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Computer Graphics and Image Processing

Lecture B4

Region Processing (2)

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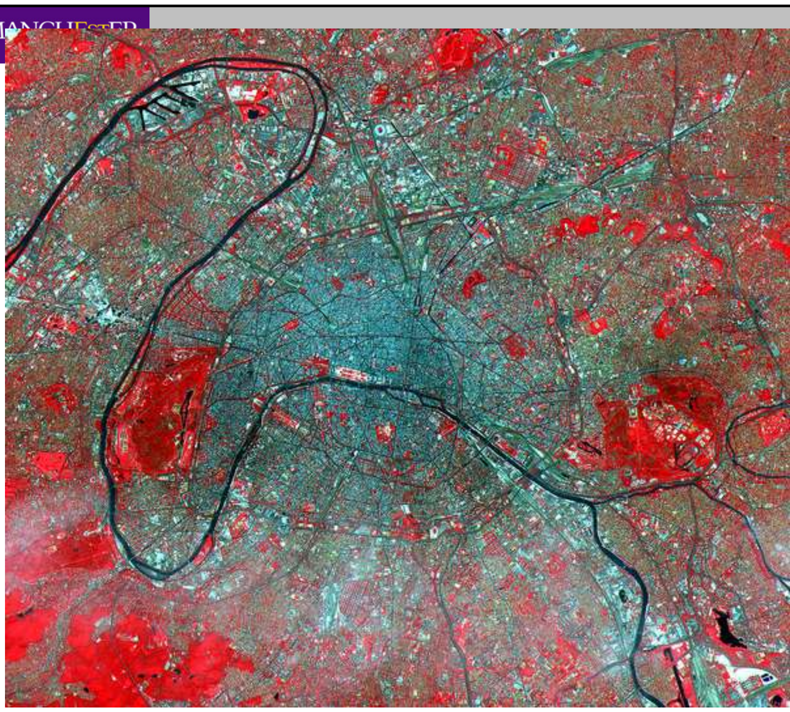

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- *n* bands of input data
  - Within and beyond visible spectrum
- 3 bands of output data
  - An input band
  - Combine sets of input
  - Ratio of input bands
- Calibration with ground truth suggests what mappings are useful

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Edge Definition

An edge is an extended, significant, local change in image intensity.

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First Derivative, Gradient Edge Detection

- If an edge is a discontinuity
- Can detect it by differencing
- Convolve with appropriate templates
  - Suggestions?

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Delta X and Delta Y

- Subtract horizontally adjacent pixels – Δx
- Subtract vertically adjacent pixels – Δy

- Can these be combined to give the correct edge strength?

Roberts Cross Edge Detector

-1	0
0	1

0	-1
1	0

- Simplest edge detector
- Awkward localisation
  - On the joint between the four pixels
- Noise sensitive
  - If one pixel is corrupted, the edge strength is equally corrupted

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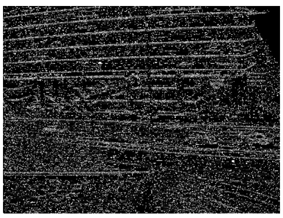
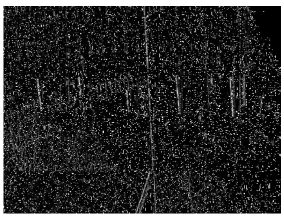
Prewitt/Sobel Edge Detector

-1	-1	-1
0	0	0
1	1	1

-1	0	1
-1	0	1
-1	0	1





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Location and Noise

- Location estimate is at the centre pixel
- More robust against noise
  - Averaging of pixels either side of edge location
  - Noise magnitude reduced by √3 or √4

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Edge Detection

- Combine horizontal and vertical edge estimates

$$Mag = \sqrt{h^2 + v^2}$$

$$\vartheta = \tan^{-1}\frac{v}{h}$$

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Problems

- Images are noise corrupted
  - Edges are noise corrupted
    - problems with detection and localisation
  - Can be improved by smoothing
- Scale
  - What is "local"?
  - Can be investigated by size of smoothing template

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Canny/Deriche Edge Detector

- Require
  - edges to be detected
  - accurate localisation
  - single response to an edge
- Solution
  - Convolve image with Difference of Gaussian (DoG)
  - Template?

