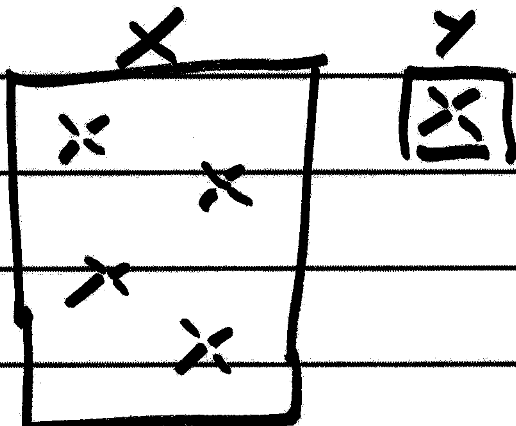
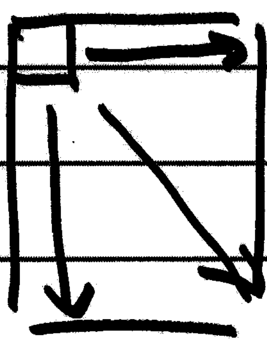
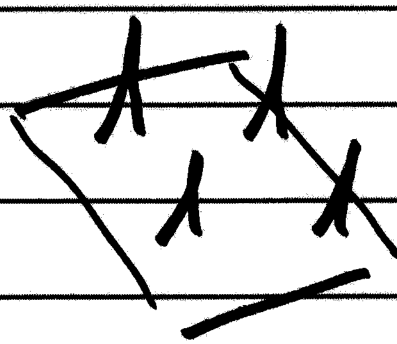
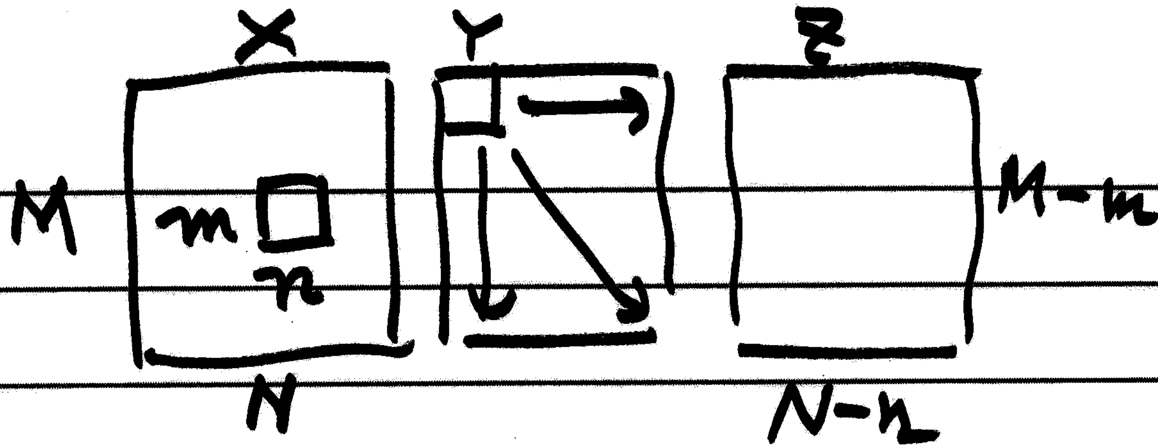
Cross Correlation: 2D

$$CC = \frac{\sum (x-\bar{x})(y-\bar{y})}{\left[\sum (x-\bar{x})^2 \sum (y-\bar{y})^2\right]^{1/2}} \quad : \; -1 \to +1$$









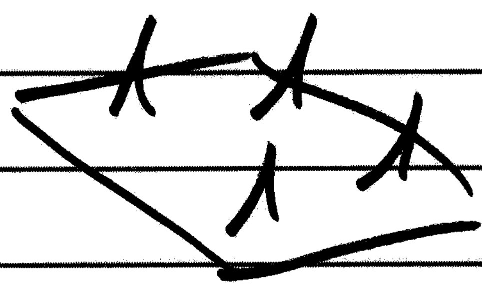
$xbar = sumx / (m*n)$

$ybar = sumy / (m*n)$

```
for I = 1:M-m
  for J = 1:N-n
    sumx = 0
    sumy = 0
    for i = 1:m
      for j = 1:n
        ii = I+i-1
        jj = J+j-1
        sumx = sumx + x(ii,jj)
        sumy = sumy + y(i,j)
      end
    end
```

```
num = 0
denx = 0
deny = 0
for i = 1 : m
  for j = 1 : n
    ii = I + i - 1
    jj = J + j - 1
    num = num + (x(ii,jj) - xbar)*(y(i,j) - ybar)
    denx = denx +
      (x(ii,jj) - xbar)^2
    deny = deny +
      (y(i,j) - ybar)^2
  end
end
```

```
cc = num/sqrt(denx * deny)
  Z(I,J) = cc
 end
end
```



