

# Image Processing: Presentation

Winter term 2005/06

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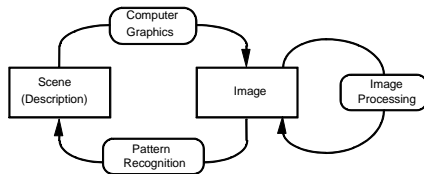
<http://diuf.unifr.ch/courses/05-06/improc>

# What is Digital Image Processing ?

- Manipulation, analysis, storage, and display of raster images such as photographs, drawings, or video
- Used in applications such as
  - digital photography,
  - animation, television and film,
  - science, astronomy, medicine, ...
  - military, satellite imaging,
  - machine vision (in robotics, ...)
  - scene analysis
  - computer-based pattern recognition
  - ...

# Terminology

- Levels of image computing
  - Image Processing : image -> image
  - Image Analysis : image -> measurements
  - Image Understanding : image -> symbolic description (topic of Pattern Recognition)
  - Computer Graphics : symbolic description -> image



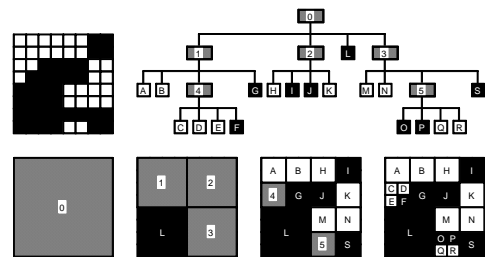
# Issues addressed by digital image processing

- Image capture and digitizing
- Image representation
  - image coding
  - color representation
  - image compression
- Image processing
  - image filtering
  - image enhancement
  - image rendering
- Image analysis
  - image segmentation
- Towards image understanding
  - image classification and indexing
  - object recognition
  - scene analysis

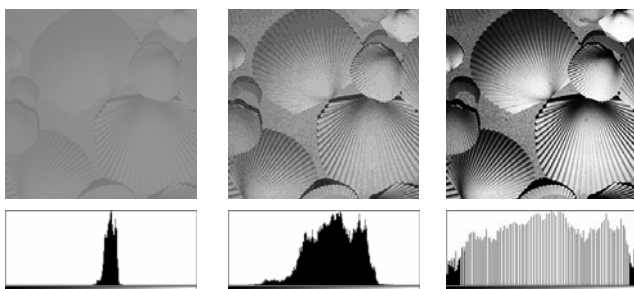
# Sampling and quantization



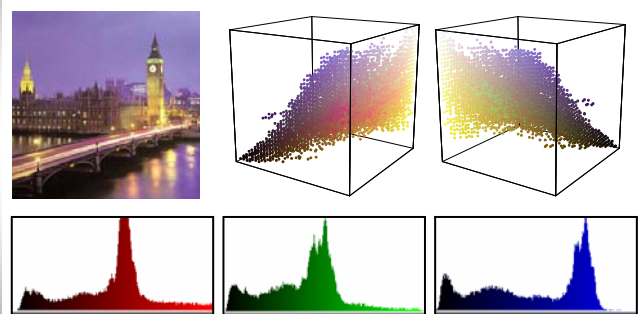
# Quadtree data structure



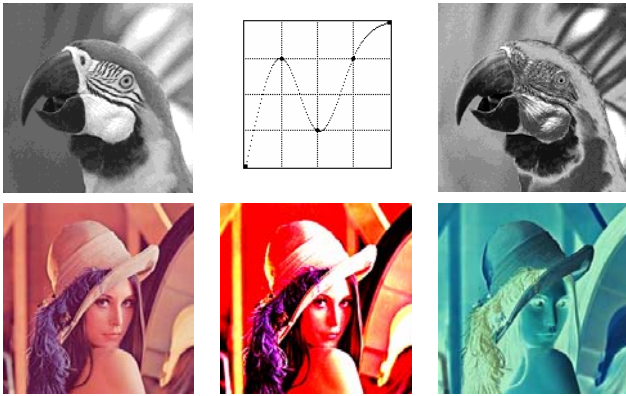
# Histograms of gray level images



# Histograms of color images



## Point operations



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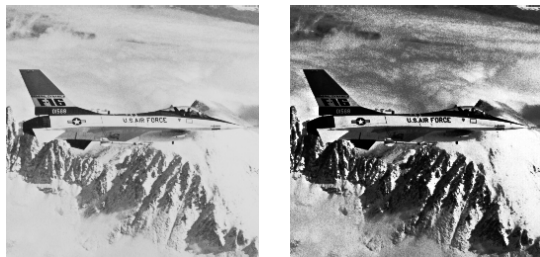
## Layer based image construction



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## Illustration: image enhancement



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## Illustration: image filtering



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## Morphological operators



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## Illustration: edge detection



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## Fourier transforms

- The Fourier transform of an image  $f(x,y)$  is defined as

$$TF\{f(x,y)\} = F(u,v) = \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} f(x,y) e^{-2\pi i(ux+vy)} dx dy$$

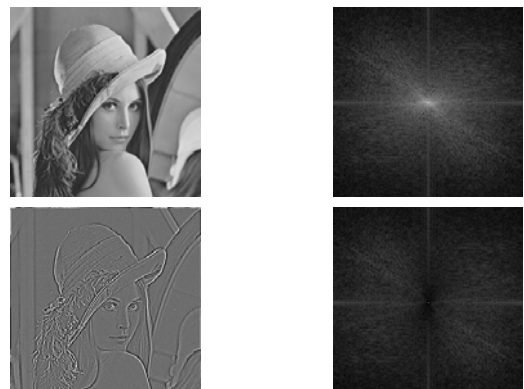
- Given a Fourier transform  $F(u,v)$  its original image can be recovered using the Inverse Fourier transform, which is defined as

$$TF^{-1}\{F(u,v)\} = f(x,y) = \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} F(u,v) e^{2\pi i(ux+vy)} du dv$$

