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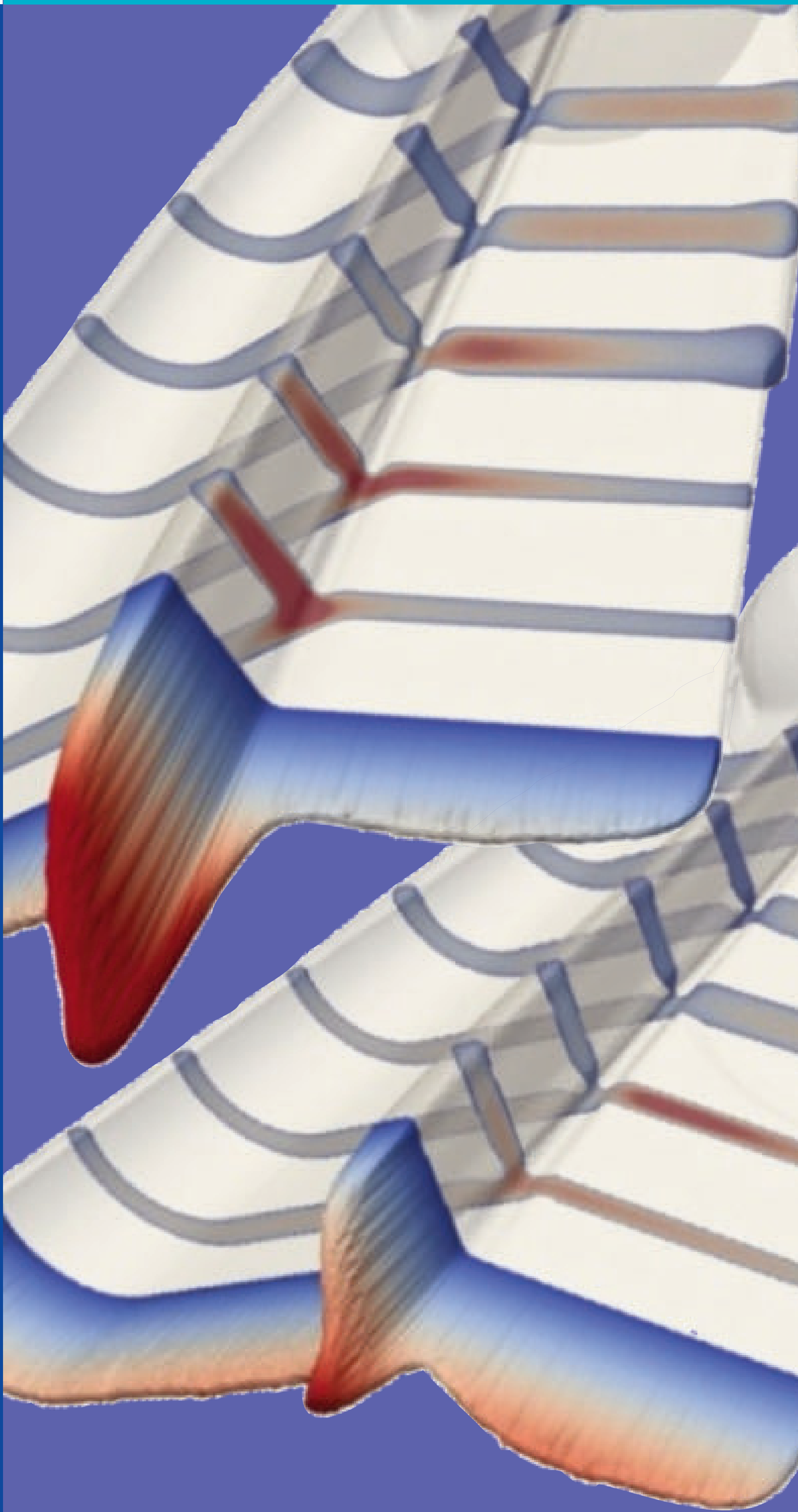

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Email: iacm@cimne.upc.edu ***Web***: www.iacm.info

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contents

editorial

When we talk about computational mechanics and education, we usually refer to the use that university lecturers and students make of numerical methods for solving selected problems in mechanics. This also implies introducing the class to the basis of numerical methods, as well as to the use of computers, the adequate software and the tools that are necessary for facilitating data input operations and the graphic visualization of the numerical results.
The trend in computational sciences, however, has been moving fast for some time already in the direction of introducing the so-called Computational Thinking at all education levels, from primary to high school and university. The term computational thinking was first used by Seymour Papert in a 1996 paper (doi:10.1007/BF00 191473). The term was brought to the forefront of the computer science community, though, as a result of an article on the subject published in 2006 by Jeannette Wing, a professor at Carnegie Mellon University and Corporate Vice President of Microsoft Research since 2013 (doi:10.1145/1118178.1118215). On her article Prof. Wing emphasizes the importance of thinking computationally all our life, and argues for the importance of integrating computational ideas into other disciplines.
Paraphrasing Prof. Wing: *"Computational thinking builds on the power and limits of computing processes, whether they are executed by a human or by a machine. Computational methods and models give us the courage to solve problems and design systems that no one of us would be capable of tackling alone. ……Most fundamentally it addresses the question: What is computable?...... Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability…….. Computational thinking involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science…"*

It is just fascinating what the computational mechanics community can gain from borrowing most (if not all) the concepts associated to Computational Thinking. Indeed by exposing students (at all levels) to the abilities that this new educational trend introduces they can improve their confidence in working with complexity, their persistence to confront and solve difficult problems, their tolerance to ambiguity, their capacity for team work…not to mention their early gain in many competences necessary to work in the field of computational mechanics in the future. As Prof. Wing says *"Computational Thinking is the new literacy of the XXI century"*.
A final note to mention the success of the 11th World Congress on Computational Mechanics of the IACM (WCCM XI) organized in Barcelona, Spain on July 20 – 25, 2014, in conjunction with the 5th European Conference on Computational Mechanics (ECCM V) and the 6th European Conference on Computational Fluid Dynamics (ECFD VI) of ECCOMAS. The joint event was attended by some 3600 participants from all over the world, thus becoming the largest congress in the field ever held so far.
The WCCM XI was also the occasion to elect the new IACM officers for the next four year period, including the new IACM President, Prof Wing Kam Liu from Northwestern University in the US, who replaces Prof. Genki Yagawa from Tokyo University. We thank Prof. Yagawa and the past IACM officers for their dedication to IACM during the last years and wish Prof Liu and the new officers best of luck and success in their duties.
You can read some highlights of all these news in the pages of this issue of Expressions.
Time flies and we have to start planning for the next IACM events in 2015 and 2016, including WCCM XII in Seoul on July 2016.
Please check the dates in the back cover of this magazine and make a note in your agenda.

Eugenio Oñate
Editor of IACM Expressions

Flow Simulation in Production Engineering

by
Marek Behr & Stefanie Elgeti
RWTH Aachen University, Germany

For decades, computer simulations have been used as a faster, cheaper version of the experiments. A perfect simulation may precisely replicate the result of a costly cryogenic wind tunnel experiment, in the case of aircraft design, or a potentially harmful in-vivo study, in the case of biomedical engineering. Such simulation solves a "direct" problem: given certain inputs, the engineering system as specified in the computer program gives certain output that can be compared with experimental measurements. But computational approach to science and engineering offers another, unique mode of operation, where we seek the inputs that would produce a certain desired result, or we are evaluating a range of possible models that will produce results that best fit the reality. In some sense, the problem is "inverted" and solved backwards. Aeronautical engineers have been using this approach perhaps the longest, fine tuning the shape of various aircraft components to achieve optimal, best possible performance. Although it is possible to perform such in-verse analyses with a "black-box" simulation program, their full potential is realized when the simulation software can be modified to produce extra information in addition to that required for direct problems.

Figures 1: *Experiment (a) and forward analysis (b) versus inverse analysis (c) of multiscale physical and engineering systems: model development, optimal design of engineered systems, and scale interaction*

Broadly-Defined Inverse Problems

Such broadly-defined inverse problems are conceptually different from direct or forward analysis problems. *Figure 1* illustrates this fundamental difference. In forward computational analysis *(Fig. 1b)*, the system output is determined as a result of assumed system characteristics and inputs, and as such is given, in direct analogy to experiment *(Fig. 1a)*. In contrast to experiment, the inner working of the system becomes "visible", since the specification of models and governing equations is a requirement for forward analysis. The illustrated coupled system is also assumed to involve multi-scale and multi-physics aspects. In inverse analysis, on the other hand *(Fig. 1c)*, system inputs, system parameters, or any other internal characteristics of the system are inferred from observations and measurements of the actual output of a real system or of the given specifications of an engineered system with desired properties. In model development *(Fig. 1c, left)*, some characteristics of one or more of the models (shaded) are yet to be determined, and the computational analysis is repeated systematically while the results are compared against either experimental data, or computational results obtained with a more exact model, presumably involving more computational effort. The iterative process of finding a suitable model form is symbolized here via bidirectional vertical arrows. A variation of this procedure is the task of finding a suitable scale interaction mechanism (horizontal arrows). In system design *(Fig. 1c, right)*, other aspects of the system such as network structure, geometrical shape or time-varying control profiles are sought, and computations are iteratively repeated while comparing the results against the objective—a suitable measure of maximum system performance.

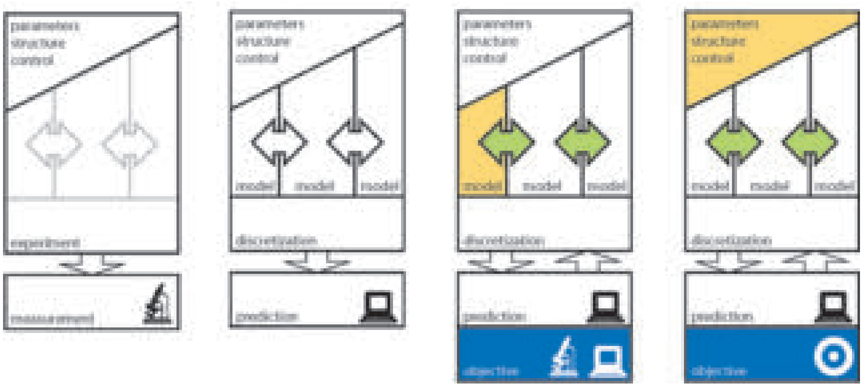


Figure 1 (a): *experiment*
Figure 1 (b): *forward analysis*
Figure 1 (c): *inverse analysis model development* *system design*

It is important to note two key points. First, while forward problems require no computation per se, and can be addressed by experimentation and measurement alone, models and computational methods are a crucial element of inverse analysis. These models and methods connect measured output data to input data or systems characteristics, in a way that cannot be accessed directly in the course of the experiments. Second, the numerical solution of inverse problems typically requires repetitive solution of the underlying forward problem, thus exposing the need both for methods such as model order reduction tecniques, which seek to accelerate the solution of the forward problem, and for high-performance computing.

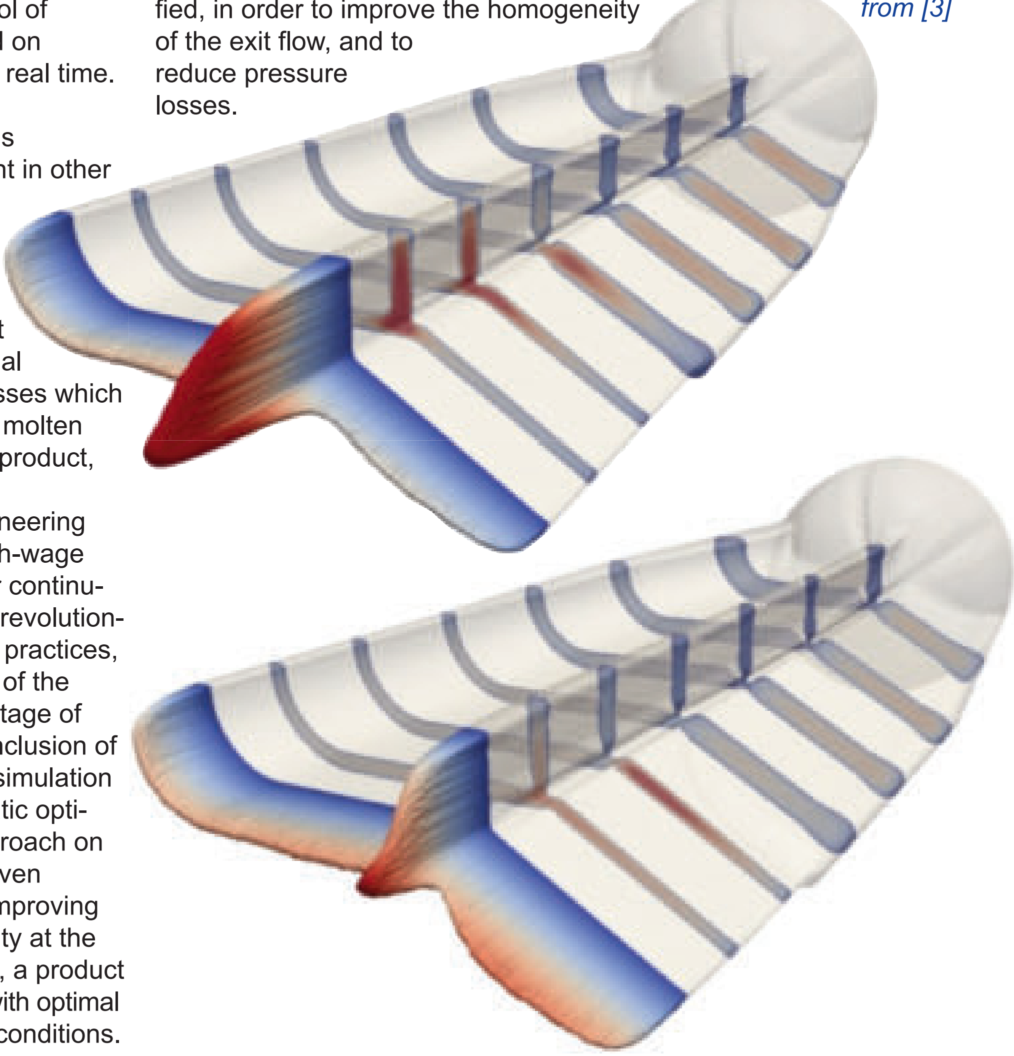
Simulation-Based Inverse Design in Engineering

In several branches of engineering, this unique capability of predictive numerical approaches has been already used extensively. In the aeronautical engineering, shape optimization of aerodynamic and structural components during the conception and design phase of modern aircraft is a critical part of the overall process, and the current challenge is for the numerical design stage to include either a growing number of airplane components—multi-objective optimization, or a growing range of operating conditions—robust optimization. In chemical engineering, where the predominant models are based on the ordinary rather than partial differential equations, the design and control of process systems has long relied on parameter optimization, often in real time.

The potential of inverse design is exploited to a much lesser extent in other branches of engineering, which nevertheless rely heavily on computational analysis. In the following, we will show exemplarily the impact of shape optimization and optimal control on the production processes which are characterized by the flow of molten material which forms a finished product, be it plastic, rubber or metal. It is in this field of production engineering where the enterprises in the high-wage countries find themselves under continuing pressure to adapt and even revolutionize their planning and operation practices, in order to remain a step ahead of the global competitors taking advantage of lower labor costs. Next to the inclusion of more process steps in a single simulation chain, the application of automatic optimization methods is a main approach on the way to reducing unit costs even for small-series production, or improving product quality and reproducibility at the same cost. In an ideal situation, a product lot of one unit can be produced with optimal cost and quality, under variable conditions.

Shape Optimization in Plastics Extrusion

Our first example comes from the field of plastics extrusion, which is the well-established process for mass production of moldings, seals and other continuous plastic profiles. The molten material coming out of the extruder is driven through a metal die, achieving the final shape at the outlet. After a so-called calibration step, which both cools the material and counteracts some of the effects of swelling at the exit of the die, the finished extruded profile is cut into lots for delivery. Such process is called continuous, as the most efficient way of operating the extrusion machine is to ensure the steady flow of material and produce a large quantity of the product. This is necessary in order to compensate for the start-up and wind-down costs, but especially, to amortize the initial effort of designing the die itself. In a typical facility, an experienced die designer may produce the first version of the die, which is then taken through many iterations of the so-called running-in trials, as the quality of the material flow is evaluated. At each iteration, the die may be manually modified, in order to improve the homogeneity of the exit flow, and to reduce pressure losses.



Figures 2
Automatic shape optimization of the extrusion die for a floor skirting profile.
Top: Initial profile, showing large inhomogeneities in the outflow velocity field.
Bottom: Optimal profile, showing largely uniform outflow velocity field.
Plastic flows from right to left. Adapted from [3]

The numerical die design [1], as an example of inverse design, represents the entire die and possibly part of the calibration section in a simulation model [2], and iterates through die shapes that achieve in the end a certain optimum (Fig. 2). Characteristic of the inverse problems is the need for

a) an objective function, quantifying the homogeneity of the outflow velocity profile,
b) geometry parametrization, allowing for shape modifications in the die in a way that is at once flexible, efficient, and aware of manufacturing constraints, and
c) an optimization driver, taking the sequence of the objective function values and suggesting new values of geometric parameters to try next.

In the best scenario, the flow simulation makes available to the optimization driver the gradient or sensitivity information, allowing to more quickly reach the optimal parameter values. In the context of plastics extrusion, the flow is governed by the Stokes equations, albeit with complex constitutive properties, reflecting the fact that most flowing plastics exhibit shear-dependence of the viscosity and viscoelasticity. The geometry parametrization, rather than being ad hoc, should focus on the features of the die that are likely to influence the outflow velocity distribution [3], leading to a secondary issue of semi-automatic feature identification *(Fig. 3)*.

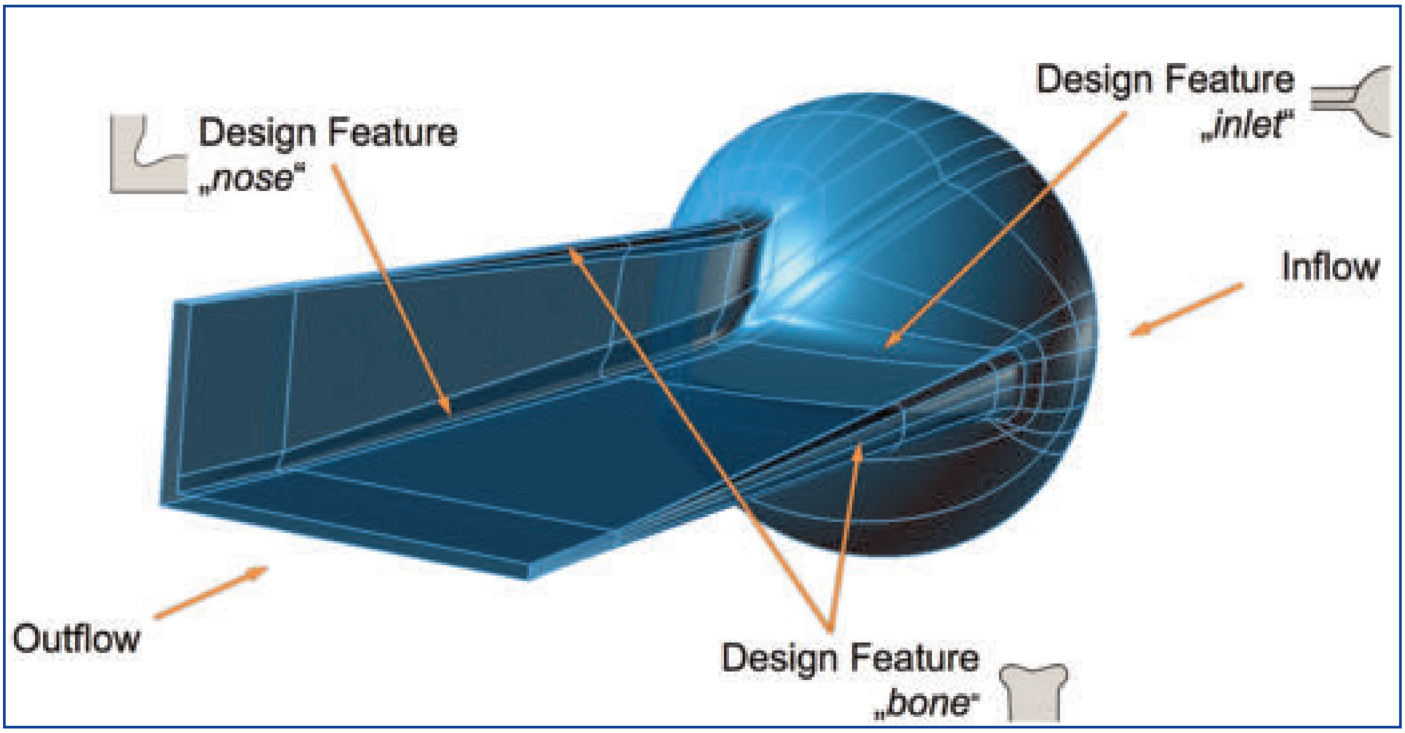
When considering the die swell as part of the optimization process, it is essential to develop accurate discretization methods—stabilized mixed finite element formulations, log-conformation approaches to the morphology tensor representation—for flow regimes where viscoelastic effects become dominant. Such methods allow the highly non-linear equation systems to be solved even for a so-called high Weissenberg number [4].

