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**In memory of Prof. J.A.C. Martins**  
1951 - 2008

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# editorial

The field of Computational Mechanics continuously broadens and embraces new areas of science and technology. Computational bio-medical-engineering has been evolving for the last two decades and can be considered an established field in computational mechanics. What is new in the bio-medical field is the fast progression of the so called *Systems Biology* community. The name refers to the study of bio-medical problems from an engineering system perspective, including the use of mechanics, computational methods and software. The views of this new generation of computational bio-scientists are clearly expressed in the revolutionary paper "Can a biologist fix a radio? Or what I learned while studying apoptosis" by Y. Lazebnik, (*Cancer Cell*, Vol. 2, 179-182, Sept. 2002). I strongly recommend its reading. The increasing number of articles on *System Biology* in recent issues of *Nature*, are an evidence of the importance of this field.

A second area of outstanding expansion is the so called *Real Time* computing. Evolving from solutions thought for the video games industry and supported by dramatic advances in computing hardware, such as GPUs, a number of algorithms for ultra-fast computing and visualization have been recently proposed as a replacement or complement to traditional numerical methods and software in computational mechanics.

# contents

One of these methods, the Proper General Decomposition, is presented in this bulletin by Prof. Francisco Chinesta and colleagues. Real Time computing will certainly mean a revolution in the way we approach the solution of many problems in engineering and applied sciences.

A third area in which computational mechanics can have a big impact is *energy*. The definition of new ways for extracting energy from natural resources, as well as the design of energy-efficient and sustainable constructions, vehicles and engineering systems in general, is of paramount importance worldwide and opens unlimited possibilities for computational mechanics. Among the many recent successful stories of colleagues in our community entering the energy field we note the excellent work of Prof. T. Yabe and his group in Japan aiming to extracting energy from the magnesium in the sea (*Time*, October 2009, pp 74-75).

The presentation of new topics in science and engineering of interest to Computational Mechanics (and vice versa) clearly exceeds the length of this editorial. These challenges are an opportunity to expand the scope of the IACM and will open possibilities for new research and application of Computational Mechanics technology aiming to solving problems of high impact in the world.

**Eugenio Oñate**  
President of IACM

# Proper Generalized Decomposition in Extreme Simulations: Towards a Change of Paradigm in Computational Mechanics?

by

Francisco (Paco) Chinesta  
EADS Chair, GEM, Centrale  
Nantes, France

Francisco.Chinesta  
@ec-nantes.fr

P. Ladeveze

EADS Chair at LMT, ENS  
Cachan, France

ladeveze@lmt.ens-cachan.fr

A. Ammar

Laboratoire de Rhéologie at  
Grenoble, France

Amine.Ammar@ujf-grenoble.fr

E. Cueto

I3A, University of Zaragoza,  
Spain

ecueto@unizar.es

A. Nouy

GEM, University of Nantes,  
France

anthony.nouy@univ-nantes.fr

Many problems in science and engineering remain today intractable because their numerical complexity is simply unimaginable. For example, when we are addressing models in quantum chemistry (the finest description of atomic and molecular bonds responsible of the structure and mechanics of materials), the so called wavefunction  $\Psi$  representing the distribution of an elementary particle is defined in the whole physical space, i.e.  $\Psi(\mathbf{x}, t)$ . Its evolution is governed by the Schrodinger equation (or its fully relativistic Dirac counterpart) that defines a standard 3D transient model. However, when the physical system contains  $N$  particles, the evolution of the associated wavefunction  $\Psi(\mathbf{x}_1, \dots, \mathbf{x}_N, t)$  is governed by a transient problem in a space of dimension  $3 \times N!$ . If one proceeds to the solution of such model by using a standard mesh based discretization technique, where  $M$  nodes are used for discretizing each space  $\mathbf{x}_i$ , the resulting number of nodes reaches the astronomical value of  $M^{3N}$ . With  $M \sim 10^3$  (a very coarse description in practice) and  $N \sim 30$  (a very small atomic system) the numerical complexity results  $M^{3N} \sim 10^{90}$ . It is important to recall that  $10^{80}$  is the presumed number of elementary particles in the universe. For this reason, the Nobel Prize R.B. Laughlin affirmed [1]:

“... the theory of Everything is not even remotely a theory of every thing. We know **this equation** (Laughlin refers to the Schrödinger equation) **is correct** because it has been solved accurately for small number of particles – isolated atoms and small molecules - **and found to agree in minute detail with experiments**. However **it cannot be solved accurately when the number of particles exceeds about 10. No computer existing, or that will ever exist, can break this barrier because it is a catastrophe of dimension**. If the amount of computer memory required to represent the quantum wavefunction of one particle is  $M$  then the amount required to represent the wavefunction of  $N$  particles is  $M^N$ . It is possible to perform approximate calculations ... But the schemes for approximating are not first-principles deductions but rather art keyed to experiment, ...”

However, the curse of dimensionality is present at many other scales in the description of the structure and mechanics of materials. For example, when we consider a linear macromolecule, its conformation can be expressed by giving the position of some points (beads) along its contour, or equivalently, by giving the vectors joining two consecutive beads as depicted in figure 1. Within the kinetic theory framework, molecular systems are described by a distribution function instead of the specification of the conformation of each individual molecule

## The Authors:

The authors - from the left to the right -: F. Chinesta, P. Ladeveze, A. Ammar, E. Cueto and A. Nouy



(in real systems there are too many molecules!). Thus, the system can be described by a function  $\Psi(\mathbf{x}, \mathbf{q}_1, \dots, \mathbf{q}_N, t)$  given the fraction of molecules that at position  $\mathbf{x}$  and time  $t$  have a conformation expressed by the vectors  $\mathbf{q}_1, \dots, \mathbf{q}_N$ . Now, the conservation of that distribution function results into an equation known as the Fokker-Planck equation whose solution is affected by the redoubtable "curse of dimensionality" because it is defined in a space of dimension  $3 + 3 \times N + 1$  (the physical space, the  $N$  conformation vectors and the time). Even for a coarse description,  $N \sim 10$  the model is defined in a space with 34 dimensions!

Other branches in science suffer this illness as for example the chemistry when the number of molecules of the reacting species is too low. In that case, the continuum approach based on the introduction of concentrations is no more a valid alternative. This situation is usually found in the modeling of genetic processes (e.g. expression of genes). Now, the state of the system is defined by the number of individuals of each one of the  $N$  coexisting species  $\Psi(\#S_1, \dots, \#S_N, t)$  and again the model governing the evolution of such system, the so-called master equation, is defined in a multi-dimensional space that makes impossible its treatment by using the standard mesh based discretization techniques. There are many other models defined in multidimensional spaces but for our discussion below these examples suffice.

Previous models could seem too far from the usual computational mechanics practice, but we are proving that usual computational mechanics models could be enriched by adding some new coordinates leading to several unimaginable exciting possibilities.

Imagine for example that you are interested in solving the heat equation but that you do not know the material thermal conductivity, because it has a stochastic nature or simply because prior to solve the thermal model you should measure it. You have three possibilities: (i) you wait to know the conductivity before solving the heat equation (a conservative solution!); (ii) you solve the equation for many values of the conductivity (a sort of Monte Carlo) and then the work is done (a sort of brute force approach!); or (iii) you solve the heat

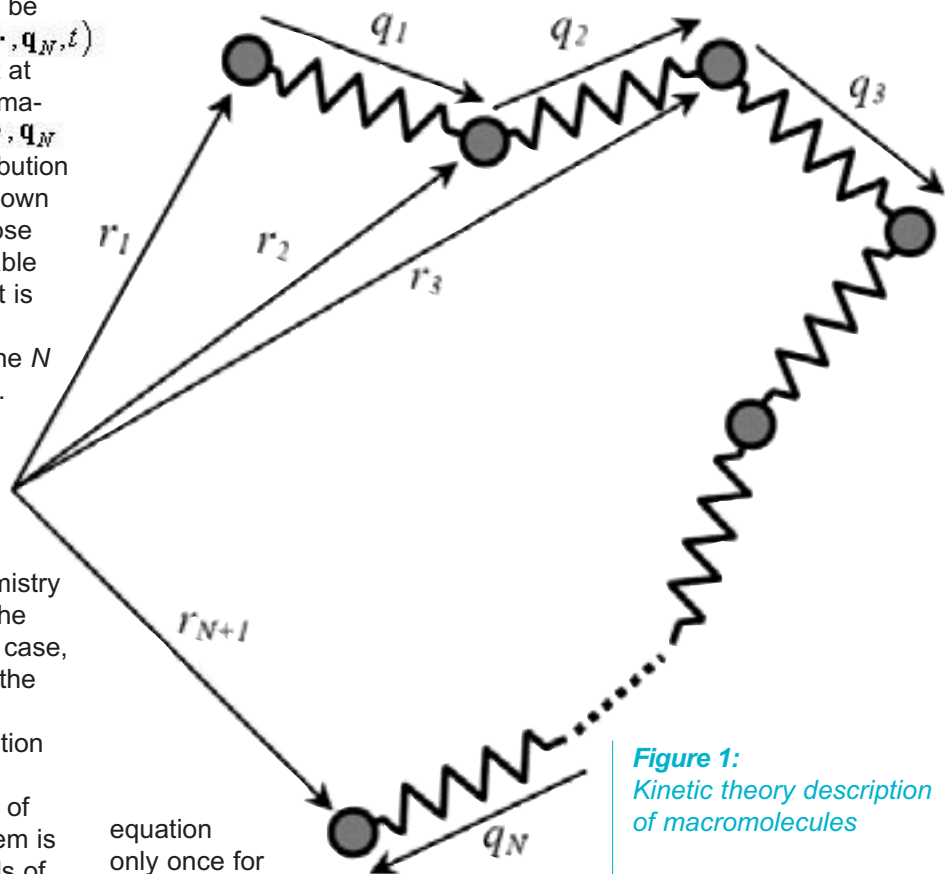


Figure 1: Kinetic theory description of macromolecules

equation only once for any value of the conductivity (the cleverest alternative!). Obviously the third alternative is the most exciting one. To compute this "magic" solution it suffices to introduce the conductivity as an extra coordinate, playing the same role than the standard space and time coordinates, even if there are not derivatives concerning this extra-coordinate. This procedure runs, very well, and can be extended for introducing many other extra-coordinates: the source term, initial condition .... This is the basic idea of spectral approaches in parametric or stochastic analyses, which are receiving a growing interest in computational science (see [2] and the references therein for a recent state of the art). It is easy to understand that after performing this type of calculations, a posteriori inverse identification or optimization can be easily handled.

But the dream is not finished, many exciting models are waiting for new reformulations: in shape optimization the geometrical parameters could be introduced as new coordinates allowing to compute the solution for all possible geometries, and from that, identify the "optimum" (in many cases the global one instead of a local one reached by standard strategies). In multi-scale modeling, fine and coarse scales



(and eventually also other intermediate scales) could coexist and be solved simultaneously if the curse of dimensionality can be circumvented. Non linear homogenization could be performed by solving the thermomechanical problem at the microstructure level for any loading trajectory, these ones acting as new extra-coordinates. If we are interested in solving a transient problem with the time scales ranging from the femto-second to the seconds, the time axis could be transformed into a 2D domain with a fast and a slow time scales, the finest one defined in a small interval and the slowest one in the whole time interval of interest. This procedure can be extended to  $ND$  by introducing intermediate time scales. In 5 dimensions and considering one thousand time steps by direction we could solve a problem with a characteristic time of a femto-second in some seconds of CPU: the complexity remains of the order of thousands because  $(10^3)^5 = 10^{15}$  the curse of dimensionality can be avoided. There are many other potential applications as for example the simultaneous description of bifurcation branches (obviously the 3D space is too poor for including all the richness that such models exhibit but moving to richer spaces -with more dimensions- everything can be allocated inside, only a little of imagination is needed!

**Everything seems exciting,  
but the main question needs an answer:  
How circumventing the curse of dimensionality?**

Different techniques have been proposed for circumventing the curse of dimensionality, being Monte Carlo simulations the most widely used. Their main drawback is the statistical noise, when other than the moments of the distribution functions are computed. Other possibility lies in the use of sparse grids [3], within the deterministic framework, but they suffer also when the dimension of the space increases beyond a certain value (of about 20 dimensions as argued in [4]).

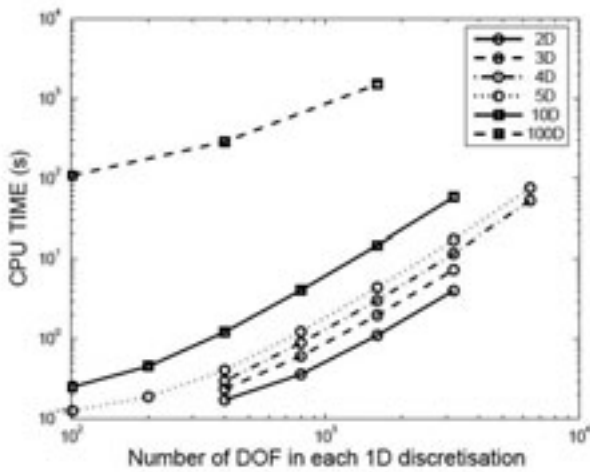
In our knowledge there are few precedents of deterministic techniques able to circumvent efficiently the curse of dimensionality in highly multidimensional spaces. An appealing choice consists of expressing the unknown field as a finite sum of functional products, i.e. expressing a generic multidimensional function  $\Psi(x_1, \dots, x_N)$  as:

$$\Psi(x_1, \dots, x_N) \approx \sum_{i=1}^{i=Q} F_i^1(x_1) \times \dots \times F_i^N(x_N)$$

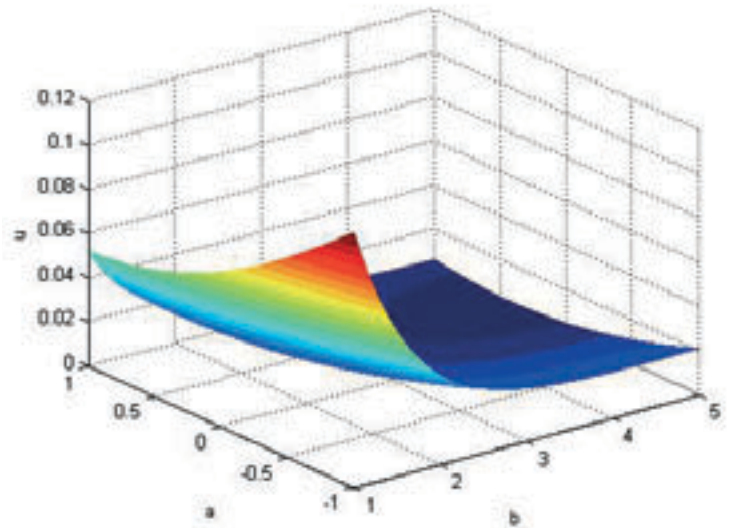
**Remark:** In this expression the coordinates  $x_i$  denote any coordinate, scalar or vector, involving the physical space, the time or any other conformation coordinate (e.g. the conductivity in the example previously discussed).

Thus, if  $M$  nodes are used to discretize each coordinate, the total number of unknowns involved in the solution is  $Q \times N \times M$  instead of the  $M^N$  degrees of freedom involved in mesh based discretizations. We must recall that these functions are not "a priori" known, they are computed by introducing the approximation separated representation into the model weak form and then solving the resulting non-linear problem. The interested reader can refer to [5] for a detailed description of the numerical and algorithmic aspects. The construction of such approximation is called Proper Generalized Decomposition because this decomposition is not orthogonal but in many cases the number of terms in the finite sum is very close to the optimal decomposition obtained by applying the Proper Orthogonal Decomposition -POD- (or the Singular Value Decomposition -SVD-) on the model solution.

As it can be noticed in the expression of the approximation separated representation the complexity scales linearly with the dimension of the space in which the model is defined, instead of the exponential growing characteristic of mesh based discretization strategies. In general, for many models, the number of terms  $Q$  in the finite sum is quite reduced (few tens) and in all cases the approximation converges towards the solution associated with a fully tensorial product of approximation bases considered in each space  $x_i$ . Thus, we can conclude about the generality of the separated representation, but its optimality depends on the solution features. When the solution of physical models can be represented up to certain precision by a reduced number of functional products, the separated representation is an optimal representation, but if we consider a strictly non-separable function, the PGD based solver proceeds to enrich the approximation until including all the elements of the functional space, i.e.  $M^N$  the functions involved in the full tensor product of the approximation bases considered in each space  $x_i$ .



**Figure 2:**  
CPU versus space dimension



**Figure3:**  $u = u(x, y, t, \alpha, \beta) \Big|_{x=0.5, y=0.5, t=1}$

This kind of representation is not new. Similar approximations were considered many years ago in the context of Quantum Chemistry [6], the main difference lying in the constructor of the separated approximation. In the context of Computational Mechanics there is -in our knowledge- a unique precedent, the so-called radial approximation introduced by Pierre Ladeveze in the early eighties within the LATIN framework. At that time, Ladeveze looked for an efficient solver of non linear models, after noticing that in general these models involve a non-linear part that is local in the physical space, and a linear one (the one related to the structure equilibrium) that is obviously global, but linear. Thus, Pierre Ladeveze proposed a solution technique for the decoupling of linear-global and non-linear-local problems. This was the first ingredient of a wonderful and powerful numerical receipt, the so-called LATIN method. But another ingredient was needed for speeding up the solution of the space-time linear global model, and for this purpose, Ladeveze proposed expressing its solution in a space-time separated form, i.e.

$$\Psi(\mathbf{x}, t) \approx \sum_{i=1}^{i=Q} X_i(\mathbf{x}) \times T_i(t) \quad [7-9].$$

If we look for the performance of such separated representations the verdict is for many models simply impressive. If one considers a standard transient model defined in a 3D physical space, and if one considers  $P$  time steps, usual incremental strategies must solve  $P$  (in

general non-linear) three-dimensional problems (do not forget that  $P$  can be millions!). However, if the radial approximation (space-time PGD) is considered, we should solve around  $Q \cdot m$  3D problems for computing the space functions  $X_i(\mathbf{x})$  and  $Q \cdot m$  1D problems for computing the time functions  $T_i(t)$  ( $m$  being the number of iterations needed for computing each term of the finite sum because its non-linear nature). As  $Q \cdot m \sim 100$  in many models the computing time savings can reach many orders of magnitude (millions and more!).

Now, if we come back to the multi-dimensional models involving the physical space, the time, and a number of "exotic" extra-coordinates, the verdict is implacable: the multidimensional-PGD (a mutation of the radial approximation that was retained by the natural selection!) allows solving models never until now solved, suffering the so-called curse of dimensionality, and that were qualified many times as irresolvable! The PGD allows solving them, in some minutes, using a simple laptop! Paradoxes of the history!

