Imaging informatics
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Main content

+ Segmentation
+ Computer-aided detection
+ Data compression
+ Image facilities design

HOW DO HUMANS CLASSIFY OBJECTS?

+ Human method is pattern recognition based upon multiple exposure to known samples.
+ We build up mental templates of objects, this image information coupled with other information about an object allows rapid object classification with some degree of objectivity, but there is always a subjective element.
+ We fill in what we think should be in the image

WHY SEGMENTATION

+ In order to recognize an object, we need segmentation.

Perceive an object

Break down to simple feature "segmentation"

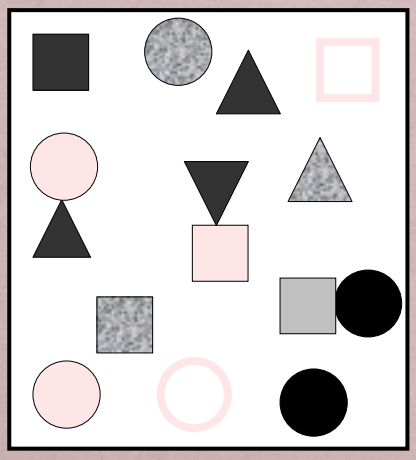
Compare with our Mental record

Mao ze dong!

Recognize an object

THE CONCEPT OF SEGMENTATION

Identify classes (features) that characterize this image!



Intensity: Bright - dark

Shape: Squares , spheres, triangles

Texture: homogeneous – speckled

Connectivity: Isolated - connected

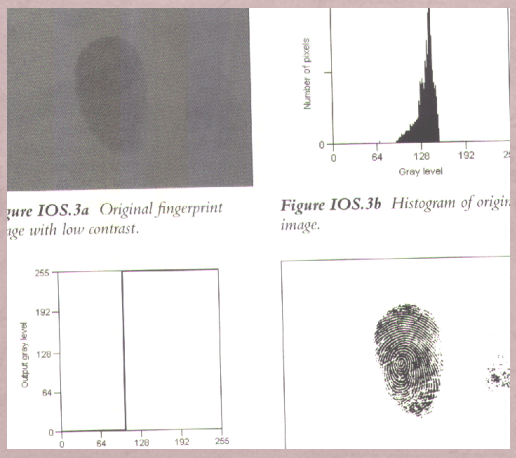
THRESHOLDING

- Image thresholding is a **segmentation** technique which classifies pixels into two categories:
  - Those to which some property measured from the image falls below a threshold,
  - and those at which the property equals or exceeds a threshold.
- Thesholding creates a binary image (binarisation).

THRESHOLDING

+ Find a grey scale level, “L”
+ Pixels are divided “L” and those below
+ May be generalized into multiple-level thresholding
  - multiple ranges of grey levels are defined and differentiated

HOW TO ENHANCE?



ure IOS.3a Original fingerprint ge with low contrast.

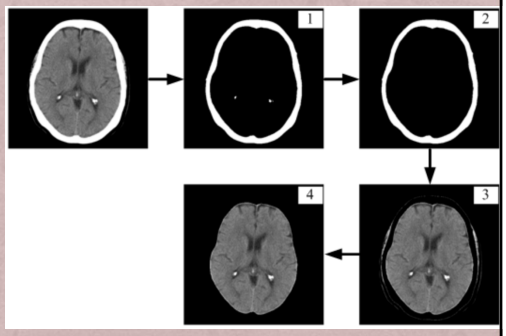
***Figure IOS.3b** Histogram of origin image.*

GLOBAL THRESHOLD

Step 1: Transform the CT image into binary image with pixel value (0, 1) using global threshold.

Step 2: Remove the region of calcification that have fewer than a certain number of pixels, say 500 square pixels.

Step 3: Remove the bone from the images with reference to the binary image.



Source: Tang FH, Ng DKS, Chow DHK. An Image Feature Approach for Computer-aided Detection of Ischemic Stroke. Computers in Biology and Medicine, 41(2011) pp525-536, 2011.

APPLICATION OF IMAGE SEGMENTATION

- Volume/area measurement
- 3D image display
- computer-aided image interpretation.

