Ανίχνευση Ακμών

Τελεστής Κλίσης

$$\nabla \mathrm{f} = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

- η πρώτη παράγωγος μιας εικόνας υπολογίζεται ως το *μέτρο της κλίσης*

$$|\nabla f| = mag(\nabla \mathrm{f}) = [G_x^2 + G_y^2]^{1/2}$$

$$= \left[\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2\right]^{1/2}$$

$$|\nabla f| \approx |G_x| + |G_y|$$

συνήθης προσέγγιση

το μέτρο είναι μη γραμμικό

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

Μάσκα υπολογισμού κλίσης

- προσέγγιση με 2x2 μάσκες

$$G_x = (z_8 - z_5) \quad \text{and} \quad G_y = (z_6 - z_5)$$

$$\nabla f = [G_x^2 + G_y^2]^{1/2} = [(z_8 - z_5)^2 + (z_6 - z_5)^2]^{1/2}$$

$$\nabla f \approx |z_8 - z_5| + |z_6 - z_5|$$

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

Άλλες 2x2 μάσκες

- Τελεστές Roberts

$$G_x = (z_9 - z_5) \quad \text{and} \quad G_y = (z_8 - z_6)$$

$$|\nabla f| = [G_x^2 + G_y^2]^{1/2} = [(z_9 - z_5)^2 + (z_8 - z_6)^2]^{1/2}$$

$$|\nabla f| \approx |z_9 - z_5| + |z_8 - z_6|$$

−1	0
0	1

0	−1
1	0

Οι πιο δημοφιλείς μάσκες

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

- Τελεστές Sobel (3x3 μάσκες)

$$G_x = (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)$$

$$G_y = (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7)$$

$$|\nabla f| \approx |G_x| + |G_y|$$

ο συντελεστής 2 χρησιμοποιείται για εξομάλυνση δίνοντας μεγαλύτερη σημασία στο κεντρικό pixel

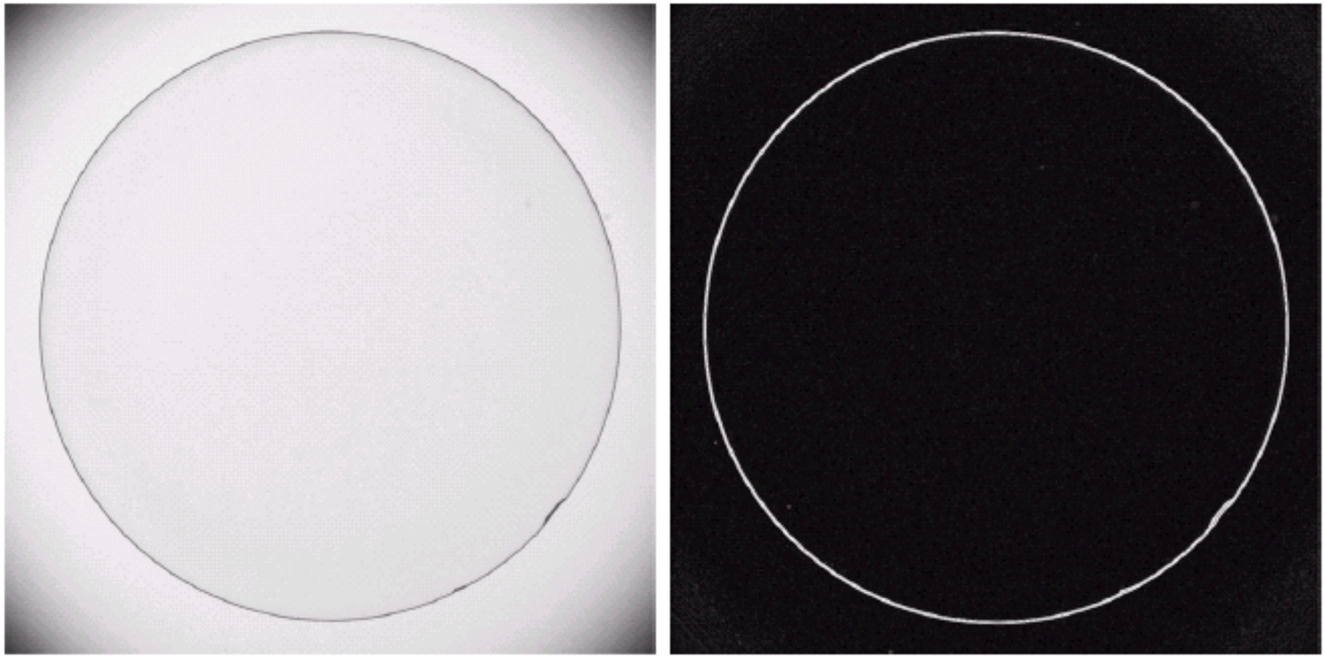
−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Σημείωση

- Το άθροισμα των συντελεστών σε όλες τις μάσκες ισούται με το μηδέν ούτως ώστε η απόκριση των τελεστών σε περιοχές σταθερών αποχρώσεων γκρίζου να είναι μηδέν.