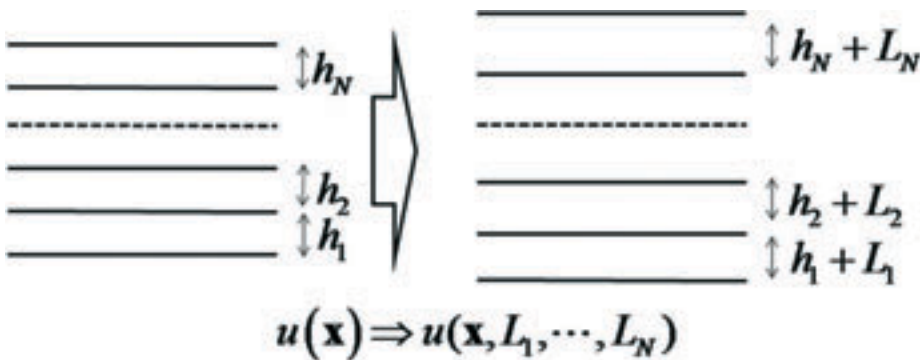
The solution of physically multidimensional models encountered in quantum chemistry and the kinetic theory description of complex fluids were deeply described in some of our former works [5,10-12]. For parametric or stochastic analyses, the PGD has first been introduced by A. Nouy [2,13] (in this context, the PGD was initially called Generalized Spectral Decomposition).

Finally, in the context of efficient non-linear solvers the space-time PGD (radial approximation) was successfully applied within the LATIN framework [7-9].

Here we are focusing in recent simulations. *Figure 2* shows the computing time associated to the solution of a simple model defined in different multidimensional spaces, up to 100 (in 20 minutes with Matlab® on a laptop, we solved problems needing  $10^{300}$  d.o.f. when using standard mesh based discretizations).

*Figure 3* shows the solution of a non-linear thermal model in which the space, the time and the two coefficients ( $a, b$ ) of the temperature-dependent thermal conductivity ( $K = a + bu$ ,  $u$  being the temperature field) were considered as extra-coordinates (the problem was thus defined in a space of dimension 5). In that figure the temperature at the central point and the final time is depicted as a function of both extra-coordinates ( $a, b$ ).

**Figure 4:**  
Shape optimization  
by using the PGD



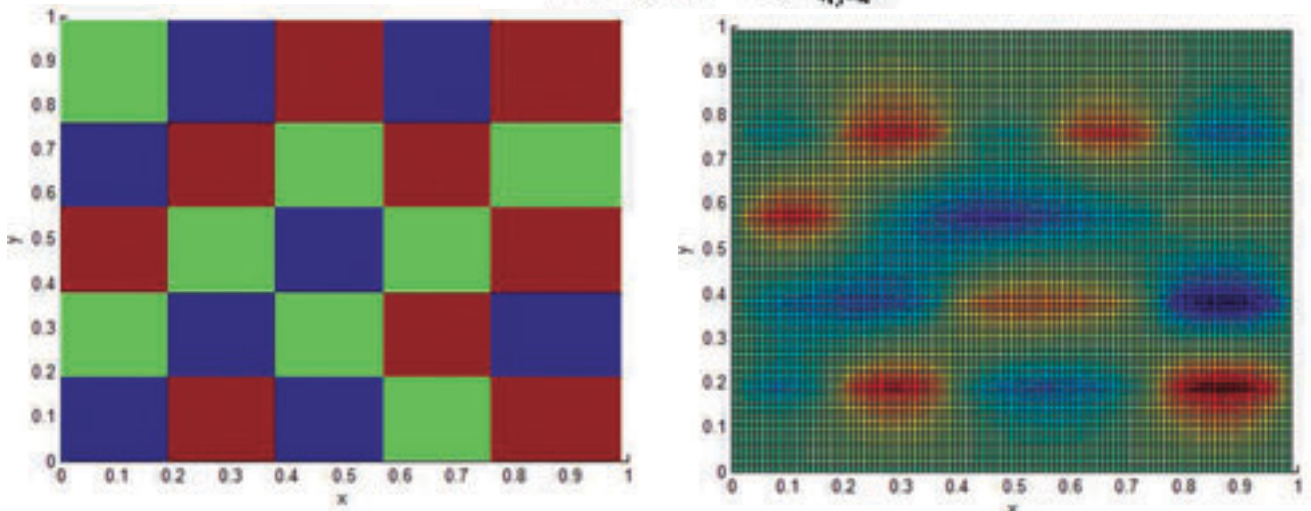
*Figure 4* shows a thermal model defined in an elementary volume in which the thermal conductivity of the squares were considered as extra-coordinates (the model was then defined in a space of dimension 27: 25 conductivities and the usual  $x, y$  coordinates and it was successfully solved by H. Lamari).

*Figure 5* shows the shape optimization performed by E. Verron and A. Leygue that optimized a sandwich structure introducing the thickness of each layer as an extra-coordinate. Thus, the model solution allows knowing the unknown field for any geometry! Now, one could simply identify the “optimum”, and sometimes, the global optimum instead of retaining a local one.

*Figure 6* depicts the transformation of the 1D time axis into a 2D domain introducing a fast time scale defined in a short interval, and a slow time scale in the whole time interval. The solution complexity reduces to the square root of the usual incremental complexity. Other intermediate scales can be defined and the complexity reduced as desired.

Finally, we applied the PGD to evolving domains and even for simulating particle dynamics (e.g. Molecular Dynamics). Exciting works in non-linear homogenization where all the loading trajectories are considered as extra-coordinates are in progress. Thus, after solving a single model we have the solution for any kind of time-loading. Preliminary results are impressive and very exciting.

**Figure 5:**  $u = u(x, y, k_{21}, k_{22}, \dots, k_{5,5})|_{k_1, \dots, k_5}$





The interested reader can refer to the different papers grouped in a thematic issue of Archives of Computational Methods in Engineering (at the present in press) devoted to a recent state of the art for the Proper Generalized Decomposition, edited by Chinesta, Cueto and Ladeveze.

You can continue dreaming, but we invite you to realize some of your simulation dreams by applying the PGD!

### Acknowledgments

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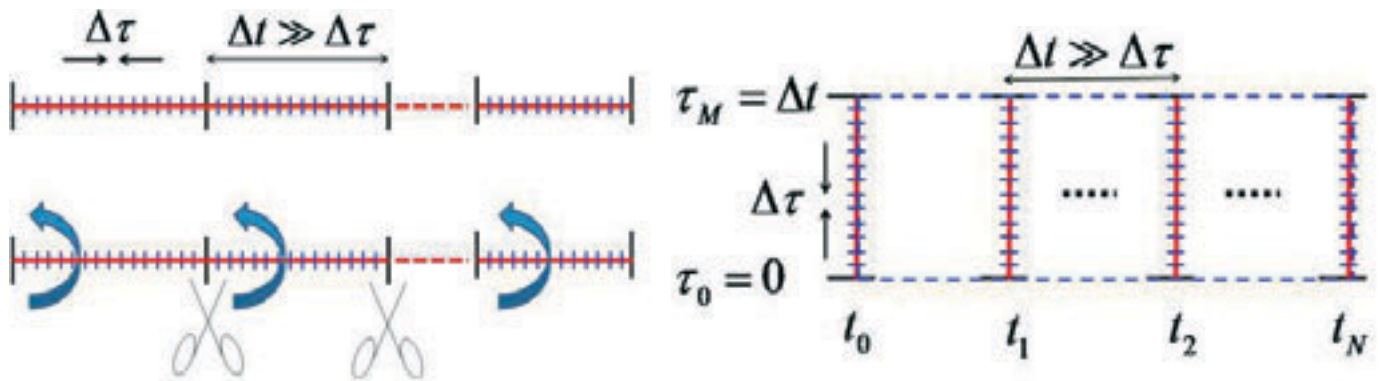


Figure 6: From  $u = u(\tau)$ ,  $0 \leq \tau \leq t_{N+1}$  to  $u = u(\tau, t)$ ,  $0 \leq \tau \leq \Delta t$ ;

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# Weakened

# Weak Formulations

by

**G. R. Liu** *a,b*

*<sup>a</sup>Centre for Advanced  
Computations in Engineering  
Science,  
National University  
of Singapore,*

*<sup>b</sup>Singapore-MIT Alliance  
(SMA), Singapore*

*<http://www.nus.edu.sg/ACES>*

*“...numerical  
methods called  
weakened  
weak ( $W^2$ ) form  
... that open a  
wide window of  
opportunity in  
the development  
of next  
generation  
computational  
methods ...”*

## At a place called Singapore

To be more precise, we should say “at a point called Singapore”. It is really a small country that is a very small dot in world map. There is a, however, a group of people under the roof of ACES centre at the National University of Singapore fascinated about computational mechanics. They have been working on numerous interesting projects for multinational companies located at Singapore, and also made substantial efforts in fundamental theoretical research in computational methods. In recent years, they were working on a class of numerical methods called weakened weak ( $W^2$ ) form methods that open a wide window of opportunity in the development of the next generation of computational methods. This article gives a briefing on the  $W^2$  formulations.

## Weak formulations: a familiar term

To solve practical engineering problems, many powerful numerical methods based on weak formulations have been developed, such as the powerful finite element method (FEM) [1-2] and recently the meshfree methods [see, e.g., 3,4]. There are a number of ways to establish a weak form [4], and one of which is to use the well-known weighted residual method.

Let us now consider the general form of the partial differential equations (PDEs) for a well-posed solid mechanics problem defined in  $\Omega$  bounded by  $\Gamma$  [4]. We therefore somehow construct a set of proper *trial functions*  $\mathbf{u}^h$ , and then seek for *one* of these trial functions such that the residual vanishes in a weighted integral sense over the problem domain:

$$\int_{\Omega} \underbrace{\hat{\mathbf{W}} (\mathbf{L}_d^T \mathbf{c} \mathbf{L}_d \mathbf{u}^h + \mathbf{b})}_{\text{residual}} d\Omega = \int_{\Omega} \hat{\mathbf{W}} (\mathbf{L}_d^T \mathbf{c} \mathbf{L}_d \mathbf{u}^h) d\Omega + \int_{\Omega} \hat{\mathbf{W}} \mathbf{b} d\Omega = 0 \quad (1)$$

where  $\hat{\mathbf{W}}$  is a vector or a diagonal matrix of *weight or test functions* properly defined in  $\Omega$ ,  $\mathbf{L}_d$  is a differential operator matrix of first order derivatives [2, 4]. If the weight or test functions are chosen differentiable, we then perform integration-by-parts (Gauss divergence theorem) to the first term in Equation (1) and apply the boundary conditions, which leads to [4]:

$$\int_{\Omega} (\mathbf{L}_d \hat{\mathbf{W}})^T \mathbf{c} (\mathbf{L}_d \mathbf{u}^h) d\Omega - \int_{\Gamma} \hat{\mathbf{W}}^T \mathbf{t}_r d\Omega - \int_{\Omega} \hat{\mathbf{W}}^T \mathbf{b} d\Omega = 0 \quad (2)$$

where  $\mathbf{t}_r$  is the external traction force applied on the natural boundary and  $\mathbf{b}$  is the external body force applied over the entire problem domain. It is clear now we have only first order derivatives  $\mathbf{L}_d$  to either the field function  $\mathbf{u}^h$  or test function  $\hat{\mathbf{W}}$ , instead of the 2<sup>nd</sup> order derivatives in the original PDE. Equation (2) is therefore called a *weak form*. When the trial and test functions are from the same space, we have the well-known Galerkin weakform.

The FEM based on the Galerkin weakform is very well developed and is a currently the most widely-used reliable numerical tool, and many established commercial software packages are available, such as ABAQUS®, ANSYS®, etc. However, there are three major issues related to the FEM: 1) the “overly-stiff” behavior; 2) the “locking” behavior for many problems; 3) inaccuracy in stress solutions; 4) mesh distortion related problems; and 5) poor solution using linear triangular elements. We engineers like to use the triangular elements, simply because they can be created much more easily and even automatically for complicated geometry. However, the FEM

does not like such elements, and we often get a warning when opting for triangular elements in using some commercial software codes.

The overly-stiff phenomenon is attributed to the *fully* compatible approach based on the Galerkin weakform. Excellent efforts have been made in resolving this issue, especially in the area of hybrid FEM formulations (see, e.g., [5]). This article introduces an alternative approach for dealing with such problems under the general framework of  $W^2$  formulation.

### A $W^2$ formulation: a window of opportunities

A  $W^2$  form can be built upon the weak form defined in Equation (2). This is done by using the so-called *gradient smoothing operation* [23] to the strains  $\boldsymbol{\varepsilon} = \mathbf{L}_n \mathbf{u}$  field (and to  $\mathbf{L}_n \bar{\mathbf{W}}$ ). The smoothing operation is not new and has been used in various situations, such as the nonlocal continuum mechanics [9,10], the smoothed particle hydrodynamics (SPH) [11-13,3], hybrid FEMs [5]. The gradient smoothing was also used in the well-known widely used finite volume method (FVM) [32], the so-called quasi-conforming elements [33], and for the discretization of differential operator based on nodes [34]. It has been applied to resolve the material instabilities [14] and spatial instability in nodal integrated meshfree methods [15], and recently obtaining upper bound solution in meshfree point interpolation methods [18, 19].

To make the  $W^2$  form workable as a general numerical formulation procedure, we have to perform the gradient smoothing operation [23] in a properly defined and systematically workable manner.

Two important requirements are needed for the creation of the smoothing domains.

1. On top of a properly defined mesh (for example  $\alpha$  FEM mesh), we divide the problem domain into a set of smoothing domains following the so-called *no-sharing rule*: the boundaries of any smoothing domain should not share any *finite* lines where the assumed displacement function is discontinuous [30]. We shall then have  $N_S$  smoothing domains such that  $\Omega = \bigcup_{k=1}^{N_S} \Omega_k^s$  where  $\Omega_k^s$  is a smoothing domain bounded by  $\Gamma_k^s$  for point at  $\mathbf{x}_k$ .
2. The smoothing domains have to be independent and the number of the smoothing domains has to be more than the minimum number [23].

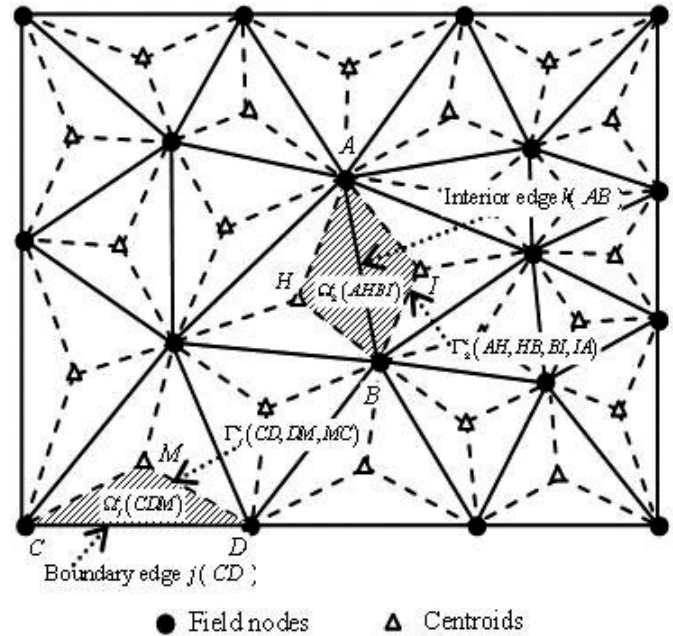
Proven types of smoothing domains are the cell-based smoothing domains that have been used in the smoothed FEM (or SFEM) [6-8] and cell-based smoothed point interpolation method (CS-PIM) [28]; node-based as used in the NS-PIM [16-20] and NS-FEM [24]; edge-based as in ES-PIM [26] and ES-FEM [25]; face-based FS-FEM [27]; as well as partial smoothing used in the  $\alpha$  FEM [31]. Fig. 1 shows a set of edge-based smoothing domains.

With the smoothing domains a “smoothed” strain field can then be constructed using

$$\bar{\boldsymbol{\varepsilon}}(\mathbf{x}_k) = \frac{1}{A_k^s} \int_{\Gamma_k^s} \mathbf{L}_n \mathbf{u}^k(\boldsymbol{s}) d\boldsymbol{s} \quad (3)$$

where  $\mathbf{L}_n$  is a matrix of the components of the outwards normal [2, 4] on the smoothing domain boundary  $\Gamma_k^s$ . In carrying out the line integrations in (3) along the boundary  $\Gamma_k^s$ , we simply use the standard Gauss integration widely used in FEM [2]. If we further assume that the strains in the entire smoothing domain is constant:

$$\bar{\boldsymbol{\varepsilon}}_k(\mathbf{x}) = \bar{\boldsymbol{\varepsilon}}(\mathbf{x}_k) = \frac{1}{A_k^s} \int_{\Gamma_k^s} \mathbf{L}_n \mathbf{u}^k(\boldsymbol{s}) d\boldsymbol{s}, \forall \mathbf{x} \in \Omega_k^s \quad (4)$$



**Figure 1:** Edge-based smoothing domains constructed on top of three-node triangular mesh

*“... engineers like to use the triangular elements, simply because they can be created much more easily and even automatically for complicated geometry. However, the FEM does not like such elements ...”*



Equation (2) becomes

$$\sum_{k=1}^{N_s} \frac{1}{A_k^s} \left( \int_{r_i} \mathbf{L}_x \widehat{\mathbf{W}}(g) dg \right)^T \mathbf{c} \underbrace{\left( \int_{r_i} \mathbf{L}_x \mathbf{u}^k(g) dg \right)}_{\text{constant in } \Omega_i^e} - \int_{r_i} \widehat{\mathbf{W}}^T \mathbf{t}_r d\Omega - \int_{\Omega} \widehat{\mathbf{W}}^T \mathbf{b} d\Omega = 0 \quad (5)$$

It is clear in Equation (5) that we require no differentiation on both test and trial functions: a weakened weak form! Therefore, the assumed function does not have to be continuous (need not be in an  $H^1$  space), it needs only to be in a  $G^1$  space [29]. When the test and trial functions are chosen from the same space we have the generalized smoothed Galerkin (GS-Galerkin) weakform [4]. The proof on the stability and convergence of a general  $W^2$  formulation can be found in [30] based on the  $G$  space theory [29].

### Some $W^2$ models: current status

Because an  $H^1 \subseteq G^1$ , functions in a proper  $H^1$  space can also be used to create  $W^2$  models. This means that many of the existing FEM techniques can be used to establish  $W^2$  models with small changes in the evaluation of the strain energy (bilinear form). Therefore, the  $W^2$  models developed so far can be categorized into two major groups: Smoothed FEM (S-FEM) and smoothed point interpolation method (S-PIM). When the displacement function used is a proper  $H^1$  space, the model is termed as S-FEM model, and when it is in a proper  $G^1$  space using PIM shape functions [4], the model is termed as S-PIM model. All the  $W^2$  models work very well with triangular cells/elements, and possess some attractive properties, such as upper bound, superconvergence in both displacement and energy norms, ultra-accuracy, free from volumetric locking, and even “nearly exact”, etc.

