

# **CANNY EDGE DETECTOR**

#### Canny (Characteristics)



- Good Detection : Robustness to noise
  - The optimum detector must minimize the probability of false positive as well as false negative
- Good Localization:
  - The edge must be as close as possible to the true edges
- Strong Response Constraint:
  - Not too many or too few responses: The detector must return one point only for each point

### Canny (Steps)



- Smoothing with Gaussian Filter
- Compute Derivative of filter image
- Find magnitude & orientation of gradient
- Apply Non Maxima Suppression
- Apply Hysteresis Threshold

## Canny (Steps – Gaussian filter)



• Smoothing with Gaussian filter on Image I(r,c)

Smoothing Gaussian Filter 
$$G(r,c) = \frac{1}{2\pi\sigma^2} e^{-\frac{r^2+c^2}{2\sigma^2}}$$
  
Smoothened Image  $SM(r,c) = I(r,c)*G(r,c)$ 

	1	4	7	4	1
1	4	16	26	16	4
	7	26	41	26	7
273	4	16	26	16	4
	1	4	7	4	1

	0	0	1	2	1	0	0
4	0	3	13	22	13	3	0
1_	1	13	59	97	59	13	1
1003	2	22	97	150	87	22	2
	1	13	59	97	59	13	1
	0	3	13	22	13	3	0
	0	0	1	2	1	0	0

# Canny (Steps - Derivative)



2	2	2	2	2	2	2
1	2	2	2	2	2	2
1	1	2	2	2	2	2
1	1	1	2	2	2	2
1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1

	-3	-1	0	0	0	
	-3	-1	-1	0	0	
	-1	-3	-4	-4	-4	
II	0	-1	-3	-4	-4	
LA	0	0	0	0	0	
		17 25 26	National and	4	9	

3	1	0	0	0	
3	3	1	0	0	
1	3	2	0	0	
0	1	1	0	0	
0	0	0	0	0	

$$I \circ S_{I}$$

$$I \circ S_V$$

	- 31	
-1	0	1
-2	0	2
-1	0	1

$$S_H$$

$$S_{V}$$

## Canny (Steps - Magnitude and Orientation)



-3	-1	0	0	0	
-3	-1	-1	0	0	
-1	-3	-4	-4	-4	
0	-1	-3	-4	-4	
0	0	0	0	0	

$$\sqrt{I \circ S_H^2 + I \circ S_V^2}$$

	-45°	-45°	D	D	D	
	-45°	-45°	-45°	D	D	
	-45°	-45°	-27°	0°	0°	
	D	-45°	-18°	0°	0°	
and the	D	D	D	D	D	
1						

$$I \circ S_H$$

3	1	0	0	0	7
3	3	1	0	0	
1	3	2	0	0	
0	1	1	0	0	
0	0	0	0	0	
			2		

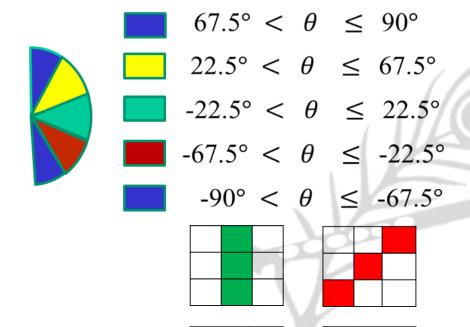
 $I \circ S_V$ 

$$tan^{-1}\left[\frac{I\circ S_V}{I\circ S_H}\right]$$

	4.2	1.4	0	0	0	
1	4.2	3.2	1.4	0	0	
	1.4	4.2	4.5	4	4	
	0	1.4	3.2	4	4	
	0	0	0	0	0	

### Canny (Steps - Apply Non Maxima Suppression)



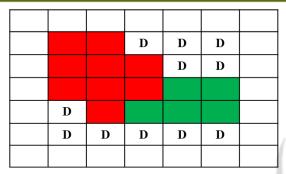


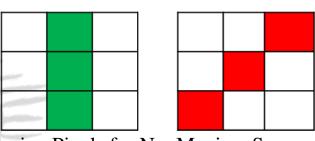
	-45°	-45°	D	D	D	
	-45°	-45°	-45°	D	D	
	-45°	-45°	-27°	0°	0°	
Migriffeldinelline	D	-45°	-18°	0°	0°	
	D	D	D	D	D	
	10					

