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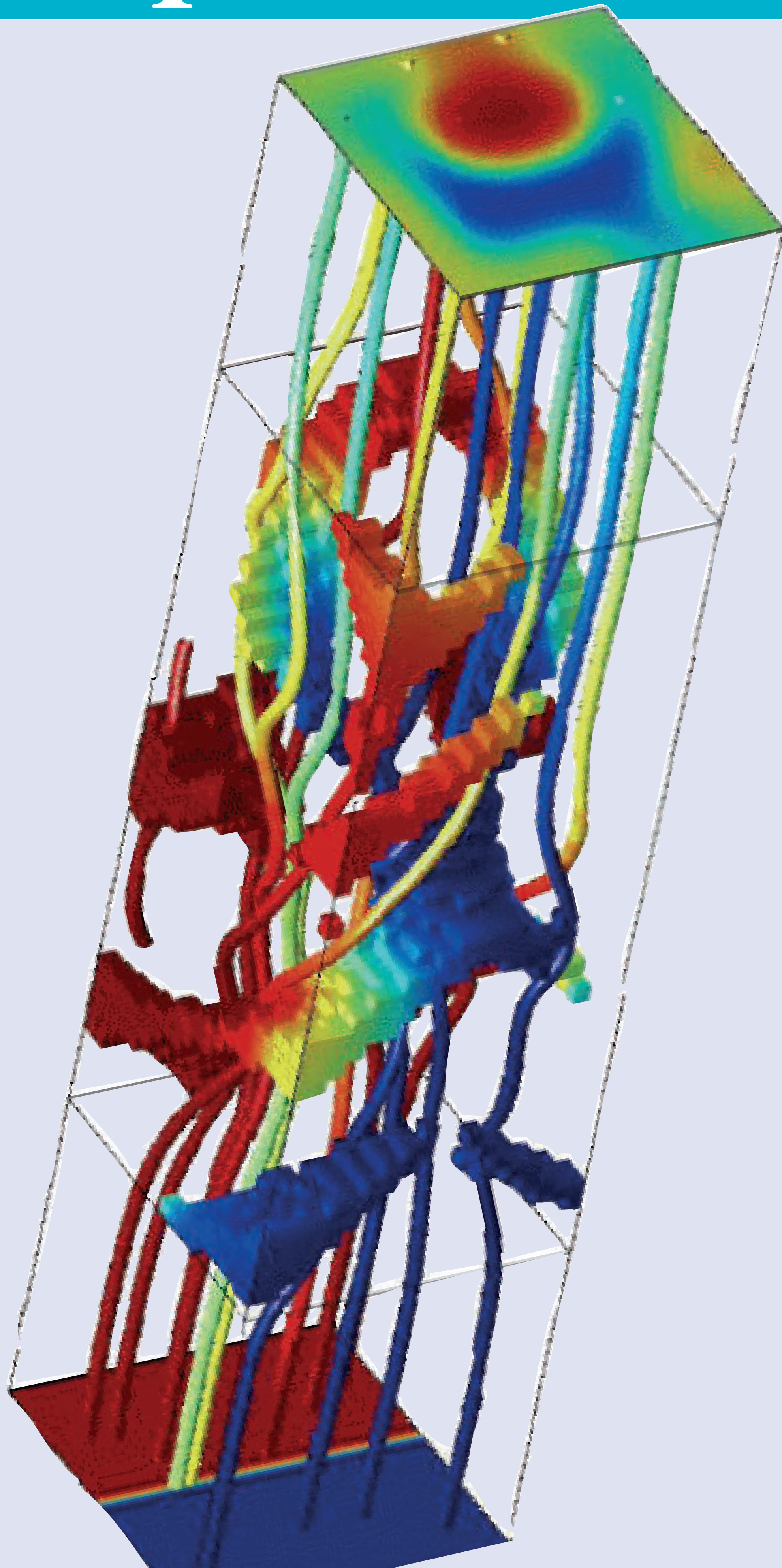

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editorial

This issue of IACM Expressions will come to light coinciding with the celebration of the joint WCCM/ECCOMAS congress to be held in Venice from June 30th to July 4th 2008. The congress merges the 7th edition of the World Congress on Computational Mechanics of the IACM and the 5th European Congress on Computational Methods in Applied Sciences and Engineering of ECCOMAS, the European organization that groups all the IACM affiliated associations in Europe. The success of this joint venture is clearly shown by the number of close to 3000 participants, a landmark in the history of past IACM and ECCOMAS congresses. Some 170 Minisimposia have been organised by leading experts in topics covering most disciplines in computational science and engineering, ranging from fundamental and emerging areas in computational mechanics, such as nano-mechanics and material modelling, to innovative industrial applications in aeronautics, forming processes, civil engineering and bio-medical engineering, among many others. I want to take this opportunity to thank the congress organisers Profs. Bernard Schrefler and Umberto Perego and their teams at Universities of Padua and Milan for an excellent and outstanding work.

Certainly the idea to merge the World Congress of Computational Mechanics of the IACM with congresses in the same field held in different regions of the world enlarges the scope and impact of the joint congress. This model was successfully implemented for the first time in Beijing in 2004 where the 5th WCCM was merged with the Asian-Pacific Congress on Computational Mechanics (APCOM). Following the Venice venue the next joint WCCM/APCOM congress will be held in the city of Sydney in Australia on 19-23 July 2010. This will be an opportunity to gather the computational mechanics community from the Asian-Pacific region with colleagues from the rest of the world. Indeed beating the number of participants in Venice will be a challenge for future editions of WCCM. Our colleagues in Sydney, lead by Profs. S. Valliappan and M. Khalili, will be the first to try. Best of luck to WCCM/APCOM 2010!.

This activity shows that the health of the Computational Mechanics community is good. Perspectives for 2009 are equally optimistic as some 20 Thematic Conferences in the field of computational engineering and sciences will take place in Europe under the auspices of ECCOMAS. In addition many regional and national conferences in computational mechanics will be held in USA, Spain, Portugal, Germany, France, Nordic Countries in Europe, Argentina, Brazil, etc. Of particular interest is the 1st African Conference in Computational Mechanics to be held in Sun City, South Africa on 7-10 January 2009. I hope that this event will be followed by many others helping to develop the activities of IACM in Africa.

What's next?

Despite the success of IACM activity worldwide we should perhaps meditate on the relative impact and influence of computational mechanics on the key areas in science and technology and act consequently. The web give us a good hint. A quick browse over the number of entries in Google gives the following result: computer science, 68.5 millions; material science, 36 millions; CAD (computer aided design), 14.6 millions; nano technology, 12.7 millions; numerical methods, 7.3 millions; numerical methods in engineering, 3.1 millions and computational mechanics, 1.5 millions!. Numbers speak for themselves. The conclusion of this arguable exercise is that the IACM community should move forward with an instinct to increase its impact and influence in traditional and emerging areas in engineering and sciences. Indeed the size and scope of the Venice congress is a sign that we are moving in a good direction.

Best wishes for a successful WCCM/ECCOMAS 2008 congress.

Eugenio Oñate
President of IACM

HeMoLab: A Computational Framework for Patient-Specific Modeling of the Cardiovascular System

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"... the development of accurate computer models is crucial to attain a better understanding of the cardiovascular system under normal conditions and under conditions altered either by vascular reconstruction or by surgical procedures in general."

1. Introduction

Over the last few years, predictive computational tools have been introduced in medical practice as a result of joint research on areas of engineering, biology and medicine. The current state of development reached by techniques of computational modeling, together with the fast increase in the performance of computer hardware, has produced highly sophisticated models with acceptable levels of predictive capability. Computational modeling and simulation techniques, in conjunction with graphic visualization and virtual reality provide high-resolution three-dimensional images representing the phenomena occurring at specific parts of the human body.

It is worth mentioning that cardiovascular diseases (CVD) are and will continue to be the main cause of human death throughout the world including developing countries such as Brazil where the social impact of the CVD's becomes more relevant due to the fact that they are the main cause of early retirement on health grounds and the second reason for in-patient treatment admissions.

The important consequences of such diseases at the individual and social levels, together with the recognition that several CVD's are closely linked to hemodynamic factors, have motivated an increasing interest in the use of computational simulation techniques in order to gain better knowledge of the cardiovascular system. Thus, the development of accurate computer models is crucial to attain a better understanding of the cardiovascular system under normal conditions and under conditions altered either by vascular reconstruction or by surgical procedures in general.

This emerging technology, consisting of **modeling - computer simulation, software and hardware**, is contributing to the development of patient-specific models so that accurate analyses of the dynamics of the cardiovascular system can be carried out. It also allows the modeling of absorption, diffusion and transport phenomena to take place in arterial wall tissue and can be used in medical training, improvement of surgical techniques and several medical procedures planning as well. Such techniques allow, in addition, the characterization (in a non-invasive manner) of in- vivo properties of biological materials needed in the computational modeling.

However, the benefits that computational modeling could bring to vascular medicine depends on overcoming a number of barriers. The first challenge consists of the development of computational models with the required level of complexity to accurately represent hemodynamic aspects of the most relevant parts of the cardiovascular system. The second challenge stems from the need to develop computational tools capable of characterizing geometrical and mechanical properties of the system with information obtained from different medical image acquisition systems. The third challenge is the difficulty in setting appropriate boundary conditions in highly sophisticated models. Examples of this are: the determination of coupling equations in a 1D-3D model, the determination of appropriate coefficients for Windkessel type terminals that allow the modeling of the peripheral beds not included in the analysis or its substitution by arterial beds built with optimization methods. The fourth challenge is related to the approximation of such models which require the solution of systems of millions of non-linear equations at each time interval and must be coupled to techniques that allow the adaptive analysis of the problem so as to keep the analysis error within prescribed bounds. Finally, the sheer amount of data generated in such analyses requires the development of efficient tools for the storage and retrieval of clinically relevant information as well as for the visualization and real-time high resolution representations of easy interpretation by clinicians, surgeons and all involved in the assessment of the problem.

On the other hand, the development of models of this type and their use in computer simulations requires multi- disciplinary teams with high level of competence in their respective areas. For example, the computer simulation of the human cardiovascular system requires specialists in areas such as medicine, biology, chemistry, continuum mechanics, solid and fluid mechanics, variational methods, approximation methods (the Finite Element Method, for instance), high performance computing, adaptive methods, image processing and visualization, automatic mesh generation, among several others.

2. The HeMoLab Project

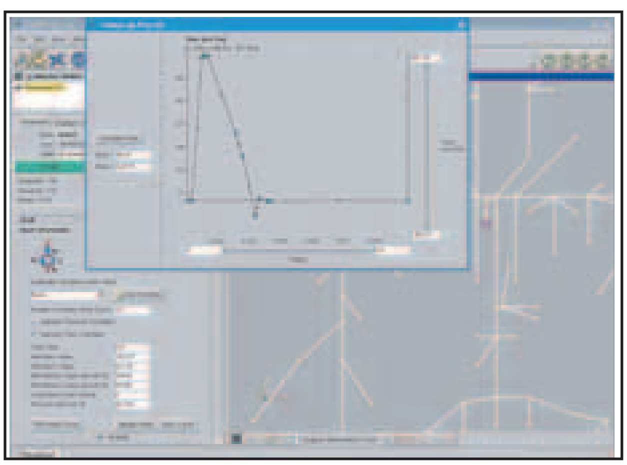
In order to attend the above paradigm, the HeMoLab Project was initiated in Brazil in 2005. The main objective of this project was the modeling and computational simulation of the cardiovascular system. The scientific and technological innovations generated within this project (HeMoLab System) will be transferred to the medical community in Brazil in the expectation that the patient-specific computational simulation of the cardiovascular system will contribute to the development of new, and more adequate, treatments to improve life quality by providing auxiliary tools for analysis.

The core of the HeMoLab Project is carried out within the National Laboratory for Scientific Computation (LNCC/MCT, Petrópolis, Brazil, www.lncc.br/prjhemo), and makes use of the computational infrastructure available there. The project is also involved in the development of human resources, and to this end it is closely connected with the LNCC's multidisciplinary pos-graduation program, from which several DSc. students are active participants. Several other cooperation agreements are part of this project with the following institutions: Instituto do Coração Edson Saad of the University Hospital Clementino Fraga Filho of the Federal University of Rio de Janeiro, Brazil; Instituto do Coração of the Clinical Hospital of the School of Medicine of the São Paulo Sate University, Brazil; National University of Mar del Plata, Argentina; Centro Atómico Bariloche, Argentina; National University of the Center of Buenos Aires, Argentina; Pompeu Fabra University, Spain and the Civil and Computational Engineering Centre of the Swansea University, UK.

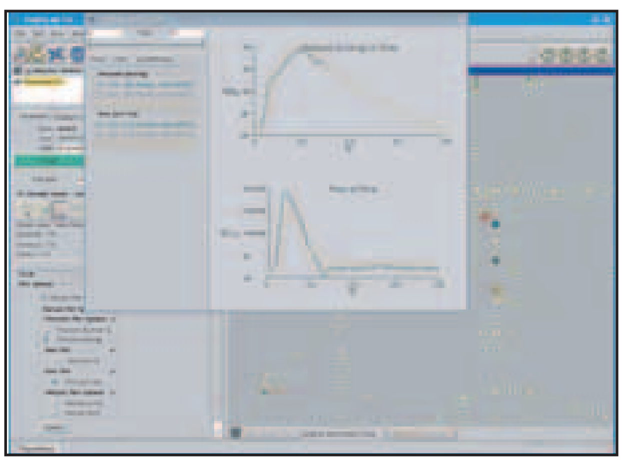
3. Development environment

The HeMoLab System is developed on top of the Paraview architecture [1], which is an open-source application based on the VTK library. The HeMoLab is developed in ANSI–C++ and exploits OpenGL rendering primitives. Paraview works with filters ordered as a pipeline pattern. This philosophy allows for easy user interactivity and facilitates the data processing in view of the automatism of the process. Paraview was also chosen because it supports distributed data processing/ rendering as well as its portability. Thus, the HeMoLab can be understood as a customization of the Paraview software that incorporates a series of filters in order to assemble a software oriented for patient-specific modeling of the cardiovascular system.

" ... a customization of the Paraview software that incorporates a series of filters in order to assemble a software oriented for patient-specific modeling of the cardiovascular system."



(a)



(b)

Figure 1

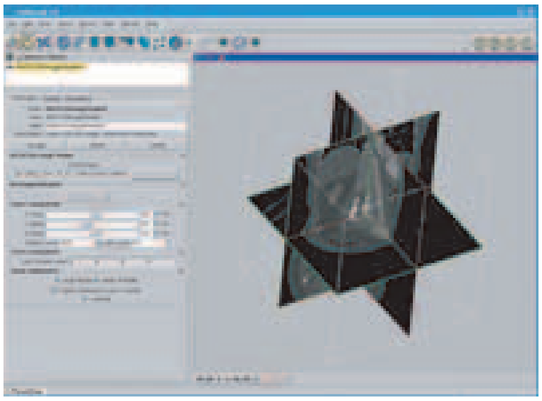


Figure 2

"... it is possible to handle in a totally arbitrary fashion the creation and edition of segments and terminals to give rise to the topology of the arterial system."

4. The HeMoLab framework

The HeMoLab software is prepared to deal, in an integrated manner, with several tasks arisen from the cardiovascular modeling.

These are:

i medical image processing including segmentation, geometry characterization and finite element mesh generation,

ii simplified blood flow simulation via 1D models,

iii complex blood flow simulation via 3D models,

iv coupled blood flow simulations via 3D-1D models and

v visualization: 1D and 3D data post-processing.

Within the HeMoLab there are five modules embedded that conveniently group the aforementioned tasks, and also an specific module that takes care of the numerical simulation, these are:

- 1D Model Module
- Image Processing Module
- 3D Model Module
- 3D-1D Coupling Module
- Visualization Module
- SolverGP Module

A brief explanation about the incumbencies of each component is given in what follows.

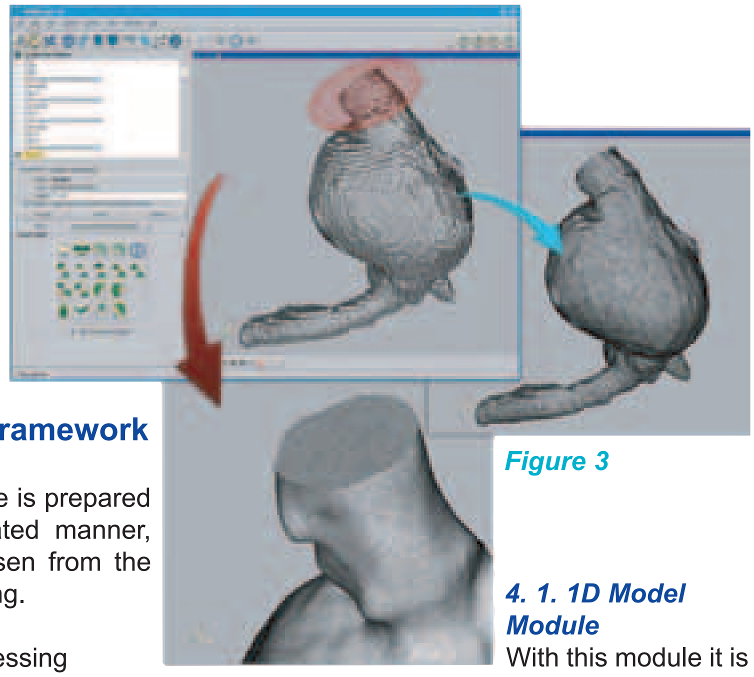


Figure 3

4. 1. 1D Model Module

With this module it is possible to handle in a totally arbitrary fashion the creation and edition of segments and terminals to give rise to the topology of the arterial system. Tools to alter geometrical and mechanical properties of the segments and elements or even to modify the data that characterize the peripheral beds are given. A parametrized curve to represent the heart inflow boundary condition is also available *(figure 1 (a))*. The last step before the simulation is the configuration of the parameters of the mathematical formulation. Also, the visualization of results coming from 1D simulations is comprised in this module, and it can be carried out simply by picking the points of interest over the segments *(figure 1 (b))*.

4. 2. Image Processing Module

The goal of this module is to segmentate a certain medical image (a set of DICOM images as in *figure 2*) in order to create an initial mesh that will be used by the 3D Model module. Proper readers are available to give support to several formats, and then numerous methodologies are implemented such as noise reduction,

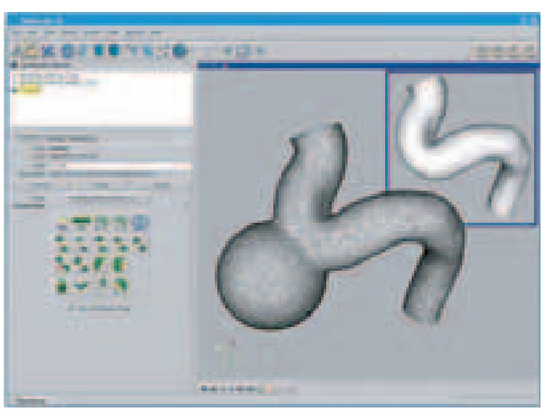


Figure 4 (a) (b)

smoothing and threshold filters among others. Finally, segmentation techniques using classical concepts and novel ones (such as the use of the topological derivative) are also implemented.

4. 3. 3D Model Module

This module is fed with an initial geometry coming from the Image Processing module. Thus, its main task is divided into two steps:

i the surface mesh generation and
ii the volume mesh generation.

The first step comprises several techniques to add and remove nodes and elements, and also to handle the different groups of elements in order to characterize properly the arterial wall and the inlets/outlets of the domain of analysis. Once the surface mesh is ready, a Delaunay method is used to mesh the volume. In the case of *figure 3* the final mesh has 728.200 nodes, 102.500 surface elements (triangles) and 4.235.800 volume elements (tetrahedra). The last step is to set boundary conditions to the inlets/outlets choosing between time-varying or stationary Dirichlet and/or Neumann boundary conditions. The wall must also be characterized through the geometrical and mechanical properties. It is also possible to develop models altered artificially by adding an anomaly in the geometry. In *figure 4(a)* it is shown an artificially created aneurysm, while in *figure 4(b)* the opposite situation, a stenosis, is simulated by removing part of the geometry.

4. 4. 3D-1D Coupling Module

With 1D and 3D models at hand, HeMoLab allows also their coupling in order to obtain a more complex model whose purpose is to get rid of boundary conditions over the 3D model (now the boundary conditions are the heart ejection and the peripheral impedance). Coupling multidimensional models is a relatively novel approach [2] that permits modeling a more wide range of physical situations such as the sensitivity of the cardiac pulse to the presence of a pathology, for instance aneurysms or stenoses, or even to assess how the blood flow changes in an arterial district when the cardiac rhythm is accelerated. The preparation of a coupled model involves three stages:

i the selection of a 1D model,
ii the selection of an arbitrary number of 3D models and
iii determining the relations between the points in the 1D model that have to be related to the inlets/outlets of the 3D districts.

Figure 5 shows how this task is done in a very interactive way selecting the corresponding objects (one point + one coupling surface) that perform the coupling. Finally, all the complementary configurations concerning the mathematical formulation have to be set before carrying out the simulation.