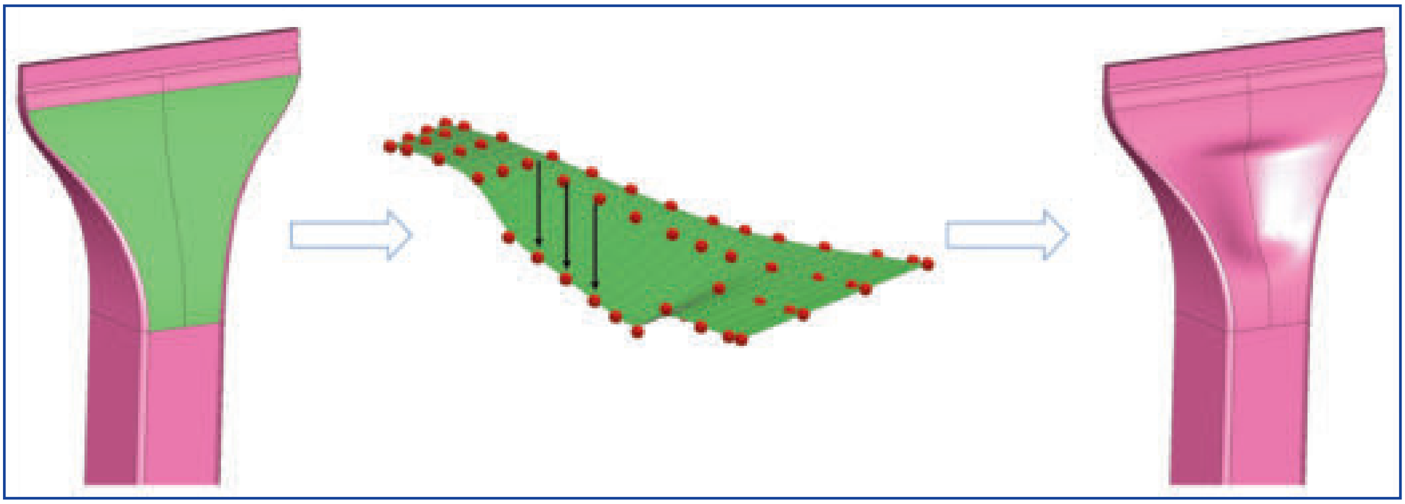
Shape and Process Optimization in Die Casting

High-pressure aluminum casting is a classical industrial process for mass-produced metal products such as engine blocks. Molten metal flows under intense pressure through a gating system into a reusable cavity, also called a die. After solidification, the die is opened and the product removed. The reliability, the high quality of the surfaces and the ability to produce thin-walled structures are among the advantages.

As is the case in plastics extrusion, the construction of the die and of the associated gating system are the main contributors to the process expenses. Here too, shape optimization of the gating system *(Fig. 4)*, supported by melt flow simulations, can have a dramatic effects on product cost for low-scale production. The flow chamber design may be varied to reduce the recirculation areas that may lead to higher product

Figure 3: *Identified profile features that will be modified in the course of shape optimization of an L-profile die. The critical sections are seen as a flared ridge or "bone", an indented corner or "nose", and a flat wedge or "inflow". Adapted from [3]*





porosity. In related efforts, the cooling channels are placed in an optimal way to increase the efficiency and uniformity of cooling of the die during the solidification process, and the plunger speed curve over time is manipulated in order to improve the form-filling characteristics [5].

Summary

Research on inverse problems in production engineering is an integral part of major consortia which have been established by the German Research Association DFG at the RWTH Aachen University. The Graduate School GSC 111 Aachen Institute for Advanced Study in Computational Engineering Science (AICES) focuses since 2006 on the methodological foundations of broadly-defined inverse problems, as outlined in the opening paragraphs of this article.

Likewise, the Excellence Cluster EXC 128 Integrative Production Technology for High-Wage Countries groups researchers working on various aspects of mould-based and mould-free production. A recently established Collaborative Research Center SFB 1120 Precision Melt Engineering involves simulation and experimental projects on the topic of melt flow and melt control, serving the goal of increased precision.

These and other large-scale projects, recently established or expanded, point out the value of and the interest in the simulation-based design and control in the field of production engineering. ●

Figure 4:
Automatic shape optimization of the gating system for aluminum die casting.
Left: Initial gate shape indicating parametrized portion of the geometry.
Middle: Control points for the parametrized geometry.
Right: Optimized geometry of the gate

"The geometry parametrization, rather than being ad hoc, should focus on the features of the die that are likely to influence the outflow velocity distribution..."

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The Time Dimension-The Next Generation Computer-Aided Simulation Techniques: Isochronous Integrators [*i*Integrators] and Significance to Computational Sciences/Engineering

by
Kumar K. Tamma
&
Masao Shimada
University of Minnesota
ktamma@umn.edu
shim0114@umn.edu

In dealing with the "Time Dimension", *time discretized operators* or those commonly referred to as to as *time integrators*, play a crucial role for linear or nonlinear transient/dynamic applications in various fields (time dependent models which are general partial differential equations: functions of space /time; encompassing mechanical, aerospace, civil, biomedical, electrical, chemical, economics and allied fields). This article provides the **"Big Picture"** of the design and development and recent *state-of-the-art* with regards to practical computer-aided modeling and simulation of time dependent problems and their general applicability to complex science and engineering applications; with emphasis also upon multi-disciplinary coupled transient problems as well governed by first/second order in time applications. In general, the governing mathematical models may or may not involve constraints. The objectives are to simulate the models in space/time through physics based simulations to preserve/explain the underlying problem physics accurately and efficiently since analytical solutions may not be feasible nor tractable. First, numerical discretization in space is conducted with space discretized techniques such as finite elements, differences, volumes, meshless/particle type methods, etc, leading to ordinary differential equations in time (or may additionally involve algebraic constraints – DAE's versus ODE's). Next, the DAE's/ODE's are solved (integrated in time) in a step by step manner to accurately track the evolution of the underlying physics of the model. *In a nutshell, the big picture and a novel design/development of fundamentally sound, practical, and robust numerical time integration algorithms by design, and therein enabling a unified framework with improved numerical and physical attributes and a wide variety of choices of algorithms that are readily available to the analyst constitutes the focus and scientific contributions*.

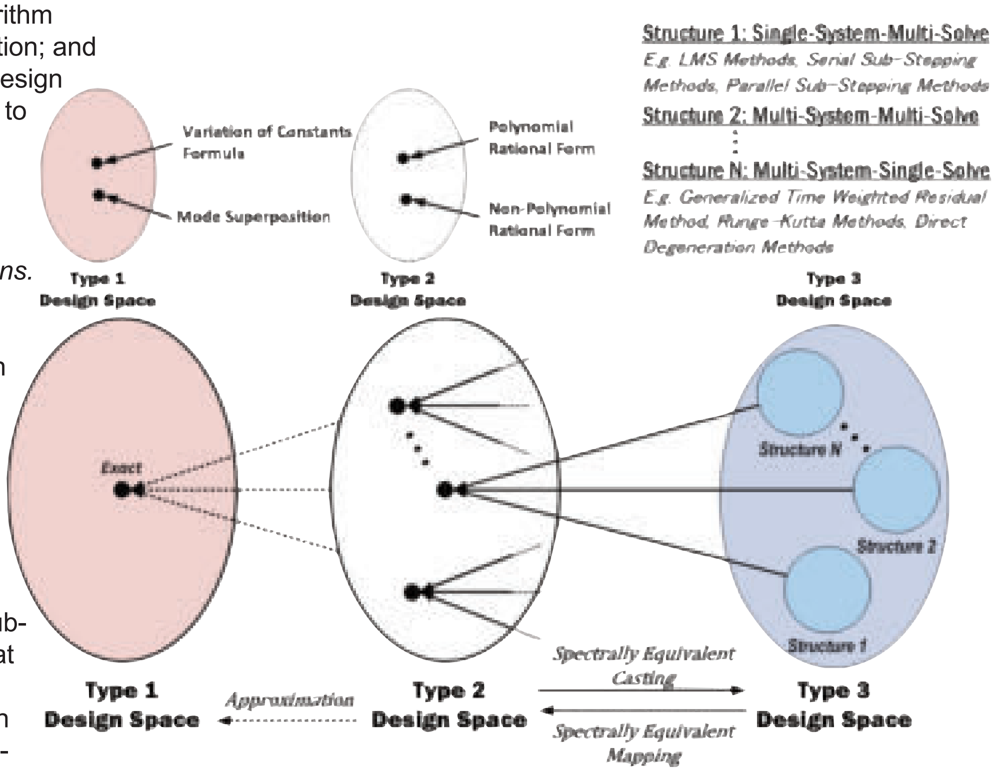
"... if new claims of algorithm designs are warranted in the future, or are simply constructions which seem to appear different ..."

Numerous efforts have been made over the past several decades to arrive at methods that can resolve the physics, enable simulations to be fully completed without failure till the desired final times of interest, and overcome numerical stability and other issues/difficulties which continue to plague the community. A fundamentally sound/optimal resolution does not exist. *This research explores and addresses most of these matters with rigorous proofs and proof of concepts as well.* We present besides the big picture, in addition, a novel next generation unified framework/architecture that encompasses not only most techniques being used over the past half century or so for first/second-order ODE/DAE systems that have been derived from various differing viewpoints, but also additionally brings forth new techniques, optimal algorithms and designs with very attractive numerical features without loss of original physics, and with significant improvements over current state-of-the-art. It is termed *isochronous integrators* (or *iIntegrators*) because this "same" unified and single simulation environment can now also be readily applied concurrently to either second and/or first order-transient systems, just by controlling its variables and algorithmic parameters (*isochronous adaptation process*). Simply put, only three free parameters (spectral properties) and three other parameters which are related to implicit/explicit treatment of velocity or damping related terms need to be adjusted to cover a wide range of practically useful new and optimal implicit or explicit algorithms and designs; it also includes most past efforts that have been derived from various other viewpoints over the decades as sub-cases which continue to be employed in various commercial/research software but inherit several drawbacks/deficiencies mentioned previously. Besides the unified formalism with new and improved attributes, an added bonus is that only a single unified framework and family of algorithms originally designed for second-order transient ODE/DAE systems can also automatically generate and cover schemes applicable also to first-order transient ODE/DAE systems as well; maintaining important attributes such as desired numerical stability, accuracy, overshoot, and other attractive numerical features which enable improved physics such as symplectic-momentum and energy-momentum conserving features as well.

Theoretical Basis, Methodology, and Highlights/Illustration of Concept: In modern science and engineering design and analysis, each engineering application has its own emphasis and analysis requirements; wishful thinking is that a wish list of desired attributes by the analyst to meet certain required analysis needs is desirable. Optimal designs of algorithms are not trivial; and alternately, how to foster such optimal designs, select, and determine whether an algorithm design is optimal for a selected application if such an optimal algorithm does not readily exist, is a desirable goal and challenging task. We term the resulting outcomes and aforementioned objectives as the notion *of algorithms by design; and the theoretical basis emanates from a generalized time weighted residual philosophy*. It comprises of three principal essentials [1-12; because of the scope of this article only our references are provided]: i) it first utilizes a unified theory underlying computational algorithms developed in [4-8] for time dependent problems which fundamentally explains the underlying principles of the evolution, classification, relationships and design of time discretized operators unlike all previous representations and various frameworks existing in the literature; ii) it also utilizes the design spaces and algorithmic measures and metrics described in [4-6, 9] for evaluation and comparison, and for qualifying the optimality of an algorithm with respect to a particular application; and iii) it finally provides an educated design procedure [4-6, 10] and guidelines to the analyst utilizing the concepts, fundamental principles and ideas described in i) and ii) above for developing *algorithms by design that meet the particular qualifications.*

More noteworthy, via the above, several additional features that can also be explained and answered include: i) the design of new algorithmic constructions leading to higher-order methods from existing low-order methods, and if they still retain the original properties at the high-order; ii) ongoing, there continue to be published numerous developments that claim to be new; however, the question is does a new contribution strictly (really) arise or do these developments and constructions simply appear new and different, and under what metrics/guidelines are they new, and/or what type of relationships exist (if any) if one employs any one of a number of a variety of approaches that exist in the literature or employ as a starting point the single-field form, the two-field form, and the like (the literature is filled with articulations that claim different computational algorithms are being developed for the underlying equation of motion in different forms)? In what manner are they different and new (if any)?; iv) interesting are the answer(s) to whether there exist (if any) differences between the resulting algorithms emanating from *time continuous frameworks* in contrast to *time discontinuous frameworks* [8,11], or do they simply only seem to appear different but in fact are theoretically spectrally equivalent to each other with both frameworks achieving the same underlying attributes for the same algorithmic complexity?; v) can one arbitrarily *(willy-nilly)* mix and match different algorithm designs within the same analysis for different parts of the domain or does a sound theoretical basis and framework exist (not perceptions) to rigorously assess feasibility and guidelines?; vi) are algorithm designs practical, in the sense that they are at least second-order time accurate in all solved variables and include zero-order overshoot characteristics and other optimal features in the sense of numerical dissipation, dispersion and overshoot and involve only a single solve and

Figure 1: *Design Spaces of Time Integrators*



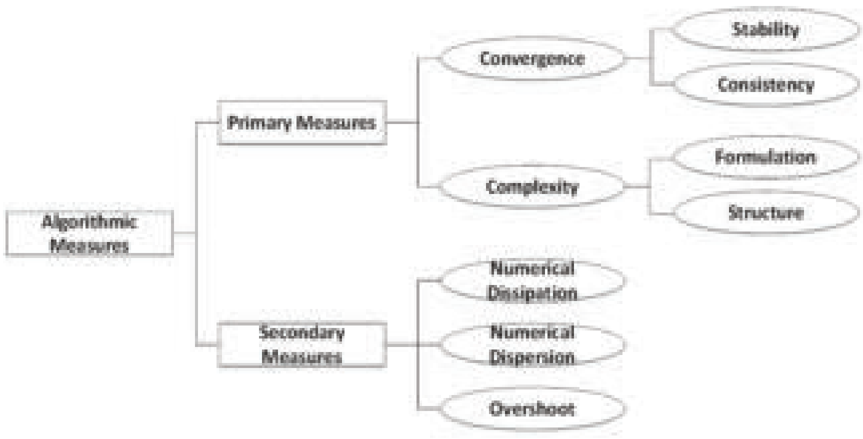


Figure 2:
Algorithmic Measures for Comparison of Time Integrators

vii) how does one properly extend the parent linear transient time integration algorithm designs to nonlinear transient situations, and can one explain and provide a sound theoretical basis such as *a new normalized time weighted residual approach* [4-6] that carefully treats each nonlinear term in the mathematical models in a unique way for enabling such extensions and leading to symplectic-momentum and energy-momentum conserving features; or is the nonlinear implementation being conducted in an *ad hoc* manner (these latter *ad hoc* practices, are in general, the basis of poor performance of the time integration algorithms and their lack of robustness; also there exist numerous misconceptions in the literature regarding algorithms for linear versus nonlinear transient situations)?. A question of interest also is whether one can finally provide closure to the design of LMS type methods with a single solve for first-order and second-order in time systems?

The big picture is as follows. In general, time discretized operators can be categorized *(Figure 1)* into Type 1, Type 2, and Type 3 classifications [1-8] which pertain to distinct design spaces for time integrators; and all classifications can theoretically attain up to n^{th} degree time accuracy *(Figures 1 & 2)*.

In a nutshell, Type 1 classifications entail an exact amplification matrix (such as an exponential matrix or its equivalent in the modal space such as the Duhamel integral), and how the load vector is treated can yield either exact or up to n^{th} degree time accuracy. On the other hand, Type 2 classifications are simply approximations of the exact amplification matrix but involve starting from first power to increasingly higher and higher powers of the amplification matrix that approximate (such as Pade, Norsett, etc.) the exact amplification matrix in Type 1. And lastly Type 3 classifications are those designs which *only* entail the first power of the approximate amplification matrix (there exists a mapping relation for each Type 3 algorithm to the corresponding Type 2 classification of algorithms which can be readily cast as Type 3 classifications).

While we have provided above a general outline and the big picture, we now turn attention to practical algorithms that are all second-order time accurate in all solved variables and involve only a single solve at each time step. It is to be noted that most computer-aided simulations we routinely perform and available in most research and commercial software belong to the lowest-order case (second-order) of the Type 3 classification and the LMS (linear multi-step) methods are a special case which mostly entail a single system of equations being solved at each time step; a generalized single system single solve or commonly referred to as GS4 for both the second-order system (GS4-2) and the first-order system (GS4-1). The corresponding *isochronous adaptation process* [12] is depicted in *Figures 3-4* for general linear/nonlinear applications wherein it not only encompasses most of the past developments designed from various different methods of approach, but additionally includes more new and optimal algorithms and designs with new and improved physical and numerical attributes including zero-order overshoot behavior.