	Λ						
d				D	D	D	
7					D	D	
		D					
		D	D	D	D	D	

## Canny (Steps - Apply Non Maxima Suppression)







Exploring Pixels for NonMaxima Suppression

**Colour Coded Orientation** 

4.2	1.4	0	0	0	
4.2	3.2	1.4	0	0	
1.4	4.2	4.5	4	4	
0	1.4	3.2	4	4	
0	0	0	0	0	

Gradient Magnitude

		_				
			handarin-		0	
	4.3	1.4	0	0	0	Λ
	4.1	3.3	1.5	0	0	78
L	1.3	4.3	4.4	4.1	4.0	. /
	0	1.5	3.3	4.0	3.9	
1	0	0	0	0	0	

Additive Noise: Dithering

	4.3	0	0	0	0	
	4.1	3.3	0	0	0	
1	0	4.3	4.4	4.1	4.0	
	0	0	0	0	0	
	0	0	0	0	0	

Gradient Magnitude after NonMaxima Suppression

# Canny (Steps – Apply Hysteresis Thresholding)



40	50	60				
	60		80	70	60	
10			55		90	
		80			100	70
	40					70
80			40			60
60		20		40		50



	0.4	0.5	0.6				
		0.6		0.8	0.7	0.6	
	0.1			0.5		0.9	
in the same of			0.8			1.0	0.7
		0.4					0.7
	0.8			0.4			0.6
	0.6		0.2		0.4		0.5
S							

0.4	0.5	0.6				
	0.6		0.8	0.7	0.6	
0.1			0.5		0.9	
		0.8			1.0	0.7
	0.4					0.7
0.8			0.4			0.6
0.6		0.2		0.4		0.5

	The state of the s									
٦	0.4	0.5	0.6							
	97	0.6		0.8	0.7	0.6				
				0.5	N.	0.9	1			
	1		0.8			1.0	0.7			
i establishmi		0.4					0.7			
	0.8			0.4			0.6			
	0.6				0.4		0.5			

0.4	0.5	0.6				
	0.6		0.8	0.7	0.6	
E			0.5		0.9	
1		0.8			1.0	0.7
	0.4					0.7
0.8			0.4			0.6
0.6				0.4		0.5

## Canny (Steps – Apply Hysteresis Thresholding)



40	50	60				
	60		80	70	60	,
10			55		90	
		80			100	70
	40					70
80			40	400	.00	60
60		20		40		50

//(				
Manager.				
		,		
	340	ATT.		



- Eg:
  - Compute derivative

2	2	2	2	2	2	2			
1	2	2	2	2	2	2			
1	1	1	2	2	2	2			
1	1	1	1	2	2	2			
1	1	1	1	1	1	2			
1	1	1	1	1	1	1			
1	1	1	1	1	1	1			
I									



- Eg:
  - Compute magnitude and orientation

-4	-3	-1	0	0	enneg
-3	-4	-3	-1	0	K
0	-1	-3	-4	-3	
0	0	-1	-3	-4	
0	0	0	0	-1	
			V	and the same of th	

	2	1	1	0	0	
Natural States	1	2	3	1	0	
	0	1	3	2	1	
	0	0	1	1	2	
30	0	0	0	0	1	
1		7	0			



- Eg:
  - Apply Non-maxima suppression

					line.
4.5	3.2	1.4	0	0	THE REAL PROPERTY.
3.2	4.5	4.2	1.4	0	K
0	1.4	4.2	4.5	3.2	
0	0	1.4	3.2	4.5	
0	0	0	0	1.4	
			V		

	-27	-18	-45	D	D	
Nagradata esta-	-18	-27	-45	-45	D	
	D	-45	-45	-27	-18	
	D	D	-45	-18	-27	
70	D	D	D	D	-45	
10			0			



