

HOUGH TRANSFORM

- ✗ Goal: recognize lines in images
- ✗ Approach:
 - + For every point in the starting image plot the sinusoid on the dual plane (parameter space): (ρ, ϑ)
$$\rho = x * \cos(\vartheta) + y * \sin(\vartheta)$$
where x and y are fixed (the considered point coordinates) while ρ and ϑ are variables.
 - + The Hough Transform of an image with K lines is the sum of many sinusoids intersecting in K points.
 - + Maxima in the dual plane indicate the parameters of the k lines

HOUGH: IMPLEMENTATION

- ✗ Consider a discretization of the dual plane for the parameters (ρ, ϑ) : it becomes a matrix whose row and column indices correspond to the quantized values of ρ and ϑ .
- ✗ The limits of ρ are chosen accordingly to the image size.

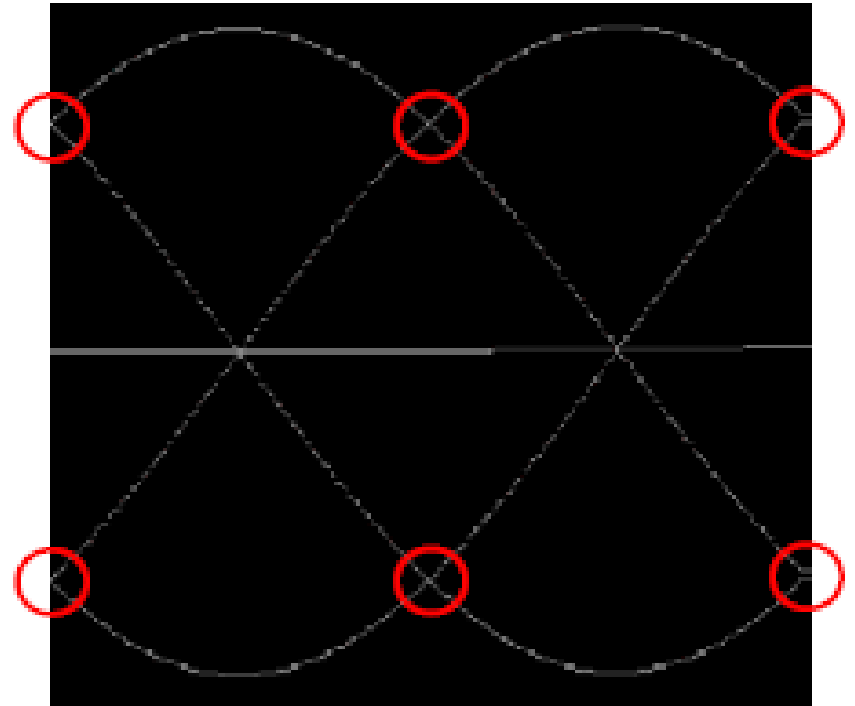
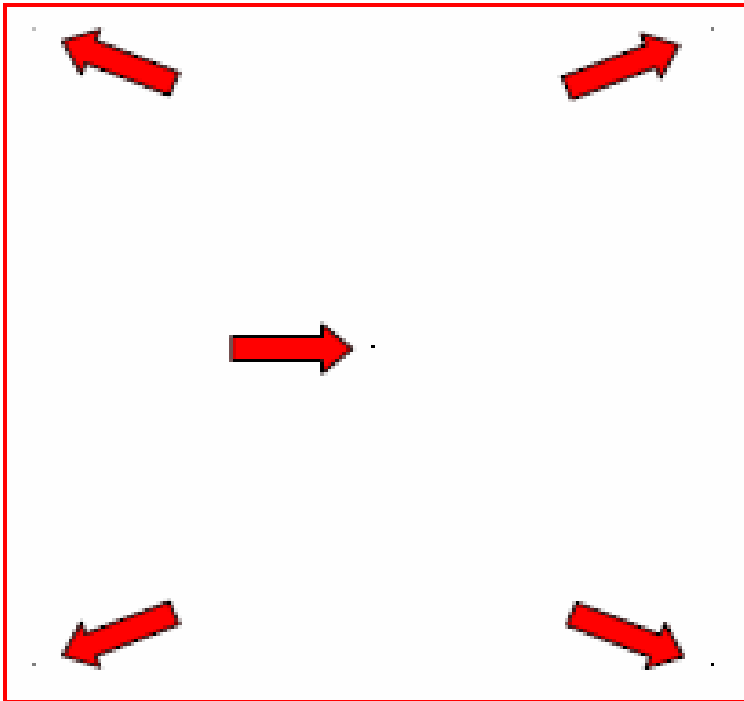
Usually: $-\rho_{\max} \leq \rho \leq \rho_{\max}$, $-\pi/2 \leq \vartheta \leq \pi/2$

HOUGH: IMPLEMENTAZIONE

- ✗ Clear the matrix $H(m,n)$;
- ✗ For every point $P(x,y)$ of the image
 - + 1. for ϑ_n that ranges from $-\pi/2$ to $\pi/2$ with step $d\vartheta$
 - ✗ 1. Evaluate $\rho(n)=x*\cos(\vartheta_n)+y*\sin(\vartheta_n)$
 - ✗ 2. find the index m corresponding to $\rho(n)$
 - ✗ 3. Increase $H(m,n)$
 - + 2. end
- ✗ end
- ✗ 4. Find local maxima in $H(.,.)$ that will corresponds to parameters of the founded lines

