Advanced Image Processing, 5 ECTS **UJM semester 2**

Course instructors: Ass Prof. Hubert Konik and Ass Prof. Damien Muselet

Language of instruction: English

Overview

The first part of this course deals with feature based methods in image processing, meanwhile the second part deals with machine learning based methods in computer vision. The idea is to apply classical and advanced methods of machine learning to computer vision tasks, such as image classification, object detection, tracking, ... Then fundamentals in deep-learning will be presented theoretically and practically. The most important features of the classical networks as well as the advanced architectures will be studied.

Learning Outcomes

On successful completion of this course, students should have the skills and knowledge to:

- Understand and master basic knowledge, theories and methods in features extraction, image classification, object detection or tracking;
- Identify, formulate and solve practical problems in image processing;
- Critically review and assess scientific literature in the field and apply theoretical knowledge to identify the novelty and practicality of proposed methods.
- Design and develop practical and innovative image processing applications using conventional or machine learning -based methods.
- Conduct themselves professionally and responsibly in the areas of image processing and deep learning.
- Code classical networks and more advanced machine learning - based architectures with Matlab or Tensorflow or Python.

Course outline

Part 1

- Advanced segmentation: kmeans and other classification-based methods; region growing; quadtree, split-and-merge. Application: semantic-oriented segmentation with blur/sharp detection (precision and recall).
- Texture: - definition, - databases, - statistical methods (histograms, first order statistics, particular points, second order statistics ...), - spectral methods (Laws filters, Fourier ...), - segmentation. Application: ground-truth evaluation on a specific database and industrial classification application.
- 2D Shape description and 2D Shape comparaison, local Shape descriptors.

Part 2

- Bags of words and classification,
- Discriminative approaches for object detection and tracking,
- Classical convolutional neural networks (CNN),
- Learning features (batch normalization, fine tuning, transfer learning, domain adaptation, self-supervised learning),
- Residual NN, Recurrent NN and Long short-term memory networks (LSTM),
- Auto-encoders and Generative adversarial Networks (GAN),

- Applications to image classification, object detection and auto-encoders.

Teaching methods

- Lectures: 24 hours
- Practical work: 24 hours
- Project work (on study case applications): 24 hours

Study materials

- Hastie, Trevor, Tibshirani, Robert, Friedman, Jerome, The Elements of Statistical Learning, 2009
- Computer Vision: Models, Learning, and Inference, Simon J.D. Prince, Cambridge University Press, 2012.
- Programming Computer Vision with Python, Jan Erik Solem, 2012.
- Machine Learning for OpenCV: Intelligent image processing with Python, Michael Beyeler, 2017.
- Deep Learning for Computer Vision : Image Classification, Object Detection, and Face Recognition in Python, Jason Brownlee, 2019.

Expected prior-knowledge:

- Basic calculus, linear algebra and basic probability theory.
- Previous knowledge of classical methods of signal and image processing will be helpful, but is not essential.
- Previous knowledge about classical methods of machine learning (regression, classification, clustering, optimization, ...).
- Entry-level computer programming experience in either Matlab, Python, or C/C++.

Evaluation criteria

- Written exam 50%
- Written assignments / Labs 30%
- Project work 20%