We have also proven that every time integration algorithm within ιIntegrators satisfies the equation of motion in temporally-discretized systems at a unique and consistent algorithmic time point within time

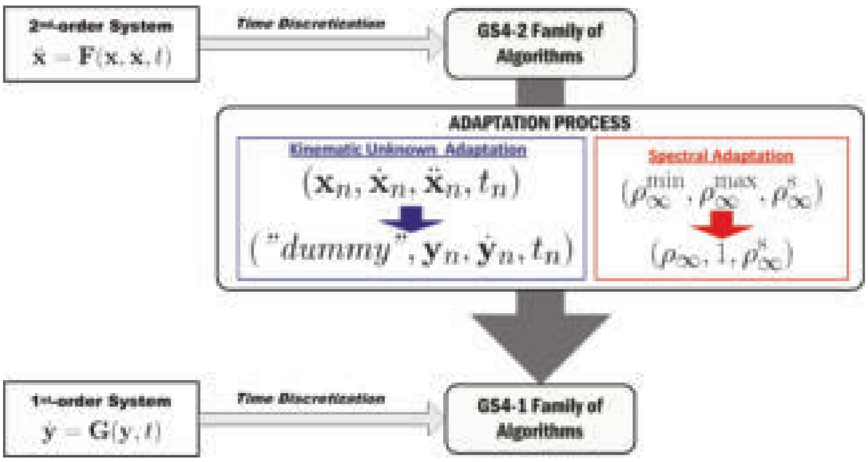
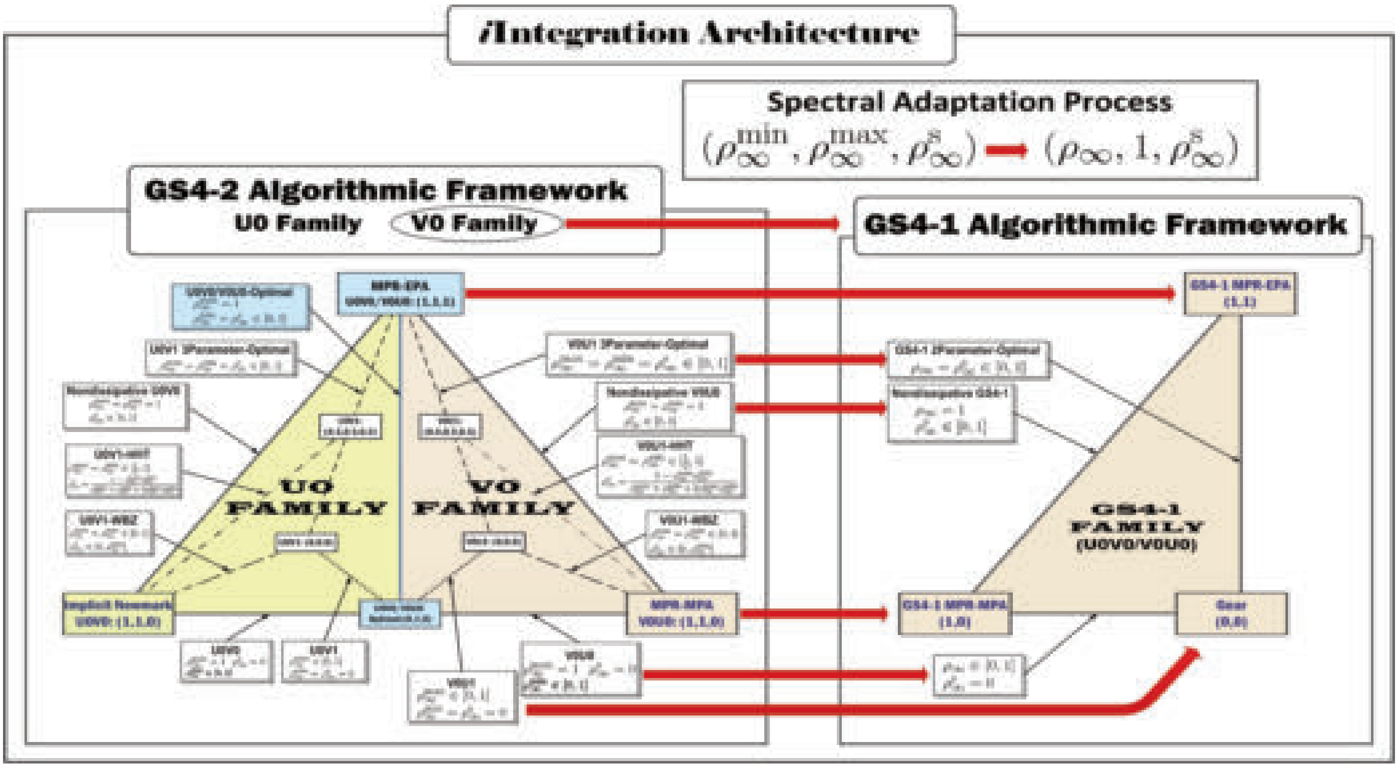


Figure 3:
Adaptation Process from 2nd –order Systems to 1st-order Systems

step (i.e., we designed where and at what time point this satisfaction exists and why, how and where each term must be computed at, and this is not well known; likewise for transient problems in various fields, similar analogies exist); and we have also formalized that no two algorithms can have the same DNA [discrete numerically assigned] markers which distinguish one algorithm from another. Uniquely these are very significant characteristics of *i*Integrators; and henceforth, to-date, a sound theoretical basis exists. One can readily assess if new claims of algorithm designs are warranted in the future, or are simply constructions which seem to appear

Figure 4:
Spectral Adaptation Process – Relationships of Various Algorithms in GS4-2 and GS4-1 Family of Algorithms



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Isogeometric Analysis: An Innovative Paradigm for Computational Mechanics

by
Alessandro Reali
University of Pavia

Isogeometric Analysis (IGA, see [1,2]) is a recent simulation framework, originally proposed by Tom Hughes, Austin Cottrell, and Yuri Bazilevs in 2005, to bridge the gap between Computational Mechanics and Computer Aided Design (CAD).
The basic IGA paradigm consists of adopting the same basis functions used for geometry representation in CAD systems - such as, e.g., Non-Uniform Rational B-Splines (NURBS) - for the approximation of field variables, in an isoparametric fashion. This may lead to a significant cost-saving simplification of the typically expensive mesh generation and refinement processes required by standard finite element analysis. In addition, thanks to the high-regularity properties of its basis functions, IGA has shown a better accuracy per-degree-of-freedom and an enhanced robustness with respect to standard finite elements in a number of applications ranging from solids and structures to fluids, opening also the door to geometrically flexible discretizations of higher-order partial differential equations in primal form.

I was introduced to IGA at JP's Java (an "historical" coffee shop close to UT Austin's campus which had been the real head-quarter of IGA until its closure, last September; see *Figure 1*, for a picture of the place) in the summer of 2004, when for some months I joined the group of Tom Hughes *(see Figure 2)* with the aim of preparing my Master thesis in Earthquake Engineering and carrying out part of my PhD under his guidance. I was supposed to work on some classical topics of computational structural dynamics,

Figure 1:
A picture of the glorious JP's Java coffee shop in Austin, i.e., the real IGA headquarter in the period 2004-2014

Figure 2:
Hanging out in Austin at the dawn of IGA (2004) with two members of the original IGA trio (Y. Bazilevs, middle, J.A. Cottrell, top-right) and the first IGA mathematician (G. Sangalli, bottom-right)

Figure 3:
IGA 2014. The organizers (from left to right): T. Dokken, T.J.R. Hughes, T. Kvamsdal, Y. Bazilevs, A. Reali, D.J. Benson

Figure 4:
IGA 2014. Conference dinner

but Tom easily convinced me of the potential of IGA and I therefore decided to explore the beneficial effect of continuity in spectrum analysis, i.e., in the approximation of structural vibration frequencies (something which could have been of interest also in the Earthquake Engineering community). A few months and several exciting results later, I decided that IGA would have become my main research topic also once back to Pavia and I have been continuously working on that subject ever since, often in collaboration with very talented colleagues.

Figure 5:
Signatures of the IGA community. Above: First IGA Conference (Austin, January, 2011). Right: Second IGA Conference (Austin, January, 2014)

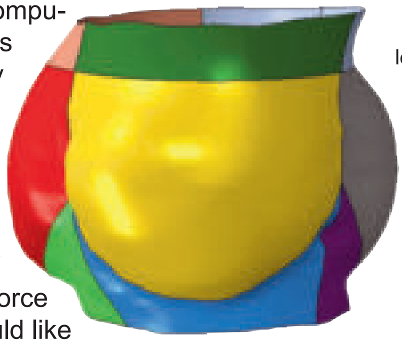
Figure 6:
IGA work meeting (wine tasting dinner on September 30, 2014, at the renowned Ricasoli vineyard in the heart of the Chianti area)

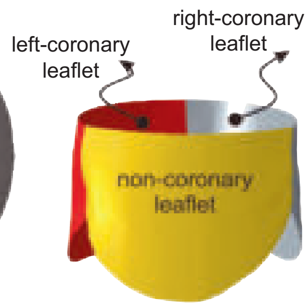
I like to mention the important friendship bonds that arose with the people I had the luck to meet along my IGA path with some pictures taken during the IGA conference in Austin last January *(Figures 3-5)*, and with a picture of Tom *(Figure 6)* I took during a nice wine tasting dinner we had together last September 30, at the renowned Ricasoli vineyard in the heart of the Chianti area.

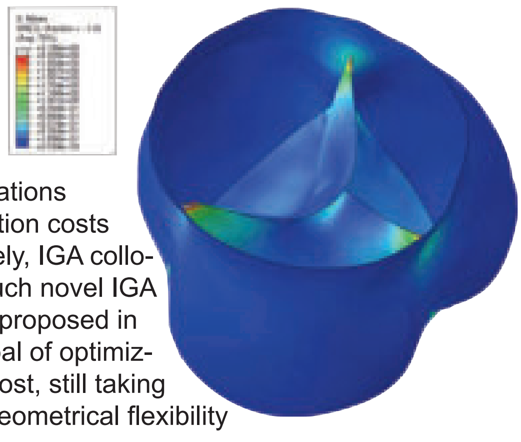
Going back to research and to my beginnings in this field, I have to say that, following the mentioned initial works on spectra [3-5], the superiority of IGA over standard finite elements now appears to be remarkably evident in the approximation of structural vibrations and dynamics, as it is, for instance, clearly shown in a recent paper [6]. Moreover, an impressive example of the potential of IGA is given by the results obtained within a project emanating from one of the frequent Austin-Pavia collaborations and completed with the help of a number of friends, where explicit dynamics simulations of the closure of a patient-specific aortic valve were carried out [7]. The complex geometrical model was built from medical images by means of conforming multiple NURBS patches *(see Figure 7, top)*, and on such a model an explicit nonlinear analysis involving large deformation shells and contact was successfully performed *(see Figure 7, bottom)*. Despite the lack of optimization of the adopted IGA implementation, for a given target level of accuracy, the IGA simulation resulted to be over 440 times faster than that carried out with what is considered to be the fastest shell finite element on the market (i.e., 1h15m versus 23 full 24-hour days!).

Figure 7:
Multi-patch IGA of a patient-specific aortic valve. Top: Conforming multi-patch NURBS geometry of the aortic valve and of the three leaflets. Bottom: Results of the valve closure simulation in terms of deformed shape and Von Mises stress

Since I mentioned explicit dynamics (where the computational cost is dominated by stress divergence evaluations at quadrature points for the calculation of the residual force vector), I would like to concisely introduce another topic that was initiated during one of my visits in Austin, and which looks indeed promising in all situations where matrix formation costs are dominant: namely, IGA collocation methods. Such novel IGA schemes were first proposed in 2010 [8] with the goal of optimizing computational cost, still taking advantage of IGA geometrical flexibility







and accuracy. The fundamental idea consists of the discretization of the governing partial differential equations in strong form, adopting the isoparametric paradigm and making use of the higher-continuity properties of the IGA shape functions. Detailed comparisons with both IGA and FEA Galerkin-based approaches have shown IGA collocation advantages in terms of accuracy versus computational cost, in particular when higher-order approximation degrees are adopted. Within the IGA collocation context, several promising significant studies have been recently published, including phase-field modeling, contact, and hierarchical local refinement. Moreover, IGA collocation has been very successful in the context of structural elements. In particular, Bernoulli-Euler beam and Kirchhoff plate elements have been proposed and shear-deformable structural elements have been considered as well. In fact, locking-free mixed formulations both for initially-straight planar Timoshenko beams and for curved spatial rods have been advanced and analyzed, and IGA collocation has been also successfully applied to the solution of Reissner-Mindlin plate problems. All these results have been published in several papers, and interested readers are referred to the review reported in [9] and to references therein.

Going back to the Galerkin framework, I remarked above that IGA opened the door to geometrically flexible discretizations of higher-order partial differential equations in primal form. In particular, I want to mention that it gave new life to Kirchhoff-Love shell models (see, among others, [10] and references therein), which possess several key advantages over Reissner-Mindlin models typically adopted in finite element simulations (such as no rotation degrees of freedom, no shear locking, etc.). In addition, IGA higher-regularity gives the possibility of efficiently implementing locking-free Reissner-Mindlin models, or novel structural models able to retain the advantages of Kirchhoff-Love formulations but including also shear deformation, as it happens with Reissner-Mindlin approaches (see, e.g., [11]).

As a final representative case study, I want to briefly mention the results of some nonlinear bending simulations of complex structures like shape memory alloy stents, just obtained within the group of Computational Mechanics and Advanced Materials at the University of Pavia [12]. These nonlinear analyses do not involve contact

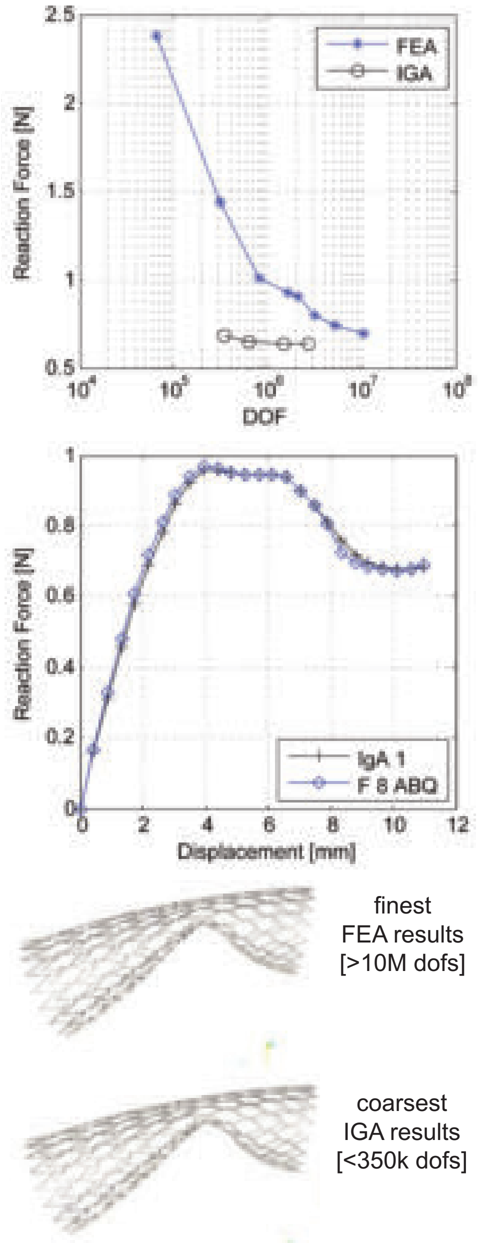


Figure 8:
SMA stent bending: IGA versus FEA. Top: Reaction force convergence plots. Middle: Force-displacement plots for finest FEA and coarsest IGA. Bottom: Comparison of deformed shapes for finest FEA and coarsest IGA

Figure 9:
Some members of the group of Computational Mechanics & Advanced Materials at the University of Pavia currently involved in IGA activities: S. Morganti, F. Auricchio, J. Kiendl, M. Conti, M. Ferraro, A. Reali

nor explicit dynamics (as in the valve case described above), but the geometrical complexity, the use of non-trivial inelastic constitutive models, and the presence of significant buckling phenomena imply that extremely fine meshes - comprising a number of degrees of freedom well beyond what is typically adopted in these kinds of computational biomechanics problems - are required to correctly describe the physical phenomenon by means of standard finite elements. Instead, IGA simulations are proven to correctly reproduce the actual physics of the problem already with coarse meshes. A remarkable note is that, within the adopted finite element framework (refer to [12] for details), 10,622,016 d.o.f.'s are required to reproduce the same results obtained within IGA with only 346,413 d.o.f.'s *(see Figure 8)*. In this case, the overall computational cost for IGA is four times lower, despite the use of a single processor versus the eight processors employed in the case of finite elements (a serial implementation within FEAP was used for IGA, while ABAQUS parallel capabilities were employed for finite elements).

Many other impressive examples could be cited here, but for the sake of brevity I would just refer to the fast-growing IGA literature. I instead would like to conclude with a picture *(Figure 9)* of the members of the group of Computational Mechanics and Advanced Materials at the University of Pavia, which are currently contributing to some of the research activities described above. I also want to acknowledge the fundamental interactions and contributions of the "Numerical Analysis crew" in Pavia, as well as of all the people I had the privilege to meet over the last decade at the Institute of Computational Engineering and Sciences, UT Austin (cf. the acknowledgement section below for a, probably still incomplete, list of collaborators and friends).

"..the superiority of IGA over standard finite elements now appears to be remarkably evident in the approximation of structural vibrations and dynamics..."

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Ted Belytschko
Personal Remembrances

by
Thomas J.R. Hughes

Ted Belytschko was my friend and professional colleague for 39 years. He suffered a stroke in 2010, and his health progressively deteriorated in the ensuing years. On September 15th, 2014 he died.

Figure 1: *Left to right, Tom Hughes, Bob Taylor & Ted Belytschko at the FENOMECH Conference in Stuttgart, Germany, 1978*

I first met Ted through one of his papers. It was 1975 and I had recently completed my PhD at the University of California at Berkeley. The paper was an investigation of the stability of finite element methods and time stepping algorithms for nonlinear structural dynamics.[1] I was thinking about this problem too. I found Ted's paper very interesting and mentioned it to Ed Wilson. Ed told me that he had recently heard Ted deliver a paper at a conference and was very impressed by him. I suggested that we invite Ted to visit Berkeley and present a seminar. The day he visited I agreed to meet him at the Civil Engineering Department Office. When I arrived, I saw an individual standing by the door of the office wearing an overcoat and a hat. I knew it was our visitor from Chicago because no from Berkeley would be wearing an overcoat and a hat on a warm and sunny California day. Ted presented a seminar that morning and after it we went to lunch at the Faculty Club with Ed and Bob Taylor, with whom I was working at the time. Ted enjoyed the opportunity to meet Ed and Bob, who already were finite element luminaries. We had interesting discussions about research, finite elements and nonlinear mechanics that lasted throughout the day. Ted's congenial personality and hearty sense of humor were immediately evident. I really liked him. We hit it off, became friends, and always remained friends.

Ted was a clear thinker and did not waste time with things that were unimportant. I recall that he told me he had learned from his PhD advisor, Phil Hodge, that "if it's not worth doing, it's not worth doing well." Words to live by. Ted had gone directly into academia from his PhD and he was already an experienced teacher at a time when I was just starting. We were the same age but I had worked in industry before pursuing my PhD. I often asked Ted for advice. I remember raising the issue of grading papers and the time I was spending devoted to equitably assigning partial credit. He told me not to waste my time, "the first time they try to snow you, 50% off, the second time, the other 50% off." I also mentioned to him that some students were difficult and would argue about their grades. He told me "do not give those students the grade they want, make them a first offer, and negotiate from there to the grade they deserve."

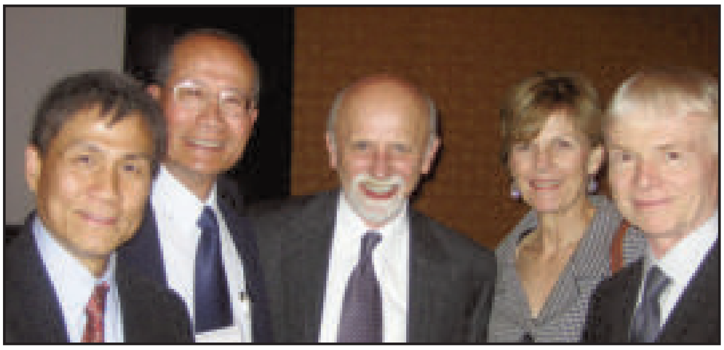


Figure 2: *From left to right, Wing Kam Liu, Ken Chong, Ted Belytschko, Susan Hughes & Tom Hughes, at the 2007 U.S. National Congress on Computatonal Mechanics, San Francisco*

Ted and I attended many of the same conferences, served on many of the same committees, and were funded by some of the same funding agencies. We spent a lot of time together at various meetings and we always had interesting things to talk about, usually over a good dinner. I remember him saying many times that he had been working hard on something and he needed "cheering up." It was then my responsibility to say something outrageous and make him laugh. I did my best and sometimes I succeeded. He had a great sense of humor and always made me laugh.