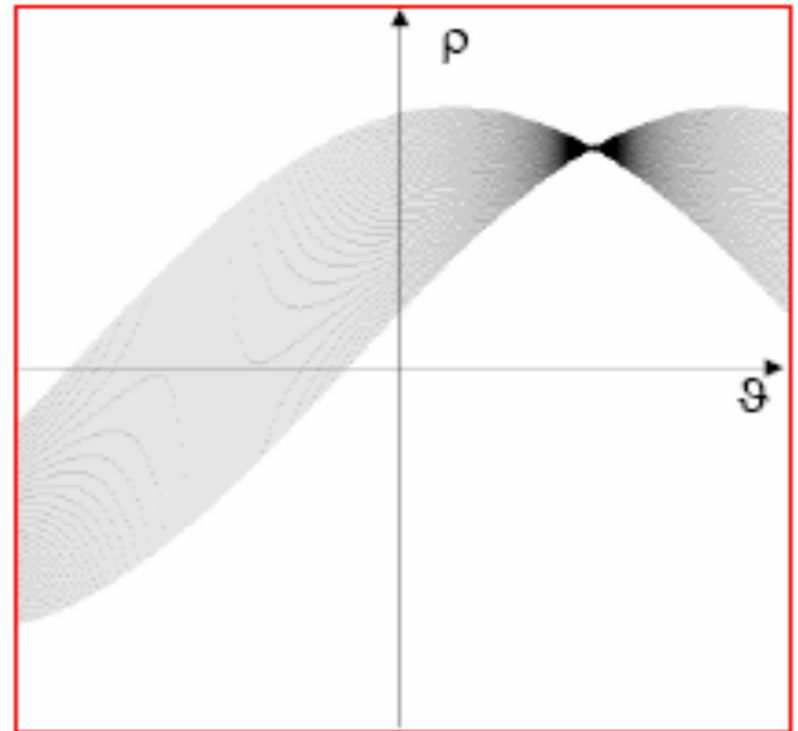
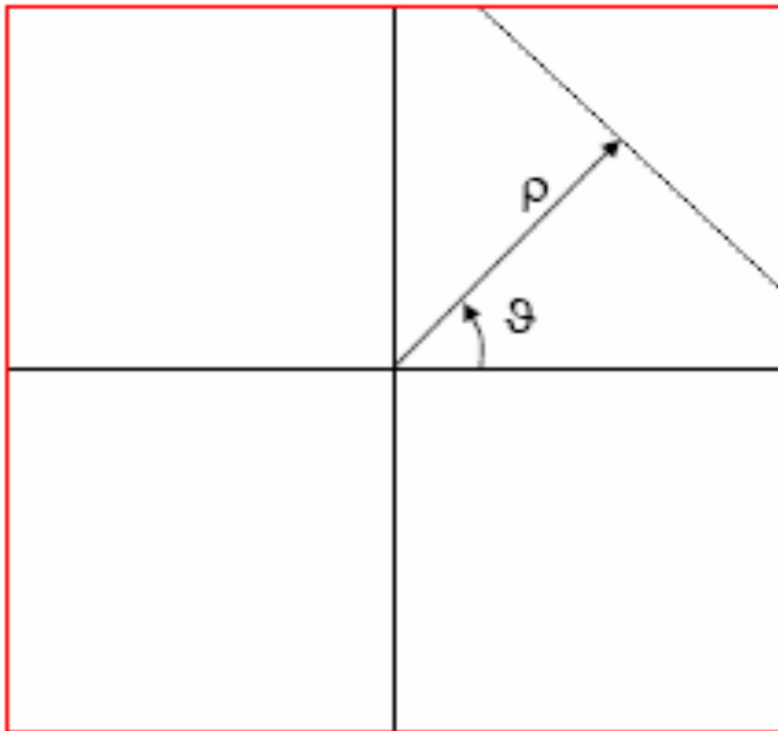
HOUGH TRANSFORM

✖ 5 points



HOUGH TRANSFORM

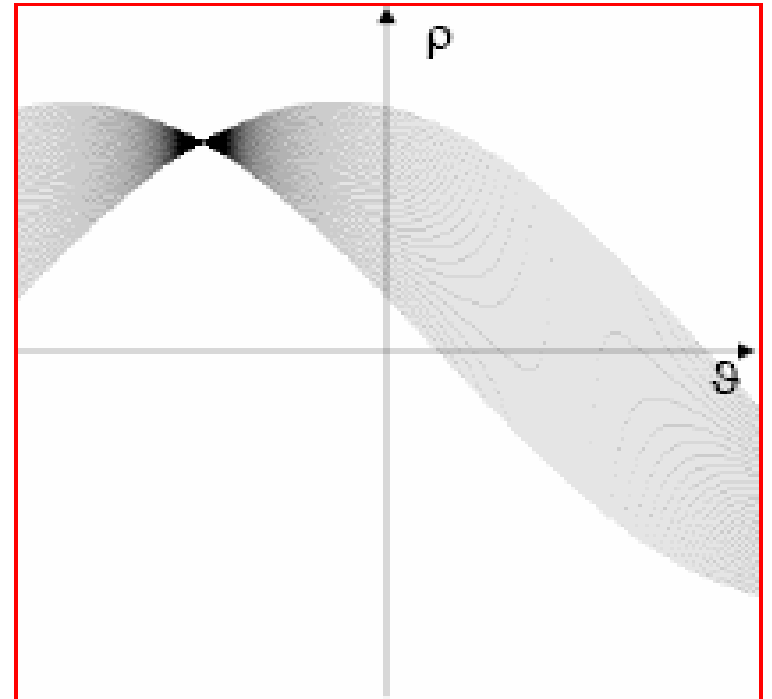
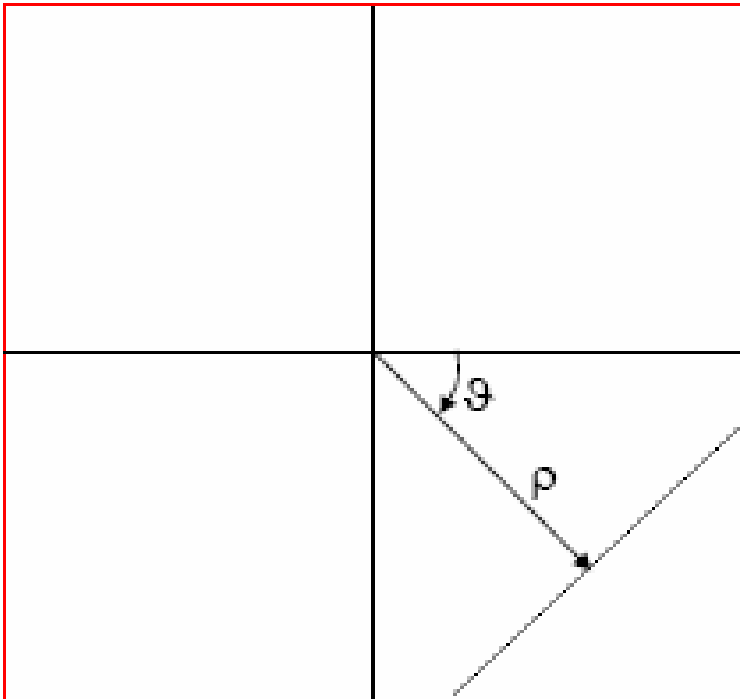
✗ line $\rho > 0, \theta > 0$