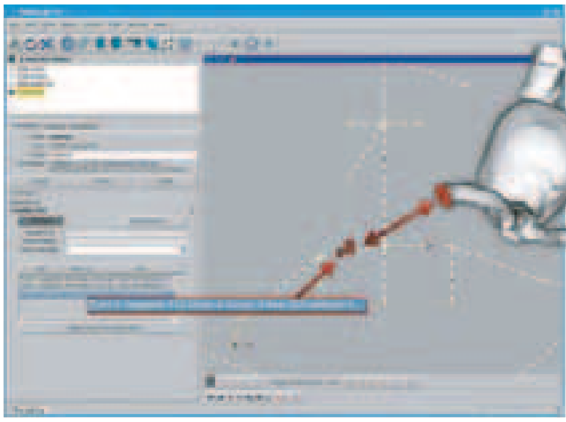


Figure 5

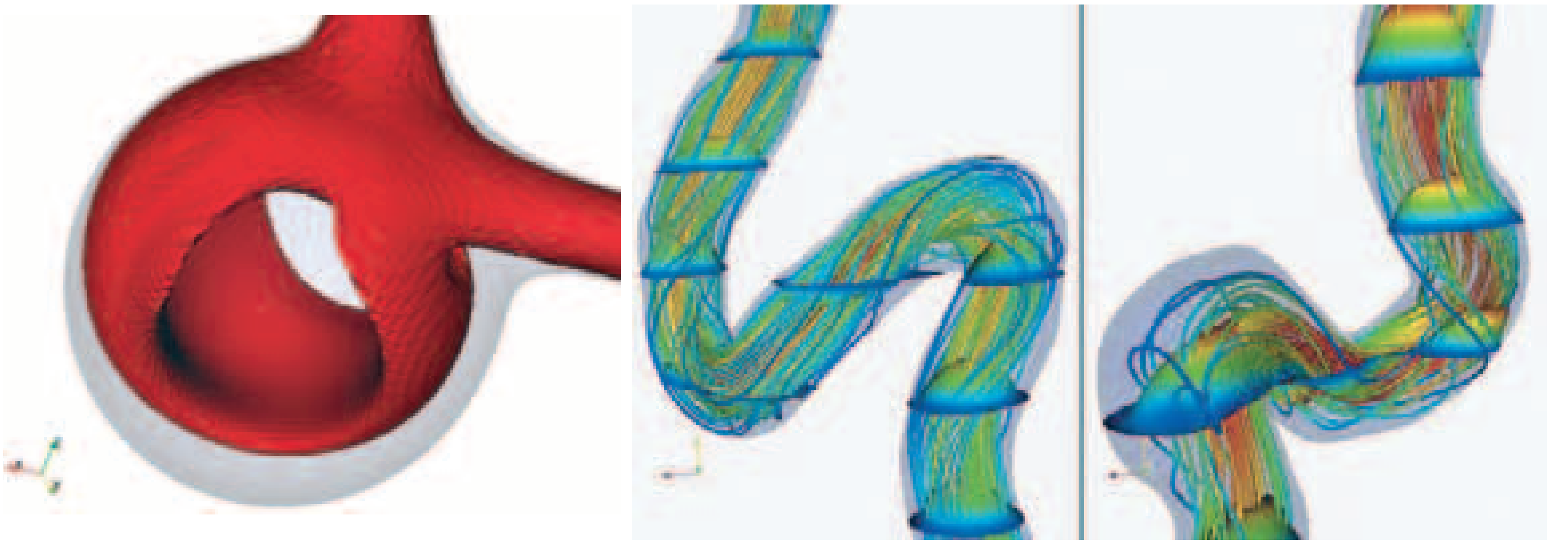


Figure 6 *(a)* *(b)*

4. 5. Visualization Module

This module makes use of the more common native Paraview filters to process, in this case, finite element data. Several classical filters are given such as glyph, iso-surface, streamline or calculator filters. *Figure 6(a)* presents the streamlines and iso-surface of blood flow in an aneurysm artificially introduced in the internal carotid artery, while *figure 6(b)* presents also the warping of the velocity field in the vertebral arteries. Since they are useful in hemodynamic simulations the OSI and WSS indexes can be computed and visualized as well, as shown in *figure 7*.

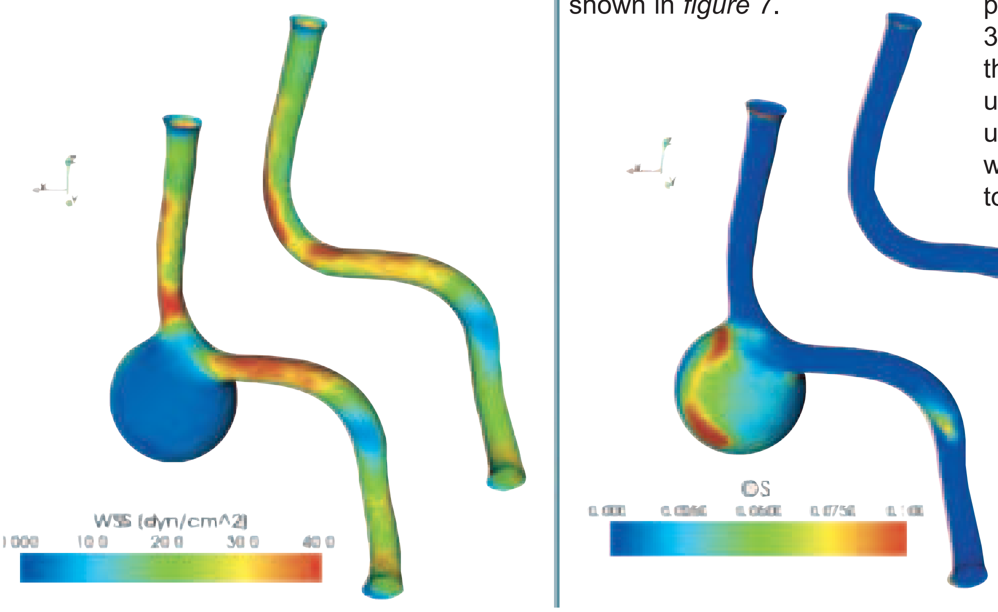


Figure 7

4.6 SolverGP

SolverGP is a general purpose numerical solver that allows in an efficient way the easy implementation of mathematical formulations such as FEM, FDM, FVM, or any other whose final form renders a linear system of equations. The HeMoLab environment includes writers in order to put the information in agreement with the input data files to be sent to the SolverGP module. Once the numerical simulation is finished the output is returned back to the HeMoLab so as to retrieve the data of interest from the simulation. SolverGP supports distributed computing via the PETSc library for the resolution of the final linear systems of equations.

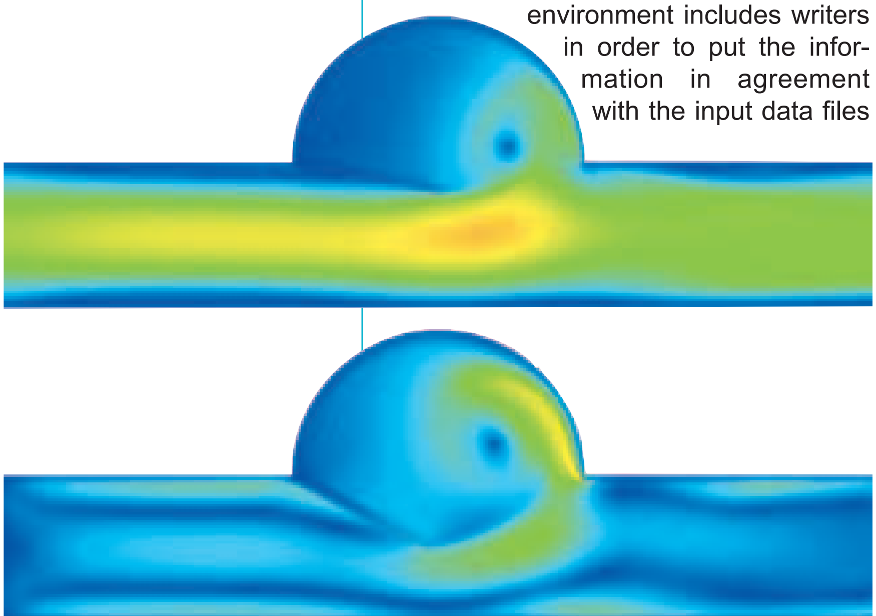


Figure 8

5. Available scenarios

The HeMoLab usage can be combined in several ways according to the interest of the final user. Three scenarios can be easily identified. For instance, it would be possible to perform classical standalone 3D or 1D numerical simulations, or even the image processing module could be used as a separate image analysis module. The richest scenario is the one in which the six modules are put to work together:

- i on one hand the medical images are segmentated and the finite element meshes are generated so as to create the 3D model (*figure 3*);
- ii On the other hand a 1D representation of the arterial network have to be set up independently (*figure 1*);
- iii the proper combination of both models yields a multidimensional coupled representation of the system (*figure 5*);
- iv the visualization module uses Paraview native filters to process the data and to give a convenient repre sentation of the obtained approximate solutions (*figures 6* and *7*).

6. Others research activities

Alongside with this project several others areas of research are being explored, always pursuing a final impact in the study of the cardiovascular system and the diseases related to it.

6. 1. Fluid-structure interaction

An interesting problem that also appears in cardiovascular modeling is the heart valve dynamics. A comprehensive study of this problem would allow for a better artificial valves planning and design. Moreover, due to the complex behavior of the valve, techniques such as immersed methods arise as appealing alternatives to solve the problem.
Preliminary results related to a bidimensional model of a rigid valve using immersed domains methods [3] can be seen in *figure 8* where the magnitude of

the velocity field is shown. It is projected that the HeMoLab embraces a module for fluid-structure analysis using immersed concepts during the present year. This tool will definitely makes research faster.

6. 2. Multiscale modeling

It is well-known that the constitutive response of the arterial wall is rather complex, and that such behavior escapes to the predictive capabilities of classical phenomenological models. In this regard, multiscale models based on variational principles [4] provide an insightful way to tackle the problem. For instance, through an assemblage of elastin and collagen (*figure 9* with a combination of a hyperelastic matrix and bars) a typical constitutive response can be obtained. (also *figure 9*).

This kind of technique provides powerful tools in order to study arterial wall behavior, and is likely to be included in the short term within the HeMoLab system as a complementary module.

6. 3. Other areas

Others areas of research are under development in our multidisciplinary team. Among them we mention two:

i image processing, an area that is continuously evolving in order to ensure a more accurate geometry characterization of the arterial districts under investigation, and

ii identification and material properties characterization of biological tissues.

In particular, this last issue is being tackled in the HeMoLab Project by means of the topological derivative. Preliminary results of location of an inclusion in a given domain from measurements are shown in *figures 10(a)* and *10(b)* for one and two inclusions respectively. ●

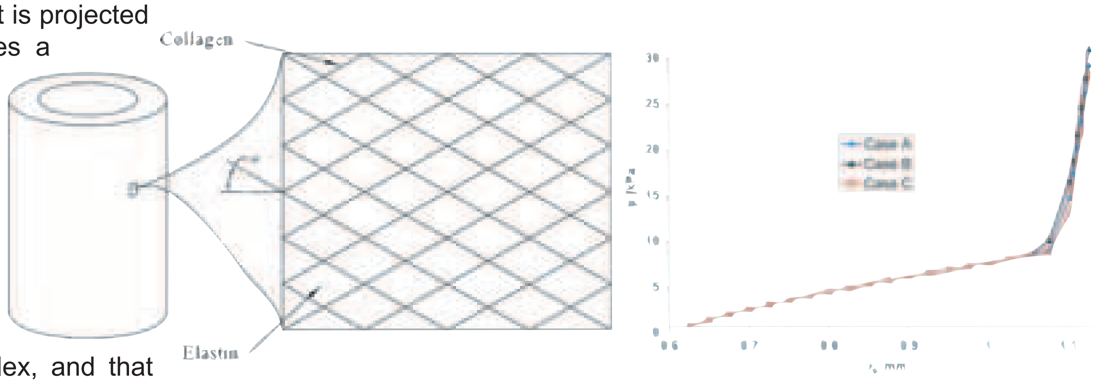


Figure 9

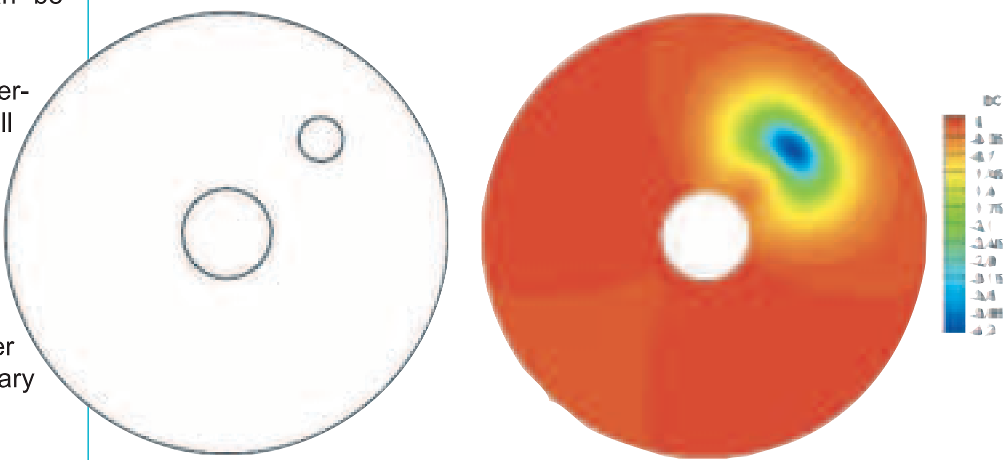


Figure 10 (a)

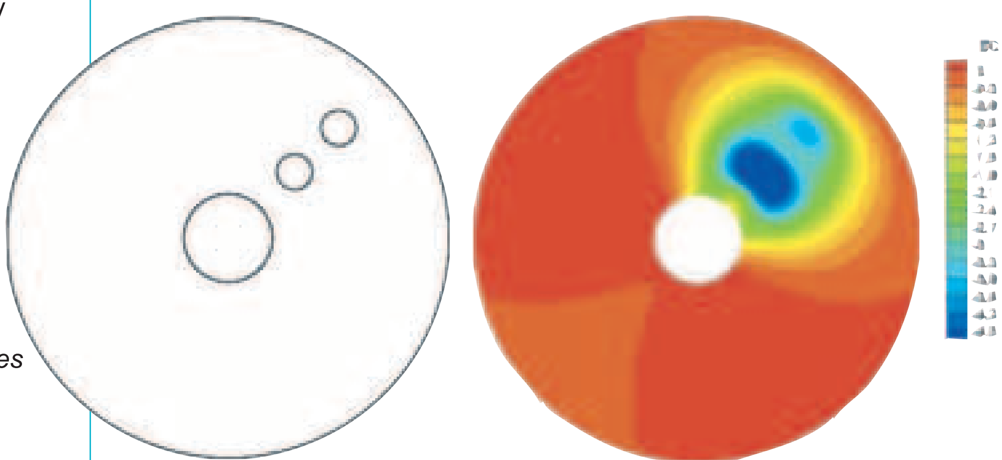


Figure 10 (b)

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Incorporating Analytic Information in Computational Schemes

by
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Israel*

I remember my excitement, as a young graduate student almost 25 years ago, when I started to understand the insides of the finite element method (FEM) for the first time and realized how general it was. In fact I was a bit carried away. My early impression was that I can take *any* given partial differential equation (PDE) or system of PDEs and apply the standard Galerkin FEM to it, generate a mesh with a few thousands degrees of freedom, and voilá, I get a perfect numerical solution! It took me some time to discover that while this procedure can technically be followed, in various important situations it does not yield satisfactory numerical results. Moreover, I later realized that this difficulty was not associated only with the Galerkin FEM; the more general observation is that there exist cases for which standard numerical treatment fails and special measures are needed in order to obtain good accuracy with manageable computational effort.

"The key ingredient ... is the fact that the solution of the problem is approximated by a superposition of functions satisfying the governing PDEs exactly."

One possible approach for tackling problems whose naive treatment fails is to make use of *analytic information* available on the behavior of their solution. The present article is concerned with this methodology. In what follows we briefly survey a few methods which have been developed for computational mechanics and that incorporate special "inside knowledge" on the exact solution. These should be contrasted with methods of brute-force numerics (which are also very useful many times!).

Trefftz Methods

Perhaps the most direct way in which analytic information is incorporated into a computational scheme is that employed in Trefftz methods. Erich Trefftz (1888-1937) *(Figure 2)* was a German mathematician who invented a numerical methodology now called by his name. See a short biography of Trefftz and comments on his work in [1]. His famous paper on the "Trefftz method" was published in 1926 [2]. Later this approach was recognized as general and powerful, and was extended in various ways. See, e.g., the new book on the subject [3], and the review papers [4,5]. See also the article on the Trefftz method in a previous issue of IACM Expressions [6].

The key ingredient in the Trefftz method is the fact that *the solution of the problem is approximated by a superposition of functions satisfying the governing PDEs exactly*. This is in contrast to the standard Galerkin FEM, where simple polynomial functions are used in each element. Depending on the specific version of the Trefftz method used, some of the boundary conditions may also be satisfied *a priori* by these functions. The unknown coefficients in the Trefftz expansion are determined so as to approximately satisfy all the remaining boundary conditions. The precise way in which this is done depends on the specific Trefftz method employed: by collocation, by least squares, by the Galerkin mechanism, etc. See, e.g., the recent paper [7] for a comparison between two popular Trefftz-type methods (the Ultraweak Variational Formulation and the Least-Squares Method) for short wave problems.

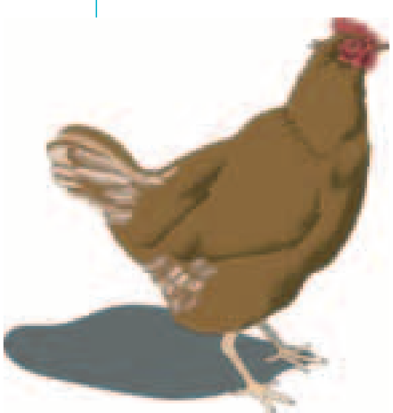


Figure 1:
Computational Hybridization of Inside Knowledge and Numerics (CHIKN) versus Brute Force (BF) numerics.

Figure 2:
Erich Trefftz

Trefftz methods can also be categorized into direct and indirect ones, and are related to the direct and indirect boundary element (BE) formulations. However, whereas BE formulations are based on the associated free-space Green's function, which is singular, the fundamental functions used as the basis for the Trefftz method are completely regular and are thus more convenient to compute with. As a single example, for the two-dimensional Laplace's equation one may use the sequence of Trefftz functions $T_n = r_n e^{in\theta}$, where (r,θ) are the polar coordinates. On the other hand, the free-space Green's function in this case is $G = (\log r) / (2\pi)$, which possesses a logarithmic singularity. Incidentally, one may view the BE method too as a method which incorporates analytical information, i.e., the Green's function. However, the use of analytic information in the Trefftz formulation is more direct.

A difficulty that is often associated with Trefftz methods is the *ill-conditioning* of the discrete system of equations. Interestingly, ill-conditioning is typical to most of the methods surveyed here that incorporate analytic information. For Trefftz methods, various remedies have been proposed to overcome this difficulty; see the review papers mentioned above.

Partition of Unity and Space Enrichment Methods

In 1996 and 1997, Melenek and Babuška published two seminal papers [8, 9] introducing the Partition of Unity Method (PUM). The framework is that of the FEM, but rather than working with the traditional piecewise polynomial space, PUM makes use of element shape functions which carry analytical information on the solution of the PDE. Two important applications where PUM is typically much more effective than brute-force FEM are problems involving (a) short waves and (b) geometrical singularities such as those at crack tips and at reentrant corners.

We elaborate a little on short wave applications. Suppose we want to solve the Helmholtz (reduced wave) equation with a very large wave number, namely for very short waves. In standard FEM we would have to use an extremely fine mesh to resolve the solution. A well-known rule of thumb claims that one should use 10 elements per wave-length, but in fact a much finer resolution would typically be required in order to overcome numerical dispersion (pollution) errors. This fact makes standard FEM computation for short waves totally impractical. By constructing a space of ``plane-wave functions" with the appropriate wave-length, PUM can be used to solve such problem with a reasonably crude mesh. Laghrouche and Bettess [10] seem to be the first to implement PUM for two-dimensional short-wave problems. Their finite element spaces with two plane-wave functions and four plane-wave functions are illustrated in *Fig.3.*

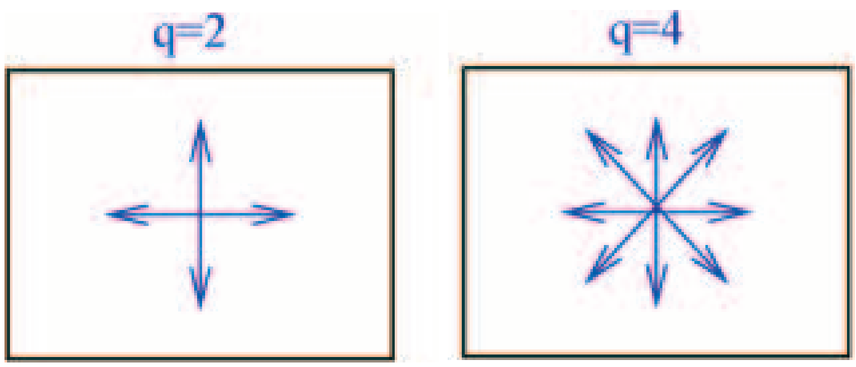
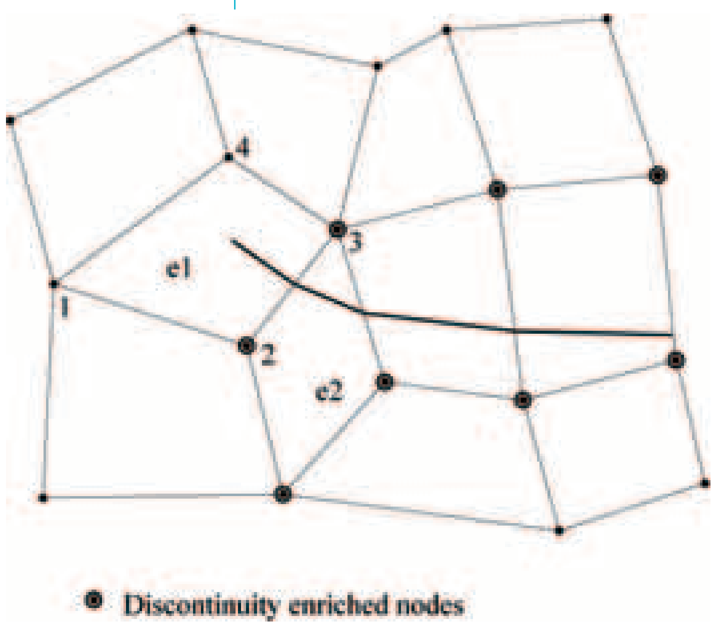


Figure 3:
Illustration of the basis functions used in PUM for a short-wave problem: two plane waves (q=2) and four plane waves (q=4)

In 2000, the idea of PUM led in a natural way to the so-called Generalized FEM (GFEM) [11] which combines the standard FEM and PUM. Thus, the GFEM space includes both the piecewise-polynomials and the special functions which carry analytical information on the solution. In the context of short-wave analysis, the role of the special (PUM-based) functions is to represent the fast variation in the computational solution, whereas the traditional polynomials reduce the error associated with the slow variation.

GFEM belongs to a class of methods that may be called *space enrichment methods*. In these methods the usual finite-element space is enriched by additional functions which represent the characteristics of the exact solution behavior. In recent years, various space enrichment methods have been proposed. We mention the *Discontinuous Enrichment Method* (DEM) [12] for short waves, in which the finite element space is enriched with discontinuous functions, and continuity across element interfaces is enforced weakly via Lagrange multipliers. One important advantage of DEM over some other space-enrichment methods is the relatively well-conditioned stiffness matrices that it produces. We also mention the method of Residual-Free Bubbles [13] which also constructs element shape functions with favourable properties based on an element-level analytic solution.

Figure 4: *Crack representation in XFEM*



The eXtended Finite Element Method (XFEM)

Belytschko and his group developed the eXtended Finite Element Method (XFEM) starting from 1999; [14,15], although the name XFEM was coined only later. XFEM is intended to treat *discontinuities* of various kinds which appear in the problem and whose geometry does not coincide with that of the finite element mesh. One important example is the treatment of cracks. In problems involving crack growth or a large amount of static cracks, it is very inconvenient and inefficient to generate a boundary-fitted mesh. XFEM allows the treatment of discontinuities (e.g., cracks) that pass through the mesh lines. See *Figure 4* for such a configuration in two dimensions.

