2EL2420 – Digital image processing

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Department: DÉPARTEMENT SIGNAL, INFORMATION, COMMUNICATION
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Fundamental Sciences
Advanced level : Yes

Description

In many fields such as health, video surveillance, microscopy or remote sensing, simple or sophisticated image acquisition systems have been designed to produce digital images of all kinds: 2D images, 3D images, color images, videos, hyperspectral images. Image analysis includes the reconstruction of images from indirect measurements (e.g. in MRI and CT scan imaging), the reconstruction of 3D scenes in computer vision, image segmentation, image registration, and hyperspectral image analysis in remote sensing.

The objective of the course is twofold. On the one hand, fundamental concepts of image processing will be taught, ranging from elementary analyses to process grayscale and color images (thresholding, histograming, coding) to linear and non-linear filtering operations, carried out in the spatial domain and in the Fourier domain. On the other hand, advanced processing will be addressed to overcome the limits of conventional filtering approaches. They include image segmentation using geometric models to describe regions and contours, and the so-called variational approach, where image reconstruction is formulated as the optimization of a large-scale criterion. The variational approach is developed extensively and illustrated in the case of image denoising and image deconvolution.

Quarter number
SG8

Prerequisites (in terms of CS courses)

- Signal processing : convolution, Fourier transform
- Probability / statistics
- Optimization

Syllabus

Introduction :
Examples of image processing : shape recognition, image registration, image segmentation, image restoration and reconstruction.
Image acquisition systems, process of image formation, image formats.

Basic analysis:

- Histogram, contrast enhancement, thresholding of gray levels.
- Image sampling, image quantization and resizing
- Format of color images (RGB, HSV, etc.) and basic analyses.

Filtering :

Linear filtering :

- Notion of separability in the spatial domain.
- Smoothing and contrast filters : averaging and Gaussian filters, differential filters, Laplacian filter, Prewitt and Sobel filters, etc.
- Filtering in the frequency domain

Nonlinear filtering: median filter, order filter.

Contour detection and image segmentation : active contour and region growing approaches.

Variational approach (based on numerical optimization) **for inverse problems in imaging :**

- Optimization based approach for image restoration
- Tikhonov regularization
- Edge preserving regulariation
- Case of image denoising and deblurring

Class components (lecture, labs, etc.)

The course is organized in two parts to present:

- Basic image processing: 5 lectures , 3 TD

- Advanced image analysis: 4 lectures, long term project (11h)

The main concepts will be illustrated and some image processing algorithms will be implemented using a simulation and data analysis software such as Matlab.

Grading

The final grade will be composed of :
- a mid-term exam, 35 % of the final mark
- a project grade, 65 % of the final mark

Course support, bibliography

- M. Nixon & A. Aguado, *Feature extraction & Image Processing*, éd. AP, 2010.
- Jiri Jan, *Medical Image Processing, Reconstruction and Restoration*, éd. CRC Press, 2005

Resources

Additional teachers (a third teacher) for practical sessions if the number of students exceeds 50 (more than 2 groups of 25).

Learning outcomes covered on the course

1. Basic knowledge on systems of acquisition of numerical images (cameras, microscopes, …) and the process of image formation.
2. Ability to analyze a numerical image.
3. Ability to implement elementary numerical image algorithms : detection of pixels in an image by thresholding the gray levels, histogram computation, linear and nonlinear filtering, smoothing and contour detection.
4. Ability to implement advanced image deconvolution algorithms.
5. Learning advanced notions such as image segmentation based on geometrical models (contours and regions) and 3D image analysis.

Description of the skills acquired at the end of the course

The mid-term exam allows to participate in the validation of skills C1

The long term project allows to participate in the validation of skills C2, C6 and C8