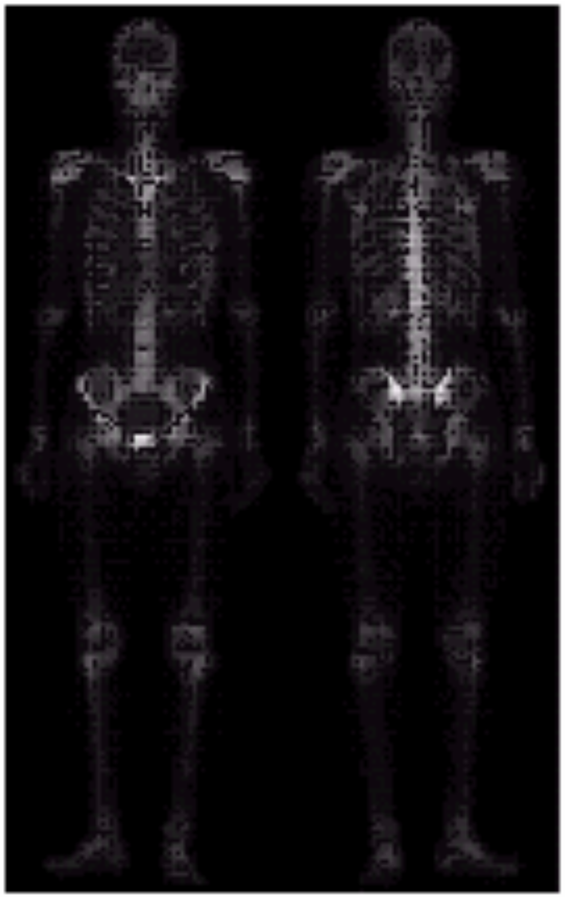
Παράδειγμα



a b

FIGURE 3.45 Optical image of contact lens (note defects on the boundary at 4 and 5 o'clock). (b) Sobel gradient. (Original image courtesy of Mr. Pete Sites, Perceptics Corporation.)

Example of Combining Spatial Enhancement Methods



- want to sharpen the original image and bring out more skeletal detail.
- problems: narrow dynamic range of gray level and high noise content makes the image difficult to enhance