DATA COMPRESSION

THREE TYPES OF REDUNDANCIES

- Coding
- Spatial, temporal and bit depth
- Psychovisual

CODING REDUNDANCY

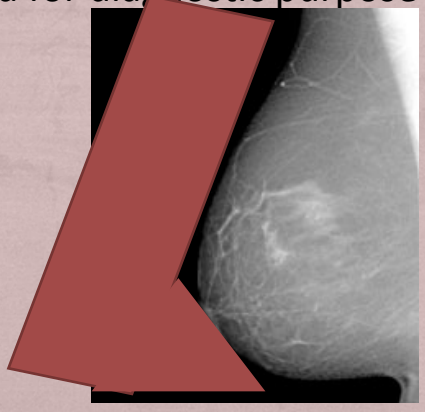
- A typical medical grayscale image composed of pixels with integer values between 0 and 4095(2^{12}-1), so each pixel is represented by a 12-bit integer.
- The use of same number of bits represent the all pixels is called fixed-length coding.
- Recall that for an US image, it is 8 bits but the program uses 16 bits to store

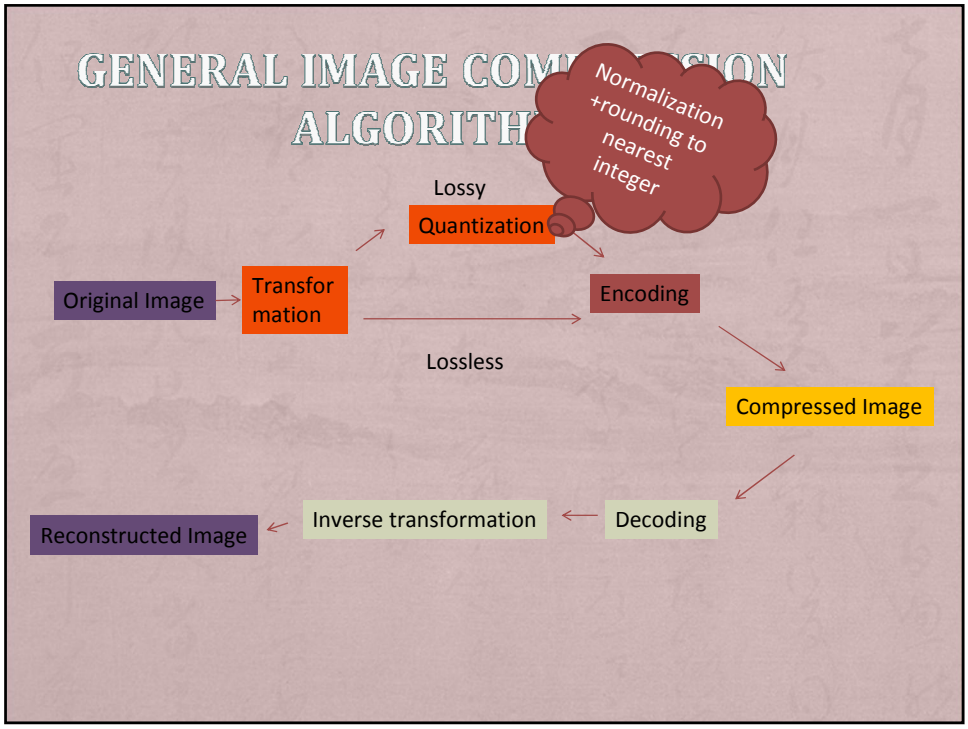
SPATIAL, TEMPORAL AND BIT DEPTH REDUNDANCY

- Pixels located in the same neighborhood in the same image/time-sequence in consecutive frames have similar values
- Special transformation (such as run-length encoding) to reduce the spatial or temporal correlation

PSYCHOVISUAL

Not all information presented in an image seen by viewer used for diagnostic purpose





JPEG 2000 COMPRESSION

- Use wavelet decomposition
- Allows higher image quality with higher compression rate
- Commonly used in medical imaging

WAVELET REPRESENTATION

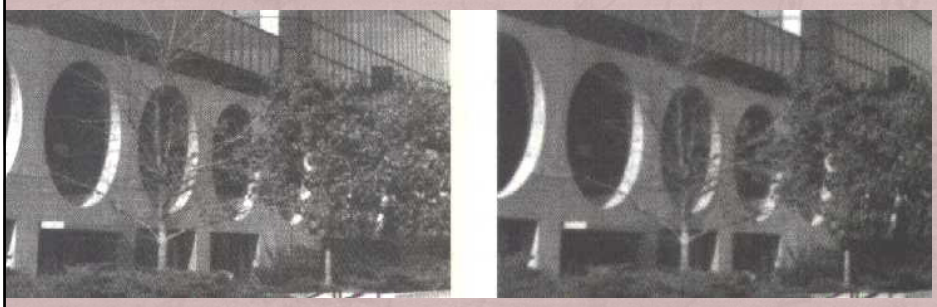
$$D_{2^j} f = (\langle f(u), \Psi_{2^j}(u - 2^{-j} n) \rangle)_{n \in Z}$$

