Integrated Multiphysics Simulation & Design Optimization

Open Express One Day Course & Integrated Multiphysics Simulation & Optimization

A Database Workshop for
Multiphysics Optimization Software Validation

Las Palmas de Gran Canaria University / Salón de Actos del Edificio Central del Parque Científico y Tecnológico

December 12–13, 2011

Organized by CEANI Division, SIANI Institute, from Las Palmas de Gran Canaria University, Spain and University of Jyväskylä, Finland, in association with CSC, VTT, Stanford / MIT Consortium for Multidisciplinary System Design and University of Houston, College of Technology

website: http://www.mit.jyu.fi/scoma/DBW2011

December 12, Monday morning

Express Optimization Course, part 1

Time

08:00–09:00 Inscription and material delivery

09:00–09:30 *Welcoming Address*
José Regidor García, Chancellor of Las Palmas de Gran Canaria University
Pekka Neittaanmäki, Dean of the Faculty of Information Technology, University of Jyväskylä, Finland

09:30–13:20 Express Optimization Course: Part 1

Session 1 Chairman: **Jacques Periaux**, University of Jyväskylä, Finland

09:30–10:20 *"Simulations, Supercomputing and Data"*
Olivier Pironneau, UPMC-LJLL, France

10:20–11:10 *"Evolutionary Multiobjective Optimizer Performance Assessment"*
Carlos M. Fonseca, Department of Informatics Engineering, Faculty of Science and Technology, University of Coimbra, Portugal

11:10–11:40 Coffee break

Session 2 Chairman: **Gabriel Winter**, CEANI (SIANI, ULPGC), Spain

11:40–12:30 *"Evolutionary Optimisation with Hybridized Games for Morphing Design of Airfoils"*
Jacques Periaux, University of Jyväskylä, Finland and International Center for Numerical Methods in Engineering (CIMNE), Barcelona, Spain

12:30–13:20 *"An Overview of Wing Design Approaches Using Evolutionary Optimization"*
Domenico Quagliarella, C.I.R.A. (Italian Centre for Aerospace Research), Italy

13:20–14:45 Lunch

December 12, Monday afternoon

Database Workshop, part 1

Time

14:45–18:30 Database Workshop Sessions: Academic Test Cases (TAs) and Industrial Test Cases (TIs)

14:45–15:00 *Welcome address*
P. Neittaanmäki and J. Periaux (JYU), G. Winter and B. Galvan (CEANI)

15:00–15:15 *"Validation of Optimization Software with DBs: Motivation"*
J. Periaux and P. Neittaanmäki (JYU)

15:15–15:45 *"Presentation of the Database: Structure, Operability and the JYU Design Lab"*
T. Varis, JYU, Finland and H. Carmona, CEANI, Spain

15:45–16:05 Coffee Break

16:05–16:35 TA1 session: chaired by M. Razzaq, TU Dortmund, Germany
"*A Numerical Set-up for Benchmarking and Optimization of Fluid-structure Interaction"*

16:35–17:05 TA2 session: chaired by J. Leskinen, JYU, Finland
"Inverse or Optimization Problems for Multiple (Ellipse) Ellipsoid Configurations"

17:05–17:25 TA4 session: chaired by P. Råback, CSC, Finland (presented by P. Neittaanmäki, JYU)
"Optimization of Beam Profile in Fluid-structure Interaction"

17:25–18:15 TA5 / TA6 session: chaired by Ning QIN and Joe Coppin, Univ. of Sheffield, UK
"Shock Control Bump Optimization on a 2-D Transonic Laminar Flow Airfoil" (TA5)
"Shock Control Bump Optimization on a 3-D Transonic Laminar Flow Wing" (TA6)

18:15–18:30 *Discussion about Results/Data Obtained on Academic Test Cases*
Academic Test Case Chairmen with Audience (part 1)

18:30 End of Day 1

December 13, Tuesday morning

Express Optimization Course, part 2

Time

10:00–13:30 Express Optimization Course: Part 2

Session 3 Chairman: **Pekka Neittaanmäki**, University of Jyväskylä, Finland

10:00–10:50 *"Some Experiences of Solving Design Problems with Interactive and Hybrid Multiobjective Optimization Methods"*
Kaisa Miettinen, Department of Mathematical Information Technology, University of Jyväskylä, Finland and Department of Mathematics, Division of Optimization and Systems Theory, KTH Royal Institute of Technology, Sweden

10:50–11:40 *"Optimization Tools of the FreeFem++ Software"*
Frédéric Hecht, UPMC-LJLL, France (presented by O. Pironneau)