XFEM is a space-enrichment method. It is in fact a special case o GFEM; however it involves a large amount of specialized techniques for the treatment of the discontinuities (related to the construction of the shape functions, the numerical integration, etc.), that justify a separate categorization. For a crack, the element space is equipped with the standard polynomials and by two types of enrichment functions: those that represent the jump in the solution across the discontinuity, and those that represent the crack-tip singularity. See the review of XFEM by Moës in a recent IACM Expressions issue [16].

Combination of Asymptotic and Numerical Methods

It is well known that the regimes where asymptotic methods on one hand and numerical methods on the other hand are at their best are typically different. The appearance of a small parameter in the problem is a blessing for asymptotics but may be a bane for numerics. As an example, the appearance of a thin boundary layer makes numerical treatment difficult, while under some simplifying conditions asymptotic treatment may be straight forward. Short wave scattering is another case in point; as indicated above standard numerical treatment is difficult, while there are powerful asymptotic methods for such problems based on ray tracing, although they usually assume simple geometry. Various methods have been proposed which *combine* a stan-

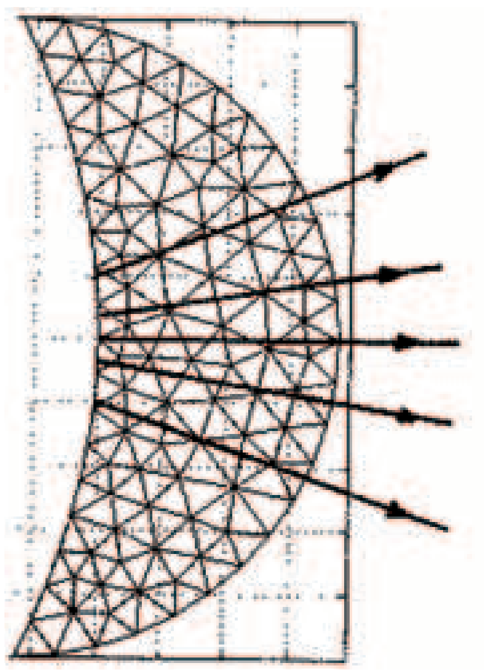


Figure 5: *Setup for the Giladi-Keller combined ray finite-element scheme for short-wave scattering.*

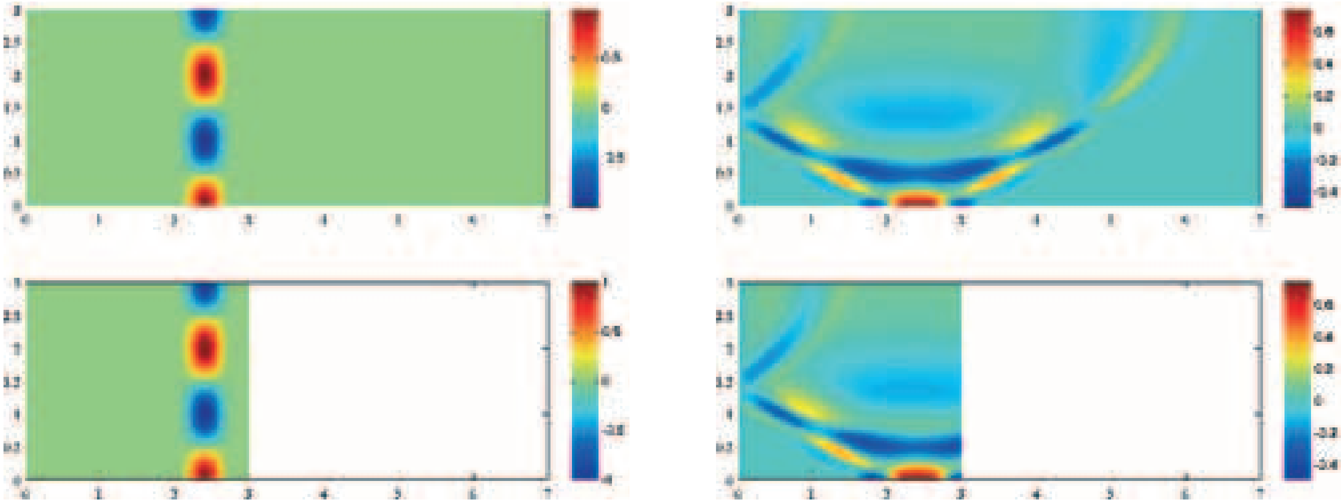


Figure 6:
Use of the high-order Hagstrom-Warburton Absorbing Boundary Condition (ABC), for a dispersive non-homogeneous medium.

dard numerical method and an asymptotic method in order to get the best of both worlds. For boundary layer problems, a method combining asymptotics and finite elements was devised by Bar-Yoseph and Israeli [17]. The method was applied to two-dimensional diffusion-convection equations and to non-linear similarity equations, and was later extended to other equations and configurations.

A `hybrid numerical asymptotic method' was devised by Giladi and Keller [18] for short wave scattering. In this method, geometrical theory of diffraction is used to provide asymptotic solutions which are sums of products of rapidly oscillating phase factors and slowly varying amplitude factors. The phase factors are determined by ray tracing, while the amplitude factors are found by the Galerkin FEM but using shape functions which are derived asymptotically. This combination is illustrated in *Figure 5* for scattering from a parabolic surface.

Another method for combining ray tracing and FEM was proposed by Barbone *at el*. [19]. The method is based on patching, on an artificial boundary, a short wavelength asymptotic expansion of the 'outer' field to a FEM interpolation of the 'inner' field. Continuity of the field and its normal derivative across the artificial boundary is enforced weakly in a variational setting. Coupling of ray tracing and boundary elements was proposed very recently by Hampel *et al*. [20].

In the context of nonlinear analysis of elastic structures, the group of Potier-Ferry has constructed powerful combined asymptotic-numerical methods. The asymptotics helps in reducing the problem to one which is much more tractable numerically. See, e.g., [21] for a method of computing bifurcating branches (e.g., postbuckling of shells), and [22] for a more recent asymptotic-numerical method for unilateral contact.

Homogenization is often employed when solving problems involving composite materials and structures, as a way to represent the small scales (associated with the fast variation of material properties) in a computationally manageable way. Various methods have been proposed which make use of asymptotics to incorporate the homogenization in the computational scheme itself. Much work in this direction has been done by Fish's group; see, e.g., the very recent paper [23].

DtN and Absorbing Boundary Conditions

The Dirichlet-to-Neumann (DtN) FEM was devised [24] for problems in unbounded domains, as typical in geophysics, oceanography, acoustics, etc. The method comprises the following steps: (a) introduce an artificial boundary $\mathcal{B}$ which encloses a finite computational domain Ω (the region of interest), (b) solve the problem *analytically* in the exterior domain, (c) use the analytic information to construct an exact boundary condition on $\mathcal{B}$, called the DtN boundary condition, and (d) solve the problem by FEM in Ω. The method was used initially to solve various elliptic infinite-domain problems, and especially time-harmonic wave scattering problems. Later the DtN method was extended to other configurations, including those which involve geometrical singularities (like cracks) in a bounded domain. See, e.g., the review paper [25].

"Various methods have been proposed which combine a standard numerical method and an asymptotic method in order to get the best of both worlds."

"When I bet without much a priori knowledge I lose on average 80% of my bets. But if I bet after gathering a lot of information on the horses and the jockeys, finding out about their success records, etc., I lose evenmore."

A closely related class of schemes for wave problems in unbounded domains are those incorporating Absorbing Boundary Conditions (ABCs). The DtN boundary condition is a *nonlocal* ABC, but *local* ABCs strongly based on analytic information can also be constructed. Their main advantage is that they are readily applicable to time-dependent problems. Recently, Hagstrom *et al*. [26] proposed high-order ABCs (which are extended versions of the Hagstrom-Warburton ABCs [27]) for some complicated configurations in wave-guides. *Figure 6* shows results generated by this method. The medium is dispersive and its material wave-speed varies linearly in the cross-section of the guide. Plotted are color-map snapshots of the computed solution in the truncated domain (lower plot) and of a reference solution in a long domain (upper plot), at times (a) $t = 0$ and (b) t = 1.096. It is apparent that the agreement between the computed and reference
solutions is excellent and no spurious reflections are visible.

Variational Multiscale (VMS) Methods

The Variational Multiscale (VMS) method was invented in 1995, when Hughes published the seminal paper [28]. Since then various applications and extensions have been proposed by many authors; see, e.g., [29, 30]. The method addresses the common situation when the sought exact solution consists of (at least) two scales: a *resolvable* scale, namely a scale which can be resolved by the computational mesh used, and an *unresolvable* or *sub-grid* scale. See the illustration in *Figure 7*. We cannot simply ignore the sub-grid scale, even if we are only interested in the coarse-scale behavior; due to the coupling that exists among the different scales of the problem, the fine scale affects the coarse scale. The challenge is to obtain an accurate solution with a finite-element mesh that can resolve only the coarse scale.

The basic VMS method can be summarized by the following steps: (a) decompose the solution in the form $u = \overline{u} + u'$ where $\overline{u}$ is the resolvable-scale solution and u' is the subgrid scale solution, (b) write u' as driven by the residual of the resolved scale, and express u' *analytically* on each element in terms of $\overline{u}$, and (c) use the expression obtained for u' to eliminate from the weak form of the problem the explicit dependence on the subgrid scale. All this results in a weak formulation in which the subgrid scale u' does not appear explicitly. Thus, the VMS method leads to a variational formulation which is an improved version of the standard variational formulation in that it *implicitly* includes the relevant (analytic) information associated with the unresolved scales.

In addition to the ability of the VMS method to solve multiscale problems very effectively, it entails great theoretical importance in that it sheds light and provides a strong basis to seemingly different types of methods such as bubble-enriched methods (such as RFB [13]) and stabilized methods.

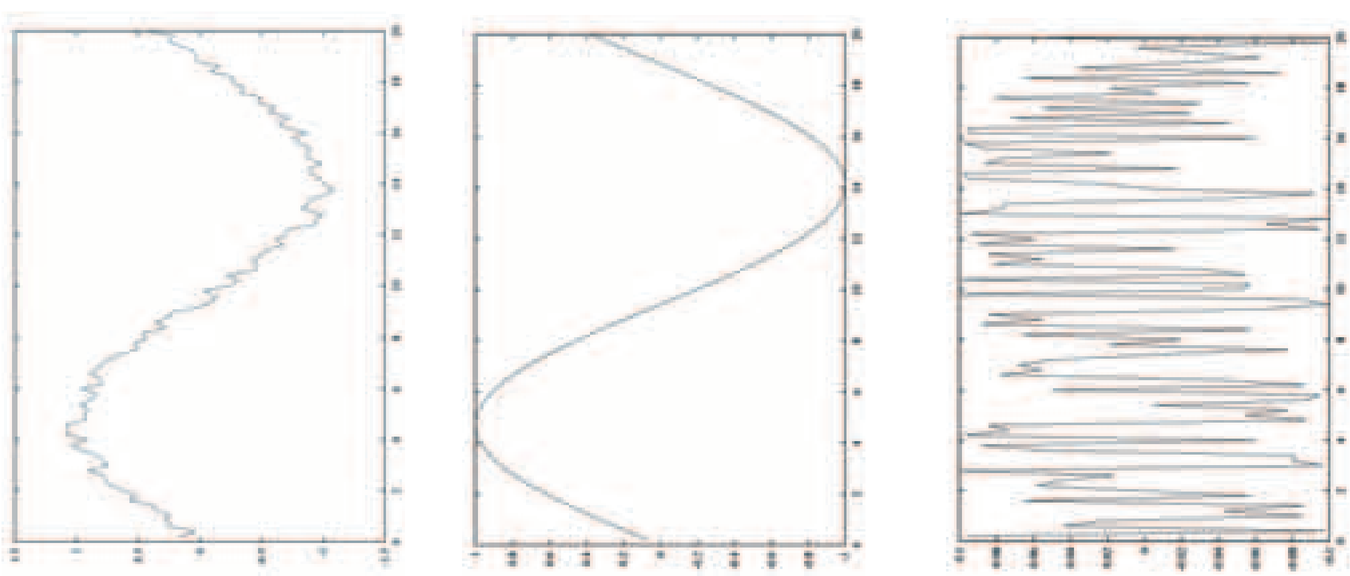


Figure 7:
An illustration of a typical multiscale solution (left), its resolvable scale (middle) and its unresolvable (subgrid) scale.

Additional methods that incorporate analytical information in computational methods have been proposed which are not included in the sections above. This article aims only at giving the reader a taste of this type of methods. The main point to be emphasized is that the use of analytical information in numerical schemes may be beneficial in many situations when standard treatment fails or is very inefficient.

A priori "inside knowledge" on the behavior of the solution may thus be very valuable. However, I cannot forget what the well-known applied mathematician Julian Cole (1925—1999) once told me over lunch in RPI, regarding his experience in horse-race betting at near-by Saratoga:

"When I bet without much a *priori* knowledge I lose on average 80% of my bets. But if I bet after gathering a lot of information on the horses and the jockeys, finding out about their success records, etc., I lose even more."

I hope that this has no analogy to the type of methods reviewed here!

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PDE-interpolations in Topology Optimization

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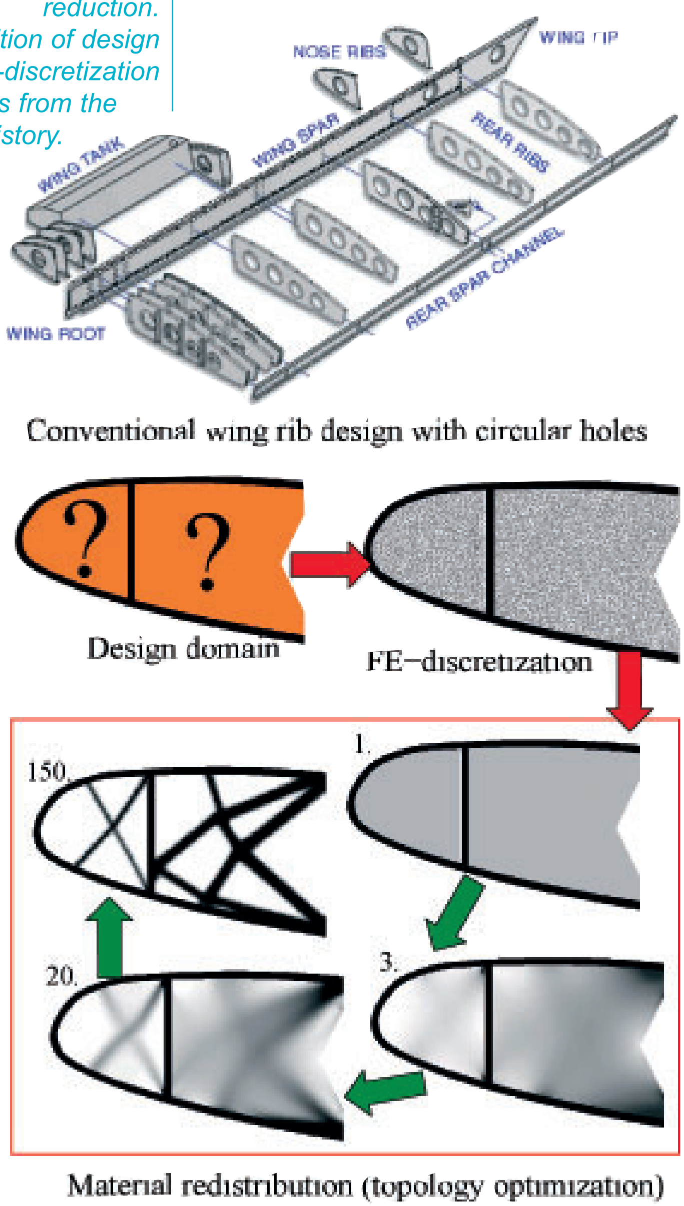
Figure 1: Wing rib design by topology optimization. Top: Conventional design with circular holes for weight reduction. Bottom: definition of design domain, FE-discretization and snap shots from the optimization history.

Since its invention by Bendsøe and Kikuchi two decades ago, the topology optimization method as a computational tool [1] has undergone a tremendous development. In the early days of the method, it was mainly seen as an academic toy for optimizing material distributions in mechanics and lots of post-processing and -interpretation had to be performed before realistic and useful designs could be extracted. In the early 90's, the automotive industry took up the method with mainly in-house codes but since then, the method has spread rapidly into all other mechanical engineering disciplines. By now, all major FE-software houses provide topology optimization functionalities and there exists a small handfull of dedicated topology optimization software providers that offer mechanical design solutions with manufacturing constraints like deep drawing and casting constraints. This expansion process has culminated with the use of the method in the structural design of the new A380 mega-plane by EADS [2]. Whereas the method enjoys great popularity for simple mechanical design criteria like stiffness, buckling, and dynamic eigenfrequencies, the method is only slowly spreading to other physics disciplines – most probably because it is difficult to systematize the transfer of the method to other disciplines. As is, every new application requires reconsideration of modeling aspects, design parameterizations, design goals and penalization schemes. Especially problems involving boundary loads have been difficult to deal with due to the paradox: where to add the boundary loads if the boundaries are unknown? In this article, we will discuss some recent developments in providing a unified scheme for topology optimization in multiple physics and loading settings.



The original topology optimization method consists of repeated finite element analyses, gradient evaluations, and material redistributions based on optimality criteria or Math Programming approaches[1]. For stiffness optimization, the design variables are the individual element material densities. In order to be able to use efficient gradient-based optimization approaches, the design variables are allowed to take any value between zero (void) and one (solid), however, discrete and well-defined solid-void solutions are obtained by choosing

1 The reader is kindly invited to visit the homepage www.topopt.dtu.dk (compliance design) to try out a topology optimization Java applet that illustrates the technique.

appropriate penalization schemes that favor discrete solutions from porous intermediate stiffness solutions [3]. The topology optimization procedure is demonstrated on a wing rib example in *Figure 1*.

Lately, alternatives to the above described density approach have appeared. In level-set approaches material boundaries are described by the zero level-set surface and boundary optimization is obtained by solving of Hamilton-Jacobi equations [4]. Parameterized level-set functions allowing for the use of Math Programming approaches have also been suggested based on the use of radial basis functions [5]. The different approaches each have their pros and cons, however, common for all is that they are based on fictitious domain modeling and hence they require interpolation schemes for the correct modeling of the solid and void domains. In simple stiffness optimization problems this may not be a problem because the void domain has no influence on the structure. However, in other physics cases, the void domain may contain pressurized fluids, moving fluids, acoustic waves, electric fields, etc. If the topology was given, such modeling problems could easily be solved by staggered approaches, i.e. for a structural-acoustic problem, the Helmholtz and Navier equations could be solved separately in each their subdomains but coupled through boundary terms. In topology optimization, the boundaries are unknown a priori and hence staggered approaches are impractical and must be substituted with monolithic approaches where all physics is modeled on the same mesh. In the following we demonstrate how monolithic (non-staggered) analysis schemes suitable for topology optimization of multiphysics problems can be based on suitable interpolations of PDEs (Partial Differential Equations).

Elasticity

The first examples of topology optimization were based on minimum compliance design of mechanical structures. The PDE for elasticity without volume load is given in *Table 1a*. The design variable ρ interpolates between empty space (ρ=0) and solid material (ρ=1) governed by the elasticity PDE. In practice, this is done by letting the Young's modulus or the whole stiffness tensor of solid material be a function of ρ.

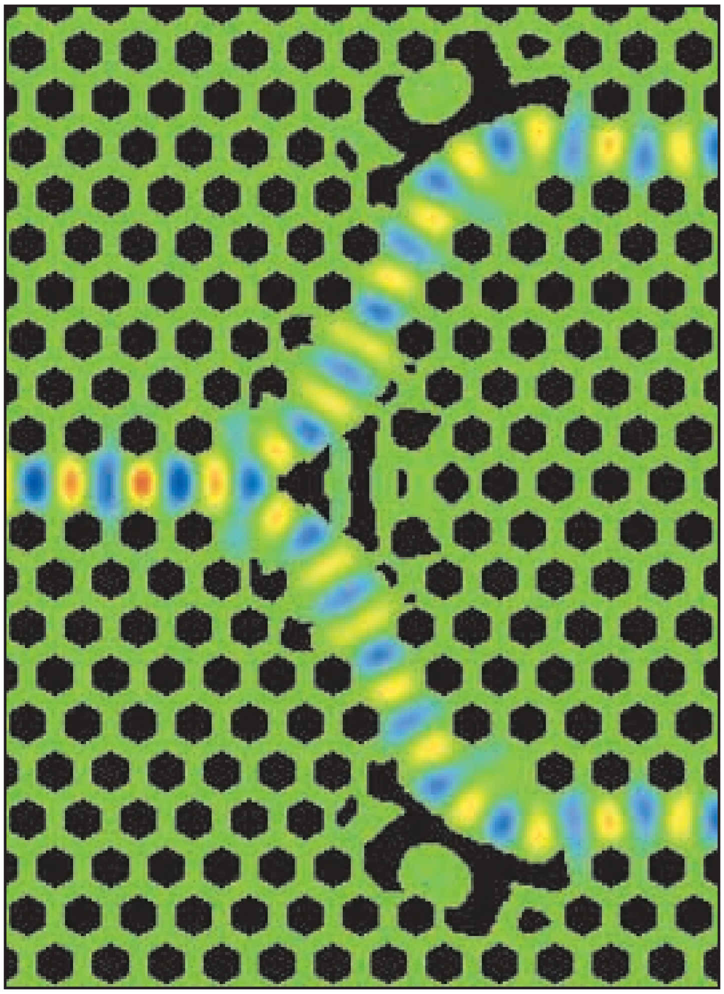


Figure 2:
A nano-scale photonic wave guide splitter designed by topology optimization.

A compliance minimization example for airplane wing-rib design is shown in *Figure 1*. A range of other design problems are also covered by this simple interpolation between void (empty space) and solid material. Examples are thermal and electric conduction problems and also multiphyscis problems like electrothermomechanical actuators [6].

Photonic crystals

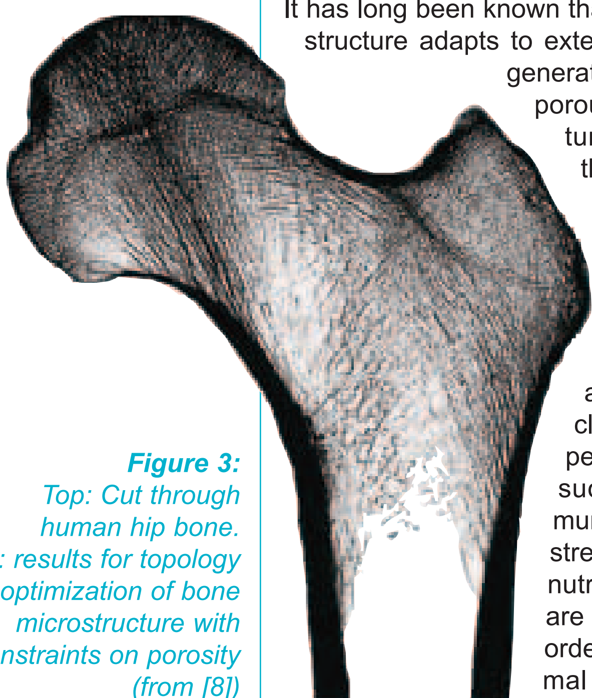
A simple extension of the solid-void scheme is to have the same PDE governing the solid and the void regions, i.e. the design variable interpolates between e.g. a low and a high value of refractive index as seen in the design of photonic crystals governed by Maxwell's equations [7]. A photonic crystal based wave guide nano-scale splitter is shown in *Figure 2*.

