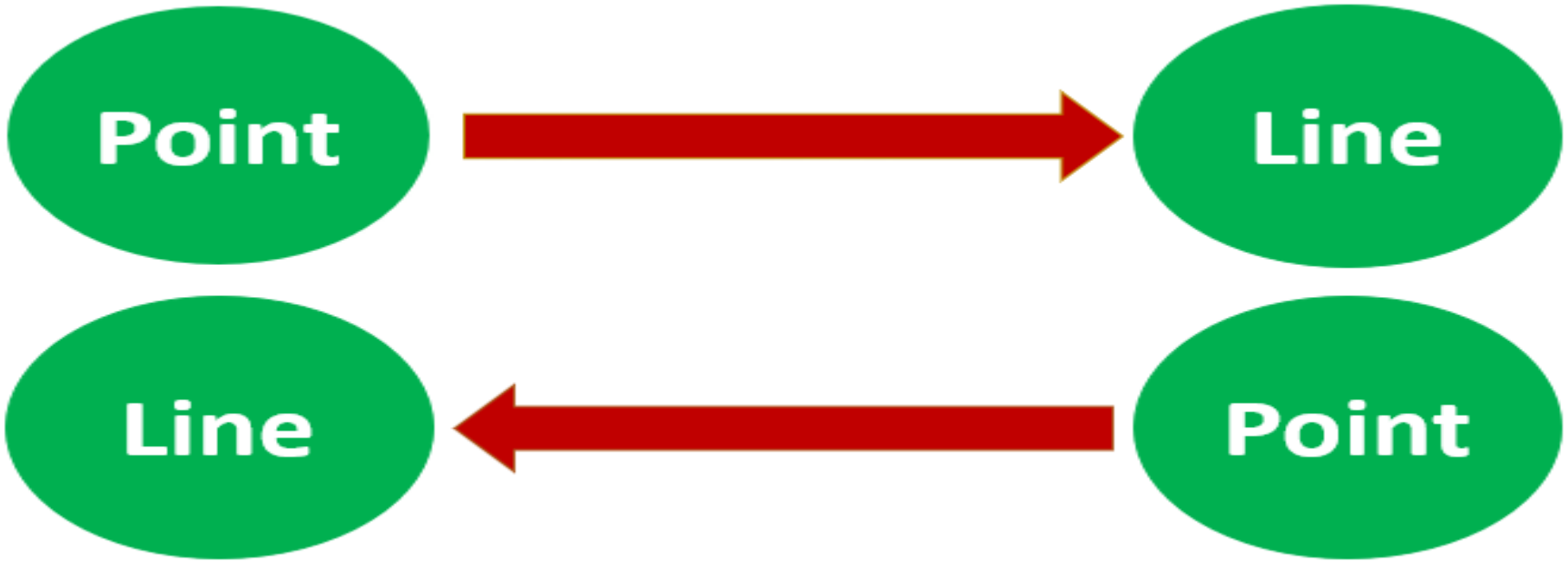


Consider a point on the line (x_i, y_i)