11:40–12:10 Coffee break

Session 4 Chairman: **Blas Galván**, CEANI (SIANI, ULPGC), Spain

12:10–13:00 *"Evolutionary Multiobjective Algorithms in Structural Engineering Optimum Design"*
David Juan Greiner Sánchez, Universidad de Las Palmas de Gran Canaria, Spain

13:00–13:30 Round Table: *"Future Optimization Methods and Tools for Multiphysics Design"*
All Lecturers and the Audience

13:30–15:00 Lunch

December 13, Tuesday afternoon

Database Workshop, part 2

Time

15:00-18:30 **Database Workshop Sessions: Academic Test Cases (TAs) and Industrial Test Cases (TIs)**

15:00–15:40 TA10 session: chaired by J. Leskinen and WANG Hong, JYU, Finland
"Reconstruction of BINACA0012 Geometry Using Discrete and Continuous Optimization"

15:40–16:10 TI3 session: chaired by J. Leskinen, JYU, Finland
"Reconstruction/Inverse and Multi-Objective Design Optimisation of High Lift Systems"

16:10–16:30 **Coffee Break**

16:30–17:00 TI4 session: chaired by Ch. Hirsch, NUMECA, Belgium (presented by Ms. WANG Hong, JYU)
"Numerical Investigation of 3D Flow over Horizontal Axis Wind Turbine NREL Phase VI"

17:00–17:20 TI5 session: chaired by J. Hämäläinen, Lappeenranta University of Technology, Finland (presented by P. Neittaanmäki, JYU)
"Optimal Flow Divider"

17:20–17:40 TI6 session: chaired by T. Varis, JYU, Finland
"Structural Optimization of Paper Machine Parts done at the JYU Design Lab"

17:40–18:00 *"Open Discussion about Results/Data Obtained on Industrial Test Cases"*
Industrial Test Case Chairmen with Audience (part 2)

18:00–18:30 General conclusion: *"Lessons Learned from the Workshop"*
P. Neittaanmäki and J. Periaux (JYU), G. Winter and B. Galvan (CEANI)
All Test Case Chairmen with Audience

18:30 **End of Day 2: Express Course and Database Workshop Adjourned**

Express Optimization Course Lecturers

- **Introduction**
- **Abstract**

December 12, 2011

"Simulations, Supercomputing and Data"
Olivier Pironneau, UPMC-LJLL, France

"Evolutionary Multiobjective Optimizer Performance Assessment"
Carlos M. Fonseca, Department of Informatics Engineering, Faculty of Science and Technology, University of Coimbra, Portugal

"Evolutionary Optimisation with Hybridized Games for Morphing Design of Airfoils"
Jacques Periaux, University of Jyväskylä, Finland and International Center for Numerical Methods in Engineering (CIMNE), Barcelona, Spain

"An Overview of Wing Design Approaches Using Evolutionary Optimization"
Domenico Quagliarella, C.I.R.A. (Italian Centre for Aerospace Research), Italy

December 13, 2011

"Some Experiences of Solving Design Problems with Interactive and Hybrid Multiobjective Optimization Methods"
Kaisa Miettinen, Department of Mathematical Information Technology, University of Jyväskylä, Finland and Department of Mathematics, Division of Optimization and Systems Theory, KTH Royal Institute of Technology, Sweden

"Optimization Tools of the FreeFem++ Software"
Frédéric Hecht, UPMC-LJLL, France

"Evolutionary Multiobjective Algorithms in Structural Engineering Optimum Design"
David Juan Greiner Sánchez, Universidad de Las Palmas de Gran Canaria, Spain

Professor **Olivier Pironneau**

Olivier Pironneau graduated from the French engineering school Ecole Polytechnique. He received his master and PhD in Optimization and Control from the University of California Berkeley with E. Polak. After a two years post-doc with Sir James Lighthill in Cambridge UK, he joined the research team of J.L. Lions at INRIA in France. He became professor of applied mathematics in 1977 first at Université Paris-Nord then at UPMC (Paris VI, Jussieu).

He has written over 200 articles and 8 books on various topics from optimal shape design to mathematical finance, which all have at the center of their preoccupation the design of efficient and precise numerical methods and algorithms to solve and control partial differential equations. He has also collaborated with many industries and three banks.

He is a member of the French Académie des Sciences and the president of the French government panel on high performance computing in.

Simulations, Supercomputing and Data

Olivier Pironneau, olivier.pironneau@upmc.fr
UPMC-LJLL, France

ABSTRACT
Simulation has becomes as important as experimentation and also complementary. In theoretical physics, finance, climatology, geology, astrphysics, biology and bioinformatics, very significant innovations are made but terabytes of data are generated by a single computation. Data storage and public availability is one problem but data treatment and data mining is a real challenge as it needs to b e done near to the supercomputing centers where the data are generated.