One of the things that we will forever be jointly identified with is the Nonlinear Finite Element Short Course that we taught together for almost 30 years. Like many things in life, it had somewhat of an accidental start. In 1980 I moved to Stanford from Caltech. MARC Analysis, the developer and marketer of MARC, the first commercial general purpose, nonlinear finite element structural analysis program, was based in Palo Alto. Soon after arriving at Stanford, I was asked to lecture in a finite element short course in Tokyo with Olek Zienkiewicz and Joop Nagtegaal in behalf of MARC. It was the first short course I had ever lectured in. It was deemed a success and I was asked to lecture in the next course in Lake Placid, New York, but this time I was asked to propose an additional lecturer, so I suggested Ted. The course attendance was small but the experience was enjoyable. The next MARC course was held in Tokyo and this time Ted and I presented all of the lectures with the exception of some lectures in Japanese delivered by the late Shohei Nakazawa. There were 125 paid attendees. A thought occurred to both Ted and me: $$$. We were to receive very small honoraria for our lectures.. After the course, we decided to politely broach the subject of some additional compensation. To make a long story short, that did not go well. Then, another thought occurred to us: We were going into the short course business – the Nonlinear Finite Element Short Course was born.

We began by holding one course in Europe and one in the U.S. each year. Later, due to our increasingly busy schedules, we cut it down to about three courses every two years. The courses were an immediate success and remained so. The European courses were organized by ZACE, the company of our mutual friend Thomas Zimmermann. In the U.S., Ted and I shared the organizational work. I worked on venue selection, hotel contracts, and preparation of course notes. Ted's responsibility was the course brochure, advertising, and sign-up of attendees. We had many nice social events in concurrence with the courses and always celebrated at the end of a course with a special dinner at the best restaurant we could find, at which we ordered a special bottle of wine to share. It was great fun. We often played harmless jokes on each other during the courses. One I initiated concerned the course evaluations. We asked attendees to fill out a written evaluation of the course. I decided to write one about Ted and sneaked it into the pile of evaluations. I wrote everything bad I could think of about his lectures. We were reading them together and when he got to the one I wrote he was aghast. He said something like "My God, this person hated my lectures." I could only control myself so long and burst out laughing, and of course he realized what had happened. He let me know, in no uncertain terms, he would eventually get even. In the years that followed, there was usually one evaluation that each of us received that advanced the art of "destructive criticism."

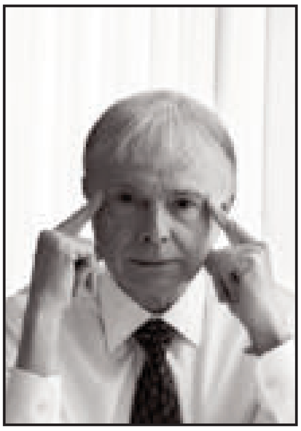
We worked very hard on the technical content of our short course lectures and tried to make the courses the best they could be. I tended to be very serious when I lectured. Ted was serious too, but after a while he started to add some jokes. He became the course comedian, and I was the straight man. In one of the course evaluations, an attendee proclaimed that the thing he liked best about the course was "Professor Belytschko's jokes." I felt I needed to lighten up, so I decided to tell a joke in one of my lectures. It was a good one and I remember Ted also really enjoyed it. Ted had compiled a list of jokes that he used in each course. Now, I had one. In our next course, during Ted's first lecture, he told my joke! He said he would get even. However, being true to academic ethical standards, he cited me.

Prior to Ted's stroke, in the last few years of the Short Course, the lectures were becoming more of a strain on him. He had been having health problems and during the courses he had trouble sleeping and experienced considerable anxiety. Neither he nor I had ever missed a lecture, but we once had a conversation about what we might do if one of us was unable to lecture. He said if something happened to me, he would call upon Wing Kam Liu (the current President of IACM). Wing was Ted's student at the University of Illinois at Chicago before he came to Caltech in 1976 to do his PhD with me. As Wing was completing his PhD, Ted called me and told me "I want him back" and in 1980 Wing rejoined Ted, this time as a faculty member and colleague at Northwestern University. Ted's stroke occurred a month before a Short Course was to be held in Berlin. It took me a day to recover from the shock of the news, and my first thought was to cancel the course, but then I recalled what Ted had said. Wing willingly and admirably filled in for Ted in Berlin. When that course ended I closed the book on the Short Course.

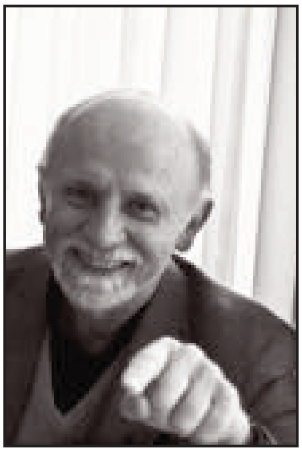
Ted had many professional successes and he also had warm personal qualities. His work gained the admiration of the academic research community and enjoyed widespread industrial and commercial utilization. His publications achieved enormous citation impact. He richly deserved and received many honors, awards and accolades throughout his career. He gave beautifully clear lectures, a quality that was also present in his written works. He encouraged and supported young scholars, and always had time for discussions with them about engineering science and the professional challenges they faced.

The last four and a half years were a terrible ordeal for Ted, for his loving wife Gail, his children, their families, and caregivers. It has been heartbreaking for his many close friends.

Ted was a very special person and one of the giants of our field. I hope the last four and a half years of Ted's life fade in my memory so that I will remember him as he was in his prime: A dynamo, energetic, hard working, productive, passionate, brilliant, creative, successful, humorous, and a kind and generous dear friend. ●



Figures 3 & 4: *(Above)Tom Hughes & (below) Ted Belytschko at the 2007 Berlin Short Course. We were asked to pose this way for the photographs. We never found out why*



[1] T. Belytschko and D. F. Schoeberle, On the unconditional stability of an implicit algorithm for nonlinear structural dynamics. ASME Paper No. 75-WA/APM-14

Robert L. Taylor - 80

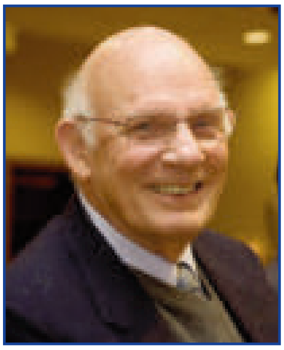


Figure 1:
Robert L. Taylor (IGA 2011)

On July 14th, 2014 Robert L. Taylor turned 80 years old *(Figure 1)*.

Our computational mechanics community owes Bob Taylor a lot for his outstanding scientific contributions, his constant enthusiasm in teaching and research, and his exceptional helpfulness which goes far beyond the usual support in academia. As a sign of appreciation for all his accomplishments and contributions some colleagues and friends gathered in Barcelona on July 20th, 2014, celebrating his birthday just before the joint IACM-ECCOMAS conference. Some photos and remarks from the presentations are quoted below.

Bob as student and colleague

Karl Pister refers to the early days in the life of Bob:
"Robert Leroy Taylor is a California native son, born in the heart of California's 'inland empire' in the city of Riverside in the days of the great depression in the United States". Bob has an older brother Harold and a younger sister Carol. *"He graduated from Riverside Polytechnic High School and then received an Associate of Arts degree at Riverside College (Figure 2). Then, it was either join his father's business selling Westinghouse appliances or go to UC Berkeley. Fortunately, he made the right choice.*

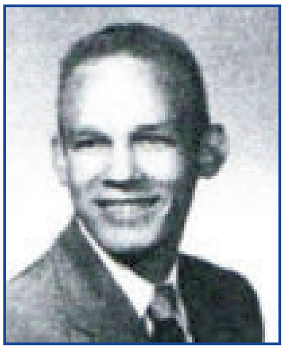


Figure 2:
Bob at Riverside, Polytechnic High School (left), City College 1954 (right)

After completing his bachelor's degree in Civil Engineering, Bob began an academic track which he is still following; he began as a Teaching Assistant, performed research as a Graduate Research Engineer, and while still working on his PhD was an Acting Assistant Professor. A decade later he was Full Professor and today as an emeritus professor supervises graduate students and visiting scholars in his capacity as a Professor in the Graduate School".

Karl Pister also mentions a *"parallel universe outside the campus"*, namely the life in an apartment complex in Berkeley called 'The Americana' in 1963. This was the place were Bob met Mary Lou Clark. They married in Rhode Island, Mary Lou's family home, on August 1963, just before he received his PhD *(Figure 3)*. It was the beginning of the happy Taylor family *(Figure 4)*. Bob was a member of Karl Pister's first research group; his doctoral dissertation was entitled 'Problems in Thermoviscoelasticity'. *"In 1963 Ray Clough and his students were busy exploring finite elements …. the potential did not escape Bob's notice …. His first FEM proceedings paper appeared in December 1967 'The FEM for Orthotropic Axisymmetric Solids' ".*

Figure 3:
Karl Pister's Graduates: Russ Westmann, Bob Taylor, Karl Pister, Leonard Herrmann, Stanley Dong; Commencement 1963 (left), 32 years later (right)

Figure 4:
The Taylors family at their Oakland home (October 1975)

Scholar - Berkeley and Swansea

Let us quote Tom Hughes: *"When I arrived at UC Berkeley in August 1969 I joined the 'Pister Research Machine'; Bob was the 'Chief Operating Officer'; but in about a month he left for Swansea, Wales, and began his life-long collaboration with Olek Zienkiewicz. While he was in Swansea, he wrote the original FEAP, Finite Element Assembly Program. But*

by
***Ferdinando Auricchio**, University of Pavia, Italy*
***Eugenio Oñate**, Technical University of Catalonia (UPC), Barcelona, Spain*
***Ekkehard Ramm**, University of Stuttgart, Germany*

that FEAP is not the famous FEAP that is used throughout the world today. After he returned to Berkeley Bob and I began an intense period of collaboration … which lasted until the summer of 1976 when Bob returned for a second sabbatical year in Swansea … in which he collaborated with Olek on the third edition of the famous FEM book". (Figure 5)

Tom Hughes mentions Bob's scholarly works: *"Many, many, many classic computational solid and structural mechanics papers with collaborators, in particular, with Juan Simo. Continued developments and dissemination of 'FEAP', the primary research platform in Computational Solid Mechanics, now including Isogeometric Analysis. Net Result: A zillion citations. Bob is one of ISI Thompson Reuters's original 100 'Most Cited Engineers' ".* Tom adds 'a few other things': *"Member of the National Academy of Engineering. Many prominent grad students and post-docs. Honorary Doctorates (Swansea, Hannover), Drucker Medal (ASME), Von Neumann Medal (USACM), Gauss-Newton Medal (IACM,),…"* and says *"a great researcher, a great teacher, a great mentor, a great collaborator, a great friend". (Figure 6)*

Bob as a teacher

As an example let's have Ferdinando Auricchio (Berkeley graduate 1990–1995) say: *"I was loving so much Berkeley, the school, the courses, the work I was doing with Bob, …, that right after my MSc graduation, I decided to go for a PhD… . It was a wonderful and unique learning process, but it was also a very tiring and stressing time for a poor young kid like me. We were used to start to work together around nine in the morning, stop for a quick lunch and continuing to work most of the afternoon and the working scheme was: Bob was doing paper derivation and coding at his usual speed (especially coding) and I was sitting right behind him, following him in all typical commands he used to create Fortran code and to shape his creature FEAP. Again ….it was great, but not an easy time…….The more I was working with Bob, the more I was learning…. Again, an incredible learning process"*.

Ferdinando also mentions the friendship of Bob and Mary Lou and says *"I never missed a Thanksgiving lunch at their house in Oakland"* and finally refers to his graduation ceremony *"This was another incredible emotion. Being on the stage of the Greek theatre in Berkeley, with my cap and gown, and having the sole placed exactly as Bob and from Bob" (Figure 7)*.

Figure 5:
Olek Zienkiewicz, Tom Hughes, Bob Taylor at FENOMECH Conference, Stuttgart 1978

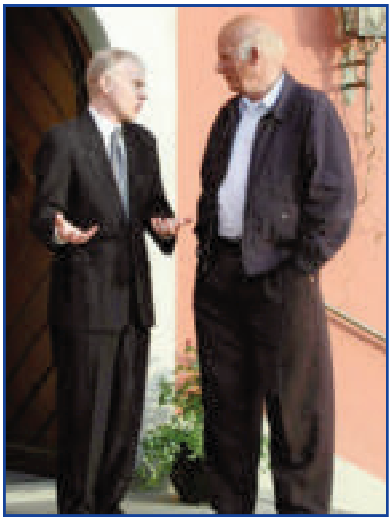


Figure 6:
Tom Hughes and Bob Taylor at Conference in Schloss Hofen, Bregenz, Austria 2001

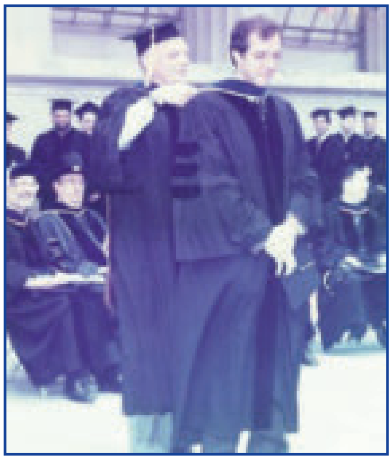


Figure 7:
Graduation Ceremony Berkeley 1995: Professor Robert L. Taylor and Dr. Ferdinando Auricchio

Barcelona

Eugenio Oñate refers to Bob Taylor's many strong relationships to Spain, in particular to Barcelona. Not only that he had several grad students and visitors from Spain; his contacts can be traced back to his sabbatical leaves in Swansea where he met quite a few young investigators from Spain starting their academic career. Later Bob was a frequent visitor

Figure 8:
CIMNE, UPC, Barcelona 2003: 82nd Birthday of OC Zienkiewicz

at CIMNE, UPC, attending ECCOMAS and IACM Conferences, and as visiting professor *(Figure 8)*. In a short essay to the 25th Anniversary of CIMNE Bob writes *"After my retirement 1994, I was privileged to join Olek at CIMNE and between 1995 and 2008 we enjoyed both scholarly and social interactions each year in Barcelona… . During this decade CIMNE also provided the environment for two revisions of The Finite Element Method which was expanded to three volumes for the fifth and sixth editions which were also translated into Spanish during those years (Figure 9). Many of the actual writing of materials evolved from discussions Olek and I had with our colleagues at CIMNE" (Figure 10)*. The times with Olek Zienkiewicz in Barcelona, in particular in the seaside town Sitges, were fruitful in two ways, leading to a deep lasting friendship and a very successful scientific interaction; this is expressed through a message from Helen Zienkiewicz [communicated by Roger Owen]: *"Your friendship through the years and your help and hard work with Olek made his last years so happy and productive. To him you were the kindest of friends…"*

Figure 9:
The Finite Element Method:
Bob's own book collection

A great person

Ekkehard Ramm points out to his many visits to Berkeley, meeting Bob and Mary Lou, including several excursions to the Golden Gate Bridge *(Figure 11)*.

"Bob Taylor is a person who takes care of people, of family, but also of people in our community, as we all experienced. His amiable wife Mary Lou, his children and grandchildren play an important role in his life (Figure 12). So Bob is not only an excellent researcher and teacher, he is simply a great personality. That's why we all like him and admire his modesty, a hard trait for such a brilliant scientist and world recognized authority in our field. We all are grateful that we met him in our lives".

Figure 10:
Bob Taylor and OC Zienkiewicz
signing 5th edition, Complas VI, 2000

This appreciation is also expressed by a statement for the nomination of Bob Taylor for the Berkeley Citation 1994, the highest campus honor, quoted by Karl Pister:

Looking beyond the strictly academic accomplishments of Professor Taylor, it is very hard not to comment on his inviting personality, his openness to students and colleagues and his modesty. The combination of his breath and depth of knowledge, intellectual potential, and work ethic, places him with those select few professors that set the standards of excellence in academics.

We all wish Bob Taylor a continued success and happiness for the years to come. *(Figure 13)* ●

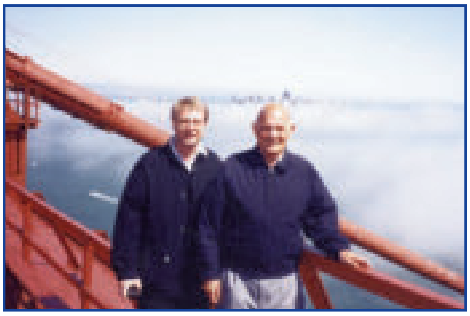
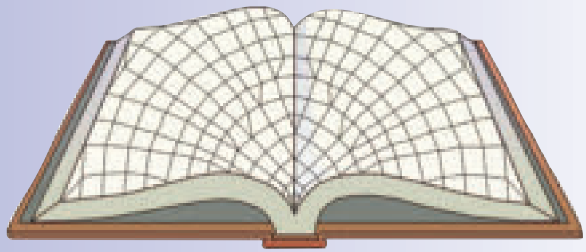


Figure 11:
Bob Taylor and Ekkehard Ramm
on South Tower of the
Golden Gate Bridge 2002

Figure 12:
Mary Lou and Bob Taylor
(Debbie Lukas née Taylor)

Figure 13:
Eugenio Oñate, Ekkehard Ramm,
Bob Taylor and Ferdinando Auricchio
at Bob's 80th Birthday Celebration,
Barcelona July 20, 2014

PRACTICAL MULTISCALING



Jacob Fish
Wiley, UK, 2014

BOOK REVIEW

ISBN: 978-1-118-41068-4, 398 pages, hard cover, £75.50 (List Price)

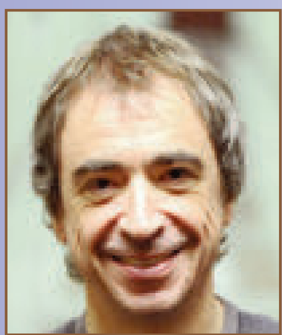
Contents: Preface; 1. Introduction to Multiscale Method;
2. Upscaling/Downscaling of Continua;
3. upscaling/ Downscaling of Atomistic/Continuum Media;
4. Reduced Order Homogenization; 5. Scale-separation-free Upscaling/ Downscaling of Continua; 6. Multiscale Design Software; Index.

Multiscale computational methods have caught a lot of attention in recent years, and constitute a very active area of research. Micro-scale features may strongly affect the macro-scale behavior, yet the problem of fully resolving the former is almost always intractable. This state of affairs is sometimes called "the tyranny of scales." The goal of multiscale analysis is to construct a coarse-scale problem that adequately reflects the fine-scale features. Despite the recognized importance of the subject, penetration of multiscale ideas into industrial practice and into commercial codes has been quite limited. The goal of the present book is manifested by its title: to explain and demonstrate how to devise and use practical multiscale methods, which account for fine-scale details without requiring their precise resolution. The book is an excellent treatise of the subject, and in my opinion achieves the stated goal admirably well.