Periodic

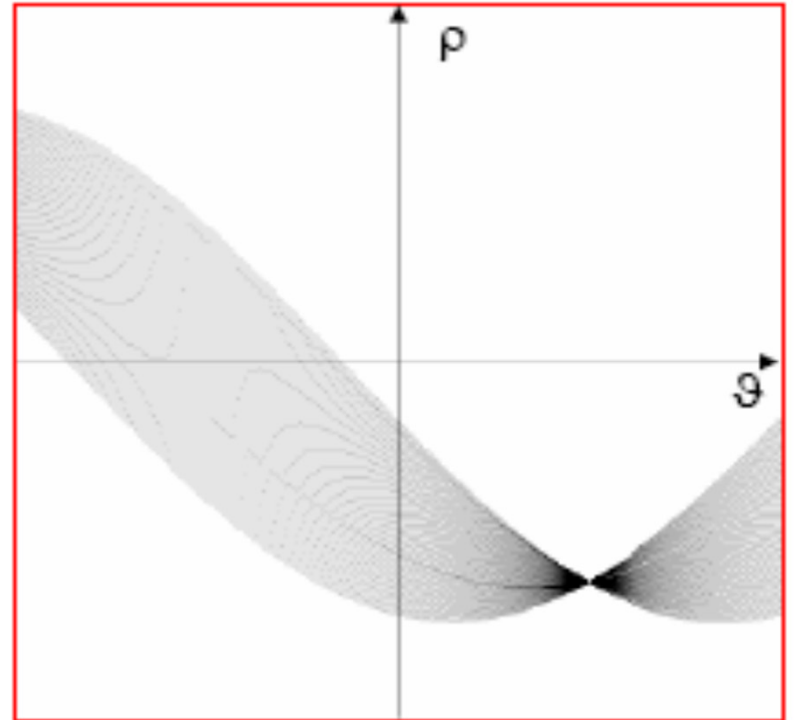
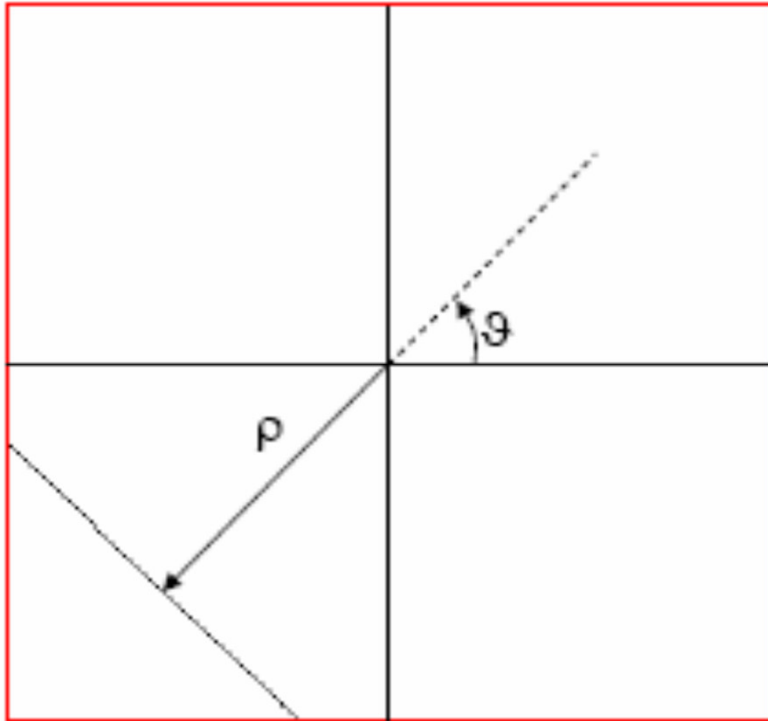
HOUGH TRANSFORM