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## Illustration : Frequency Domain Filtering



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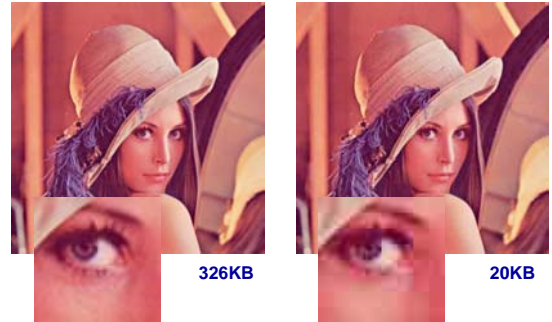
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## Illustration of Dyadic Wavelet Transform



## Illustration : JPEG compression

original size : 512 x 512 x 24 bits = 768KB



## Compression based on Karhunen-Loève transform

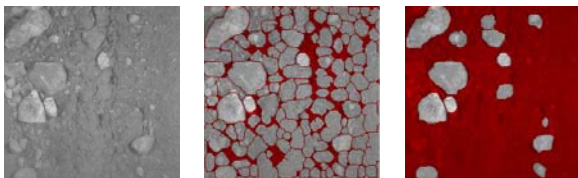
- Original image compared to
  - 1/4 of KLT coefficients quantized with multiples of 16 (size = 3'834 bytes, compression rate = ~1:17)
  - 1/8 of KLT coefficients quantized with multiples of 16 (size = 2'152 bytes, compression rate = ~1:30)



## Segmentation by color clustering

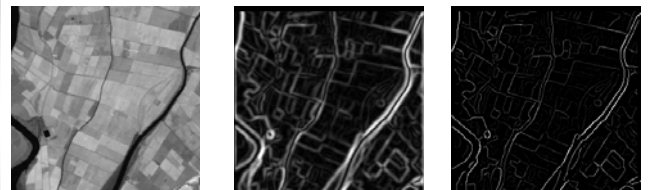


## Segmentation by Watershed

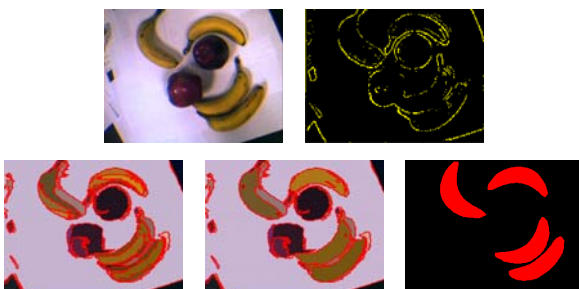


example from Simphiwe Mkwelo, University of Cape Town

## Segmentation by edge detection



## Segmentation by mixed method



example from <http://cs-people.bu.edu/liulf/demo> (Boston university)

## Why is image understanding difficult ?



## Objectives of the course

- Understand the basis of human vision
- Understand fundamental image processing theory
- Know classical image processing methods
- Implement and evaluate image processing algorithms

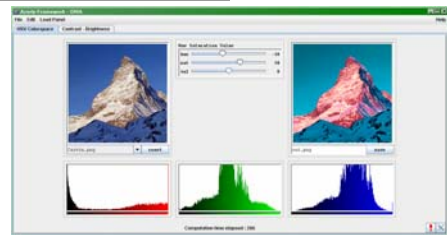
## Content of the course

- List of topics
  - Fundamentals of Image Processing
  - Human Visual System
  - Point Operators
  - Spatial Domain Operators
  - Frequency Domain Operators
  - Image Coding
  - Image Segmentation
  - Edge Detection
  - Clustering and Binarization
  - Morphological Operators
  - Application: Document Image Processing

## Bibliography

- Rosenfeld & Kak: Digital Picture Processing, 2nd edition, 2 volumes, Academic Press, 1982
- Gonzales, Woods: Digital Image Processing, Addison-Wesley, 1992.
- Jain: Fundamentals of Digital Image Processing
- Russ: The Image Processing Handbook, CRC Press, 3rd edition, 1999 (4th edition, 2002)
- Jähne: Practical Handbook on Image Processing for Scientific Applications, CRC Press, 1997
- Watkins, Sadun, Marenka, Modern Image Processing: Warping, Morphing, and Classical Techniques, Academic Press, 1993
- ... many others

## Presentation of the ImProc framework



- An interactive tool to experiment image processing algorithms
- Using a plug-in technology based on panels
  - configurable using an XML file
- Designed to easily prototype new algorithms and to test them
  - using a high level API, hiding low level data structures

## Organization

- Teacher : Rolf Ingold, rolf.ingold@unifr.ch, room B241, 026 300 84 66
- Assistant : Jean-Luc Blöchle, jean-luc.bloechle@unifr.ch, room B440, 026 300 92 94
- Course : Wednesday, 13:15-14:00 & 14:15-15:00
- Exercise : Wednesday, 15:15-16:00
  - requirements: 2/3 of series made, 1/2 considered satisfactory
- Home work : estimated to 4-6 hours per week
- Website : <http://diuf.unifr.ch/courses/05-06/improc/>
- Software : <http://diuf.unifr.ch/courses/05-06/improc/improc/improc.zip>
- Exam :
  - oral, 20 minutes (alternatively written, 120 min)
  - end of winter term (February 2005) or fall (October 2005)
- Credits : 5ECTS