- Eg:
  - Apply Hysteresis Threshold

					No.
-27	-18	-45	D	D	Maria de la constanta de la co
-18	-27	-45	-45	D	K
D	-45	-45	-27	-18	
D	D	-45	-18	-27	
D	D	D	D	-45	
			Z	and the same of th	

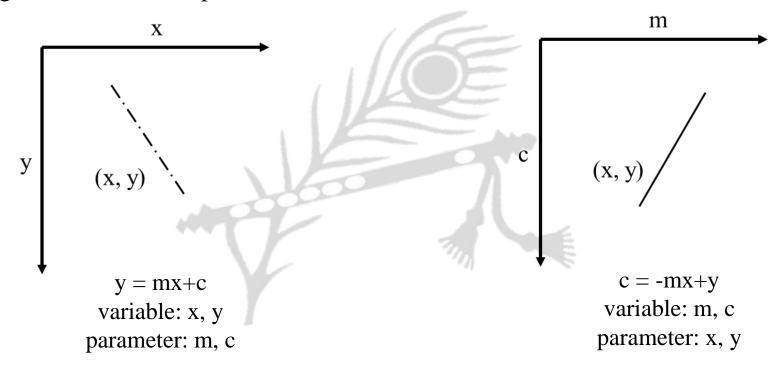
	4.5	0	0	0	0	
National States	0	4.5	4.2	0	0	
	0	0	4.2	4.5	0	
	0	0	0	0	4.5	
70	0	0	0	0	1.4	
10			0			



# **HOUGH TRANSFORM**

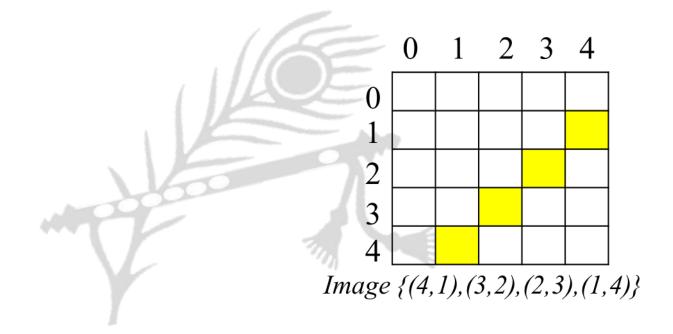


• Image and Parameter space





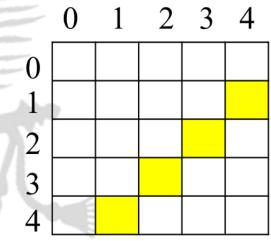
• Eg:





#### • Step 1:

- Known
  - -1.2<=m<=-0.8
  - $step_m = 0.1$
  - m = -0.8, -0.9, -1.0, -1.1, -1.2
  - c = -mx + y





#### Step 2:

- Compute c

$$(x,y) = (4,1)$$
  $(x,y) = (3,2)$   $(x,y) = (2,3)$   
 $c = -4m+1$   $c = -3m+2$   $c = -2m+3$ 

m	c
-0.8	4.2
-0.9	4.6
-1.0	5.0
-1.1	5.4
-1.2	5.8

$$(x,y) = (4,1)$$
  $(x,y) = (3,2)$   $(x,y) = (2,3)$ 

m	c
-0.8	4.4
-0.9	4.7
-1.0	5.0
-1.1	5.3
-1.2	5.6

$$(x,y) = (2,3)$$
  
 $c = -2m+3$ 

	1
m	c
-0.8	4.6
-0.9	4.8
-1.0	5.0
-1.1	5.2
-1.2	5.4

c
4.8
4.9
5.0

5.1

5.2

-1.1

-1.2

(x,y) = (1,4)

