Seminar in Spring Semester 2013

Shape Calculus

Supervisors	: Prof. R. Hiptmair
Venue	: HG G 5
Time	: Tue 15-17
Language	: English
First session	: Tue, Mar 19, 2013
Prep meeting	: Tue, Feb 19, 2013, 15:15, HG G 5
Contact	: R. Hiptmair, hiptmair@sam.math.ethz.ch
Prerequisites	: Knowledge of analysis and functional analysis; knowledge of PDEs is an advantage and so is some familiarity with numerical methods for PDEs
Audience	: MSc Students of Mathematics, RW/CSE

Description:

Shape calculus studies the dependence of solutions of partial differential equations on deformations of the domain and/or interfaces. It is the foundation of gradient methods for shape optimization. The seminar will study several sections of monographs and research papers dealing with analytical and numerical aspects of shape calculus.

Presentations:

The seminar will comprise up to 10 student presentations of a duration of about 60 minutes. They should be partly based on PDF slides prepared using the BEAMER LaTeXpackage (or LaTeXbased tools under MacOS). The presentations should be done using a laptop computer (which can be provided). Speakers are advised to elaborate technical manipulations and proofs on the blackboard. MATLAB demonstration of simple numerical experiments is expected whenever appropriate. The lecture slides in PDF format should be made available immediately after the presentation.

Quizz:

Participants of the seminar will be asked questions about the previous presentations at the beginning of each session.

Available topics:

1. The velocity method and Eulerian shape derivatives, [SZ92, Sect. 2.8–2.11]
2. Material derivatives and shape derivatives [SZ92, Sect. 2.25–2.30]
3. Shape derivatives for linear PDEs [SZ92, Sect. 3.1–3.3]
4. The shape Hessian [BZ97]
5. Velocity method and Lagrangian formulation for the computation of the shape Hessian, [DZ91]
6. Elements of shape calculus [DZ11, Ch. 9, Sects. 3.4,4.5.7]
7. PDE constrained shape calculus [DZ11, Ch. 9, Sect. 5]
8. Shape derivatives in differential forms [HL12]
9. Second derivatives and sufficient optimality conditions for shape functionals [Epp00a]
10. Shape calculus for acoustic scattering [FMOP01, FOP04]
11. Boundary integral representations of shape derivatives [Epp00b]

Speakers and dates for presentations:

Date	Speaker	Topic #
26.3.2013	D. Schwarz	1
9.4.2013	T. Welti	2
16.4.2013	C. Zingg	3
23.4.2013	A. Paganini	5
30.4.2013	R. Hiptmair	7
7.5.2013	L. Scarabosio	9
21.5.2013	S. Sargheini	10
28.5.2013	E. Spindler	11

References

[BZ97] Dorin Bucur and Jean-Paul Zolsio. Anatomy of the shape hessian via lie brackets. *Annali di Matematica Pura ed Applicata*, 173:127–143, 1997. 10.1007/BF01783465.

[CLL12a] Martin Costabel and Frédérique Le Louër. Shape derivatives of boundary integral operators in electromagnetic scattering. Part I: Shape differentiability of pseudo-homogeneous boundary integral operators. *Integral Equations Operator Theory*, 72(4):509–535, 2012.

[CLL12b] Martin Costabel and Frédérique Le Louër. Shape derivatives of boundary integral operators in electromagnetic scattering. Part II: Application to scattering by a homogeneous dielectric obstacle. *Integral Equations Operator Theory*, 73(1):17–48, 2012.

[DZ91] Michel C. Delfour and Jean-Paul Zolésio. Velocity method and Lagrangian formulation for the computation of the shape Hessian. *SIAM J. Control Optim.*, 29(6):1414–1442, 1991.

[DZ11] M. C. Delfour and J.-P. Zolésio. *Shapes and geometries*, volume 22 of *Advances in Design and Control*. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, second edition, 2011. Metrics, analysis, differential calculus, and optimization.

[EHS07] Karsten Eppler, Helmut Harbrecht, and Reinhold Schneider. On convergence in elliptic shape optimization. *SIAM J. Control Optim.*, 46(1):61–83 (electronic), 2007.

[Epp00a] K. Eppler. Second derivatives and sufficient optimality conditions for shape functionals. *Control Cybernet.*, 29(2):485–511, 2000.

[Epp00b] Karsten Eppler. Boundary integral representations of second derivatives in shape optimization. *Discuss. Math. Differ. Incl. Control Optim.*, 20(1):63–78, 2000. German-Polish Conference on Optimization—Methods and Applications (Żagań, 1999).

[FMOP01] G.R. Feijóo, M. Malhotra, A.A. Oberai, and P.M. Pinsky. Shape sensitivity calculations for exterior acoustics problems. *Engineering Computation*, 18(3/4):376–391, 2001.

[FOP04] G.R. Feijóo, A.A. Oberai, and P.M. Pinsky. An application of shape optimization in the solution of inverse acoustic scattering problems. *Inverse Problems*, 20:199–228, 2004.

[HL12] Ralf Hiptmair and Jingzhi Li. Shape derivatives in differential forms I: an intrinsic perspective. *Annali di Matematica Pura ed Applicata*, pages 1–22, 2012. DOI: 10.1007/s10231-012-0259-9.

[Kir93] A. Kirsch. The domain derivative and two applications in inverse scattering theory. *Inverse Problems*, 9(1):81–96, 1993.

[Pot94] Roland Potthast. Fréchet differentiability of boundary integral operators in inverse acoustic scattering. *Inverse Problems*, 10(2):431–447, 1994.

[Pot96a] Roland Potthast. Domain derivatives in electromagnetic scattering. *Math. Methods Appl. Sci.*, 19(15):1157–1175, 1996.

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[Sch12] V. Schulz. A riemannian view on shape optimization. Technical Report 1203.1493v1 [math.OC], arXiv, 2012.

[SMSY11] Ganesh Sundaramoorthi, Andrea Mennucci, Stefano Soatto, and Anthony J. Yezzi. A new geometric metric in the space of curves, and applications to tracking deforming objects by prediction and filtering. *SIAM J. Imaging Sciences*, 4(1):109–145, 2011.

[SZ92] J. Sokolowski and J.-P. Zolesio. *Introduction to shape optimization*, volume 16 of *Springer Series in Computational Mathematics*. Springer, Berlin, 1992.

[Zol84] J.-P. Zolésio. Numerical algorithms and existence result for a Bernoulli-like steady free boundary problem. *Large Scale Systems*, 6(3):263–278, 1984.