Medical Images

Programme course

6 credits

Medicinska bilder

TSBB31

Valid from: 2017 Spring semester

Determined by
Board of Studies for Electrical Engineering, Physics and Mathematics

Date determined
2017-01-25

Main field of study
Electrical Engineering

Course level
First cycle

Advancement level
G2X

Course offered for
- Biomedical Engineering, M Sc in Engineering

Entry requirements
Note: Admission requirements for non-programme students usually also include admission requirements for the programme and threshold requirements for progression within the programme, or corresponding.

Prerequisites
Continuous 1-D Fourier transform and its theorem for scaling, translation, derivation, convolution and multiplication. Basic knowledge of Matlab programming. Linear algebra: vector, matrix, determinant and scalar product. One- and multidimensional calculus.

Intended learning outcomes
After completing the course, the student will be able to:
- Describe the generalization from 1-D to 2-D continuous Fourier transform and related theorems, such as scaling, translation, derivation, convolution and multiplication.
- Explain the following concepts in 1-D and 2-D: sampling and reconstruction, DFT, the sampling theorem and aliasing, resampling and interpolation.
- Interpret the results of a 2-D Fourier transform of an image, such as understanding what a spatial frequency means. Describe simple convolution kernels and filters that perform differentiation, low-pass and high-pass filtering.
- Know of the most common types of medical images, what they show, their underlying physics and technique: ultrasound, x-ray, CT, MRI, gamma-camera, SPECT, PET.
- Have a deeper understanding of some of the above techniques, ultrasound, CT, MRI and SPECT.

Course content

The course consists of two parts. The first part provides fundamental knowledge about 2D signal processing on images. In the second part, these skills are used in the study of various medical imaging techniques. The course aims to give a deeper understanding of ultrasound, CT, MRI, SPECT and PET.

- The digital image: pixels/size/zoom, storage and quantization, grayscale/color, real/complex. Histogram and gray-scale transformations. Color Tables: grayscale, RGB true, pseudo.
- Repetition of 1-D Fourier transform. From 1-D to 2-D Fourier transform. Theorems for 1-D and 2-D Fourier transform, such as scaling, translation, derivation, convolution and multiplication. Theorems for the 2-D Fourier transform such as the rotation and projection theorem. Looking at images and their Fourier transforms and relating them to the theorems.
- The Dirac impulse. Sampling and reconstruction. Effects on the image during aliasing in the spatial or Fourier domain.
- 1-D and 2-D DFT and FFT. Discrete 1-D and 2-D convolution. Convolution kernels/filters in the spatial and Fourier domain: low-pass (gauss), high-pass (Laplace), derivative (Sobel). Edge detection using the magnitude of the gradient.
- Resampling and interpolation, especially up- and down-sampling. Ideal up-sampling by zero-padding.
- Some simple image analysis tools: threshholding, erosion, labelling.
- Important measurements on images such as: contrast, MTF, resolution, SNR.
- Ultrasound.
- Briefly on different imaging techniques: digital radiography, angiography, fluoroscopy, mammography.
- Briefly on the physics for plain radiography and CT: X-ray spectrum, physical interactions such as photoelectric effect, Compton and Rayleigh radiation, noise. The idea is to show how the physics influence the image quality.
- CT: the projection theorem, 2-D reconstruction using the direct Fourier method, 2-D reconstruction using filtered back projection, parallel beam and fanbeam, rebinning, briefly on 3-D reconstruction.
- PET and SPECT. CT-PET and CT-SPECT.
- Carefully about MRI basics. Overview of MRI-variants, e.g. fMRI.

The computer exercises:

- 1) The digital image: pixels/size/zoom, quantization and storage, grayscale/color, real/complex. Histogram and grayscale transformations. Color tables: grayscale, RGB true, pseudo. 2-D Fourier transform of the images: appearance, properties. Simple convolution kernels in the spatial domain. Linear filters in the Fourier domain.
- 2) Resampling and interpolation. Up-and downsampling. Ideal up-sampling by zero-padding. Effects of sampling in the spatial and Fourier domain, e.g. aliasing.

- 3) CT reconstruction.
- 4) Measurement of noise. Some simple image analysis methods. Preparation for computer exercise 6.
- 5) Ultrasound images, demodulation and low pass filtering, interpolation to the correct geometry.
- 6) Measurements on SPECT/CT-volumes. Example volumes form healthy and COPD patients.
- 7) Basic MRI.

Study visit: The course includes a study visit to CMIV, where we will look at a CT-scanner and an MRI-camera. We will also listen to a lecture about how medical images are used today at the University Hospital in Linköping

Teaching and working methods

The course consists of lectures, tutorials and laboratory sessions based on Matlab.

Examination

LAB1	Laboratory work	2 credits	U, G
TEN1	Written examination	4 credits	U, 3, 4, 5

Grades

Four-grade scale, LiU, U, 3, 4, 5

Department

Institutionen för systemteknik

Director of Studies or equivalent

Klas Nordberg

Examiner

Maria Magnusson

Course website and other links

https://www.cvl.isy.liu.se/education/undergraduate/

Education components

Preliminary scheduled hours: 66 h
Recommended self-study hours: 94 h

Course literature

Additional literature

Books

Parts of books, doctoral theses, master theses, journal articles and PPT-presentations, e.g.: Prince and Links: Medical Imaging Signals and Systems, 2005 or newer.

Compendia

Laboratory instructions
2D signalbehandling på bilder
(in Swedish)

Common rules

Regulations (apply to LiU in its entirety)

The university is a government agency whose operations are regulated by legislation and ordinances, which include the Higher Education Act and the Higher Education Ordinance. In addition to legislation and ordinances, operations are subject to several policy documents. The Linköping University rule book collects currently valid decisions of a regulatory nature taken by the university board, the vice-chancellor and faculty/department boards.

LiU's rule book for education at first-cycle and second-cycle levels is available at http://styrdokument.liu.se/Regelsamling/Innehall/Utbildning_pa_grund-_och_avancerad_niva.