$$y_i = mx_i + c$$

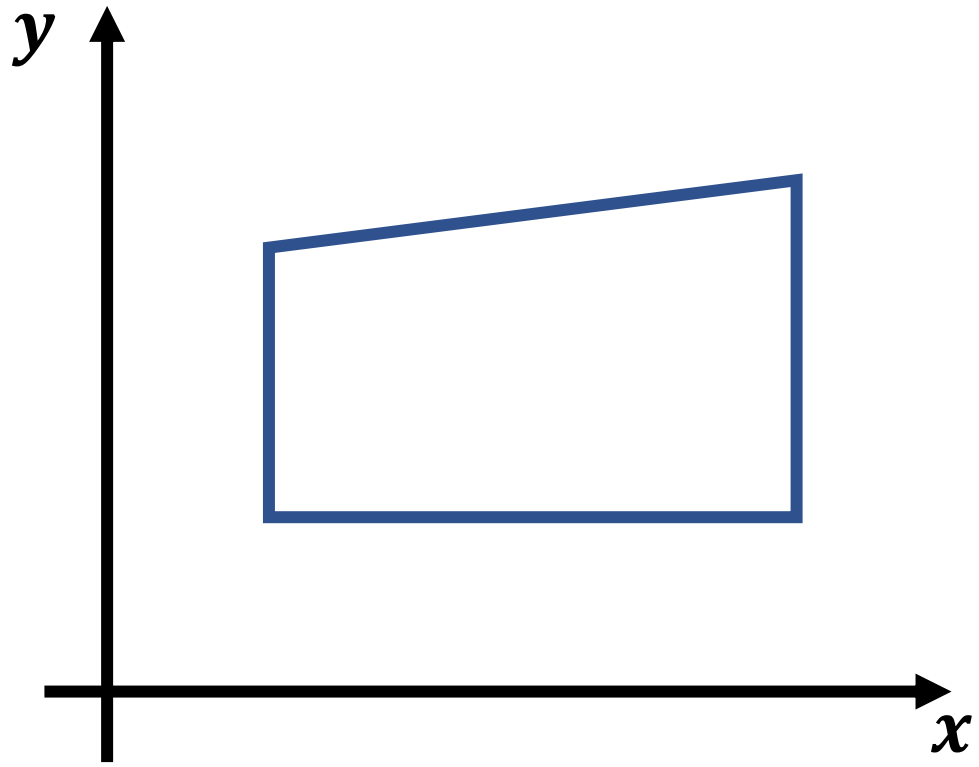
$$c = -mx_i + y_i$$

Hough Line Transform

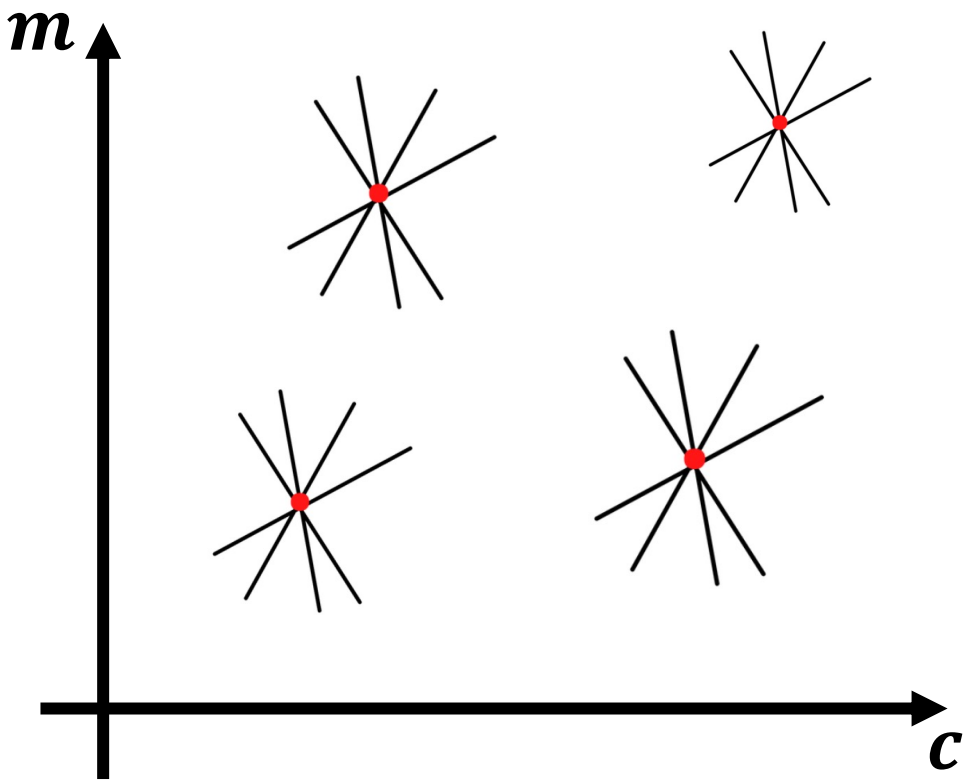


Hough Line Transform

Image Space

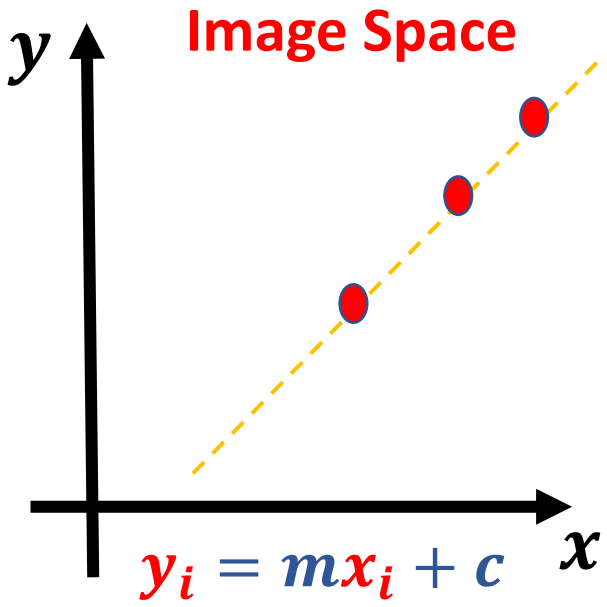


Parameter Space

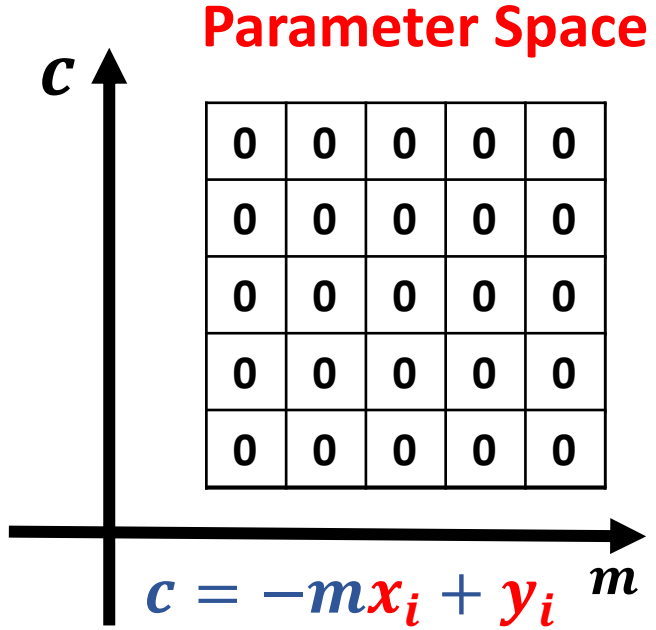


Adjusted from Prof. T. C. Change slide

Hough Line Transform



1. Quantize parameter space *(m,c)*
2. Create accumulator array *A(m,c)*
