Optimization

Syllabus for the TEMPUS–SEE PhD Course

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1 General goals of the course

The course should provide an overview on a wide range of methods for various optimization problems, such as unconstrained and constrained optimization problems as well as global optimization problems. The students should learn about the essential theoretical results and – equally important – also about numerical algorithms for solving optimization problems. Solving exercise problems will be an integral part of the course.

It is recommended that the course will be modified in the future in order to focus more on topics which are represented as research topics at the partner universities.

2 Prerequisites on the students side

Participating students need to have programming skills and a sound knowledge of numerical mathematics (in particular numerical linear algebra). Fundamentals of functional analysis are also required. Of course, English language proficiency is an absolute necessity.

3 Modules of the course

PART I: Constraint and Unconstraint Optimization (20 units)

Module	No. of units	Contents
I: Unconstrained optimization	10	Fundamentals Line search methods Trust-region methods Conjugate gradient methods Quasi-Newton methods BFGS-methods Calculus of variations and optimal control
II: Constraint optimization	10	Optimality conditions Linear programming, interior point methods Quadratic programming SQP methods PDE-constraint optimization

PART II: Optimal Control and Stochastic Optimization (20 units)

III: Dynamic programming,	9	The Hamilton-Jacobi-Bellman equation Linear-quadratic control problems
IV: Stochastic optimization	11	Implicit filtering Direct search algorithms

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PART III: Global Optimization (20 units)

V: Global optimization	20	Branch and bound methods Cutting plane methods Interval methods Simulated annealing Clustering methods Genetic agorithms
Total no. of units:	**60**	

4 Literature

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[5] D. E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley, New York 1989.

[6] E. Hansen, Global Optimization Using Interval Analysis, Pure and Applied Mathematics Vol. 165, Marcel Dekker, New York 1992.

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[10] C. T. Kelley, Iterative Methods for Optimization, Frontiers in Applied Mathematics Vol. 18, SIAM, Philadelphia 1999.

[11] D. G. Luenberger, Linear and Nonlinear Programming, Addison-Wesley, Reading (USA) 1984.

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[14] R. E. Steuer, Multiple Criteria Optimization: Theory, Computations and Applications, John Wiley & Sons, New York 1986.

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[16] A. A. Törn and A. Žilinskas, Global Optimization, Lecture Notes in Computer Science Vol. 350, Springer-Verlag, Berlin 1989.

[17] A. A. Zhigljavsky, Theory of Global Random Search, Mathematics and Its Applications Vol. 65, Kluwer, Dordrecht 1991.

5 Teaching

The course should be accompanied by homework exercises which should require at most 2 of the afternoon sessions as indicated below. The major part of the afternoon session should be spent by working independently in teams on little projects on practical or pseudo-practical problems. The results also should be presented in the afternoon sessions. During the afternoon session the teacher should be available for questions respectively be present in order to get an impression on performance of the students. Homework exercises and projects for teamwork should also involve programming of algorithms respectively use of available software.

The course is planned for 4 weeks, each week from Monday till Friday. This implies that there will be 3 teaching units (45 minutes) per day. The following schedule is proposed for each day:

8:00 till 11:00:	three units with breaks in between;
11:30 till 12:30:	discussion with the teacher;
15:00 till 17:30:	work on homework exercises, work in teams on problems posed by the lecturer, presentation of results, respectively

Teachers for the course:

Mikhail Ivanov Krastanov (Bulgarian Academy of Sciences, Sofia),
Franz Kappel, Gregory D. von Winckel (University of Graz)

6 Grading

The basis for grading is provided by the performance of students in the following items:

a) Exercises for *homework* involving also numerical computations will be regularly given in order to provide possibilities for a better understanding of the material presented in the course.
b) *Team projects* and presentation of results.
c) An *oral examination* concerning the course.

The oral examination could consist of several parts taken at different times and should give the lecturer an impression on how well the student has understood the material of the course.

In order to obtain the grade for the course the following weights will be used for the items a), b) and c) from above:

Homework exercises	20%
Team projects	50%
Oral examination	30%