Image Processing for feature extraction

Outline

- Images as discrete functions
- Rationale for image pre-processing
- Gray-scale transformations
- Geometric transformations
- Local preprocessing

- Reading: Sonka et al 2.2, 2.3

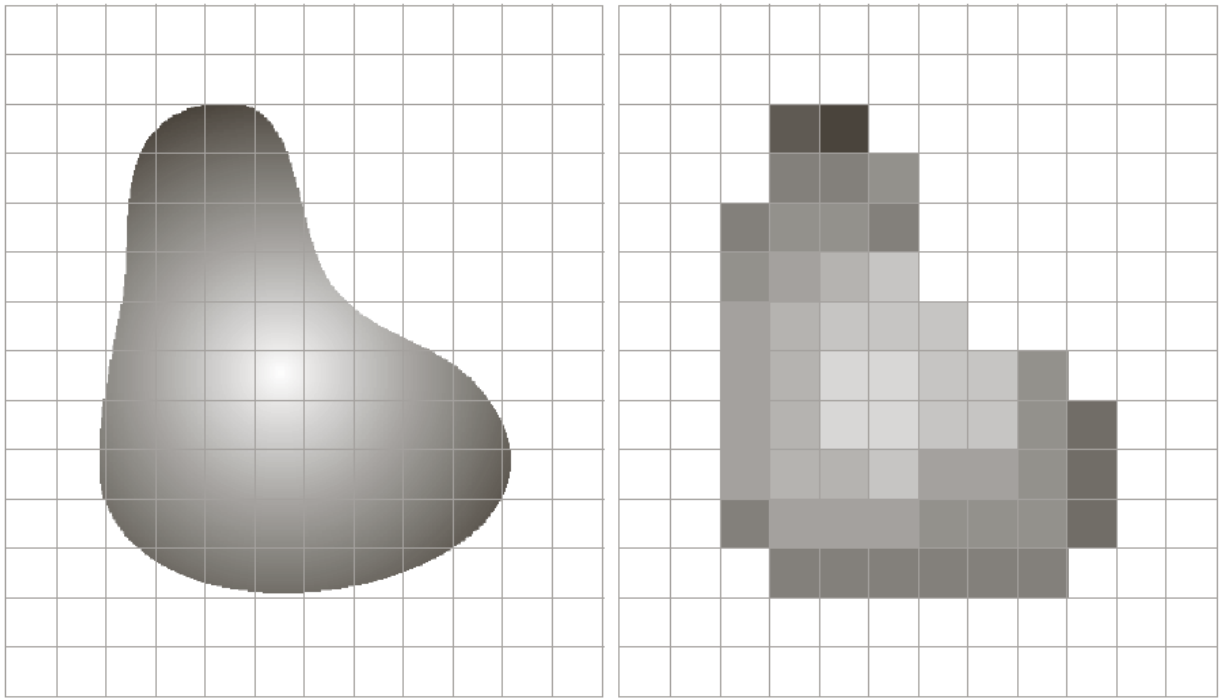
Image functions

- The **image** can be modeled by a function of two or three variables;
  - f(x,y)
  - f(x,y,z)
  - f(x,y,t)
- Values in an image can be of many types:
  - Scalars: monochromatic images;
  - Physical significance: X-Ray, MRI, Range images
  - Vectors:
    - color images (R,G,B);
    - LANDSAT images (7 distinct channels)

Digital images

- **Sampling**=spacing of discrete values in the domain of an image
  - sampling rate–how many samples are taken per unit of each dimension. “dots per inch”, etc.
- **Quantization**= spacing of discrete values in the range of an image
  - number of bits per pixel. “black and white images” (1 bit per pixel), “24-bit color images”, etc.
- Sampling and quantization are independent
- Shannon’s sampling theorem: must sample at at least twice the highest spatial frequency in the image.
- **Resolution:** ability to discern fine detail in the image

Effects of sampling and quantization-1



a b

FIGURE 2.17 (a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.

