Computer Vision
MAP-I Curricular Unit

Context

This document describes a PhD level course, corresponding to a Curriculum Unit credited with 7 ECTS, intended for the MAP-I doctoral program. It is offered jointly by (i) Departamento de Ciência de Computadores, Universidade do Porto, (ii) Departamento de Engenharia Informática, Universidade do Porto, (iii) Departamento de Engenharia Electrotécnica e de Computadores, Universidade do Porto (iv) Departamento de Electrónica, Telecomunicações e Informática, Universidade de Aveiro.

Course Description

The proposed unit intends to be a specialization in computer vision topics, namely image and video processing, pattern recognition and machine learning.

The impressive technological evolution of signal and image capturing hardware has slowly created a new and demanding problem: How do we handle so much data? There is a clear need for automatic tools that can help us analyse, find and annotate the massive amount of video information captured by modern technology. A *Computer Vision* learning unit is therefore vital for motivating and preparing PhD students with mathematical tools that will help them handle the various real-world problems where computer vision methods might provide robust solutions.

Teaching Staff

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Prerequisites

Familiarity with basic signal processing methods, namely frequency domain analysis, is highly desirable. Also, some familiarity with a popular programming language such as C or Java is desirable. None of these are strictly necessary but students who have not previously taken courses in these topics may have to work harder to keep up.

Textbooks and references

- D. Forsyth, J. Ponce, "Computer Vision: A Modern Approach", Prentice Hall, 2002.
- R. Gonzalez, R. Woods, "Digital Image Processing – 3rd Edition", Prentice Hall, 2008.
- L. Shapiro, G. Stockman, "Computer Vision", Prentice Hall, 2001.

- M. Sonka, V. Hlavac, R. Boyle, "Image Processing, Analysis, and Machine Vision", Brooks/Cole Publishing, 1999.

Course Objectives

The main objectives of this unit can be summarized in the following topics:

- Present and motivate the student for the various topics of *Computer Vision*.
- Provide the students with a core-set of mathematical tools, useful for most *Computer Vision* challenges.
- Introduce the student to national and international institutions and companies where *Computer Vision* is a potential solution to their real-world problems.
- Help the student develop rigorous research and development methodologies.

Course Topics

- **Chapter I - Image and Video Processing**
  - **Definitions**: optics and image formation; digital image; colour models; medical imaging; noise.
  - **Low-level feature extraction**: colour; texture; shape.
  - **Image pre-processing**: filtering; enhancement.
- **Chapter II - Image Segmentation**
  - **Basic methods**: thresholding; colour segmentation; region-based segmentation; mathematical morphology.
  - **Segmentation by clustering**: background subtraction; mean-shift; k-means; graph-teoretic clustering; normalised cuts.
  - **Segmentation by fitting**: fitting lines; fitting curves; robust methods.
- **Chapter III – Pattern Recognition**
  - **Fundamentals**: definitions; feature vectors; classes; principal component analysis.
  - **Generic pattern recognition techniques**: statistical pattern recognition, soft-computing machines, neural networks, support vector machines.
  - **Pattern recognition for computer vision**: hypothesize and test; template matching; relations between templates.
- **Chapter IV – Video Processing**
  - **Motion analysis**: block matching; optical flow: motion as a low-level feature; visual tracking.
  - **Video Compression**: fundamentals, data redundancy, standards.

Expected number of students

10

Teaching Methodology

- Theoretical presentation of *Computer Vision* topics in the form of classes and/or seminars given by lecturers of the learning unit or invited speakers.
- Integration of students into the teaching process, namely the presentation of state-of-the-art reviews on certain *Computer Vision* topics, enabling them to tighten their relationship with the learning unit and stimulating their interest on a set of specific topics.

Time scheduling

- 7 ECTS (189 hours)
- 3 hours/week for 14 weeks
- 1.5 hours/week guided study

Evaluation Criteria

- 50%: Final Exam.
- 40%: Scientific paper submission. This can be either an individual paper with a review on a specific computer vision topic, or a group paper (two students) which describes scientific results obtained by the students.
- 10%: Presentations of selected papers during lectures.