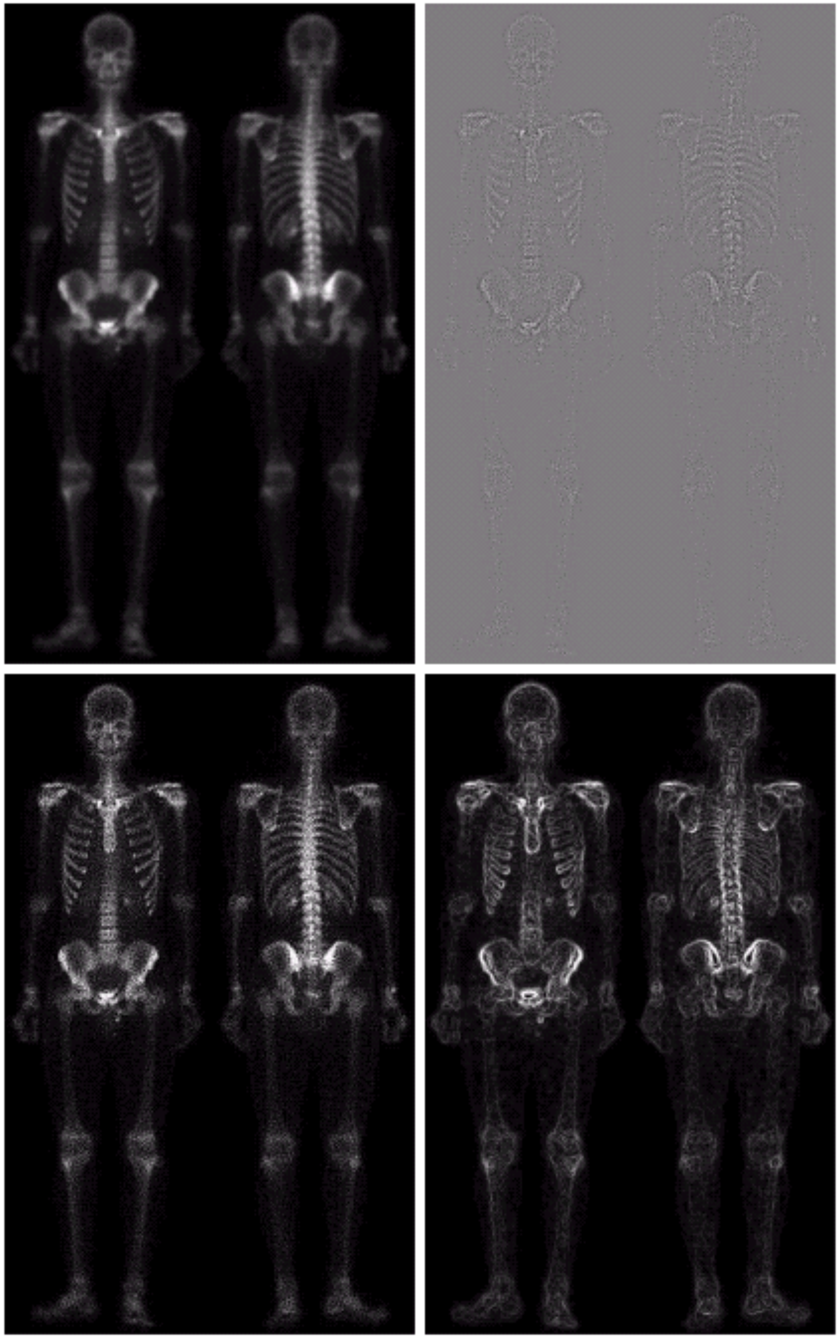
Example of Combining Spatial Enhancement Methods

- Enhancement steps:

  1. Laplacian to highlight fine detail

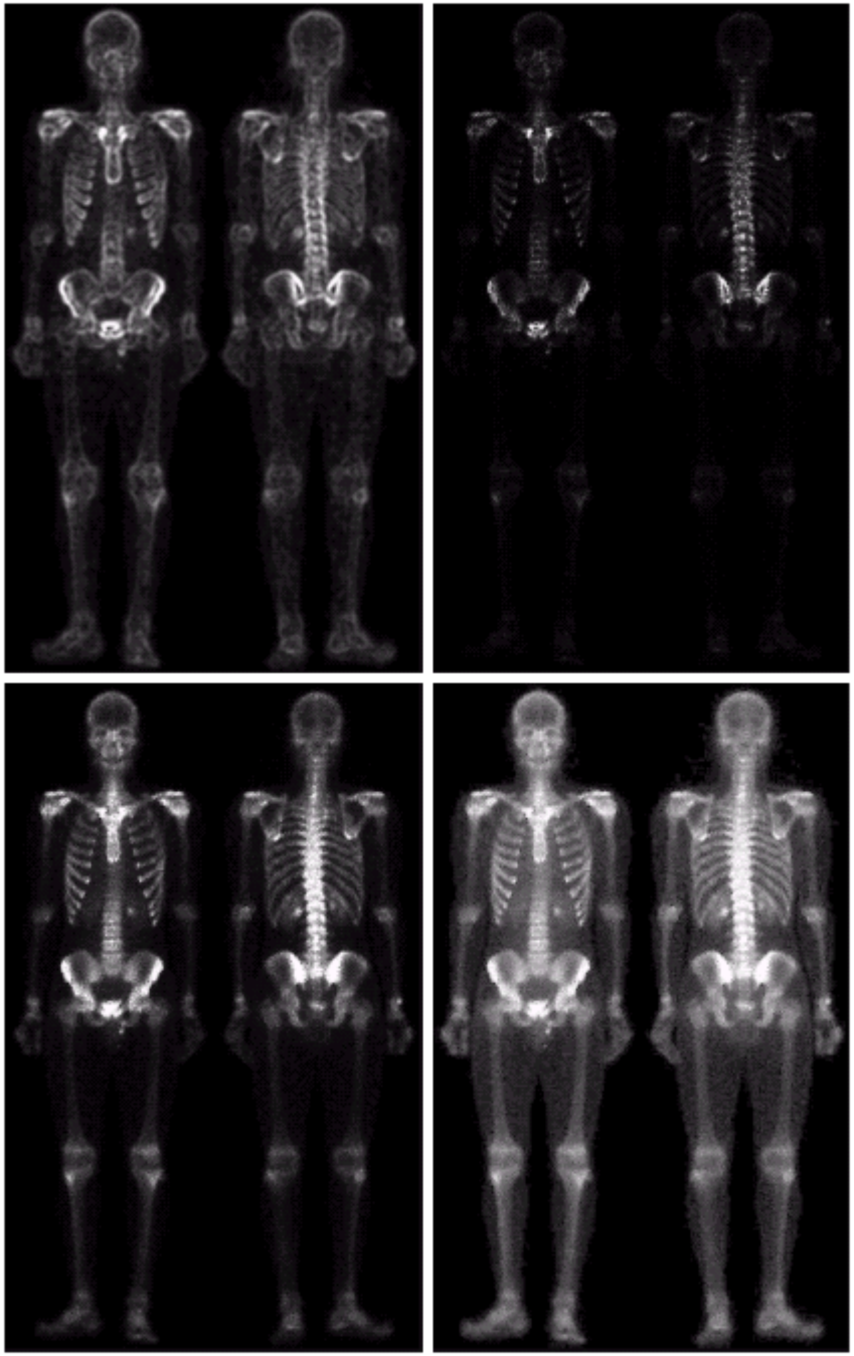
  2. Gradient to enhance prominent edges