Reasoning on the pixel grid

- Many of the image processing algorithms we'll study involve "neighboring" samples
  - "Who is my neighbor?"
- Common neighborhoods:
  - 4-connected (N, S, E, W)
  - 8-connected (add NE, SE, SW, NW)
- How can we compute the distance between two spatial locations in the same image?
  - Euclidean
  - 4-connected ("city block", "Manhattan")
  - 8-connected ("chessboard")

See also textbook Section 2.3.1

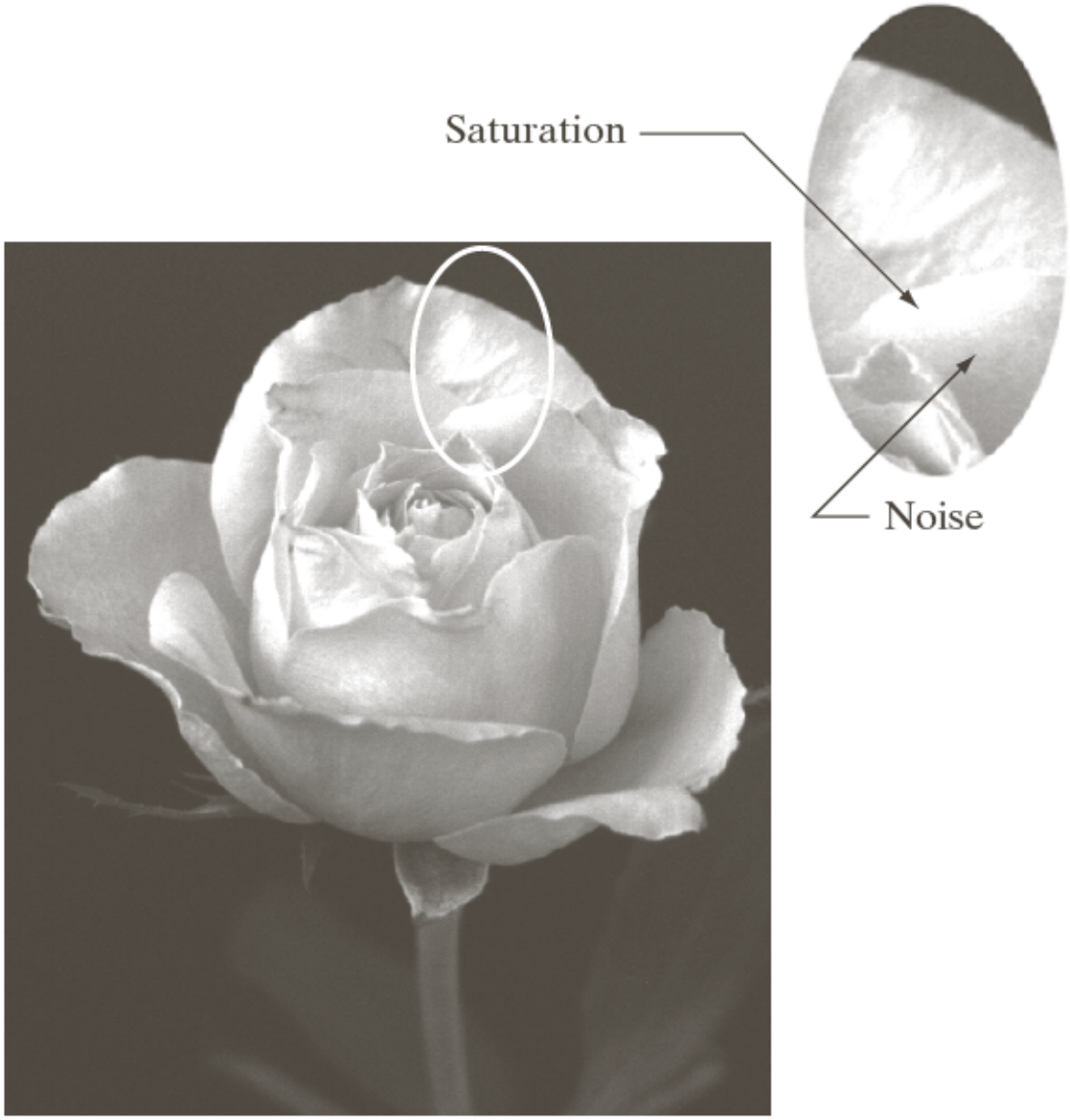
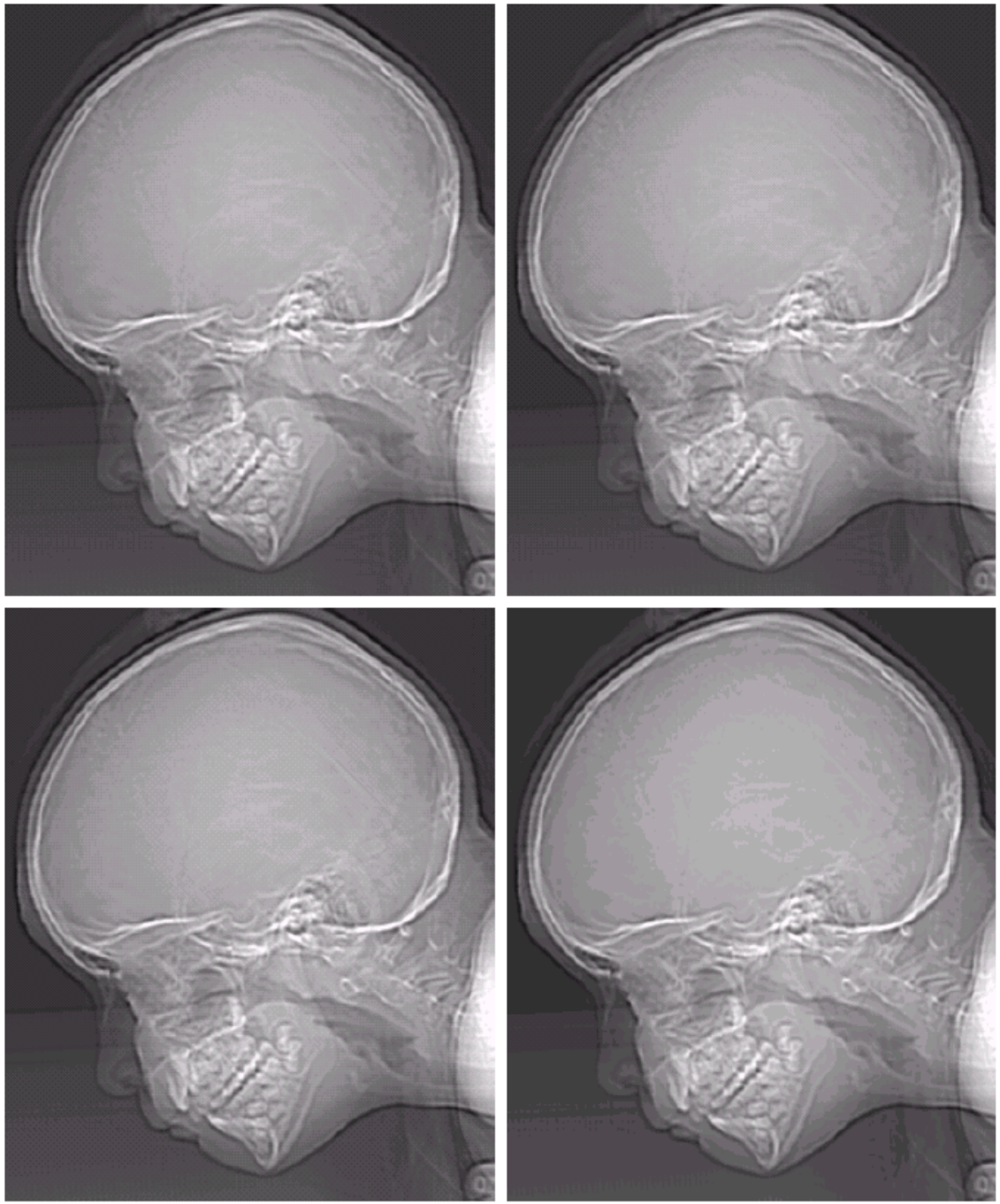