The S-FEM models developed so far are summarized in TABLE 1, together with their properties. Detailed discussions on these S-FEM models can be found in [6-8, 24-27].

**TABLE 1:**  
**Versions of S-FEM models and properties**

Abbreviation	Full Name	Formulation	Features/properties
CS-FEM (2D)	Cell-based Smoothed Finite	Smoothed Galerkin Linear or enriched* PIM	Good accuracy Softer than FEM
CS-FEM (3D)	Element Method Q4 elements	Quadrilateral cell-based smoothing domains	Super convergence Conditionally stable
nCS-FEM (2D)	Cell-based Smoothed Finite	Smoothed Galerkin Linear or enriched* PIM	Good accuracy Super convergence
nCS-FEM (3D)	Element Method n-sided elements	Triangular cell-based smoothing domains	Spatially and temporally stable
NS-FEM (2D & 3D)	Node-based Smoothed Finite Element Method n-sided elements	Smoothed Galerkin Linear or enriched PIM Smoothing operation based on nodes	Volumetric locking free Upper bound [21,22] Strong super convergence in energy Temporally instable
ES-FEM (2D)	Edge-based (Face-based)	Smoothed Galerkin Linear or enriched PIM	Ultra accuracy Very efficient
FS-FEM (3D)	Smoothed Finite Element Method n-sided elements	Smoothing operation based on the edges (faces) of the cells	Strong super convergence Spatially & temporally stable
$\alpha$ FEM (2D)	Alpha Finite	Smoothed and Standard	Nearly "exact" solution
$\alpha$ FEM (3D)	Element Method using T3 & T4 elements	Galerkin Linear or enriched PIM Smoothing based on the nodes and cells	Strong super convergence Upper and lower bounds Spatially & temporally stable

Compared to S-FEM, S-PIM models use PIM shape functions that are in general not continuous but in a  $G^1$  space. Detailed discussions can be found in [4].

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“... many of the existing FEM techniques can be used to establish  $W^2$  models with small changes in the evaluation of the strain energy ...”

# FEA for Understanding the Cranial Mechanics of a Dinosaur from Patagonia

by

Adrián P. Cisilino<sup>1</sup>,

Néstor Calvo<sup>2</sup>,

Gerardo V. Mazzetta<sup>3</sup>

& R. Ernesto Blanco<sup>4</sup>

<sup>1</sup> Dep. de Ingeniería  
Mecánica / INTEMA,  
Universidad Nacional de  
Mar del Plata, Argentina  
[cisilino@fi.mdp.edu.ar](mailto:cisilino@fi.mdp.edu.ar)

<sup>2</sup> Centro Internacional de  
Métodos Computacionales  
en Ingeniería (CIMEC),  
Universidad Nacional del  
Litoral, Argentina  
[ncalvo@ceride.gov.ar](mailto:ncalvo@ceride.gov.ar)

<sup>3</sup> Departamento de  
Paleontología, Universidad  
de la República, Uruguay  
[mazzetta@fcien.edu.uy](mailto:mazzetta@fcien.edu.uy)

<sup>4</sup> Instituto de Física,  
Universidad de la República,  
Uruguay  
[blanco@fing.edu.uy](mailto:blanco@fing.edu.uy)

## Introduction

The large amount of fossils found in Patagonia has turned this land into a kind of Mecca of Paleontology. The discovery that giant and bizarre dinosaurs walked Patagonia in ancient times fuels the imagination of paleontologists and public alike. Nonetheless, the research that continues apace is about more than just a fascination with the extinct and the exotic. Examining the way that those long-gone species lived can yield important lessons about how life on Earth works today.

Among the finds in Patagonia was *Carnotaurus sastrei*, a very interesting and unusual carnivorous dinosaur from the Cretaceous period (Bonaparte, 1985, and Bonaparte et al., 1990). The name *Carnotaurus*, or carnivore bull, makes reference to its robust pair of frontal appendages and the carnivore diet of the animal, while *sastrei* is in

dedication to Mr. Ángel Sastre, the owner of the ranch where the specimen was found (Department of Telsen, Province of Chubut, Argentina). The skeleton of *Carnotaurus* is, up to the present, the most complete and best preserved material of a carnivorous dinosaur from the ancient supercontinent of Gondwana. Its remarkable preservation has allowed paleontologists to restore the dinosaur's morphology with a high degree of accuracy, and Mazzetta et al. (1998), using a geometric approximation of *Carnotaurus*' body shape, estimated its body mass at 1,500 kg. A view of *Carnotaurus*' life restoration is illustrated in Figure 1.



**Figure 1:**

Life restoration of *Carnotaurus sastrei*.

Shown in the background is the posture that individuals probably adopted for delivery of frontal blows.

Artwork courtesy of Luis V. Rey (1995), reproduced with permission.

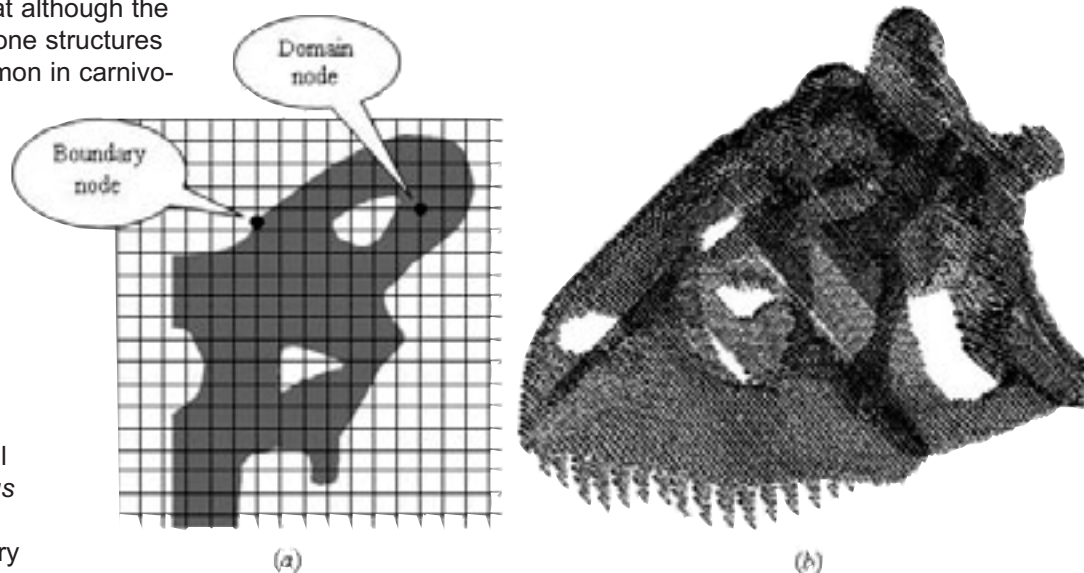
Inset:  
Lateral view of the skull.



It is worth highlighting that although the presence of accessory bone structures in the skull is not uncommon in carnivorous dinosaurs, *Carnotaurus* is the only example found so far of its kind having a large pair of frontal horns. Anterior and lateral views of the skull are also shown in Figure 1.

Understanding the cranial mechanics of *Carnotaurus* requires a diversity of information; it is necessary to know the material properties of the skull, as well as its size and shape, and its mechanical relationships with other body parts. Data on the forces applied during use are also essential. As it is easy to guess, to achieve this level of analysis with a species that have been extinct for at least 65 million years is naturally not without problems. To this end, the paleontological research focuses on either deductive studies that assume a close relationship between shape and function, or inductive studies that aim to test this relationship. Explicit hypothesis-testing bridges these two standpoints.

Finite element analysis (FEA) has been used for more than 30 years to assess the biomechanics of the human musculoskeletal system, including soft tissue mechanics, heat transfer, and computational fluid dynamic problems. Until recently, however, the potential of FEA to engage in questions of vertebrate biomechanics and evolution remained largely unexplored, being the study by Rayfield et al. (2001) the first comprehensive work of a fossil vertebrate structure using this methodology. Among other factors, this delay can be attributed to the differences in philosophical and methodological approaches between engineering and paleontological researchers (Rayfield, 2007). Nonetheless, recent collaborative FEA work developed by a team of engineers and palaeontologists has proven useful in gaining insights on the skull mechanics of Patagonian dinosaurs (Mazzetta et al., 2004, 2004a, 2009); a description of this work when applied to the cranium of *Carnotaurus* is presented in this article.



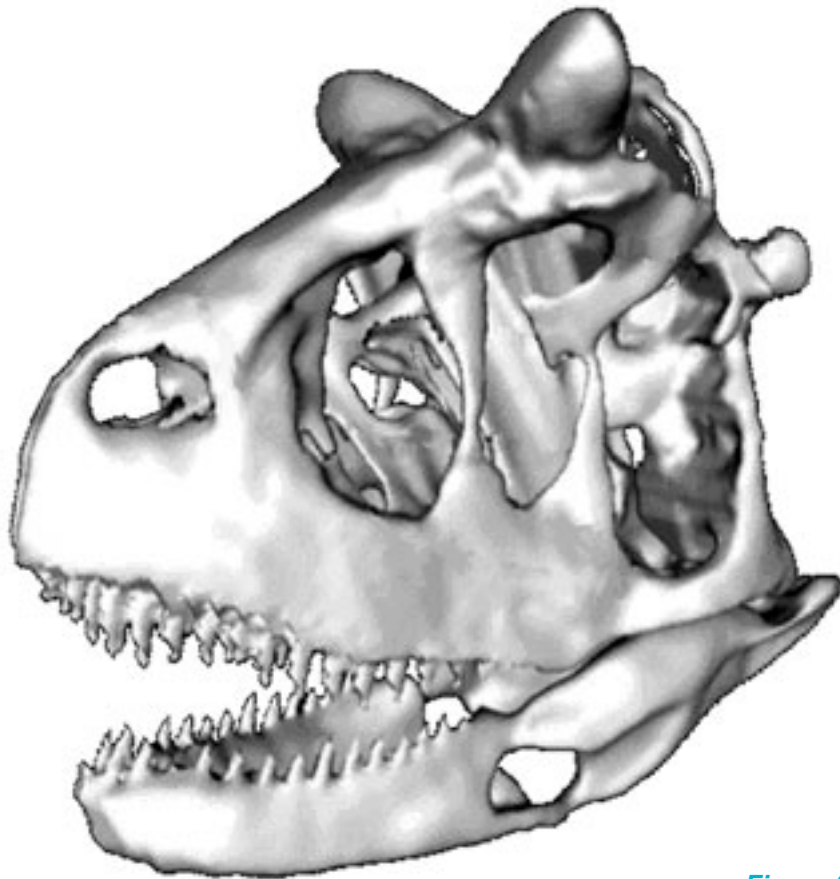
**Figure 2:**  
 (a) Silhouette corresponding to the cross-section coincident with the position of the frontal horn with the grid used to obtain points on the boundary and the domain;  
 (b) Cloud of points for the skull model.

### From CT scans to the FE model

The first issue we faced when creating a finite element (FE) model with the morphological complexity of the dinosaur skull was how to capture the problem geometry to produce the FE mesh. Computed tomography (CT) scanning is currently the best method available to capture both external and internal geometries (Rayfield, 2007). CT scanning works by detecting the attenuation of an X-ray source passed through a specimen. Grayscale units (named Hounsfield Units) demonstrate the density of the specimen within a series of cross-sectional slices taken through it. The image resolution is dependent on the size of the specimen, the capabilities of the scanner, and the contrast between fossilized bone and matrix in paleontological specimens.

A life-sized resin cast of the cranium of *Carnotaurus* from the holotype specimen MACN-CH 894 was subjected to CT scanning using a General Electric, Prospeed Hilight model, helicoidal tomographer. A series of 130 transaxial images separated by 5-mm intervals were obtained for the skull.

*“... remarkable preservation has allowed paleontologists to restore the dinosaur’s morphology with a high degree of accuracy ...”*

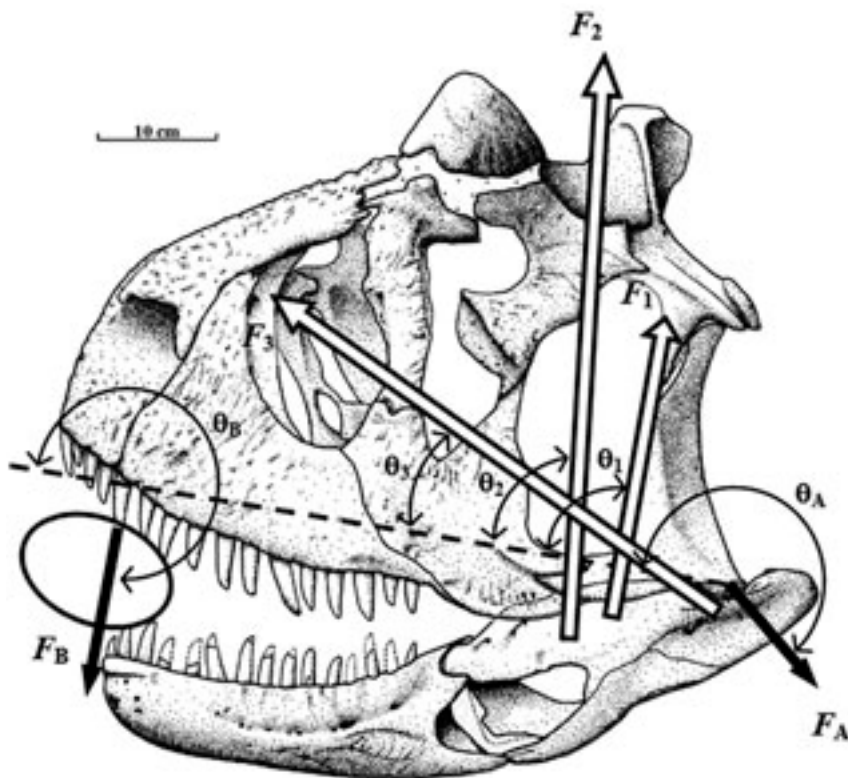


**Figure 3:**  
Rendered view of the finite elements model after the smoothing process

The images were converted to a bitmap format and manually edited in order to reconstruct the missing parts of the structures, and to correct the small distortion present in their geometries as a consequence of the high compressive loads involved during the fossilization process.

The edited images were then used to obtain cross-sectional silhouettes. A regular grid was superimposed on each of the silhouettes to determine the coordinates of the nodes (see Figure 2a). These coordinates were set at the intersections between the vertical and horizontal grid lines located within the silhouettes, and at the intersections of the grid lines (either horizontal or vertical) with the boundary of the silhouettes. The grid interval was set to 2.76 mm (6 pixels), which is approximately half the separation between consecutive CT scans. The process resulted in 98,375 points for the skull (see Figure 2b). A mesh of tetrahedral elements was built from the nodal positions using the software MeshSuite developed at CIMEC (Idelsohn et al., 2003). The resultant discretization had 488,444 elements.

The discontinuities in the model geometry caused by abrupt transitions between successive cross-sectional images were fixed by applying a Laplacian smoothing algorithm to the surface nodes. Since the smoothing process tends to eliminate geometric details from the model, the number of smoothing iterations that was chosen resulted from a compromise between the improvement of the discretization topology and the loss of accuracy in relation to the geometric representation of the cranium. After qualitative comparisons of the resulting model geometry to those of the actual cranium components, it was concluded that the best result was that obtained after two smoothing iterations. The smoothing process yielded a good quality FE mesh. An element distortion analysis measuring the element aspect ratio showed that only 1.5% of the elements presented high distortion ratios (>10). These highly distorted elements were mostly confined to the discretization of the teeth.



**Figure 4:**  
Action lines of the forces applied on the skull and lower jaw of *Carnotaurus saastrei*:  $F_1$ = posterior muscle,  $F_2$ = temporal group,  $F_3$ = pterygoideus group,  $F_4$ = intramandibular muscle,  $F_A$ = condylar reaction,  $F_B$ = bite reaction,  $F_C$ = tug of a prey,  $F_D$ = frontal blow. (Sketch of the skull and lower jaw modified from Bonaparte et. al. 1985)



A rendered image of the model is shown in *Figure 3*.

Histologically, the bone of carnivorous dinosaurs most closely resembles the bone of fast-growing bovine mammals, since they are both composed of secondary remodelled Haversian bone with primary compact bone restricted to the surface (Reid, 1996). Following Rayfield et al. (2001), it was assumed that similar histology indicates broadly similar material properties. Hence, the properties of bovine Haversian bone were assigned to the model: Young's modulus  $E=10$  GPa; shear modulus  $G=3.6$  GPa, and Poisson ratio  $\nu=0.4$ . The material response was considered linearly elastic, homogeneous and isotropic. The yield stress of bone was taken from Currey (2002) as 132 and -196 MPa, in tension and compression, respectively.