For any J > 0, the original discrete signal $A_1 f$ measured at the resolution 1 can be represented by

coarse $(A^d_{2^{-J}} f, (D_{2^j} f)_{-J \le j \le -1})$ detail

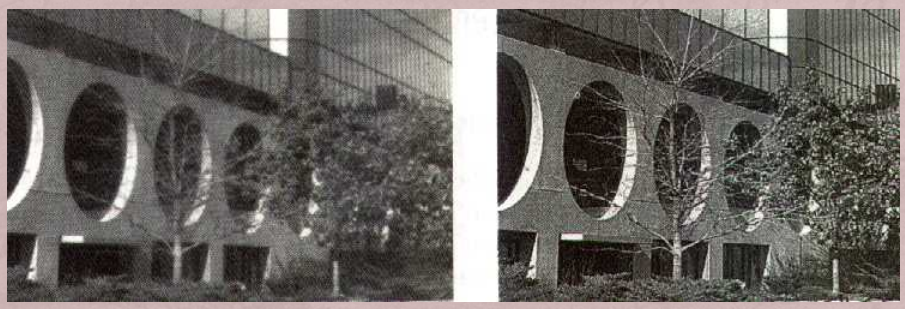
This set of discrete signals is called an orthogonal wavelet representation, and consists of the reference signal at a coarse resolution $A_{2^{-J}} f$ and the detail signals at the resolution 2^j for $-J \le j \le -1$.

LOW PASS FILTER



- Attenuates high spatial frequency data
- Emphasis low spatial frequency data
- Improve signal to noise at the expense of spatial spatial resolution

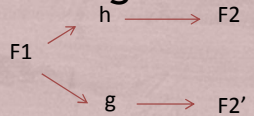
HIGH PASS FILTER



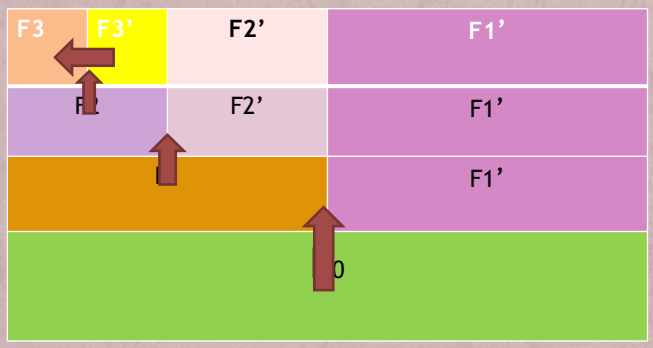
+ Attenuates low spatial frequency data
+ Emphasize high spatial frequency data
+ Enhances edges; but also enhances image noise

WAVELET TRANSFORM

- Consider a discrete signal F1 is decompose to level 2 by convoluting is with low pass filter(h) to form smooth signal F2 and with high pass filter (g) to form detailed signal F2'



+ At level 3, the signal is composed of the detailed signals F1',F2' and F3' and one smooth signal F3.



F0=F1'+F2'+F3'+F3

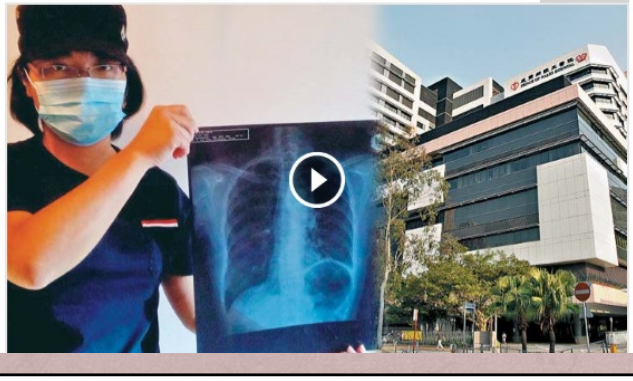
It is the lossless reconstruction using wavelet transform

WAVELET TRANSFORMS IN TWO DIMENSION

WHY CAD?

X光片有陰影　院方無診斷　威院醫生睇漏眼　累死肺癌婦

2



COMPUTER AIDED DETECTION AND DIAGNOSIS

- Human make errors during interpretation due to fatique, information overload,inexperience, environmental conditions
- Computer are able to rapidly process large volumes of imaging data in a more consistent fashion
- Suitable for screening exams with standardized format and pathologies with limited appearances

CAD (Computer Aided Diagnosis/ (Detection))

- CADx – CA Diagnosis
- Provide computer output to assist human (radiologist) in image interpretation
- One of the major research subjects in medical imaging and diagnostic radiology during the past 5 years
- Being applied in clinical practice

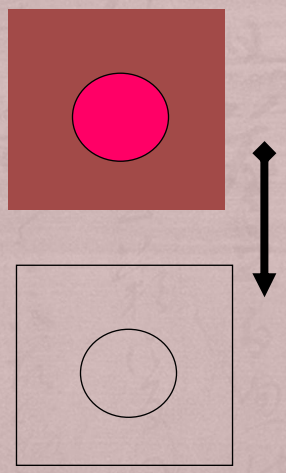
COMPONENTS OF CAD

1. Image acquisition: digitized or acquire from imaging modalities
2. Image enhancement: image filtering, edge enhancement, window width and level adjustment
3. Feature extraction: image registration, subtraction and segmentation
4. Feature classification: pattern recognition, neural network
5. Clinical decision

HOW CAN COMPUTER DETECT IMAGE FEATURES?