✕ line $\rho > 0, \theta < 0$



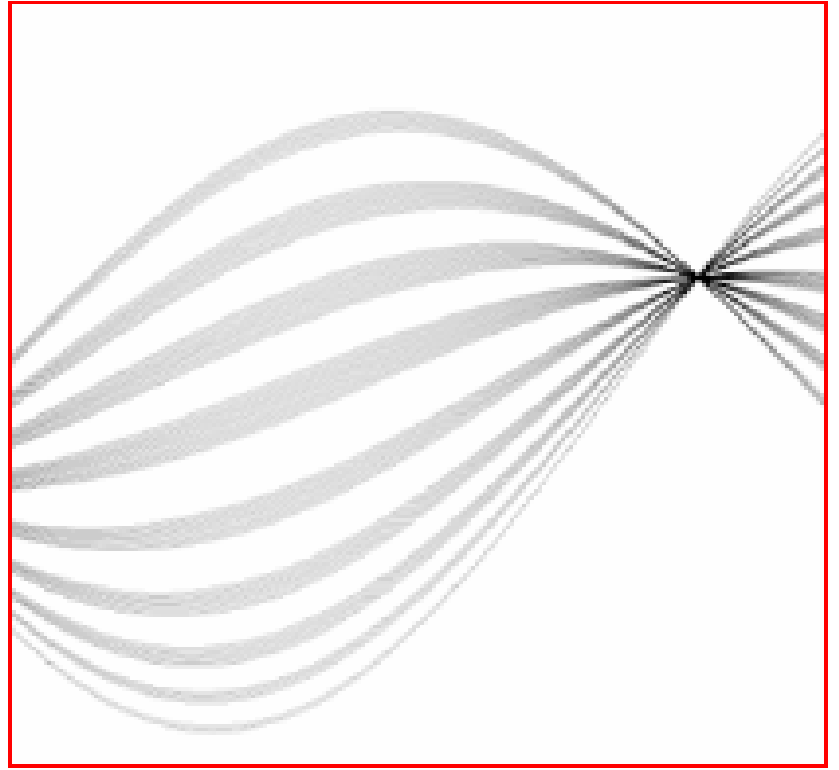
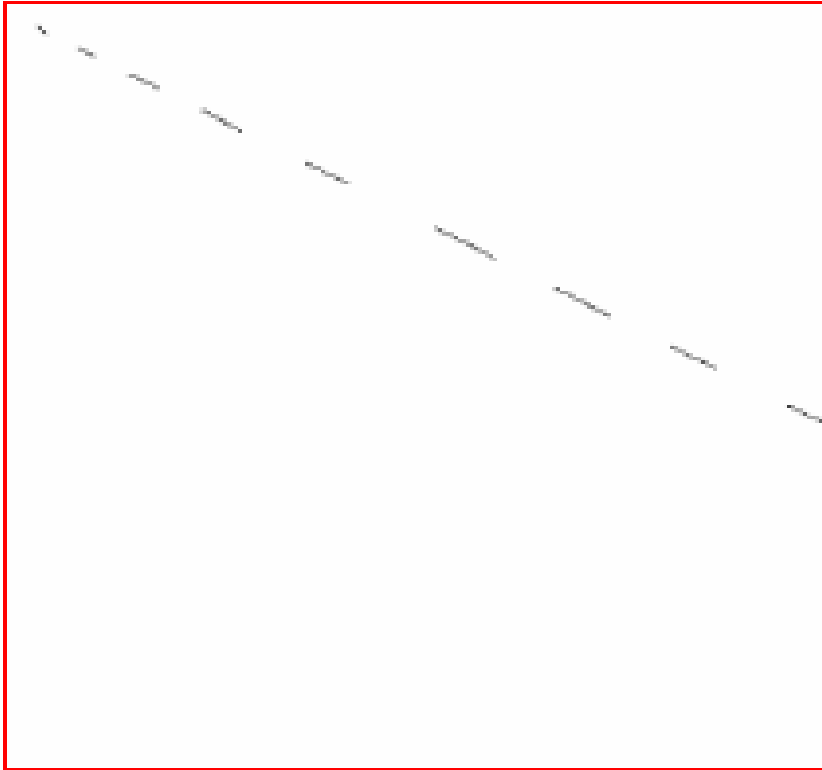
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✗ line $\rho < 0, \theta > 0$