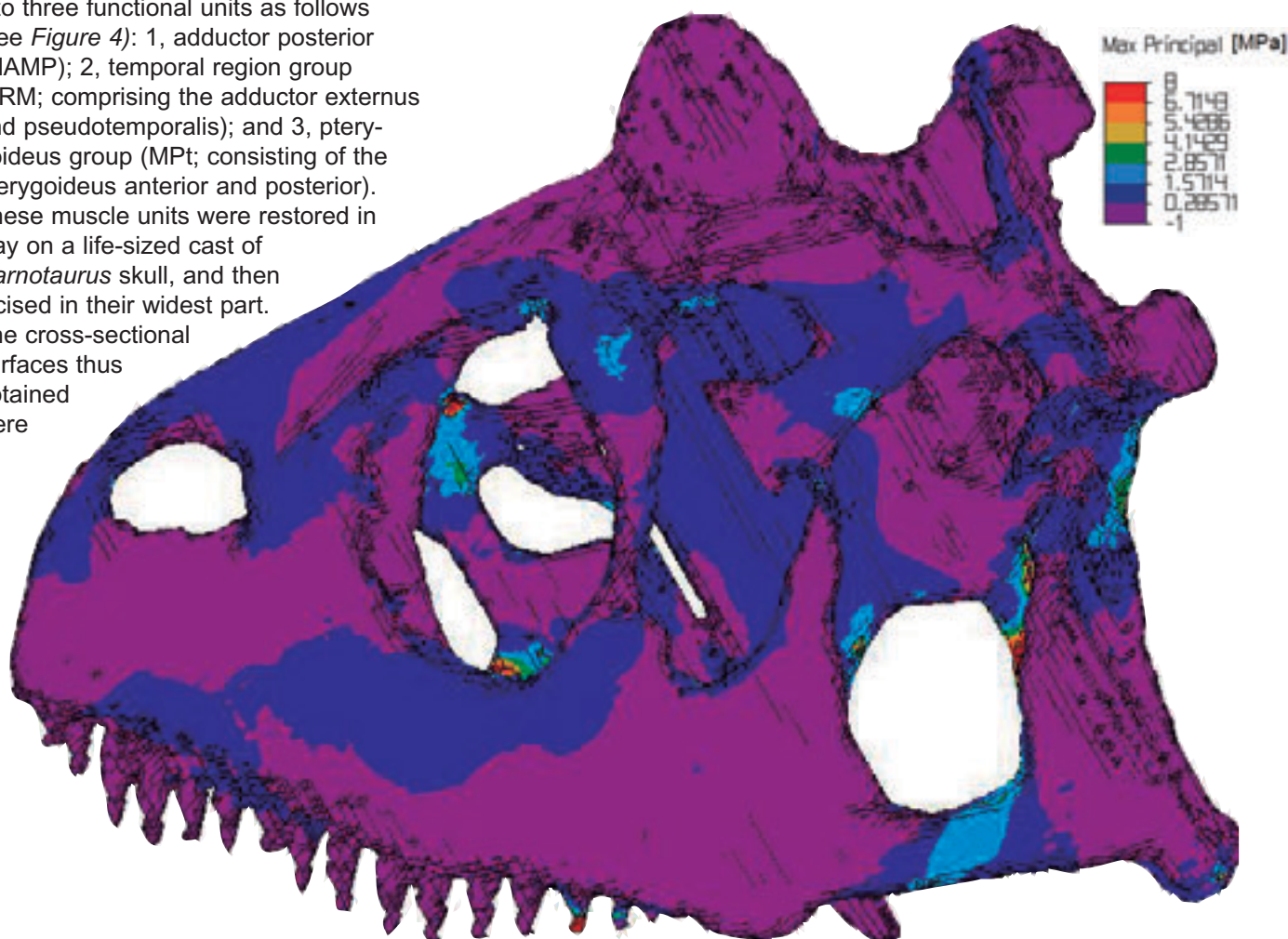
The restoration of the musculature was based upon the examination of the scars left by its muscles on the bones of the cranium and mandible of the specimen MACN-CH 894, and comparing their positions with extant crocodylians and lizards. The jaw muscles were grouped into three functional units as follows (see *Figure 4*): 1, adductor posterior (MAMP); 2, temporal region group (TRM; comprising the adductor externus and pseudotemporalis); and 3, pterygoideus group (MPt; consisting of the pterygoideus anterior and posterior). These muscle units were restored in clay on a life-sized cast of *Carnotaurus* skull, and then incised in their widest part. The cross-sectional surfaces thus obtained were

measured digitally on Scion Image (version Beta 3b, Scion Image Corporation, MD, USA). Muscle forces were calculated from cross-sectional area measurements. Different hypotheses on the angle of pinnation of the muscle fibres, the area of insertion of the muscles and the orientation of their lines of action were assessed for the different load cases considered. This provided a basic sensitivity analysis whereby we were able to determine the extent to which our conclusions depend on the muscle restoration and muscle architecture we adopted.

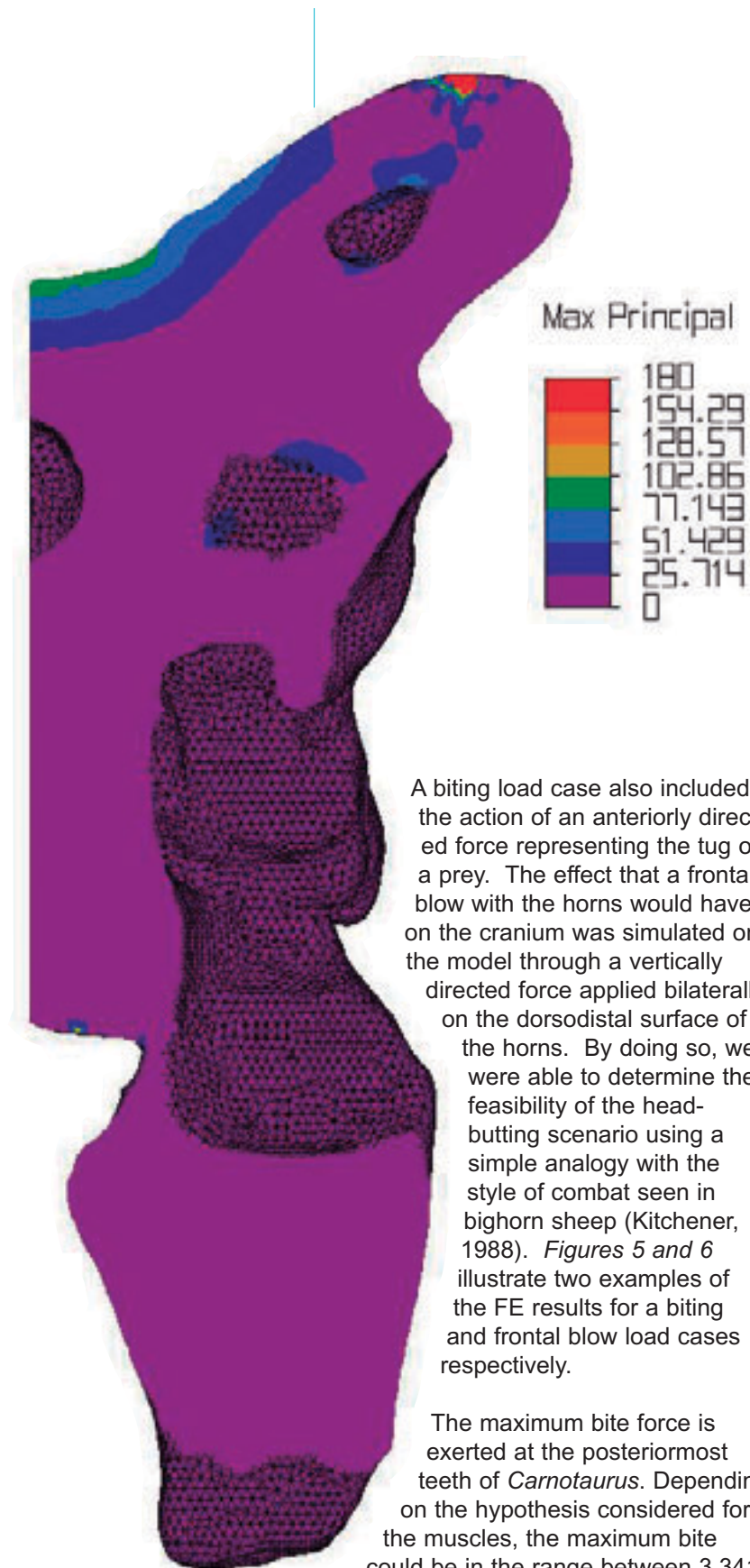
### Finite Element Analysis and Results

Biting as well as hypothetical situations involving biting or head-butting were analyzed through FE models. Biting load cases corresponded to the physiologic loads exerted on the cranium during static biting for selected positions along the tooth row (anterior, central, and posterior bite points).

**Figure 5:** Lateral views of the finite element model of the skull showing the results for the maximum principal stresses due to a muscle-generated bite at the three rear teeth.







**Figure 6:** Cross-section of the skull coincident with the tip of the horns. In this section is shown the stress distribution pattern for maximum principal stresses due to a frontal blow with the horns.

A biting load case also included the action of an anteriorly directed force representing the tug of a prey. The effect that a frontal blow with the horns would have on the cranium was simulated on the model through a vertically directed force applied bilaterally on the dorsodistal surface of the horns. By doing so, we were able to determine the feasibility of the head-butting scenario using a simple analogy with the style of combat seen in bighorn sheep (Kitchener, 1988). Figures 5 and 6 illustrate two examples of the FE results for a biting and frontal blow load cases respectively.

The maximum bite force is exerted at the posteriormost teeth of *Carnotaurus*. Depending on the hypothesis considered for the muscles, the maximum bite could be in the range between 3,341 N and 5,274 N. This bite force appears to be comparatively weak in relation to those reported for other flesh-eating dinosaurs (for instance the bite force of *Tyrannosaurus rex* has been estimated by Erickson et al., 1996, at around 13,400 N) and living carnivorous

vertebrates like the American alligator (9,452 N, according to Erickson et al., 2003). The bite force of *Carnotaurus* is comparable to those of lions (4,168 N; Thomason, 1991) and hyenas (4,500 N; Binder and Van Valkenburgh, 2000). It was also found that, during the butting scenario studied, the stresses in the cranium do not affect the braincase. Regardless the hypothesis considered for the muscles, the peak stresses on the cranium (in both tension and compression) are not critical when compared with the corresponding yield stresses. The peak stresses generated were found to be from two to seven-fold lower than those required to initiate yielding.

Interestingly, FE results revealed that the action of prey tugging during biting produces a stress distribution pattern very similar to that caused by a simple bite. These results allowed estimating that the cranium of *Carnotaurus* could have resisted a static tug force in the range from 38,520 N to 45,464 N before yielding. Besides, the load cases devoted to the study of the frontal blow showed that the cranium of *Carnotaurus* could have resisted forces of up to 225 kN, statically applied on the dorsodistal surfaces of the frontal horns. The magnitude of the blow and tug forces were assumed equal to those causing the maximum stress on the cranium before yielding.

## Discussion and Conclusions

FEA results allowed reaffirming and refining paleobiological interpretations previously advanced for this species. The main interpretations resulting from the present study are given next. The reader can find a comprehensive discussion of these results in the work by Mazzetta et al. (2009).

The FEA indicated that the jaw-closing musculature of *Carnotaurus* would have played a key role in diminishing the stress level on the cranium during biting, particularly for the braincase. Besides, the unremarkable bite force of *Carnotaurus* suggests that, like in modern crocodylians, this dinosaur probably relied heavily on the speed of jaw closure for prey capture.

The FEA also provide quantitative evidence to suggest that the cranium of *Carnotaurus* could have withstood high velocity impacts to its teeth resulting from a hypothetical hatchet-like biting mode, but could not have endured severe, rapid frontal blows during agonistic encounters.

## Closure

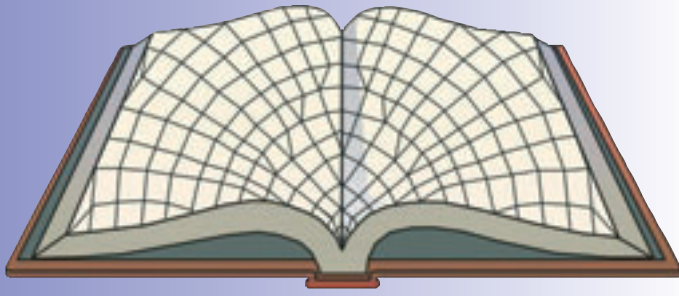
Man has a natural appeal for dinosaurs. Paleontologists study these extinct species by doing a detective work following a handful of clues that have survived for an enormously vast amount of time. The application of FEA tools

to help understanding the functional morphology of extinct animals is a fascinating field of collaboration for engineers and paleontologists. FEA is unlikely to uncover absolute answers to the questions paleontologists formulate, but hypothesis testing and comparative analysis offer much potential in understanding extinct animal function. ●

*“... like in modern crocodilians, this dinosaur probably relied heavily on the speed of jaw closure for prey capture.”*

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# A FIRST COURSE IN FINITE ELEMENTS

Jacob Fish and Ted Belytschko

Wiley, Chichester, West Sussex, UK, 2007

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**ISBN:** 978-0-470-03580-1, 336 pages, with CD, paperback, US \$77.95 (in the USA).

**Contents:** Preface; Chap. 1: Introduction; Chap. 2: Direct Approach for Discrete Systems; Chap. 3: Strong and Weak Forms for One-Dimensional Problems; Chap. 4: Approximation of Trial Solutions, Weight Functions and Gauss Quadrature for One-Dimensional Problems; Chap. 5: Finite Element Formulation for One-Dimensional Problems; Chap. 6: Strong and Weak Forms for Multi-dimensional Scalar Field Problems; Chap. 7: Approximations of Trial Solutions, Weight Functions and Gauss Quadrature for Multidimensional Problems; Chap. 8: Finite Element Formulation for Multidimensional Scalar Field Problems; Chap. 9: Finite Element Formulation for Vector Field Problems — Linear Elasticity; Chap. 10: Finite Element Formulation for Beams; Chap. 11: Commercial Finite Element Program ABAQUS Tutorials; Appendix; Index.

I am glad to open this Book Review section (hopefully to appear regularly in IACM Expressions from now on) with this delightful book. Introductory texts on the Finite Element Method (FEM) are abundant; according to the estimate appearing in the Introduction of this book there are about 600. Some of these books are very good and popular. In such a saturated market one needs vision and courage to publish yet another introductory FEM book. To be successful, a new book on the subject must not only be of good quality (a property required of any book) but must also be based on new concepts or ingredients, and in some sense should close an existing gap. This book satisfies these requirements admirably.

Introductory books on FEM may differ from each other in many ways, for example in their being generic or focused on a special discipline (e.g., structures or fluid flow); in the types of mathematical problems that they discuss (elliptic, eigenvalue, parabolic, hyperbolic); in their emphasized variational approach (functional minimization and Rayleigh-Ritz vs. weak form and Galerkin); and in the amount and level of mathematics included in them. *Figure 1* shows a table, taken from the Appendix of my 1992 book, which classifies a number of good FEM books written till the end of the 1980's according to the amount of mathematics and engineering associated with them. This parameter is particularly important, because to a large extent it determines the book's target audience. The appropriate place for the book of Fish and Belytschko in this classification is not obvious. On one hand, it is in essence an elementary presentation of FEM, but on the other hand, the approaches it adopts and a number of added topics included in it definitely go beyond the elementary. It is mostly intended to engineering students and practitioners, but it is more rigorous than some other books that are intended for this audience. It should probably be placed somewhere between the two central columns of the table shown in *Figure 1*.

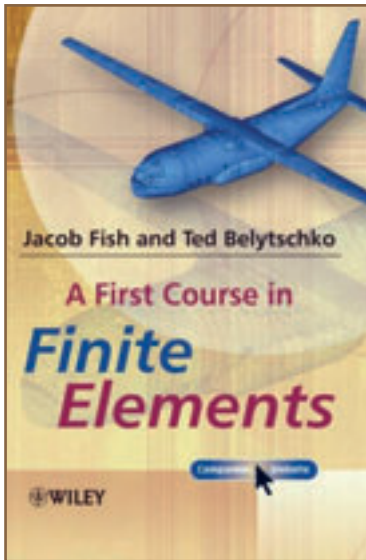
Engineering		Mathematics	
Irons & Ahmad [1980]	Bathe & Wilson [1976]	Carey & Oden [1983]	Ciarlet [1978]
	Cook, Malkus & Plesha [1989]	Hughes [1987]	
	Kikuchi [1986]	Johnson [1987]	
	Martin & Carey [1973]	Oden [1972]	
	Zienkiewicz [1977]	Reddy [1984]	
		Strang & Fix [1973]	
		White [1985]	

**Figure 1.**

Classification of a number of good FEM books written till the end of the 1980's according to the amount of mathematics and engineering associated with them.

by  
**DAN GIVOLI**  
Technion – Israel Institute  
of Technology  
givolid@aerodyne.technion.ac.il





This book is generic in nature, but it nevertheless tends towards applications in structural mechanics. It covers only linear elliptic boundary value problems (no eigenvalue or time-dependent problems are mentioned). According to the Preface, “this book is written to be an undergraduate and introductory graduate level textbook.” I have discovered that this book has also become, extremely quickly, very popular with FEM practitioners in some Israeli industrial companies. I have heard from a few of them that they found it an excellent source and felt that it catered to their needs more than any other existing book on FEM.

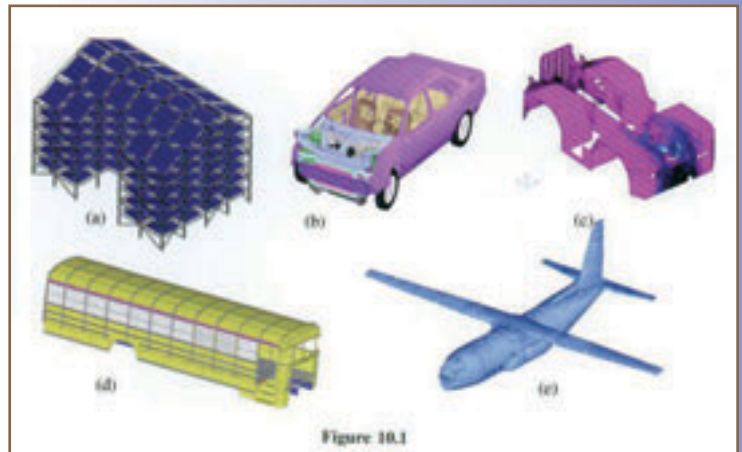
The book is attractive and well edited. It contains many illustrations, some of them having color versions. *Figure 2* is an example for a color figure appearing in the book (Fig. 10.1 there), showing five industrial FE models related to various applications.

The book contains many detailed examples within the chapters, and many helpful problems at the end of each chapter. The Index is comprehensive and allows convenient use. All this makes reading and consulting this book an enjoyable experience.

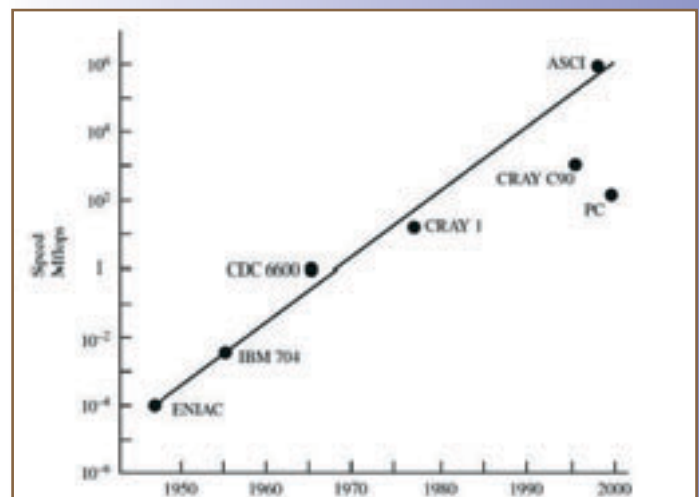
Here are 10 things, most of them non-standard, that I especially liked in this book. (There are actually more good things about it that I have no room to discuss here.) I list them here in no particular order.

- Section 1.1 entitled *Background* in the very beginning of the book is inspiring. It contains a nice historical account on FEM and some fascinating related facts, told by the authors in a light and humorous style. (“It is interesting that in the 1980s a famous professor predicted that by 1990 wind tunnels will be used only to store computer output.”) Among other things, Moore’s law is discussed and illustrated. *Figure 3* (which is Fig. 1.2 in the book) is a version of the famous graph which supports Moore’s law, indicating the doubling of the speed of computers every 18 months. The Background section even discusses briefly the economics of the FEM industry, and it leads to the following advice: “Young people should always consider starting their own companies; generally, it is much more lucrative and exciting than working for a big corporation.” Refreshing!
- Each of the book’s sections is associated with one or more of the following three “tracks”: the *Broad Science and Engineering* track; the *Advanced* track and the *Structural Mechanics* track. This is very helpful for both the teacher and the student, from obvious reasons.
- The book is *self-contained*. When a certain application is discussed – beams, two-dimensional elasticity, etc. – the authors develop all the equations themselves rather than “send the reader” to books on mechanics. I find this pleasing, since it shows the reader how the physics, the mathematics and the numerics are all tied together.
- The book contains a CD with the *ABAQUS Student Edition software*. Chapter 11 is a tutorial written by the ABAQUS team. This is a fine bonus indeed, that helps to connect in the student’s mind FEM theory and practice.