In this talk we shall present the problem, how each research field deals with it and some of the research programs which are being setup for solutions.

Associate Professor ***Carlos M. Fonseca***

Carlos M. Fonseca was born in Aveiro, Portugal, in 1968. He graduated in Electronic and Telecommunications Engineering from the University of Aveiro in 1991, and obtained his doctoral degree from the University of Sheffield, U.K., in 1996, for his work on Multiobjective Evolutionary Algorithms with Application to Control Engineering Problems. He is an Associate Professor at the Department of Informatics Engineering of the University of Coimbra, Portugal, and a member of the Centre for Management Studies of Instituto Superior Técnico, Lisbon. He was a Research Associate with the Department of Automatic Control and Systems Engineering of the University of Sheffield, U.K., from 1994 until 1997, and a Lecturer at the Department of Electronic Engineering and Informatics, Faculty of Science and Technology, University of Algarve, Faro, Portugal, from 1997 until October 2010. His main research interests are multicriterion optimization, evolutionary algorithms, experimental assessment of algorithms, and dynamical systems.

Evolutionary Multiobjective Optimizer Performance Assessment

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ABSTRACT

Evolutionary algorithms (EAs) are stochastic search and optimization algorithms that have reached great popularity in the engineering community, and in many other scientific communities, due to their ability to deal with many problems which are not suited to more conventional optimization techniques. Although they are usually seen as offering a good combination of flexibility and power, EAs may be very computationally demanding, and the solutions they produce are not guaranteed to be close to optimal in any way. Nevertheless, the many successful applications of evolutionary algorithms reported in the literature, both in academic and in industrial settings, attest to their performance and usability in practice.

Informally, a good optimizer should be able to produce good solutions to difficult problems in a short amount of time. In addition, it should be able to do so consistently across multiple runs on the same problem instance and over different instances of the same problem class. Since EAs are stochastic, both the quality of the solutions produced and the time needed to produce them are random, and are associated with some probability distribution. Performing multiple optimization runs allows one to sample from such distributions independently and arbitrarily often, making statistical analysis based on the frequency argument a natural approach to the assessment of evolutionary optimizer performance.

In a multiobjective optimization scenario, where solution quality is characterized by several objective functions, or criteria, there is usually no single optimal solution, but multiple Pareto-optimal solutions, incomparable to each other. Evolutionary Multiobjective Optimizers (EMO) attempt to approximate this set, in some sense, through sets of mutually incomparable, or non-dominated, solutions. Since the result of such an optimization run is now a (random) set, studying the corresponding distributions is less straightforward than in the single-objective case. As a result, two main approaches to EMO performance assessment have arisen: the quality-indicator approach, which maps each set of non-dominated solutions onto a scalar value and studies the corresponding distribution of indicator values, and the attainment-function approach, which directly considers the distribution of the images of the optimization results in objective space.

In this talk, the quality-indicator approach and the attainment-function approach will be reviewed, and their distinctive features will be highlighted. Then, recent progress relating them to each other will be presented. Current challenges and opportunities for future developments will be identified at the end.

*Professor **Jacques Periaux***

Jacques Periaux worked for Dassault Aviation from 1970 to 1995 as Leader of the Numerical Analysis Group in the Theoretical Aerodynamic Department on the development of 3-D finite element software for the design of military and civil aircraft, space vehicles (like HERMES) before being appointed a High Scientific Adviser in 1996- of the Advanced Studies Division.

From 1998 to 2004, he chaired the Pôle Scientifique Dassault Aviation jointly with University Pierre et Marie Curie and was appointed in 2003 Adjoint Director at Division de la Prospective.

From 2007 to 2010 he had the national position of Finnish Distinguished Professor at the Mathematical Information Technology of the University of Jyvaskyla, Finland in charge of a MDO project supported by the R&D Tekes institution, and including the development of a Finnish Database for the validation of multi physics optimization software. Since 2008 - he is a UNESCO Chair Professor on Numerical Methods in Engineering at CIMNE/UPC Barcelona, Spain.

Jacques Periaux has set up and developed during the last two decades many scientific and technical cooperations abroad, in particular with Finland, USA, Australia and Spain and more recently with China in the context of EC Framework Programs. He received in 2010 in Beijing the National Awards from Foreign Affairs for cooperation with China. In July 2011, he was elected a Corresponding Member of the International Academy of Astronautics (IAA).

His current research interests include Parallel Evolutionary Computing, Game Strategies and Hybridized Methods for the Multidisciplinary Design Optimization (MDO) of Aerospace Engineering problems.

