Digital Image Processing

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INSTITUUT VOOR PERMANENTE VORMING

The lecturer

version: 16/11/2006

Coordinates

Department: Telecommunications and Information Processing (TELIN)
Research group (Head W. Philips): Image Processing and Interpretation (IPI)

Location:

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Teaching activities

At Ghent University:

Exercises and projects for the course
- Image Processing (Prof. W. Philips)

Supervising thesis students (BC, BE, LI) in image processing topics

VION (UGent, IPV)
Digital Image Processing course (at Barco - Kortrijk)

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Research activities

Research area: image and signal processing

- Image and video restoration
- Statistical image modeling
- Multiresolution (wavelet) representations
- Applications to medical imaginmg, remote sensing, video, surveillance,…

Co-supervising Ph. D. students (together with Prof. W. Philips) on the topics:

- Image and video denoising
- Statistical image modeling in multiresolution representations
- Video segmentation and tracking
- Distributed video coding
- Error concealment in networks with packet loss

Introduction

Several selected topics in image processing

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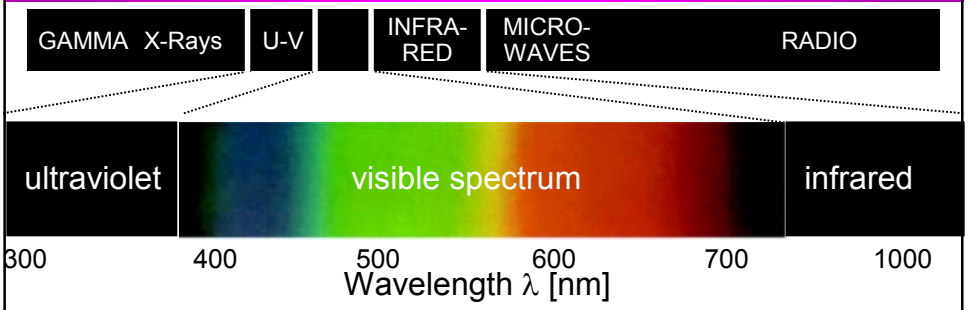
EM spectrum and image sources



All these parts of the electromagnetic (EM) spectrum appear as imaging sources in different imaging modalities

Photon (a bundle of energy) a massless particle traveling in a wave-like pattern

Photon energy: $E=h\nu$; $\nu=c/\lambda$;
h – Planck constant;
c – speed of light in vacuum

Visible light –
- frequency in THz

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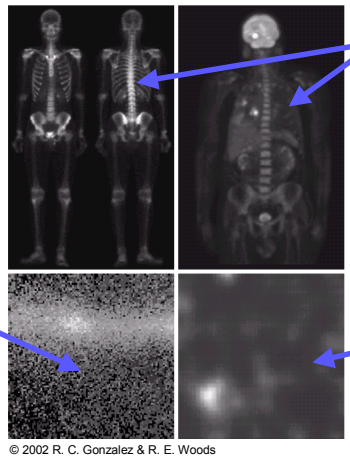
Different imaging sources: Gamma rays

Major use of gamma rays is in nuclear medicine and astronomy



PET scans

Astronomical
(Cygnus loop)

Gamma radiation
from a reactor
valve

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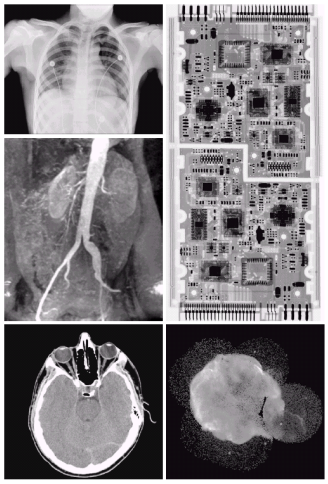
Different imaging sources: X-rays

Main applications in medicine (X-ray, CT) and in industrial inspection

Chest X-ray

Aortic angiogram

Head CT scan



Circuits board

Astronomical (Cygnus loop)