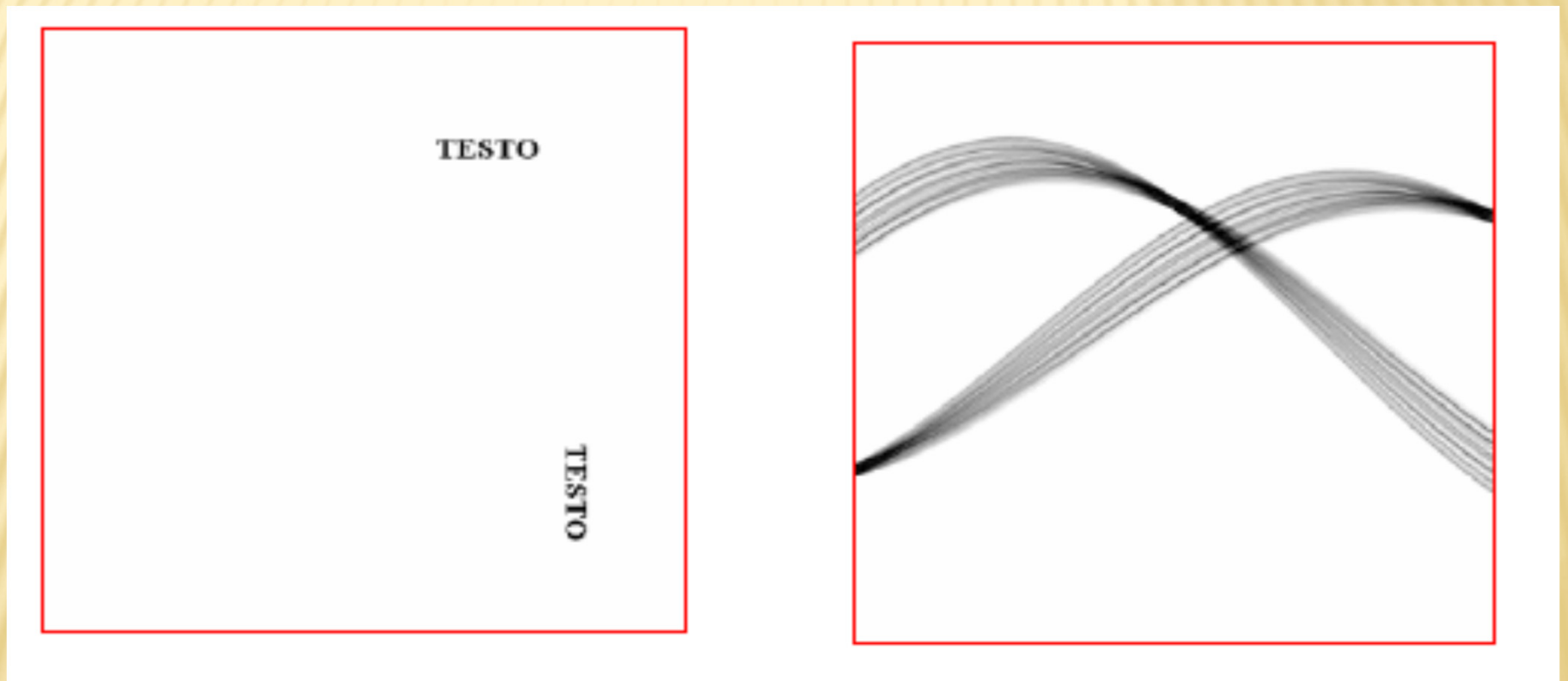
HOUGH TRANSFORM

✕ Dotted line



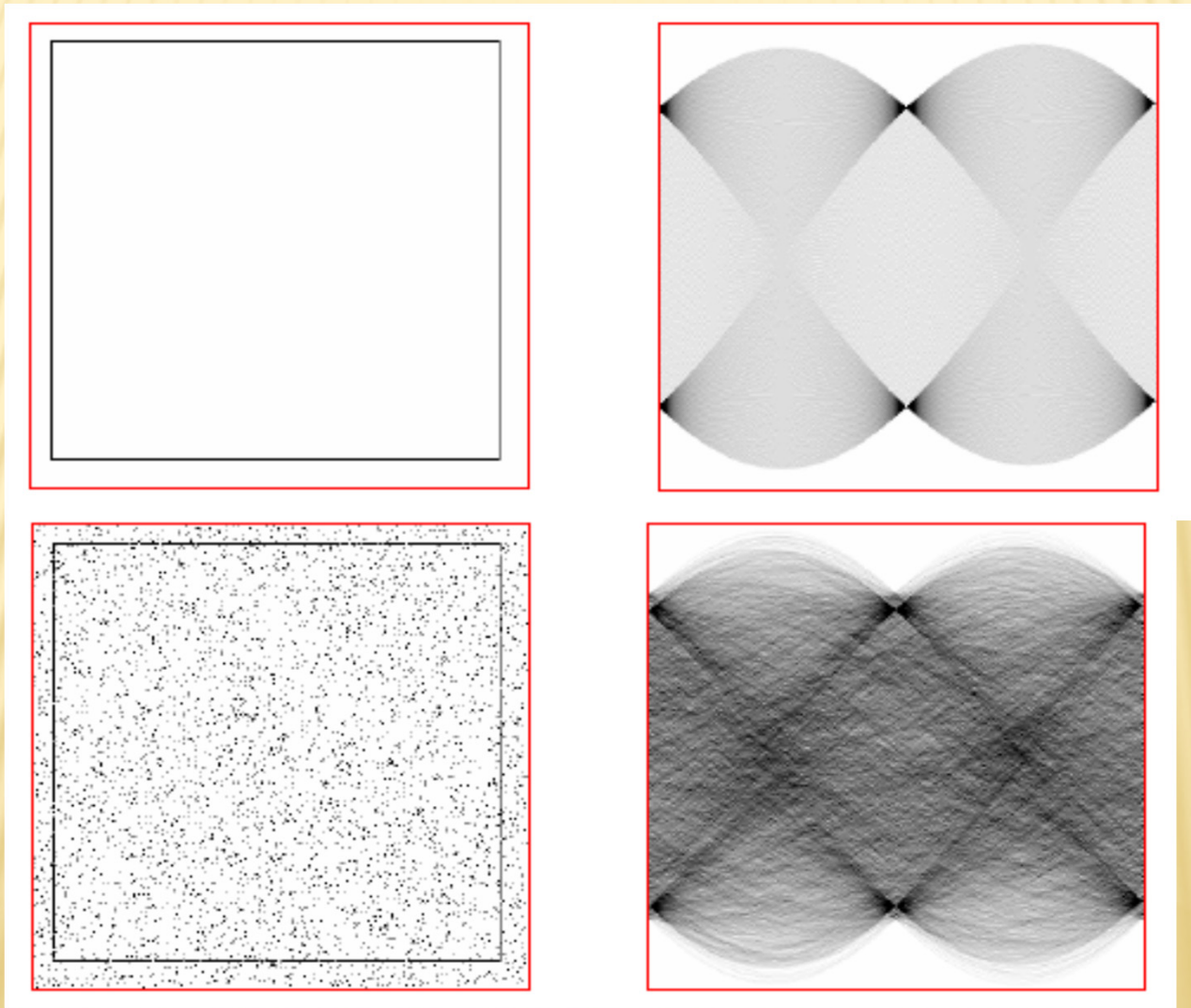
HOUGH TRANSFORM

- ✗ Same text with different orientations



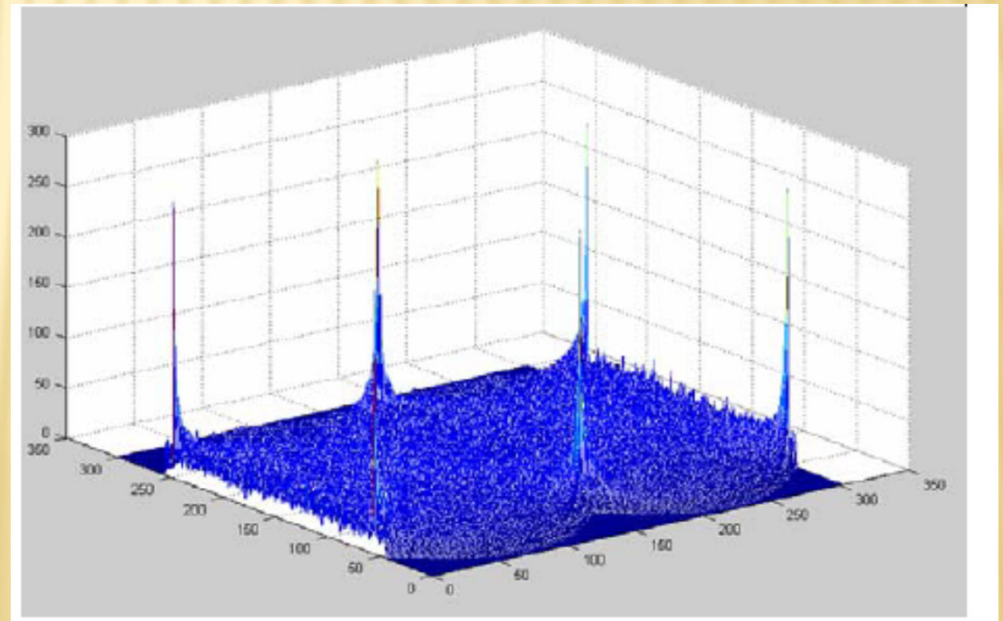
