# 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) Escola de Engenharia, Universidade do Minho (ii) Departamento de Electrónica, Telecomunicações e Informática, Universidade de Aveiro (iii) Departamento de Ciência de Computadores, Universidade do Porto.

## 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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|---|---|---|
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| João Paulo Silva Cunha | DETI, UA | jcunha@det.ua.pt |
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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.
  - **Motion analysis**: block matching; optical flow: motion as a low-level feature; visual tracking.
- **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 – Selected Topics**
  - **Geometry and 3D reconstruction**: geometry of multiple views; stereo vision; structure from motion.
  - **Content-based image retrieval**: introduction; popular methods; adding context to content.
  - **Medical imaging**: brain imaging; human motion analysis; molecular and cellular imaging; medical image registration.

## Expected number of students

15-20

## 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.
- Practical implementation of some of the studied mathematical tools in a research lab environment.
- 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%** - A written final exam covering the topics studied in the learning unit.
- **50%** - A written scientific article, concerning either results obtained during their experimental work or a state-of-the-art review on a Computer Vision topic, which must be presented orally in a public seminar.