3. Set *A(m,c)* = 0 for all *(m,c)*
4. For each point on image space
   A(m,c) = *A(m,c)* + 1
   If *(m,c)* lies on the line :
   C= -mx+y
5. Find the local maximum



0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

1	0	0	0	0
0	1	0	0	0
0	0	1	0	0
0	0	0	1	0
0	0	0	0	1

1	0	0	0	1
0	1	0	1	0
0	0	2	0	0
0	1	0	1	0
1	0	0	0	1

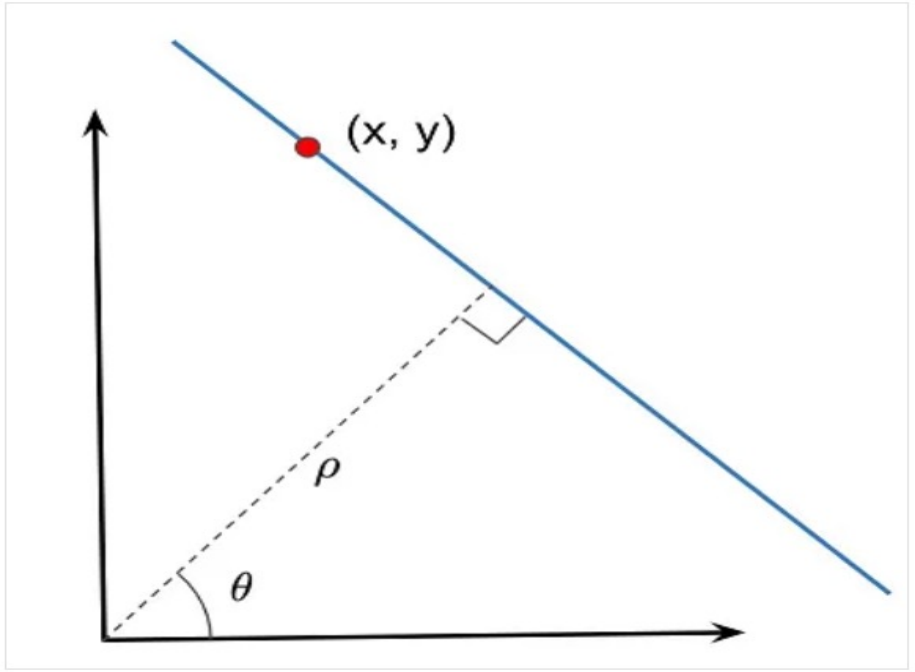
1	0	0	0	1
0	1	0	1	0
1	1	3	1	1
0	1	0	1	0
1	0	0	0	1