PDE	Interpolation	Void region $\rho = 0$	Solid region $\rho = 1$
a) Elasticity, compliance minimization			
$\nabla \cdot (\mathbf{C}(\rho)\nabla \mathbf{u}) = \mathbf{0}$	$\mathbf{C}(\rho) = \rho \mathbf{C}_s$	void	$\nabla \cdot (\mathbf{C}_s \nabla \mathbf{u}) = \mathbf{0}$
b) Elasticity and porous flow, bone optimization			
$\nabla \cdot (\mathbf{C}(\rho)\nabla \mathbf{u}) = \mathbf{0}$ $\nabla \cdot (\kappa(\rho)\nabla \psi) = 0$	$\mathbf{C}(\rho) = \rho \mathbf{C}_s$ $\kappa(\rho) = (1-\rho)\kappa_f$	porous flow $\nabla \cdot (\kappa_f \nabla \psi) = 0$	elastic bone $\nabla \cdot (\mathbf{C}_s \nabla \mathbf{u}) = \mathbf{0}$
c) Stokes flow			
$-\nabla \cdot (\mu \nabla \mathbf{u} - \mathbf{I}p) + \alpha(\rho)\mathbf{u} = \mathbf{0}$ $\nabla \mathbf{u} = 0$	$\alpha(\rho) = (\rho - 1)\alpha_f + \rho \alpha_s$	fluid ($\alpha_f = 0$) $\nabla \cdot (\mu \nabla \mathbf{u} - \mathbf{I}p) = \mathbf{0}$ $\nabla \mathbf{u} = 0$	support ($\alpha_s = \infty$) $\mathbf{u} = \mathbf{0}$
d) Elasticity with pressure loads			
$\nabla \cdot (2G(\rho)\nabla \mathbf{u} - \mathbf{I}p) = \mathbf{0}$ $p = -K(\rho)\nabla \mathbf{u}$	$K(\rho) = (\rho - 1)K_f + \rho K_s$ $G(\rho) = \rho G_s$	fluid $p = K_f \nabla \mathbf{u}$	solid $\nabla \cdot (2G_s \nabla \mathbf{u} - \mathbf{I}p) = \mathbf{0}$ $p = -K_s \nabla \mathbf{u}$
e) Electrostatic actuation			
$\nabla \cdot (\mathbf{C}(\rho)\nabla \mathbf{u}) = \nabla \mathbf{F}$ $\mathbf{F} = \varepsilon(\rho)\nabla\phi\nabla\phi - \frac{1}{2}\nabla\phi \cdot \nabla\phi \mathbf{I}$ $\nabla \cdot (\tilde{\varepsilon}(\rho)\nabla\phi) = 0$	$\mathbf{C}(\rho) = \rho \mathbf{C}_s$ $\varepsilon(\rho) = (1-\rho)\varepsilon_0 + \rho\varepsilon_0\varepsilon_r$ $\tilde{\varepsilon}(\rho) = \varepsilon_0(1 + \rho\alpha\varepsilon_r)$, $\alpha \gg 1$	vacuum $\nabla \cdot (\varepsilon_0 \nabla\phi) = 0$ $\mathbf{F} = \varepsilon_0 \nabla\phi\nabla\phi - \frac{1}{2}\nabla\phi \cdot \nabla\phi \mathbf{I}$	solid $\nabla \cdot (\mathbf{C}_s \nabla \mathbf{u}) = \nabla \mathbf{F}$ $\nabla \cdot (\alpha\varepsilon_0\varepsilon_r \nabla\phi) = 0$ $\mathbf{F} = \varepsilon_r \nabla\phi\nabla\phi - \frac{1}{2}\nabla\phi \cdot \nabla\phi \mathbf{I}$
$_s$: solid, $_f$: fluid, no volume loads assumed			

Table 1: Monolithic PDE interpolation schemes for various physics problems.

Elasticity and porous flow

It has long been known that human bone structure adapts to external loads and generates an-isotropic porous microstructures. However, the exact objective function behind the adaption is still not clearly understood although it is clear that competing objectives such as maximum stiffness or strength as well as nutrition transport are in play. In order to study optimal microstructures governed by the porous flow PDE in the void region and the elasticity PDE in the solid regions, reference [8] suggested to interpolate between the two PDEs as seen in the *Table 1b*. With ρ=0 we obtain porous flow governed by Poisson's equation and with ρ=1 we obtain solid structure governed by Navier's equation. An example of micromechanical bone design with varying constraints on permeability/conductivity is shown in *Figure 3.*



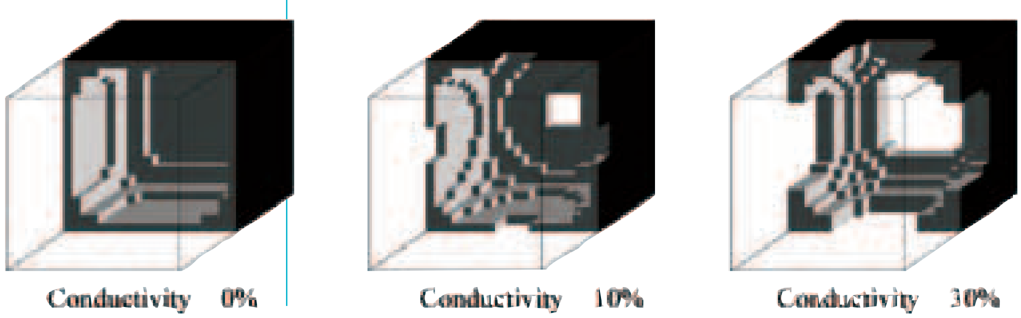


Figure 3: Top: Cut through human hip bone. Bottom: results for topology optimization of bone microstructure with constraints on porosity (from [8])

Stokes flow

The extension of the topology optimization to fluid mechanics problems was not straightforward and has only been solved recently [9]. Following the ideas from elasticity, a first thought was to interpolate the material property, i.e. the viscosity between fluid and non-fluid region by switching between the physical viscosity of the relevant fluid and an infinitely high viscosity (non-fluid) region. However, this does not work since the high viscosity regions only will stop flow if they are attached to no-slip boundaries. A better solution proved to be to add a dissipation (inverse permeabili-

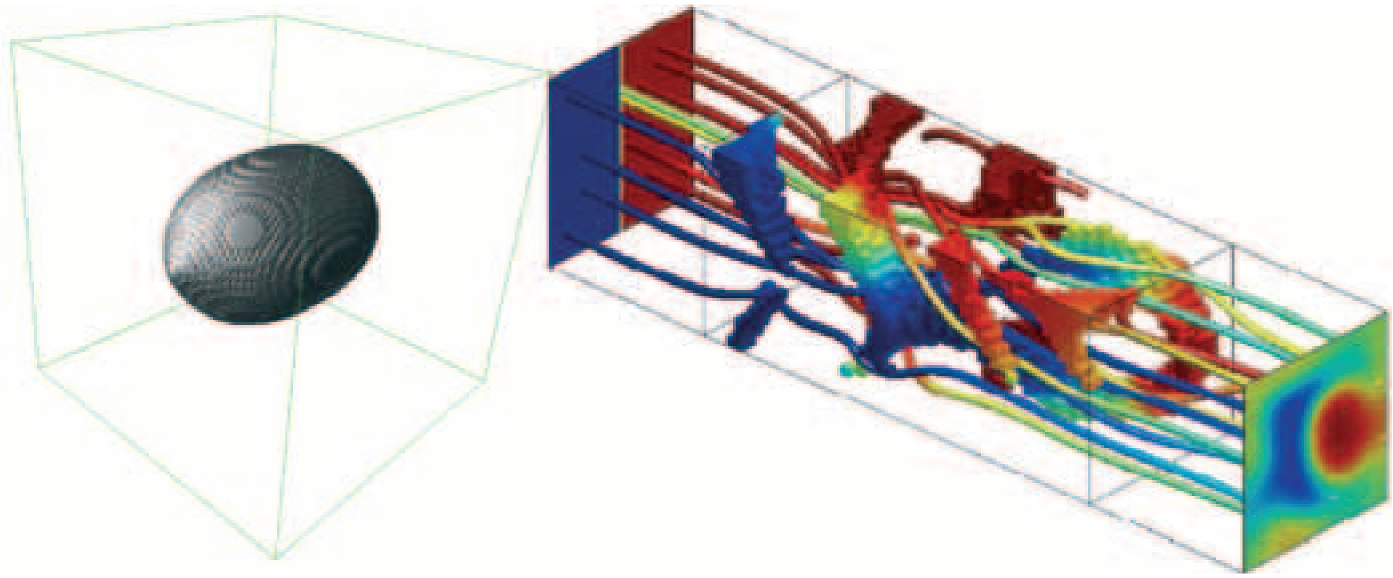


Figure 4:
Stokes flow examples.
Left: minimizing drag of of given volume Figure 4: Stokes flow examples.
Left: minimizing drag of obstacles of given volume (from [10]).
Right: a flow mixer with flow lines and colors indicating temperature from inlet (left) to outlet (right) (from [11])

ty) term to the Stokes equation, i.e. turning it into the Brinkman equation and then letting the design variable determine the magnitude of the dissipation term. As seen in *Table 1c*, switching the inverse permeability ρ between 0 and infinity, one can interpolate between the pure Stokes flow equation (ρ=0) and no flow (ρ=1). Examples of topology optimization for fluids are shown in *Figure 4.*

Elasticity with pressure loads

Solving pressure load problems using the topology optimization is inherently a problem since it is unclear where to apply the pressure loads if the boundaries are unknown. In order to solve the problem previous works used various shape descriptors and boundary optimization techniques on top of the topology optimization parameterization. However, it has turned out [12] that a reformulation of the standard elasticity formulation into a mixed form makes it possible to solve the problem by simple interpolation between zero shear stiffness but finite bulk modulus (i.e. a compressible stationary fluid) in the pressurized void region and finite shear and bulk moduli in the solid region. The equations are given in *Table 1d* and an example is shown in *Figure 5*. The idea can also be extended to structural acoustic problems by the same interpolation of the mixed form but now including inertia terms [13].

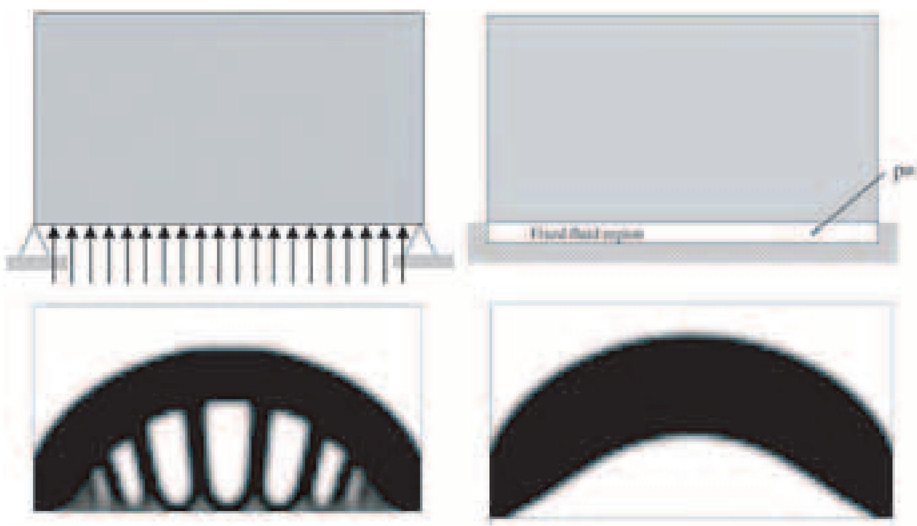


Figure 5:
Topology optimization with pressure loads. Left: Suboptimal topology obtained by vonventional formulation with fixed pressure load line. Right: Optimized solution based on mixed formulation (from [12])

Electrostatic actuation

The last and most challenging example of a PDE interpolation for topology optimization, that we will discuss here, is the design of electrostatically actuated micro systems. Electrostatic forces between two conductors are inversely proportional to the square of the gap between them, hence in micro scale these forces become large enough for mechanical actuation. Normally the electromechanical modeling problem is solved by staggered analysis approaches but recently it was shown that monolithic schemes amenable to topology optimization can be set up [14,15]. Table 1d shows the scheme that interpolates between the electrostatic Poisson's equation (void regions) and the elasticity equations (solid region). The boundary loads (Maxwell stresses) **F** generated by the electrostatic field enter the elasticity equation as volume loads. An example of electrostatic actuator design is shown in *Figure 6.*

With these five examples it has been demonstrated how various multiphysics and boundary load problems can be posed in monolithic settings amenable to topology optimization formulations by proper interpolations between the governing PDEs. It is the authors vision that any kind of physical design problem can be formulated in similar monolithic forms. Ideally, one would set up a table of all known PDEs and generate the proper interpolations between them. As long as the PDEs are formulated in the same coordinate systems this should indeed be possible.

However, when considering "incompatible PDEs" like for instance the fluid-structure problem where the fluid problem is formulated in an Eularian coordinate system and the elastic problem is formulated in a Lagrangian system, the proper interpolation scheme is not yet clear. Amongst others, it is the formulation and solution of such advanced incompatible coupled problems that constitute the future challenges within the field of topology optimization. ●

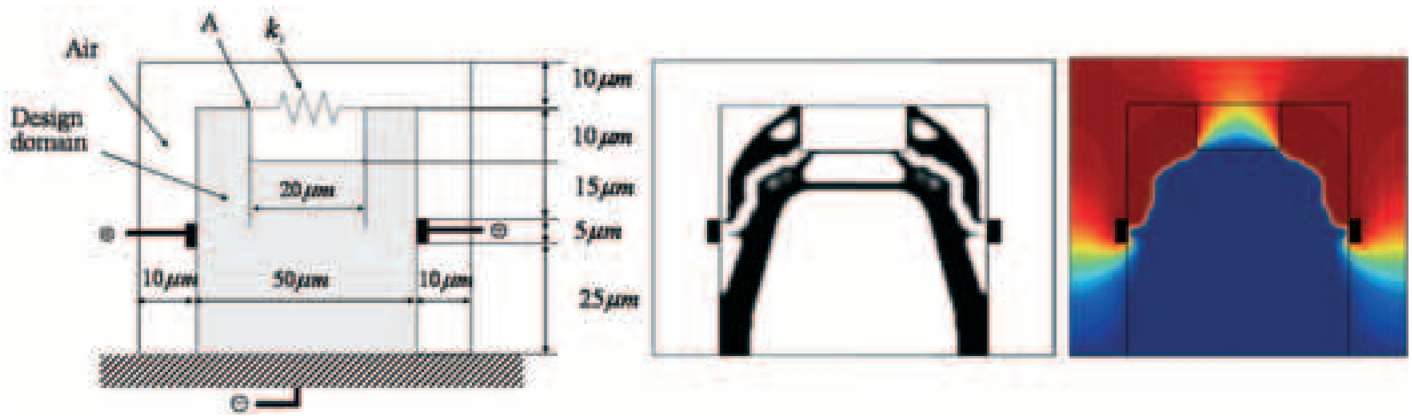


Figure 6: *Topology optimization with electrostatics forces for MEMS. Left: design domain. Center: topology optimized micro gripper. Right: Electric field distribution (from [15]).*

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Research Activities at the Structural Mechanics and Coupled Systems Laboratory

by
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http://www.cnam.fr/lmssc/

Historical background

The Conservatoire National des Arts et Métiers (*Figure 1*), is a higher education and research public establishment dedicated to providing education and conducting research for the promotion of science and industry. It has a large museum of inventions accessible to the public (Musée des Arts et Métiers).

It was founded by the abbot Henri Grégoire in 1794, during the French Revolution and is located on the old Benedictine priory of Saint-Martin-des-Champs (Merovingian period, 1060). The medieval perimeter wall can still be partially seen.

Figure 1: *Conservatoire National des Arts et Métiers, Paris*

The Conservatoire National des Arts et Métiers is located in the IIIe arrondissement of Paris, in the historical area of the city named Le Marais (*Figure 2*).

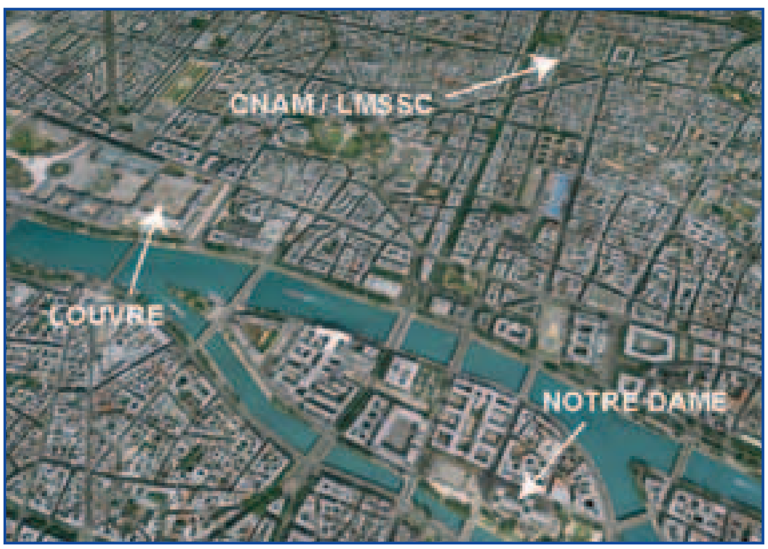


Figure 2: *Aerial view of the location of CNAM in Paris*

Research activities at the LMMSC

The research group entitled Structural Mechanics and Coupled System Laboratory (in French Laboratoire de Mécanique des Structures et des Syst mes Couplés, LMSSC) has been created in 1997 when Roger Ohayon left the Aerospace French Lab (ONERA) to join academia as Professor holding the Chair or Mechanics at CNAM, maintaining the research links with ONERA though PhD students. The Lab is involved in various projects with governmental French agencies (DGA, CNES, Ministry of Research), industries (EADS, SAFRAN ...), and European projects (InMAR, Marie Curie SMART)

The members of the team are affiliated to IACM through the French Association of Computational Structural Mechanics (CSMA). They are also involved in ASME (Adaptive Structures Technical Committee) and AIAA societies.
Professor Roger Ohayon (Fellow IACM and Fellow ASME) is currently the head of the Lab.

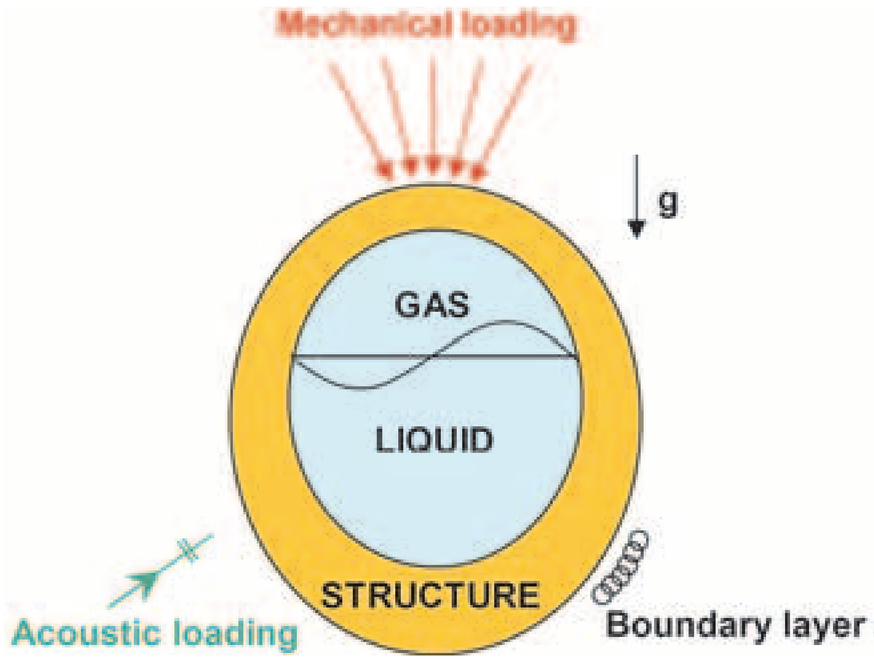


Figure 3: Fluid Structure Interaction Problem

The research activities of LMSSC (http://www.cnam.fr/lmssc) concern computational and experimental mechanics in the following domains:

- Linear and Non Linear Structural Dynamics and Vibration;
- Fluid Structure Interaction, Structural Acoustics, Adaptive Dissipative Interfaces;
- Vibration Reduction using Smart Structures and Intelligent Systems.

In the following, we illustrate some research activities concerning fluid structure interaction problems and vibration reduction using dissipative interfaces and smart structures. For general references on fluid structure interaction and structural acoustic mechanical and computational modelling, the reader can refer for instance to *Refs.* [8, 9, 10, 11].

Among the various applications, let us cite:

- hydroelastic and sloshing vibrations of liquids, for instance for aerospace industry, for propelled launch vehicles taking into account if necessary surface tension effects which occur in stability studies and in vibration studies of satellites, spacecrafts, airplanes…
- structural-acoustic vibrations occurring in the payload of launchers (due to engine noise), in fuselage of aircraft, in automobiles.

The particularity of the problems under consideration lies in their multiphysic and multiscale aspects due to the disparity of wavelengths in the structure (metallic or composite) and fluid domains. The fluid structure coupled system may be submitted to various types of dynamic excitations (see *Figure 3*)

The numerical methods developed herein are of interest for various industrial domains, such as automotive industry engineering, nuclear engineering, civil engineering, naval engineering, biomechanics,…

Various symmetric matrix equations derived from appropriate variational formulations by means of the finite element method have been developed and are the subject of current investigations.

The following two objectives are pursued:

- Direct resolution of the coupled systems by the finite element method.
- Reduced order models using appropriate Ritz projection basis such as eigenmodes of "ele mentary subsystems" (structural modes, sloshing modes, acoustic modes). Those reduced order models are of prime importance for sensitivity analyses, for updating procedures and for hybrid passive/active control of vibration.

The general physical hypothe ses concerning the fluid are summarized in (*Figure 4.*) and allow a description of the fluid domain by a scalar field (pressure, displacement or velocity potential…).

