Image Analysis
(MO445/MC940A)

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1 Overview

This course provides the knowledge to build image-based decision-making/support systems. Such systems require techniques for representation, description, classification, and segmentation of images.

Representation, description, classification, and segmentation of images are topics with many different techniques. Each topic could easily justify a separate course. Therefore, the course focuses on the main concepts and in the study of successful approaches. Prior knowledge in image processing is important, but the course reviews fundamental concepts and their extension to multidimensional and multiband images.

Image analysis is based on some content of interest, whose representation facilitates measure (feature) extraction. From image descriptors, one can use regression to predict physical attributes, classification to detect events, and segmentation to isolate and quantify objects. The course focuses on image classification and segmentation problems.

2 Location and schedule

The lectures will happen every Tuesday and Thursday from 2PM to 3:40PM at room CC52, with the subsequent 20 minutes for student assistance.

3 *Syllabus*

1. Introduction to image analysis.
    - Fundamental concepts of image processing: point-based, adjacency-based, and connectivity-based transforms.
    - Extending concepts to multiband and multidimensional images.
2. Image representation.
    - Point, region, and shape-based approaches.
    - Superpixel and hierarchical segmentation.
    - Iso-contours, multiscale skeletons, and shape saliences.
    - Space-frequency transforms: from Fourier to wavelets.
3. Image description.
    - Color, texture, shape decriptors and their combination.
    - Popular image descriptors.

- Data clustering and bag of visual words.
- Convolutional layers.

4. Image classification.
   - Fundamentals of machine learning.
   - From perceptron to deep convolutional neural networks.
5. Image segmentation.
   - From image-based to model-based approaches.
   - Semantic and instance segmentation.

4 Evaluation criteria

Evaluation will be based on a practical project, with multiple tasks, and according to the following criteria:

- the student's participation during the lectures,
- the quality of the presented report about the project,
- the quality of the implemented code (in C/C++/Python) and its documentation.

The project receives a score in [0,10] and the students are graded as follows.

- grade A for average score in [8.5,10];
- grade B for average score in [7.0,8.5);
- grade C for average score in [5.0,7.0);
- grade D for average score in [0.0,5.0);

The reports should have a maximum of 20 pages each with letter-size 11pt, including figures, tables, graphics, and references. It should present the following organization.

- Cover page: provide the name of the discipline, name of the student, academic identification number (RA), and delivery date, followed by a summary of the implemented techniques and their main results.
- Subsequent pages: present the literature that has been studied to implement the project, its difficulties, given solutions, implemented algorithms, and their results with illustration and discussion.
- Final page: present a conclusion about what has been accomplished with the task and provide suggestions to improve it.

5 Bibliography

Complementary literature (journal/conference papers) will be provided whenever needed.

1. V.K. Ayyadevara and Y. Reddy. Modern Computer Vision with Pytorch. Packt, 2020.
2. F. Chollet. Deep Learning with Python. Manning, 2018.
3. A. Géron. Hands-on Machine Learning with Scikit-Learn, Keras & Tensorflow. O'Reilly, 2nd Ed., 2019.
4. K. Koutroumbas and S. Theodoridis. Pattern Recognition. 4th Ed., Academic Press, 2009.

5. R. C. Gonzalez & R. E. Woods. Digital Image Processing, Pearson, 4o. edition, 2018.

6. R. Szeliski. Computer Vision Algorithms and Applications, Springer, 2011.

7. M. Kubat. An Introduction to Machine Learning. 2nd. edition, Springer, 2017.

8. S. Skansi. Introduction to Deep Learning: From Logical Calculus to Artificial Intelligence, Springer, 2018.

9. C.C. Aggarwal. Neural Networks and Deep Learning: A Textbook, Springer, 2018.

10. M. Petrou and P. Garcia. Image Processing: Dealing with Texture. Wiley, 2006.