**Figure 2:** Applications of beam and shell elements: (a) building; (b) car; (c) tractor; (d) school bus; (e) fuselage of an aircraft. Model (a) was provided courtesy of Granite Engineering and Design. Models (c)-(e) were provided courtesy of Mercer Engineering. [This is Figure 10.1, color version, taken from the book.\*]



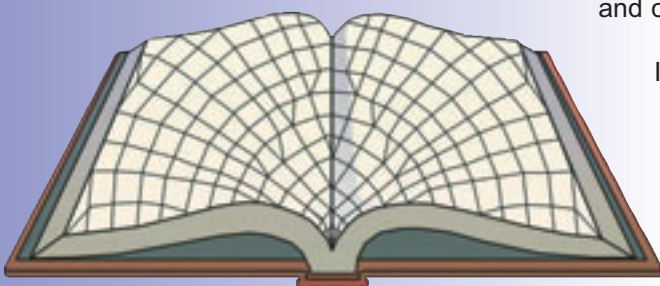
**Figure 3.** Historical evolution of speed of computers, supporting Moore’s law. [This is Figure 1.2 taken from the book.\*]



5. The book puts a special emphasis on explaining the concept of *the weak form* and deriving it for various problems. Many pages are dedicated to this subject. I do not recall any other book on FEM giving so much attention to it, and I think that this is an excellent idea. The motivation can be found at the bottom of p. 49: “The above is called the *weak form*. ... Understanding how a solution to a differential equation can be obtained by this rather abstract statement, and why it is a useful solution, is not easy. It takes most students considerable thought and experience to comprehend the process.” Every one who has taught a course on FEM using weak forms knows that this is very true.
6. The *penalty method*, for enforcing essential boundary conditions as a limiting case of natural boundary conditions, is discussed here (pp. 22, 63, 112). This is a nice example for non-standard material included in an introductory book. Such “diversions” are beneficial in that they show the student that there is more than a single way in going about FEM.
7. The *analogy* among three different physical problems in one dimension (diffusion, heat conduction and rod elasticity) is nicely summarized on p. 62.
8. A second example for non-standard material included here is the treatment of the *advection-diffusion* equation, in a number of sections along the book. On p. 70, the authors discuss the concept of variational principles, and mention that simple variational principles cannot be developed for the advection-diffusion equation, thus demonstrating an advantage of the weak-form approach.
9. A third example for non-standard material is the discussion on *instability*, manifested by spurious oscillations, in the case of advection-dominated advection-diffusion (p. 122). Later the authors briefly present in this context the Galerkin Least Squares (GLS) stabilization method (pp. 208-209). (Incidentally, there is no demonstration in the book that GLS indeed cures the spurious oscillations shown on p. 122, something that the reader would expect to see after learning about the GLS formulation and its motivation. I suggest that a graph to this effect be added in the 2<sup>nd</sup> edition.)
10. Section 8.2 discusses *verification and validation*, including the *patch test* and “*manufactured solutions*.” This is very important material that students should be exposed to very early in their FEM education.

No book is perfect, and I can point to a number of small things that should be improved in the 2<sup>nd</sup> edition of this book. One such thing is the mathematical precision of some statements and notation. Throughout the book, the empty set is denoted by 0 (zero). On p. 67, a functional is defined as “a function of a function” rather than a mapping from a function to a scalar. On pp. 208-209, in the presentation of the GLS method, the stabilization term is written as an integral over the global domain rather than an integral over the union of element interiors; this gives rise to unnecessary singularities, and leads the authors to write that “it is one of the big mysteries of these methods that these unbounded terms are simply neglected, and yet the method works.”

I can appreciate the authors’ dilemma: simplification vs. preciseness. This is perhaps a matter of taste, but I think that mathematical inaccuracies that engineering students absorb at an early stage of their studies following the teacher’s desire to simplify things for them, carry a significant price later and are very difficult to uproot. However, these small points by no means diminish from the high quality of the book and can easily be corrected in the 2<sup>nd</sup> edition.



In summary, this is a delightful book that I very highly recommend to teachers and students of FEM courses and to FE practitioners in the industry. ●

\* Figures from the book are shown by permission of **John Wiley and Sons and the authors.**

# **Prof. J.A.C. Martins**

**1951 - 2008**

Prof. João Arménio Correia Martins passed away suddenly at his home in Lisbon on August 4th 2008. He was survived by his wife, Prof. Anabela Fernandes, and two daughters, Maria Rita and Susana.

Prof. J. A. C. Martins was born on November 11th, 1951 at the Portuguese town of Olhão. He graduated in Civil Engineering in 1976 at the Instituto Superior Técnico - IST (School of Engineering of the Technical University of Lisbon) and completed his M. Sc. and Ph. D. degrees at the University of Texas at Austin (U.S.A.) in 1983 and 1986, under the supervision of Prof. J. T. Oden. He became Full Professor at the Department of Civil Engineering and Architecture of the IST in 2005. At the time of his death he was President of the ICIST (Instituto de Engenharia de Estruturas, Território e Construção) a research center of the IST and a member of the General Assembly of the IUTAM. Moreover, he had been Vice-President of The Portuguese Association of Theoretical, Applied and Computational Mechanics - APMTAC - in 2000-2007.

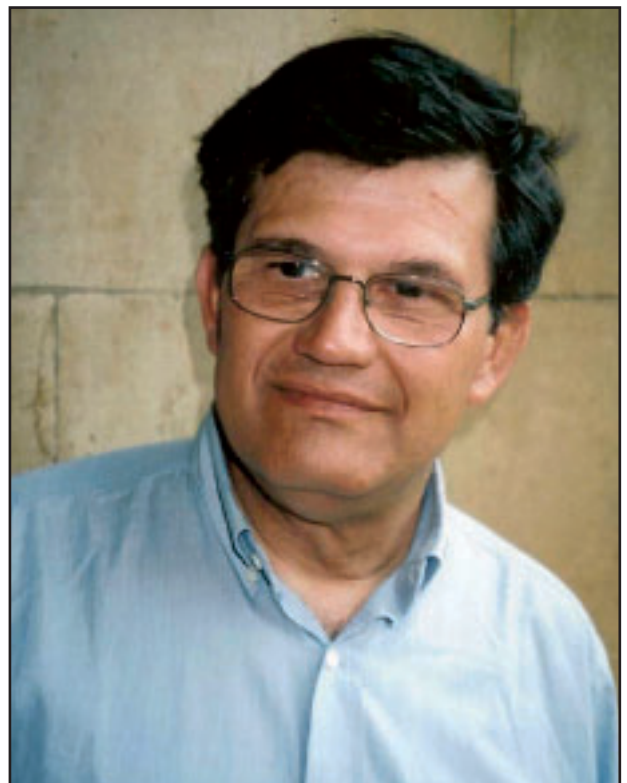
Prof. João Martins' remarkable personality inspired all those who were privileged to know and work with him. He had exceptional human, teaching and scientific qualities that were put to the service of his University and of the international scientific community, with great commitment and availability, for over more than 35 years. His main scientific achievements are briefly summarized next.

Prof. J. A. C. Martins made important contributions to Mechanics, in particular with respect to problems involving dynamic frictional contact between metallic bodies, the subject of his Ph. D. thesis. He later became deeply interested and involved in the study of frictional induced instabilities. He was seriously committed to develop a general theoretical framework for the stability of systems with a finite number of degrees of freedom. In order to achieve this objective Prof. João Martins studied thoroughly several types of instability of finite dimensional systems with frictional contact: acceleration-reaction discontinuities at equilibrium, divergence and flutter instabilities of equilibrium states and of straight equilibrium paths. In connection with divergence instabilities of frictional contact systems, he dedicated research effort to the bifurcation behaviour of structures and to the comparison of such frictional systems with plasticity models. Prof. João Martins was interested also in the relationship between the first order rate quasi-static and quasi-static evolution problems, exploring such issues as solvability and solution multiplicity of these problems. His latest research topic in frictional contact problems was the dynamic stability of quasi-static paths of mechanical systems involving two time scales; he achieved a rigorous definition for this concept, which led him to study singularly perturbed systems.

Prof. João Martins made important contributions also in the area of Biomechanics, namely on the behaviour of soft tissues of the human body. He was particularly interested in the modelling of the passive and active behaviour of skeletal muscles. He played an important role in the successful launching and implementation of a M. Sc. degree in Biomedical Engineering at the IST.

João Martins enjoyed very much connecting Mechanics and Mathematics. This made him a permanent source of mechanically meaningful problems worth being studied by mathematicians.

*Eduardo Arantes e Oliveira  
Carlos A. Mota Soares  
Eduardo Borges Pires  
Instituto Superior Técnico  
Technical University of Lisbon*





# CMM 2009

## The 18<sup>th</sup> International Conference on Computer Methods in Mechanics

by  
**Tadeusz Burczynski**,  
*Tadeusz.Burczynski@polsl.pl*  
**Mieczysław Kuczma**,  
*M.Kuczma@ib.uz.zgora.pl*  
**Krzysztof Wilmański**,  
*K.Wilmanski@ib.uz.zgora.pl*

The 18th International Conference on Computer Methods in Mechanics (CMM 2009) was held on May 18-21, 2009, at The University of Zielona Góra in the city of Zielona Góra, Poland, (Figure 1).

The International CMM Conferences take place in Poland every two years and have a long, 36-year tradition reaching back to the year 1973, when the first conference of this series was organized in Poznań.

The CMM conferences are jointly organized by The Polish Association for Computer Methods in Mechanics (its Polish acronym is PTMKM), The Polish Academy of Sciences (its Polish acronym is PAN) through its sections: Section of Computer Methods in Mechanics (Committee on Mechanics), and Section of Mechanics of Structures and Materials (Committee of Civil and Water Engineering).

Already at the previous conference, CMM 2007 in Łódź-Spala, it was announced that the 18th CMM Conference will be hosted by the University of Zielona Góra in 2009.

The Steering Committee of CMM 2009 (Professors T. Burczyński, Michał Kleiber, Janusz Orkisz, Zenon Waszczyszyn) has nominated Prof. Mieczysław Kuczma and Prof. Krzysztof Wilmański as chairmen of CMM 2009 and Dr. Waldemar Szajna as conference secretary.

Professor Olgierd C. Zienkiewicz was the honorary chairman of CMM2009. We truly hoped that Professor Zienkiewicz would be our distinguished guest at the conference and on his birthday (May 18) would collect the awarded Polish State Distinction. With deep sadness and regret we learned that Professor Zienkiewicz passed away on January 2, 2009. The vivid memories of him were perceptible during the whole meeting in Zielona Góra. Personal recollections of Olek Zienkiewicz were presented by Prof. Eugenio Oñate (Figure 2). The Zienkiewicz Memorial Lecture was instituted and the first one was given by Prof. Tadeusz Burczyński (Silesian University of Technology at Gliwice; Cracow University of Technology, Cracow, Poland),

**Figure 1:**  
*Participants of the  
CMM 2009  
(after the opening session)*



who talked on *"Immune computing: intelligent methodology and its applications in bioengineering and computational mechanics"*. An award ceremony of the Zienkiewicz Medal took place during the conference. The Zienkiewicz Medal (Figure 3), issued by the Polish Association for Computational Mechanics, is awarded by the Chapter of the Medal for outstanding merit in the development of computational mechanics. The recipients of the The Zienkiewicz Medal 2009 are Professors (in alphabetic order):

- Leszek Demkowicz (The University of Texas at Austin, Austin, USA),
- Eugenio Oñate (International Center for Numerical Methods in Engineering (CIMNE), Technical University of Catalonia, Barcelona, Spain),
- Janusz Orkisz (Cracow University of Technology, Cracow, Poland),
- Erwin Stein (Leibniz University of Hannover, Hannover, Germany), and
- Zenon Waszczyszyn (Cracow University of Technology, Cracow, Poland), (Figure 4).

This was the second edition of this medal, whereas the recipients of

- The Zienkiewicz Medal 2007 were
- Professors: *Giulio Maier* (Politecnico de Milano, Milan, Italy),
  - *Herbert Mang* (Vienna University of Technology, Vienna, Austria),
  - *J. Tinsley Oden* (The University of Texas at Austin, Austin, USA), and
  - *Zbigniew Kaczkowski* (Warsaw University of Technology, Warsaw, Poland),



**Figure 2:**  
*Prof. Eugenio Oñate, President of IACM presenting his personal recollections of Prof. Olek Zienkiewicz in the Zielona Góra Philharmonic Hall*

- *Michal Kleiber* (Institute of Fundamental Technological Research, Warsaw, Poland) and posthumously
- Jan Szmelter (Gdańsk University of Technology, Gdańsk, Poland).

The CMM 2009 was organized under the auspices of The European Community on Computational Methods in Applied Sciences (ECCOMAS) and The Central European Association for Computational Mechanics (CEACM).





We also greatly appreciate the honorary patronage of Marshall of the Lubuskie Province - Krzysztof Jabłoński, Mayor of the City of Zielona Góra - Janusz Kubicki, and Rector of the University of Zielona Góra - Prof. Czesław Osekowski, who were the main sponsors of CMM 2009.

About 300 participants from 24 countries attended the conference, out of which 90 came from abroad, mainly from Germany (29 researches).

44 researches were under the age of 30. Over 280 papers were

Gliwice; Cracow University of Technology, Cracow, Poland), Leszek Demkowicz (The University of Texas at Austin, Austin, USA), Guilo Maier (Politecnico de Milano, Milan, Italy), Herbert Mang (Vienna University of Technology, Vienna, Austria), Tomasz Lodygowski (Poznań University of Technology, Poznań, Poland), Eugenio Oñate (CIMNE, Technical University of Catalonia, Barcelona, Spain), John Osborn (University of Maryland at College Park, USA), M.B. Rubin (Technion - Israel Institute of Technology, Haifa, Israel), Jörg Schröder (University of Duisburg-Essen, Essen, Germany), Erwin Stein (Leibniz University of Hannover, Hannover, Germany).

The prominent researches organized 14 Minisymposia that covered a wide spectrum of topics: *Meshless and Related Methods* (Janusz Orkisz), *Multiscale Modelling and Nanomechanics* (T. Burczyński, P. Dłużewski, M. Pietrzyk), *Optimization and Identification of Structures* (K. Dems, A. Garstecki, W. Gutkowski), *Computational Methods of Artificial Intelligence* (T. Burczyński, Z. Waszczyszyn, L. Ziemiański), *Topology Optimization* (T. Lewiński, A. Zochowski), *Textile Reinforced Concrete* (B. W. Zastra), *Computer Methods in Geomechanics and Granular Flow* (P. Vermeer, Z. Wiśkowski), *Heat Transfer* (E. Majchrzak, B. Mochnacki), *Computational Mechanics of Composite Materials and Structures* (R. de Borst, T. Sadowski), *Computer Methods in Biomechanics* (R. Bedziński, K. Scigala), *Boundary Element Methods* (M. Maischak), *Computational Contact Mechanics* (P. Litewka, A. Zmitrowicz), *Adaptive Methods and Error Estimation* (W. Cecot, W. Rachowicz, G. Zboiński), *Computational Mechanics of Multiphase Porous Materials Including Durability* (D. Gawin, F. Pesavento, B. A. Schrefler). All lectures provided exchange of ideas and induced a lot of lively discussions. The written versions of most of the plenary and keynote lectures will appear in the book dedicated to the late Professor O.C. Zienkiewicz, published by Springer-Verlag: M. Kuczma, K. Wilmański (eds.), *"Computer Methods in Mechanics - Lectures of the CMM 2009."*

**Figure 3:**  
The Zienkiewicz Medal  
(obverse)



submitted out of which, after an evaluation process, 248

contributions were finally printed in the conference proceedings of "Short papers." The CMM 2009 had a rich scientific programme encompassing 11 Plenary Lectures, 28 Keynote Lectures given within 14 Minisymposia, 8 Thematic Sessions, 2 Industrial Sessions, preceded by the 3-day course *"hp-Adaptive Finite Element Methods"* given by Prof. L. Demkowicz, and accompanied by book exhibitions of Springer-Verlag, the Scientific-Technical Publishers (its Polish acronym is WNT), and Kubicz (a book importer). Over 230 papers were presented in 53 parallel sessions in 6 rooms during the 4 days. The plenary lectures were delivered by the most distinguished researches from around the world: Rene de Borst (Eindhoven University of Technology, Eindhoven, The Netherlands), Tadeusz Burczyński (Silesian University of Technology,



This intensive technical programme was complemented by social events, which included a concert given by the Zielona Góra Philharmonic Orchestra accompanied by a soloist of the Polish National Opera, a conference banquet in the Zielona Góra Palm House, a dinner with regional specialties, and trips to interesting places in and around Zielona Góra, the Muskauer Park among others. Once again a competition for the best paper presented by a young researcher was organized. The winners were Dr. Sławomir Milewski and Mr. Łukasz Skarżyński.

Finally, we would like to express again our gratitude to the members of the International and National Scientific Committees of CMM 2009 for their kind help in the reviewing procedures, as well as to the members of the Organizing Committee for their enthusiasm and commitment to the organization of the conference. All the events of the CMM 2009 were successful, which should be attributed also to the conference participants and their high-standard presentations, as well as to all the conference supporters and sponsors, whose aid allowed us to organize the conference with substantial freedom. The next CMM conference will be held in Warsaw, Poland, in May 2011.

Please visit the conference website <http://www.cmm.uz.zgora.pl> for further details. ●

**Figure 4:**  
*Prof. Michael Kleiber, President of PAN, and Prof. Tadeusz Burczyński, President of PTMKM, awarding The Zienkiewicz Medal to Professors: Leszek Demkowicz (top right), Eugenio Oñate (middle left), Janusz Orkisz (middle right), Erwin Stein (bottom left), and Zenon Waszczyszyn (bottom right).*



For all inclusions under APACM please contact:

**Genki Yagawa**  
yagawag@yahoo.co.jp

## The 1<sup>st</sup> International WCU Joint Workshop

### on Simulation Based Engineering and Science

The 1st World Class University (WCU) Joint Workshop on Simulation Based Engineering & Science (SBE&S) was held in the School of Mechanical Engineering at Sungkyunkwan University (SKKU), South Korea on Monday, August 31, 2009.

In this international joint workshop, eight technical talks were delivered through two sessions entitled "Application of interdisciplinary simulation technologies for environment friendly artificial structure design" and "Nano-Bio Interface SBE&S and Experimental Validations". The highlights included two SKKU Chair Professors at SKKU: Dr. Genki Yagawa (Toyo University) and Dr. Wing Kam Liu (Northwestern University) talked about "Large Scale Simulation of Growing Crack and Comparison with Experiment" and "Multiscale Bio-Chemo-Mechanics for Nanodiamond Based Therapeutics", respectively.