Evolutionary Optimisation with Hybridized Games for Morphing Design of Airfoils

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** International Center for Numerical Methods in Engineering (CIMNE), Barcelona, Spain

ABSTRACT
This lecture describes two advanced evolutionary optimisation methods applied to morphing aerofoil/wing shape design optimisation of Unmanned Aerial Vehicle (UAV). The first evolutionary method uses a standard Genetic Algorithm (GAs) and the second one uses hybridized Game Strategies combined with GAs (HGAs) and a new dynamic Nash-Game concept to accelerate the optimisation procedure. Validation aspects of the HGA approach (Pareto and Nash games) are illustrated by single/multi-objective mathematical design problems of increasing complexity. During the optimisation procedure, the Nash Game has a pre-conditioning effect when dynamically coupled to a global single objective optimization or a cooperative multi objective Pareto-Game. Both GAs and HGAs optimisation methods are used for capturing global solution and ensuring Pareto optimality respectively coupled with Euler Computational Fluid Dynamic (CFD) analyser and Computer Aided Design (CAD) systems.

For practical applications, one type of morphing techniques such as Leading and Trailing Edge Deformation (LTED) is selected to control the flow over an aerofoil/wing. A LTED approach is applied on a Natural Laminar Flow (NLF) RAE 5243 airfoil. Two morphing UAV applications operating at cruise and take-off & landing conditions are considered to maximise:

- lift to drag ratio (L/D) at cruise condition ($M_\infty = 0.75$, $\alpha = 3.0^o$) to extend the aircraft range,
- lift coefficient (Cl) at take-off and landing conditions, (Take-off: $M_\infty = 0.2$, $\alpha = 15.0^o$, Landing: $M_\infty = 0.12$, $\alpha = 17.18^o$) for short Take-Off and Landing (STOL)

using GAs and Hybridised GAs. Performances of GAs and HGAs are compared in terms of cost and design quality from the computational results.

From numerical results, it is concluded that dynamic Nash-Games combined with an evolutionary optimisation method speed up the global optimisation procedure while producing better aerodynamic quality solutions in complex single and multi-objective design optimisation problems.

Finally, on a more practical aspect, this new CFD optimization design method demonstrates also that morphing techniques applied to current aerofoil or wing design problems can improve significantly aerodynamic performances at both cruise regime and take-off & landing conditions when compared to those obtained from a baseline design. These morphing techniques are potential candidates in the future for active control of air foil test cases of the Finnish Database.

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Work
1988 – present
C.I.R.A. (Italian Centre for Aerospace Research) in the Informatics Department where he worked until October 1994. During this periods he got his Ph.D. degree; then he moved in the Fluid Mechanics Department where he currently works. He has been member of the AIAA (American Institute of Aeronautics and Astronautics) National Technical Committee on Intelligent Systems.

Education
1993 PhD in Aerospace Engineering at University "Federico II" in Naples, Italy
1988 Master degree in Aeronautic Aerospace Engineering at University "Federico II" in Naples, Italy

Research Areas
His main current research interests is the application of multi-objective optimisation methods to aerodynamic design problems giving particular attention to hybrid optimization techniques such as genetic algorithms coupled with gradient based local search methods. Other research interests are in the field of surrogate/ approximated methods for fitness function evaluation and uncertainties handling in robust design problems.

He participated to the INGENET (NETworked Industrial Design and Control applications using GENetic algorithms and evolution strategies) European thematic network, where he worked on hybrid multiobjective evolutionary algorithms. Afterwards, he participated to the AEROSHAPE (Multi-Point AEROdynamic SHAPE Optimisation) developing both Evolutionary Computing and Adjoint based optimization techniques. Finally, he worked to practical optimization problem within the VELA (Very Efficient Large Aircraft), NACRE (New Aircraft Concept Research), EUROLIFT II (European High Lift Programme II), TELFONA (TEsting for Laminar Flow On New Aircraft), SUPETRAC (SUPERsonic

TRAnsitionControl) CESAR (Cost Effective Small Aircraft) and NICETRIP (Novel Innovative Competitive Effective Tilt Rotor Integrated Project) European projects.

He has been general chair of the EUROGEN 2011 ECCOMAS thematic conference on Evolutionary and Deterministic Methods for Design, Optimization and Control with Applications to Industrial and Societal Problems.