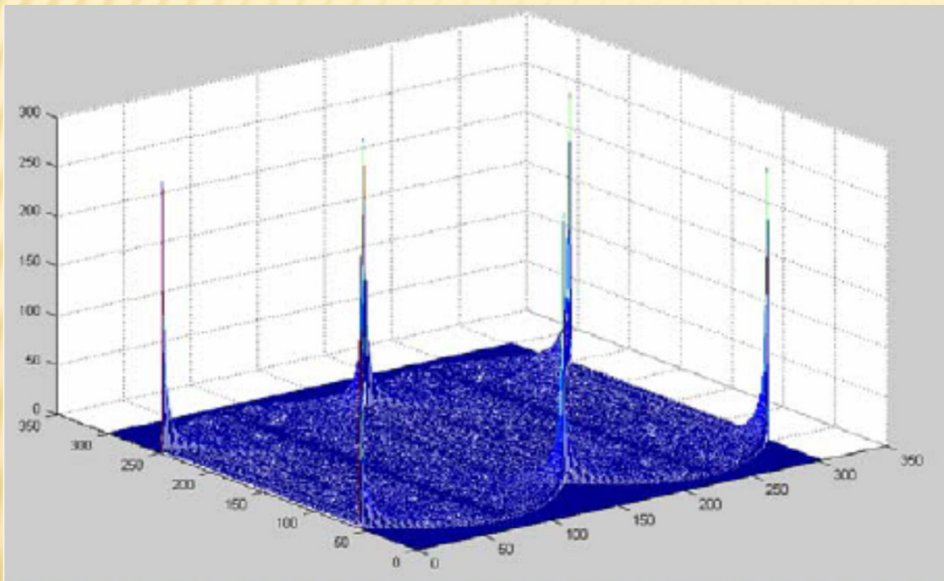
HOUGH TRANSFORM

✕ Noise and noiseless square



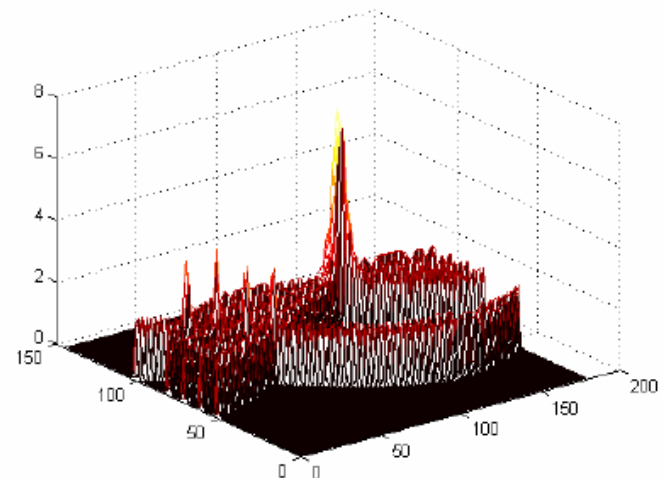
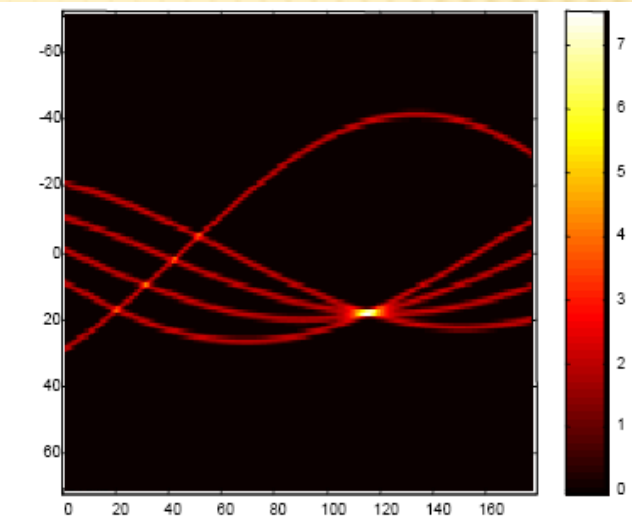
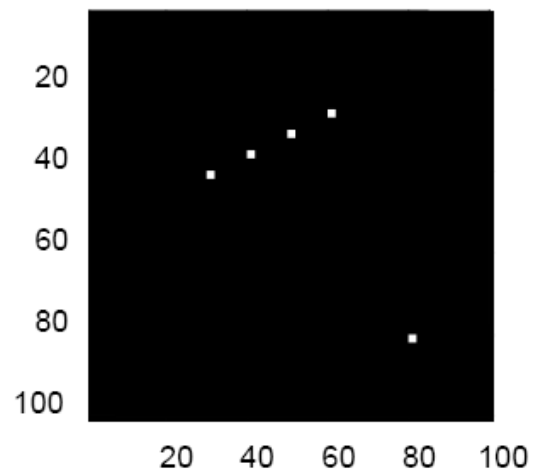
HOUGH TRANSFORM

