

Image processing and analysis (IPA)

PhD course

The International Doctoral School of Technology and Science

The Faculty of Engineering, Science and Medicine

Aalborg University.

First part: March, 22–24, 2010, Aalborg University, Aalborg.

Second part: April, 12–13, 2010, Aalborg University, campus Esbjerg, Esbjerg.

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Course description

The IPA course is giving an introduction to image processing and analysis methods and algorithms. The course consists of two parts – basic and advanced. The basic part is primarily devoted to general principles of image acquisition, preprocessing and some simple analytical methods. The second part introduces several advanced methods for image analysis and classification as well as analysis of hyperspectral images. In both parts the theory is supplemented with real life examples and exercises.

The course is introductory and practical oriented, all lectures illustrate the theoretical material with real world examples, but the most of the methods are given without deep mathematical background. However, all corresponding math can be found in the books and articles, presented in reference section at the end of this document.

The first part of the course includes 7 lectures (120–150 minutes each) with live exercises. The second part includes 5 lectures and exercises. The outline of the lectures is given below. Most of the lectures have corresponding practice sets, where students will try the discussed methods. Each set includes Exercises – a list of required tasks, and (some of the sets) Assignments – more advanced problems to solve. Assignments are not required to do, but highly recommended. The practice sets as well as dataset with images, needed to complete the sets, are distributed among course participants.

Each part of the course has 2 ECTS points value. In order to evaluate the student activity a report is needed for each practice set. The reports should include all used images (originals and processed) and their descriptions, details of how a particular problem has been solved, answers to questions, student comments, necessary to understand what have been done, and conclusions.

Requirements and software

There are no special requirements needed besides some basic knowledge in math (elementary statistics, geometry, linear algebra) and good computer skills (experienced user level).

The practical exercises imply using *ImageJ* software (rsbweb.nih.gov/ij/) for the first part of the course and *Evince* (www.umbio.com) for the second part. The ImageJ is free and open source software for image processing and analysis, it can be download from the mentioned website and used either with Windows, Mac OS X or Linux (or any other Unix clones). The Evince is also cross-platform program and it has a trial version for education purposes. You are welcome to install both programs to your laptops in advance, if you have any questions or problems with installation, please, feel free to contact me.

Lectures plan

Lecture presentations will be available for download after the course.

First part

1. *Introduction. Digital images. Color models and modes*

Basic terms and definitions. Color models and modes. Representation of digital images. Properties of raster images. Acquisition, displaying and storing of raster images. Lossless and lossy image compression. Main problems of digital image processing and analysis – an overview. Software for image processing and analysis. Simple operations with images in ImageJ.

2. *Geometrical transformations and distortions correction*

Transformation of coordinates and transformation of objects. Linear and nonlinear transformations. Interpolation methods for geometrical transformations. Spatial distortion corrections using control points. Geometrical measurements on images. Geometrical operations in ImageJ

3. *Image adjustments. Pointwise operations and filtering*

Common definitions. Image intensity histogram and its properties. Arithmetical and logical operations. Basic pointwise operations – linear, power law, piecewise linear. Histogram equalization. Image filtering. Linear and nonlinear filtering. Basic linear filters. Median filter. Adaptive filtering. Image processing and filtering in ImageJ.

4. *Image segmentation and edge detection*

Problem statement. Classification of segmentation methods. Thresholding. Pixels clustering. Merging regions methods. Watershed segmentation. Segmentation of textures. Image derivative and edge detection. Zero crossing filter. Canny edge detector. Active contours. Thresholding and edge detection in ImageJ.

5. *Morphology based operations*

Basic terms and definitions, math background. Basic morphology operations – dilation, erosion, opening and closing. Hit and miss. Contour and skeleton. Object filling. Complex operations. Morphology operations for grayscale images. Morphological operations in ImageJ.

6. *Image analysis basics. Statistical analysis. Analysis of particles.*

Introduction to image analysis problem. Getting image features – examples. Calculating and using image statistics. Analysis of cells and particles.

7. *Advanced image processing and analysis with ImageJ*

Automate tasks and create custom tools using macros. Process and analysis of images in batch (stacks). Extending ImageJ with plugins, developing your own plugins.

Second part

1. *Image analysis and classification.*

Problem statement, the main steps of image analysis. Overview of methods for data analysis. Short introduction to multivariate data analysis concept. Getting image features – examples. Using statistics as feature vector for image classification.

2. *Analysis of textures*

Basic terms and definitions. Types of textures. Texture classification based on statistical features. Getting textural features using gray level co-occurrence matrices. Using principal component analysis for texture discrimination. Wavelet decomposition of images. Using statistics of wavelet decomposition coefficients for description of textures.

3. *Description of isotropic images with fractal analysis and Angle Measure Technique*

Concept of fractal dimension, analysis of fractal objects in nature. Using fractal dimension for description of image complexity. Traditional AMT algorithm, description of complexity of geomorphic lines. Mean angle spectrum as an image feature vector. Texture classification and image regression with AMT.

4. *Multivariate image analysis*

Problem statement. Image as a multivariate data. Basic aspects of MIA – scores plots, density of pixels, scores images. Image segmentation and classification with MIA. Applications of MIA in different scientific and industry areas. Multivariate image regression. Analysis of multivariate images in Evince – an overview and examples.

5. *Preprocessing and analysis of hyperspectral images*

Multispectral and hyperspectral imaging – background and equipment. Image calibration. Preprocessing of hyperspectral images. Analysis of hyperspectral images in Evince. Classification of hyperspectral images.

References

Textbooks

1. R.C. Gonzales, R.E. Woods. *Digital image processing* (3rd edition). Prentice Hall, 2007 (ISBN 978-0131687288).
2. R.C. Gonzales, R.E. Woods, S.L. Eddins. *Digital image processing using Matlab* (2nd edition). Gatesmark Publishing, 2009 (ISBN 978-0982085400).
3. W. K. Pratt. *Digital Image Processing*. Wiley, 1991 (ISBN 978-0471857662).
4. J.C. Russ. *The Image Processing Handbook* (5th edition). CRC, 2006 (ISBN 978-0849372544)
5. J.J. Friel. *Practical Guide to Image Analysis*. ASM International, 2000 (ISBN 978-0871706881)
6. P. Geladi, H. Grahn. *Multivariate Image Analysis*. Wiley, 1997 (ISBN 978-0471930013).

Internet resources

1. *Image Processing Fundamentals* – a nice on-line introductory course [<http://www.ph.tn.tudelft.nl/Courses/FIP/noframes/fip.html>]
2. *Image Processing Place* – site, devoted to the book [1]. Contains a lot of corresponding materials (datasets, tutorials, software, Matlab code, etc.) [<http://www.imageprocessingplace.com/>]
3. *Graphics and media lab at department of Computer Science of MSU* [<http://graphics.cs.msu.ru/index.html.en>]
4. *List of Image Analysis Software* [http://en.wikipedia.org/wiki/List_of_image_analysis_software]
5. *ITK* – open source image segmentation and registration toolkit [<http://www.itk.org>]
6. *ImageJ* – Java based free software for image processing and analysis [<http://rsbweb.nih.gov/ij/>]
7. *Hypermedia Image Processing Reference* [<http://homepages.inf.ed.ac.uk/rbf/HIPR2/>]
8. *TINA* – open source image analysis environment [<http://www.tina-vision.net/>]

Journals

1. [Pattern Recognition](#)
2. [Pattern recognition letters](#)
3. [IEEE Transactions on Image Processing](#)
4. [IET Image Processing](#)