Universidade do Porto
FEUP Faculdade de Engenharia

Doctoral Programme in Electrical and Computer Engineering at FEUP

Course Description

Course

Title	Language	Level	Term
Image Analysis and Recognition	English	PhD	2

Course coordinator

Name	Category	Institution
Aurélio Campilho	Professor	FEUP

Other lecturers (not TA)	Institution
Mohamed Kamel (Professor)	UW Canada

Pre-requisites (max 600 characters)

Knowledge at undergraduate level of Image Processing and Pattern Recognition

Objectives (max 600 characters)

This graduate course on Image Analysis and Recognition aims to give the student the ability to understand and apply some of the recent advances in this rapid evolving field. There is a text book together with a list of selected original research papers in order to allow the students to follow the advances in the addressed topics. The course main topics are: image segmentation, tracking, Image registration and object and pattern recognition and matching. The course will discuss the use of the learned methods and techniques in applications such as visual inspection, document processing, biomedical and biometrics.

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Contents (2500-3000 characters)

1. From edges to textures
    a. Edge and corner detection
    b. Texture analysis. Texture segmentation and texture matching.
2. Segmentation by clustering
    a. Grouping and gestalt theory
    b. Image Segmentation using basic clustering methods. Embedding local constrains
    c. Segmentation by graph-theoretic clustering. Graphs. Affinity measures. Eigenvectors and segmentation. Graph Cuts and normalized cuts.
3. Model-based segmentation
    a. Fitting lines and curves.
    b. Robustness. M-estimators and RANSAC
4. Cooperative Methods in Image Segmentation
    a. Sequential and Parallel frameworks
    b. Hybrid Methods
    c. Other forms of co-operation (wrapper-based, iterative and interactive methods)
5. Tracking
    a. Tracking using linear dynamical models. Kalman filtering. Tracking examples (tracking people, tracking vehicles).
    b. Tracking with non-linear dynamical models. Particle filtering. Extended Kalman filters.
6. Image Registration
    a. Similarity measures. Invariant local features.
    b. Strategies for image registration of rigid and non-rigid objects
7. Image Recognition
    a. Object and shape representation using invariant features.
    b. Feature extraction and selection, Principal Component analysis.
    c. Classifiers for object recognition. Weak classifiers. Combining classifiers.
    d. Recognition examples (face detection and recognition, pedestrian finding)

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Main Bibliography (max 1000 characters)

Textbook:

Forsyth and Ponce, *Computer Vision. A Modern Approach*, Prentice Hall, 2002.

Other reference books:

R. O. Duda, P. E. Hart, D. G. Stork, *Pattern classification*, John Wiley & Sons, 2001.

Papers (some reference and selected readings):

- J. Shi, J. Malik. Normalized cuts and image segmentation. IEEE Trans. on PAMI, vol. 22, no. 8, pp. 888–905, 2000.
- P. Viola, M. Jones, "Rapid object detection using a boosted cascade of simple features," *Conf. on CVPR,* 2001, pp. 511-518.
- D. G. Lowe, "Distinctive image features from scale-invariant keypoints", *Int. Journal of Computer Vision,* 60, 2 (2004), pp. 91-110.
- M.E. Farmer, A.K. Jain. A wrapper-based approach to image segmentation and classification. IEEE Trans. on Image Processing, vol. 14, no. 12, pp. 2060–2072, 2005.
- D. Comaniciu, P. Meer. Mean Shift: a robust approach toward feature space analysis. IEEE Trans. on PAMI, vol. 24, no. 5, pp. 603–619, 2002
- R.J. O' Callaghan, D.R. Bull. Combined morphological-spectral unsupervised image segmentation. IEEE Trans. on Image Processing, vol. 14, no. 1, pp. 49–62, 2005.
- N. Snavely, S. M. Seitz, R. Szeliski, "Photo tourism: Exploring photo collections in 3D," ACM Trans. on Graphics, 25(3), 2006, 835-846.

Software (max 600 characters)

Matlab image processing toolbox and other programs

Teaching (max 600 characters)

The course will be organized in a set of 30 lectures of 90 min each. Each chapter has an approximate duration of one week.

Assignments (max 1200 characters)

The workload of the course consists of 5 assignments, presentation of one reading and a project.

List of assignments:

Assignment 1: From Edges to Textures

Assignment 2: Image Segmentation

Assignment 3: Tracking

Assignment 4: Registration

Assignment 5: Recognition

The assignments 1 and 2 can be developed by groups of 2 students. No collaboration is allowed in assignments 3, 4 and 5. Commented code and illustrative results must be published in html or in a pdf file.

To each student will be assigned a reading of a selected research paper, that will be presented at the end of the term.

A project will be also assigned to a team of 2 students in the second half of the course. A report in IEEE PAMI format is required with a minimum of 6 pages without exceeding a maximum of 10 pages. Commented code and illustrative results must be reported in an additional pdf file. The projects will be presented in special sessions of the course.

Late policy: The students must meet the deadlines. One week delay is allowed for the assignments and project with a 10% discount on the corresponding grade.

Grading policy (max 400 characters)

Grading and evaluation is based on the following scheme::

- Assignments: 30% (6% for each one of the 5 assignments)
- Presentation of a selected research paper (15%)
- Project: 30%
- Exam: 25%
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- The exam is a closed book exam with no notes allowed.
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Grading will be either PASS or FAIL.

A PASSing grade corresponds to a minimum of 2/3 of the maximum score.

Evaluation procedure for students under special legal provisions

The students will be subjected to all evaluation procedures of regular students, i.e., they must deliver their assignments as specified during the course plus any special works also specified plus a final exam, the only difference towards regular students being that they are not required to attend classes and deliver assignments in the same dates as regular students, in the cases the law specifically states it.

Improving grades

Not applicable in a PASS/FAIL policy.