- ✖ Accumulation matrices of the previous images



EXAMPLES

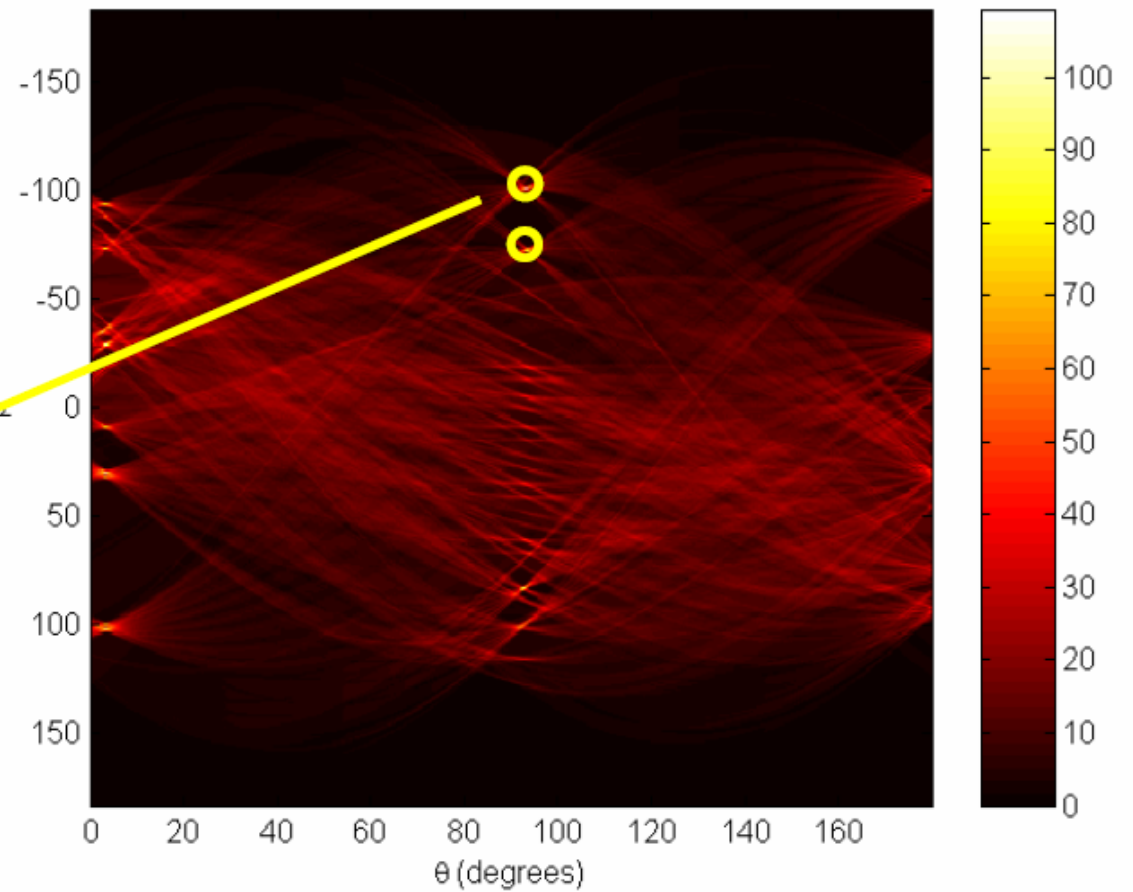
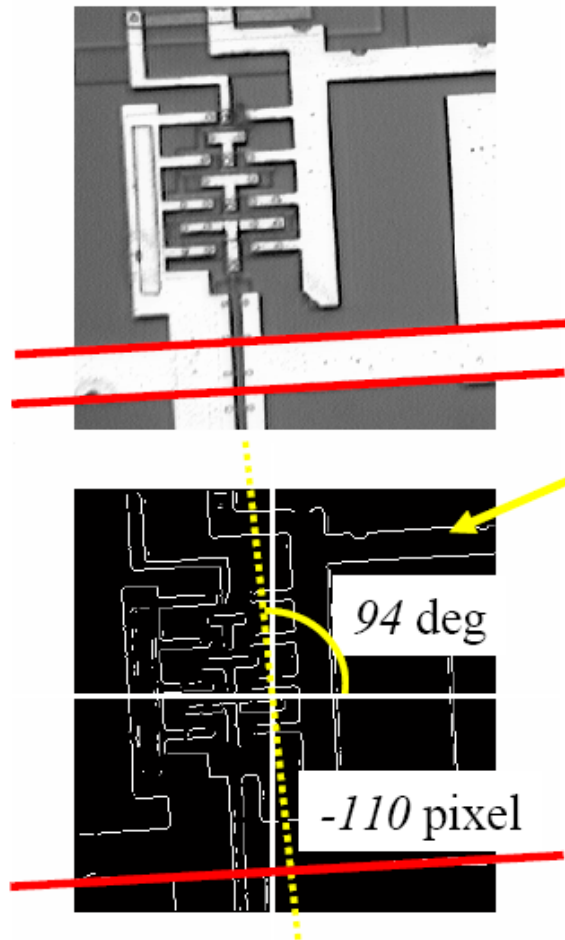
Original image