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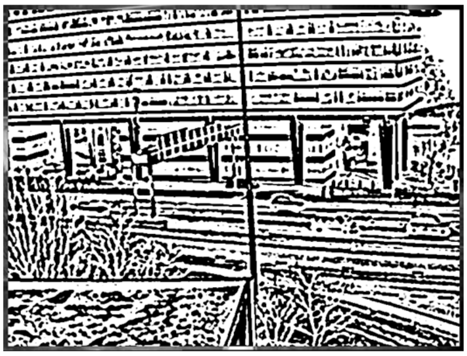
Example Results



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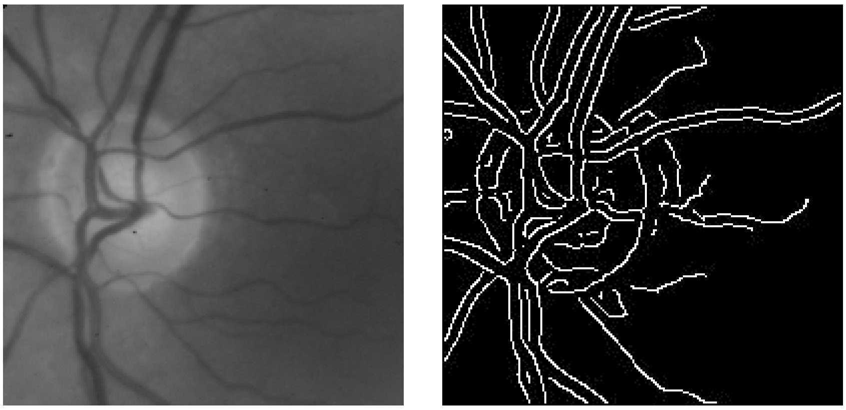
Canny applied to eye image



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Second Derivative Operators Zero Crossing

- Models HVS
- Can locate edge to subpixel accuracy
- Convolve image with Laplacian of Gaussian (LoG)
  - Template?
- Edge location at crossing of zero axis

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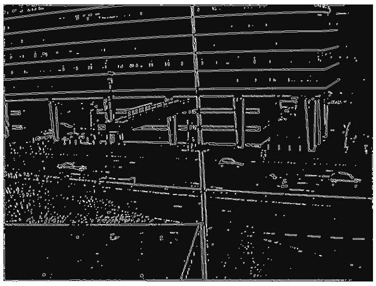
Example Results



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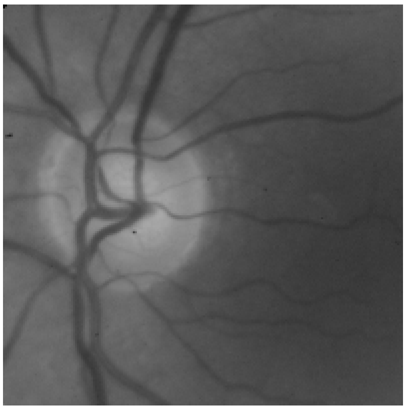
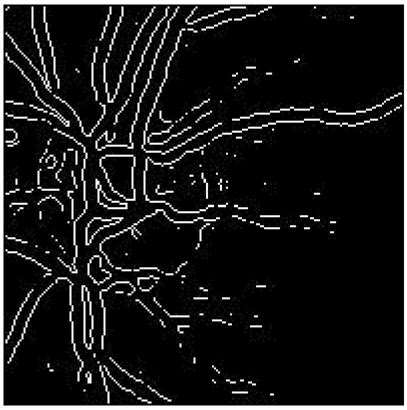
LoG applied to eye image





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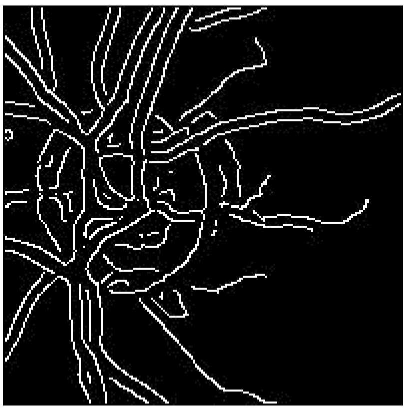
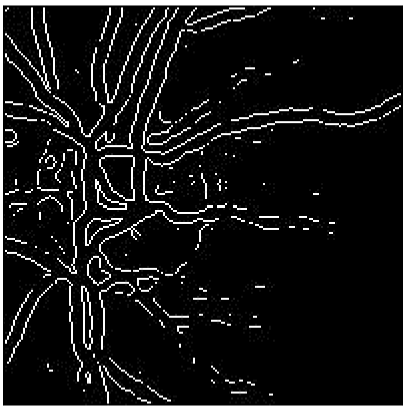
Comparison of Canny and LoG





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Parameter Choices

- Width of Gaussian controlled by σ
- Large σ
  - More smoothing before edge detection
  - Small scale edges are blurred out
- What is a good value for σ?