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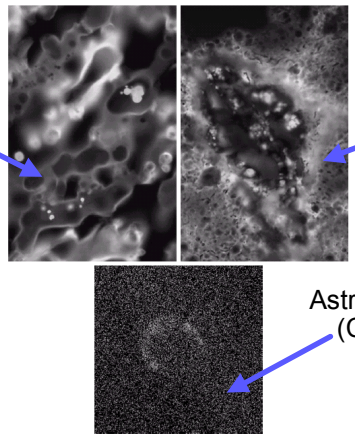
Different imaging sources: ultraviolet

Applications in fluorescence imaging. When an ultraviolet photon collides with an electon in an atom of a fluorescent material, it elevates the electron to a higher energy level. Subsequently, the excited electron relaxes to a lower energy level and emits a lower-energy photon in the visible (red) light region.

Normal corn



Corn infected by a parasitic fungi called smut

Astronomical (Cygnus loop)

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Imaging in visible and infrared regions

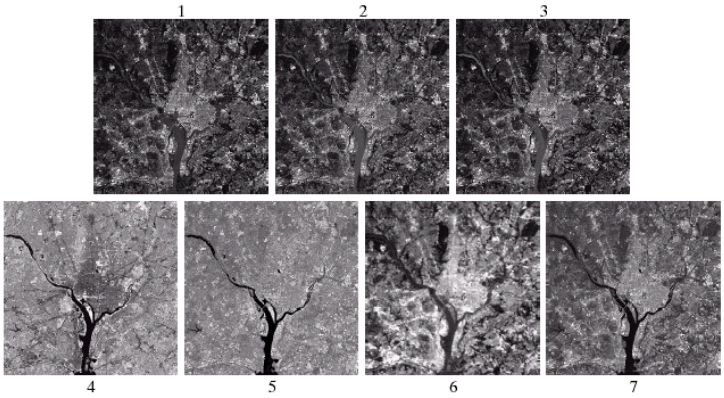

Image courtesy of NASA

Landsat satellite images
(blue, green, red, and four images from infra-red part of the spectrum)

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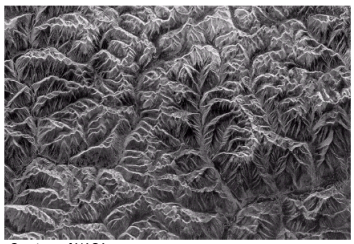
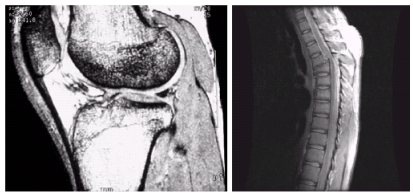
Imaging in the radio band

Spaceborne radar image



Courtesy of NASA

Magnetic Resonance Images (MRI)



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Imaging without light (EM) sources

Imaging using sound is used in geological exploration, industry and medicine.
Geological applications use the low-end of the sound spectrum (~100 Hertz).
Medical imaging uses ultrasound (milions of Hertz)

Principle: transmit sound pulses through a body (or an object under investigation) and measure the reflected sound waves

ultrasound imaging

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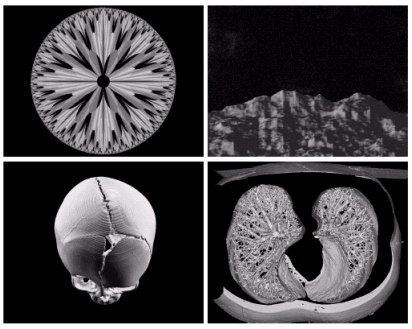
Other imaging modalities

Computer generated images



Some examples

Image restoration
- •noise reduction in satellite images
- •sharpening and noise reduction in confocal microscopy

Printing
- •rastering

Image analysis
- •Segmentation in ultrasound images
- •Quality control in image databases

