3MD3080 - Morphologie mathématique moderne

Responsables : **Fragkiskos MALLIAROS**

Langues d'enseignement : **ANGLAIS**

Campus où le cours est proposé : **CAMPUS DE PARIS - SACLAY**

Nombre d'heures d'études élèves (HEE) : **40**

Nombre d'heures présentielles d'enseignement (HPE) : **24**

Année académique : **2024-2025**

Niveau avancé : **non**

Présentation, objectifs généraux du cours :

Mathema(cal morphology (MM) is a non-linear theory of image analysis developed from the 1960s at the Ecole des Mines, now Mines Paristech. The main architects of the theory are Georges Matheron and Jean Serra.

The driving idea for MM is to start from set theory and ordering rela(ons instead of linear algebra for its operators. In image processing and computer vision, for many problems, linear algebra is a limita(on. In par(cular, it is difficult to model occlusions. Mathema(cal morphology is useful in many contexts, especially for image analysis, which allows to perform measurements from image data.

The classical theory of MM starts from laKce theory in the con(nuous domain. This causes difficul(es due to topology aspects. A modern descrip(on of mathema(cal morphology starts from graph theory and builds discrete operators. This allows this course to describe seamlessly operators and their mathema(cal proper(es, as well as efficient algorithms and applica(ons.

This course starts from basic operators and finishes with machine learning applica(ons. In par(cular, it is interes(ng to note that Convolu(onal Neural Networks, which combine convolu(on with ac(va(on, can be interpreted as combina(ons of morphological operators.

Prérequis :

There are few prerequisites for this course. Having followed a graph theory and applica(ons course is very useful; as well as mastering the python language and numpy. Knowledge of the scikit-image, opencv and networkx packages is also useful.

Plan détaillé du cours (contenu) :

- Graphs and operators on graphs; proper(es and algorithms
- Basic MM operators: no(on of morphological dila(on and erosion ; Algebraic MM

operators; abstract erosion and dila(on

- Combina(ons of operators: opening, closing ; extension to weighted graphs ;

residues: gradients, top-hat.

- Geodesic operators; morphological reconstruc(on; extension to color and

mul(spectral operators

- Discrete geometry: homotopy-invariant operators, thinning and skeletons
- Segmenta(on, graph cuts and watershed operators
- Deep learning and MM. Binary neural networks.

Students will implement MM operators from scratch ini(ally, then use the implementa(on found in scikit-image and OpenCV for applica(ons.

Déroulement, organisation du cours :

The course is highly interac(ve with lectures, tutorials and applica(ons performed simultaneously during a session. There are more lecture elements at the beginning of the course and more applica(ons towards the end.

Organisation de l'évaluation :

The course is evaluated via a short interac(ve project.

Description des compétences acquises à l'issue du cours :

Students following this course will gain a beUer understanding of low-level vision operators and mechanism, as well as the mathema(cal background behind them.

They will be beUer able to develop and u(lise both designed and learned computer vision pipelines, in par(cular how linear and non-linear operators can combine to deliver interpretable, coherent, efficient and useful computer vision applica(ons.

Bibliographie :

[1] L. Najman and H. Talbot, editors. Mathema(cal Morphology: from theory to applica(ons. ISTE-Wiley, London, UK, September 2010. ISBN 978-1848212152.
[2] Michel SchmiU and JulieUe MaKoli. Morphologie mathéma(que. Presses des MINES, 2013.

[3] J. Serra. Image Analysis and Mathema(cal Morphology. Academic Press, 1982.