CAP 5415 Computer Vision
Fall 2005

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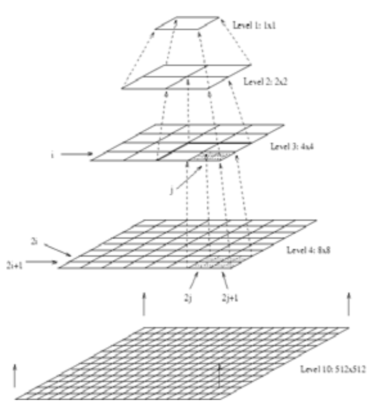
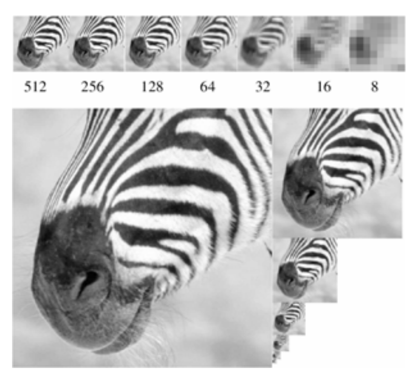
www.cs.ucf.edu/courses/cap5415/fall2005
Office: CSB 250

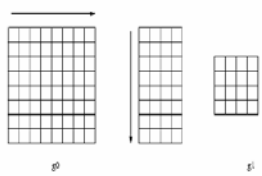
Recap
Pyramids





Recap
Gaussian Pyramids

- Smooth rows 1, 3, 5, … N by 1D Gaussian
  - Select filtered rows
- Smooth columns 1, 3, 5, … N by 1D Gaussian
  - Select filtered columns
- Create image ¼th of original image size



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Recap
Laplacian Pyramid

- Synthesis (Coding)
  - Compute Gaussian pyramid
  - Compute Laplacian pyramid

$$L_1 = g_1 - EXPAND[g_2]$$
$$L_2 = g_2 - EXPAND[g_3]$$
$$L_3 = g_3 - EXPAND[g_4]$$
$$L_4 = g_4$$

- Analysis (Decoding)
  - Compute Gaussian pyramid from Laplacian pyramid
  - g_1 is reconstructed image

$$g_4 = L_4$$
$$g_3 = EXPAND[g_4] + L_3$$
$$g_2 = EXPAND[g_3] + L_2$$
$$g_1 = EXPAND[g_2] + L_1$$

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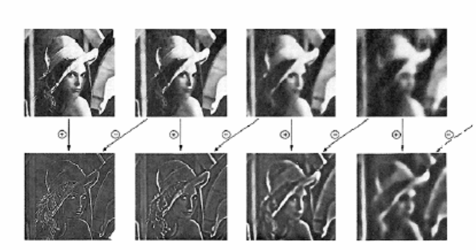
Constructing Laplacian Pyramid

- Compute Gaussian pyramid

$g_k, g_{k-1}, g_{k-2}, \cdots g_2, g_1$

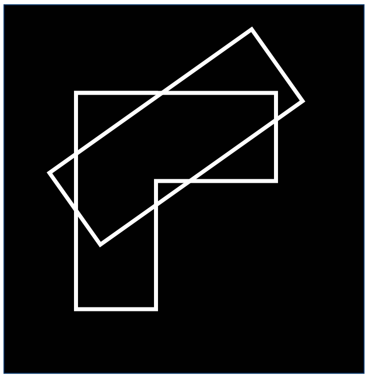
- Compute Laplacian pyramid as follows:

$$
\begin{aligned}
L_k &= g_k - EXPAND(g_{k-1}) \\
L_{k-1} &= g_{k-1} - EXPAND(g_{k-2}) \\
L_{k-2} &= g_{k-2} - EXPAND(g_{k-3}) \\
&\vdots \\
L_1 &= g_1
\end{aligned}
$$

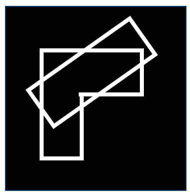


Hough Transform

Line Fitting



Line Fitting



- Line equation

  $y = mx + b \qquad m$ is slope, b is y-intercept
- Using edge pixels
  - Compute b for every m

  $b_i = y - m_j x$
- Problematic for vertical lines
  - m and b grow to infinity

Line Fitting

- Polar coordinate representation
  - For each point on line θ and ρ are constant
  - Numerically stable for lines in any orientation

$$x\cos\theta + y\sin\theta = \rho \qquad \textbf{(A)}$$

- Different choices of θ for constant ρ gives different choices of lines

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Algorithm

- Construct accumulator array in 2D (θ,ρ)
  - Initial values 0
- Select granularity of angle θ
  - For instance 10° increments
- For every edge point
  - Compute ρ using (A)
  - Increment accumulator array by one for each computed (θ,ρ) pair.