An Overview of Wing Design Approaches Using Evolutionary Optimization

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ABSTRACT

Aerodynamic wing design and optimization is, historically, a challenging task for evolutionary optimization techniques. Here some examples, of increasing difficulty and complexity, are illustrated and discussed to show how evolutionary techniques can take advantage of advanced efficiency improvement methods to provide effective and efficient approaches to the aerodynamic shape design problems. In particular, a classic wing design optimization with static aero-structural coupling is first illustrated and discussed as introductory example for multi-objective design optimization [1]. Subsequently, with the help of another design example, it is illustrated how a complex, real world, aerodynamic shape design problem can be approached with a pilot, preparatory multi-objective sub-problem to enhance the subsequent convergence of the evolutionary computation that optimizes the high fidelity model [2]. This last point is then further investigated and an innovative approach to surrogate and reduced fidelity modelling introduction in the optimization loop is described, in which the multi-objective optimization framework is used to analyze the implications of mixing fitness evaluators with different levels of precision. A new 'Asymmetric elitist Multi-Objective Genetic Algorithm' (AMOGAe) is, consequently, introduced. In "AMOGAe" one objective is computed using "low fidelity" evaluations and the other one with "high fidelity" evaluations [3,4]. This algorithm is characterized by an asymmetry in the evaluation of the objectives, so that the low fidelity objective is computed much more times than the high fidelity one. Finally, the above proposed approach, when applied to computationally challenging design cases, is complemented by the introduction of computational methodologies to define and exploit a reduced order model as surrogate evaluator. In particular, the potentialities of Proper Orthogonal Decomposition (POD) techniques will be explored [5].

REFERENCES

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[2] Iuliano, E. and Quagliarella, D., "Efficient aerodynamic optimization of a very light jet aircraft using evolutionary algorithms and Reynolds-averaged Navier-Stokes flow models", Journal of Aerospace Engineering, Vol. 225, n. 10, (2011), pp. 1109-1129.

[3] Quagliarella, D. and Chinnici, G., "Usage of Approximation Techniques in Evolutionary Algorithms with Application Examples to Aerodynamic Shape Design Problems" in Evolutionary Algorithms and Intelligent Tools in Engineering Optimization, Annicchiarico, W., Périaux, J., Cerrolaza, M. and Winter, G., ed., CIMNE, Barcelona, Spain, ISBN: 1-84564-038-1, 2005, pp. 167--189.

[4] Quagliarella, D., Iannelli, P., Vitagliano, P. L. and Chinnici, G., "Aerodynamic shape design using hybrid evolutionary computation and fitness approximation", in 'AIAA 1st Intelligent Systems Technical Conference', 2004.

[5] Iuliano E. and Quagliarella D., Surrogate-Based Aerodynamic Optimization Via a Zonal POD Model, in 'Proceedings of EUROGEN 2011', September 2011.

Professor ***Kaisa Miettinen***

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Education

Doctor of Philosophy, University of Jyväskylä, 1994
Adjunct Professorships

- University of Jyväskylä since 1997
- Aalto University since 2008

Professional Experience

- September 2011 - August 2013: Part-time visiting professor in optimization and systems theory, KTH Royal Institute of Technology, Stockholm
- Since September 2007: Professor in industrial optimization, University of Jyväskylä, (part-time: September - December 2007, September 2011 - August 2013
- January 2004 - December 2007: Professor in financial mathematics, Helsinki School of Economics (part-time: January 2004 - April 2005 and September - December 2007)

Scientific Positions of Trust

- International Society on Multiple Criteria Decision Making: President 2011-2015, President-Elect 2008-2011, Secretary 1997-2008
- EUROPT - The Continuous Optimization Working Group of EURO: President (Chair) 2010-2012, General Vice-Chair 2008-2010, Newsletter Editor, 2006-2008
- Member of the Steering Committee of EMO (Evolutionary Multiobjective Optim.) 2008-
- Finnish Society on Computational Sciences: President 2010, Vice-president 2007-2009
- Member of the Science Council of the University of Jyväskylä, 2010-2011
- Member of the International Steering Committee of OIPE - Workshop on Optimization and Inverse Problems in Electromagnetics Series, 2008-2012
- Finnish Operations Research Society: President 2002-2003, member of the board 2007-2008, 2010-2011, deputy of the board 1997-2001, 2004-2006, 2009
- Member of the Systems Analysis Division of the Scientific Advisory Board for Defence, 2006-2012

Scientific Tasks and Positions as an Expert

- Member of the Editorial Board, OR Spectrum, 2009-
- Member of the Editorial Board, International Journal of Optimization: Theory, Methods and Applications, 2008-
- Member of the Editorial Board, Optimization Letters, 2005-
- Member of the Editorial Board, Journal of Global Optimization, 2001-

Supervision of Postgraduate Theses

- Supervisor of ten doctoral theses, six licentiate theses and six doctoral theses in progress