To broaden our outreach, we have invited two distinguished Taiwanese scholars: Dr. Kuen Ting (Lunghwa University of Science & Technology) and Dr. Chia Ching Chang (National Chiao Tung University) to deliver lectures on measurement of nano-mechanical properties and FEM simulation of dragon fly wing as well as laser induced popcorn like conformational change of nanodiamond and its biomedical application. Four Korean speakers also provided a variety of research topics ranging from biomimetic, eco-friendly design, to mechano-chemistry of biomolecules.

Under the support of the WCU program, South Korea, this type of WCU joint workshop will continually be held annually at SKKU, which will lead to be one of leading East-Asia highlights on SBE&S. ●

**Figure 1:**  
A commemorative photo with all workshop participants

For any inquiries, please contact:  
**Dr. Moon Ki Kim at SKKU**  
mkkim@skku.ac.kr





# Report from the Japan Association for Computational Mechanics



On the occasion of USNCCM-X held in Columbus, Ohio, last July, the JACM meeting was held to discuss the prospects of JACM and to present the JACM awards.

More than 20 members got together. The JACM Awards for Computational Mechanics was presented to Professor Ichiro Hagiwara and Professor Yutaka Miyake. The JACM Fellows Award was presented to Professor Hiroshi Okada, Professor Hiroshi Okuda and Professor Feng Xiao. The JACM Award for Young Investigators in Computational Mechanics was presented to Dr. Takehiro Fujimoto and Dr. Ryosuke Matsumoto.

The photos of these recipients are shown here. ●



**Figure 1:**  
The JACM Awards for Computational Mechanics:  
**Ichiro Hagiwara** (left) and  
**Yutaka Miyake** (right)



**Figure 2:**  
The JACM Award for Young Investigators in Computational Mechanics:  
**Takehiro Fujimoto** (left) and  
**Ryosuke Matsumoto** (right)



**Figure 3:**  
The JACM Fellows Award:  
**Hiroshi Okada** (left),  
**Hiroshi Okuda** (centre) and  
**Feng Xiao** (right)



**Figure 4:**  
Photo at JACM meeting in Columbus, Ohio



## MACM NEWS

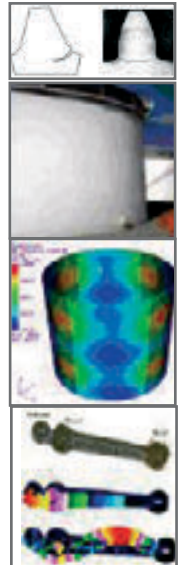
Malaysian Association for Computational Mechanics

The activities of Computational Mechanics Research cover both numerical and experimental approaches to mechanics research focusing on Computational Modeling of Materials, Metal Processing, Engineering Components and Structures, Techniques and Software Tools for Computational Mechanics, Techniques and Tools on Parallel Processing.



MACM Members

- Finite element computation is the most popular numerical technique for engineers and scientists. In looking at trends, the demand for numerical simulation is increasing because it is one of the most powerful tools in developing a deeper understanding of the effects of variables on a system. Empirical and experimental methods are expensive and considered only to complement or validate of the simulation.
- Parallel finite element model crack propagation incorporating elastic-plastic features of the material is developed. The programs for crack growth simulations are implemented on the computer systems made up of a numbers of processors running in parallel using Message Passing Interface (MPI) libraries on a Linux cluster. Research is carried out in determining and visualizing crack propagation of a 2-D plate under mixed modes.
- Probabilistic fracture mechanics is becoming increasingly popular for realistic evaluation of fracture response and reliability of crack structure. A computational methodology base on linear FEM for deterministic stress analysis, statistical model for load and material properties and Monte Carlo method for probabilistic analysis has been developed. The methodology developed is capable of predicting deterministic and probabilistic characteristics for used in linear elastic fracture mechanics.
- Corrosion is major factor for early failure in many infrastructure or equipment and costly problem. Corrosion monitoring is often needed to aid in the prevention system. Cathodic protection (CP) is often applied to protect the infrastructure such as long line pipe and underground tank from corrosion attacks. A method based on BEM has being developed for corrosion location detection and the effectiveness of cathodic protection system evaluation. ●



### Special points of interest:

- Computational Mechanics Research
- Seminar on "Non-traditional Concepts for the Treatment of Uncertainty & Imprecision in Engineering with Applications".
- Mini Symposium on Fracture & Strength of Solids '09
- Announcement of FEOFS 2010

### Non-traditional Concepts for the Treatment of Uncertainty and Imprecision in Engineering with Applications

The Seminar given by Dr. Michael Beer from National University of Singapore (NUS). Besides that his research interest is focusing on non-traditional methods for modeling and processing of uncertainty in engineering with emphasis on reliability and risk analysis. ●



**Left:** Some Seminar Participants  
**Right:** Ahmad Kamal Ariffin, Michael Beer & Nik Abdullah

### The following subject areas have been selected:

Fracture-Mechanics & Mechanisms, Fatigue & Crack Propagation, Environmental Degradation & Durability, Damage Tolerance & Fracture Control, Interface Failure & Delamination, Failure Analysis, Dynamic Fracture & Impact Problem, Creep Problems & Modeling, Composite, Polymer, Ceramics & Metallic Materials, Smart Materials & Structures, Comp. Methods & Modeling, & more...

<http://www.feofs2010.com>

### The 8<sup>th</sup> International Conference on Fracture and Strength of Solids (FEOFS) 2010.

6-9 June 2010. Kuala Lumpur, MALAYSIA.

The Far East and Oceanic Fracture Society (FEOFS) is pleased to announce that the 8<sup>th</sup> FEOFS 2010 will be held in MALAYSIA during June 7<sup>th</sup>-9<sup>th</sup>, 2010.

The society has arranged a mini symposium on **Fracture & Strength of Solids '09** prior to the Conference. This mini symposium was held in Penang, MALAYSIA on **June 4<sup>th</sup> - 5<sup>th</sup> 2009**. The aim of Mini Symposium is to unite researchers from the world's academia, industry, and the governments, for a few days, to share their experience and knowledge with each other, to review and discuss the state of progress, recent advances and to present their latest findings, as well as to exchange ideas among engineers and scientists involved in Fracture and Strength of Solids, Experimental and Computational Mechanics. The mini symposium is also expected to facilitate future collaborative research efforts. ●



For all inclusions under CSMA please contact:

**Alain Combescure**  
INSA de LYON  
France  
alain.combescure@insa-lyon.fr

## Giens 2009

### 9<sup>th</sup> edition of CSMA meeting

During the last week of may (25-29 may), the 9th edition of CSMA meeting was organized at the village of Giens, near Toulon, France. This conference gathers junior and senior scientists as well as PHD students, many of them in their 2nd or final PhD year.

The presentations are of high quality and nearly all in French, allowing rapid and profound discussions. Each day, a general lecture is given. This year they were given by A. Combescure (LaMCos), J.P. Vilotte (IPG), M.G. Geers (Eindhoven University of Technology), P.E. Gauthier (SNCF) and Ch. Soize (LMSME, Université Paris-Est). The nice tradition of combining a high scientific level with a relaxed French Riviera life style has been extended once more.

The congress gathered 350 participants from all French laboratories associated with computational mechanics and also about 25 participants from foreign countries, such as Belgium, Canada, Germany, Netherlands, UK, Spain, Switzerland and USA.

For its 9<sup>th</sup> edition, the minisymposia were organised around the following themes: composite structure and materials, multidisciplinary optimization, computational mechanics at small scales, energies, multi-model approach, and multi-scale approach for contact problems.

**Figure 1:**

*The General Assembly Animation.*  
In front of the white screen from left to right: C. Rey, A. Combescure and M. Raous



The CSMA PhD awards for the years 2007 and 2008 were distributed during a dedicated session where all the laureates gave a short plenary presentation.

If you want to test or practice your french language visit the conference web site: <http://giens2009.lmt.ens-cachan.fr>, where all the papers can be downloaded.

C. Rey (LMT), Conference Chairman  
M. Raous (LMA), Scientific Chairman  
A. Combescure (LAMCOS), Head of CSMA Association ●



**Figure 2, 3 and 4**  
*Groups of participants enjoying moments during the conference*





## ENIEF 2009

### XVII Congress on Numerical Methods and their Applications

Tandil, Argentina, November 3-6, 2009

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](mailto:sonzogni@intec.unl.edu.ar)

<http://amcaonline.org.ar>

The XVIII Congress on Numerical Methods and their Applications, of the Argentine Association of Computational Mechanics (AMCA) was held from November 2nd to November 6th, 2009 in Tandil, Argentina.

This congress, has been organized by the PLADEMA Institute at the National University of the Center of Buenos Aires (UNCPBA), Argentina. The congress was attended by 250 delegates, mainly from Argentina, but also from Brazil, Bolivia, Chile, Colombia, Paraguay, Spain, United States, Uruguay, and Venezuela.

The event lasted three and half days and took place at the Cultural Center of the UNCPBA. Prior to the Congress, on November 2 and 3, there was a series of short courses in plasticity and damage dictated by J. Signorelli, P. Frontini, C. Garcia Garino and A. Huespe. Also a capacitation course on the use of ABAQUS was offered by KB Engineering.



**Figure 1:**  
*Opening Ceremony of ENIEF 2009*

The technical program included two plenary lectures given by Professors Raul Fejoo and Rainald Löhner. A total of 51 sessions, covering Fluid Mechanics; Water Resources and Environmental Engineering; Acoustics; Solid Mechanics; Material Constitutive Modeling; Fracture, Fatigue and Failure Material Modeling; Heat Transfer; Structural Dynamics; Mathematical Fundamentals of Finite Elements and Meshless Methods; Interdisciplinary Mathematical Models; Inverse Problems and Applications; Optimization and Control; High Performance Computing in Computational Mechanics; Computational Geometry; Aerospace Technology; Numerical Methods for Simulation and Analysis in Bioengineering were run in four parallel sessions.

Full length papers were submitted to a review process prior to publication. From them, 228 papers have been accepted and included in the XXVIII Volume of the AMCA Series "Mecánica Computacional". The editors of this volume were Cristian Garcia Bauza, Pablo Lotito, Lisandro Parente and Marcelo Venere. The papers of "Mecánica Computacional" are available at the website:

<http://www.cimec.org.ar/ojs/inex.php/mc/issue/archive> .

**Figure 2:**  
*Participants at ENIEF 2009*

An undergraduate student posters competition was also carried out. The students Guillermo Hazebrouck, Sebastian Toro and Marcos San Martin received an award for their papers. A cocktail reception was organized on Tuesday and Congress Banquet took place on Wednesday. The congress received support from the Consejo de Investigaciones Cientificas (CIC) of Buenos Aires State, the UNCPBA, Intel Argentina Software Development Center (Intel ASDC), KB Engineering S.R.L. and SCILAB. ●



# MECOM 2010 - CILAMCE 2010

IX Argentine Congress on Computational Mechanics  
XXXI Ibero Latinoamerican Congress on Computer Methods in Engineering  
II South American Congress on Computational Mechanics  
15 – 18 November 2010, Buenos Aires, Argentina

The Congress is organized jointly by the AMCA (Argentine Association for Computational Mechanics), the ABMEC (Brazilian Association for Computational Mechanics), the Engineering School of Universidad de Buenos Aires and Sim&Tec S.A.

**Congress Chair:** Marcela Goldschmit

**Scientific Committee Chair:** Eduardo Dvorkin

**Local Organizing Committee:** J. L.D. Alves; M. Cavaliere; Ph. R.B. Devloo; S. D’Hers; P. Folino; A. Levy; M. Storti; R. Toscano

Buenos Aires, with its museums, theaters, libraries, art galleries and gourmet restaurants, is the political, cultural and intellectual center of Argentina. It is a modern city that preserves its original European style. Buenos Aires is a cosmopolitan city that grew from a blend of local and international population and now has about 3 million people.

Corrientes Avenue with its typical pizzerias, bars, bookstores and theaters will host the community of Computational Mechanics in the year of the Bicentennial of the first independent government of the country.



**Figure 3:**  
“Cabildo de Buenos Aires”,  
chair of the first national  
government.

**Plenary Lectures:** K.-J. Bathe; S. Estefen; S. Idelsohn; M. Ortiz; R.Radovitzky.

**Semi-Plenary Lectures:** P. Balbuena; A. Cardona; D. Celentano; M. Cerrolaza; A. Cuitiño; G. Etse; M. Koslowski; A. Lew; J. Oliver; E. Oñate; C. Prato; S. Rugonyi.

### Important Dates

Deadline for mini-symposium proposals:	March 30, 2010
Acceptance of mini-symposium proposals:	April 15, 2010
Deadline for one page abstracts:	May 31, 2010
Acceptance of abstracts:	June 30, 2010
Deadline for final paper:	August 31, 2010
Acceptance of paper:	September 15, 2010
Deadline for registration at a reduced rate:	September 30, 2010
Congress:	November 15 – 18, 2010

[www.mecom2010.net](http://www.mecom2010.net)

e-mail: [info@mecom2010.net](mailto:info@mecom2010.net) - Phone: 54-11-48078348 ●

## AMCA Annual Assembly

The annual general assembly of AMCA took place on November 4<sup>th</sup> 2009, in the city of Tandil, Argentina. A new Executive Council has been elected for the Argentine Association for Computational Mechanics (AMCA), for the period 2009-2011.

It is formed by: Victorio Sonzogni (president), Norberto Nigro (secretary), Victor Fachinotti (treasurer), and as members of the executive council: Adrian Cisilino, Victor Cortinez, Enzo Dari, Sergio Elaskar, Guillermo Etse, Carlos Garcia Garino, Angel Menendez, Oscar Moller, Marcelo Venere, Axel Larreteguy and Marta Rosales. ●



**Figure 4:**  
Some participants  
at the AMCA Assembly





**Figure 1:**

Prof. Karniadakis with the IACMM Council and the local organizers of the 25<sup>th</sup> IACMM Symposium. Left to right: Amiel Herszage, Dan Givoli, Zohar Yosibash, George Em Karniadakis, Isaac Harari, Alex Yakhot, Emanuel Ore. Sitting: Erez Gal.

The Israel Association for Computational Methods in Mechanics (IACMM) has held two **IACMM Symposia** since our last report (see IACM Expressions No. 24). In this issue we shall report on them and on other important events that took place during 2009.

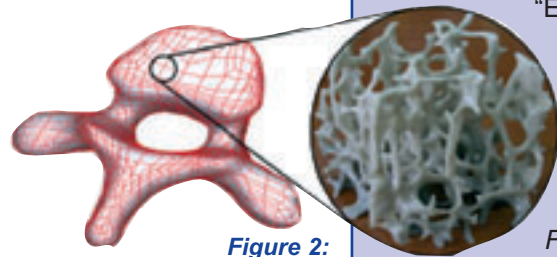
The **25<sup>th</sup> IACMM Symposium** was held in October 2008 at the Ben Gurion University of the Negev (BGU). The local organizers were Zohar Yosibash and Erez Gal. The Opening Lecture was given by Prof. George Em Karniadakis from Brown University, USA, and was entitled "Predictability and Uncertainty in Large-Scale Simulations."

See *Figure 3*.

*Figure 1* is a photo taken after the end of the Symposium.

This symposium included 10 contributed talks, among them the one by Lev Podshivalov, a Technion student of Anath Fischer and Pinhas Bar-Yoseph, on multi-scale analysis of bone tissue. *Figure 2*

is taken from this lecture. During the symposium, Netta Omer, a BGU student of Zohar Yosibash, received an award from IACMM for her 2007 PhD thesis "Edge Stress Intensity Functions in 3-D Domains." See *Figure 4*.



**Figure 2:**

A figure from the lecture of Lev Podshivalov at the 25<sup>th</sup> IACMM Symposium, on multi-scale analysis of bone tissue.

The **26<sup>th</sup> IACMM Symposium** was held in April 2009 at the Department of Civil and Environmental Engineering of the Technion. The local organizers were Kosta Volokh and Oded Rabinovich. The Opening Lecture was given by Prof. Patrick Le-Tallec from Ecole Polytechnique on "Data Assimilation in Mechanics." See *Figure 9*.

A Keynote Lecture was given by Prof. Edriss Titi from the Weizmann Institute of Science on "Subgrid Scale Models of Turbulence." See *Figure 7*. An additional guest that we were delighted to host was Prof. Christos Xenophontos from the University of Cyprus. *Figures 5 and 6* are photos taken during a special outing in honor of the guests.



**Figure 3:**

Prof. Karniadakis gives the Opening Lecture in the 25<sup>th</sup> IACMM Symposium.



**Figure 4:**

Netta Omer (middle) receiving an award for her PhD thesis from the President (left, Dan Givoli) and Secretary (right, Emanuel Ore) of IACMM.

## Computational Methods in Mechanics

Nine additional talks were given during this symposium, including the one by Zvi Zaphir from the Israel Aviation Industries (jointly with Vered Mahpari) on an elasto-plastic membrane analysis of a fuel tank exploiting some model analogies. *Figure 8* is taken from this lecture.

All the contributed lectures in the two IACMM Symposia mentioned above participated in a special **IACMM Lecture Competition**. As the winner of the competition, the judge panel chose the lecture of the student Nir Trabelsi from BGU, entitled "Patient-specific simulation of the proximal femur's mechanical response validated by experimental observations" (a joint work with Zohar Yosibash). Nir's prize is the support of IACMM in his travel to the ECCOMAS conference ECCM-2010 in Paris to present his work there.

In May 2009, the **one-day course** "Model Updating for Validation" was given by Dr. Scott Cogan from CNRS, France, at the Technion, under the auspices of IACMM. This course was a great success, and attracted many participants from the industry and academia.



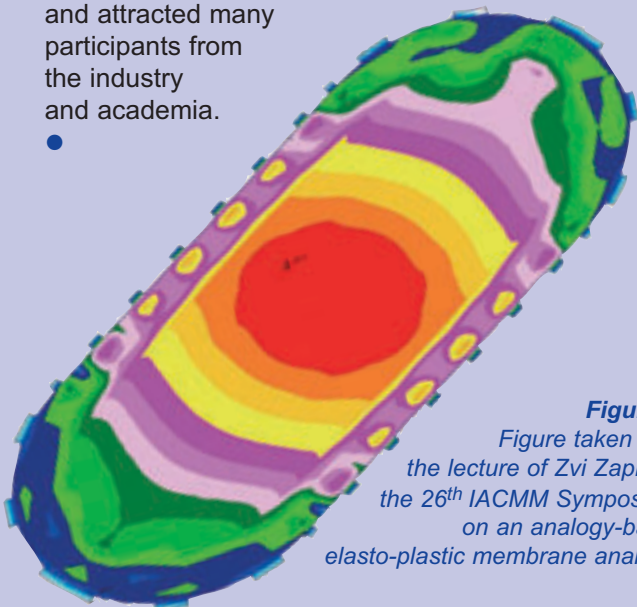
**Figure 5:**

Guests of the 26<sup>th</sup> IACMM Symposium, IACMM Council members and the local organizers. From left to right: Zohar Yosibash, Isaac Harari, Christos Xenophontos, Edriss Titi, Patrick Le-Tallec, Dan Givoli, Amiel Herszage, Emanuel Ore, Oded Rabinovich, Kosta Volokh.