Adjusted from Prof. T. C. Change Slide

Hough Line Transform

$$y_i = mx_i + c \qquad c = -mx_i + y_i$$

Problems: We need a large memory and a lot of computation due to slope of line



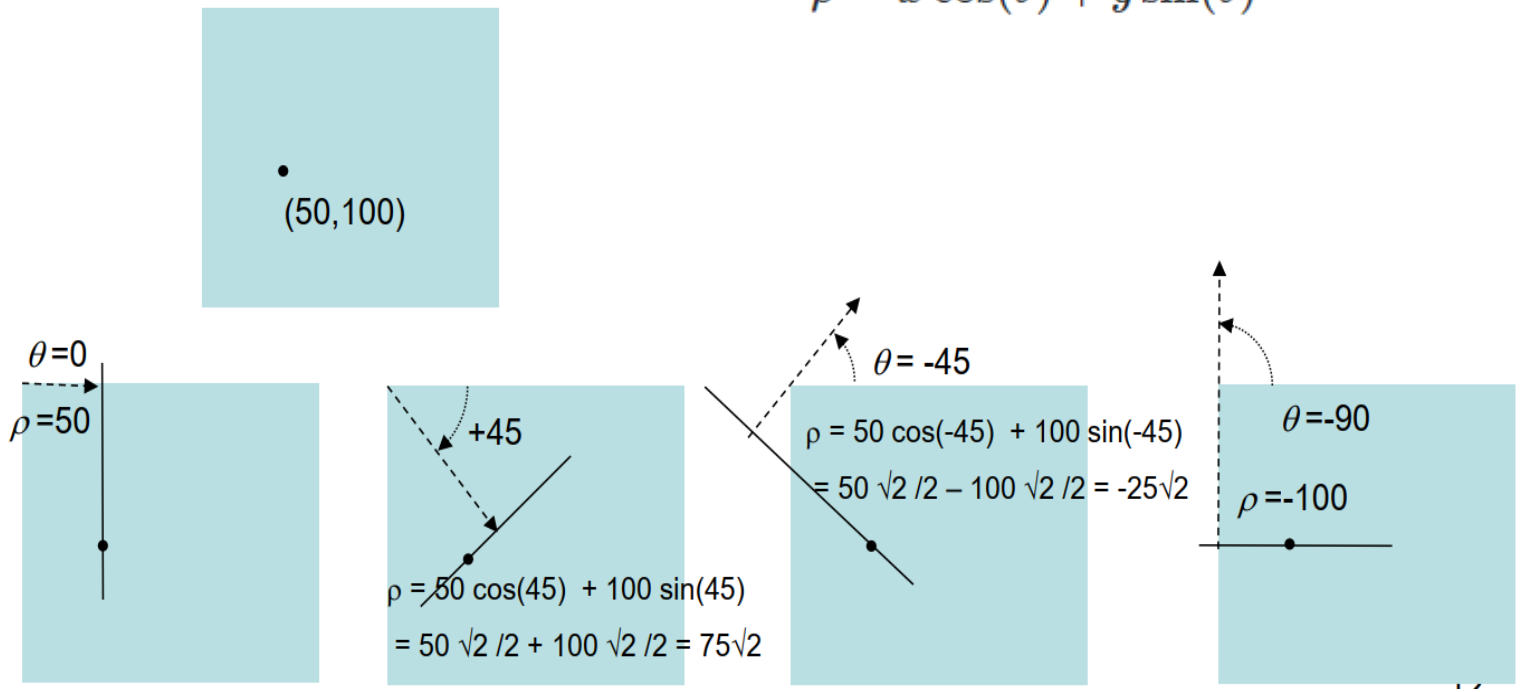
Polar Coordinates

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

Hough Line Transform

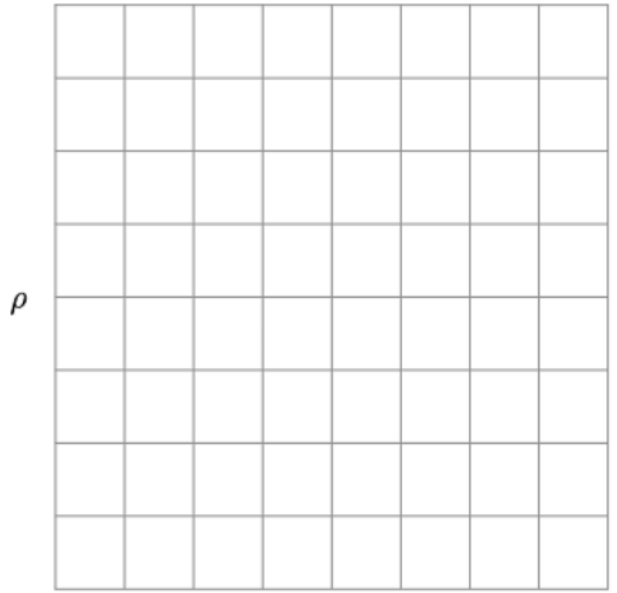
Consider a point at (x,y) = (50,100)

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



Angle, axis conventions

- angle range is -90°..+89°
- rho range is –dmax..+dmax
  - dmax is the largest possible distance