Video processing
- •Noise reduction
- •Object tracking

Wavelet based noise reduction

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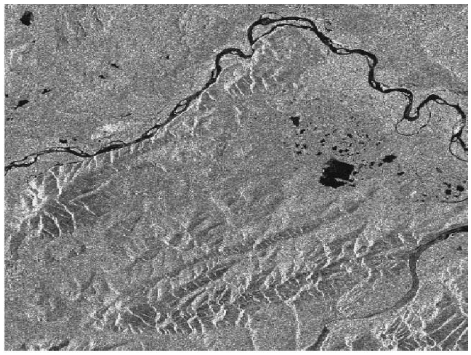
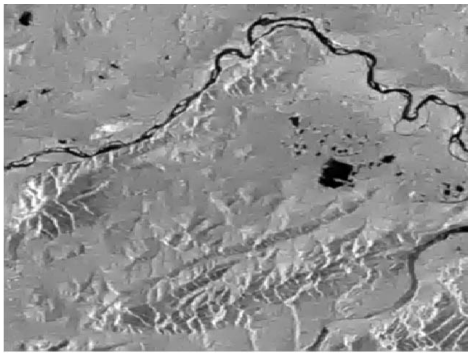
Noise reduction in SAR images

original



After noise reduction with wavelets



SAR=Synthetic Aperture Radar

Speckle arises as a consequence of the interference of the radio waves

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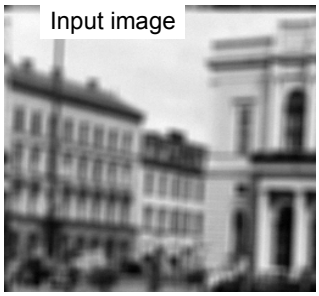
Image restoration

Input image



Ideal image

Wiener filtering

Wiener+noise reduction

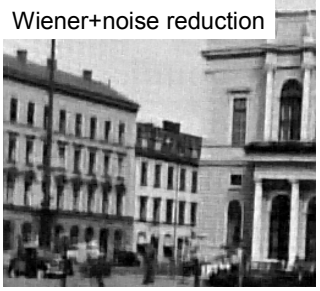


Image restoration=

estimating true image data from their degraded observations.

This involves in practice:

- sharpening
- removing noise
- improving contrast …

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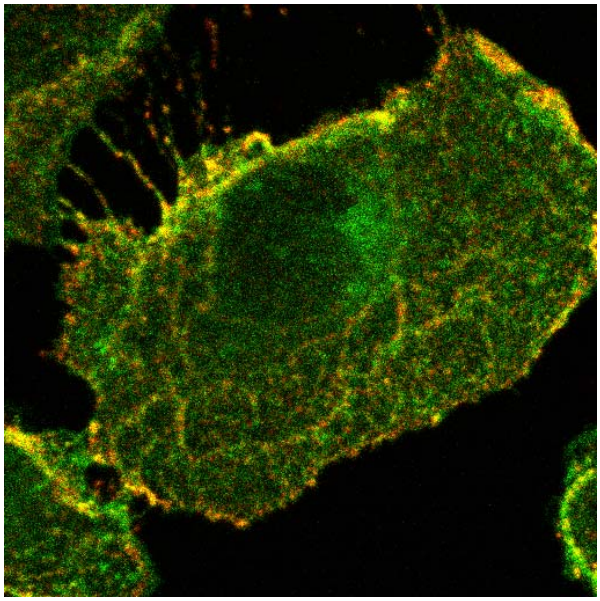
Restoration of confocal microscopy images



©Max Planck Institute for Biophysical Chemistry

groen=transmembrane receptorproteïne (b.v. groeifactorreceptor)

rood=ligand (b.v. groeifactor hormoon)