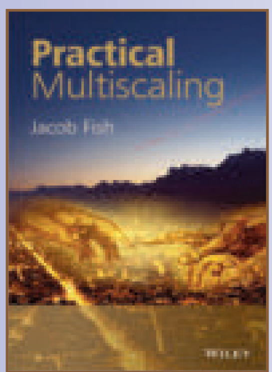
The book is intended for graduate students and researchers, practitioners in industry and commercial software vendors. It can be used as teaching material for a one-semester course. The author assumes the reader to have basic knowledge of continuum mechanics and finite element analysis. I would add to these prerequisites some knowledge of asymptotic (perturbation) methods. A reader without such knowledge would find it hard to follow the derivation of the homogenized equations which heavily relies on asymptotic analysis, and is not explained at the length required for a reader who has not been exposed to this subject previously.

After the Introduction in Chapter 1, there are four chapters (2-5) that discuss various multiscale methods, emphasizing the notions of upscaling and downscaling, for various types of solid media. Incidentally, the fact that the book handles only *solid* media should have been mentioned at least on the back cover (if not declared in the book's title), since multiscale analysis is certainly relevant in other fields of mechanics, like fluid dynamics. Chapter 6 is a user's manual for an academic version of the software MDS, which performs multiscale analysis using the methods presented in Chapters 4 and 5. The software is accessible at the internet site http://multiscale.biz and can be plugged into one of several commercial codes, or to a built-in coarse scale solver.

by
DAN GIVOLI
Technion — Israel Institute of Technology
givolid@technion.ac.il



Jacob Fish



The book is very nicely edited. It contains many colorful illustrations, and the text is relatively easy to read and to follow, despite the complexity of the subject and the almost unavoidable heaviness of the notation. The general appearance of the book is very pleasing. Each chapter ends with several wisely crafter Problems, followed by a list of references.

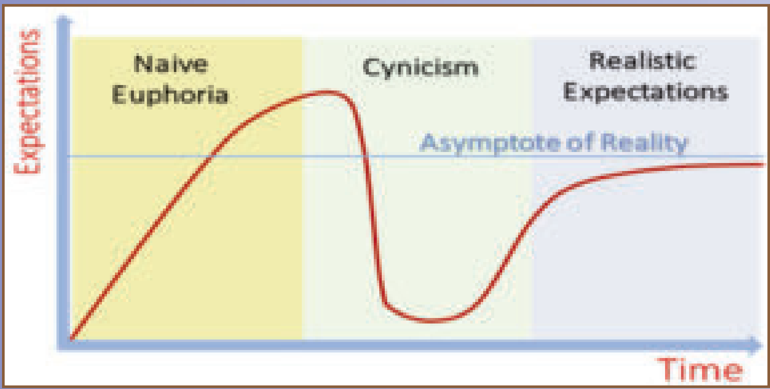


Figure 1: Evolution of a new technology. This figure appears in the book as Fig. 1.2 on p. 3

The first part of the Introduction is an interesting short overview of the subject, in the famous clear and humorous style of the author. Among other things, the author discusses the evolution of a new technology like computational multiscale analysis. See *Figure 1*, which is taken from the book. After a period of "naïve euphoria'', followed by a period of disappointment and cynicism, we are now at the phase of "realistic expectations'', where the true practical force of multiscale analysis may be exploited.

There are two general types of multiscale methods: information passing, which is hierarchical in nature, and concurrent, in which fine- and course-scale resolutions are simultaneously employed. The book focuses on information passing methods. A major ingredient in such methods is the "unit cell'', which represents the fine-scale behavior. *Figure 2*, which is taken from the book, shows three examples of unit cells. The two crucial operations in multiscale analysis are *upscaling*, which means constructing coarse-scale equations from fine-scale equations, and *downscaling*, which means extracting fine-scale information from coarse-scale information. It should be remarked that there may be more than two scales (e.g., the added mezoscale in composite laminates), in which case these notions are used recursively.

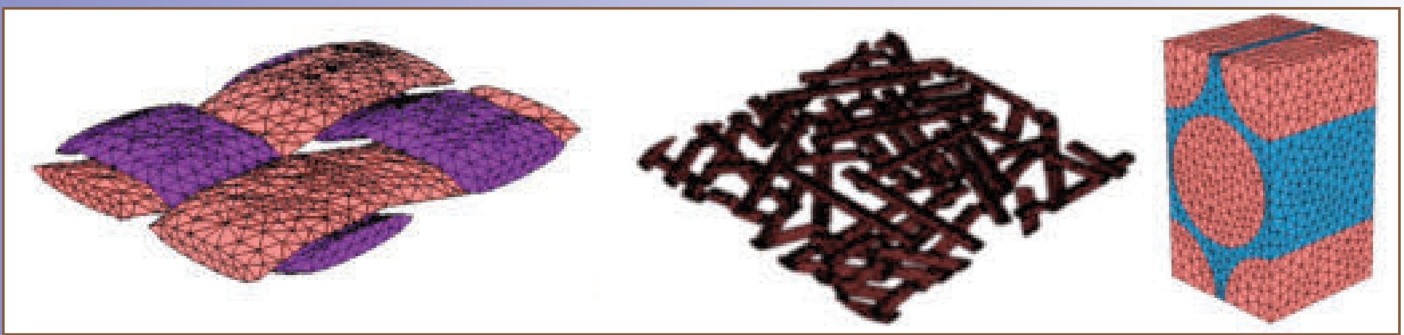


Figure 2: Examples of unit cells. This is a part of the book's Fig. 4.7 on page 163

The second part of the Introduction is subsection 1.5, entitled "Notation". This is essential reading material, since not only it introduces non-trivial notation to be used throughout the book, but it also lays the foundation to some basic concepts of multiscale analysis. For example, the coordinates used in the various scales are introduced here, e.g., $y=x/\zeta$, where ζ is the small parameter (alas, ε is used for the linear strain) which relates the fine-scale coordinate to the coarse-scale coordinate. This is a fundamental notion that goes much beyond "notation". The formula that relates the derivatives of a function in the fine and coarse scales is also given here. In books on asymptotic analysis, the two-scale method for singular perturbation problems is slowly explained, usually after simpler methods have been covered, while here the exposition is quite brief. Readers who would try to skip the Introduction and "get down to business'' by starting reading Chapter 2, would quickly regret this. If a second edition of this book is to be published, I suggest that these fundamental notions be expanded, and that they find a better place than a subsection entitled "notation" in the Introduction.

Chapter 2 discusses multiscale methods for linear and nonlinear continua. The homogenization procedure is derived for 3D linear elasticity. This raises a pedagogical question: would it perhaps be better to start with the scalar problem (eq. (2.1) on p. 14), e.g., representing heat conduction, in order to demonstrate all the issues involved in a simple setting, before plunging into the 3D anisotropic elasticity problem? Different authors and teachers may choose either of the two ways of presentation. Both are legitimate, and the best way depends on the reader's background. Here the more complicated problem is treated immediately, while simpler problems are posed and left for the reader at the end of the chapter. This is an excellent way of presentation for the advanced reader, for whom starting with the thermal problem (which is less relevant physically) would be repetitious.

Within the derivation of the upscaling (homogenization) procedure, on p. 19, the author assumes "for simplicity" that the elastic moduli depend only on the fine-scale coordinates. No explanation is given in this context. This is worth an elaboration, since it raises a few questions: Is this a reasonable assumption in practice? Under what circumstances does it hold? Can the formulation be generalized if this assumption does not hold? How? Other places in the derivation could have also seen some elaboration.

Chapter 2 also includes a short discussion on boundary layers (taking the approach of Dumontet and of Lefik and Schrefler), on error estimates, and on enhanced-kinematics upscaling methods (including MsFEM, VMS and MEPU). In Section 2.4 the homogenization procedure is extended to the nonlinear regime. What seems to be missing from the statement of the problem and from the numerical examples is a constitutive relation. For instance, in the perforated plate example on p. 62, the material is said to be hyper-elastic with energy of neo-Hookean form; an explicit expression would have been in place here. Section 2.5 discusses "higher-order homogenization". This is not about a high-order asymptotic treatment of the homogenization process (i.e., valid up to $O(\zeta^2)$ instead of up to $O(\zeta)$), but about higher-order continuum theories. These may be very important when scales near the continuum limit are involved. Section 2.6 extends the theory to more than two scales.

Section 2.7 presents the employment of multigrid (MG) solvers in the homogenization process. The author has done a lot of important and impressive work on this subject. It seems that MG is viewed here differently than in some classical mathematical treaties. The traditional view of MG is as an acceleration method, which allows the solution of an N-dimensional linear algebraic system, resulting from the discretization of a PDE, in $O(N)$ operations (which is optimal). In the present book, the goal is "to improve the quality of the upscaling solution by combining MG and homogenization ideas." A discussion about the relation between the two views would have been beneficial.

Chapter 3 deals with multiscale methods that couple the atomistic scale, where molecular dynamics (MD) equations govern, with the continuum scale. The author shows very effectively, with the aid of asymptotics and time-averaging operations, how the MD equations lead to continuum equations. Chapter 4 is about "reduced order homogenization", which includes any homogenization method which involves shortcuts and approximations to the exact mathematical homogenization of Chapter 2. These shortcuts are required since the ineasltic problems dealt with in this chapter are history-dependent and hence involve a large computational effort. A variety of methods are surveyed in this chapter, including methods that provide a seamless transition between the atomistic and continuum scales.

In Chapter 5 the author presents a method he devised with his group, called Computational Continua (or in short C^2, which may be slightly confusing since this is a C^0 formulation, i.e., requires only simple continuity, as opposed to the C^1 formulation presented in Chapter 2 for high-order continua). The advantages of C^2 is that it allows the use of standard finite element shape functions even though the medium is of high order, that it is consistent in that it does not assume anywhere that the unit cell is infinitesimal, and that it avoids artificial scale separation.

The MDS manual, in Chapter 6, shows many nice examples for the capability of the software. *Figure* 3 shows a unit cell containing random ellipsoids, which the software has constructed.

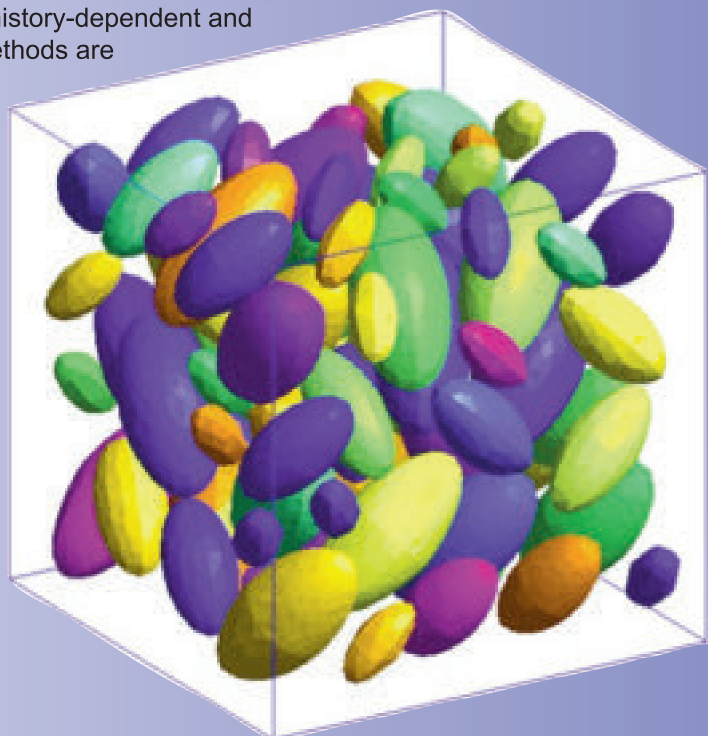


Figure 3: *Random ellipsoids until cell. This figure appears as Fig. 6.50 in the book, on p. 341*

In summary, this book delivers exactly what it promises to deliver: it is an excellent provider of practical methods for multiscale analysis. I highly recommend it. ●

for all inclusions under
PACM
please contact:

Jerzy Pamin
jpamin@l5.pk.edu.pl

O.C. Zienkiewicz Medal
of Polish Association for Computational Mechanics

The O.C. Zienkiewicz Medal of PACM, shown here, was established in 2007. The medals are awarded for outstanding merit in the development of computational mechanics upon recommendation of Medal Chapter, the Commander of which is Prof. M. Kleiber, President of Polish Academy of Sciences. The award ceremony takes place every two years during international conferences on Computer Methods in Mechanics CMM in Poland.

The original of the medal by sculptor A. Praxmayer was presented to Professor O.C. Zienkiewicz in Swansea *(Figure 1)*.

In years 2007- 2013 the awardees of the medal were:

- in the category 'Medal for foreign scientists of particular merit for the development of computational mechanics in Poland' the following professors: *Giulio Maier, Herbert Mang, John T. Oden, Eugenio Oñate, Erwin Stein, Bernhard Schrefler and Robert L. Taylor;*
- in the category 'Medal for outstanding achievements during recent two years' only *Leszek Demkowicz;*
- in the category 'Medal for the whole of activity the following Polish scientists': *Zbigniew Kączkowski, Michał Kleiber, Jan Szmelter (postmortally), Janusz Orkisz, Zenon Waszczyszyn, Andrzej Garstecki and Tadeusz Burczyński.*

Figure 1:
(From left) T. Burczyński, O.C. Zienkiewicz, his wife & J. Orkisz in Swansea

During the jubilee 20th International Conference on Computer Methods in Mechanics CMM-2013 in Poznań the medals in respective categories were awarded to the following professors *(Figure 2)*:

- First category: *Manolis Papadrakakis, Peter Wriggers;*
- Second category: *Mieczysław Kuczma, Wiesław Ostachowicz;*
- Third category: *Adam Borkowski, Jacek Chróścielewski.* ●

Figure 2:
(From left) M. Kleiber, A. Borkowski, W. Ostachowicz, M. Kuczma, P. Wriggers, M. Papadrakakis during award ceremony in Poznań

AIMETA
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please contact:
Giorgio Zavarise
giorgio.zavarise
@unisalento.it

GIMC-AIMETA News

- **The Italian Group of Computational Mechanics (GIMC)** has a new web site **www.gimc.it**. The web site is now under development, and soon it will offer the possibility to register, both for affiliated, and interested people.

- With the forthcoming **AIMETA XXII Conference** (Genova, 14-17 September, 2015), GIMC will organize a special session on Computational Mechanics, and will also hold its annual Meeting.

- **A special issue of the journal** "Frattura ed Integrità Strutturale" ("Fracture and Structural Integrity"), which is the official journal of the Italian Group of Fracture (see: http://www.gruppofrattura.it/sito/en/journal/description-and-aims), containing recent progresses in the Computational Mechanics and Mechanical of Materials, mainly achieved by Italian researchers, was published in July 2014 (volume 8, issue 29). This special issue also contains some full-length papers from the GIMC-GMA 2014 Conference.

Figure 1:
The journal "Frattura ed Integrità Strutturale"

GIMC-GMA 2014

GIMC - GMA 2014

XX Italian National Conference of Computational Mechanics GIMC

VII Italian Meeting on Advances in mechanics of materials, GMA

The AIMETA Computational Mechanics and Material Groups are pleased to announce that the conference GIMC-GMA 2014, held in Cassino, at the Department of Civil and Mechanical Engineering, June 11-13, 2014, had a large turnout.

- Over 90 participants, from Italian and foreign Universities;
- 88 presentations organized in GIMC and GMA sessions;
- Two invited lectures given by Prof. Luchini and by Prof. Mensitieri;
- A special session for the presentation of Phd theses, candidated to ECCOMAS award.

Figure 2:
A view of the Montecassino Abbey

gacm German Association for Computational Mechanics

Visit our new website www.gacm.de!

At the last general assembly during WCCM 2014, the German Association for Computational Mechanics (GACM) proudly presented the new website *www.gacm.de* to its members. Some weeks later, this new official gateway to all GACM activities went online for the general public. The GACM Executive Council would particularly like to thank our Secretary General, Alexander Popp (TU Munich), for his dedication and tireless efforts to put the idea of a new contemporary website into practice.

Both GACM members and visitors interested in computational mechanics research in Germany and abroad will receive miscellaneous information services on *www.gacm.de*. Among the most important is an overview of recent, current and future GACM activities, such as the GACM Colloquia for Young Scientists, the news bulletin GACM Report, different awards conferred by GACM and other events or initiatives. There are also dedicated subpages presenting the members of the GACM Executive Council, the 25-year history of our association and the scientific network into which GACM is embedded. As a special service to the young members of our community, GACM currently works on establishing a new job database with job openings in the field of computational mechanics (education, research and practice) in both Germany and all over Europe. It is also planned to further expand the association's activities for young researchers, which will be done in close collaboration with the ECCOMAS Young Investigators Committee.

Last but not least, the success of a scientific association largely depends on the dedication and commitment of its members. This is why the new website comes with an entirely new Members Area, which will serve as first contact point for all GACM members. After logging in, our members have access to internal news and a download section, and they can administrate their membership data with an easy-to-handle set of web forms. Those interested in becoming a member of GACM are invited to visit the Membership section, which contains all necessary information regarding the benefits and membership fees as well as an online application form. ●

Figure 1:
The new website www.gacm.de comes with a contemporary design and layout

for all inclusions under **GACM**
please contact:
Wolfgang A. Wall
gacm@lnm.mw.tum.de

Summer School

"Multiscale Modeling of Interfaces and Advanced Solution Techniques"

Leibniz Universität Hannover, September 8-12, 2014

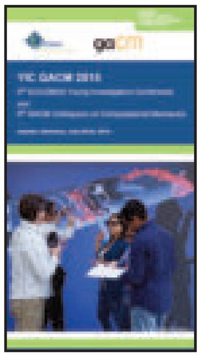
The 2nd MUSIC Summer School on "Multiscale Modeling of Interfaces and Advanced Solution Techniques" was organized in Hannover from September 8-12, 2014. About 60 participants, coming from 5 countries and having 15 different nationalities, followed 26 lectures, given by 12 scientists from France and Germany. Due to the collaboration with our partners from the LMT at the ENS in Cachan, France, it was organized as a German-French summer school, also supported by the Franco-German University. The lectures on various topics related to interface mechanics, reduced order models and virtual testing methodologies were presented by Prof. P. Ladevèze and O. Allix from the LMT, R. Rolfes, U. Nackenhorst and H.-J. Maier, S. Löhnert, B. Avci and C. Weissenfels from the University of Hannover, F. Gruttmann from the TU Darmstadt, W. Wagner from the KIT and Laura de Lorenzis from the TU Braunschweig.

The late summer sun welcomed the group at the campus Herrenhausen where the summer school was held in the green atmosphere of the Faculty of Architecture and Landscape Sciences. The social program included Hannover-sightseeing tours and a banquet at the old city hall of Hannover. ●

GACM Announcements:

GACM and JSCES are happy to announce that the **3rd German-Japanese Workshop on Computational Mechanics** will take place in **Munich, Germany** on **30 & 31 March, 2015**. The aim of this workshop series is to intensify the scientific relationship between senior and junior German and Japanese researchers in the broad field of computational mechanics. The first two workshops in this series took place in Yokohama, Japan, and Hannover, Germany. More information on this workshop can be found at ***http://www.gacm.de/GJ-Workshop-2015/***

GACM endorses the **2nd International Workshop on Latest Advances in Cardiac Modeling** which takes place on 12 & 13 March, 2015, at the German Heart Center in Munich. More info at: ***http://www.lnm.mw.tum.de/lacm2015***



And don't forget to submit your abstract or encourage your young colleagues to attend the **6th GACM Colloquium on Computational Mechanics** held together with the **3rd ECCOMAS Young Investigator Conference (YIC)** and the **3rd Aachen Conference on Computational Engineering Science (AC.CES)** Additional information can be found under ***www.yic.rwth-aachen.de***

A workshop on **Variational Multiscale Methods and Stabilized Finite Elements (VMS 2015)** will take place in Munich on February 25 to 27, 2015. More info at ***http://www.lnm.mw.tum.de/vms2015***

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please contact
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Passing of USACM Founding Member
Ted Belytschko

With the passing of Ted Belytschko on September 15, 2014, members of the U.S. Association for Computational Mechanics lost one of its founding fathers and strongest participants. Prior to the formation of a U.S. Association for Computational Mechanics (USACM), there had been much interest from a number of specialists in computational mechanics in the U.S. Until the late 1980s most computational mechanics papers in the US were presented at ASME conferences in sessions organized by the Computational Mechanics Committee of the Applied Mechanics Division.