Courtesy: P. Salembier

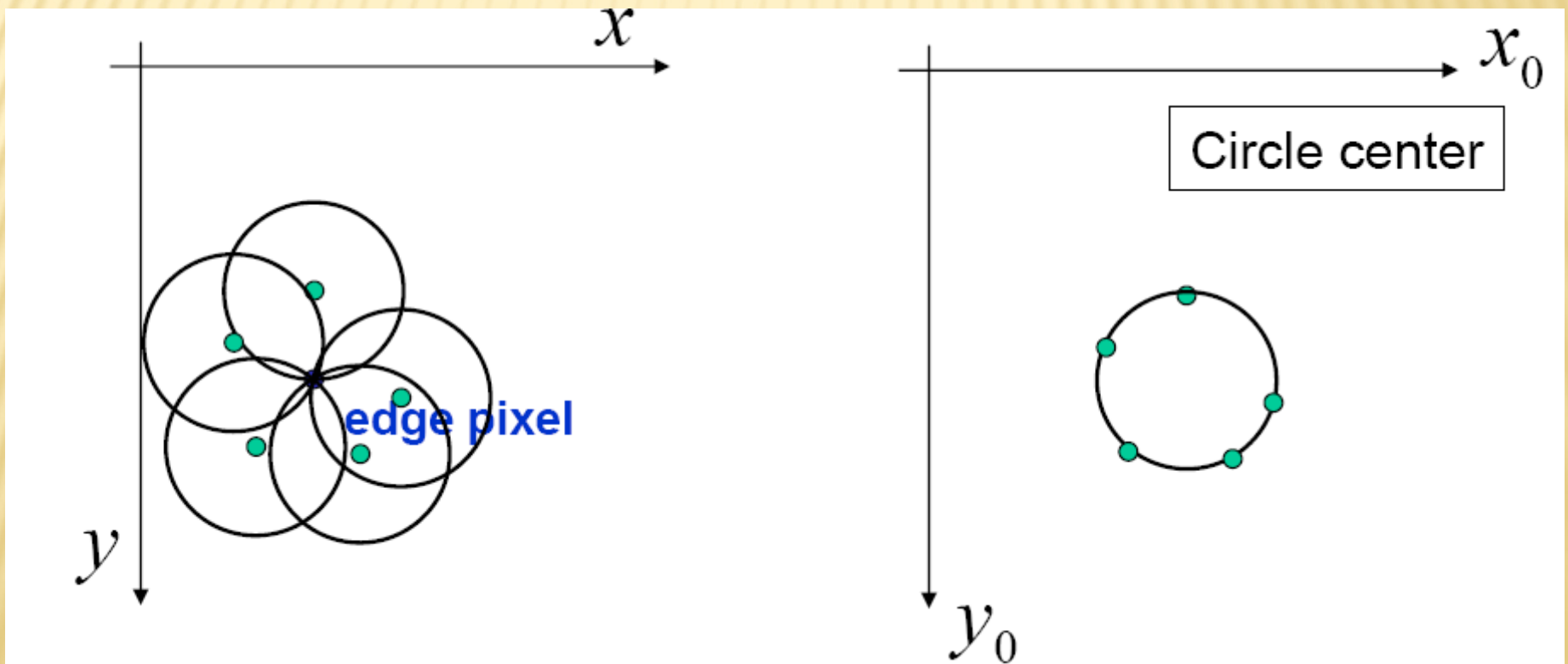
EXAMPLE

Original IC image (256x256)



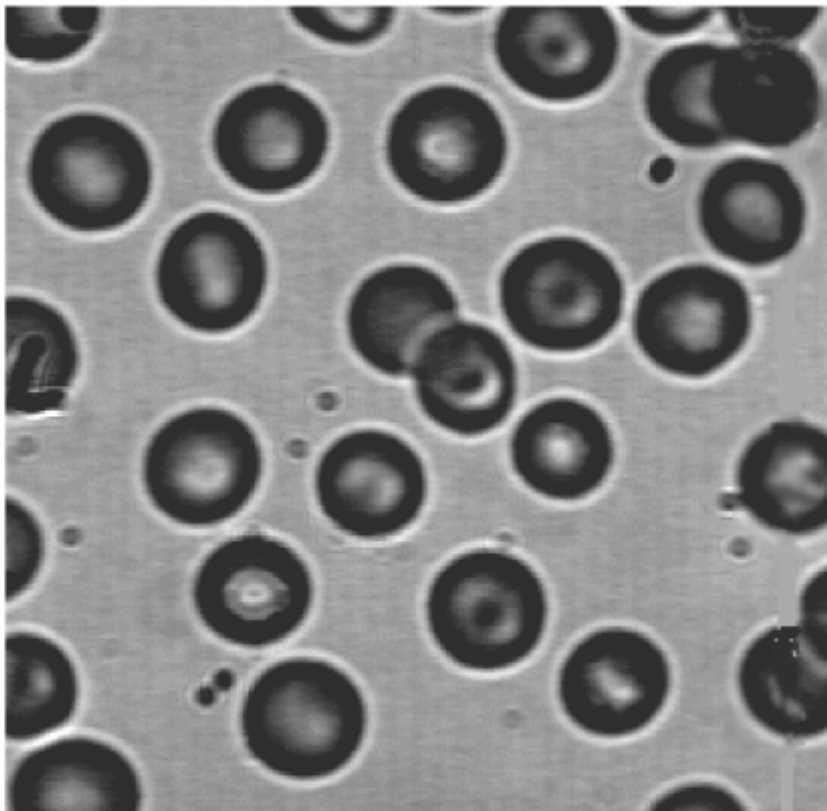
CIRCLE DETECTION BY HOUGH TRANSFORM

- ✖ Find circles of fixed radius r
- ✖ For circles of undetermined radius, use 3-d Hough transform for parameters (x_0, y_0, r)



EXAMPLE: CIRCLE DETECTION BY HOUGH TRANSFORM

Original *blood* image



Prewitt edge detection