Original

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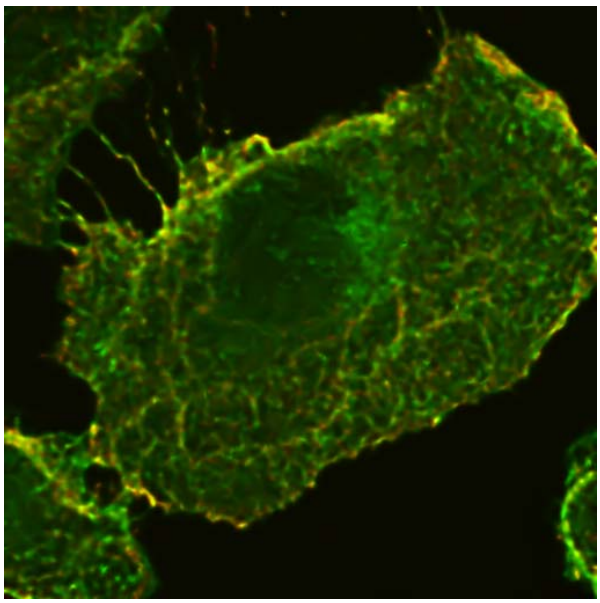
Restoration of confocal microscopy images



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Processed image:

Dr Filip Rooms

Noise reduction with stereerable filters

Several examples

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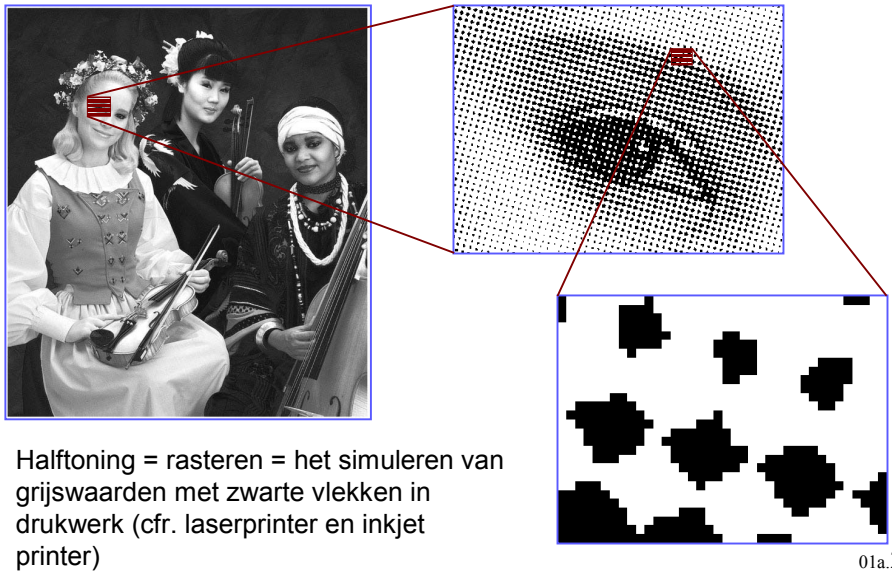
Halftoning for printing



Halftoning = rasteren = het simuleren van grijswaarden met zwarte vlekken in drukwerk (cfr. laserprinter en inkjet printer)

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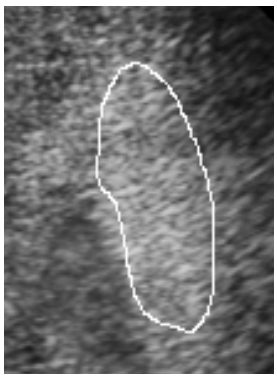
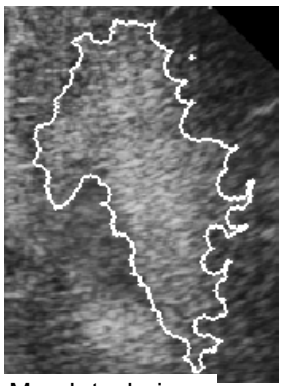
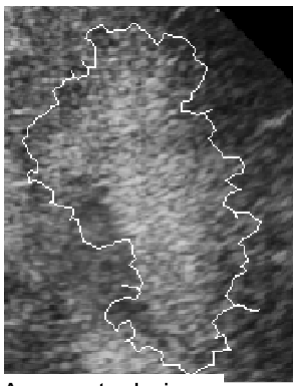
Segmentation of ultrasound images



