Topological Derivative:
Theory and Applications

Overview of the short course

The topological derivative is defined as the first term of the asymptotic expansion of a given cost-functional with respect to a small parameter that measures the size of singular domain perturbations such as holes, inclusions, defects, source-terms, and cracks. This relatively new concept has applications in many different fields such as shape and topology optimization, inverse problems, image processing, multi-scale material design, and mechanical modeling including damage and fracture evolution phenomena. In this short course, the topological derivative concept is presented together with a portfolio of applications in the context of topology optimization and inverse problems. The short course shall be useful for those interested in the mathematical aspects of topological asymptotic analysis as well as on applications of topological derivatives in computational mechanics and structural optimization.

The course will be taught in a manner that appeals to engineers and mathematicians. There will be lectures, tutorials, and computer sessions. It will be taught by a pioneer in the field, who has been developing the topological derivative technique for more than a decade. Requisite preliminaries will be taught on the first day.

The course will begin with an overview of shape and topology optimization and will introduce the concept of topological derivative. In addition to presenting mathematical aspects of the subject matter, adequate emphasis will be placed on hands-on computation and applications of topological derivative. The course will be accessible to students, faculty, and industry practitioners involved in structural optimization and computational mechanics.

Important information	**Jan. 15 – 20, 2018** **Indian Institute of Science, Bengaluru** **Number of participants for the course is limited to 50.**
You should attend if…	▪ you are interested in structural optimization. ▪ you are interested in sensitivity analysis in computational mechanics. ▪ you are a student or faculty member or a scientist in a research organization or a practitioner in the industry with an interest in structural optimization, multi-disciplinary optimization, or computational mechanics.
Fees	The participation fees for taking the course is as follows: **Participants from abroad : US $300** **Industry/Research Organizations: INR 10,000** **Faculty: INR 5,000** **Students and post-docs: INR 2,000** The above fee includes all instructional material, lunches, and snacks during the day. The participants will be provided with accommodation on payment basis, first-come-first-served.

Schedule and Topics

Each topic is covered in a one-hour lecture and a one-hour tutorial or a computer session. Thus, each day will have 3 h of lectures and 3 h of tutorials/computer sessions, from 9 am to 5:30 pm with breaks.

Jan. 15, 2018	**Preliminaries:** (1a) Parameter derivative [GKA]; (1b) shape derivative [GKA]; (1c) homogenization [AKN]
Jan. 16, 2018	**Introduction:** (2a) Concept of topological derivative; (2b) Why is making holes is a good idea?; (2c) Applications of topology optimization [AAN]
Jan. 17, 2018	**Singular perturbation of energy functional:** (3a) Laplacian in two spatial dimensions; (3b) Dirichlet and (3c) Neumann boundary conditions on the holes [AAN]
Jan. 18, 2018	**Configurational perturbations of energy functionals:** (4a) Existence of the topological derivative; (4b) asymptotic expansion of the shape functional; (4c) estimation of the remainders
Jan. 19, 2018	**Topological derivative with adjoint states:** (5a) existence of the topological derivative; (5b) asymptotic expansion of the shape functional; (5c) estimation of the remainders [AAN]
Jan. 20, 2018	**More applications of the topological derivative:** (6a) fluid mechanics; (6b) inverse problems; (6c) damage and fracture mechanics [AAN]

The Faculty

Prof. Antonio André Novotny [AAN] is a senior researcher at the National Laboratory for Scientific Computing, Petrópolis, Brazil. He is one of the pioneers of topological derivative. Trained as a mechanical engineer and applied mathematician, he has extensive experience in PDE-constrained optimization and inverse problems.

Prof. G. K. Ananthasuresh [GKA] is a professor of mechanical engineering at the Indian Institute of Science. He has extensive experience in optimization of compliant mechanisms, stiff structures, MEMS devices, and bistable structures.

Prof. A. K. Nandakumaran [AKN] is a professor of mathematics at the Indian Institute of Science. His research interests include homogenization, optimal control, image reconstruction, and differential games.
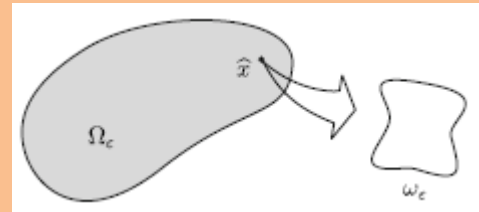
Course Coordinators

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http://www.iisc.ac.in/GIAN/TopDerivative