Fast Algorithms for Boundary Integral Equations

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Format: this class will be taught over Zoom, by mimicking the original chalk lectures. A convenient time will be agreed upon with prospective students.

Office Hours: to be agreed upon.

Prerequisites: This is a graduate level class for Master students of CES and Technical Mathematics. The intended audience should be familiar with basic concepts of functional analysis, Lebesgue integration, numerical linear algebra, and probability theory.

Course Description: The main objective of this class is twofold: on one hand, to establish a connection between boundary value problems and boundary integral equations; on the other, to study discretization techniques for boundary integral operators. We will begin by covering some classical results of potential theory (single and double layer potential, jump conditions) for the Laplace and Helmholtz problems. We will discuss numerical discretization techniques, and focus on fast multipole methods. We will establish a connection to the modern concept of hierarchical matrices and randomized numerical linear algebra.

Workload: 3.0 hours VU | 4.5 ECTS

Textbook: The notes by the instructor found in TISS are intended as the main course material; additional reading material can also be found in TISS, and might be posted as the semester progresses. The following is an incomplete bibliography:

- R. Kress, *Linear Integral Equations*, Springer 2014;
- D. Colton and R. Kress, *Inverse Acoustic and Electromagnetic Scattering Theory*, Springer 2013;
- G.H. Golub and C.F. Van Loan, *Matrix Computations*, The John Hopkins University Press, 1996;
- G. Strang, *Computational Science and Engineering*, Wellesley Cambridge Press, 2012;
- L.N. Trefethen, *Approximation Theory and Approximation Practice*, SIAM 2013;
- P.G. Martinsson, *Fast Direct Solvers for Elliptic PDEs*, SIAM 2019.

Assignments: The lecture notes contain exercises that complement the material and will be assigned as the class progresses. Students are expected to present their solutions during exercise sessions.

Attendance: It is in students best interest to attend lectures; if you are unable to attend, you are personally responsible for the material covered in class.

Grading/Exam: To be decided, possibly dependent upon the size of class.

Miscellanea: This class is partially based on a workshop given by P.G. Martinsson at Dartmouth College in 2014, see `https://amath.colorado.edu/faculty/martinss/2014_CBMS/`. For lectures about approximation of functions by L.N. Trefethen see `https://people.maths.ox.ac.uk/trefethen/atapvideos.html`.

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