**Figure 6:**

P. Le Tallec and C. Xenophontos (right), guests of the 26<sup>th</sup> IACMM Symposium, with Dan Givoli, Oded Rabinovich and Pinhas Bar-Yoseph (left).



**Figure 8:**  
Figure taken from the lecture of Zvi Zaphir in the 26<sup>th</sup> IACMM Symposium, on an analogy-based elasto-plastic membrane analysis.



**Figure 7:**

Prof. Titi gives a Keynote Lecture in the 26<sup>th</sup> IACMM symposium.



**Figure 9:**

Prof. Le Tallec gives the Opening Lecture in the 26<sup>th</sup> IACMM Symposium.



**Manolis Papadrakakis**  
**President**  
**ECCOMAS**

## Current changes and structure of ECCOMAS

The **European Community on Computational Methods in Applied Sciences** (ECCOMAS) is an umbrella organization of 26 national and regional Member Associations with the mission to foster the exchange of information and promote joint efforts of European universities, research institutes and industries which are active in the broader field of Numerical Methods and Computer Simulations in Engineering and Applied Sciences. ECCOMAS is the regional Organization of IACM in Europe.

In the General Assembly meeting of ECCOMAS on May 28, 2009 in Vienna, the new By-laws of ECCOMAS were unanimously approved. The new Bylaws introduce certain modifications in the composition and the operation of ECCOMAS Boards. The **General Assembly** (GA) is composed of representatives of the Members Associations. Each Member Association is represented in the GA by a number of representatives proportional to its active members. For National or Regional Associations and Scientific Committees with individual membership: one vote for 50 to 100 individual members; two votes for 101-300 members; three votes for more than 301 members. For Associations whose members are research groups and industries without individual membership, an equivalent individual membership is defined by multiplying the number of members by the equivalent number of individuals they represent. The GA is the highest authority of the Association and is responsible for all major decisions including the admission and exclusion of members and the election of the President of ECCOMAS. The President is elected for one four year term only.



*The ECCOMAS President Manolis Papadrakakis with the two Vice-Presidents Pekka Neittaanmaki and Ekkehard Ramm.*

Each Member Association is represented by one member in the **Managing Board** (MB) with voting rights equal to its corresponding voting rights in the GA. Membership in the MB is restricted to two four year terms. The MB is in charge of managing the scientific, technical and financial affairs of ECCOMAS and elects the two Vice Presidents, the Treasurer and the Secretary. The **Executive Committee** (EC), formed by the President, two Vice-Presidents, the Treasurer, the Secretary and up to two members of the MB, is responsible for daily administration, the content of the Newsletter, the role of the strategic and ad hoc committees. The MB is entitled to co-opt up to 5 persons on the basis of specific merits and expertise and to establish ad hoc committees when deemed appropriate.

### **The members of the Managing Board are the following:**

N. Bicanic (ACME/UK); F. Auricchio (AIMETA/ Italy); C. Mota Soares (APMTAC/ Portugal); D. Vandepitte (BNCM/Belgium); J. Eberhardsteiner (CEACM/Central Europe); P. Ladev□ze (CSMA/France; C. Hirsch (ERCOFTAC); P. Neittaanmaki (FMS/Finland);

E. Ramm (GACM/Germany); P. Steinmann (GAMM/Germany); M. Bernadou (GAMNI-SMAI/ France); M. Papadrakakis (GRACM/ Greece); M. Bercovier (IACMM/Israel); M. Gilchrist (ISSEC/Ireland); D. van Campen (NMC/Netherlands); T. Kvamsdal (NOACM/Nordic); A. Maslov (ONIV/Russia); T. Burczynski (PACM/Poland); C. Parés (SEMA/ Spain); P. Díez (SEMNI/Spain); M. Morandi-Cecchi (SIMAI/Italy); M. Kojic (SSCM/Serbia); V. Schroeder (SWICCOMAS/Switzerland); I. Tuncer (TNCTAM /Turkey).



*Members of ECCOMAS MB, Athens, October 15-16, 2009 - left to right: F. Auricchio, C. Mota-Soares, J. Eberhardsteiner, C. Pares, D. Vandepitte, P. Neittaanmaki, P. Steinmann, T. Kvamsdal, M. Papadrakakis, M. Morandi-Cecchi, C. Hirsch, P. Díez, M. Bernadou, O. Allix, E. Ramm*

The General Assembly, in its meeting in Vienna on May 28, 2009, elected **Manolis Papadrakakis** as the President of ECCOMAS for the period 2009-2013 and the MB, which convened just after the GA, elected **Ekkehard Ramm** and **Pekka Neittaanmaki** as Vice-Presidents, **Michel Bernadou** as the Treasurer and **Pedro Díez** as Secretary.

The first meeting of the MB was held in Athens on October 15-16, 2009 with its new officials. A number of issues, some of them are stated below, were elaborated on and decisions were taken, while priorities and the action plan of ECCOMAS for the next four year period were discussed:

**Election of co-opted members to the MB:** The MB elected the following persons as co-opted members with no voting rights: E. Onate and J. Périaux, as past Presidents, O. Allix and E. Stein as present and previous Chairmen of the Solids and Structural Mechanics Committee. In addition to these members, the previous past President of ECCOMAS, H. Mang, will be co-opted ex officio to the MB.

**ECCOMAS Committees:** Five Committees have been created representing major components of ECCOMAS with the objective to promote, foster, organize and coordinate research, academic and industrial activities in the corresponding scientific and technological fields. These activities encompass organization of conferences, symposia, workshops and other technical meetings in collaboration with academia and industry. The ECCOMAS Committees are the following: (i) Computational Solid and Structural Mechanics; (ii) Computational Fluid Dynamics; (iii) Computational and Applied Mathematics; (iv) Scientific Computing; (v) Industrial Liaison Activities.

**ECCOMAS Awards:** ECCOMAS has established three major awards to honor individuals with outstanding and sustained contributions in the fields of ECCOMAS. These can be nominated by individual members of an ECCOMAS Member Association. The **Ritz-Galerkin** Medal is the highest award given every four years at the ECCOMAS Congress. The **Leonhard Euler** Medal and the **Ludwig Prandtl** Medal are awarded for outstanding contribution in the fields of Computational Solid and Structural Mechanics and Computational Fluid Dynamics, respectively. In addition to these major awards, two awards for young scientists have been established, namely the **O.C. Zienkiewicz** Award in the field of Computational Engineering Sciences and the **J.L. Lions** Award in the field of Computational Mechanics, which are given every two years at the ECCOMAS congress and the Solids and Fluids conferences. Furthermore, the seventh edition of the selection of the two best Ph.D theses is underway for young scientists who presented a thesis within the fields of ECCOMAS and was approved by a university or research organization in Europe in 2009. The Awards will be conferred at one of the ECCOMAS conference to be held in 2010.

**ECCOMAS Newsletter:** One printed issue per year will be produced for distribution to the Member Associations and to the participants of the ECCOMAS conferences and one electronic issue will be distributed via the email addresses. The Editorial Board of the Newsletter will consist of the Executive Committee members.

**Major Conferences for 2010:** The two major ECCOMAS conferences in 2010 will be held in Paris and Lisbon: the IV European Conference on Computational Mechanics-Solids, Structures and Coupled Problems in Engineering (ECCM 2010), Paris, May 16-21, 2010 (<http://www.eccm2010.org>); Conference Chairmen: O. Allix and P. Wriggers and the Fifth European Conference on Computational Fluid Dynamics (ECCOMAS CFD 2010), Lisbon, June 14-17, 2010 (<http://www.eccomas-cfd2010.org>); Conference Chairman J.F.C. Pereira.

**ECCOMAS Congress 2012:** The 6<sup>th</sup> European Congress on Computational Methods in Applied Sciences (ECCOMAS 2012) will be held in Vienna, September 10-14, 2012 (<http://www.eccomas2012conf.tuwien.ac.at>). Congress Chairmen: H.J. Bohm, J. Eberhardsteiner, F.G. Rammerstorfer.

**Thematic Conferences:** In odd years, starting from 2003, ECCOMAS supported the organization of a series of Thematic Conferences (listed on <http://www.cimne.com/eccomas/html/link3.htm>). In 2009, twenty three (23) Thematic Conferences have been organized with more than 3,000 participants/papers total. Proposals for Thematic Conferences in 2011 can be sent, by the Member Associations or individual members, to the ECCOMAS Secretariat in Barcelona ([eccomas@cimne.upc.es](mailto:eccomas@cimne.upc.es)) anytime before October 1<sup>st</sup>, 2010. The Thematic Conferences are subject to the approval by the MB of ECCOMAS.

**Organization of Young Investigators Colloquia:** ECCOMAS, recognizing the importance of bringing together young investigators, will encourage and support the National and Regional Members to organize Young Investigators Colloquia on a local scale. The colloquia aim at providing a forum for young scientists for presenting and discussing results emanating from recent research efforts and non-standard industrial applications. Based on this experience, ECCOMAS will consider organizing a global event of this nature on a European level in the coming years. ●

**ECCOMAS**, thanks to the dedicated efforts of its past Presidents, the Vice-Presidents and members of the Managing Board, is enjoying its high stature as a scientific association engaged in the development and application of computational methods in science and engineering at the forefront of technological progress worldwide. ECCOMAS is confident that with the current changes and its new structure will competently fulfill its mission and meet the challenges of the new technological era, with great scientific and social impact that is unveiling before us, in Simulation-Based Applied Sciences and Engineering. ●





# news

## 3<sup>rd</sup> GACM Colloquium on Computational Mechanics

for all inclusions under GACM please contact:

**Stefan Löhnert**  
Leibniz Universität  
Hannover  
Germany  
+49 511 762 19056  
loehnert@  
ikm.uni-hannover.de

From **21.-23. September 2009** the '3<sup>rd</sup> GACM Colloquium on Computational Mechanics', a forum for young researchers from academia and industry hosted by the German Association for Computational Mechanics, took place at the Leibniz Universität Hannover. The conference was visited by around 160 participants and was the successor to previous meetings at Bochum and Munich.



Several minisymposia were organized by young researchers on topics such as biomechanics, contact mechanics, coupled problems, fluid dynamics, fluid structure interaction, fracture mechanics, homogenization, multi-body dynamics, multiscale methods, multifunctional materials and numerical mathematics.

Plenary lectures were held by Thomas J.R. Hughes, University of Texas at Austin, Burhard Wies, Continental AG tire company and Stefanie Reese, University of Brunswick. Erwin Stein, professor emeritus at the Leibniz Universität Hannover, gave a guided tour of the Leibniz exhibition, which displays the work of Hanover-based philosopher and scientist Gottfried Wilhelm Leibniz (1646-1716).

For the first time, the colloquium held a best poster contest among PhD students. Benedikt Kriegesmann from Hanover was awarded the best poster award for his work on 'Semi-analytical and numerical probabilistic buckling analysis of composite shells'.

The next GACM colloquium will be held in 2011 at the Technical University of Dresden. ●

**Figure 1:**  
Organisers and plenary lecturers of the Colloquium - from left to right:  
Prof. P. Wriggers, Dr. S. Loehnert, Prof. T.J.R. Hughes, Prof. E. Stein,  
Dr. R. Sauer, Prof. S. Reese



**Figure 2:**  
Best poster award ceremony.  
The winner (left) Benedikt Kriegesman,  
and Prof. P. Wriggers hands out the  
award.



## First International Workshop on Computational Engineering - Special Topic Fluid-Structure Interaction -

From **October 12-14, 2009** the 'First International Workshop on Computational Engineering - Special Topic Fluid-Structure Interaction' took place in Herrsching, Ammersee. The workshop was organised by the DFG Research Unit 493 Fluid-Structure Interaction (FOR493), TU München's International Graduate School of Science and Engineering (IGSSE), and TU Darmstadt's Graduate School of Computational Engineering.



The focus of this workshop was to provide scientists a forum for state-of-the-art research in Computational Engineering, covering all relevant aspects including modelling, numerical methods, parallelisation, software, visualisation, validation, and specific application scenarios. Therefore, after its 6-year funding period, scientists of FOR493 presented their final results on Fluid-Structure Interaction, accompanied by several tutorials and minisymposia on various topics such as computational steering, simulation software for supercomputers, GPU computing, room acoustics, or an industrial session presented by ANSYS Germany GmbH. The highlights of the workshop were the invited talks given by Hester Bijl (TU Delft), Carlos Felippa (University of Colorado, Boulder), Tayfun Tezduyar (Rice University, Houston), Jan Vierendeels (University Gent), and Chien Ming Wang (National University of Singapore).

Further information as well as the workshop's programme are available online under [http://fsw.informatik.tu-muenchen.de/workshop/workshop2009\\_en.php](http://fsw.informatik.tu-muenchen.de/workshop/workshop2009_en.php) . ●

## ECCOMAS Thematic Conference XFEM 2009

The **ECCOMAS Thematic Conference 'Extended finite element methods - Recent developments and applications'**, XFEM 2009, took place in **Aachen, Germany**, from **September 28-30, 2009**. More than 120 delegates attended the event. This first thematic conference on the XFEM and related methods was organized by T. P. Fries and A. Zilian, reflecting the continuously increasing interest in this field from academia and industry.

The technical program featured a well-balanced mix of method-oriented as well as application-oriented research topics. The keynote lectures delivered by distinguished experts in this field such as T. Belytschko, A. Combescure, T.P. Fries, P. Hansbo, S. Löhner, G. Meschke, N. Moës, Y. Renard, G. Ventura, and W.A. Wall may be viewed as movie streams on the conference webpage at [www.xfem2009.rwth-aachen.de](http://www.xfem2009.rwth-aachen.de). The conference proceedings and a photo gallery may also be found there.

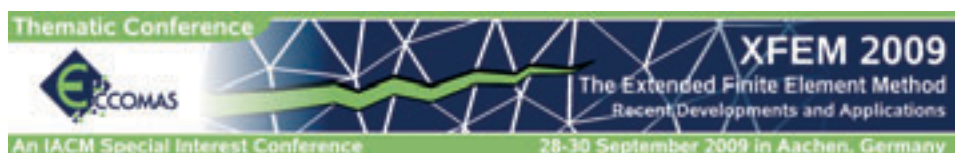
The follow-up event **XFEM 2011** will be organized by S. Bordas and B.L. Karihaloo at Cardiff University, UK.



**Figure 3:**  
*Conference dinner at the Ratskeller in Aachen*



**Figure 4:**  
*Participants of the XFEM'09 Conference during a coffee break*





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please contact:

[info@usacm.org](mailto:info@usacm.org)

## ASME 2010 First Global Congress on NanoEngineering for Medicine and Biology (NEMB2010)

Feb. 7-10, 2010  
Houston, TX.

The ASME Nanotechnology Council and the Alliance for NanoHealth invite you to join the growing NanoEngineering community at the ASME 2010 First Global Congress on NanoEngineering for Medicine and Biology (NEMB2010) held Feb. 7-10, 2010 in Houston, TX.

NEMB2010 will focus on the integration of Engineering Sciences, Mechanical Engineering and Nanotechnology to aid in addressing fundamental problems in Biology and Medicine and in developing devices for the early detection, imaging and cure of diseases.

Papers are solicited from members of the engineering community, scientists and clinicians involved in the development of new tools and materials in nanomedicine, experts from industry in the field of life sciences and all those investigating the potential of future emerging technologies.

[arandai@asme.org](mailto:arandai@asme.org)

## 11th U.S. National Congress Minneapolis and St. Paul Minnesota, USA July 25-29, 2011

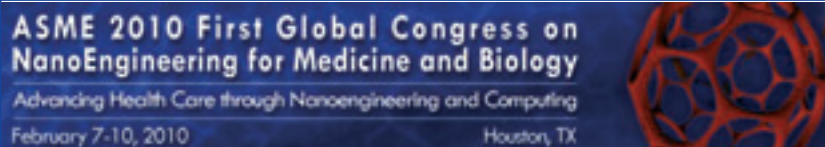


The 11th U.S. National Congress will take place in the beautiful and attractive twin cities of Minneapolis and St. Paul, Minnesota, USA, July 25-29, 2011

We expect a large turn out with state of the art themes and topics of interest to the broad research community at large in various disciplines related to computational mechanics. We also expect to have state of the art lectures by highly renowned researchers from across the world. The organizers are committed to making this an enjoyable, rewarding, and memorable congress.

USACM Mission is to promote, foster, organize and coordinate various activities concerning computational mechanics in the United States and to represent U.S. interests in computational mechanics as an affiliate of the International Association for Computational Mechanics (IACM).

[www.usacm.org](http://www.usacm.org)



### New USACM Fellows:

**Arif Masud:** Associate Professor, Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign

**John Hallquist:** President and Founder, Livermore Scientific Technology Corporation, Livermore, CA  
**Zdenek Bazant:** McCormick School Professor and Walter P. Murphy Professor, Northwestern University.

**Tarek Zohdi:** Professor, Department of Mechanical Engineering, University of California, Berkeley.

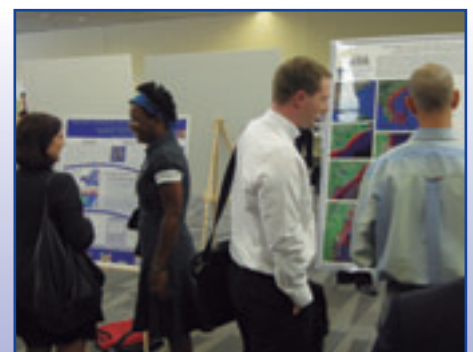
## Picture Diary of - USACM National Congress 2009



**Figure 1:**  
Opening remarks at USNCCM10 by Prof. S. Ghosh, Dr. T. Bickel, Prof. J.T. Oden, & Prof. S. Suresh look on.



**Figure 2:**  
Lecture presented during USNCCM10.



**Figure 3:**  
An evening session featured posters by some attending graduate students.

## USACM 2009 Awardees

### **John von Neumann Medal - Charbel Farhat**

Charbel Farhat is currently the Vivian Church Hoff Professor of Aircraft Structures, Chairman of the Department of Aeronautics and Astronautics, Professor of Mechanical Engineering, Professor in the Institute of Computational and Mathematical Engineering, and Director of the Army High Performance Computing Research Center at Stanford University. He has pioneered the development of parallel finite element solution methods that have enabled faster and more accurate analyses of a broad range of engineering and pathfinder systems. In particular, Farhat developed the Finite Element Tearing and Interconnecting (FETI) method for massively parallel computer systems which enabled the simulation and solution of many challenging engineering problems, particularly in the defense industry.