Special Scientific Acknowledgements and Activities

- MCDM Conference Chairmanship Award of the International Society on Multiple Criteria Decision Making, 2011
- Recognition from the MASI programme of Tekes, 2010
- Vaisala Award of the Finnish Academy of Science and Letters in the field of mathematics for research merits, 2009
- Researcher of the year 2007 at Helsinki School of Economics, 2007
- Organizer of Dagstuhl Seminars on Multiobjective Optimization, 2004, 2006, 2008, 2012

Some Experiences of Solving Design Problems with Interactive and Hybrid Multiobjective Optimization Methods

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ABSTRACT

Many methods have been developed for multiobjective optimization. Typically, they aim at supporting a decision maker in finding the best compromise solution in problems where several conflicting criteria are to be optimized simultaneously. Because the compromise solutions, so-called Pareto optima, cannot be ordered without additional information,

the solution process requires preference information from a decision maker in some form or another. In his talk, some new interactive and hybrid multiobjective optimization methods are introduced. In interactive methods, a solution pattern is formed and repeated several times, and in each iteration further information about the decision maker's preferences is inquired. In this way, the decision maker can learn about the nature of the problem and about the interdependencies among the criteria involved. (S)he can also adjust one's preferences while learning and concentrate on such solutions that seem most promising. On the other hand, hybrid methods combine elements of different methods in order to benefit from their strengths and overcome their weaknesses. An example of new interactive methods is NAUTILUS which starts from the worst possible objective values and proceeds towards the most preferred Pareto optimal solution without the need of trading off between the objectives. Other methods to be introduced include Pareto Navigator, PAINT and NIMBUS. Finally, some design applications in industrial engineering are outlined and experiences of solving them with the methods described are discussed.

Professor ***Frédéric Hecht***

Frederic Hecht passed his thesis in 1980 at the University Paris VI. After 18 years at INRIA where he developed many softwares for fluids and automatic mesh generation. He became professor at the Université Pierre et Marie Curie (Paris VI) in 1999. He received the IBM supercomputing prize in 1989. He is the co-author of 2 books, one on mesh generation and the other on C++ for numerical analysis. He has also written about 100 research papers. Frederic Hecht is well known for his work on anisotropic mesh generation and adaptation, for the software freefem++ and for many contributions to the numerical solutions of partial differential equations by the finite element method.

For more details see http://www.ann.jussieu.fr/hecht

Optimization Tools of the FreeFem++ Software

ABSTRACT

Freefem++ is a software to solve numerically PDEs with Finite element methods. We present the optimization tools built in freefem++. This toolbox in based on classical optimization algorithms: Conjugate gradient, BFGS, algorithms from the NLopt library, and the stochastic, derivative-free methods cm-aes (Covariance Matrix Adaptation Evolution Strategy) in sequential or in parallel and also more technical algorithms like semi smooth Newton Method. We use the capability of Freefem++ to compare different algorithms on some classical test cases.

REFERENCES

[1] Steven G. Johnson, The NLopt nonlinear-optimization package, http://ab-initio.mit.edu/nlopt CMA_ES http://en.wikipedia.org/wiki/CMA-ES.

[2] Hinter Muller, K. Ito, K. Kunisch Primal-Dual Active set strategy as a semi smooth Newton Method SIAM J. Optim. V 13, I 3, 2002.

[3] A Wächter and L. T. Biegler, On the Implementation of a Primal-Dual Interior Point Filter Line Search Algorithm for Large-Scale Nonlinear Programming, Mathematical Programming 106 (1), pp. 25-57, 2006 link.

Assistant Professor ***David Greiner***

David Greiner is assistant professor at Universidad de Las Palmas de Gran Canaria, Spain, where he belongs to the Institute of Intelligent Systems and Numerical Applications in Engineering (SIANI). He studied Industrial Engineering (Mechanical) and Doctorate in Intelligent Systems and Numerical Applications in Engineering (phD), both by ULPGC. His research publication record (1995-2011), focused mainly in optimum design in engineering applications using evolutionary algorithms, covers more than 60 papers including JCR indexed journals, edited book, book chapters, and national and international conferences. He has been involved in several national and international research projects and contracts (including INGENET research network funded by European Union, 1997-2002). He has served as reviewer in more than ten JCR journals, and as scientific / programme committee member of several international conferences. Nowadays he also acts as Vicedean of Postgraduate Studies at the Industrial and Civil Engineering School –ULPGC-.

Evolutionary Multiobjective Algorithms in Structural Engineering Optimum Design

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Universidad de Las Palmas de Gran Canaria, Spain

ABSTRACT
In the last two decades the field of engineering design has benefited from the capabilities of global optimization through evolutionary algorithms, without requiring any condition of the objective function, even allowing discrete variables and functions, and being able to locate optimum non-dominated fronts when various conflicting objectives are required -in the case of evolutionary multiobjective algorithms-. This has been experienced in various and diverse fields of engineering, such as aeronautical engineering, mechanical engineering, or electrical, electronics and telecommunications engineering, among others; moreover, when combining various disciplines, also there are many fruitful applications in multidisciplinary design optimization.