The Computational Mechanics Committee had seen rapid growth under chairs such as Ted Belytschko, Tinsley Oden, and Tom Hughes. However because of limitations on the total number of sessions allocated to the Applied Mechanics Division, the number of sessions available for computational mechanics was very limited and insufficient for representing the rapidly expanding volume and scope of work in computational mechanics throughout the country. Ted Belytschko, who was chair of the Computational Mechanics Committee in the late 1980s, discussed this problem with Tinsley Oden, who at the time was the IACM Vice-President for the Americas, and in the discussion it was decided that the best solution was to found a new organization devoted to computational mechanics in the U.S. While attending the Winter Annual Meeting of the American Society of Mechanical Engineers at the Boston Sheraton, a dinner meeting on December 13, 1987 was organized and attended by Ted Belytschko, Tinsley Oden, Richard Gallagher, and Ted Pian as well as 19 others. At this meeting it was decided to launch a new organization called the US Association for Computational Mechanics which would organize meetings in this discipline.

Ted Belytschko served as the first Treasurer of the Association, was President from 1992-1994 and was a permanent member of the Executive Committee. He organized the highly successful First U.S. National Congress on Computational Mechanics in Chicago in 1993 and continued to contribute to the bi-annual congresses throughout the years. In 2012, the USACM named a medal in his honor.

He is greatly missed but the national community in computational mechanics is incredibly grateful for his contribution to USACM. ●

USACM Upcoming Events

- **4th International Conference on Material Modeling**
  May 27-29, 2015, Berkeley, California
  http://icmm4.usacm.org/

- **13th U.S. National Congress on Computational Mechanics**
  July 26-30, 2015, San Diego, California
  http://13.usnccm.org/

- **14th U.S. National Congress on Computational Mechanics**

Meshfree Methods for Large-Scale Computational Sciences and Engineering Workshop

The USACM Thematic Workshop entitled Meshfree Methods for Large-Scale Computational Sciences and Engineering was held in Tampa, Florida, October 27-28, 2014 at the Embassy Suites Hotel on the campus of the University of South Florida (USF). The two day meeting, organized by Dan Simkins (USF), John Foster (UT-Austin), J.-S. Chen (UC, San Diego) and W.K. Liu (Northwestern), brought together over 30 researchers in the area of meshfree methods to discuss problems in the following areas:

- Problems with large deformations – localized plasticity
- Multiscale modeling - geomaterials, polymer matrix composites, alloys, ceramics, material defects, atomistic-to-continuum coupling
- Multiphysics problems – coupled thermo-mechanics, electromigration, electro-active polymers, poro-elasticity, mixture theories
- Nonlocal methods – nonlocal elasticity, peridynamics
- Granular materials
- Software implementations and advances in parallel computing – traditional distributed, accelerator-based, and heterogeneous
- Mathematical theory of meshfree, generalized finite element, and particle methods
- Fast and stable domain integration methods
- Enhanced treatment of boundary conditions
- Identification and characterization of problems where meshfree methods have clear advantage over classical approaches

More information concerning about the workshop may be found at **mmlcse2014.usacm.org.**
Plans are being made to hold the next workshop in two years. ●

USNCCM13
Abstract Submission Open

Figure 2:
San Diego, California; site of the 13th U.S. National Congress on Computational Mechanics, July 26-30, 2015.

Over 100 minisymposia have been organized for the 13th U.S. National Congress on Computational Mechanics to be held July 26-30, 2015 in San Diego, California, organized by Yuri Bazilevs and David Benson (University of California, San Diego). Abstracts may be submitted by going to http://13.usnccm.org/abstract-submission. Submissions may be entered until February 15, 2015. A student poster competition will also take place. For more information on the congress, go to **http://13.usnccm.org/.** ●

The Israel Association for Computational Methods in Mechanics

Figure 1:
Prof. Leszek Demkowicz lecturing at ISCM-35

The Israel Association for Computational Methods in Mechanics (IACMM) has held two **IACMM Symposia** since our last report (see IACM Expressions No. 34). In this issue we shall report on them.

The **35th IACMM Symposium** was held in October 2013 at the Ben-Gurion University in Beer Sheba. The local organizer was Zohar Yosibash from the Mechanical Engineering Department. The very interesting Opening Lecture was given by Prof. Leszek Demkowicz from the University of Texas at Austin, and was entitled "Discontinuous Petrov Galerkin Method (DPG) with Optimal Test Functions." *Figure 1* shows Prof. Demkowicz lecturing, and *Figure 2* shows him with some of the IACMM Council members.

The Symposium also included 8 other lectures, presented by practitioners and researchers from industry and academia. These included talks by Dalia Fishelov on high-order compact schemes *(Figure 3)*, Romina Mayo on human femur analysis using p-FEM *(Figure 4)* and Orna Agmon Ben-Yehuda on the future of cloud computing *(Figure 5)*.

Figure 2:
Prof. Leszek Demkowicz with some of the IACMM Council members.
From left to right:
Jonathan Tal, Emanuel Ore, Zohar Yosibash, Leszek Demkowicz, Isaac Harari, Dan Givoli (President) & Amiel Herszage (Secretary/ Treasurer)

Figure 3:
Prof. Dalia Fishelov from the Afeka Academic College lecturing at ISCM-35

Figure 4:
Ms. Romina Mayo from Ben-Gurion University lecturing at ISCM-35

Figure 5:
Dr. Orna Agmon Ben-Yehuda from the Technion lecturing at ISCM-35

*for all inclusions under **IACMM** please contact*
Dan Givoli
givolid@technion.ac.il
IACMM site: www.iacmm.org.il

The **36th IACMM Symposium** was held in April 2014 at the Department of Aerospace Engineering of the Technion. The local organizers were Dan Givoli and Pinhas Bar-Yoseph. Attendance was especially large. A very impressive Opening Lecture was given by Prof. Anthony Patera from MIT, on "Computational Mechanics and Experimental Observations: Real-time In-situ Data Assimilation." *Figure 6* shows him with part of the IACMM Council.

Figure 6:
Prof. Anthony Patera with some of the IACMM Council members. From left to right: Jonathan Tal, Michel Bercovier, Dan Givoli, Anthony Patera, Pinhas Bar-Yoseph & Amiel Herszage

The afternoon Keynote Lecture was given by Prof. Steven Frankel from the Technion, on hybrid RANS-LES. *Figure 7* is a figure taken from his delightful lecture. The symposium included 8 additional contributed talks. One of them was given by Gabi Luttwak from Dynamic 123-D consulting, entitled "RayleighTaylor Instability Growth Using the Staggered Mesh Godunov Scheme." *Figure 8* is an illustration from his talk. ●

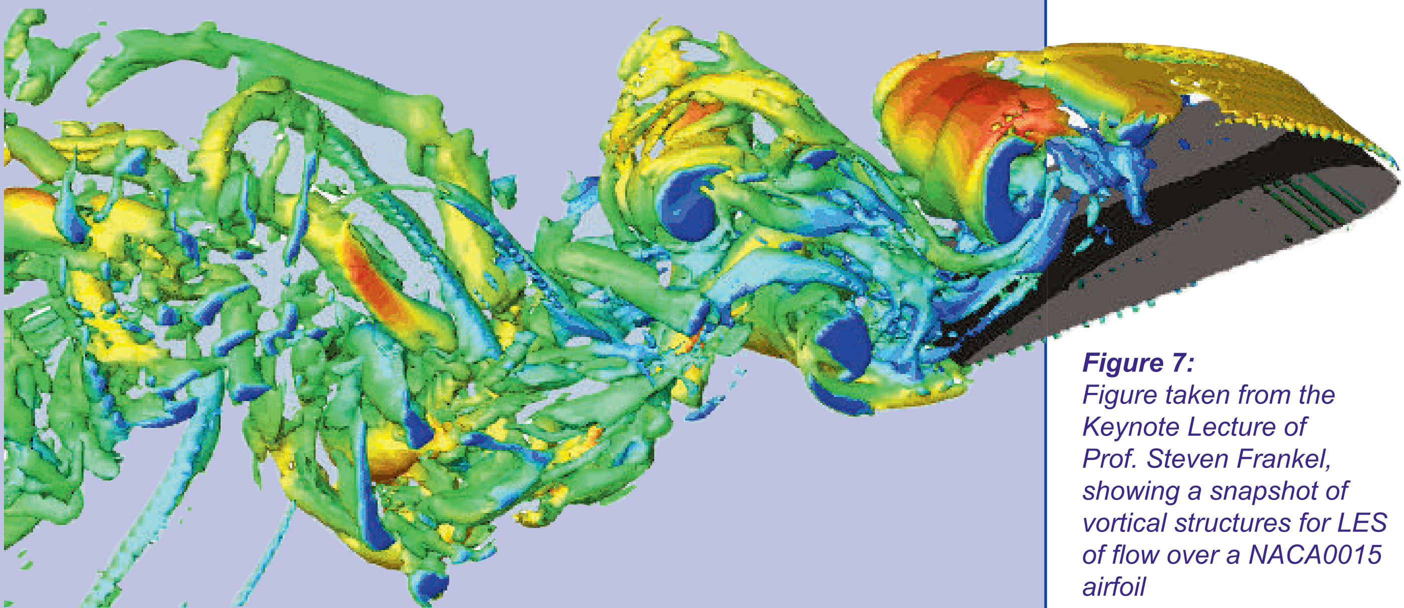


Figure 7:
Figure taken from the Keynote Lecture of Prof. Steven Frankel, showing a snapshot of vortical structures for LES of flow over a NACA0015 airfoil

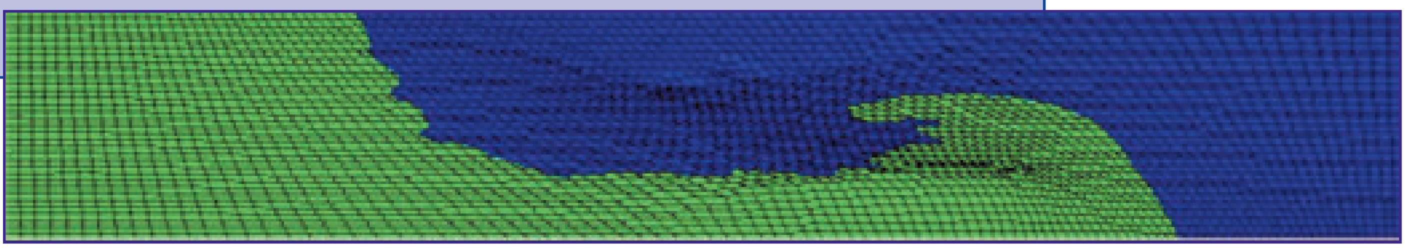


Figure 8:
Figure taken from the talk of Gabi Luttwak, showing resolution of the interface between a dense fluid over a lighter one under earth gravity, using ALE

Present status and activities in

CACM

On behalf of the Chinese Association of Computational Mechanics (CACM), I would like to introduce the present status and activities in CACM as one of the largest academic societies in the field of computational mechanics in the world.

Fiugre 1:
Prof. Zhuo Zhuang
The president of CACM

The CACM was founded in 1984 for researchers and engineers in the field of computational science and engineering. The first president was Prof. Wanxie Zhong (Dalian University of Technology). The CACM has successfully hosted the sixth WCCM and APACM in 2004, in Beijing, China. Now, there are tens of thousands of people working for study, research and application related to computational mechanics in China. At the WCCM2014 in Barcelona, there were 191 CACM members to participate in the conference, which ranks No. 7 from all delegations in the world. If considering the worldwide Chinese scholars on computational mechanics, there were more than 400 in Barcelona last July.

Every odd year, The Chines Society of Theoretical and Applied Mechanics host a Chins Mechanics Congress. Recent congress was held in Xian City in 2013 and more than 2500 people participated in the event. During the congress, the CACM organizes a branch-symposium and a few mini-symposiums focusing on computation mechanics. A few hundred people join the series symposiums, which is one of the largest groups in the congress. The next congress will be held on August 2015 in Shanghai, where is the most excited and commercial city in the world.

Every even year, we have a national conference of computational mechanics organized by CACM. The conference of CACM2014 was held in Gui Yang City, where is the capital of Guizhou province, on August 11-13, 2014. More than 420 people participated in the conference. They were coming from 70% of universities and research institutes and 30% of industries. More than 390 people made presentations, which were the largest numbers for the people and presented papers in the CACM 30 years history. The meeting was very successful achievement *(see attached Figure 2 and 3)*.

Figure 2:
Photograph of all delegates in CACM2014

for all inclusions under
CACM,
please contact:
Zhuo Zhuang
zhuangz@tsinghua.edu.cn

A new CACM General Council has been elected in 2014, which consist of 32 members, as shown in *Figure 4 and 5*. Prof. Zhuo Zhuang (Tsinghua University) is a new president to replace the former president Prof. Mingwu Yuan (Beijing University), who is still an EC member of IACM. The vice-presidents are Prof. Hongwu Zhang (Dalian University Technology), Prof. Yao Zheng (Zhejiang University), Prof. Qing Zhang (Hehai University), Prof. Yingbo He (China Academy of Engineering Physics), Prof. Pu Chen (Beijing University) and Prof. Xu Han (Hunan University). The aim of CACM will unite all computational mechanics researchers and engineers in China to carry out the scientific research and innovation, as well as engineering application. We also encourage the cooperation between academia and industries, and between national and international organizations.

The next CACM2016 will be held in Hangzhuo City, where is the capital of Zhejiang Province. In Hangzhou, the most beautiful West Lake is very famous in the world. We warmly welcome the world-wide academic researchers to participate in CACM2016. The announcement on the website will be provided in 2015. ●

by
Zhuo Zhuang

Figure 3:
Opening ceremony of CACM2014

Figure 4:
CACM General Council meeting

Figure 5:
The former president Prof. Mingwu Yuan (second from left), president Prof. Zhuo Zhuang (first from right), vice president Prof. Xu Han (first from left) during the conference

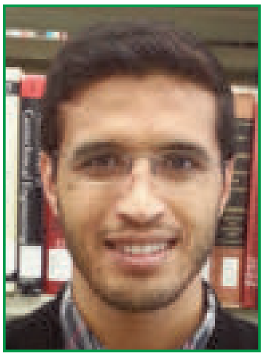
French Computational Structural Mechanics Association

CSMA Prizes

Every year CSMA rewards the best two PhD theses of the year. In 2013, the “CSMA prize commitee has examined 23 applications. The two awardees are:

Lucas BOUCINHA
PhD title: ***A priori model reduction through separation of space-time variables. Applications to transient elastodynamics.***
Laboratory: ***LaMCoS (INSA Lyon/CNRS)***
Supervisors: ***Profs. Anthony Gravouil & Amine Ammar***

Classical approximation methods, such as the finite element method, have become an essential part of the mechanical engineer's toolbox. However, their use requires considerable computational resources when trying to simulate complex industrial problems. Even if such resources are more and more affordable thanks to the remarkable progress in computer industry, new approximation methods have to be designed in order to better exploit all available resources. Reduced order modelling techniques are one of the serious challenges to address this issue. Among them, methods based on construction of low rank separated approximations, like the Proper Generalized Decomposition (PGD), have been shown to be very efficient in a wide variety of problems, reducing costs by several orders of magnitude. Nonetheless, efficiency of these methods depends significantly on the considered problem. In this work, that was directed by Prof. Anthony Gravouil (INSA Lyon) and done in collaboration with Prof. Amine Ammar (ENSAM Angers), we investigated the ability of classical PGD methods to solve transient elastodynamic models in space-time domain. Our numerical results highlighted the lack of optimality of the most robust PGD. Therefore, we developed in collaboration with Prof. Anthony Nouy (Ecole Centrale Nantes) a new PGD solver, based on minimization of an ideal residual norm. This solver allows to find a very good approximation of the best approximation of a given rank, without having to calculate more space-time modes than needed. This work was done at INSA Lyon and supported by the French National Research Agency under grant ANR-10-COSI-006.
Current situation: Currently, Lucas Boucinha is working as a developer at Sciences Computers Consultants (www.scconsultants.com). SCC is a software editor located at Saint-Etienne, France. He is responsible for numerical developments in SCC’s CFD software dedicated to the simulation of industrial material forming processes (heat treatment, mixing or casting processes).



Mohamed JEBAHI
PhD title: ***Discrete-continuum coupling method for simulation of laser-induced damage in silica glass***
Laboratory: ***I2M (CNRS/Université Bordeaux 1/Institut Polytechnique de Bordeaux/Arts et Métiers ParisTech/INRA)***
Supervisors: ***Profs. Ivan Iordanoff, Frédéric Dau & Jean-Luc Charles***

A discrete-continuum coupling approach was developed to simulate the laser-induced damage in silica glass. First, a classification of the different numerical methods was performed to select those that best meet the objectives of this work. Flowing this classification, the Discrete Element Method (DEM) which is a discrete method and the Constrained Natural Element Method (CNEM) which is a continuum method were retained. These methods were coupled using the Arlequin technique which involves several coupling parameters. To simplify their setting and then the application of the DEM-CNEM coupling approach on complex problems, a parametric study of these parameters was performed. The second part of this work was dedicated to the modeling of silica glass mechanical behavior. A numerical model taking into account the complex anomalous mechanical behavior of silica glass was developed to better characterize the response of this material under highly dynamic stresses and particularly under stresses generated by laser irradiations. To correctly characterize the silica glass cracking mechanisms, a new fracture model was proposed in this work. Finally, all these developments were used to simulate the Laser Shock Processing (LSP) on silica glass. Relatively good results were obtained, compared with theoretical and experimental observations reported in the literature.
Current situation: Mohamed JEBAHI is currently occupying a post-doctoral position at Université Laval (Canada). He is working on "Discrete-continuum modeling of integrated materials and processes for design and process optimization of an aircraft landing gear component."

for all inclusions under ***CSMA***
please contact:
Francisco Chinesta
francisco.chinesta@ec-nantes.fr

CSMA selected PhD thesis for the ECCOMAS Olympiads 2014

Luc LAURENT, Mohamed JEBAHI and Jérémy LEBON were selected to represent CSMA at the ECCOMAS Olympiads 2014.

Luc LAURENT
PhD title: ***Multilevel optimisation of structures using a multiparametric strategy and metamodels***
Laboratory: ***LMT Cachan (ENS-Cachan/CNRS)***
Supervisors: ***Profs. Pierre-Alain Boucard & Bruno Soulier***
Optimisation strategies on assembly design are often relatively time expensive because of the large number of non-linear calculations (due to contact or friction problems) required to localize the optimum of an objective function. In order to achieve this kind of optimization problems with an acceptable computational time, this work propose to use a two-level model optimization strategy based on two main tools: (1) the multiparametric strategy based on the LaTIn method that enables to reduce significantly the computational time for solving many similar mechanical assembly problems and (2) a cokriging metamodel built using responses and gradients computed by the mechanical solver on few sets of design parameters. The metamodel provides very inexpensive approximate responses of the objective function and it enables to achieve a global optimisation and to obtain the global optimum. The cokriging metamodel was reviewed in detail using analytical test functions and some mechanical benchmarks. The quality of the approximation and the building cost were compared with classical kriging approaches. Moreover, a complete study of the multiparametric strategy was proposed using many mechanical benchmarks including many kinds and numbers of design parameters. The performance in term of computational time of the whole optimisation process was illustrated.
Current situation: Luc Laurent has first occupied during 7 months a post-doctoral position at the Institut für Kontinuumsmechanik (Leibniz Universität Hannover) where he worked on the use of Virtual Element Method for nonlinear problems (contact, large deformations). Since September 2014, he has joined the « Laboratoire de Mécanique des Structures et des Systèmes Couplés» at CNAM as an assistant professor. His activities are related to optimisation problems under nonlinear dynamics context.