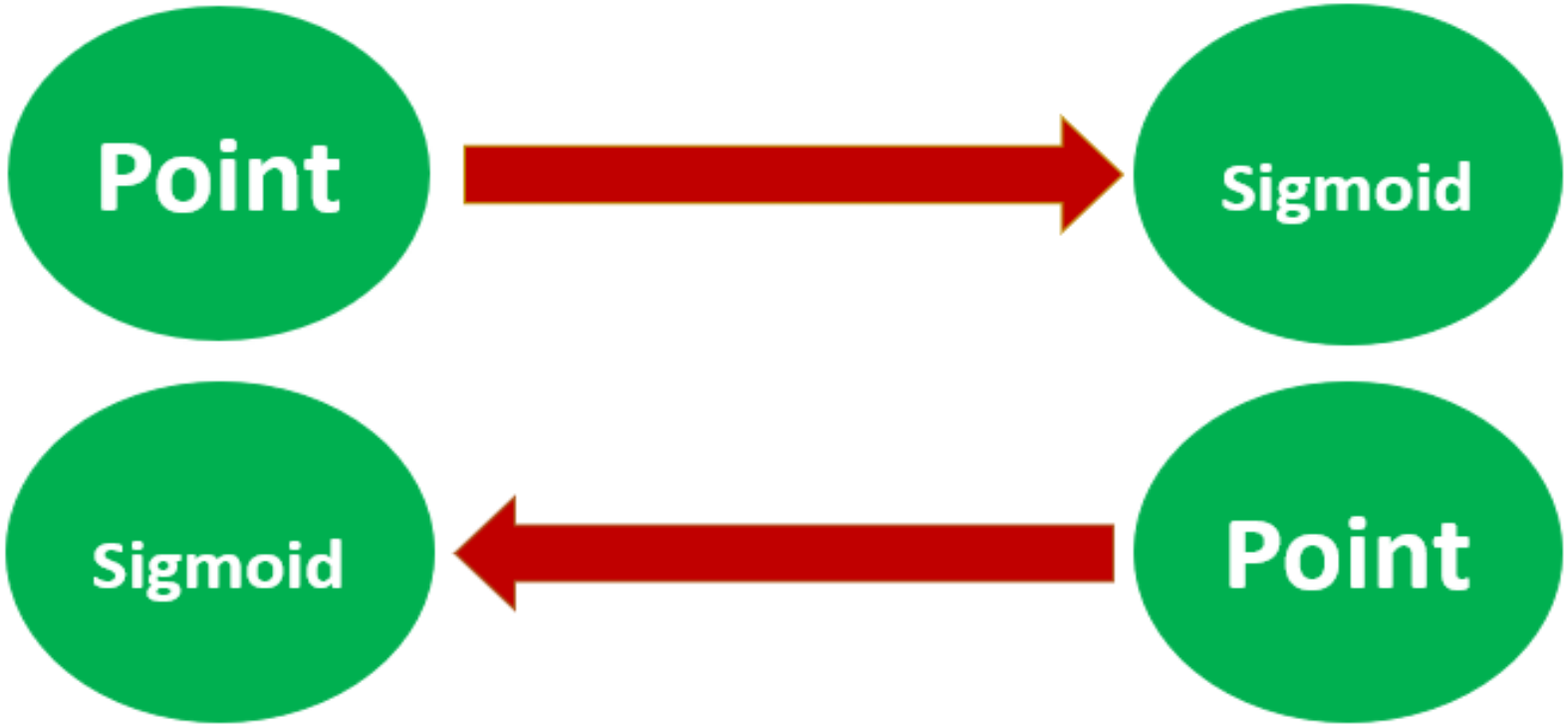


Adjusted from Prof. William Hoff slide

Hough Line Transform

Image Space

Parameter Space



Adjusted Straight Line Detection Through Sub-pixel Hough Transform paper

Hough Line Transform

MATLAB Hough Transform Function

- `[H, theta, rho] = hough(bw)`

Output Hough array, size NRho x NTheta

Vectors of theta and rho values

Input binary image of edge points

- `peaks = houghpeaks(H,numpeaks, …`
  `'Threshold',thresh, 'NHoodSize', [M N]);)`

Output array (row,col) of peaks (up to numpeaks)