Optimum Engineering Design with Evolutionary Algorithms in Structural Engineering began in the middle eighties with the spread of evolutionary algorithms (Goldberg and Samtani, 1986). A good review about this field can be found in (Kicinger et al., 2005). Concerning bar structures optimum design, the introduction of considering real discrete cross section types as variables appear in the first nineties (Rajeev and Krishnamoorthy, 1992), as well as the first multiobjective optimization proposals (Hajela and Lin, 1992), (Galante,1996).

An overview of evolutionary multiobjective algorithms focused on structural engineering optimum design through structural bar cases is shown in this lecture, based mainly on research performed during recent years at the Institute of Intelligent Systems and Numerical Applications in Engineering (SIANI) of Universidad de Las Palmas de Gran Canaria (ULPGC). Among the covered topics of evolutionary methods in single- and multi-objective structural applications are: successful usefulness for global search in discrete problems; elitist versus non-elitist algorithms; gray versus binary codification; auto-adaptive rebirth operator; multiobjectivization and/or using helper objectives; and finally, the consideration of multicriteria-decision making based evolutionary algorithms, particularly when considering preference information in terms of a reference point.

Chairmen of the Test Cases

- **Introduction**

Academic test cases are marked with TA and industrial test cases with TI.

TA1 *A Numerical Set-up for Benchmarking and Optimization of Fluid-structure Interaction*

Chairmen: Stefan Turek, ture@mathematik.uni-dortmund.de and Mudassar Razzaq, mudassar.razzaq@math.tu-dortmund.de
Organization: TU Dortmund

TA2 *Inverse or Optimization Problems for Multiple (Ellipse) Ellipsoid Configurations*

Chairman: Jyri Leskinen, jyri.a.leskinen@jyu.fi
Organization: University of Jyväskylä

TA4 *Optimization of Beam Profile in Fluid-structure Interaction*

Chairman: Peter Råback, raback@csc.fi
Organization: CSC - IT Center for Science

TA5 *Shock Control Bump Optimization on a 2-D Transonic Laminar Flow Airfoil*

Chairman: Ning QIN, n.qin@sheffield.ac.uk and Joe Coppin
Organization: University of Sheffield

TA6 *Shock Control Bump Optimization on a 3-D Transonic Laminar Flow Wing*

Chairmen: Simon C. McIntosh
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TA10 *Reconstruction of BINACA0012 Geometry Using Discrete and Continuous Optimization*

Chairmen: Jyri Leskinen, jyri.a.leskinen@jyu.fi
Hong WANG, hong.m.wang@jyu.fi
Organization: University of Jyväskylä

TI3 *Reconstruction/Inverse and Multi-Objective Design Optimisation of High Lift Systems*

Chairman: Jyri Leskinen, jyri.a.leskinen@jyu.fi
Organization: University of Jyväskylä

TI4 *Numerical Investigation of 3D Flow over Horizontal Axis Wind Turbine NREL Phase VI*

Chairman: Charles Hirsch, charles.hirsch@numeca.be
Organization: NUMECA International S.A

TI5 *Optimal Flow Divider*

Chairman: Jari Hämäläinen, Jari.Hamalainen@lut.fi
Organization: Lappeenranta University of Technology

TI6 *Structural Optimization of Paper Machine Parts done at the JYU Design Lab*

Chairman: Tuomo Varis, tuomo.j.varis@jyu.fi
Organization: University of Jyväskylä

International Scientific & Technical Organizing Committee

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Mudassar Razzaq

Mudassar Razzaq, (born 10.01.1979, in Renala Khurd, Okara, Pakistan), graduated from Quaid-i Azam University of Islamabad, Pakistan, with Master of Mathematics (2000-2002) and Master of Philosophy (2002-2004) degree in Applied Mathematics. Recently, he is pursuing PhD studies under supervision of Prof. Dr. Stefan Turek at the Institute of Applied Mathematics, TU Dortmund, Germany, since April 2006, and he is about to finish his work in spring 2010. His field of interest is finite element methods applied to fluid structure interaction (FSI) problems and, in particular, to perform optimization techniques to such problems arise in the vast, complex field of biomechanics.

Jyri Leskinen

Jyri Leskinen is a PhD student at the University of Jyväskylä. His responsibility in the workshop is to manage the optimization results.

