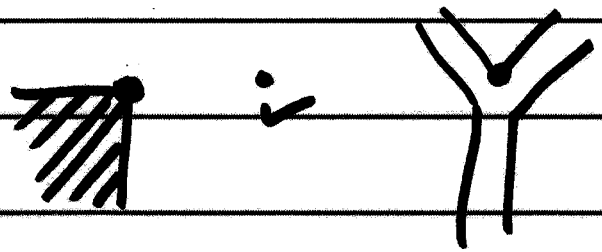
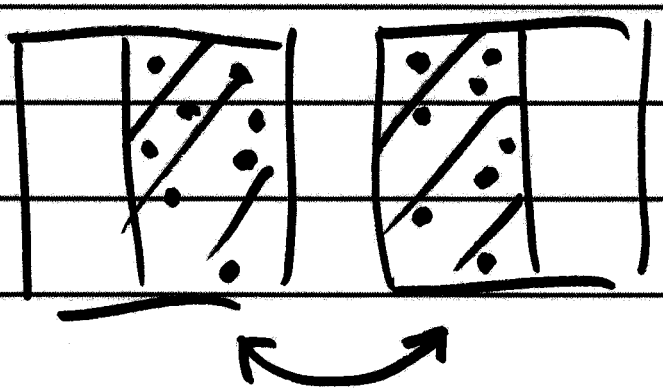
Automation

- Interest Points
- Hough Transform

W. Förstner

well defined point





LSM : geometric transform

$$x' = a_1 x + a_2 y + a_3$$
$$y' = b_1 x + b_2 y + b_3$$

$$\frac{\partial F}{\partial a_1} = -g_x x$$

$$\frac{\partial F}{\partial a_2} = -g_x y$$

$$\frac{\partial F}{\partial a_3} = -g_x$$

$$\frac{\partial F}{\partial b_1} = -g_y x$$

$$\frac{\partial F}{\partial b_2} = -g_y y$$

$$\frac{\partial F}{\partial b_3} = -g_y$$

g_3 b_3

$$B: \begin{bmatrix} -g_x\alpha & -g_x\gamma & -g_x & -g_y\alpha & -g_y\gamma & -g_y \\ \vdots & \vdots & \vdots & & & \end{bmatrix} \quad n \times 4$$

$$N = B^T B$$

$$\begin{bmatrix} g_x g_x + g_x g_x \cdots & g_x g_y + g_x g_y \cdots \\ 1 \quad 2 & 1 \quad 2 \\ g_x g_y + g_x g_y \cdots & g_y g_y + g_y g_y \cdots \\ 1 \quad 2 & 1 \quad 2 \end{bmatrix}$$

N :

$$\begin{bmatrix} \Sigma g_x g_x & \Sigma g_x g_y \\ \Sigma g_x g_y & \Sigma g_y g_y \end{bmatrix}$$

inverse:

$$\frac{\begin{bmatrix} \Sigma g_y g_y & -\Sigma g_x g_y \\ -\Sigma g_x g_y & \Sigma g_x g_x \end{bmatrix}}{\Sigma g_x g_x \Sigma g_y g_y - (\Sigma g_x g_y)^2}$$

Covariance Matrix of shift parameters

Criteria:

(1) ellipse area small
πab

(2) equality between major + minor axes

$$\frac{a}{b} \approx 1$$

Selection of interest points:

(1) choose points with

area < threshold

and

$1 - \frac{a}{b} <$ threshold

$$q = \frac{4 \det(C)}{tr^2(C)}$$

C: covariance matrix

$$w : \frac{\det(C)}{\text{trace}(C)}$$

q: 1: circle
0: line

w: large ⇒ large area
small ⇒ small area

Hough Transform : Straight line detection

1. find edge pixels

Prewitt

$$\begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix} \quad M_x$$

$$\begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \quad M_y$$

Sobel

$$\begin{pmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{pmatrix} \quad M_x$$