  3. Gray-level transformation to increase the dynamic range of gray levels



a	b
c	d

FIGURE 3.46
(a) Image of whole body bone scan.
(b) Laplacian of (a). (c) Sharpened image obtained by adding (a) and (b). (d) Sobel of (a).



e	f
g	h

FIGURE 3.46 *(Continued)* (e) Sobel image smoothed with a 5×5 averaging filter. (f) Mask image formed by the product of (c) and (e). (g) Sharpened image obtained by the sum of (a) and (f). (h) Final result obtained by applying a power-law transformation to (g). Compare (g) and (h) with (a). (Original image courtesy of G.E. Medical Systems.)

Canny Edge Detection

- Optimal edge detector
- Canny: "A Computational Approach to Edge Detection"
- Criteria of optimality:
  - low error rate, i.e., do not miss important edges and do not respond to non-edges
  - edge localization, i.e., the distance between the edge pixels found and the actual edge is minimal
  - one response, i.e., eliminate the possibility of multiple responses to an edge

Algorithm implementation: Step 1

- Filter out any noise in the original image before trying to locate and detect any edges
- Choose suitable Gaussian mask and convolve it with the image
- The larger the width (σ) of the Gaussian mask, the lower the detector's sensitivity to noise
- Example of Gaussian mask for σ = 1.4

$$\frac{1}{115}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix}$$

Algorithm implementation: Step 2

- Find edge strengths by taking the gradient of the image
- Use Sobel operators Gx and Gy

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

- The magnitude, or edge strength, of the gradient is then approximated using the formula:

$$\boxed{|G| = |Gx| + |Gy|}$$

Algorithm implementation: Step 3

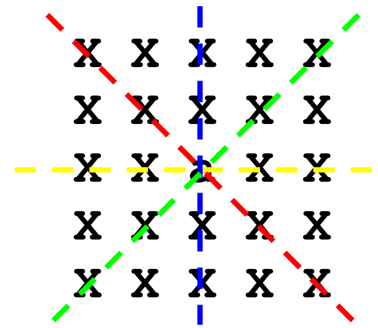
- Use gradient information in the x and y directions in order to find the edge orientation:

$$\theta = \tan^{-1} (Gy / Gx) - 90^{o}$$

- Caution, when $Gx = 0$:
  - whenever $Gy = 0$, then there is no edge and θ will be arbitrary
  - otherwise, when $Gy \neq 0$, the edge orientation will be equal to 0 degrees

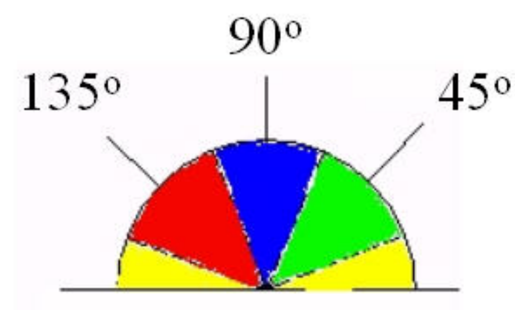
Algorithm implementation: Step 4

- Relate the edge direction to a direction that can be traced in an image.



