Multimedia Retrieval
Ch 5 Image Processing

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Agenda

- Types of image processing
- Application areas
- Image analysis
- Image features

Types of Image Processing

- Image Acquisition
  - Camera
  - Scanners
  - X-ray imagers
  - Computer tomography (CT)
  - Magnetic resonance scanners (MR)
  - Ultra sound devices (US)

Types of Image Processing

- Image Restoration
  - Geometric distortions
  - Noise
  - Unsharpness

Types of Image Processing

- Image Reconstruction
  - using models
  - different viewpoint
  - another imaging device

Types of Image Processing

- Image Enhancement
  - Contrast enhancement
    - amplitude scaling
    - contrast modification
  - Histogram normalization
    - nonadaptive histogram modification
    - adaptive histogram modification
  - Edge enhancement
    - linear edge crispening
    - statistical differencing

Types of Image Processing

- Image Registration
  - Rigid registration
  - Non-rigid registration
- Used in medical applications, cartography, face recognition, etc.

Types of Image Processing

- Image Compression, Storage and Transmission
  - Lossless
    - image can be exactly reconstructed
  - Lossy
    - approximate reconstruction

Types of Image Processing

- Image Analysis
  - Image analysis aims to generate a description of the image or of objects present in the image.

Application Areas

- Medical Imaging
  - MR, CT, US
- Geo Information Systems, Satellite, Aerial photography and Cartography
- Biometry
  - Face and fingerprint recognition, handpalm recognition, tracking people
  - feature-based and holistic approaches
- Optical Character Recognition
- Industrial Vision
- Multimedia and Image Databases

Image Analysis

- extract information from an image
  - detection
  - classification
  - parameter estimation
  - structural analysis