$$\begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix} \quad M_y$$

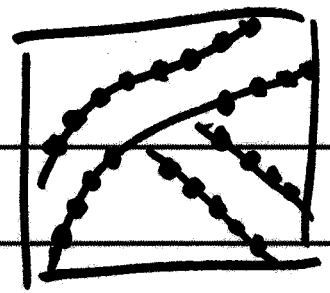
threshold

select pixels with

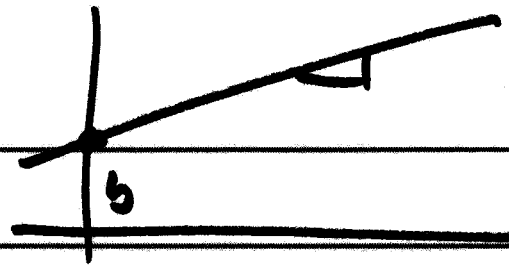
$m > M_{Thresh.}$

$$M = \sqrt{M_x^2 + M_y^2}$$

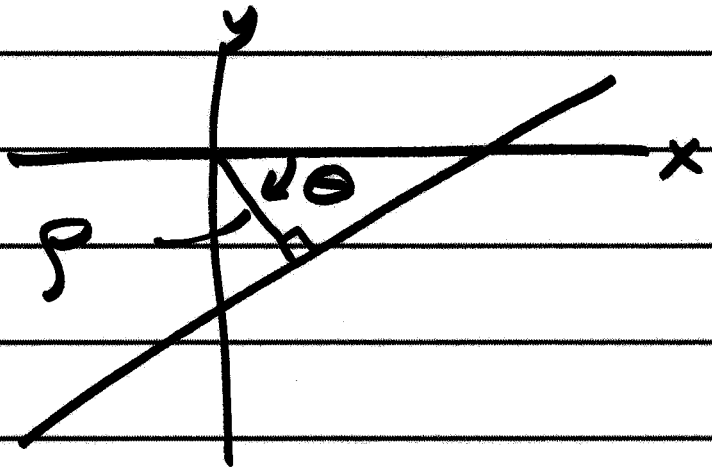
$$\Theta = \tan^{-1} M_y / M_x$$



$y = \underline{m}x + \underline{b}$

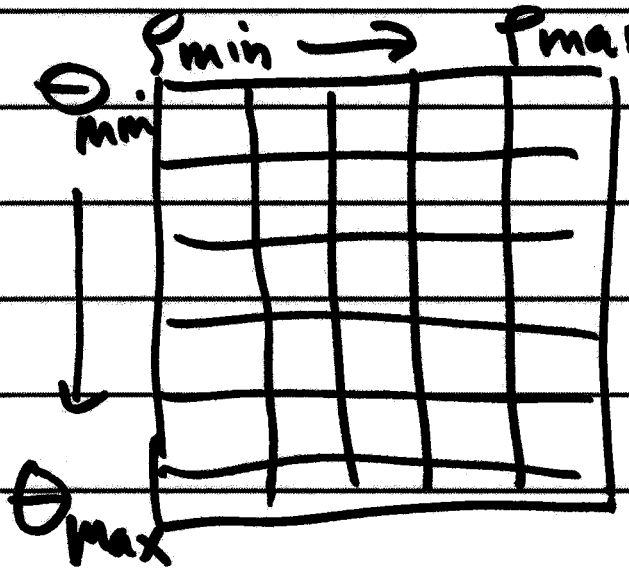


$\rho = x\cos\theta + y\sin\theta$

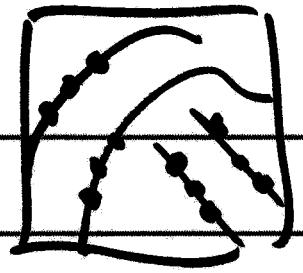


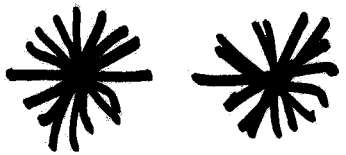
$\rho_{min} \rightarrow \rho_{max}$

$\theta_{min} \rightarrow \theta_{max}$



counting or accumulator matrix



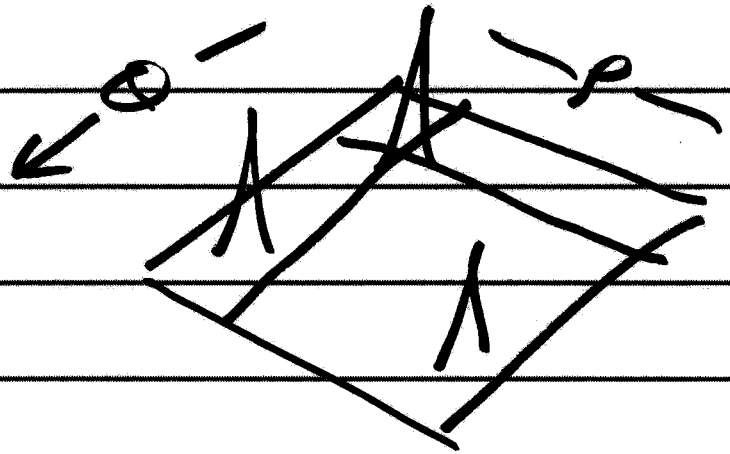


$\rho = x\cos\theta + y\sin\theta$

line detection

circle detection

ellipse detection



$R^2 = (x-x_0)^2 + (y-y_0)^2$

edge pixels

lines

parallel lines
polygons

roadway
airport
building

low level features

high level features