Jérémy LEBON
PhD title: ***Towards multifidelity uncertainty quantification for multiobjective structural design.***
Laboratory: ***Roberval (UTC/CNRS) & BATir (Université Libre de Bruxelles)***
Supervisors: ***Profs. Piotr Breitkopf & Rajan Filomeno Coelho***
This thesis aims at Multi-Objective Optimization under Uncertainty in structural design. We investigate Polynomial Chaos Expansion (PCE) surrogates which require extensive training sets. We then face two issues: high computational costs of an individual Finite Element simulation and its limited precision. From numerical point of view and in order to limit the computational expense of the PCE construction we particularly focus on sparse PCE schemes. We also develop a custom Latin Hypercube Sampling scheme taking into account the finite precision of the simulation. From the modeling point of view, we propose a multifidelity approach involving a hierarchy of models ranging from full scale simulations through reduced order physics up to response surfaces. Finally, we investigate multiobjective optimization of structures under uncertainty. We extend the PCE model of design objectives by taking into account the design variables. We illustrate our work with examples in sheet metal forming and optimal design of truss structures.
Current situation: Jérémy Lebon is working as a design and developer engineer for C-S (Communications - Systèmes, SSII). He is currently working on a project for CEA Saclay – Laboratoire LM2S on the development of dedicated applications for forth generation nuclear powerplant.

Annual Conference

The 19th JSCES's Annual Conference on Computational Engineering and Science, chaired by Prof. H. Okada (Tokyo University of Science), was held during June 11-13, 2014, at International Conference Center Hiroshima. The conference was co-supported by Hiroshima University. The number of participants was 486 including 121 students. Presentations and fruitful discussions were exchanged in 32 organized sessions associated with a plenary lecture, a special lecture by Mazda Co., a special event for young engineers, graphic awards and special symposia.

The plenary lecture entitled "Multiscale Modeling and Simulation of Materials: The Archetype-Genome Exemplar" was given by Professor Wing Kam Liu of Northwestern University, USA. His lecture covered from fundamental theories to recent applications of multiscale simulation, which has recently become one of the main research areas in computational mechanics. Prof. Liu also received "The JSCES Grand Prize 2014", for his outstanding contributions in the field of computational engineering and sciences, at the following ceremony *(Figure 1).*

Figure 1:
Prof. Wing Kam Liu receiving the JSCES Grand Prize from Prof. Kazuo Kashiyama, the president of JSCES

A special lecture entitled "Model Based Development in Mazda" was given by Mr. Tomoshi Fujikawa of Mazda Co., a leading car company that represents Hiroshima. He emphasized the importance and contribution of computational engineering in the SKYACTIV technology which went public in 2012. His lecture inspired the attendees by demonstrating actual application cases of computational models in designing process of automobiles *(Figure 2).*

Six lunch-on seminars altogether were held during every lunchtime by the sponsoring software venders and distributers. Each room was fully packed with attendees who were interested in software development and applications. Many live discussions were exchanged *(Figure 3).*

A special event for young engineers, "Course Lectures for Creating Future Vision of Young Scientists and Engineers in the Ph.D Increase Program", which aimed at motivating students to take Ph.D in the area of computational engineering and science, was held at lunchtime of the third day. The former presidents of the JSCES, Prof. Norio Takeuchi (Hosei U) and Dr. Koichi Ohtomi (Toshiba Co.) served as panelists, and introduced their experiences and thoughts they carried in early days. Their talks were worth following not only for students, but for young researchers who are about to set out in a long career.

Figure 2:
Special lecture given by Mr. Tomoshi Fujikawa of Mazda Co.

The conference banquet was held in one of the rooms of the International Conference Center, and the participants had privileges to welcome the governor of Hiroshima Prefecture, Mr. Hidehiko Yuzaki, who was invited as a special guest. He made a wonderful speech with a touch of humor, presenting various sightseeing spots and specialties of Hiroshima *(Figure 4).* ●

Figure 3:
Lunch-on seminars provided by sponsoring software venders and distributers

Figure 4:
Steering committee members and directors gathered around the governor of Hiroshima Prefecture, Mr. Hidehiko Yuzaki (at the middle), who arrived at the banquet as a special guest

Summer Camp for Students

"The summer camp for students 2014" was held during September 20-21, 2014, at a seminar facility located in Mt. Tsukuba. This camp first started in 2013, hosted by the JSCES. The main objective of this camp is mutual-encouragement of graduate students of different universities who study in the field of computational mechanics.

Figure 5:
Attendees during one of the lectures

This year, 37 students from various universities and 12 members of the society got together and held a lecture meeting at a beautiful location surrounded by nature *(Figure 5).* Four members of the society, Mr. T. Saruwatari (JSOL Co.), Prof. M. Kurumatani (Ibaraki U), Prof. T. Matsuda (U Tsukuba) & Dr. K. Sato (Mazda Co.), gave keynote lectures, presenting their research field and personal background as researchers.

Figure 6:
Get-together barbeque event after the lecture meeting

Pre-volunteered students also presented their ongoing research outcomes, and best presentation awards were given to two students out of all the delegates. All the participants from students to society members exchanged their ideas in the get-together barbeque after the lecture *(Figure 6, Figure 7).* ●

Figure 7:
Participants of the JSCES summer camp held at Mt. Tsukuba

Other Upcoming Events

The JSCES will hold the **3rd Germany-Japan (GJ) Joint Workshop on Computational Engineering** under the joint sponsorship with the GACM (German Association for Computational Mechanics) in Munich, during March 30-31, 2015. Also, the **7th Korea-Japan (KJ) Joint Workshop on Computational Engineering** is planned to be held with the Computational Structural Engineering Institute of Korea (COSEIK) in Pusan, on April 10, 2015. Both these joint workshops are ranked as very important meetings between the two societies.

The **JSCES will be celebrating the 20th anniversary in 2015**. As one of the events celebrating the anniversary, the JSCES will hold the **3rd International Workshops on Advances in Computational Mechanics (IWACOM-III)** at Ryogoku, Tokyo, during October 12-14, 2015. Ryogoku is famous for the location of many Sumo-beya (Sumo wrestler's training room) and Kokugikan. Although the presenters are all invited through selection, general participants are welcome to join the workshops. ●

Prof. Tadahiko Kawai

Prof. Tadahiko Kawai passed away in Tokyo (Japan) on October 31, 2014.
He was the founder and the first president of the JSCES. We express our deep and sincere condolences to his family.

His achievements and contributions to computational mechanics societies will be presented in the next edition of IACM Expressions. ●

JAPAN ASSOCIATION FOR COMPUTATIONAL MECHANICS

The JACM is a union of researchers and engineers working in the field of computational mechanics mainly in Japan. JACM is a loosely coupled umbrella organization covering 26 computational mechanics related societies in Japan through communication with e-mail and web page (http://www.sim.gsic.titech.ac.jp/jacm/index-e.html). The number of individual members is about 300. The members of JACM organized 15 min-symposia at APCOM & ISCM 2013 held in Singapore in December 2013, and 10 mini-symposia at WCCM XI – ECCM V – ECFD VI held in Barcelona, Spain in July 2014. The JACM also co-organized COMPSAFE 2014 held in Sendai, Japan in April 2014 together with JSCES and Tohoku Univ. IRIDeS.

In July 22nd, 2014, the 2014 JACM award ceremony was held at its annual meeting on the occasion of WCCM XI – ECCM V – ECFD VI. At the annual meeting, the JACM members discussed the current state of JACM and future plans *(Figures 1 & 2)*. The 2014 JACM award winners are listed below *(Figures 3 - 10).*

Figure 1:
Professor S. Yoshimura (President of JACM) discussing about the present status of JACM

Figure 2:
The attendees of the 2014 annual meeting of JACM

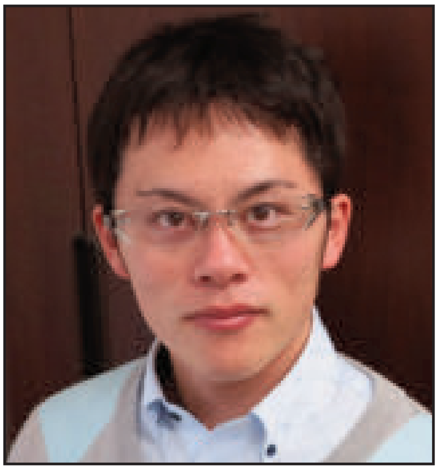
Figures 3 - 5:
The JACM 2014 Computational Mechanics Award winners:
Professors K. Hashiguchi - Kyushu Univ. (left), T. J. R. Hughes - UT Austin (center), T. Yamaguchi - Tohoku Univ. (right)



For all inclusions under
***JACM** news please contact:*
Shinobu Yoshimura
jacm-jim@save.sys.t.u-tokyo.ac.jp

***Figures 6 - 7:** right*
The JACM 2014 Fellows Award winners: Professors M. Ohsaki - Hiroshima Univ. (left), M. Yamamoto - Tokyo Univ. Science (right)

***Figures 8 - 10:** below*
The JACM 2014 Young Investigators Award winners: Professors S. Ii - Osaka Univ. (left), S. Tanaka - Hiroshima Univ. (center), T. Yamada - Kyoto Univ. (right)



In October 2-3rd, 2014, a JACM supported event, the 5th International Industrial Supercomputing Workshop (IISW2014) (http://www.toyo.ac.jp/site/ccmr/iisw2014.html) organized by Center for Computational Mechanics Research (CCMR) of Toyo University was held at Toyo University in Tokyo. Its main organizers are Professors R. Shioya - Toyo Univ. (Chair), H. Kawai - Tokyo Univ. Science, Suwa (Secretary General), T. Tamura and Y. Nakabayashi - Toyo Univ. and M. Ogino - Nagoya Univ.. The main participants are researchers who are in charge of industrial applications of supercomputer in world's supercomputer centers, including BSC (Spain), HLRS (Germany), SURFsara (Netherlands), NCSA (USA), OSC (USA), KISTI (South Korea), JAMSTEC ESC, JAXA JEDI, RIKEN AICS, TokyoTech GSIC, UTokyo ITC.

Figure 11:
Snapshot photo at the reception of IISW2014 on October 2nd, 2014

The participants discussed policy / strategic plans, success stories, and technical issues related to industrial supercomputing. Some Japanese participants presented Japanese general purpose parallel simulation software such as FrontFlow/red, FrontISTR, and ADVENTURECluster with industrial applications.
The 6th Workshop will be held in USA next year. ●

ENIEF 2014

XXI Congress on Numerical Methods and their Applications
Bariloche, Argentina, 23 - 26 September 2014

The XXI Congress on Numerical Methods and their Applications (ENIEF 2014) took place from September 23th to September 26th, 2014 in the city of Bariloche, Argentina. It was organized by the Department of Computational Mechanics of the National Comission of Atomic Energy, the Balseiro Institute and the Bariloche Atomic Center.

The organizing committee was chaired by Mariano Cantero, and integrated by Claudio Padra, Enzo Dari, Pablo Argañaras, Daniela Arnica, Graciela Bertolino, Florencia Cantargi, Matías Farías, Pablo García Martinez, Alejandra González, Gabriel Paissan, Fernando Quintana, Roberto Saliba, Natalia Salva, Mario Scheble, Nicolas Silin, Federico Teruel and Eduardo Villarino.

The Congress counted with invited lectures: S. Balachandar (Institute for Computational Engineering, University of Florida, USA), Alberto Cardona (CIMEC, UNL-CONICET, Argentina), Ramón Codina (CIMNE, UPC, España), Ricardo G. Durán (UBA, Argentina), Leo Gonzalez (U. Politécnica Madrid, España), Adrian Lew (Stanford University, USA), Norberto Nigro (CIMEC, UNL-CONICET, Argentina), Rizwan Uddin (University of Illinois at Urbana-Champaign, USA), Rodolfo Rodriguez (Universidad de Concepción, Chile) and Pablo D. Zavattieri (Purdue University, USA).

Figure 1: ENIEF 2014 opening ceremony

AMCA Awards 2014

The ceremony of the AMCA Awards 2014 took place during the Congress Banquet of ENIEF 2014

The award for Young Researchers was granted to Mariano Cantero, from National Comission of Atomic Energy and CONICET, Argentina. The award for Scientific, Professional and Teaching Career was for Luis A. Godoy, from the National University of Córdoba, Argentina. The award to the International Scientific Career was for Thomas J. R. Hughes, from the University of Texas at Austin, USA (he will receives the award during the next PANACM-2015). ●

Figure 2: AMCA Award 2014 for Young Resercher: Mariano Cantero

Figure 3: AMCA Award 2014 for Scientific, Professional & Teaching Career: Luis Godoy

*for all inclusions under **AMCA** please contact:*
Victorio Sonzogni
sonzogni@intec.unl.edu.ar
http://www.amcaonline.org.ar

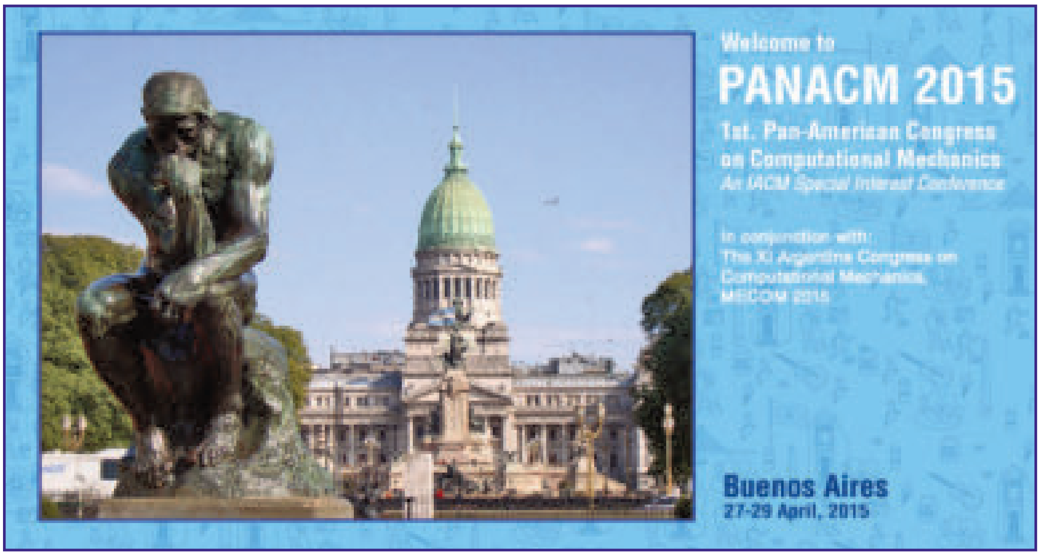
275 persons attended the Congress. Full length papers were submitted to a review process prior to publication. From them, 336 papers were accepted and published in the proceedings which are publicly available at the website:
http://www.amcaonline.org.ar/mcamca

A special session, in honor of Dr. Fernando Basombrío took place. Dr. F. Basombrío is one of the pioneers of computational mechanics in Argentina and one of the founders of AMCA. The First ENIEF was organized by Basombrío in Bariloche in 1983.

A special session was devoted to graduate and undergraduate students, with awards for the best posters. Within the Graduate Students, the awards were for: Jorge S. Salinas, Paola A. Córdoba Estrada, Carlos J. Ruestes and F. T. Borghi. The awards for Undergraduate Students were for: Pablo J. Vilar, Miguel A. Aguirre, Diego Aguilera and Ana Carolina Heidenreich and Sabrina Nava.

ENIEF 2014 give frame also to other activities: a course on OpenFOAM and a meeting of OpenFOAM users; a course on Serpent; a workshop on Neutron Calculation Codes: Capabilities and Perspectives; the ceremony of AMCA Awards 2014; and the AMCA Assembly. ●

Figure 4:
Participants ENIEF 2014



Next rendez vous...

First Pan-American Congress on Computational Mechanics
PANACM 2015
and
XI Argentine Congress on Computational Mechanics
MECOM 2015

27 - 29 April 2015
Buenos Aires, Argentina

http://congress.cimne.com/PANACM2015

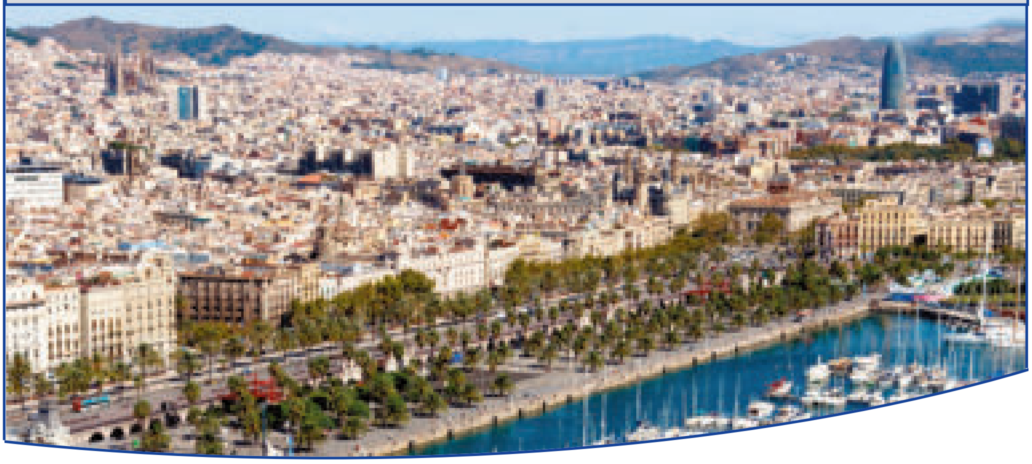
World Congress on Computational Mechanics **(WCCM XI)**

20 – 25 July 2014 - Barcelona, Spain

5th European Conference on Computational Mechanics **(ECCM V)**

6th European Conference on Computational Fluid Dynamics **(ECFD VI)**

www.wccm.eccm.ecfd2014.org



On July 20 – 25, 2014 the 11th World Congress on Computational Mechanics of the IACM (WCCM XI) was jointly organized with the 5th European Conference on Computational Mechanics (ECCM V) and the 6th European Conference on Computational Fluid Dynamics (ECFD VI) of ECCOMAS in Barcelona, Spain.

The joint congress was organized by the Spanish Association of Numerical Methods (SEMNI), in the year of its 25th Anniversary, with the support of the International Center for Numerical Methods in Engineering (CIMNE).

Figure 1:
The organization team of the Congress: From left to right: Prof. Xavier Oliver (chairman of ECCM V, UPC), Prof. Eugenio Oñate (chairman of WCCM XI, CIMNE/UPC), Mrs. Cristina Forace (general manager of the conference, CIMNE) and Prof. Antonio Huerta (chairman of ECFD V, UPC)

The joint organization of the WCCM XI - ECCMV – ECFD VI aroused a big interest in the computational methods community. It was hosted at the Congress Complex constituted by the Hotel Rey Juan Carlos and the Palau de Congressos de Catalunya. Sixty three countries were represented by over 3600 participants. This has been, so far, the largest congress in the computational methods history.

The congress was a forum to communicate and share new ideas and methods that will foster the development in computational methods and their applications in mechanics, engineering and applied sciences. The congress also gave participants the opportunity to visit Barcelona, one of the most appealing and interesting cities in the south of Europe, always open to multicultural events and innovation.

