UCLouvain

linma2380

2023

Matrix computations

5.00 credits	30.0 h + 22.5 h	Q1

Teacher(s)	Jungers Raphaël ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	Basic knowledge (1st cycle) in linear algebra and numerical analysis.
Main themes	The course builds on the solid mathematical foundations of Matrix theory in order to elaborate algorithmic solutions to major challenges involving computations with/on matrices. • Matrices defined over a field/ring/nonnegative: applications and challenges • Canonical forms, decompositions, eigen- and singular values • Norms, convexity, structured matrices: sparse/adjacency matrices • Recent computational challenges: Nonnegative Matrix Factorization, matrix semigroups
Learning outcomes	**At the end of this learning unit, the student is able to :** Contribution of the course to the program objectives : • AA1.1, AA1.2 • AA5.5 • AA6.3 After successful completion of this course, the student will : 1 • have acquired a solid basis of matrix theory and its applications in several engineering disciplines • understand the use of matrix properties in the solution of these problems • have acquired a solid background in matrix problems involving eigenvalues, singular values, non-negative and polynomial matrices • have shown how to apply his theoretical background in concrete matrix problems. • be able to model an engineering problem by choosing the adequate concepts and the good tool within the wide panel offered by Matrix theory.
Evaluation methods	The evaluation of the students is partly based on a written (or oral, depending of the circumstances) exam organized according to the rules imposed by the EPL. The exam material corresponds to the contents of the lectures and lecture notes, with the possible exception of certain parts specified after the last session of the course. The exam represents 14/20 of the final grade. For a written exam, in case of doubt, the teacher might invite the student for a supplementary oral exam. The other part of the evaluation is based on the assignments and presentations made during the semester. It amounts to 6/20 of the final grade, in Jan and ---unchanged--- in Sept.
Teaching methods	• Regular classes with a schedule fixed by the EPL. • A seminar with presentations by the students is organized at the end of the quadrimester. • Exercises or homeworks made individually or in small groups, with the possibility to consult teaching assistants.. • Details announced during the first class. Some activities could be organized in remote fashion, e.g. on MS Teams.
Content	After an introduction recalling some basic notions, we discuss the following topics: 1. Complements on determinants 2. The singular value decomposition and its applications. Angles between subspaces, generalized inverses, projectors, least-squares problems 3. Eigenvalue decomposition: Schur and Jordan form 4. Approximations and variational characterization of eigenvalues 5. Congruence and stability: inertia, Lyapunov equation, stability analysis of dynamical systems 6. Structured and Polynomial matrices: Euclid algorithm, Smith normal form, fast algorithms. 7. Nonnegative matrices: Perron-Frobenius theorem, stochastic matrices 8. Matrix semigroups: algebraic structure, algorithms and applications (NMF, Joint Spectral Characteristics)

Inline resources	http://moodleucl.uclouvain.be/course/view.php?id=7969
Bibliography	Le support de cours se compose d'ouvrages de référence, de notes de cours détaillées et de documents complémentaires disponibles sur Moodle. Ouvrages de référence : • G.H. Golub and C.F. Van Loan (1989). Matrix Computations, 2nd Ed, Johns Hopkins University Press, Baltimore. • P. Lancaster and M. Tismenetsky (1985). The Theory of Matrices, 2nd Ed, Academic Press, New York
Faculty or entity in charge	MAP

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Mathematics	MATH2M	5		
Master [120] in Electrical Engineering	ELEC2M	5		
Master [120] in Mathematical Engineering	MAP2M	5		
Master [120] in Data Science Engineering	DATE2M	5		
Master [120] in Data Science: Information Technology	DATI2M	5		