



Universität Greifswald, Institut für Mathematik und Informatik, Prof. Schmidt, 17487 Greifswald

Institut für Mathematik
und Informatik

Professur für Numerische Analysis

Prof. Dr. Werner Schmidt

Telefon: +49 3834 86-4629

Telefax: +49 3834 86-4640

wschmidt@uni-greifswald.de

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Syllabus for the course „Variational Calculus and Optimal Control”

The aim of the course is to derive analytically optimality conditions for various extremal and control problems and to propose numerical methods. The analysis is oriented to a general, abstract model and it is applied to different problems with ordinary differential and integral equations. It will be shown that the view of the optimality conditions depends on the control functions and state functions which will be considered. The optimality conditions are used in indirect numerical methods. The solutions of direct numerical methods are checked to fulfil the optimality conditions.

The 60 h course aimed for master- students. As prerequisites are required: Calculus, Real analysis and basics of functional analysis, basic knowledge in numerical mathematics. The course contains about 34 h lectures, 20 h tutorials, 6h computer lab.

In detail the syllabus is:

1. Introduction (6h + 4h)
 - 1.1 Mathematical models for some practical examles.
 - 1.2. Variational calculus. Euler equation, Weierstrass condition.

2. Optimality condition for extremal problems with constraints. (4h + 4h)
 - 2.1 The finite dimensional case.
 - 2.2 The Lagrange-principle in infinite dimensional problems.
 - 2.3. Adjoint equations.

3. An abstract model of optimal control. (8h + 4h)
 - 3.1 The Variational inequality
 - 3.2 Problems with ODE and integral equations with piecewise continuous controls.
 - 3.3 Contol problems with piecewise constant controls.
 - 3.4 Discrete control problems.

4. Reachable sets. (6h + 2h)
 - 4.1 Definition
 - 4.2 Convexity of reachable sets.
 - 4.3 Counterexample

5. Existence of optimal controls (6h +2h)

5.1 The Theorem of Roxin and Filippow

5.2 Relaxation of control problems

6. Numerical methods (4h + 4h)

6.1 Direct methods and SQP-methods

6.2 Indirect methods using multiple shooting

6.3. Iterative schemes of Chernousko

7. Numerical experiments using the package (6h) OCODE

Literature:

Joffe/Tichomirov. Theory of Extremal Problems. North Holland Pub. 1979

Leitmann. The Calculus of Variations and Optimal Control.

Macki/Strauss. Introduction to Optimal Control Theory. Springer 1982

Pesch. Schlüsseltechnologie Mathematik. Teubner-Verlag 2002

Trötzsch. Optimale Steuerung partieller Differentialgleichungen. Vieweg-Verlag 2005

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