Property of Fourier Transform

Convolution $\Longleftrightarrow$ multiplication
(domain 1) (domain 2)

$g(t),\ h(t)$

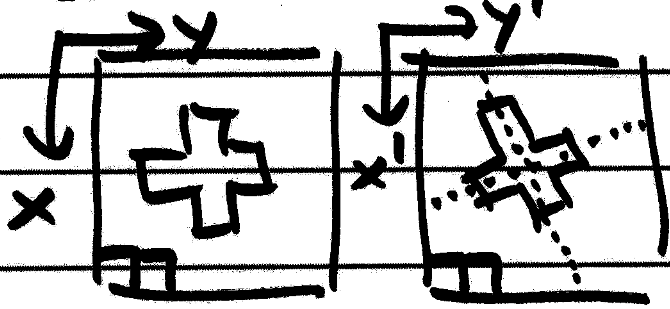
$G(\omega) = \mathcal{F}(g(t))$

$H(\omega) = \mathcal{F}(h(t))$

conv: $\underline{g(t) \otimes h(t)} = \mathcal{F}^{-1}(\underline{G(\omega) \cdot H(\omega)})$

corr: $g(t) \circledast h(t) = \mathcal{F}^{-1}(G(\omega) \cdot H^{*}(\omega))$

Least Squares Matching



g h

$$\begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ b_1 \\ b_2 \\ b_3 \\ K_1 \\ K_2 \end{bmatrix}$$

- $g(x,y) = h(x',y')$

$$x' = \underline{a_1}x + \underline{a_2}y + \underline{a_3}$$

$$y' = \underline{b_1}x + \underline{b_2}y + \underline{b_3}$$

$$g(x,y) = \underset{\substack{\uparrow \\ \text{gain}}}{\underline{K_1}}\, h(x',y') + \underset{\substack{\uparrow \\ \text{offset}}}{\underline{K_2}}$$

$$F = g(x,y) - k_1 h(x', y') - k_2 = 0$$

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

$$a_1 \approx 1,\ a_2 \approx 0,\ a_3 \approx 0$$
$$b_2 \approx 1,\ b_1, b_3 \approx 0$$

$$B = \left[\frac{\partial F}{\partial a_1} \ \frac{\partial F}{\partial a_2} \ \frac{\partial F}{\partial a_3} \ \frac{\partial F}{\partial b_1} \ \cdots \right]$$

$$\frac{\partial F}{\partial a_1} = -K_1 \underbrace{\frac{\partial h}{\partial a_1}} = -K_1 \underbrace{\frac{\partial h}{\partial x'}}_{\text{gradient } x} \cdot \frac{\partial x'}{\partial a_1} = -\underbrace{h_x}\, x$$

$K_1 = 1,\ k_2 = 0$

$$h_x = \frac{\Delta h}{\Delta x} \approx \frac{\partial h}{\partial h}$$

$$h_x = h(x'+1, y') - \cancel{h(x', y')}$$

$$h_x = \frac{h(x'+1, y') - h(x'-1, y')}{2}$$

$$h_y = \frac{h(x', y'+1) - h(x', y'-1)}{2}$$

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

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

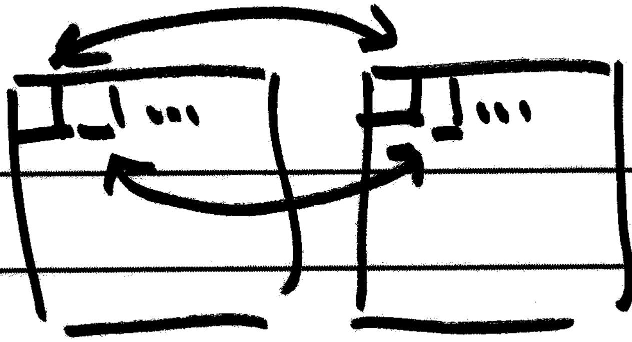
$$\frac{\partial F}{\partial b_1} = -h_y x$$