The (rho, theta) values for the ith peak are

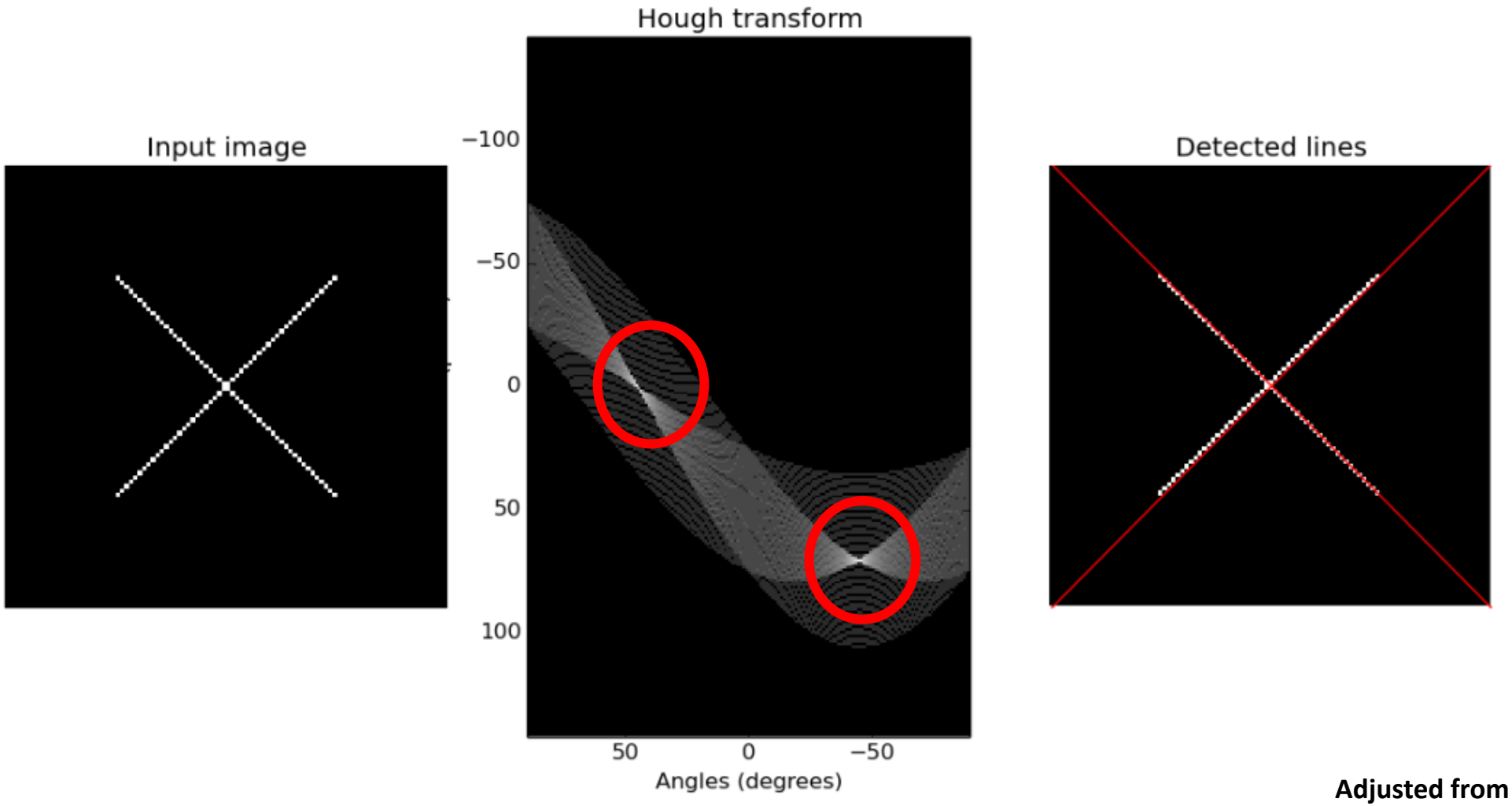
```
r = rho(peaks(i,1));
t = theta(peaks(i,2));
```

- `lines = houghlines(bw, theta, rho, peaks)`

Output structure array of lines. Each line has fields: (endpoint1, endpoint2, rho, theta)