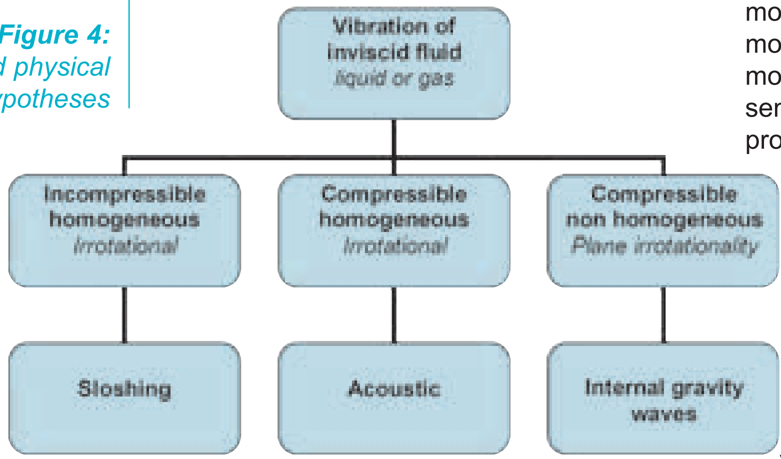


Figure 4: Fluid physical hypotheses

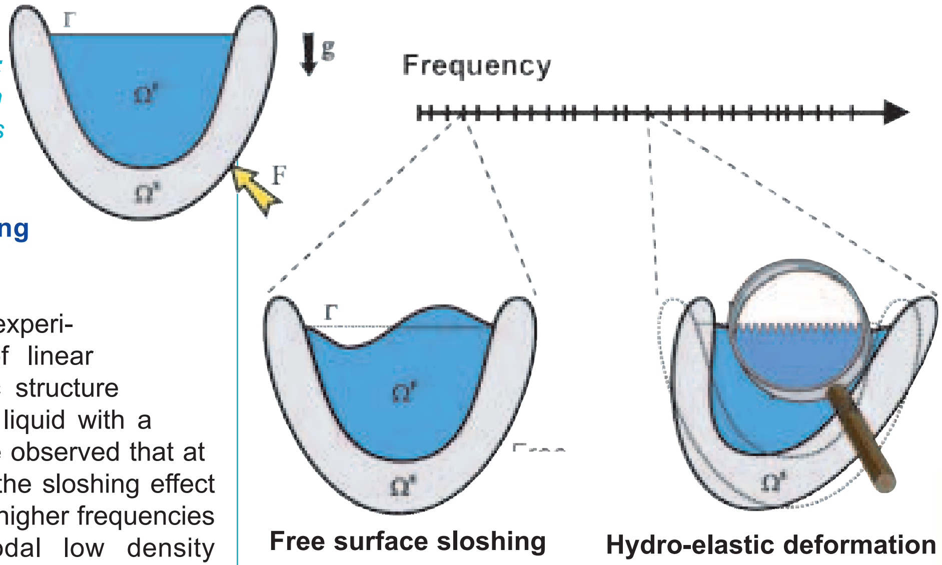


Figure 5:
Frequency domain considerations

Vibration of structures containing liquids

Figure 5 illustrates an experimental observation of linear vibration of an elastic structure containing an inviscid liquid with a free surface. It can be observed that at very low frequencies, the sloshing effect dominates and that at higher frequencies (but still in the modal low density domain), the hydroelastic effect dominates (gravity effect being neglected). For those two cases, the liquid can be considered as incompressible. For higher frequency domain, compressibility effect becomes important [1]. Of course, the previous two distinct cases, in some particular situations, can interact [12, 13].

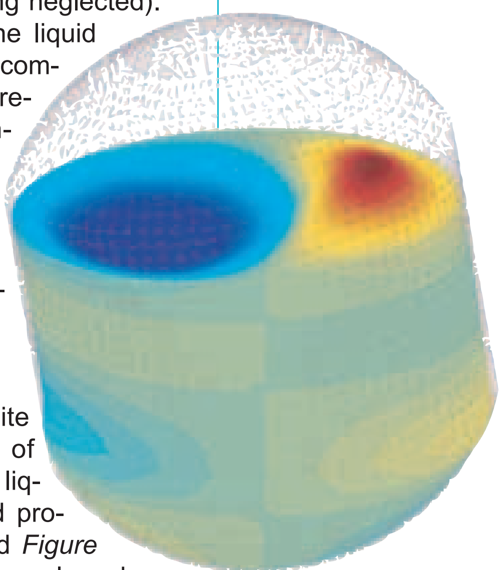


Figure 6:
Tank partially filled with liquid

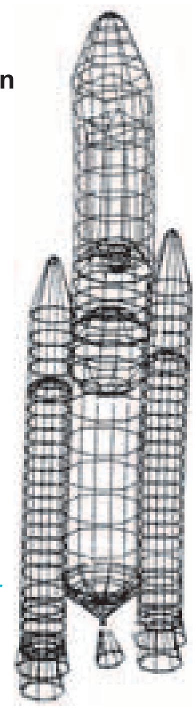
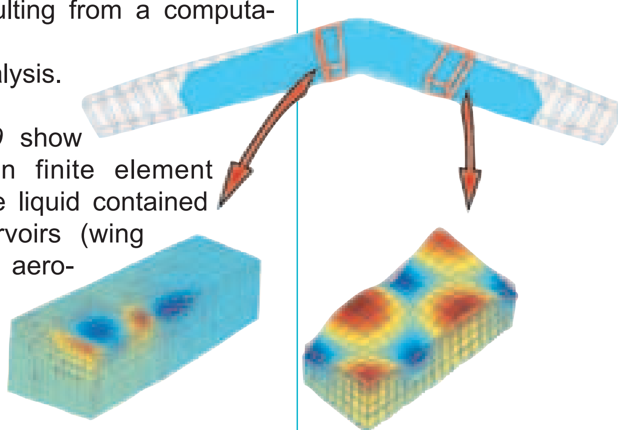


Figure 7:
Ariane Launcher mode shape

Figure 6 illustrates finite element simulations of sloshing vibrations of a liquid contained in a liquid propelled launcher tank and *Figure 7* presents a typical Ariane launcher mode shape resulting from a computational coupled fluid-structure analysis.

Figures 8 and *9* show sloshing vibration finite element simulations of the liquid contained in airplane reservoirs (wing tails or store) for aeroelastic analyses.



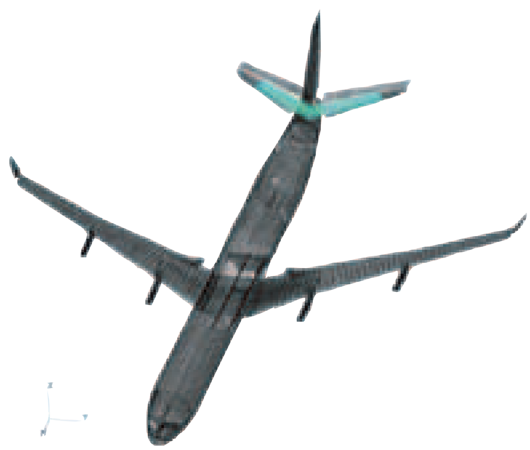


Figure 8:
Sloshing of liquids in an airplane reservoir (wing tails)

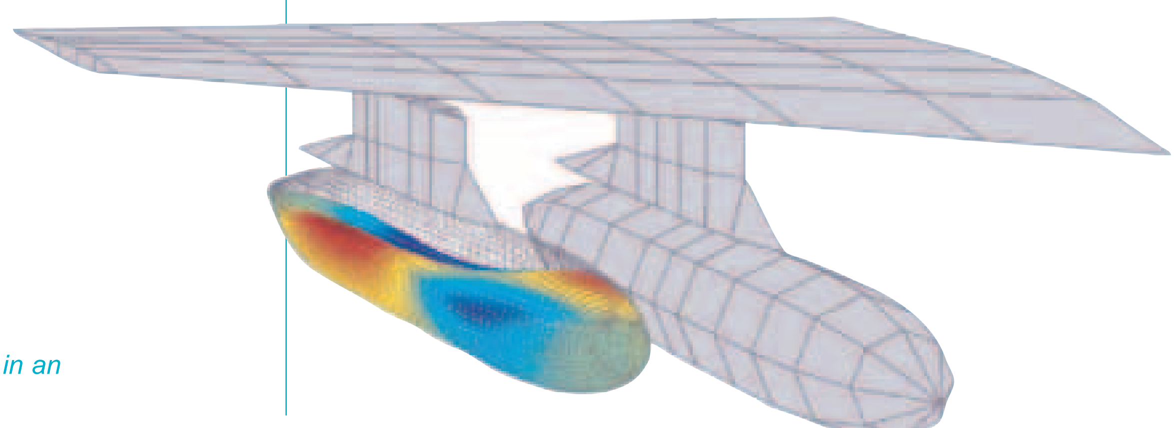


Figure 9:
Sloshing of liquids in an airplane reservoir

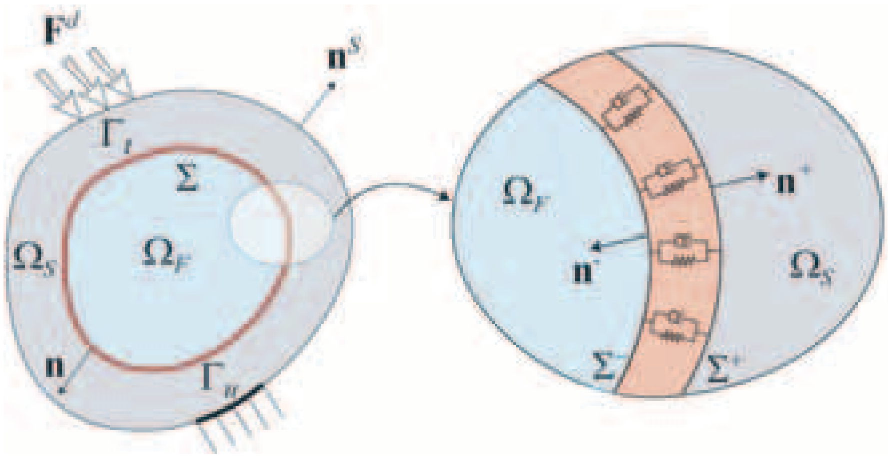


Figure 10: Dissipative interface for structural acoustic vibration reduction

Structural acoustic interior problems with dissipative interface

This research concerns finite element methods for interior noise reduction of coupled structural acoustic systems. This problem is of prime importance in automobile and aerospace industries, especially, for the latter, since the use of composite materials for the fuselage of aircraft. Three reduction procedures are currently under investigation:

- Dissipative fluid structure interfaces (*Figure 10*) using viscoelastic materials for structural vibration reduction and/or porous medium for noise absorption [6].
- Adaptive treatments using smart materials such as piezoelectric wafers [3]. In this case, it should be noted that the electromechanical coupling coefficient, which characterizes the conversion efficiency between electrical and mechanical energy, plays a fundamental role.
- The combination of both for hybrid passive/active (viscoelastic/piezo electric) treatments (see [5] for structures)

Current investigations concern vibration reduction by switch shunting of piezoelectric elements. This concept has been initially proposed by Professor Guyomar and his co-workers from the Electrical Engineering and Ferro-electricity Lab (LGEF) of INSA-Lyon, France. Appropriate modelling and experiments are carried out at LMSSC (in collaboration with LGEF) on typical structures in order to validate and evaluate this new smart device. *Figure 11* presents a comparison between shunt and switch techniques in terms of vibration attenuation [4]. Extension to vibroacoustic situation is the subject of further investigations.

In addition to the research topics described above, other subjects are under investigation:
(i) computational descriptions of fluid-structure interface using XFEM and Level Set techniques [7, 15],
(ii) active control of structures containing liquid [2], and
(iii) non linear vibration analyses [Ref. 14].

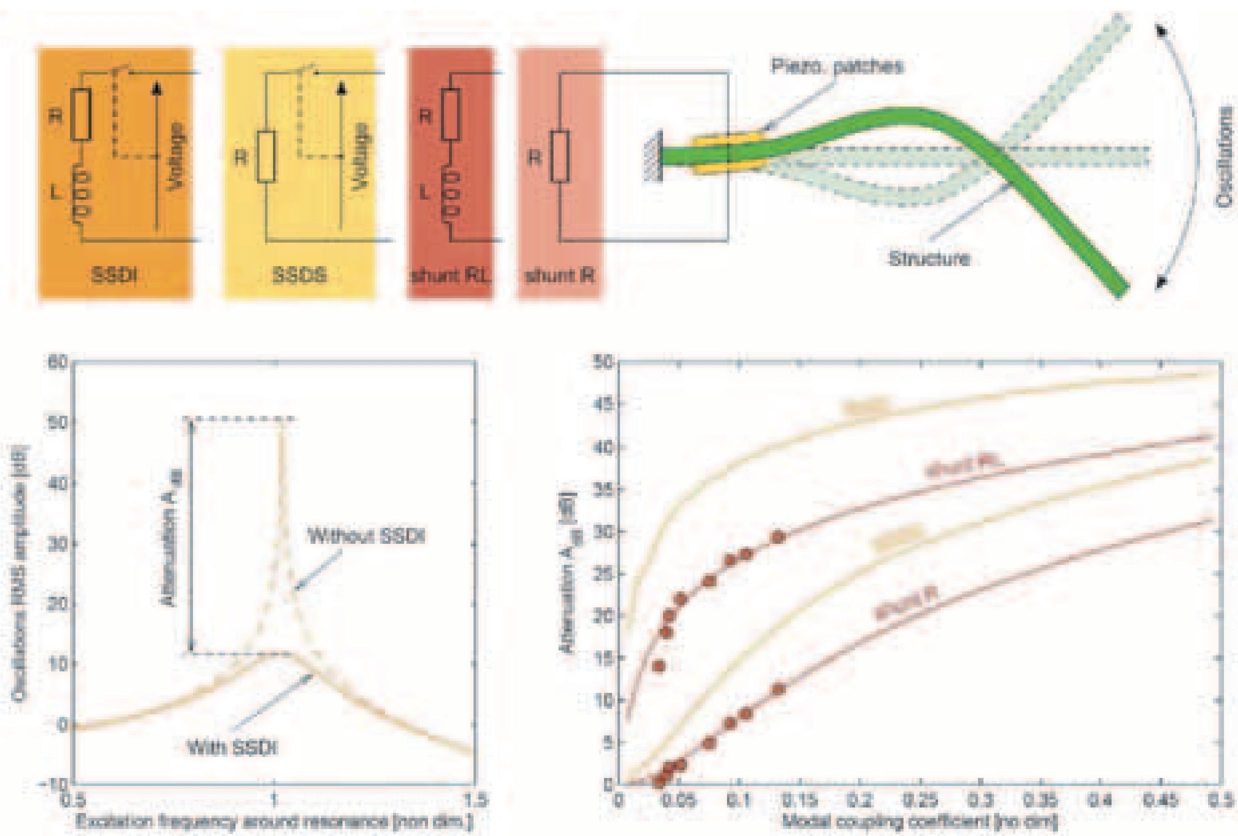


Figure 11: Oscillation amplitude attenuation by various shunt devices: theory (solid lines) and experiments (points)

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Professor Bernhard Schrefler awarded at CNAM

Professor Bernhard Schrefler from University of Padova, Italy, and chairman of 8th World Congress on Computational Mechanics (WCCM8) and the 5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008) held in Venice on 30 June - 4 July 2008, **has been distinguished the 19 January 2007 as *Chevalier dans l'Ordre des Palmes Académiques*** from the French Ministry of Research and Education.

The Palmes Académiques award was established by Napoléon in order to honour excellence in the academic world.

The official award ceremony took place in Paris, at the Structural Mechanics and Coupled Systems Laboratory of the Conservatoire National des Arts et Métiers. The medal has been presented to Professor Bernhard Schrefler by Professor Jean Salençon from the French Academy of Science.

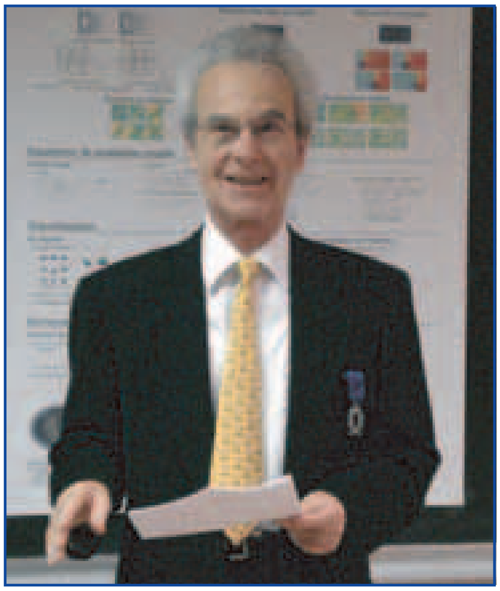

Figure 12:
Professor Bernhard Schrefler during his speaking of thanks

Figure 13:
From left to right: Professors Jean Salençon, Roger Ohayon and Bernhard Schrefler

A Break-Through Enhancement of FEM using Node-based Kriging Interpolation

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Simulation of physical phenomena is very useful and important both in academic researches and in industrial product designs. The underlying mathematical models of the simulation are usually so complex that it is very difficult or even impossible to obtain analytical solutions. Thus, numerical methods have become indispensable in simulations. Among various numerical techniques, the finite element method (FEM) has been widely used in industries. Its versatility and robustness have been tested by several decades of real engineering practices.

Motivated by the desire to minimize efforts in preparing finite element meshes, various mesh-free methods have been proposed. Their common advantages are as follows: (1) No element mesh is required for the construction of approximate functions; (2) High-order continuity of the approximate functions can be achieved; (3) Superior performance can normally be expected over the standard FEM. A detailed review of the methods is presented in [1-3].

Among countless mesh-free methods, we were interested in the methods of which formulation basis is the same as that of the FEM, *i.e.*, those employing a global Galerkin weak form. One earliest mesh-free method in this category is the element-free Galerkin methods (EFGM) presented by T. Belytschko *et al.* in 1994 [4], which is an improved version of the diffuse element method proposed by B. Nayroles *et al.* two years earlier [5]. The mesh-free character of the EFGM is made possible by the use of moving least-squares (MLS) approximant for the test and trial functions in the Galerkin weak form. The MLS approximation is essentially a least-squares *regression* with a local weighting function. Therefore, it is generally not passing through the data nodes. In other words, MLS shape functions do not possess the Kronecker delta property. Because of this, the enforcement of essential boundary conditions has been a major issue in the EFGM; a special constraint technique must be utilized to impose essential boundary conditions.

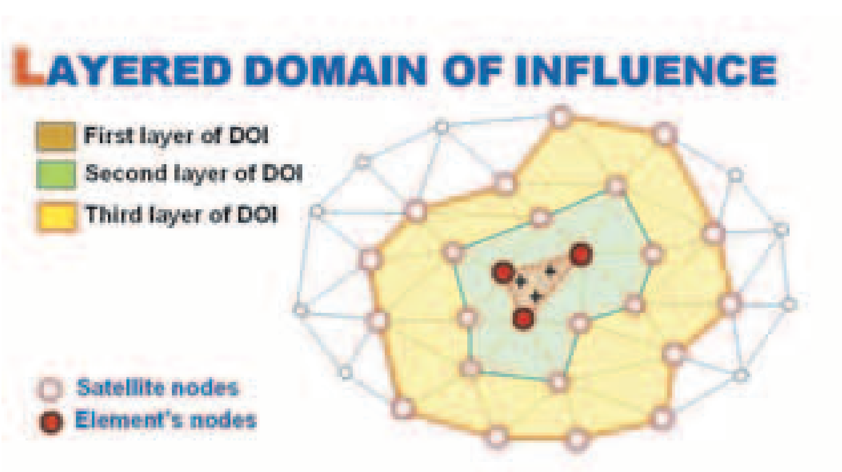


Figure 1: *Domain of influence for element E with one, two and three layers of element.*

In 2003, L. Gu [6] proposed an EFGM with moving Kriging (MK) interpolation to replace the MLS because of its two key properties: the Kronecker delta property and the consistency (polynomial reproducing) property. Following this work, P. Tongsuk and W. Kanok-Nukulchai [7] in 2004 found that, with the same number of nodes, the EFGM with MK interpolation consistently outperformed the original EFGM in terms of accuracy. A further application of the method to shell problems was presented by V. Sayakoummane and W. Kanok-Nukulchai [8] in 2007.

Even though EFGM is claimed to be "element free", a mesh of background cells, a term used to differentiate from "elements", is still needed for numerical integration. In problems dealing with material and geometric discontinuities, the need for a mesh to outline these discontinuities is practically unavoidable. Another disadvantage of the EFGM and its variants is the difficulty in their implementation based on existing general purpose FEM codes. Due to these inconveniences, their acceptance in real engineering practices seems to be unsatisfactory.

In 2005, K. Plengkhom and W. Kanok-Nukulchai [9] proposed a more convenient implementation of the EFGM with Kriging interpolation (KI). In their method, the field variables (trial and test functions) are approximated by "element-by-element" piecewise KI. For each element, KI is constructed from a set of nodes in its *domain of influence* (DOI) defined over surrounding layers of elements, as illustrated in *Figure 1*. Like FEM, elements are also used as subdomains for numerical integration. The method is named *Kriging-based FEM* (K-FEM). This variant of EFGM can be viewed as a generalization of FEM for which the influence of a node is not limited only to *hat functions*. In standard FEM, the element stiffness is exclusively influenced by its element nodes, whereas the element stiffness in K-FEM can also be influenced by *satellite nodes* not directly connected to the element. If we limit the DOI to only one element layer with no satellite nodes, K-FEM is then identical to the conventional FEM.

Kriging Interpolation

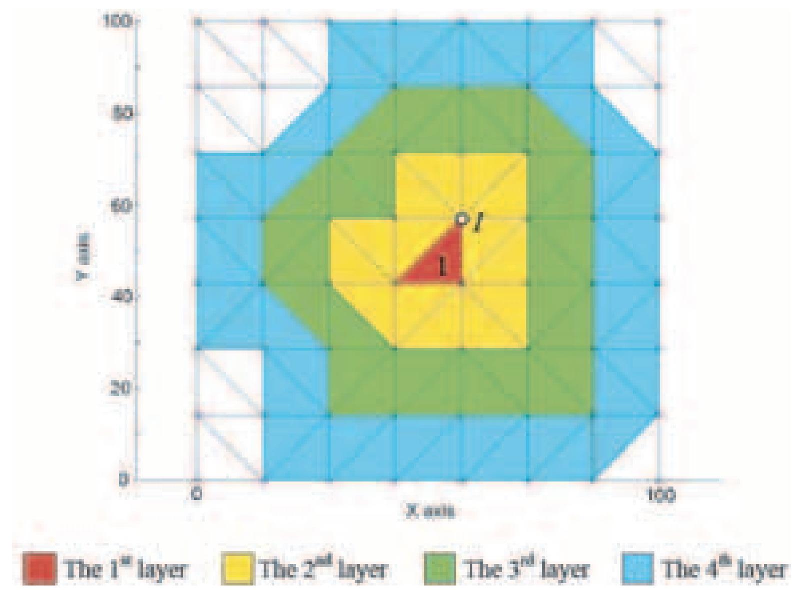
Named after Danie G. Krige, a South African mining engineer, Kriging is a well-known geostatistical technique for spatial data interpolation in geology and mining. Using this interpolation, unknown at any point can be interpolated from known values at scattered points in its specified neighborhood. The basic concepts of the KI in the context of K-FEM are presented in the following. A detail explanation and derivation of Kriging can be found in the geostatistics literatures (*e.g.* [10, 11]).