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

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

$$\frac{\partial F}{\partial k_1} = -h\,(x', y')$$

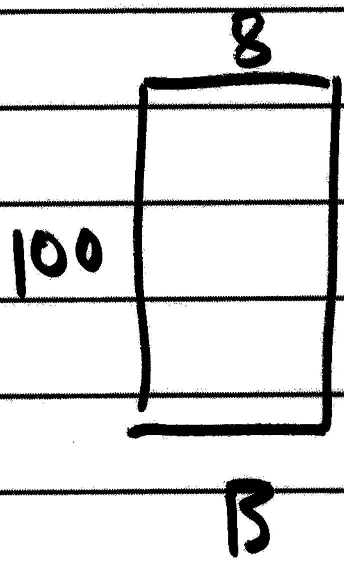
$$\frac{\partial F}{\partial k_2} = -1$$



$a_3 \perp b_3$

$\Sigma_{\Delta\theta}$

$\Sigma \begin{pmatrix} a_3 \\ b_3 \end{pmatrix}$



$B^T B : 8 \times 8$

- solve for 8 parameters
- resample one image
- repeat until converged

TIN : Generation

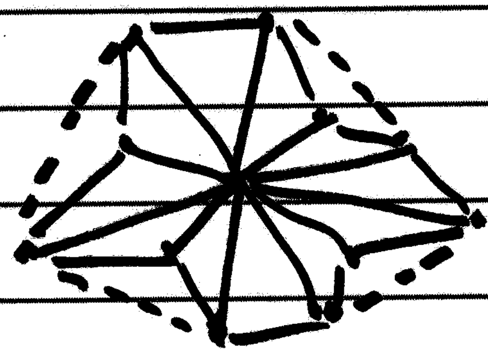
start with x, y, z random
end with Δ's such that
nearly equilateral

- Radial Sweep algorithm
- Watson algorithm

Delaunay Triangulation

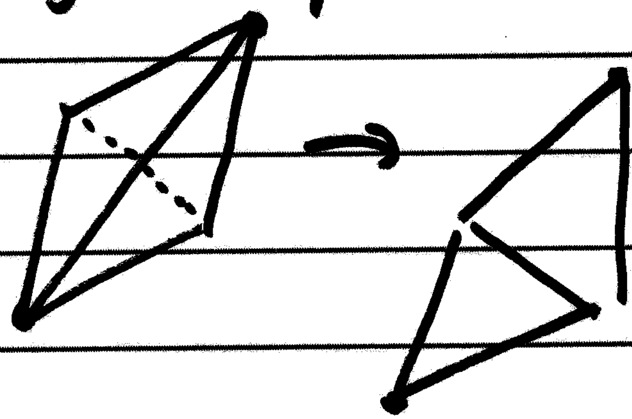
Radial Sweep

1. select point near centroid of data
2. compute bearing + distance to all other points
3. sort by bearing + distance



4. from radial △'s build △ list
5. fill concave areas @ border
6. Now you have convex polygon for boundary & complete triangulation but – nonoptimal shape

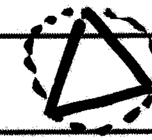
7. optimization - compare shape of adjacent pairs



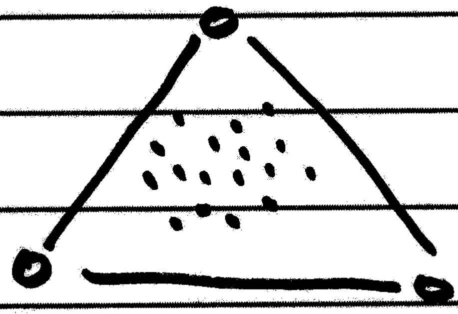
8. do until no changes

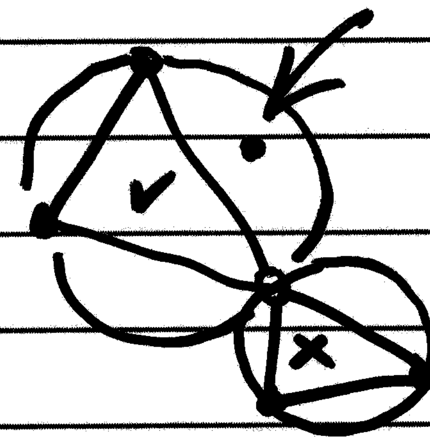
Watson Algorithm

26- 14



1. create fictitious points (3) and Δ to include all others





2. pick a point
3. find all Δ's whose circumscribed circle contains point