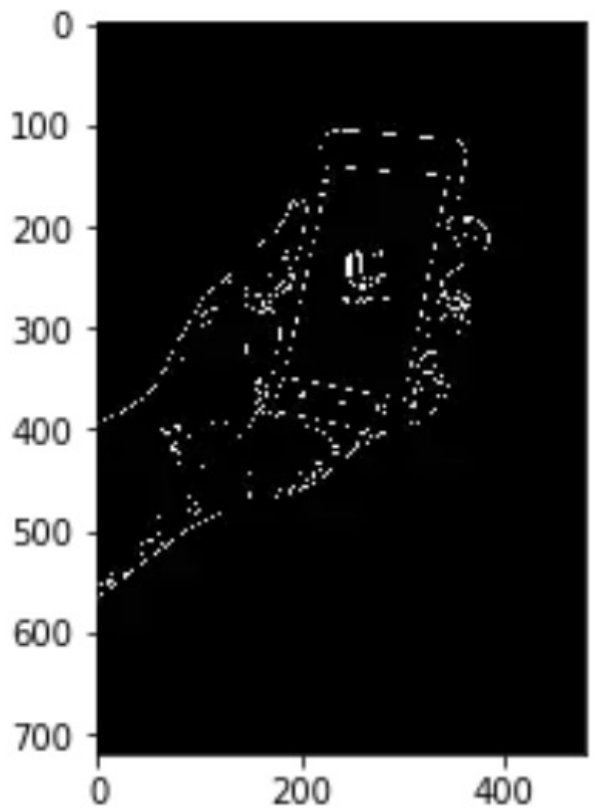
Adjusted from Prof. William Hoff

Hough Line Transform

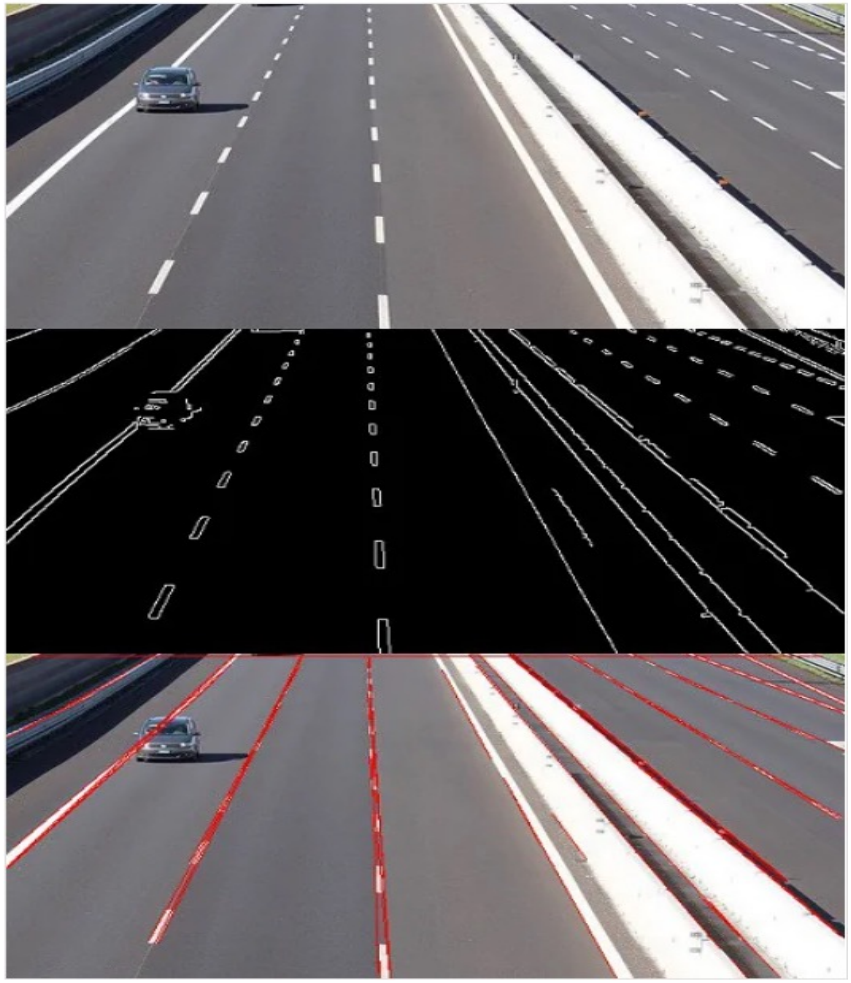


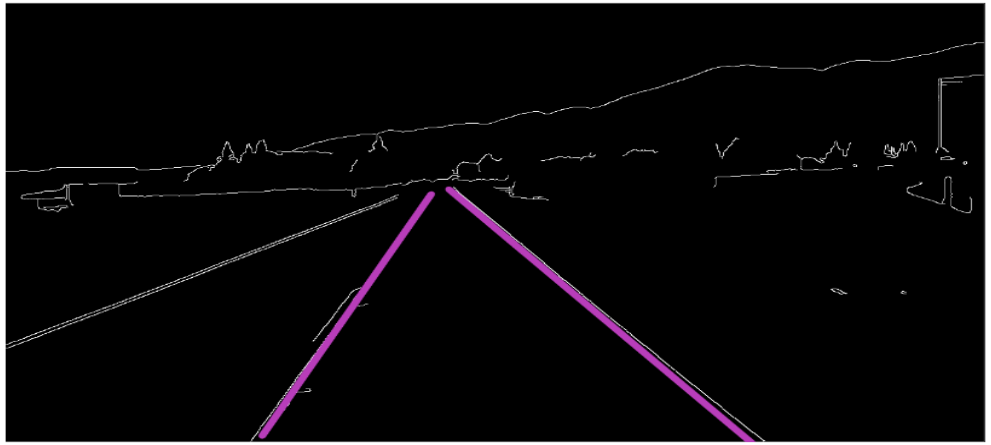
Adjusted from Prof. William Hoff

Hough Line Transform



Hough Line Transform

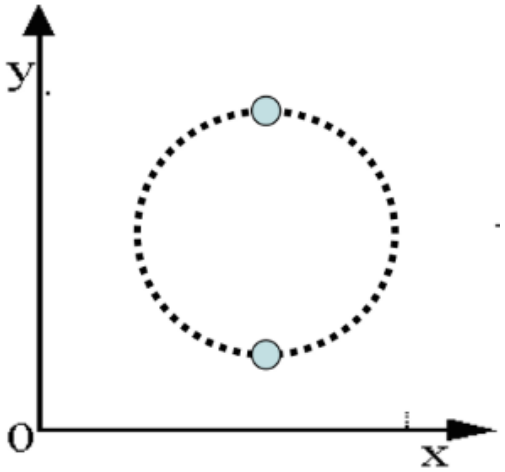




Hough Circle Transform

Image Space