Delineated by a doctor



Morph technique

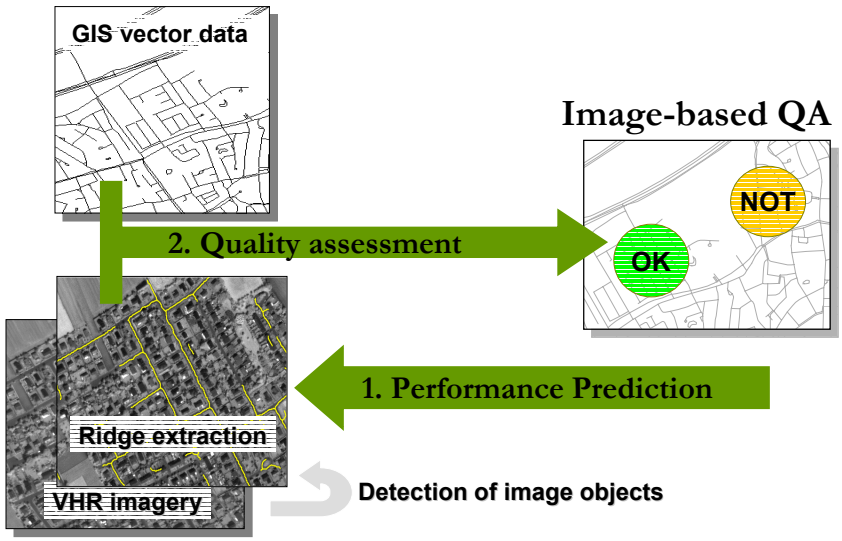


Acuson technique

How can we autoomatically delineate a sick region?

Different techniques are based, e.g., on texture analysis, morphological filters, active contours,…

GIS Quality Assessment Framework



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Motion compensated video denoising

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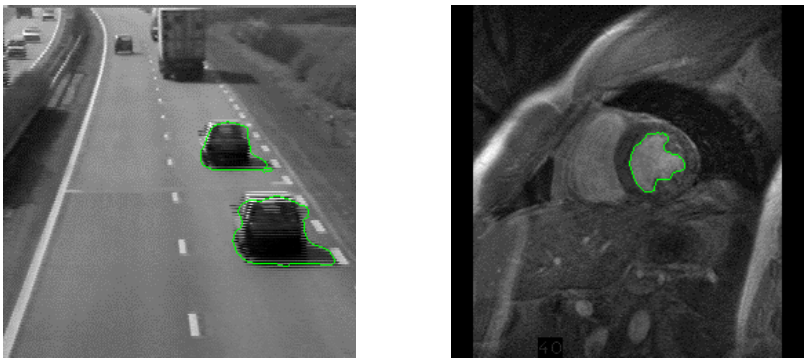
Object tracking



The content of this course

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Overview of the course

Image perception and color reproduction
Image transforms
Image enhancement
Image and video restoration
Image and video compression
Image segmentation
Image analysis
Pattern recognition and interpretation

Literature

Boeken

+ R.C. Gonzalez and R.E. Woods. Digital Image Processing. Addison-Wessley, 2nd edition, 2002. ISBN 0-130-94650-8.
+ W.K. Pratt. Digital Image Processing. John Wiley and Sons, 3rd edition, 1992. ISBN 0-471-37407-05.
+ J.C. Russ. The Image processing handbook. IEEE Press, 3 edition, 1998. ISBN 0849325323.

Software

+ xv (unix): visualisatie, kleuraanpassing, enkele filteroperaties
+ ImageMagick (unix): visualisatie, kleuraanpassing, enkele filteroperaties
+ gimp (unix): beeldmanipulatieprogramma
+ khoros (unix): visueel programmeren (en combineren) van algoritmen
+ photoshop: visualisatie en beeldmanipulatie
+ scilab (met sip image processing toolbox) http://siptoolbox.sourceforge.net/
+ matlab: visualisatie en beeldmanipulatie