FIGURE 2.19 An image exhibiting saturation and noise. Saturation is the highest value beyond which all intensity levels are clipped (note how the entire saturated area has a high, *constant* intensity level). Noise in this case appears as a grainy texture pattern. Noise, especially in the darker regions of an image (e.g., the stem of the rose) masks the lowest detectable true intensity level.

a b
c d

FIGURE 2.20 Typical effects of reducing spatial resolution. Images shown at: (a) 1250 dpi, (b) 300 dpi, (c) 150 dpi, and (d) 72 dpi. The thin black borders were added for clarity. They are not part of the data.



a b
c d

FIGURE 2.21 (a) 452 × 374, 256-level image. (b)–(d) Image displayed in 128, 64, and 32 gray levels, while keeping the spatial resolution constant.

e f
g h

FIGURE 2.21 *(Continued)* (e)–(h) Image displayed in 16, 8, 4, and 2 gray levels. (Original courtesy of Dr. David R. Pickens, Department of Radiology & Radiological Sciences, Vanderbilt University Medical Center.)

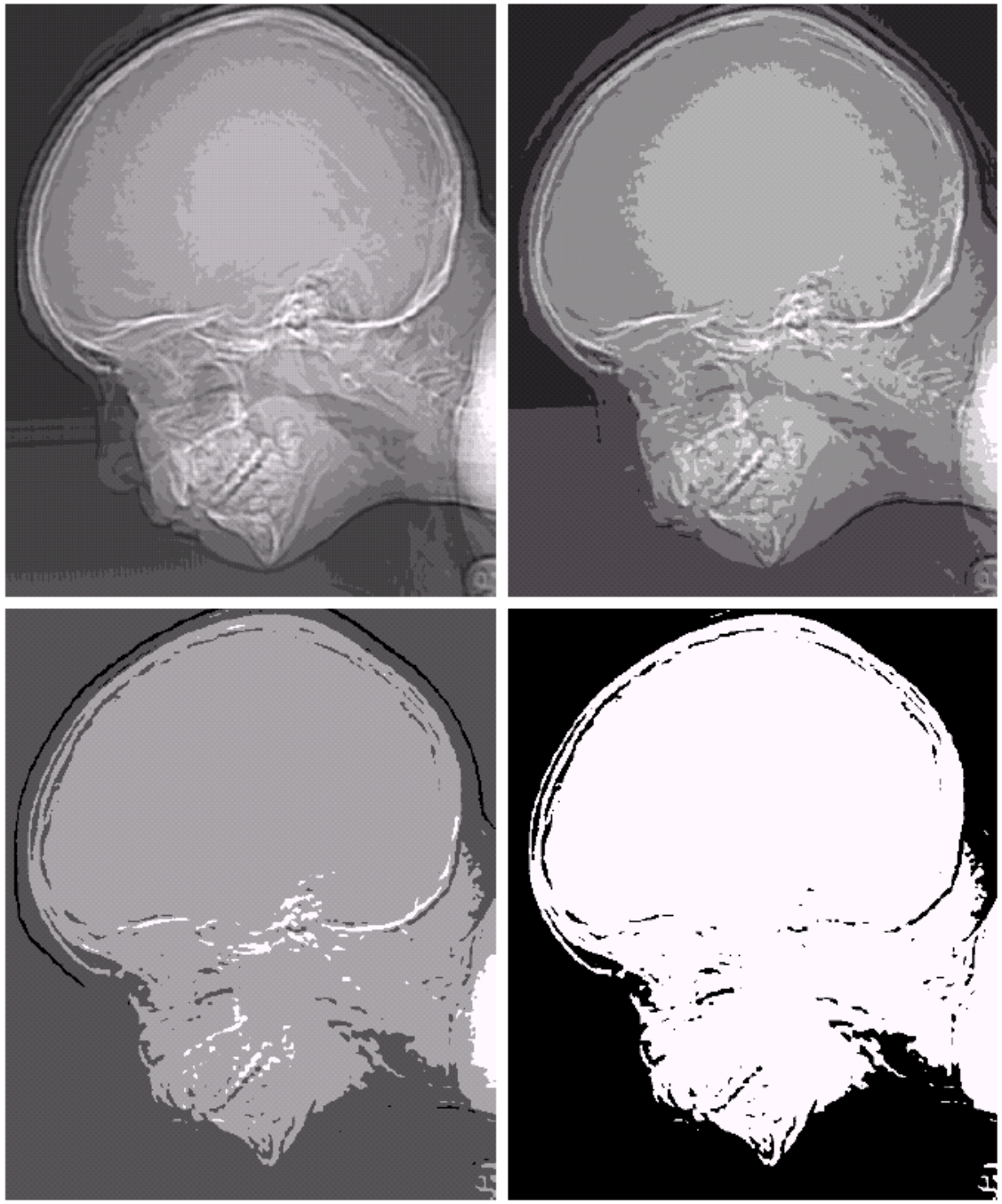


Image (pre)processing for feature extraction

- Pre-processing does not increase the image information content