5x5 subimage

- Looking at pixel "a", the four possible directions are – 0^o, 45^o (positive diagonal), 90^o and 135^o (negative diagonal). Resolve edge orientation into closest direction.



Algorithm implementation: Step 5

- Apply nonmaximal suppression
- Nonmaximal suppression is used to trace along the edge in the edge direction and suppress any pixel value (sets it equal to 0) that is not considered to be an edge. This will give a thin line in the output image.

Algorithm implementation: Step 6

- Eliminate streaking, i.e., the breaking up of the edge contour caused by the operator fluctuating above and below the threshold used to decide if a gradient strength should be considered an edge.
- Streaking can be eliminated by thresholding with hysteresis. Hysteresis uses 2 thresholds, a high T1 and a low T2. Any pixel in the image with a value greater than T1 is presumed to be an edge pixel, and is marked as such immediately. Then, any pixels connected to this edge pixel having a value greater than T2 are also selected as edge pixels.

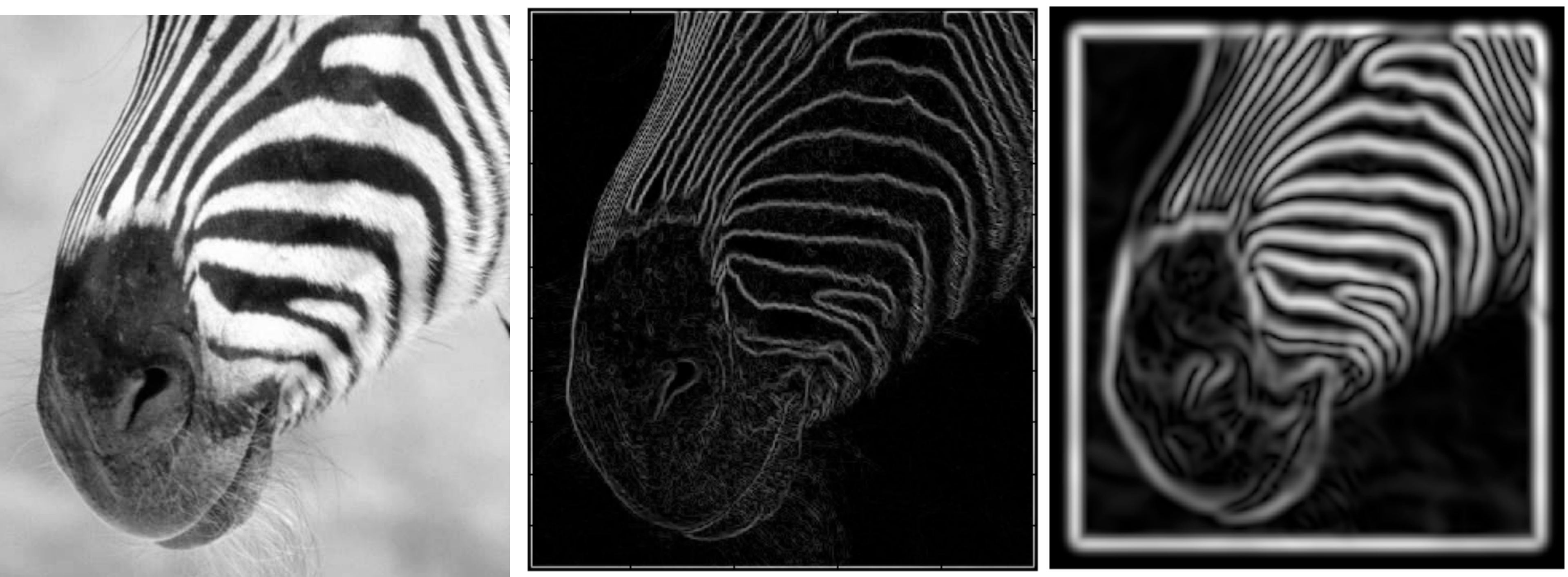
Canny Edge Detection

- Gaussian Smoothing
- Gradient Estimation
- Non-maximal suppression
- Thresholding with hysteresis
- Feature Synthesis

Scale is selected through smoothing

Smoothing:

- **Eliminates spurious edges**
- **Removes fine detail**



fine scale
high
threshold

coarse scale, high threshold

coarse
scale
low
threshold

Βιβλιογραφία

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