Image Analysis

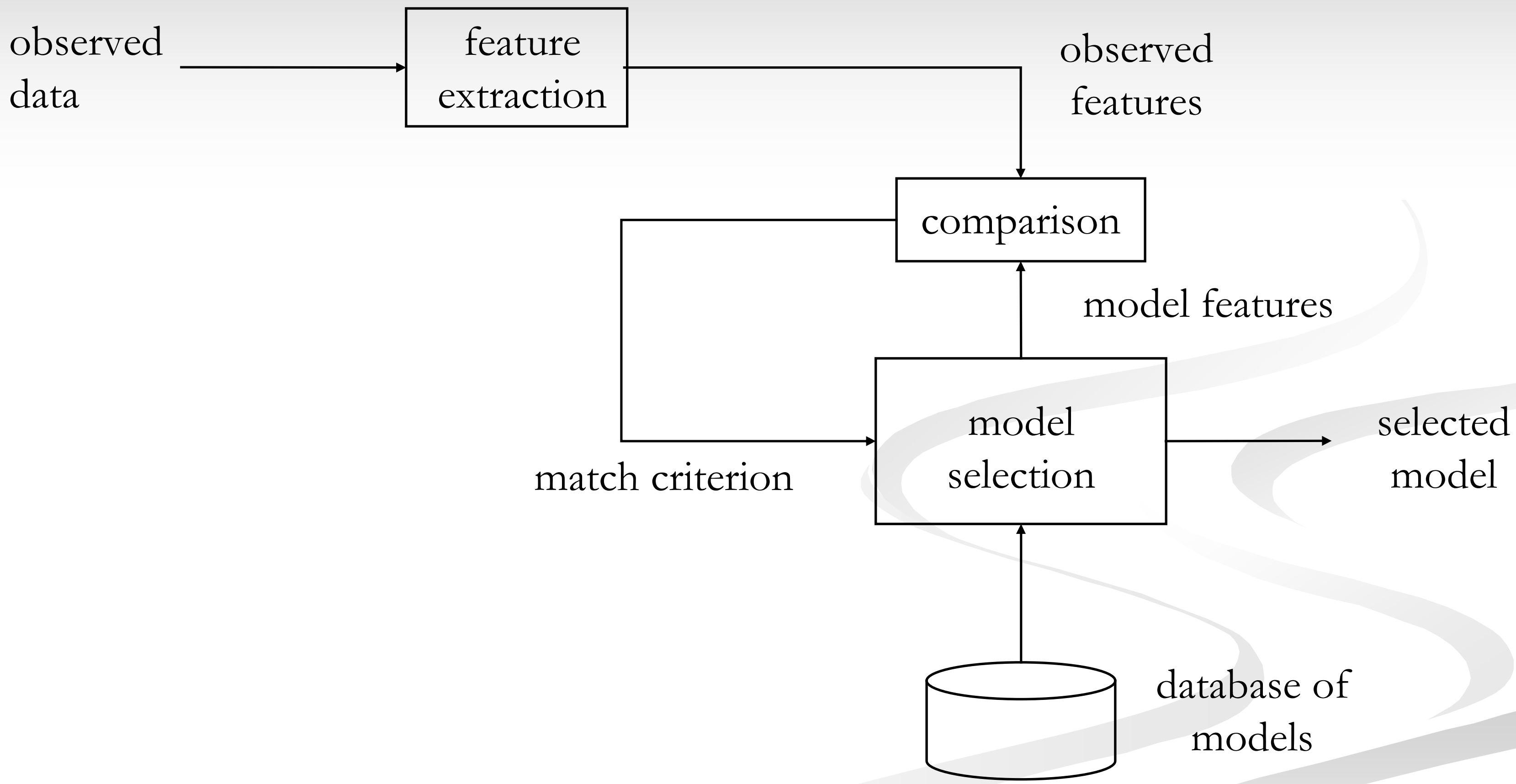


Image Analysis

- Image analysis task
  - the selection of the features
  - the representation of the models
  - the matching criterion
  - the selection strategy

Image Features

- Image
  - 2-dimensional signal
  - represented by a matrix F of pixels of N rows and M columns
  - A pixel value f(n,m) is an intensity or a vector of 3 RGB components
  - mathematical operations are possible e.g. derivative and Fourier transformation

Image Features

- Pixel Features
  - Neighborhood and Image filtering
    - each pixel an individual feature
    - neighboring pixels grouped together
    - used to obtain higher level features

Image Features

- Scale space and derivatives
  - scale at which objects are seen in an image depends on the distance between object and camera
  - scale space theory for handling image structures at different scale
  - derivatives important for edge detection, point feature detection, and so on

Image Features

- Texture
  - small elementary pattern repeated periodically or quasi-periodically
  - geometric or radiometric pattern
  - important clues for segmenting the image
  - typified by
    - the distance over which the patter is repeated
    - the direction in which the pattern is repeated
    - the properties of the elementary pattern
  - co-occurrence matrices

Image Features

- Point Features
  - Interest points
    - corner points and spots
    - video tracking, stereo matching, object recognition
    - Harris corner detector

Image Features

- Harris corner detector
  - image I(x,y) and sifted image I(x+u, y+v)
  - Gaussian window function w(x,y) $E(u,v) \cong au^2 + bv^2 + 2cuv$
  - E(u,v) should change fast for small sifts of (u,v)

$$E(u,v) = \sum_{x,y} w(x,y)\left[I(x+u, y+v) - I(x,y)\right]^2$$

Image Features

$$E(u,v) \cong [u,v]M\begin{bmatrix} u \\ v \end{bmatrix}$$

where

$$M = \sum_{x,y} w(x,y)\begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix}$$