Dr. Peter Råback

Peter Råback holds M.Sc. and D.Sc. in Engineering Physics from Helsinki University of Technology. Most of his career he has been working at CSC - IT Center for Science in the area of multiphysical modeling. He is one of the main developers of Elmer finite element software.

Professor Ning QIN

Professor Ning Qin is currently Head of Thermofluids and Chair of Aerodynamics at the University of Sheffield in the UK. He obtained his BSc (Math 1982) and MEng (Aerodynamics 1984) from NUAA in China, and PhD (Aerospace Engineering 1987) from the University of Glasgow in the UK. Before moving to Sheffield in 2003, he was Professor of Computational Aerodynamics at Cranfield University College of Aeronautics.

He is a Fellow of the Royal Aeronautical Society and an Associate Fellow of the American Institute of Aeronautics and Astronautics. He was awarded the RAeS Hafner Prize on VTOL Technology in 2000.

His recent research activities are in flow control (shock and separation control), aerodynamic design (drag reduction), CFD method development including adaptive mesh techniques. His current research projects are funded by UK research Councils, Airbus, and Rolls-Royce and EC FP7.

Dr. ***Simon C. McIntosh***

Simon McIntosh came to the University of Sheffield after competing his PhD at the University of Cambridge. He obtained his masters degree in Aerospace engineering from the University of Bristol, with a year spent at McGill University working within the Shock Wave Physics Group. Prior to starting his PhD, one year was spent in industry developing a Coanda jet UAV for GFS Projects Ltd.

The subject of his PhD research was the prediction and optimisation of power output from vertical axis wind turbines operating within the built environment. This involved the creation of a time and space accurate free vortex model capable of simulating turbine performance in a fluctuating wind as well as accounting for building-turbine and turbine-turbine interactions.

Present research work involves the design and optimisation of shock control bumps on natural laminar flow wings using RANS CFD.

Professor ***Charles Hirsch***

Prof. Charles Hirsch is Em. Professor at the Vrije Universiteit Brussel (VUB) and President-Founder of the CFD software company NUMECA International. He is Fellow of the Royal Flemish Academy of Belgium for Sciences and Arts and Honorary Professor at the Xi'an JaiTong University, Xi'an, China.

He is author of the books Numerical Computation of Internal and External Flows; Vol. 1: The Fundamentals of Computational Fluid Dynamics, 2nd ed., Elsevier, 2007, and the earlier editions of Numerical Computation of Internal and External Flows; Vol. 1: Fundamentals of Numerical Discretisation, 1988; Vol. 2: Computational Models for Inviscid and Viscous Flow Models, John Wiley & Sons, 1990. He has published many papers on CFD; turbomachinery aerodynamics; turbulence; wind energy.

He is currently Editor-in-Chief of John Wiley's Series on Computational Methods in Applied Sciences European Editor of the International Journal of Computational Fluid Dynamics.

Hong WANG

Hong Wang is a PhD student at the University of Jyväskylä; in Finland. She obtained her Bachelor of Engineering (2002-2006) in Aerospace Engineering and Master of Engineering (2006-2009) in Aerodynamics from NUAA in China. Her field of interest is multi-criteria robust design optimization using games and mesh/meshless solvers in computational fluid dynamics.

Professor ***Jari Hämäläinen***

Education

- 2000- Docent (Adjunct professor), Scientific computing in industrial applications, University of Jyväskylä, Faculty of Information Technology
- 1991-1993 Ph.D., University of Jyväskylä, Department of Mathematics
- 1990-1991 Ph.Lic. University of Jyväskylä, Department of Mathematics

Work experience

Lappeenranta University of Technology (LUT), Faculty of Technology

- 2010- Director, Centre of Computational Engineering and Integrated Design (CEID)
- 2010- Professor, Applied mathematics, Department of Mathematics and Physics

Univ. of Eastern Finland (UEF), Faculty of Science and Forestry, Dep. of Physics and Mathematics

- 2009- Professor, Industrial physics (permanent position, leave of absence since Sep, 2010)
- 2004-2008 Professor, Physics (5 years fixed-term position)

Metso Paper, Inc. (Valmet Corp.)

- 2002-2004 Research Manager, Process Simulation
- 1996-2002 Senior Research Scientist, Headbox and short circulation R&D

Technical Research Centre of Finland (VTT)

- 1994-1996 Senior Research Scientist

University of Jyväskylä, Department of Mathematics, Laboratory of scientific computing

- 1990-1994 Research Scientist
- 1986-1993 Part-time lecturer, assistant, summer worker, trainee, etc. during university studies

Tuomo Varis

Tuomo Varis is a student of Information Systems Science at the University of Jyväskylä and is responsible for administration of the Design Test Case Database.


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