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.

Textbook

- Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London, 2011 (Available online: http://szeliski.org/Book/).

Other references

- Making Things See, Greg Borenstein, O'Reilly 2012
- Learning OpenCV: Computer Vision in C++ with the OpenCV Library, Gary Bradski, Adrian Kaehler, O'Reilly 2012
- *Machine vision*: Theory, algorithms, practicalities, E. R. Davies, Morgan Kaufmann 2005.
- *Digital Image Processing*, Rafael C. Gonzalez, Richard E. Woods, Prentice Hall, 2007.
- *Image Processing: Analysis and Machine Vision*, Milan Sonka et al., Chapman & Hall, 2007.
- D. Forsyth, J. Ponce, "Computer Vision: A Modern Approach", Prentice Hall, 2002.

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 – Digital Images**
  - optics and image formation;
  - digital image;
  - color models;
  - noise;
  - pixel manipulation.
- **Chapter II - Image and Video Processing**
  - image pre-processing;
  - low-level feature extraction;
  - image segmentation;
  - image compression.
- **Chapter III – Multiple Views and Motion**
  - camera calibration;
  - stereo reconstruction;
  - optical flow;
  - active contours;
  - structured light range imaging.
- **Chapter IV – Object detection and classification**
  - Hough transform;
  - principal component analysis;
  - template matching;
  - statistical pattern recognition;
  - support vector machines;
  - local descriptors
  - feature detection and classification.

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)
- 4 hours/week for 8 weeks
- 1.5 hours/week guided study

Evaluation Criteria

- 60%: Final Exam.
- 40%: Review and presentation of selected papers during lectures on a specific computer vision topic.