To detect a circle in an image

1. We need to perform thresholding to obtain a binary image



2.Calculate the perimeter of the feature,p

3. And the diameter, d
4. To obtain a value, p.
5. If p/d≈ 3.14, then it is a circular structure

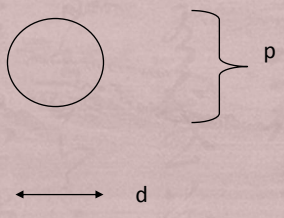


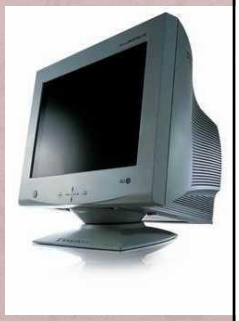
IMAGE FACILITIES DESIGN

- The Radiology Workstation
  - Provide adequate information to the clinician to maintain acceptable level of sensitivity and specificity
  - Provide efficient viewing and interpretation process, reducing stress and strain
  - General two image displays with one additional for information
  - QC and QA of display:AAPM: Task Group 18 QC program, DICOM 14 GSDF

DISPLAY CHARACTERISTICS

- Liquid Crystal Display (LCD) replace Cathode Ray tube CRT display
- Consists of a matrix of liquid crystal elements that acts as shutters in front of a light source (backlight).
- The matrix allows light through or blocks the backlight
- Grayscale display: no color filters
- Color display: reed/green/blue filters in front of element--each generates the color of pixels

3. OPERATING PRINCIPLE

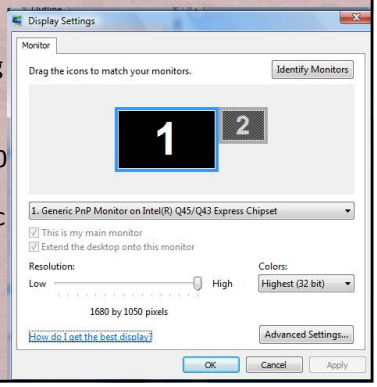


Advantage of LCD over CRT

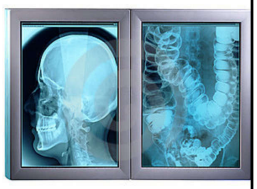
- **Smaller size**—Active Matrix **Liquid Crystal Display (AMLCD)** occupy approximately **60 percent less space** than CRT displays—an important feature when office space is limited.
- **Lower power consumption**—AMLCDs typically **consume about half the power** and **emit much less heat** than CRT displays.
- **Lighter weight**—AMLCDs **weigh approximately 70 percent less** than CRT displays of comparable size.
- **No electromagnetic fields**—AMLCDs **do not emit electromagnetic fields** and are not susceptible to them. Thus, they are suitable for use in areas where CRTs cannot be used.
- **Longer life**—AMLCDs have **a longer useful life** than CRTs; however, they may require replacement of the backlight.

TYPES OF MONTIORS

- most personal computer displays are color, 1024 x 768 pixels. This is referred to as a “three quarter megapixel [MP]” display (the total is actually 786,432 pixels).
- personal computers; increasing to 1280 x 960 pixels results in a “1.2 megapixel” display (actual: 1,228,800 pixels).
- Medical displays are more typically monochrome with display matrix sizes ranging from 1280 x 1024 (1.3MP) to 2560 x 2048 (5 MP).
- An intermediate display matrix of 2048 x 1520 pixels (3MP) is becoming more popular for many clinical applications, including diagnostic work



- A “standard” PACS hardware configuration:3 LCD displays per workstation: a single color display + a pair 3-MP grayscale panels.
- A pair of 5-MP for tasks that commonly rely on high resolution (some pediatric and adult musculoskeletal work, digital mammography, and some chest radiography).
- The color flat panel :for display of integrated dictation system controls, radiology information system (RIS) or electronic medical record displays, and worklists.
- The color panel can also be used for the display of color-containing images, such as ultrasound, nuclear medicine, and three-dimensional (3-D) rendered studies, when needed.



PIXEL RESOLUTION

- 1 megapixel (MP):1027x768:CT
- 5MP(2560x2048) mammography
- A CR/DR 3000x2500

ACR RECOMMENDATION

- Small matrix: The data set should provide a minimum of 512 x512 matrix size at a minimum 8-bit pixel depth for processing or manipulation with no loss of matrix size or bit depth at display.
- Large matrix: The data set should allow a minimum of 2.5 lp/mm
- spatial resolution at a minimum 10-bit pixel depth.