Consider a two-dimensional domain modeled by a mesh of triangular elements *(Figure 1)*. Suppose there is a single field variable over the domain, $u(\mathbf{x})$. For each element, the KI is constructed over a set of nodes in a sub-domain Ω_E ûΩ encompassing a predetermined number of layers of elements. The KI over sub-domain Ω_E can be expressed in the usual FE form, *i.e.*,$u^h(\mathbf{x})=\mathbf{N}(\mathbf{x})\mathbf{d}$, where $\mathbf{N}(\mathbf{x})$ is the 1xn matrix of Kriging shape functions and **d** is the 1xn matrix of field values at the nodes. In contrast to the FEM, here n is not necessarily only the number of nodes associated with the element, but also includes all its satellite nodes.

In Kriging formulation, the field variable $u(\mathbf{x})$, which is a deterministic function, is viewed as the realization of a random function $U(\mathbf{x})$. The shape function matrix can be expressed as $\mathbf{N}(\mathbf{x})=\boldsymbol{p}^T(\mathbf{x})\mathbf{A}+\mathbf{r}^T(\mathbf{x})\mathbf{B}$, where $\boldsymbol{p}^T(\mathbf{x})$ is the 1xm vector of m-terms-polynomial basis and $\mathbf{r}^T(\mathbf{x})$ is the 1xn vector of covariance associated with respective random function U at nodes i =1,…,n, and U at the point under consideration, **x**. Matrices $\mathbf{A}_{mxn}$ and $\mathbf{B}_{nxn}$ are defined as $\mathbf{A}=(\mathbf{P}^T\mathbf{R}^{-1}\mathbf{P})^{-1}\mathbf{P}^T\mathbf{R}^{-1}$ and $\mathbf{B}=\mathbf{R}^{-1}(\mathbf{I}-\mathbf{PA})$, in which $\mathbf{P}$ is the nxm matrix of polynomial values at the nodes in the DOI, $\mathbf{R}$ is the nxn matrix of covariance between $U(\mathbf{x})$ at a pair of nodes, and $\mathbf{I}$ is the nxn identity matrix.

From the above formulation, constructing Kriging shape functions requires a *polynomial basis* function and a *correlation function*. For the basis function, besides complete polynomial bases, it is also possible to use incomplete polynomial bases such as bi-linear, bi-quadratic and bi-cubic bases.
A widely used correlation function in the area of computational mechanics is the Gaussian correlation function [6-9]. This

Figure 2: Various layers of elements around Element 1 to illustrate a system of layered DOI in a square mesh of triangular elements.



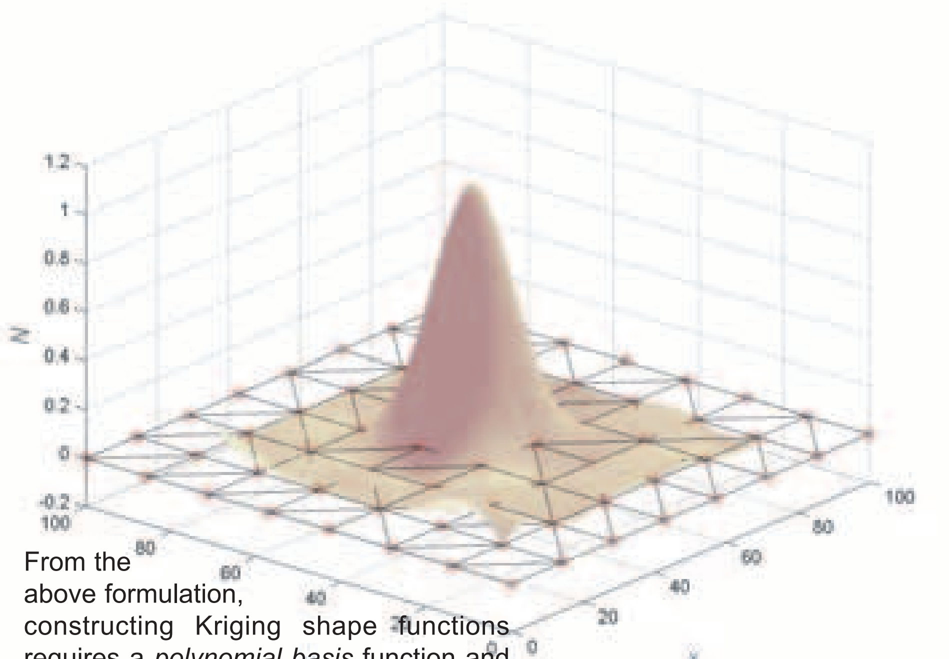
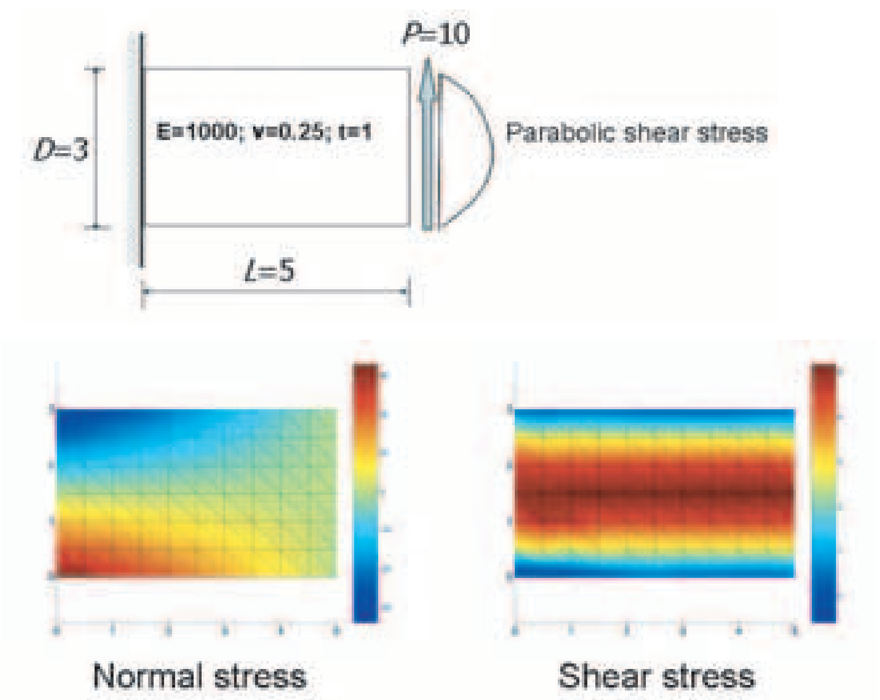


Figure 3: Kriging shape function corresponding to node I (in Figure 2) obtained using quadratic basis function, three element-layers, and quartic spline correlation function.

function contains an important parameter affecting the quality of KI, known as the correlation parameter θ. In order to obtain reasonable results in K-FEM, K. Plengkhom and W. Kanok-Nukulchai [9] suggested a criterion for choosing a stable range of θ. Recently the authors introduced a new correlation function [12] in the form of a quartic spline (QS) correlation function. Our studies indicate a superior performance of QS to the Gaussian correlation function, as the resulting Kriging shape functions are less sensitive to the change of θ.

To illustrate further the concept of element-layered DOI, consider a square domain as shown in *Figure 2*. Suppose that the element of interest is one of the triangular elements in the center, *i.e.* Element 1. The choices of DOI, comprising one up to four element layers, are shown in the figure. It is noted that the DOI does not have to be convex. If we use quadratic basis function (m=6) and choose to use three-layered DOI to construct KI over Element 1, the DOI will encompass 30 (n=30) nodes. The plot of Kriging shape function associated with node I, based on QS correlation function, is shown in *Figure 3*.

Figure 4:
Stress contours of cantilever plane-stress beam obtained by K-FEM with cubic basis function and three element layers of DOI.



Key Advantages of K-FEM

- **The stress field can be obtained with remarkable accuracy and global smoothness.**

Using the same mesh size, K-FEM yields a stress field with higher accuracy and better smoothness than that of the standard FEM. This is because one can freely adopt a higher-order basis function and a larger DOI for any fixed mesh. To show this, a cantilever plane-stress beam, *Figure 4,* under end parabolic shear is modeled with a crude mesh of 6x10 triangular elements. In the same figure, the quality of stress output obtained by K-FEM using cubic basis and three-layered DOI is demonstrated by the stress contours generated directly from nodal values with *no* post-processing manipulation. Like FEM, there is no guarantee for stress field to be perfectly continuous across the inter-element boundaries; however, the degree of discontinuity is found to be rather insignificant.

- **Solution refinements can be achieved with no re-meshing.**

In K-FEM, quality improvement of solutions can be achieved by:
(a) increasing the order of the basis function or p-refinement, or
(b) enlarging the element-layered DOI or l-refinement.

For illustration, the cantilever plane-stress beam is modeled with 3 mesh sizes, *i.e.*, with 6x10, 12x20 and 24x40 triangular elements. Each mesh is tested with linear (P1), quadratic (P2) and cubic (P3) polynomial basis functions. For P1, it is possible to use 1, 2 or 3 element layers for the DOI. However, at least 2 layers must be used for P2 and at least 3 layers for P3, following the general rule that the number of nodes covered in the DOI must not be fewer than the number of terms in the polynomial basis. Results of the end deflection, normalized by the exact solution, for all cases are presented in *Table 1* together with the corresponding computational times.

Accuracy performance and compu-tational times over the matrix of the h-refinement and the l-refinement, all using linear basis function, are presented in *Figure 5*. For relatively crude meshes, the accuracy can be enhanced by adopting a larger

DOI with more layers of elements. Almost the same accuracy can be achieved by *h*-refinement from 6x10 to 24x40 mesh sizes, or by *l*-refinement from 1 to 3 element layers. The latter requires about 20% more computational time. However for the case of *h*-refinement, we do not consider engineer's time for the remesh. A more detailed comparison of beam displacement profile between *h*-refinement and *l*-refinement is illustrated in *Figure 6*.

Accuracy performance and compu-tational times over the matrix for *h*-refinement and *p*-refinement, all using DOI of three element layers, are presented in *Figure 7*. From the figure, higher accuracy can be achieved for a fixed mesh by simply adopting a higher order basis function without significantly increasing the computing time.

h-refinement	*p*-refinement	*l*-refinement	Normalized solution	Time* (sec)
6x10	P1-Basis	1 (FEM)	0.928	1.22
		2 layers	0.979	6.86
		3 layers	0.986	23.17
	P2-Basis	2 layers	0.999	7.02
		3 layers	0.998	23.41
	P3-Basis	3 layers	1.000	23.69
12x20	P1-Basis	1 (FEM)	0.981	4.81
		2 layers	0.994	30.06
		3 layers	0.997	115.00
	P2-Basis	2 layers	1.000	30.20
		3 layers	1.000	116.45
	P3-Basis	3 layers	1.000	111.78
24x40	P1-Basis	1 (FEM)	0.995	19.34
		2 layers	0.998	134.92
		3 layers	0.999	527.44
	P2-Basis	2 layers	1.000	136.55
		3 layers	1.000	527.64
	P3-Basis	3 layers	1.000	531.36

* Note: Execution on Laptop PC with Core2 DuoT5200 processor, 1.6 GHz

Table 1:
Results obtained from K-FEM with different options for the plane-stress model of a cantilever beam

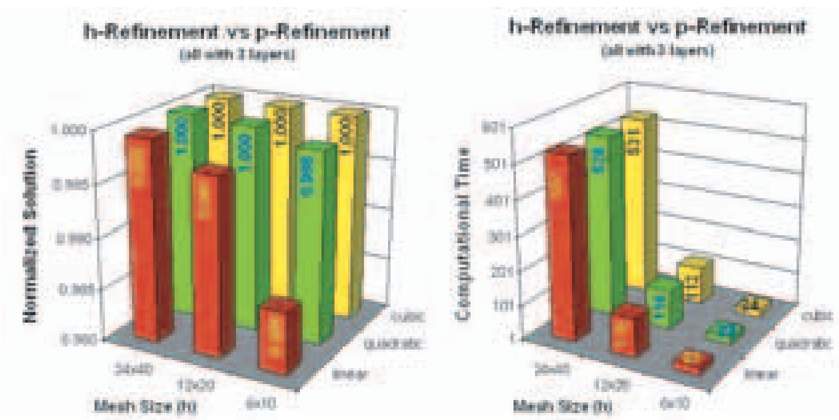


Figure 5:
Matrices of solution accuracy and computational times for h-refinement and l-refinement, all using linear basis function.

Geometry of curved domain can be represented more accurately by KI isoparametric mapping.

The same set of Kriging shape functions for field variable can be used to interpolate the geometric field. This is very useful for curved shell problems. To demonstrate this advantage, a cantilever quarter cylinder shell under pure bending is modeled by triangular elements as shown in *Figure 8*. K-FEM is used to solve the shell problem with quartic basis functions and a DOI of 4 element layers.

This shell problem will be tested for two different situations, one with and the other without isoparametric mapping. In the first case, the geometry of individual shell elements shall be interpolated by Kriging shape functions. In the latter case, the geometry of individual shell element is basically a flat facet. The results shown in *Figure 9* clearly confirm the advantage of the Kriging interpolated shell geometry.

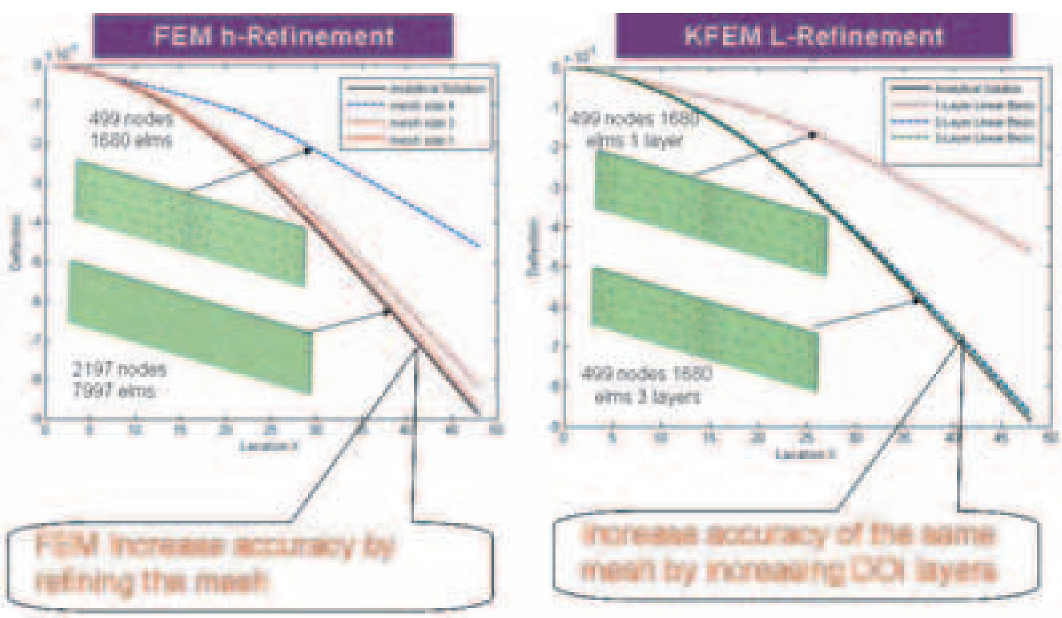


Figure 6:
Cantilever beam modeled by tetrahedral solid elements: comparison of h-refinement in FEM versus l-performance in KFEM using linear basis function

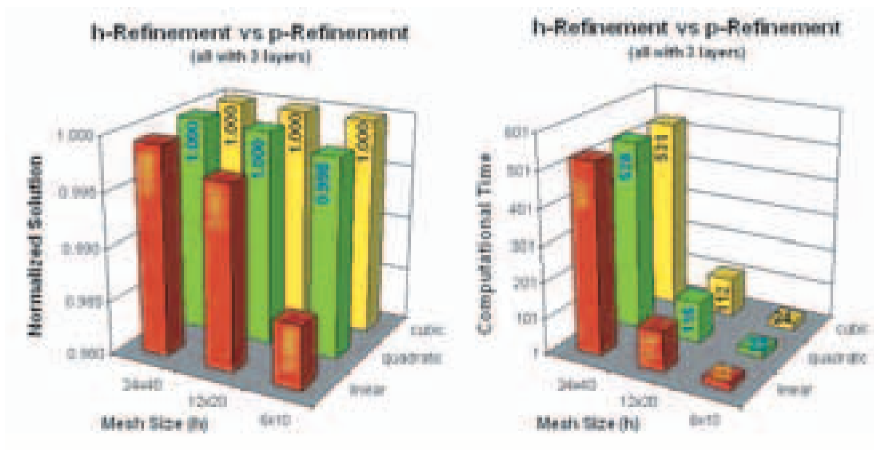


Figure 7:
Matrices of solution accuracy and computational times for h-refinement and p-refinement, all using three element layers DOI.

❍ **Implementation of K-FEM can be easily incorporated into existing FEM codes.**

As K-FEM inherits the computational procedure of FEM, existing general-purpose FE programs can be easily modified for this new concept. *Figure 10* shows the flow diagram of a typical FEM code extended for K-FEM.

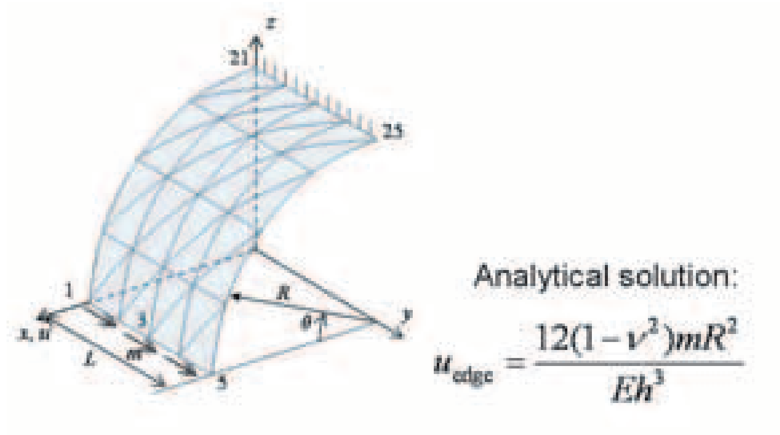


Figure 8:
A finite element model of cantilever cylindrical shell subjected to pure bending

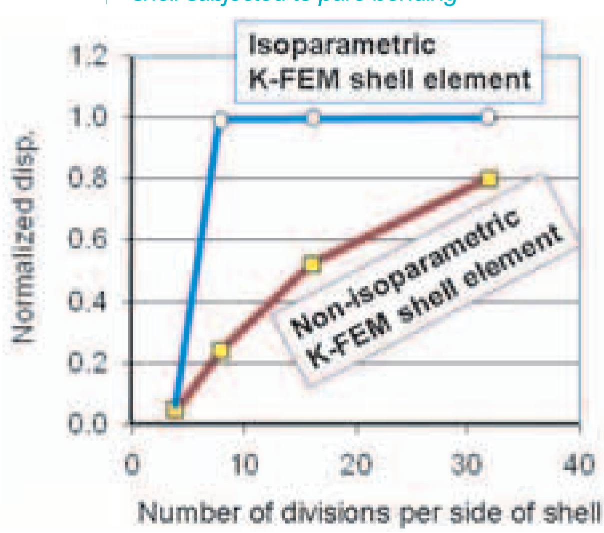


Figure 9:
Cantilever cylindrical shell: performances of isoparametric triangular K-FEM shell element (with shell surface generated by the same Kriging shape functions) versus non-isoparametric triangular K-FEM shell element (with flat shell surface interpolated exclusively from its own 3 nodes).

After the modification, the standard FEM becomes in fact a subclass of K-FEM. With this convenience, K-FEM has a high chance to be widely accepted in practice.

Final Remarks

The basic concept and the advantages of K-FEM have been described. The present method is as simple as the conventional FEM in terms of its implementation; yet it retains much of the advantages of mesh-free methods.

K.Y. Dai *et al.* [13] pointed out that the method using standard Galerkin weak form with KI is *nonconforming* and so is K-FEM. This means the elemental piecewise KI is not fully compatible across the inter-element boundaries. Its effect on the convergence was studied in the context of 2D elastostatic problems [14, 15]. It was found that K-FEM with appropriate choice of correlation function passes the weak patch test and therefore the convergence can be guaranteed.

One possible drawback of K-FEM is its excessive demand of the computational time, as Kriging shape functions are constructed element by element during the computation. Moreover, a larger DOI means a longer time for stiffness formation and for solving a system with larger average bandwidth. However under the current trend, the cost of running a FEM project is heavily weighted on the engineer's time for preparing meshes, rather than on the computational time.

Several investigations have been carried out successfully on different applications of K-FEM. Aside from plane elasticity problems [9, 16, 17], so far Kriging-based finite elements have been developed for degenerated solid beams, plates and shells [12, 18, 19].

The results confirmed that K-FEM is indeed a viable alternative to the conventional FEM and has great potential in engineering applications.
Future research may be directed at
(1) applications of K-FEM to nonlinear problems and
(2) improvement of its computational efficiency. ●

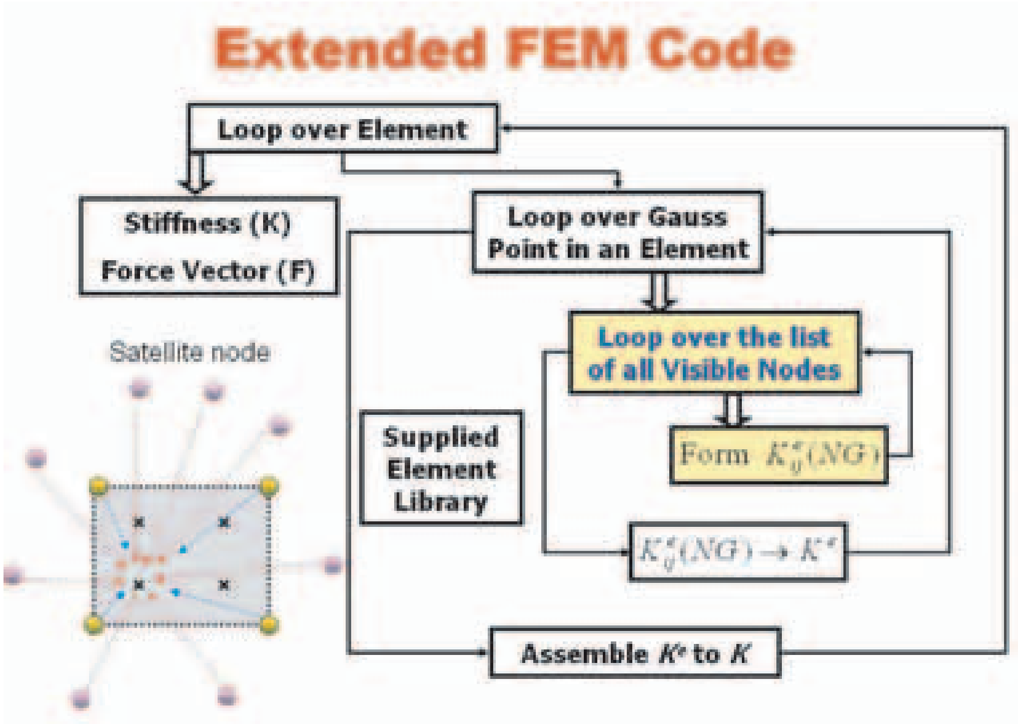


Figure 10:
Flow chart of a typical FEM code extended to include K-FEM. Note that only yellow boxes were modified from the standard FEM code.

