Organizational issues

- What type of lecture?
  - 2 hours classroom lecture, 2 hours tutorials
  - Tutorial consisting of mostly programming assignments and some theoretical assignments
  - Introductory course in the fields of image processing, computer vision, and pattern recognition
  - (Soft) requirement for starting a diploma thesis in this field

- Prerequisites
  - Undergraduate mathematics
  - Some programming experience in C/C++
    (for the programming assignments)

Grading policy

- Oral or written exam (depends on the number of participants)
  after the lecturing period
- Regular attendance in the tutorials required to qualify for the exam

Tutorials start next week

These slides will be made available at
http://www.inf.tu-dresden.de/content/institutes/ki/is/bv_ws0708.de.html

They are password protected. Access via…
  - username: open
  - password: sesame

Other courses

- This winter term:
  - Pattern Matching in Computer Vision (2+2, called Mustererkennung)

- Next summer term (planned):
  - Computer Vision (2+2)
  - Image Segmentation (2+2)
    or Pattern Recognition and Machine Learning (2+2)
What is an image?

- Digital image: regular grid $I_{ij}$ of intensity values
- Continuous function $I: \Omega \subset \mathbb{R}^2 \rightarrow \mathbb{R}, (x, y) \mapsto I(x, y)$

Where do images and image processing play a role?

- Imaging (e.g. photography, ultrasound, x-ray, magnetic resonance)
- Image enhancement (e.g. Adobe Photoshop)
- Image and video compression
- Computer graphics (model $\rightarrow$ image)
- Computer vision (image $\rightarrow$ model)
- Focus of this and the following courses: image enhancement and computer vision

Imaging – ultrasound, MRI

Ultrasound image of a human embryo
Magnetic resonance image of a human head

Image enhancement - denoising
Image enhancement - deblurring

Welk et al. 2005: variational deblurring

Image compression - JPEG

Computer graphics – water simulation

Guendelman et al. 2005: Simulating the flow of water with level sets

Computer vision – 3D reconstruction

Kolev et al. 2007: multiview reconstruction
Difference between image processing and computer vision

- Usually, the term “image processing” is used for the general subject of processing images with a computer
- Computer vision signifies the specific task to make the computer interpret the content of images
- This is a difficult and so far unsolved task
- Computer vision has similar motivations as artificial intelligence and cognitive neuroscience
Why is computer vision difficult?

• Vision is a natural and easy task for humans (and many animals)

• This is not for free: ~50% of the primate's cortex deals with the processing of visual information (Felleman-van Essen 1991)

• Making a computer see like humans see means to solve a large part of the AI problem (this cannot be easy)

• What do you see in this image?

• A lot of high level knowledge and content information necessary

Images are only a structured grid of numbers

• What's that?

• This is how the computer sees Einstein

• Demonstrates what our brain achieves at the unconscious level

Importance of the spatial arrangement

• Image content is defined by the spatial arrangement of intensities

• It is not sufficient to treat images as vectors and to analyze these vectors

Importance of image processing and computer vision

• Computer vision is a very young research field
  – Main computer vision conference (ICCV) founded in 1987
  – Main computer vision journal (IJCV) founded in 1988

• Nonetheless, it belongs already to the most influential subfields of computer science; tendency: growing rapidly

• By 2006, the International Journal of Computer Vision had the highest impact factor of all computer science journals: 6.085

• Impact factor in 2002: 2.03

• Computer vision applications not restricted by a small market but by the limited quality provided so far

• More research \rightarrow more products
Some image processing applications

- Quality control, visual inspection
- Security systems
  - Fingerprint recognition
  - Iris recognition
  - Face recognition
  - Tracking
- Medical systems
  - Image enhancement
  - Data analysis
  - Routine diagnostics
- Entertainment industry
  - 3D reconstruction
  - Motion capturing
  - Augmented reality
  - Human-machine interaction
- Information systems
  - Document analysis
  - Image Google
- Earth surveillance
  - Weather forecasts
  - Google Earth
- Driver assistance systems
  - Lane control
  - Collision avoidance
  - Autonomous driving
- Robotics
  - Autonomous robots (e.g. pathfinder)
  - Domestic robots
- Artificial intelligence

Related sciences

- Computer science
  - Audio processing
  - Pattern recognition
  - Optimization
  - Machine learning
  - Data retrieval
  - Computer graphics
  - Robotics
  - Control theory
  - Software engineering
- Mathematics
  - Numerics
  - Statistics
  - Linear algebra
  - Functional analysis
  - Graph theory
  - Geometric algebra
- Physics
  - Optics
  - Computational physics
- Electrical engineering
  - Signal processing
- Neuroscience
  - Neurophysiology
  - Computational neuroscience
  - Psychophysics
- Medicine
- Philosophy

Conferences and Journals

- Conferences
  - ICCV: International Conference on Computer Vision
  - ECCV: European Conference on Computer Vision
  - CVPR: Int. Conference on Computer Vision and Pattern Recognition
  - NIPS: Neural Information Processing Systems
  - DAGM: Tagung der Deutschen Arbeitsgemeinschaft für Mustererkennung
  - ICIP: International Conference on Image Processing
  - ICPR: International Conference on Pattern Recognition
  - SSVM: Int. Conf. on Scale Space and Variational Methods
- Journals
  - International Journal of Computer Vision
  - IEEE Transactions on Pattern Analysis and Machine Intelligence
  - IEEE Transactions on Image Processing
  - Computer Vision and Image Understanding
  - Image and Vision Computing
  - Journal of Mathematical Imaging and Vision
  - Journal of Visual Communication and Image Representation
  - Realtime Imaging
  - Pattern Recognition

Overview (planned)

- Class 1: Introduction
- Class 2: Image acquisition and representation
- Class 3: Noise, point operations
- Class 4: Fourier transform
- Class 5: Linear filters
- Class 6: Wavelets
- Class 7: Morphological filters
- Class 8: Nonlinear diffusion filters
- Class 9: Variational methods I
- Class 10: Variational methods II
- Class 11: Deconvolution
- Class 12: Texture analysis and filtering
- Class 13: Color spaces
- Continued next term with the course Computer Vision
Summary

- Image processing, and particularly computer vision, are important research fields.
- Their importance grows rapidly with the number of successful applications.
- Image processing makes use of techniques from various other sciences.
- Especially mathematics provides many helpful tools.

Literature

- CV Online: Online compendium on numerous image processing and computer vision topics, http://homepages.inf.ed.ac.uk/rbf/CVonline/