Figure 2:
Participants during a coffee-break

Figure 3:
Opening Session at the main Auditorium hall

Scientific Program

The cooperation of the Scientific Committees members and Minisymposia Organizers, and the enthusiasm of researchers from all over the world, resulted in a high level scientific program.

The quality of the scientific program was highlighted by the **Invited Lectures** given by the following scientists of international prestige in the fields of the congress.

Figure 4:
Opening session head table, from left to right:
X. Oliver, A. Huerta, G. Yagawa, A. Mas Colel (Minister of Economy and Knowledge of Catalonian Government and President of CIMNE), E. Ramm, S. Olivella and E. Oñate

Opening Session: J. Tinsley Oden (USA)

Plenary Lecturers: Rémi Abgrall (France), Patrick Le Tallec (France), Shigeru Obayashi (Japan), Michael Ortiz (USA), Jaume Peraire (USA) and Kenjiro Terada (Japan).

Semi-plenary Lecturers: Marino Arroyo (Spain), Santiago Badia (Spain), Manfred Bischoff (Germany), Javier Bonet (UK), Tadeusz Burczynski (Poland), J. S. Chen (USA), Francisco Chinesta (France), Bernardo Cockburn (USA), Elías Cueto (Spain), Leszek Demkowicz (USA), Pedro Díez (Spain), Alberto Figueroa (UK), Jacob Fish (USA), José Manuel García Aznar (Spain), Hector Gomez (Spain), Sergio R. Idelsohn (Argentina), Umberto Perego (Italy), Alessandro Reali (Italy), Bernhard Schrefler (Italy), Katsuyuki Suzuki (Japan), Harald van Brummelen (Netherlands), Peter Wriggers (Germany), Shinobu Yoshimura (Japan) and Yong Yuan (China).

Industrial Lecturer: Klaus Becker (Airbus, Germany)

Closing Session: Thomas J.R. Hughes (USA)

Figure 5:
From left to right:
Professors J. Tinsley Oden, Michael Ortiz, Rèmi Abgrall, Kenjiro Terada, Jaume Peraire, Patric Le Tallec, Shigeru Obayashi and Thomas J.R. Hughes addressing the opening, plenary and closing lectures

Young Investigators awardees were invited to present their scientific work in special semi-plenary sessions.

The ECCOMAS PhD Olympiads were also organized as a part of the congress. Young researches coming from different European associations presented the best PhD theses defended during 2013.

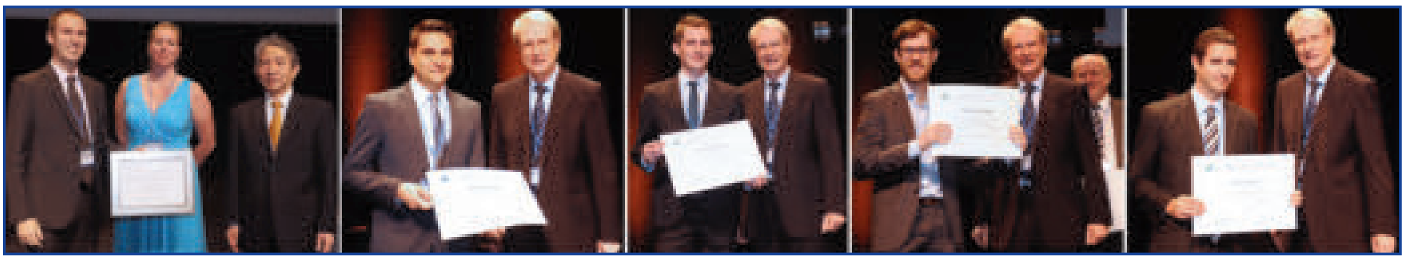


Figure 6:
From left to right:
IACM John Argyris Award for Young Investigators: ***Alessandro Reali****,*
J. L. Lions Award for Young Scientists in Computational Mathematics: ***Gianluigi Rozza****,*
ECCOMAS Award for the Best Ph.D Theses of 2013 on Computational Methods in Applied Sciences and Engineering: ***Henning Sauerland*** *and* ***Francesc Verdugo****,*
O. C. Zienkiewicz Award for Young Scientists in Computational Engineering Sciences: ***Julien Yvonnet***

Exhibition

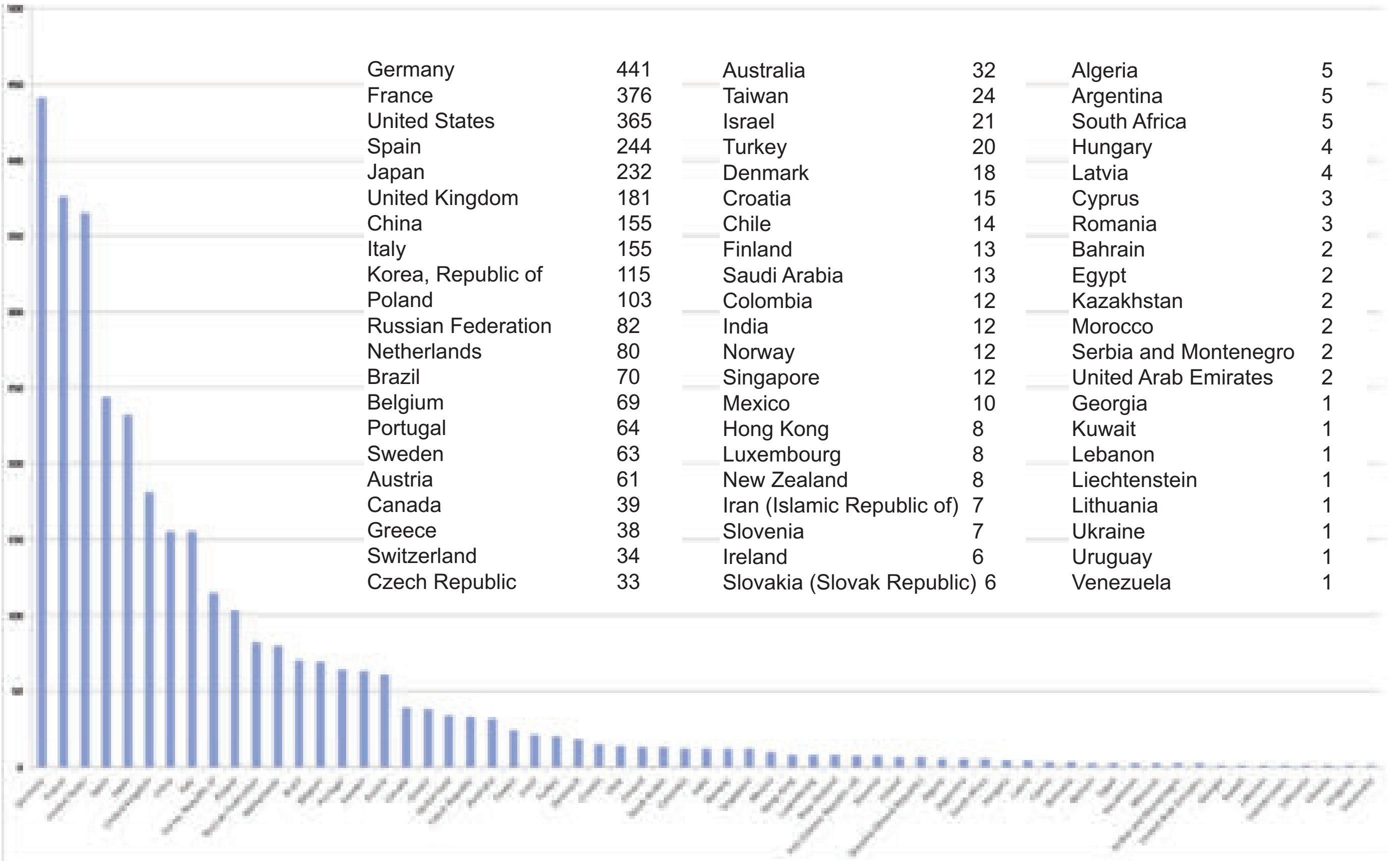
The technical program was complemented by an exhibition, strategically located at the center of the daily activities of the congress to facilitate the interaction of participants interested in viewing and discussing publications, software, hardware, and other materials related to computational mechanics.

Figure 7: *Exhibition at the WCCM-ECCM-ECFD 2014*

The Congress in Figures

As a response to the call for abstracts, 4142 contributions were received and went through the review process. In the end, the scientific program scheduled 3152 papers presented in 543 sessions (48 parallel rooms).

- Registered participants: 3636 from 63 countries
- Papers: Oral presentations: 3037 Poster presentations: 115
- Minisymposia: 218
- Contributed sessions: 26
- Maximum number of parallel sessions: 48



Germany	441	Australia	32	Algeria	5
France	376	Taiwan	24	Argentina	5
United States	365	Israel	21	South Africa	5
Spain	244	Turkey	20	Hungary	4
Japan	232	Denmark	18	Latvia	4
United Kingdom	181	Croatia	15	Cyprus	3
China	155	Chile	14	Romania	3
Italy	155	Finland	13	Bahrain	2
Korea, Republic of	115	Saudi Arabia	13	Egypt	2
Poland	103	Colombia	12	Kazakhstan	2
Russian Federation	82	India	12	Morocco	2
Netherlands	80	Norway	12	Serbia and Montenegro	2
Brazil	70	Singapore	12	United Arab Emirates	2
Belgium	69	Mexico	10	Georgia	1
Portugal	64	Hong Kong	8	Kuwait	1
Sweden	63	Luxembourg	8	Lebanon	1
Austria	61	New Zealand	8	Liechtenstein	1
Canada	39	Iran (Islamic Republic of)	7	Lithuania	1
Greece	38	Slovenia	7	Ukraine	1
Switzerland	34	Ireland	6	Uruguay	1
Czech Republic	33	Slovakia (Slovak Republic)	6	Venezuela	1

Female Researchers Meeting

Figure 8: *Miriam Mehl and Dörte C. Sternel, promoters of the meeting*

All female researchers (from junior to senior) of the WCCM-ECCM- ECFD 2014 were invited to a network meeting in the evening of Wednesday July 23. The meeting was promoted by Miriam Mehl and Dörte C. Sternel.

The meeting started with three short presentations on general and personal career paths given by Dörte C. Sternel (TU Darmstadt), Lois Curfmann McInnes (Argonne National Lab) and Sabine Roller (Universität Siegen) followed by a reception with some snacks financed by the SPPEx Priority Program of the German Research Foundation. Among the participants there where a few established senior researchers but also a lot of very promising young researchers still figuring out whether to select an academic career.

Social Events

The Social Program included an ***Ice-breaking Reception*** in the evening of Sunday July 19 at the Palau de Congressos de Catalunya.

In the evening of Monday July 21, during the ***Welcome Reception***, participants were able to appreciate the magnificence of a Mediterranean style garden adjacent to the congress premises, and spent a nice evening with colleagues and friends while having a drink and a snack, accompanied by enjoyable live music, among native pines, palm trees and serene ponds in the heart of vibrant Barcelona.

Figure 9:
Welcome Reception at the Gardens of the Hotel Rey Juan Carlos

Appreciation Concert

Figure 10
"Barcelona 4 Guitars" playing during the concert

As a token of appreciation for their cooperation towards the success of the congress a number of participants involved in the scientific and organizational aspects of the event were invited to a Spanish Guitar Concert held in the evening of Tuesday July 22nd at the "Palau de la Música Catalana".

Figure 11:
Concert Hall at the "Palau de la Música Catalana"

The Palau is an architectural jewel of Catalan Art Nouveau, the only concert venue in this style to be listed as a World Heritage Site by UNESCO, which today represents an essential landmark in the cultural and social life of Catalonia.

Congress Banquet

The congress banquet, on Thursday July 24, gathered 2200 people at the International Convention Center of Barcelona (CCIB). The CCIB is unique in Europe for the impact and originality of its architecture, for the versatility of its column-free meeting halls and spaces and for the superb use it makes of the warm, natural Mediterranean light.

Figure 12:
Spot shoots of the banquet in the CCIB

Awards

Both IACM and ECCOMAS delivered their awards for 2014, most of them during the opening ceremony of the congress.

The following IACM Awards were delivered by the then still president of IACM, Prof. Genki Yagawa (Prof. Wing-Kam Liu was elected new president of IACM just a few days later):

* IACM Congress Medal (Gauss-Newton Medal): ***Charbel Farhat***
* IACM Award: ***J.N. Reddy***
* IACM Computational Mechanics Award: ***Leszek Demkowicz***
* IACM John Argyris Award for Young Investigators: ***Alessandro Real***i
* IACM Fellow Award: ***Marek Behr, John Dolbow, Paulo Pimenta, Kumar K. Tamma, Kenjiro Terada, Shinobu Yoshimura***.

Figure 13:
IACM Gauss-Newton Medal Award to Ch. Farhat

Figure 14:
IACM Award to J.N. Reddy

Figure 15:
IACM Computational Mechanics Award to L. Demkowicz

The president of ECCOMAS, Prof. Ekkehard Ramm, delivered the following Awards:

* Euler Medal: ***Franco Brezzi***
* O. C. Zienkiewicz Award for Young Scientists in Computational Engineering Sciences: ***Julien Yvonnet***
* J. L. Lions Award for Young Scientists in Computational Mathematics: ***Gianluigi Rozza***
* ECCOMAS Award for the Best Ph.D Theses of 2013 on Computational Methods in Applied Sciences and Engineering: ***Henning Sauerland*** and ***Francesc Verdug***o.
* During the closing ceremony ECCOMAS also delivered an award to Two Best PhD Olympiad Oral Presentations: ***Debora Clever*** and ***Evangelos Papoutsis-Kiachagias.***

Figure 17:
IACM and ECCOMAS Awardees during the Opening Ceremony of the congress

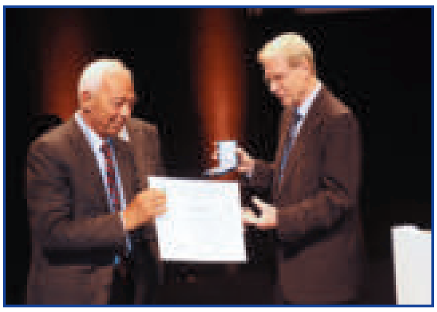


Figure 16:
ECCOMAS Euler Medal Award to Franco Brezzi


KSCM
WCCM XII
World Congress on
Computational Mechanics
Seoul, Korea
24-29 July 2016
APCOM VI
Asia-Pacific Congress on
Computational Mechanics


KSCM
WCCM XII & APCOM VI
Date: 24-29 July, 2016
Venue: COEX, Gangnam, Seoul
Organizer: Korean Society for computational Mechanics (KSCM)

conference diary planner

2 - 5 March 2015	**Continuous Media with Microstructure**
	Venue: Lagow Poland *Contact:* www.cmwm.put.poznan.pl
16 - 18 March 2015	**FEF 2015: 18th International Conference on Finite Elements in Flow Problems**
	Venue: Taipei, Taiwan *Contact:* http://fef2015.tw/
26 - 27 March 2015	**SYMCOMP 2015 - 2nd Int.Conf. Numerical '& Symbolic Computation Developments & Applications**
	Venue: Algarve, Portugal *Contact:* http://symcomp.net/index.htm
27 - 29 April 2015	**PANACM-2015: Pan-American Congress on Computational Mechanics**
	Venue: Buenos Aires, Argentina *Contact:* http://congress.cimne.com/PANACM2015
18 - 20 May 2015	**COUPLED PROBLEMS 2015: VI Int. Conf. on Coupled Problems in Science and Engineering**
	Venue: Venice, Italy *Contact:* coupledproblems@cimne.upc.edu
27 - 29 May 2015	**4th International Congress on Material Modeling**
	Venue: Berkeley, California *Contact:* http://icmm4.usacm.org/
1-3 June 2015	**IGA 2015 - III International Conference on Isogeometric Analysis**
	Venue: Trondheim, Norway *Contact:* http://congress.cimne.com/iga2015/
7- 10 June 2015	**ADMOS 2015 - International Conference on Adaptive Modeling and Simulation**
	Venue: Nantes, France *Contact:* http://congress.cimne.com/admos2015/
7 - 12 June 2015	**WCSMO-11: World Congress of Structural and Multidisciplinary Optimization**
	Venue: Sydney, Australia *Contact:* http://www.aeromech.usyd.edu.au/WCSMO2015/
15 - 17 June 2015	**MARINE 2015: VI International Conference on Computational Methods in Marine Engineering**
	Venue: Rome, Italy *Contact:* marine@cimne.upc.edu
29 June - 1 July 2015	**4th International Conference on Computational & Mathematical Biomedical Engineering**
	Venue: Cachan, France *Contact:* http://www.compbiomed.net/2015/
29 June - 2 July 2015	**ECCOMAS Thematic Conference on Multibody Dynamics**
	Venue: Barcelona, Spain *Contact:* http://congress.cimne.com/multibody2015/
29 June - 2 July 2015	**CMN2015 : Congresso de Métodos Numéricos em Engenharia1**
	Venue: Lisbon, Portugal *Contact:* http://www.dem.ist.utl.pt/cmn2015/
13 - 15 July 2015	**FEM/MESHLESS 2015 : Finite Elements and Meshless Methods for Science and Engineering**
	Venue: Porto, Portugal *Contact:* https://sites.google.com/site/femmeshless2015/
20 - 23 July 2015	**6th GACM Colloquium and 3rd ECCOMAS Young Investigator Conference**
	Venue: Aachen, Germany *Contact:* http://www.gacm.de/index.php?id=21
26 - 30 July 2015	**USNCCM13: U.S. National Congress on Computational Mechanics**
	Venue: San Diego, CA *Contact:* http://13.usnccm.org/
1 - 3 Sept 2015	**COMPLAS XIII: International Conference on Computational Plasticity**
	Venue: Barcelona, Spain *Contact:* complas@cimne.upc.edu
8 - 11 Sept 2015	**CMM: 21st International Conference on Computer Methods in Mechanics**
	Venue: Gdańsk, Poland *Contact:* http://www.pcm-cmm-2015.pg.gda.pl/
9 - 11 Sept 2015	**X–DMS 2015: eXtended Discretization Methods**
	Venue: Ferrara, Italy *Contact:* http://x-dms2015.sciencesconf.org/
14 - 16 Sept 2015	**ICCB´2015: Sixth International Conference on Computational Bioengineering**
	Venue: Barcelona, Spain *Contact:* iccb2015@cimne.upc.edu
28 - 30 Sept 2015	**PARTICLES 2015: IV International Conference on Particle-based Methods**
	Venue: Barcelona, Spain *Contact:* particle-basedmethods@cimne.upc.edu
29 Sept - 2 Oct 2015	**ICCSM 2015 8th International Congress of the Croatian Society of Mechanics**
	Venue: Opatija, Croatia *Contact:* http://www.ceacm.org/
19 - 21 Oct 2015	**STRUCTURAL MEMBRANES 2015: VII Int. Conf. on Textile Composites & Inflatable Structures**
	Venue: Barcelona, Spain *Contact:* membranes@cimne.upc.edu
4 - 6 Nov 2015	**3rd Workshop Reduced Basis, POD or PGD-Based Model Reduction Techniques**
	Venue: Cachan, France *Contact:* http://www.iacm.info
24 - 29 July 2016	**APCOM 2016: 6th Asia Pacific Congress on Computational Mechanics**
	Venue: Seoul, Korea *Contact:* http://apacm-association.org
24 - 29 July 2016	**WCCM XII: World Congress on Computational Mechanics**
	Venue: Seoul, Korea *Contact:* http://kscm-society.org
21 - 26 Aug 2016	**24th International Congress of Theoretical and Applied Mechanics**
	Venue: Montreal, Canada *Contact:* http://www.ictam2016.org/