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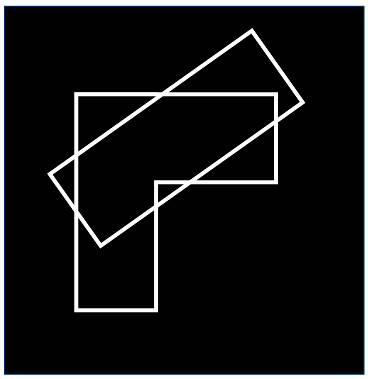
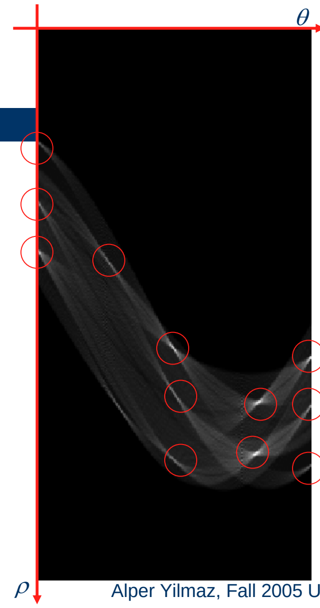
Line Fitting





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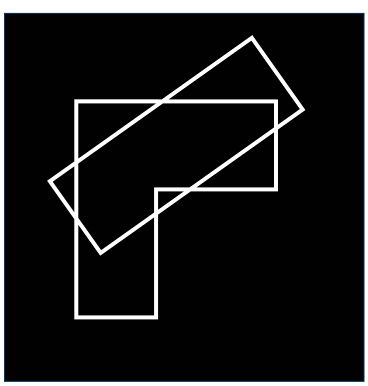
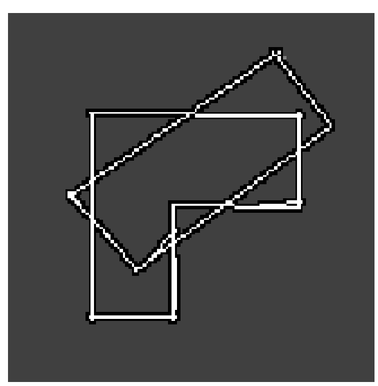
Line Fitting





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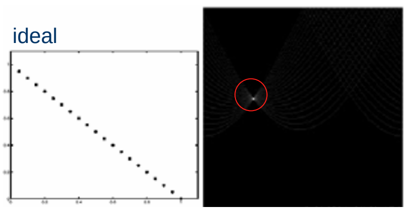
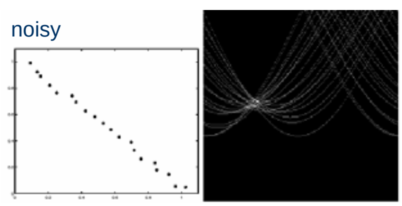
Line Fitting Examples

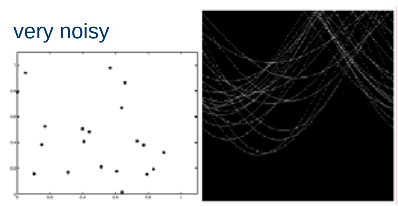
ideal



noisy



very noisy



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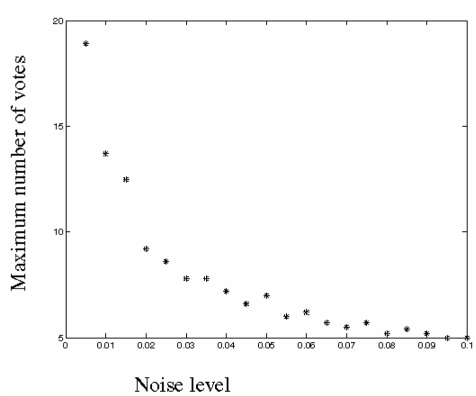
Noise Factor



This is the number of votes that the real line of 20 points gets with increasing noise

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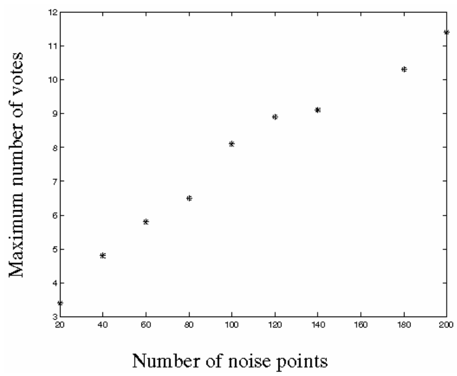
Noise Factor



as the noise increases in a picture without a line, the number of points in the max cell goes up, too

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Difficulties

- What is the increments for θ and ρ.
  - too big? We cannot distinguish between different lines
  - too small? noise causes lines to be missed
- How many lines
- Which edge point belongs to which line
- Hardly ever satisfactory due to noise.

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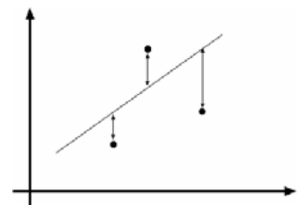
Least Squares Fit

- Standard linear solution to estimating unknowns.
  - If we know which points belong to which line
  - Or if there is only one line

$$y = ax + b = f(x, a, b)$$

$$\text{Minimize } E = \sum_i \left[y_i - f(x_i, a, b) \right]^2$$

Take derivative wrt *a* and *b* set to 0



Line Fitting

$$y = ax + b$$

$$\Downarrow$$

$$y_1 = ax_1 + b$$
$$y_2 = ax_2 + b$$
$$\vdots$$
$$y_n = ax_n + b$$

$$\underbrace{\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}}_{B} = \underbrace{\begin{bmatrix} x_1 & 1 \\ x_2 & 1 \\ \vdots & 1 \\ x_n & 1 \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} a \\ b \end{bmatrix}}_{C} \Rightarrow B = AC$$

$$\Downarrow$$

$$A^T B = A^T A C$$
$$\left(A^T A\right)^{-1} A^T B = \left(A^T A\right)^{-1} \left(A^T A\right) C$$
$$C = \left(A^T A\right)^{-1} A^T B$$

Programming assignment

- Implement line fitting algorithm
- Due date October 24
- You will be given an image of the following form

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Programming Assignment Reminder

- A week from today
- Submit hardcopy of the code.
- Submit program on a CD.
- Do NOT email your projects!!

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