- It is useful on a variety of situations where it helps to suppress information that is not relevant to the specific image processing or analysis task (i.e. background subtraction)
- The aim of preprocessing is to improve image data so that it suppresses undesired distortions and/or it enhances image features that are relevant for further processing

Image (pre)processing for feature extraction

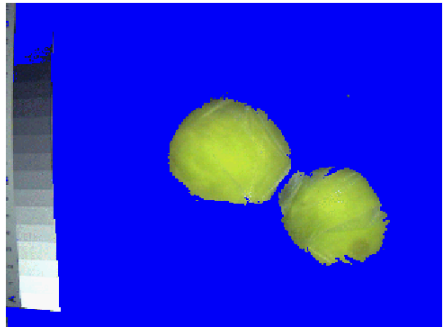
- Early vision: pixelwise operations; no high-level mechanisms of image analysis are involved
- Types of pre-processing
  - enhancement (contrast enhancement for contour detection)
  - restoration (aim to suppress degradation using knowledge about its nature; i.e. relative motion of camera and object, wrong lens focus etc.)
  - compression (searching for ways to eliminate redundant information from images)

What are image features?

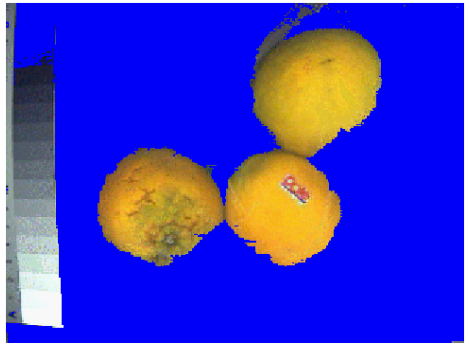
- Image features can refer to:
  - Global properties of an image:
    - i.e. average gray level, shape of intensity histogram etc.
  - Local properties of an image:
    - We can refer to some local features as image primitives: circles, lines, texels (elements composing a textured region)
    - Other local features: shape of contours etc.