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Highlights of Third APCOM in conjunction with Eleventh EPMESC

The **Third Asian-Pacific Congress on Computational Mechanics (APCOM'07)** in conjunction with the **Eleventh International Conference on the Enhancement and Promotion of Computational Methods in Engineering and Science (EPMESC XI)** was successfully held in **Kyoto, Japan**, during **December 3-6, 2007**.

Following the first congress (APCOM'01) held in Sydney in 2001, Asian- Pacific Association for Computational Mechanics (APACM) decided to hold the Asian-Pacific Congress every three years, which is in line with the other two regional congresses organized under the auspices of International Association for Computational Mechanics –US National Congress and European Congress. The second APCOM Congress (APCOM'04) was held in Beijing in conjunction with the Sixth World Congress on Computational Mechanics (WCCM VI). On the other hand, the first EPMESC Conference was held in Macao in 1985 and, thereafter, held alternately in Macao and a city in China. EPMESC has evolved from the conference title acronym for "Education, Practice and Promotion of Computational Methods in Engineering Using Small Computers" to "Enhancement and Promotion of Computational Methods in Engineering and Science".

Nearly 700 people from 33 countries around the world attended this Kyoto Congress. As the largest event held in the Asian-pacific region in the field of computational mechanics, the Congress offered 44 mini-symposia and 19 general sessions. Furthermore, one opening special lecture and 25 plenary lectures were presented by the most distinguished researchers around the world.

The financial support was received from Japan Society for the Promotion of Science, Commemorative Organization for the Japan World Exposition '70, JSME Computational Mechanics Division, the Japan Society for Computational Engineering and Science and other societies and companies in addition to 27 exhibitors from the academic and the commercial sectors. ●

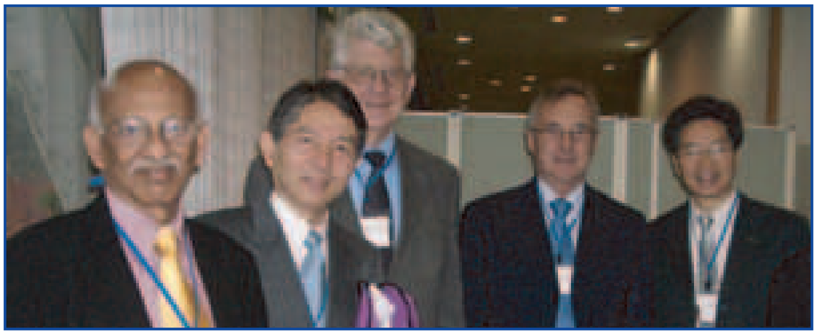

Figure 1:
S.Valliappan, G.Yagawa, H.Mang, R.Owen and G.R.Liu during a Coffee- break

Figure 2:
E.Oñate, Mrs Oñate, Mrs Yagawa, S.Valliappan, T.Kawai and G.Yagawa during the Banquet

Figure 3:
Members of the Congress Organizing Committee

Figure 4:
Participants at the Social Programme

APACM

the Asian Pacific Association for Computational Mechanics

APACM AWARDS 2007

awarded at the

Third Asian-Pacific Congress on Computational Mechanics (APCOM'07)

Congress Medal (Zienkiewicz Medal)
Genki Yagawa ***Japan***

Award for Computational Mechanics
Noriyuki Miyazaki ***Japan***

Award for Computational Mechanics
Takashi Yabe ***Japan***

Award for Computational Mechanics
S.K.Youn ***Korea***

Award for Young Investigators in Computational Mechanics
T. Adachi ***Japan***

Award for Young Investigators in Computational Mechanics
K.Y. Dai ***Singapore***

Award for Young Investigators in Computational Mechanics
K. Krabbenhoft ***Australia***

Award for Young Investigators in Computational Mechanics
M.B. Liu ***Singapore***

Award for Young Investigators in Computational Mechanics
D. Wang ***China***

Genki Yagawa

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ACMT

Recent Activities of

the Association of Computational Mechanics Taiwan ACMT

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The key members of the Association of Computational Mechanics Taiwan (ACMT) have been highly involved in organizing the following three events related to the computational mechanics.

The first is the Cross-Strait Conference on Computational Mechanics, to be held on **August 25-26, 2008** at the National Taiwan University (NTU). The conference is called "**Cross-Strait"** in the sense that only participants from China and Taiwan are invited for attendance. A delegation composed of about 20 scholars from universities in China will attend this conference, headed by Prof. Mingwu Yuan, Vice President, Chinese Association of Computational Mechanics. Roughly the same number of participants will represent the Taiwan side, under the arrangement of Prof. Y. B. Yang of the NTU, also Chairman of ACMT.

The second event is the **Taiwan-Austria Joint Workshop on Computational Mechanics of Materials and Structures,** scheduled for **November 16-17, 2008**. One key function of this workshop is to offer a forum for presentation of undergoing researches in each side, and to seek for the areas of common interest for future cooperation. The Taiwan and Austria delegations respectively are led by Prof. Y. B. Yang of the NTU and Prof. Herbert Mang of the Vienna University of Technology (VUT). Ten delegates coming from the VUT, University of Innsbruck, and University of Linz of Austria will attend this meeting. As the counterpart, twelve participants from major universities in Taiwan are invited to attend this workshop.

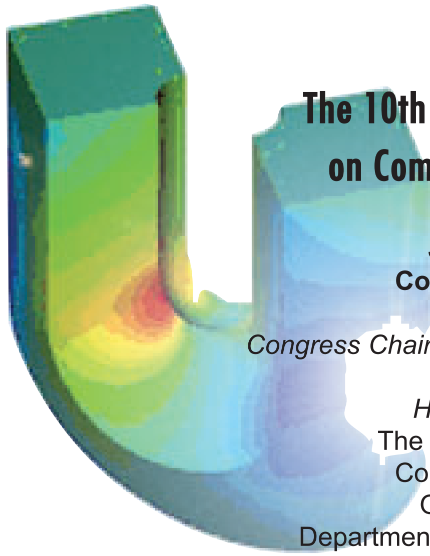
The third event is the **Eleventh East Asia-Pacific Conference on Structural Engineering and Construction (EASEC-11)**, to be held on **November 19-21, 2008** at the Taipei International Conventional Center. The main theme of this conference is "Building a Sustainable Environment". This is one of the biggest events that have been regularly held in the Asia-Pacific in the past twenty years for the scope specified. The total number of participants is expected to be over 450. There will be a memorial session for the late Prof. Fumio Nishino of the University of Tokyo, a key founder of the EASEC conference.

The keynote speakers for this conference include:
Prof. Herbert Mang, Vienna University of Technology, Austria,
Prof. Wai-Fah Chen, University of Hawaii at Manoa, U.S.A.,
Prof. Yozo Fujino, University of Tokyo, Japan,
Prof. Chang-Koon Choi, Korea Advanced Institute of Science and Technology, Korea,
Prof. Norden E. Huang, National Central University, Taiwan, and
Prof. S. Kitipornchai, City University of Hong Kong.

EASEC-11
East Asia-Pacific Conference on Structural Engineering and Construction
November 19-21, 2008 - Taipei

http://usnccm-10.eng.ohio-state.edu

Invitation to Participate in



USNCCM X

The 10th U.S. National Congress on Computational Mechanics

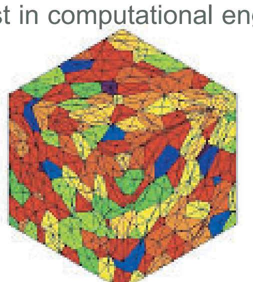
July 16-19, 2009
Columbus, Ohio USA

Congress Chairman: Professor Somnath Ghosh

Host and Sponsors:
The Ohio State University
College of Engineering
Office of Research
Department of Mechanical Engineering

Congress Mission

The U.S. National Congress of Computational Mechanics has been the biennial congress of the U.S. Association for Computational Mechanics (USACM) since 1991. Hosted by The Ohio State University, the 10th U.S. National Congress of Computational Mechanics (USNCCM-X) will be held in Columbus, Ohio in July 2009. It will provide a forum for researchers and practitioners from academia, industry, government and laboratories all over the world to discuss the latest advancements and future directions in fields pertaining to computational engineering and sciences. The Congress will feature the theme "Multi-disciplinary Computational Modeling in Engineering and Sciences," transcending traditional boundaries of computational mechanics to encompass a wide range of multi-disciplinary topics, including nanotechnology, materials, manufacturing, bioengineering and high-performance computing. Plenary lectures, mini-symposia with keynote lectures and regular presentations, poster sessions for students, and product display by various industries and software companies will be the Congress highlights. In addition, pre- and post-conference short courses will address advances in current topics of interest in computational engineering and sciences.

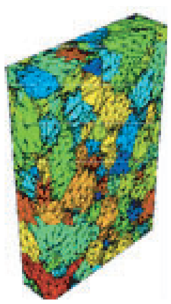


Important Dates

Congress Events: July 16-19, 2009
Pre-Congress Short Course: July 15, 2009
Post-Congress Short Course: July 19, 2009

Congress Location

USNCCM-X will be held at the Greater Columbus Convention Center (www.columbusconventions.com), located 2.5 miles south of the Ohio State campus (www.osu.edu), one of the country's largest research universities. The Convention Center is centrally located and accessible from the Columbus airport and all major highways and is steps away from shopping, nightclubs, restaurants and entertainment.



USNCCM X Secretariat

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ABMEC New Executive and Advisory Board Take Office

The new Executive Board and the renewed Advisory Board of ABMEC took office last March. The Boards were elected at the gathering of the General Assembly of the Brazilian Association for Computational Methods in Engineering that took place in Porto, Portugal during the CMNE/CILAMCE 2007 (**http://numiform.inegi.up.pt/CMNE/**). The new Executive Board, elected for a two years term from 06/03/2008 to 05/03/2010, is composed of:
President: *Prof. José Luis Drummond Alves*, (COPPE/UFRJ);
Vice-President: *Prof. Estevam Barbosa de Las Casas* (UFMG);
1st Secretary: *Prof. Sérgio Scheer* (CESEC/UFPR);
2nd Secertary: Prof. Severino Pereira Cavalcanti Marques (EES/CTEC/UFAL) and Treasurer: *Prof. Sandra Mara Cardoso Malta* (LNCC/MCT).
Prof. *Agustín Juan Ferrante* is the Honorary President of ABMEC.

Effective members of the Advisory Board for the term from 06/03/2006 to 05/03/2010 are professors: *Abimael Fernando Dourado Loula* (LNCC), *Alvaro Luiz Gayoso de Azeredo Coutinho* (COPPE/UFRJ), *Guillermo Juan Creus* (UFRGS), *Marcio Arab Murad* (LNCC) and *Phillipe Remy Bernard Devloo* (UNICAMP). Their substititutes are professors: *Armando Miguel Awruch* (UFRGS); *Eduardo Morais Rego Fairbairn* (COPPE/UFRJ); *João Luis Filgueiras Azevedo* (IAE-CTA); *João Nisan Correia Guerreiro* (LNCC/MCT) and *Nelson Francisco Favilla Ebecken* (COPPE-UFRJ).

Effective member of the Advisory Board for the term from 06/03/2008 to 05/03/2012 are professors: *Eduardo Fairbairn* (UFRJ); *Hélio José Corr□a Barbosa* (LNCC/MCT); *Luis Paulo da Silva Barra* (UFJF); *Paulo Matos Pimenta* (USP) and *Paulo Roberto Maciel Lyra* (UFPE). Substitute member: *Prof. Gray Farias Moita* (CEFET-MG). ●

ABMEC Proposal for X WCCM

Brazil - 2012

The Brazilian Association of Computational Methods in Engineering (ABMEC) has presented to the IACM its proposal for hosting the 10th World Congress on Computational Mechanics (X WCCM) in Sao Paulo and is waiting for the deliberation by the executive committee. ABMEC's bid has institutional support from the University of Sao Paulo (USP), the State University of Campinas (UNICAMP) and the Federal University of Rio de Janeiro (UFRJ).

ABMEC has also received full support from the Federal Ministry of Tourism, from the National Council for Scientific and Technological Development (CNPq), from the Governor of the State of Sao Paulo, from the Mayor of the City of Sao Paulo and from the Foundation for Research of the State of Sao Paulo (FAPESP).

Sao Paulo is the world's second largest city, has world class facilities and an unparalleled track record in hosting large national and international events.
It also offers a magnificent cultural life, splendorous museums, beautiful beaches and state parks within a small distance. Sao Paulo is the hub of technology, education, trade, finance, shopping and gastronomy in Brazil and boasts some of the top universities within the country. ●

by Prof. Paulo Pimenta, USP

Forthcoming Events

SIMMEC 2008

Symposium on Computational Mechanics, **June 25 to 27**, at Pontifical University of Minas Gerais, PUC-Minas, in Belo Horizonte, MG. Organizing committee: Prof. Jánes Landre Jr. (PUC-Minas, chairman) Prof. Cristiana Brasil Maia (PUC Minas), Prof. Estevam B. de Las Casas (UFMG), Prof. Gray Farias Moita (CEFET-MG), Prof. Marcelo Becker (PUC Minas)
Prof. Yukio Shigaki (PUC Minas), website at **http://www.pucminas.br/simmec/** ●

ENEBI 2009

The 2nd National Meeting on Biomechanical Engineering, on dates to be announced, in Florianópolis, SC, 2009. ●

CILAMCE2008

The XXIX Iberian Latin American Congress on Computational Methods in Engineering

The 29th edition will be held in Maceió, Alagoas, Brasil, **4th to 7th of November 2008.** It is being organized by the Federal University of Alagoas (UFAL). The organizing committee consists of:
Eduardo Setton. S. da Silveira, as Co-Chairmen, Adeildo S. Ramos Jr., Eduardo N. Lages, Viviane C. L. Ramos and William W. M. Lira, as members.

The congress will be held at the Convention and Exhibition Center, in the beautiful city of Maceió, capital of the State of Alagoas (AL), Brazil. Maceió is famous for its beaches, seafood and folk expressions, being a very attractive tourist city in the northeast region with a lively nightlife.

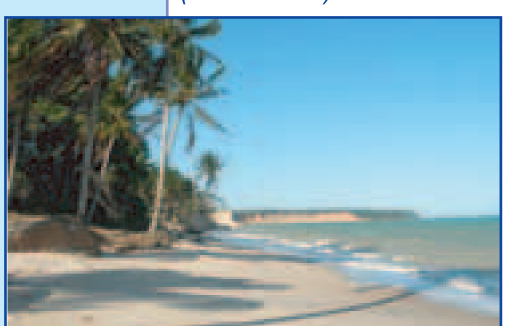
Relevant Dates:
Full paper submission: July 30th, 2008;
Full paper acceptance notification: August 30th, 2008;
Author Registration: September 15th, 2008;
Congress: November 04 to 07, 2008.

The **CILAMCE 2008** will be organized in a set of mini-symposia covering a vast range of multidisciplinary subjects on computational methods in engineering and applied sciences. The scientific program of the Congress consists of invited plenary lectures and invited mini-symposia keynote lectures by respected experts, contributed papers and poster presentations by under-graduated students.
The Organizing Committee has invited major researchers and scientists for the Plenary Conferences. Confirmed lecturers are:
Álvaro Maia da Costa - Petróleo Brasileiro S/A - PETROBRAS, Brazil.
Estevam Barbosa de Las Casas - Universidade Federal de Minas Gerais, Brazil.
Eugenio Oñate - Universitat Politècnica de Catalunya (UPC), Spain.
Gláucio Hermógenes Paulino - University of Illinois at Urbana-Champaign, USA.
Graham F. Carey - The University of Texas, Austin, USA.
Luiz Fernando Ramos Martha - Pontifícia Universidade Católica, Brazil.
Marek-Jerzy Pindera - The University of Virginia, USA.

The conference will cover a vast range of classical and new themes on computational modeling and simulation, from theoretical to application.

For further information: **www.acquacon.com.br/cilamce2008** or send an e-mail to **cilamce2008@acquacon.com.br**. ●

Figure 1: Beach of the "Carro Quebrado" (Broken Car)



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ibb.uni-stuttgart.de
http://www.gacm.de

Recent Initiatives for Promotion of Young Scientists in Germany

The traditional system in German universities did not know the position of an Assistant Professor. Associate and Full Professors have been hired directly from a postdoc position or from practice. They automatically got tenure once they had been appointed. This procedure makes a lot of sense in those areas, where a person leaves the academic world for a couple of years in order to gain experiences in practice. However, no independent career could be started in disciplines in which a young scientist decided to start a career in academia.

In the mean time quite a few new programs for young scientists have been implemented in German universities. The position of an Assistant Professor, called Junior Professor, has been introduced, unfortunately not all of them in conjunction with tenure though. In addition special postdoc positions have been established where the young scientist gets his or her own infrastructure, for example PhD grants and a decent budget. The main purpose of this initiative is that the young researcher gains early academic independence. In particular the German Science Foundation DFG has been very instrumental in this process and offers different programs, see for example the Independent Junior Research Group in connection with a Collaborative Research Center or the Emmy-Noether Program exactly designed for young researchers "to trade on their own account", see homepage of DFG:

http://www.dfg.de/en/research_funding/programmes_at_a_glance.html

The success of these highly appreciated initiatives depends on the situation whether or not enough tenured professor positions for young scientists are offered, hopefully avoiding a critical bottleneck.

This is a serious issue currently discussed in the German scientific community.

Ekkehard Ramm

Figure 1: *One of the new initiatives by the DFG to promote young German scientists is named after the German mathematician and physicist Emmy Noether (1882 - 1935)*

- Master of Science in Computational Mechanics -

An overview of international master programs with relation to computational mechanics at German universities

Long before the so-called Bologna process initiated the replacement of the classical German diploma by the bachelor and master system various universities had already implemented programs to attract international students to obtain a master of science in computational mechanics or related disciplines.

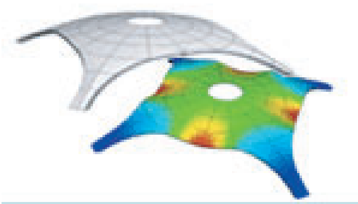
In the following, a brief overview of such master degree programs is given. The duration is usually 2 years, starting in winter term each year. The focus of this list is on courses at *universities*, *taught in English*, emphasizing *computational mechanics* rather than computer science or engineering in general. It is of course impossible to list all related programs implemented today and the author apologizes in advance for any omission.

Computational Mechanics, Munich
Technische Universität München
Science oriented, extra track "with honors"
http://www.come.tum.de/cms/

Computational Mechanics of Materials and Structures, Stuttgart
Universität Stuttgart
Science oriented and interdisciplinary, including contributions from civil, mechanical and aeronautical engineering as well as mathematics and natural sciences.
http://www.msc.commas.uni-stuttgart.de/

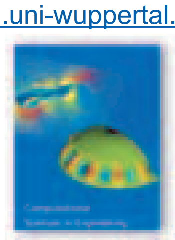
Computational Mechanics, Duisburg-Essen
Universität Duisburg-Essen
Interdisciplinary, cross-linking numerical concepts and experiments. Lectures in English (first year) and German (second year), knowledge of German language required.
http://www.uni-due.de/computationalmechanics

Simulation Techniques in Mechanical Engineering, Aachen
Rheinisch-Westfälische-Technische Hochschule Aachen
Application oriented, including a two-month industrial internship
http://venus.iam.rwth-aachen.de/Master/



Computational Engineering, Bochum
Ruhr-Universität Bochum
Run by the Department of Civil Engineering, including solid and fluid mechanics as well as environmental aspects
http://www.ruhr-uni-bochum.de/comp-eng

Computational Mechanical Engineering, Wuppertal
Bergische Universität Wuppertal
Run by the Department of Architecture, Civil Engineering, Mechanical Engineering and Safety Engineering.
http://mbau.uni-wuppertal.de/index.php?id=66



Computational Sciences in Engineering, Braunschweig
Technische Universität Braunschweig
Combining civil, mechanical and electrical engineering with mathematics and computer science.
http://www.tu-braunschweig.de/cse

- ENIEF 2008 -
Call for papers

For all inclusions under AMCA please contact:

Victorio Sonzogni
Güemes 3450
3000 Santa Fe
Argentina

Tel: 54-342-451 15 94
Fax: 54-342-455 09 44
Email:
sonzogni@intec.unl.edu.ar
http://amcaonline.org.ar

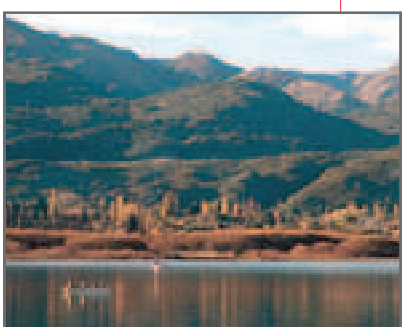
The **Argentine Association for Computational Mechanics** (AMCA) is proud to announce the next **XVII Congress on Numerical Methods and their Applications ENIEF 2008**, to be held at San Luis, Argentina, on **November 10-13, 2008**. In this occasion, the Congress is organized jointly by the Department of Mathematics of the National University of San Luis, Argentina, and the International Center for Computational Methods in Engineering (CIMEC), from INTEC (UNL-CONICET), Santa Fe, Argentina.

The Congress will take place in the very peaceful and beautiful environment of city of San Luis, Argentina, located at the bottom of the "Sierras Grandes", over the "Chorrillo" river, and at the "Punta de los Venados" extreme. The first ENIEF Congress took place in 1983. Since then, sixteen ENIEF and eight MECOM (Argentine Congress on Computational Mechanics) congresses have been organized by AMCA.