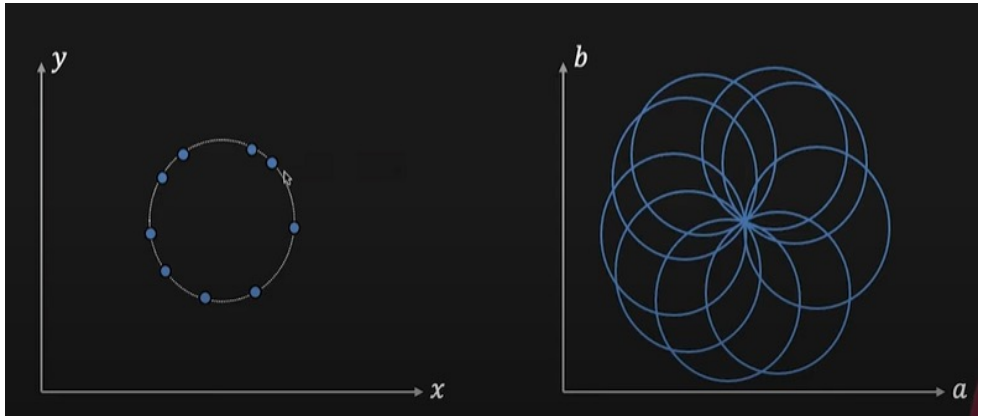
$$(x-a)^2+(y-b)^2=r^2$$

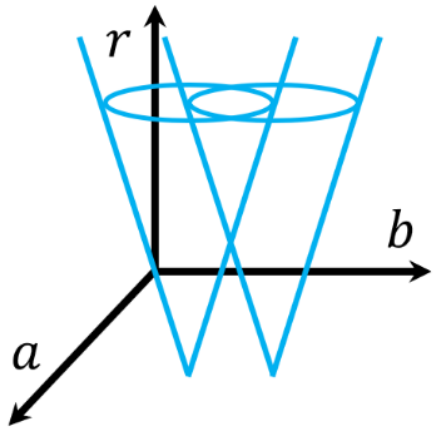


If r is known:

If r is an unknow:

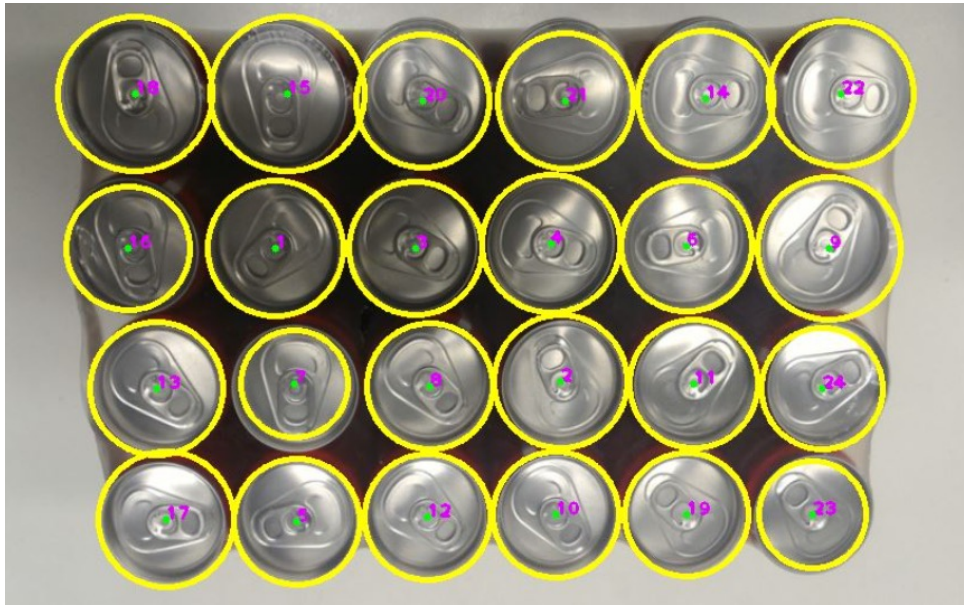
Parameter Space





Adjusted from Arbitrary ball detection using the circular Hough transform paper

Hough Circle Transform



Thank you for listening !
Any questions?