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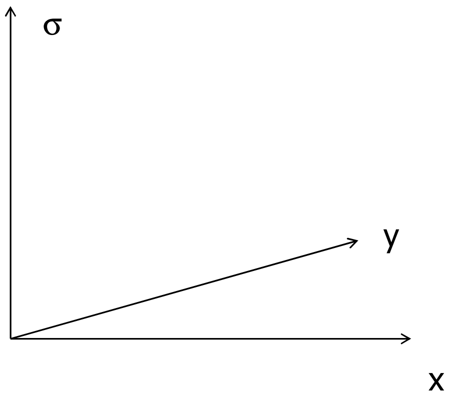
Scale Space



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Template matching

- Technique to measure similarities – hence find things
- Define a template
  - a model of the object to be recognised
- Define a measure of similarity
  - between template and similar sized image region

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Aside: How to measure similarity and why use convolution

Measure dissimilarity between image $f[i,j]$ and template $g[i,j]$

Place template on image and compare corresponding intensities

Need a measure of dissimilarity

$$\max_{[i,j]\in R} |f-g| \qquad \sum_{[i,j]\in R} |f-g| \qquad \sum_{[i,j]\in R} (f-g)^2$$

Last is best....

...easiest to manipulate

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Expanding

$$\sum_{[i,j]\in R} (f-g)^2 = \sum_{[i,j]\in R} f^2 + \sum_{[i,j]\in R} g^2 - 2\sum_{[i,j]\in R} fg$$

If f and g fixed (is this reasonable?)

- $-\Sigma fg$ a good measure of mismatch
- Σfg a good measure of match

Compute match between template and image with cross-correlation

$$M[i,j] = \sum_{k=-m}^{k=m} \sum_{l=-n}^{l=n} g[k,l] f[i+k, j+l]$$

Compare this to expression for convolution

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g is constant, *f* varies and so influences *M*

Normalisation

$$C[i,j] = \frac{\sum_{k=-m}^{k=m} \sum_{l=-n}^{l=n} g[k,l] f[i+k, j+l]}{\sqrt{\left(\sum_{k=-m}^{k=m} \sum_{l=-n}^{l=n} f^2[i+k, j+l] \right)}}$$

C is maximum where *f* and *g* are same.

Limitations

- number of templates required
- rotation and size changes
- partial views

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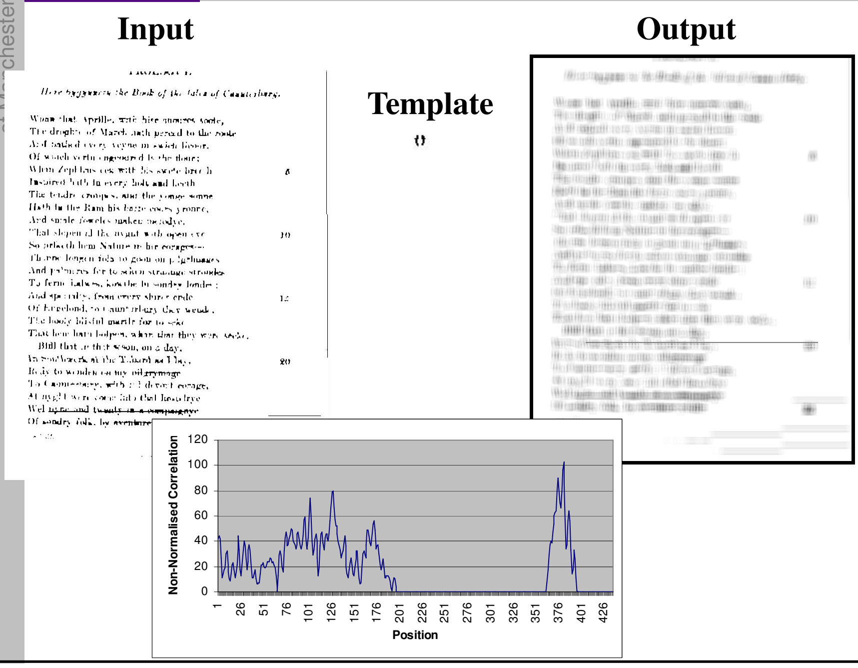
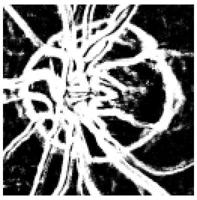
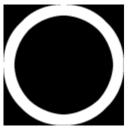


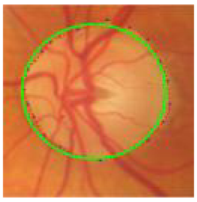
Source



Texture based classification



Template



Result

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Summary

- Sections 3.3, 2.4, 5.5, 7.2

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Computers in the future may weigh no more than 1 ½ tons

Popular Mechanics, 1949