The Congress topics include the development and application of numerical methods to solve engineering problems, including topics as: Fluid mechanics; Turbulence; Heat and mass transfer; Solid mechanics; Fracture mechanics; Structural analysis; Multiphysics problems; Multiscale modeling; Biomechanics; Algorithms and software development; Computational mathematics; Mesh generation and error estimation; High performance computing; Innovative computational methods; Inverse problems and optimization; Industrial applications

Researchers and professionals from all along the country, as well as from Latin American countries (Brazil, Chile, Uruguay, Venezuela) regularly participate in ENIEF congresses. This time, the following renowned specialists have confirmed their participation and will give Plenary Lectures at the Congress:

Prof. Ted Belytschko (*Northwestern University, USA*) "Multiscale analysis of Failure".
Prof. Carlos Felippa (*University of Colorado at Boulder, USA*) "Recent Advances in Multiphysics Simulation using Partition Methods"
Prof. Rainald Lohner (*George Mason University, USA*) "Patient-Specific Device Optimization"
Prof. Alan Needleman (*Brown University, USA*) "Discrete Dislocation Modeling of Plastic Flow Processes"
Prof. Xavier Oliver (*Universitat Politécnica de Catalunya, Spain*)"The New Domain Method for Contact Problems in Solid Mechanics"
Prof. Peter Wriggers (*Leibniz Universitat Hannover, Germany*) "On Micro-Macro Simulations for the Characterization of Heterogeneous Materials"


San Luis, Argentina

The deadline for presenting a one-page abstract is April 30, 2008. The full length paper should be submitted before July 31, 2008. Conference proceedings are published in the book series "Mecánica Computational" edited by AMCA, which is in its twenty-seventh volume. This series is also published on-line. For more information, please look at **http://www.cimec.org.ar/enief2008**, or **http://enief2008.unsl.edu.ar**, for local organization details. You can also contact the organizers e-mail: **enief2008@intec.unl.edu.ar**. ●

- AMCA Awards 2008 -

The Argentine Association for Computational Mechanics call for nominations to the AMCA Awards 2008.These awards have been instituted as recognition of scientific careers in the field of computational mechanics and are granted in three categories:
i) Young Researchers; ii) Scientific, Professional and Teaching Career; and iii) International Scientific Career.
Candidates to the awards may be nominated:
1) By self-nomination; 2) By third party or institutions; 3) By any member of the Award Committee

In any case a short CV and reasons for the nomination should be addressed to the AMCA Secretary, before July 31 2008.The AMCA Awards will be delivered at the ENIEF 2008 Congress in San Luis, Argentina, 10-13 November 2008. ●

One and a half years without Pat.

Homage to Patricio A. A. Laura: 1935-2006

In our academic and research activities into the field of Mechanical Sciences, and for every body that had the happiness of being a friend, a student or a colleague of Patricio Adolfo Antonio Laura (Pat), Ph. D., his absence since one and half years continue being of great sadness.

Prof. Laura, an internationally recognized researcher and professor in the area of Mechanical Sciences died on November 6 of 2006. He was born in Lincoln, Buenos Aires Province, Argentina on June 13, 1935. He graduated as Civil Engineer at the Universidad de Buenos Aires in 1959. He pursued graduate studies in the United States at the Catholic University of America where he got his Ph. D. degree in 1965. In 1962, he joined the Mechanical Engineering Faculty of Catholic University. He began as an Instructor and eight years later he became Professor. He returned to Argentina in 1970 as Professor in the Department of Engineering of the Universidad Nacional del Sur, where he was nominated Professor Emeritus in 2001.

Prof. Laura´s publications (over 600 among Papers, Technical Notes and Letter to the Editors) has been cited by prominent authors from U.S.A., England, Russia, etc. His contributions covered several fields of Mechanical Sciences: Mechanical vibrations; dynamics of cable systems; structural dynamics; eigenvalue problems (microwave theory), acoustics, heat conduction, thermoelasticity, variational methods, approximate methods of conformal mapping, bioengineering, buckling of structural elements, acoustic emission in mechanical cables. Among his books, it is worthy of mention "Conformal mapping: Methods and applications" which he coauthored with Professor Roland Schinzinger of the University of California at Irvine. The book was published by Elsevier in 1991 and reissued by Dover Publications in 2003.

He directed several Doctoral and Master´s thesis in U.S.A. and Argentina. He was a Fellow and Founding Member of the American Academy of Mechanics (USA) and Fellow Emeritus of The Acoustical Society of America (USA), Miembro Académico at the Academia Nacional de Ingeniería (Argentina), Académico Correspondiente at Academia Nacional de Ciencias Exactas, Físicas y Naturales (Argentina) and at Academia Nacional de Ciencias (Córdoba, Argentina). Along his scientific path, Prof. Laura integrated many Editorial Boards in scientific publications.

At the moment of his death , he was Associate Editor Emeritus of Ocean Engineering and member of the Editorial Board of Journal of Sound and Vibration, Acta Mechanica, International Journal of Mechanical Sciences, Structural Engineering and Mechanics and Structural Health Monitoring.

Patricio A. A. Laura: 1935-2006

Those of us who have had the privilege of being Prof. Laura´s pupils and friends for many years shall never forget his persistence and determination, his infectious enthusiasm for every achievement no matter how small and above all his deep insight in scientific and philosophical matters.

Prof. Laura leaves behind his wonderful wife, Yiyi, five children, fifteen grandchildren and so many pupils and friends who will ever remember him with affection and respect.
I had the honour and happiness of being a student, a colleague, and a friend of Prof. Laura, but more than these, he was for myself an example of life. ●

Dr. Gustavo Sánchez Sarmiento
Professor, Universidad de Buenos Aires.

Sergio Idelsohn

Sergio Idelsohn received the Scopus Award 2007

Scopus, the world wide data base of scientific literature, recognized eight researchers of Argentina. These awards have been granted in 2006 and 2007 in Brazil; and in 2007 in Mexico, Colombia, Venezuela and Argentina. The selection criteria identify researchers based on the numbers of articles indexed by Scopus and the number of citations in the last 10 years. The ceremony took place on October 11, 2007 in Buenos Aires jointly organized by Elsevier and the Secretary for Science, Technology and Productive Innovation of Argentina. The former president of AMCA, Sergio Idelsohn was one of the eight Argentine researchers which received the Scopus Award.

It is a great honor for AMCA to have Sergio Idelsohn within the eight recognized researchers. It is important also to see reflected in this award the improving activity in the field of the computational mechanics developed in the country. ●

– ECCOMAS Multidisciplinary Jubilee Symposium –

New Computational Challenges in Materials, Structures, and Fluids

Vienna 18 - 20 February 2008

Founded in 1993, the **European Community on Computational Methods in Applied Sciences (ECCOMAS)** is a relatively young organization grouping European associations engaged in the development and application of computational methods in science and technology. The missio of ECCOMAS is to encourage the exchange of information and to enable the transfer of knowledge between research and industry on the European scale. Main fields of interest are the application of mathematical and computational methods to major areas such as fluid dynamics, structural mechanics, semiconductor modelling, electromagnetism, etc.

To believe that 15 years of existence of ECCOMAS was the sole reason for organizing the ECCOMAS Multidisciplinary Jubilee Symposium in the form of a meeting of invited elite scientists in the wide research area to which ECCOMAS is committed would be overly simplistic. The main purpose of this Symposium was to accentuate the political intention of and the strong desire within the European Community to support research in the field of Computational Methods in the Applied Sciences, in a multidisciplinary setting, and to disseminate research results in this field in and outside Europe.

The Local Organizing Committee, consisting of Profs. Josef Eberhardsteiner, Christian Hellmich, and Herbert Mang, and the Conference Secretary Martina Pöll, could welcome nearly 50 participants to the Symposium, including representatives of the European Commission, not forgetting several young scientists. The International Organizing Committee of the Symposium was unusually small. It consisted of the three former presidents of ECCOMAS, Profs. Jacques Periaux, Oskar Mahrenholtz, and Eugenio Onate. They have contributed significantly to realize the vision of a European organization in the area of Computational Methods in Applied Sciences as a spearhead of modern technology-driven research. In the Editorial of the 15 Years Jubilee Issue of the ECCOMAS Newsletter tribute was paid to them.

Irrespective of its European focus, ECCOMAS is a global player in the field of Computational Methods in the Applied Sciences, as was reflected by the participation of distinguished colleagues from overseas in the Jubilee Symposium. In passing, it should be mentioned that the global dimension of ECCOMAS is also reflected by the joint organization of the 5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008) and the 8th World Congress on Computational Mechanics (WCCM8), which will take place in Venice-Lido from June 30 to July 5, 2008.

In my editorial in the last but one ECCOMAS Newsletter I wrote, with reference to the Jubilee Symposium, among other things: "Solutions of complex problems in engineering and in the applied sciences call for efficient interdisciplinary research activities". Successful interdisciplinary research work not only requires profound monodisciplinary expertise of each one of the cooperating partners but also basic knowledge of the disciplines of the partners. This is indispensable for mutual understanding and joint progress."

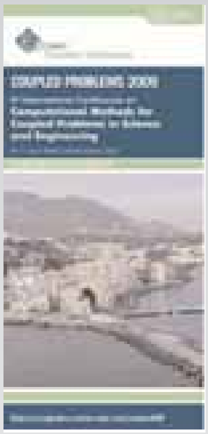
Excellent presentations of a variety of challenging multidisciplinary problems permit to say that the ECCOMAS Multidisciplinary Jubilee Symposium has lived up to expectations. The Symposium was the proper place to remember important milestones along the way of ECCOMAS from adolescence to adulthood.

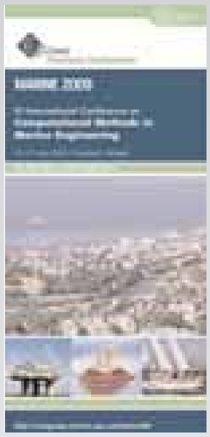
It was also the appropriate place to express sincere thanks to the ECCOMAS Founding Fathers. Not the least it was a meeting place with representatives of the European Commission. The Social Program contributed to the success of a scientific premiére within ECCOMAS. ●

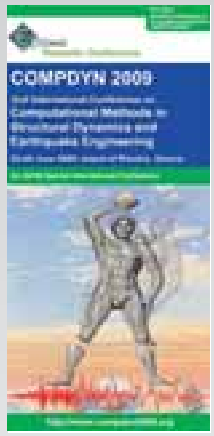
by
Herbert A. Mang
President of ECCOMAS
Vienna University of Technology, Austria

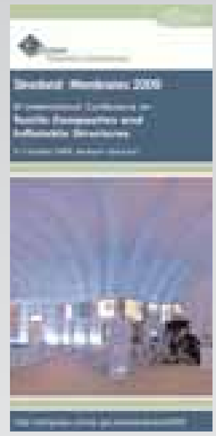
Thematic Conferences 2009

ECCOMAS organizes in Europe Thematic Conferences and Workshops in state of the art and emerging topics in computational engineering and applied sciences in cooperation with universities, research centers and industry. Previous Thematic Conferences of ECCOMAS were held in 2003 (7 conferences), 2005 (15 conferences) and 2007 (24 conferences). A total of 21 ECCOMAS Thematic Conferences are already planned for 2009. For details of new and past Thematic Conferences visit the web address of each conference or **www.eccomas.org**









KOMPLASTECH 2009
International Conference on Computer Methods in Materials Science
January 11-14, 2009, Krakow-Krynica Zdroj, Poland

SEDUREC 2009
Symposium on Safety and Durability of Materials and Constructions
February 25-27, 2008, Barcelona, Spain

WPTFF 2009
High Order Non-oscilatory Methods for Wave Propagation, Transport and Fluid Flow,
30 march -2 April 2009, Trento, Italy

ATOM2 Part 2009
From the Atom to the Part: Models and Computational Methods
February 2009, Cambridge, UK

COMPOSITES 2009
International Conference on Mechanics Response of Composites
April 1 - 3, 2009, London, UK

IPM 2009
International Conference on Inverse Problems in Mechanics of Structure and Materials
April 23-25, 2009, Lancut-Rzeszow, Poland

ADMOS 2009
International Conference on Adaptive Modeling and Simulation
May 25 - 27, 2009, Belgium, Brussels

COUPLED PROBLEMS 2009
International Conference on Computational Methods for Coupled Problems in Science and Engineering
June 8 - 11, 2009, Ischia, Italy

MARINE 2009
International Conference on Computational Methods in Marine Engineering
June 15 - 17, 2009, Trondheim, Norway

EUROGEN 2009
International Conference on Evolutionary and Deterministic Methods for Design, Optimization and Control with Applications to Industrial and Societal Problems
June 15-17, 2009, Cracow, Poland

COMPDYN 2009
International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering
June 17 - 19, 2009, Island of Rhodes, Greece

CMAS 2009
International Conference on Computational Methods in Applied Sciences
June 30 – July 3, 2009, Bratislava, Slovakia

MULTIBODY DYNAMICS 2009
International Conference on Multibody Dynamics
June/July 2009, Warsaw, Poland
International Conference on Tissue Engineering
July 2-4, 2009, Leiria, Portugal

SMART STRUCTURES 09
International Conference on Smart Structures and Materials
July 20 - 22, 2009, Porto, Portugal

COMPLAS X
International Conference on Computational Plasticity
September 2 - 4, 2009, Barcelona, Spain

EURO:TUN 2009
Computational Methods in Tunnelling
September 9-11, 2009, Bochum, Germany

XFEM 2009
International Conference on Extended Finite Element Methods – Recent Developments and Applications
September 28 - 30, 2009, Aachen, Germany

CONTACT MECHANICS 2009
International Conference on Computational Contact Mechanics
September 16-18, 2009, Lecce, Italy

MEMBRANES 2009
International Conference on Textile Composites and Inflatable Structures
October 5 - 7, 2009, Stuttgart, Germany

VIPIMAGE 2009
International Conference on Computational Vision and Medical Image Processing -
October 21 - 23, 2009, Porto, Portugal

Particle 2009
International Conference on Particle-Based Methods. Fundamentals and Applications.
November 25-27, 2009, Barcelona, Spain

http://www.wccm2010.com

http://www.wccm2010.com.au

WCCM / APCOM 2010

19- 23 JULY SYDNEY AUSTRALIA

Joint

IX World Congress on Computational Mechanics

and

IV Asian Pacific Congress on Computational Mechanics

The Joint 9th World Congress on Computational Mechanics and 4rd Asian Pacific Congress on Computational Mechanics will be held in Sydney, Australia during July 19-23, 2010 under the auspices of Australian Association for Computational Mechanics (AACM), Asian Pacific Association for Computational Mechanics (APACM) and International Association for Computational Mechanics (IACM).

Sydney is one of the most beautiful cities in the world. It has a reputation for friendly people, a cosmopolitan lifestyle, wonderful shopping and world class entertainment. Sydney's magnificent harbour, renowned Opera House and sunny beaches combined together make this city a unique destination.

"Early planning for the congress is well underway and we have put together a magnificent program for our guests. Sydney is colourful, sophisticated, vibrant and progressive, with everything needed to make the congress an outstanding success", says Professor Khalili, Chairman of WCCM/APCOM 2010. The congress and exhibition will be held at the Sydney Convention and Exhibition Centre at Darling Harbour, which is adjacent to the heart of the city. The centre offers first class facilities to delegates, presenters and exhibitors alike and is the focal point of Darling Harbour which itself is alive with shops, restaurants and visitor attractions. Hotel accommodation of all standards is within walking distance from the Convention Centre.

The format of the congress will be based on the previous congresses in the sense that a number of Mini-Symposia will be organized by leading academics and researchers on latest developments in computational mechanics applied to various fields of engineering, science and applied mathematics. Plenary and Semi-Plenary lectures on important, recent developments in computational mechanics will be delivered by leading authorities in these fields.

For further information, please contact Conference Secretariat or register your interest online at **www.wccm2010.com**

Congress Secretariat
WCCM/APCOM2010
GPO Box 3270, Sydney
NSW 2001 Australia
Telephone: (+61 2) 9254 5000
Facsimile: (+61 2) 9251 3552
Email: wccm2010@icmsaust.com.au
Website: http://www.wccm2010.com

iacm news

Adnan Ibrahimbegovic received Foreign Scientist award

Adnan Ibrahimbegovic of ENS-Cachan, France received the Award of Slovenian Research Agency for **Internationally Recognized Foreign Scientists.** This is one of eight awards given by Slovenia in 2007 for all scientific disciplines.

J. Argyris Award

The J. Argyris Award presented by Elsevier to the best paper published in 2007 in the journal Computer Methods in Applied Mechanics and Engineering, was granted to "A Non-Intrusive Method for the Calculation of Strict and Efficient Bounds of Calculated Outputs of Interest in Linear Viscoelasticity Problems" authors **L. Chamoin** and **P. Ladeveze** from LMT Cachan (France)

Sergio Idelsohn received the Scopus Award 2007

Scopus, the world wide data base of scientific literature, recognized eight researchers of Argentina. These awards have been granted in 2006 and 2007 in Brazil; and in 2007 in Mexico, Colombia, Venezuela and Argentina. **Sergio Iselsohn**, the former president of **AMCA**, the IACM affiliated organisation in Argentina, was one of the eight Argentine researchers which received the Scopus Award.

XX Anniversary of CIMNE

The International Center for Numerical Methods in Engineering (CIMNE), located in Barcelona, Spain, celebrated in 2007 its 20th anniversary. A number of activities such as conferences, courses and workshops were organised by CIMNE in 2007 to commemorate the anniversary. For more information of CIMNE activities visit www.cimne.com

Tom J.R. Hughes

Tom J.R. Hughes received various awards in Europe and the USA

Tom Hughes was elected a **Fellow of the American Academy of Arts and Sciences** in the area Engineering Sciences and Technologies. This is the oldest academy in North America and was founded before independence by John Adams. George Washington, Thomas Jefferson, Benjamin Franklin and Albert Einstein were members.

He was also elected a **Foreign Member** of the Istituto Lombardo Accademia di Scienze e Lettere in the area of Mathematics.

Tom also went on to receive the **doctorate honoris causa** in civil engineering from the University of Padua.as well as another one from the University of Pavia

ECCOMAS Award to the best Ph.D. Thesis in Europe

The European organization ECCOMAS has selected the following two theses for the Award to the best Ph.D. thesis in Europe in 2007:
Jeroen Wackers, for the thesis entitled "Surface Capturing and Multigrid for Steady Free-Surface Water Flows", Centrum voor Wiskunde en Informatica (CWI), Amsterdam, Netherland
Lukasz Madej, for the thesis entitled "Development of the Multi-Scale Analysis Model to Simulate Strain Localization Occurring During Material Processing", Akademia Górniczo-Hutnicza, Krakow, Poland

The awards were selected from a list of some 15 candidates proposed by the ECCOMAS affiliated organisations in different countries in Europe.

15th Jubilee Anniversary of ECCOMAS

The European Community on Computational Methods in Applied Sciences (ECCOMAS), an association that groups the IACM affiliated organizations in Europe, celebrated its 15th anniversary in 2007. A Symposium on New Computational Challenges in Materials, Structures and Fluids was held in Vienna, Austria on 18-20 February 2008 to commemorate the ECCOMAS anniversary. More information can be found on page 42 of this bulletin.

conference diary planner

30 June - 5 July 2008	**8th World Conference on Computational Mechanics and Engineering** **5th ECCOMAS Congress on Computational Methods in Applied Sciences** *Venue:* Venezia, Italy *Contact:* www.iacm.info / www.eccomas.org
25 - 26 August 2008	**Cross-Strait Conference on Computational Mechanics** *Venue:* Taipei, Taiwan *Contact:* ybyang@ntu.edu.tw
2 - 5 September 2008	**ECT 2008 - 6th Int. Conference on Engineering Computational Technology** *Venue:* Athens, Greece *Contact:* http://www.civil-comp.com/conf/ect2008.htm
5- 6 September 2008	**JMC 2008 - 7th Workshop on Computational Mechanics** *Venue:* Sanitago, Chile *Contact*: www.scmc.cl
1 - 6 October 2008	**12th IACMG Conference** *Venue:* Goa, India *Contact:* www.12iacmag.com
4 - 7 November 2008	**CILAMCE 2008 - 29th Iberian Latin American Congress on C.M. in Engineering** *Venue:* Maceió, Brasil *Contact:* www.acquacon.com.br/cilamce2008
10 - 13 November 2008	**ENIEF 2008 - XVII Congress on Numerical Methods and their Applications** *Venue:* San Luis, Argentina *Contact:* http://enief2008.unsl.edu.ar
16 - 17 November 2008	**Taiwan-Austrian Workshop on Computational Mechanics of Materials & Structures** *Venue:* Taipei, Taiwan *Contact*: ybyang@ntu.edu.tw
19 - 21 November 2008	**EASEC 11 - IIth East Asia-Pacific Conference on Structural Engineering & Construction** *Venue:* Taipei, Taiwan *Contact*: http://easec11.esasec.org/
7 - 10 January 2009	**AfrCCM'09 - 1st African Conference on Computational Mechanics** *Venue:* Sun City, South Africa *Contact:* http://www.afrccm.com/
26 - 27 May 2009	**ADMOS 2009 - International Conference on Adaptive Modeling & Simulation** *Venue:* Brussels, Belgium *Contact*: http://congress.cimne.upc.es/admos09
8 - 11 June 2009	**Computational Methods for Coupled Problems in Science & Engineering** *Venue:* Ischia Island, Italy *Contact*: coupledproblems@cimne.upc.edu
15 - 17 June 2009	**III ECCOMAS Int. Conference on Computational Methods in Marine Engineering** *Venue:* Trodheim, Norway *Contact:* http://congress.cimne.upc.es/marine09/
15 - 17 June 2009	**EUROGEN 2009 - Int. Conf. on Evolutionary & Deterministic Methods for Design, Optimization & Control with Applications to Industrial and Societal Problems -** *Venue:* Cracow, Poland *Contact*: www.eccomas.org
17 - 19 June 2009	**5th MIT Conference on Computational Fluid and Solid Mechanics** *Venue:* Cambridge, ,MA, USA *Contact:* http://www.fifthmitconference.org/
17 - 19 June 2009	**COMPDYN 2009 - Int.Conf. on CM in Structural Dynamics & Earthquake Engineering -** *Venue:* Island of Rhodes, Greece *Contact*: http://www.compdyn2009.org
16 - 19 July 2009	**USNCCM X - 10th U.S: National Congress on Computational Mechanics** *Venue:* Columbus, Ohio USA *Contact*: http://usnccm-10.eng.ohio-state.edu
20 - 22 July 2009	**SMART 2009 - International Conference on Smart Structures and Materials** *Venue:* Porto, Portugal *Contact:* www.eccomas.org
2 - 4 September 2009	**COMPLAS 2009 - X International Conference on Computational Plasticity** *Venue:* Barcelona, Spain *Contact:* http://congress.cimne.upc.es/complas09/
5 - 7 October 2009	**MEMBRANES 2009 - Int. Conference on Textile Composites & Inflatable Structures** *Venue:* Stuttgart, Germany *Contact:* http://congress.cimne.upc.es/membranes09
16 - 21 May 2010	**ECCM 2010,4th European Conference on Computational Mechanics** *Venue:* Paris, France *Contact:* www.eccm2010.org
14 - 17 June 2010	**CFD 2010, Fifth European Conference on Computational Fluid Dynamics,** *Venue:* Lisbon, Portugal *Contact:* http://www-ext.lnec.pt/APMTAC
19 - 23 July 2010	**IX World Congress on Computational Mechanics** **III Asian Pacific Congress on Computational Mechanics** *Venue:* Sydney, Australia *Contact*: http://www.wccm2010.com.au

WCCM / APCOM

9th World Congress on Computational Mechanics
and
4th Asian Pacific Congress on Computational Mechanics

19-23 July 2010, Sydney, Australia

www.wccm2010.com