Example of global image features

a) apples



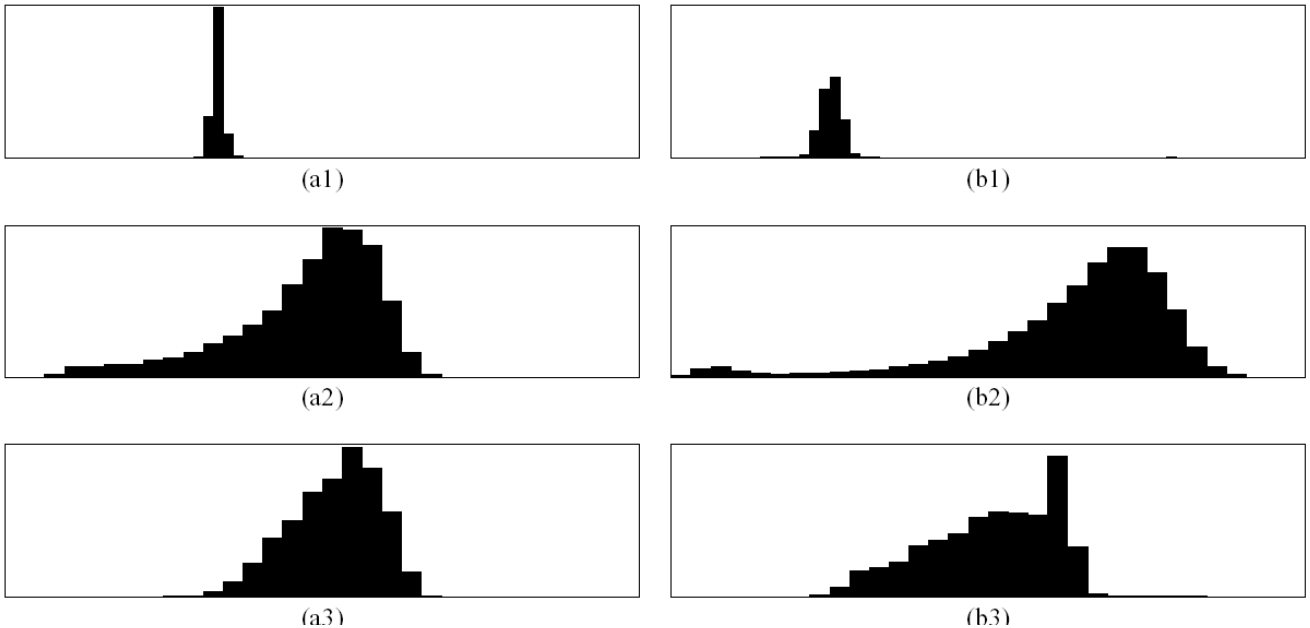
b) oranges



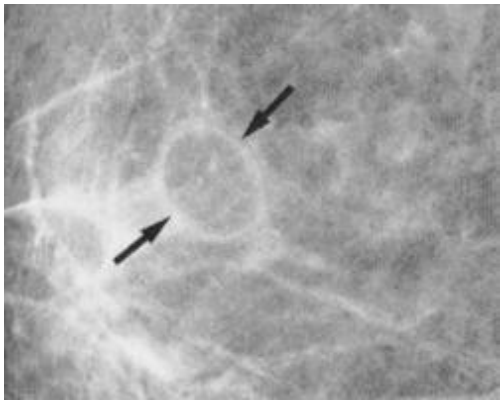
hue

saturation

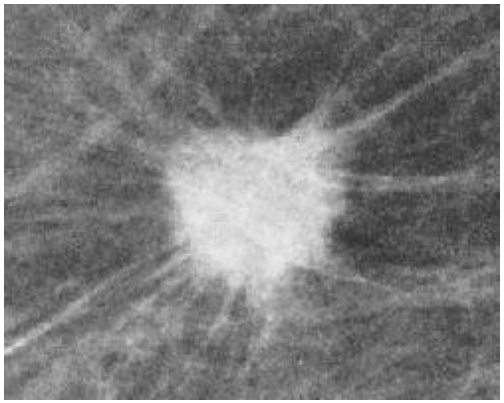
intensity



Example of local image features



Circumscribed (benign) lesions in digital mammography



Spiculated lesions in (digital mammography)

The feature of interest: shape of contour; regularity of contour

-Can be described by Fourier coefficients

-We can build a feature vector for each contour containing its Fourier coefficients

Image features

- Are local, meaningful, detectable parts of an image:
  - Meaningful:
    - features are associated to interesting scene elements in the image formation process
    - They should be invariant to some variations in the image formation process (i.e. invariance to viewpoint and illumination for images captured with digital cameras)
  - Detectable:
    - They can be located/detected from images via algorithms
    - They are described by a feature vector