λ_1, λ_2 eigenvalues of M

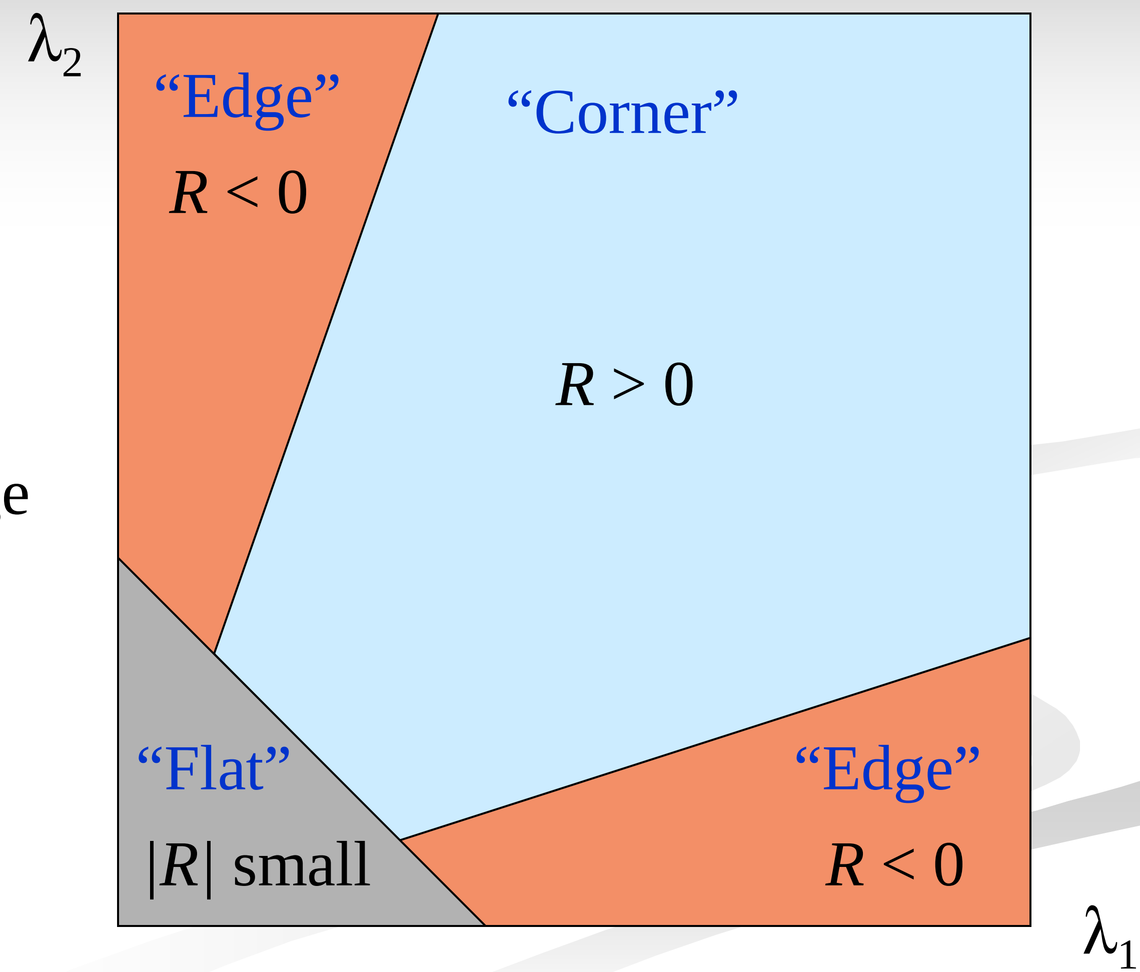
$$R = \det M - k(traceM)^2$$

$$\det M = \lambda_1 \lambda_2$$

$$traceM = \lambda_1 + \lambda_2$$

Image Features

- R depends only on eigenvalues of M
- R is large for a corner
- R is negative with large magnitude for an edge
- $|R|$ is small for a flat region



sourse(www.wisdom.weizmann.ac.il/~deniss/vision_spring04/files/InvariantFeatures.ppt)

Image Features

- Line elements
  - line segments have a width in the image equal to the scale of the image, Gaussian like profile across the line
  - calculate the second derivative in the direction orthogonal to the gradient vector
  - more stable result is obtained by approximating the neighborhood of each candidate line element by quadratic surface:
  - (n,m) is the position of the candidate line element

$$f(n-k, m-l) \cong f(n,m) + ak^2 + bl^2 + 2ckl$$

Image Features

- using Taylor expansion

$$f(n-k, m-l) \cong f(n,m) + \begin{bmatrix} k & l \end{bmatrix} H \begin{bmatrix} k \\ l \end{bmatrix}$$

where

$$H = \begin{bmatrix} f_{xx} & f_{xy} \\ f_{xy} & f_{yy} \end{bmatrix}$$

- λ_1, λ_2 are eigenvalues of H
- for true line element, one eigenvalue should be large and the other small

Image Features

- Edge elements
  - stepwise transition in intensities
  - neighboring edge elements linked to gether form an edge segment
  - gradient is large at the position of an edge
  - Gradient-based methods
  - Laplacian-based methods
  - Canny's method

Image Features

- Canny's method

1. Smooth the image with Gaussian filter
   $g(x,y)=g_c(x,y)*f(x,y)$
   where
   $$g_c(x,y)=\frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right)$$
   where σ represents the width of the Gaussian distribution

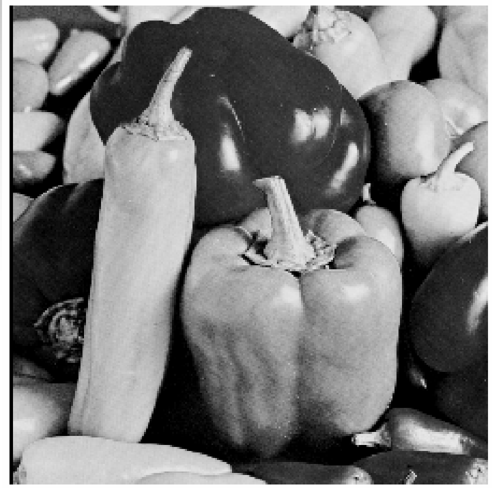
2. Compute the second derivative in the gradient direction

$$\frac{\partial^2 g}{\partial n^2}=\frac{g_x^2 g_{xx}+2g_x g_y g_{xy}+g_y^2 g_{yy}}{\sqrt{g_x^2+g_y^2}}$$

3. Find zero crossings of the second derivative

Image Features

- Pros:
  - One pixel wide edges
  - Edges are grouped together (often good for segmentation)
  - Robust against noise!
- Cons:
  - Complicated to understand and implement
  - Slow



References

- Blanken et al, Multimedia Retrieval, 2007, Springer
- Pratt, W: Digital Image Processing, 2001, John Wiley & Sons INC
- Bovik, A: Handbook of Image & Video Processing, 2000, Academic Press
- Castelman, K: Digital Image Processing, 1996, Prentice Hall
- Harris, C: A Combined Corner and Edge Detector, 1988,