c = -m+4

	0	1	2	3	4
0					
1					
2					
2 3 4					
4				·	

Image  $\{(4,1),(3,2),(2,3),(1,4)\}$ 



- Step 3:
  - Find min and max of c
- Range: 4.2 to 5.8
- Interval: 0.1

$$(x,y) = (4,1)$$
  
 $c = -4m+1$ 

$$(x,y) = (3,2)$$
  
 $c = -3m+2$ 

$$y) = (3,2)$$
  $(x,y) = (2,3)$   
 $c = -3m+2$   $c = -2m+3$ 

$$(x,y) = (2,3)$$
  $(x,y) = (1,4)$   
 $c = -2m+3$   $c = -m+4$ 

m	c
-0.8	4.2
-0.9	4.6
-1.0	5.0
-1.1	5.4
-1.2	5.8

m	c
-0.8	4.4
-0.9	4.7
-1.0	5.0
-1.1	5.3
-1.2	5.6

m	c
-0.8	4.6
-0.9	4.8
-1.0	5.0
-1.1	5.2
-1.2	5.4

m	c
-0.8	4.8
-0.9	4.9
-1.0	5.0
-1.1	5.1
-1.2	5.2



- Step 4:
  - Voting

$$(x,y) = (4,1)$$
  $(x,y)$   
 $c = -4m+1$ 

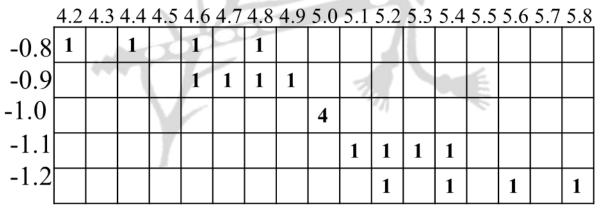
$$(x,y) = (3,2)$$
  
 $c = -3m+2$ 

$$(x,y) = (2,3)$$
  $(x,y) = (1,4)$   
 $c = -2m+3$   $c = -m+4$ 

$$(x,y) = (1,4)$$
  
 $c = -m+4$ 

m	c
-0.8	4.2
-0.9	4.6
-1.0	5.0
-1.1	5.4
-1.2	5.8

No.	m	c
projecti projection	-0.8	4.4
rijedle	-0.9	4.7
	-1.0	5.0
lance.	-1.1	5.3
	-1.2	5.6





- Step 5:
  - Find equation

	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8
-0.8	1		1		1		1										
-0.9				Pos.	1	1	1	1	in the same of the								
-1.0			///	The same of	L	7	깇		4								
-1.1				K	The second		National States		30	1	1	1	1				
-1.2			Z								1		1		1		1

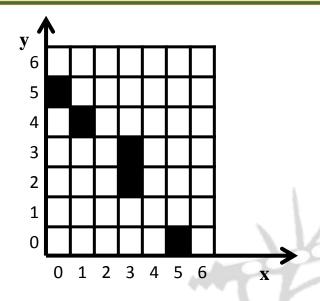
- m = -1.0
- c = 5.0
- y = -x+5



#### Problem

- The slope of line parallel to y axis is infinity, the computer can not handle it.
- So, we follow another parameterization of a line
- $p = x \cos \theta + y \sin \theta$





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

Edgels: (0,5), (1,4), (3,2), (3,3), (5,0)



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

$$p = 0 \cos \theta + 5 \sin \theta \qquad (0,5)$$

$$p = 1 \cos \theta + 4 \sin \theta \qquad (1,4)$$

$$p = 3\cos\theta + 2\sin\theta \tag{3,2}$$

$$p = 3\cos\theta + 3\sin\theta \qquad (3,3)$$

$$p = 5 \cos \theta + 0 \sin \theta \qquad (5,0)$$



	$0\cos\theta + 5\sin\theta$	$1\cos\theta + 4\sin\theta$	$3\cos\theta + 2\sin\theta$	$3\cos\theta + 3\sin\theta$	$5\cos\theta + 0\sin\theta$
0	0	1	3	3	5
30	2.5	2.9	3.9	4	4.3
45	3.5	3.5	3.5	4.2	3.5
60	4.3	3.9	3.2	4	2.5
90	5	4	2	3	0



• The equation for the edge will be:

$$3.5 = x \cos 45 + y \sin 45$$

