# ASM420 Image Processing, 7.5 credits

Image Processing, 7,5 högskolepoäng

*Second Cycle*

## Confirmation

This course syllabus was confirmed by Department of Physics on 2008-09-16 and was last revised on 2018-08-16 to be valid from 2018-08-16, autumn semester of 2018.

*Field of education:* Science 100%
*Department:* Department of Physics

## Position in the educational system

The course ASM420 is a programme course in the Physics Master Programme, as well as a single subject course at the University of Gothenburg.

The course can be part of the following programmes: 1) Physics and learning, Master's Programme (N2FOL), 2) Applied Data Science Master's Programme (N2ADS), 3) Complex Adaptive Systems, Master's Programme (N2CAS), 4) Physics of Materials and Biological Systems, Master's Programme (N2PMB) and 5) Physics, Master's Programme (N2PHY)

| *Main field of studies* | *Specialization* |
| --- | --- |
| Physics | A1N, Second cycle, has only first-cycle course/s as entry requirements |

## Entry requirements

To be eligible for the course ASM420 the student needs knowledge in mathematics and physics equivalent to a Bachelor degree. The student should also have basic knowledge in programming.

Applicants must prove knowledge of English: TOEFL test result of at least 600 points (computerized 250 points, on Internet 100 points) or IELTS test result of at least 6.0, including at least 6.5 for the Writing. This requirement does not apply to students with a

Bachelor degree from an English speaking university, or to students having passed English level B at Swedish/Nordic Upper Secondary School.

**Learning outcomes**

Students who have followed the course ASM420 Image processing and interferometry will:

- Visualise via means of mental images the process of forming 1D and 2D Fourier transforms and also the convolution process. Describe the similarities and differences between the continuous and discrete Fourier transforms and their inter-relationship.
- Describe the human vision system in terms of an engineering 'block diagram'. Explain common optical illusions, quantify colour and understand how colour space transformations are used in lossy compression methods.
- Select and apply appropriate image enhancement methods for different applications. Discriminate between cases where automated image enhancement methods produce appropriate results and where they do not.
- Understand the differences between averaging and median filtering for reducing image noise.
- Demonstrate understanding of image smoothing and sharpening in both the image and Fourier domains. Select between optimum methods of edge detection in different applications.
- Describe common distorted images as convolutions of the true image with point spread functions (PSF). Describe and decide under which conditions different image restoration algorithms can be used and describe the strengths and weakness of these algorithms.
- Calculate Radon transforms of simple images and be able to explain the steps involved in applying back-projection and filtered back-projection algorithms for accomplishing the inverse transform.
- Understand as a mathematical process the concept of the general transform in 1D and 2D. Describe the Cosine transform and its relationship to the Fourier transform. Explain wavelet transforms in terms of forming successive approximations and details.
- Explain the difference between lossy and lossless compression methods and explain the concept of data redundancy as the source of compression. Describe the subcomponents of general compressor/decompressor algorithms Calculate theoretical limits to lossless compression using the Shannon noiseless coding theorem and implement Huffman coding.

- Describe a variety of different mapping functions that can be used to obtain compression and decide when different methods are appropriate. Show via examples why Digital Pulse Code Modulation (DPCM) works and is stable in the face of quantisation errors.
- Describe the main components of the JPEG standard.
- Write computer code in MATLAB or other environments to implement selected image processing algorithms.

**Course content**

The aim of this course is for students to become familiar with a wide variety of techniques in modern Image Processing. These techniques can be used to subjectively improve image quality for the end-user (image enhancement), remove known image distortions (image restoration) and to reduce image data sizes for storage or transmission (image compression). These techniques are valuable in a range of applications and careers including, but not limited to, medical imaging, astronomy, remote sensing, automation etc. Stress is placed on deep understanding of the principles underlying the techniques rather than memory learning of algorithms.

The course contains the following parts:

- Summary of applications of Image Processing
- The continuous 2D Fourier transform
- The discrete 2D Fourier transform
- The human vision system
- Pixel transformations, histogram equalization
- Image smoothing and sharpening. Edge detection, median and Wiener filtering for noise reduction.
- Image sharpening and smoothing via Fourier methods.
- Image restoration problems, point spread functions and noise.
- Restoration by inverse and pseudo-inverse methods, Wiener filter restoration. Constrained minimisation and non-linear methods.
- Restoration from projections. Application to computed tomography.
- Radon transform, inverse radon transform via back-projection and filtered back-projection methods.
- General transforms. The cosine transform. The KL or Hotelling transform. Wavelet transforms, application to compression.
- Lossless and lossy compression methods. The general compressor/decompressor.
- The Shannon noiseless coding theorem. Entropy coding, re-quantization.
- Run length coding, application to FAX standards. Pixel differencing. Predictor-error methods, Digital Pulse code modulation.

- Cosine transform based compression methods. Details of the JPEG standard.
- Wavelet compression, movie compression, MPEG standards.

## Form of teaching

The course consists of 14 lectures and 7 practical labs in the EDIT studio. In addition there is a compulsory project to be handed in by the end of the course.

To pass the course students must obtain a passing grade on the written exam and submit a project report. Most of the points for determining grades will come from the written exam (50pts) with up to 5pts based on the project work.

A student who has failed a test twice has the right to change examiner, unless weighty argument can be adduced. The application shall be sent to the board of the department and has to be in writing.

*Language of instruction:* English

## Assessment

## Grades

The grading scale comprises: Pass with Distinction (VG), Pass (G) and Fail (U).
ECTS grades are also given on this course.

## Course evaluation

The results of the evaluation will be communicated to the students and will function as a guide for the development of the course.

## Additional information

The course is given jointly with Chalmers University of Technology. The Chalmers code for the course is RRY025.