His citation reads: "For outstanding and sustained contributions in high-performance computing, fluid-structure interaction, and computational acoustics and their impact on real-world engineering applications." ●

### **Computational and Applied Sciences Award - Leszek Demkowicz**

Leszek Demkowicz is a Full Professor in the Aerospace Engineering and Engineering Mechanics Department at The University of Texas at Austin where he is also Assistant Director of the Institute for Computational Engineering and Sciences. His interests cover topics in computational mechanics, applied mathematics, numerical analysis, and scientific computing. In the last decade, his research has focused on hp-adaptive finite elements, with applications to elasticity, acoustics and electromagnetic waves. He is a scholar of truly eminent stature, who has made pioneering and fundamental contributions in computational mechanics.

His citation reads: "For pioneering work in both the theory and implementation of hp-Finite Element Methods, its application to numerous areas of computational mechanics, and in particular to computational electromagnetics." ●

### **Computational Structural Mechanics Award - Roger Ghanem**

Roger Ghanem is Professor in the Viterbi School of Engineering at the University of Southern California where he has been since 2005. Ghanem is a world expert in the field of computational stochastic structural mechanics and probabilistic modeling. He is credited with the development of stochastic projection methods for solving stochastic differential and algebraic equations governing structural mechanics problems. He has also been a catalyst in disseminating these methods to the scientific community. These stochastic projection methods, also known as Polynomial Chaos expansion methods, have provided a theoretical foundation to a number of outstanding problems in the science and engineering, including model validation, model reduction, and problems involving coupled physics and scales.

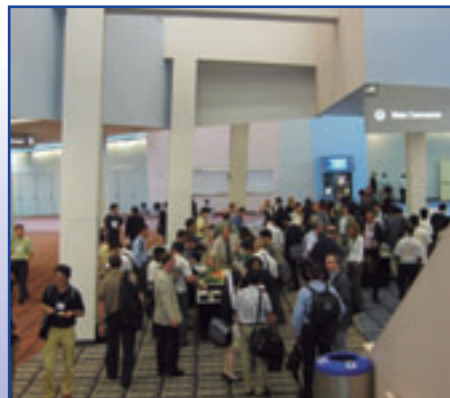
His citation reads: "For outstanding and sustained contributions to the development and dissemination of uncertainty quantification methods and their application to structural engineering." ●

### **R.H. Gallagher Young Investigator Award - Harold Park**

Dr. Harold Park is Assistant Professor in the Department of Mechanical Engineering, University of Colorado, Boulder, Colorado, USA. His research concentrates on the synergy between computational methods and materials physics, and the advances in the understanding of material behavior that can be possible as a result. Currently, he is interested in the modeling and simulation of metal nanowires, as well as in using multiple scale methodology to capture surface effects and surface stresses on the mechanical behavior of nanostructured materials such as nanoparticles, nanowires, and quantum dots. He was awarded the R.H. Gallagher Young Investigator Award for his groundbreaking work on computational nano mechanics and materials. ●



**Figure 4:**  
*USNCCM Banquet.  
Prof. & Mrs. J.T. Oden and Dr. T. Bickel.*



**Figure 5:**  
*Participants between sessions at the  
Greater Columbus Convention Center.*



**Figure 6:**  
*The Congress Banquet was held on the  
last evening.*





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For all inclusions under  
**ABMEC**  
please contact:

**José Luis Drummond Alves**  
*President*  
LAMCE-COPPE/UFRJ  
Civil Engineering Dept.  
Caixa Postal (PO Box) 68552  
21941-972 Rio de Janeiro  
Brazil  
Phone: (21) 2562-8416  
Fax: (21) 2562-8414  
presidente@abmec.org.br  
<http://www.abmec.org.br>

For additional information  
& photos of CILAMCE 2009,  
please go to:  
<http://eventos.nacad.ufrj.br/>

#### Figure 1:

*Prof. Ferrante memorial:  
Prof. Fernando Rochinha,  
Ms. Elisa Ferrante,  
Profs. José Alves,  
Paulo Lyra,  
Mrs. Dorinda Ferrante,  
Profs. Alvaro Coutinho,  
Sandra Malta,  
Gilberto Ellwanger,  
Sergio Scheer  
& Roberto Daledonne*

## *The 30<sup>th</sup> CILAMCE 2009: echoes from Buzios*

Following the success of its earlier editions, the 30<sup>th</sup> Iberian-Latin-American Congress on Computational Methods in Engineering, CILAMCE 2009 was held from **November 8th to 11th, 2009** in the city of Armação dos Búzios, a well known world-class beach resort close to Rio de Janeiro, RJ, Brazil. This new edition of the Brazilian Association for Computational Methods in Engineering (ABMEC) flagship conference was organized by the Graduate Center for Engineering of the Federal University of Rio de Janeiro (COPPE/UFRJ) and the National Laboratory for Scientific Computing (LNCC/MCT). The Organizing Committee comprised Prof. José L.D. Alves (COPPE/UFRJ), President of ABMEC and Chair of the Congress, Profs. Alvaro Coutinho, Fernando Rochinha and Luiz Landau (COPPE/UFRJ), Prof. Leo Franca (University of Colorado at Denver) and Prof. Sandra Malta (LNCC/MCT).

The conference was attended by more than 650 delegates, mainly from Brazil, including also delegates from the United States, Portugal, Chile, Argentina and Singapore. Special lectures have been given by: Omar Ghatass (UT Austin, USA), John Dolbow (Duke University, USA), Ramon Codina (UPC, Spain), Patrick Le Tallec (École Polytechnique, France), Nicholas Zabaraz (Cornell University, USA), Marcio Murad (LNCC, Brazil), Frederic Valentin (LNCC, Brazil), Luiz Bevilacqua (COPPE/UFRJ) and Heitor Araújo (PETROBRAS SA, Brazil).

The technical program included: plenary, semi-plenary lectures and ordinary sessions across nine rooms in parallel,

specially organized under 30 thematic mini-symposia. The congress took place during four days at the Atlantico Buzios Convention and Resort. A Conference Ice-Breaker cocktail was served to the delegates on Sunday. The ordinary annual assembly of ABMEC took place on Monday. On Tuesday night, During the Dinner Party, the Prof. Agustin J. Ferrante Awards were granted to the five distinguished Research Beginners (undergraduate students) contributions, selected for oral presentation among the circa 60 contributions in the category. All the Research Beginners' contributions were displayed in poster sessions, during the event.

#### *Special Sessions under the 30<sup>th</sup> CILAMCE*

##### **Prof. A.J.Ferrante Memorial Session**

On Tuesday morning, a memorial session took place in tribute to the late Prof. Agustin Juan Ferrante (1934-2009), starting with a very typical Brazilian folklore poem, a "cordel", authored and delivered by Prof. Paulo Lyra (UFPE, Brazil). Long time friends and collaborators shared with the audience memories of Prof. Ferrante.

Prof. Guillermo Creus (UFRGS, Brazil) shared memories of his personal life and Dr. Alvaro M. Costa (PETROBRAS SA) highlighted the importance of Prof. Ferrante's legacy to the oil industry in Brazil. On behalf of ABMEC, Prof. Nelson Ebecken (COPPE/UFRJ) was invited to forward a memorial plate to Mrs. Dorinda Ferrante and Ms. Elisa Ferrante, Prof. Ferrante's wife and daughter, who honored us all with their presence to the ceremony.





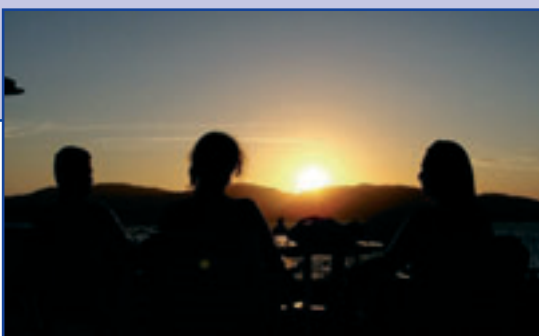
Starting in this edition of CILAMCE, the already traditional Research Beginners Award is henceforth named “Agustin Juan Ferrante Award” and granted to distinguished undergraduate student contributions to CILAMCE. A special Committee is in charge of the selection.

### Celebration of Prof. Nelson Ebecken’ 60<sup>th</sup> Birthday

Closing Tuesday afternoon program, a semi-plenary lecture was delivered by Prof. Luiz Bevilacqua (COPPE/UFRJ) and a special session organized took place, celebrating Prof. Nelson Ebecken’ 60<sup>th</sup> birthday. Prof. Ebecken is a pioneer in Computational Mechanics in Brazil, a former student of Prof J.T.Oden in the middle 70’s when he seeded in Brazil a small group of students interested in the subjects of Computational Mechanics and finite elements mathematical background. Prof. Nelson Ebecken is holder of the highest commend granted by the Brazilian Ministry of Science and Technology.

A packed audience had the unique chance to attend a very touching gathering of lifetime friends and collaborators. Addresses were given by Profs. Edison Lima (COPPE/UFRJ), Ronaldo Battista (COPPE/UFRJ), Eugenius Kaszkurewicz (COPPE/UFRJ and FINEP), Augusto Galeão (LNCC), Cid Gesteira and Dr. Alvaro M. Costa (PETROBRAS SA). The session was chaired by Prof. Luiz Landau (COPPE/UFRJ). The President of ABMEC, Prof. José Alves, delivered a celebration plate to Prof Nelson Ebecken. ●

**Figure 5:**  
*Delegates attending the  
Sunset at Armação Beach*



**Figure 2:**  
*Prof. Agustín Juan  
Ferrante†*



**Figure 3:** *Opening address by Prof. José Alves*



**Figure 4:** *Our plenarists in action, top left to right:  
Profs. Omar Ghatass, John Dolbow  
& Luiz Bevilacqua; bottom, left to right:  
Profs. Nicholas Zabarass, Patrick Le Tallec,  
Marco Murad & Frederic Valentin*



**Figure 6:**  
*Profs. Nelson Ebecken, Alvaro Coutinho, José Alves,  
Abimael Loula & Ronaldo Battista*





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## **abmec Executive and Advisory Board are elected**

Electons for the Executive Board and the Advisory Board of ABMEC took place a few weeks before the 30<sup>th</sup> CILAMCE and the results were officially announced in the ABMEC Meeting. The Executive Board, elected for a two years term from 2010 to 2012, is composed of: **President: Prof. José L. D. Alves**, (COPPE/UFRJ) ; **Vice-President: Prof. Philippe R.B Devloo** (UFMG); **1st Secretary: Prof. Sérgio Scheer** (CESEC/UFPR); **2nd Secretary: Prof. Severino P. C. Marques** (UFAL) and **Treasurer: Prof. Sandra M. C. Malta** (LNCC/MCT).

Effective members of the **Advisory Board** for the term from 2008 to 2012 are professors: **Eduardo Fairbairn** (UFRJ), **Hélio J.C. Barbosa** (LNCC), **Luis P.S. Barra** (UFJF), **Paulo M. Pimenta** (USP) and **Paulo R.M. Lyra** (UFPE); for the term 2010 to 2014: **Estevam B. de las Casas** (UFMG), **Fernando A. Rochinha** (COPPE/UFRJ), **Nelson F.F. Ebecken** (COPPE/UFRJ), **Alvaro L.G.A. Coutinho** (COPPE/UFRJ) and **Ramiro B. Willmesdorf** (UFPE). ●

## **Brazil ranks position 76 in Top500 list**

The Brazilian community is proud to announce that at Super Computing 2009 (SC09), a system installed in our country was awarded as #1 machine in Latin America. This machine supports research associated to the discovery of a vast new oil field in the Santos Basin, offshore Brazil. To address those challenges, Petrobras, the Brazilian Oil Company, is sponsoring an HPC grid managed by an alliance of five federal universities. The country-wide HPC project, called the Petróleo Brasileiro (BR) Network, would be used for computer simulations to aid oil production in Brazil's pre-salt basin. The Alberto Luiz Coimbra Institute-Graduate School and Research in Engineering from the Federal University of Rio de Janeiro (COPPE/UFRJ), which has been working with Petrobras on HPC projects since the early 1980's, realized that the universities needed a high-performance computing grid to handle the complex project. Installed in June 2009, the BR Network currently includes three universities: the University of São Paulo (USP), the Federal University of Alagoas (UFAL), and COPPE/UFRJ. The grid provides approximately 100 teraflops of peak performance and 21.5 TB of memory. The alliance is currently running benchmark tests to submit to the Top500 list of the world's fastest supercomputers. The node installed at COPPE/UFRJ has already ranked position #76 in the world, according to the last edition of the TOP500 list issued in November 2009, during the SC09, held at Portland, OR, USA. When the tests are complete, the universities will deploy custom software on the BR Network and prepare for production. The alliance expects that the BR Network will be fully operational by February 2010. ●

## **- FORTHCOMING EVENTS -**

### **9<sup>th</sup> SIMMEC 2010**

The 9<sup>th</sup> Symposium on Computational Mechanics will be held in May 26<sup>th</sup> to 28<sup>th</sup> 2010, in the historic city of São João del Rey, MG, organized by the Federal University of São João del Rey (UFSJ) and the coordination of Prof. Avelino M.S. Dias (conference chair). Further information on the 9<sup>th</sup> SIMMEC can be found in the symposium website at <http://www.ufsj.edu.br/simmec2010/> ●

### **MECOM del Bicentenario, 31<sup>st</sup> CILAMCE and 2<sup>nd</sup> South American Congress on Computational Mechanics**

ABMEC and AMCA, the Argentinean Association for Computational Mechanics, will be jointly organizing the 31<sup>st</sup> Iberian Latin American Congress on Computational Methods in Engineering, CILAMCE 2010 in conjunction with the "MECOM del Bicentenario", celebrating the 200<sup>th</sup> Anniversary of the Argentinean Independency. The conference will take place in Buenos Aires, Argentina, in November 2010. ●

### **WCCM 2012**

A meeting of the Organizing Committee took place during CILAMCE, reporting the ongoing arrangements to host the 10<sup>th</sup> WCCM in São Paulo, July 2012. The organizers now include the Universities of São Paulo (USP), of Campinas (UNICAMP), the Federal Universities of Rio de Janeiro (COPPE/UFRJ), Minas Gerais (UFMG) and Pernambuco (UFPE). ●

# letter

## to the editor

**Victorio Sonzogni**

CIMEC

International Center for  
Computational Methods

in Engineering

Universidad Nacional  
del Litoral and CONICET  
Santa Fe, Argentina

### **Computational Mechanics: Nice achievements, but ...does it really exist?**

*It may be sound at least strange such a statement. But, in what extent can we say that someone/ something does exist? In which planes/spaces does it occurs?*

*In spite of the sustained growth in research and development of Computational Mechanics (CM), and their incommensurable economic impact in industrial applications, it simply does not exist among the scientific disciplines when we must talk with universities, foundations, scientific councils and so on.*

*In Argentina (and the same happens in other countries) when filling forms for grants, when writing reports, etc., we can find some half a thousand of scientific disciplines to choose, but neither serves to refer to our work. I am working in improving a finite element for mechanics, or to solve some fluid/solid interaction problem. Depending on my professional grade, I can select among the scientific discipline descriptors: Hidrology, Applied Mathematics, Engineering-Buildings, Geotechnics, Mechanical Engineering, Bioengineering, Metalurgy, Aeronautics, and many other. We can find Numerical Methods within Mathematics, or Computations. But they are just parts of the CM basement, as you know. CM requires Numerical Methods, to solve Mechanical Problems by making use of Computers.*

*Computational Mechanics is an extended descriptor of this discipline. We have an International Association as well as many National Associations; there are several journals and congresses with this name. However it has been referred to with other names as well: Numerical Methods in Engineering; Computer Methods in Engineering; Applied Numerical Methods; Computer Sciences for Engineering; etc. The problem now is that we don't have a name, recognized in scientific tables, to use. Neither CM, nor any synonym of it. I think it is important to be aware of this, and to make an effort to produce a change in the tables of scientific disciplines so as to include the CM.*

*As a first step we should agree, as CM community, about a proposal for the designation of this discipline and its situation among the areas, subareas, disciplines, etc. Next we could work with each national agencies, but greater impact we could get if these modifications are accepted in international organizations.*

### **Announcement of the John Argyris Award**

*for the best paper by a young researcher in the field of  
Computational Mechanics*

Fifth competition for the John Argyris Award for the best paper by a young researcher in the field of Computational Mechanics. This Award has been initiated to honor Professor John Argyris and is sponsored by Elsevier. It holds a prize of 2000 euros which will be conferred on the winner by the President of IACM at the IX World Congress (WCCM IX) in Sydney, 19-23 July 2010.

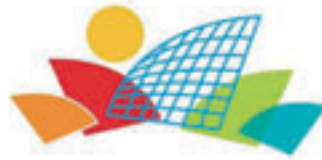
Applicants should submit a paper that has been accepted for publication in the journal **Computer Methods in Applied Mechanics and Engineering** not earlier than March 31, 2008.

All applicants must be under the age of 35 on 31 March 2010.

The papers are to be submitted electronically by March 31, 2010 to:

Professor Eugenio Onate, The John Argyris Award,  
IACM Secretariat, CIMNE, Barcelona, Spain  
e-mail: [iacm@cimne.upc.edu](mailto:iacm@cimne.upc.edu)





# WCCM APCOM 2010

19- 23 July | sydney | australia

## 9th world congress on computational mechanics and 4th asian pacific congress on computational mechanics

You are invited to the Joint 9th World Congress on Computational Mechanics and 3rd Asian Pacific Congress on Computational Mechanics which will be held in Sydney, Australia during July 19-23, 2010.

The format of the congress is 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. In addition to mini-symposia, Plenary and Semi-Plenary lectures on important, recent developments in computational mechanics will be delivered by leading authorities in these fields.

### *The congress themes will include:*

- Computational solid and structural mechanics
- Computational fluid mechanics
- Computational materials science
- Computational biomechanics
- Computational nanotechnology
- Computational MEMS and bio-MEMS
- Computational engineering sciences and physics
- Computational nonlinear dynamics
- Computational adaptive materials systems, structures and smart materials
- Computational advances in composite machining
- Computational geomechanics
- Computational inverse problems and optimization
- Computational environmental science
- Computer simulation of processes and manufacturing
- Computational damage mechanics

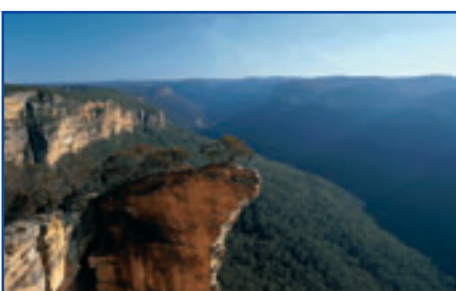
- Computational dynamic failure and fracture
- Computational ice mechanics
- Computational NDE and wave propagation
- Computational infrastructures and aging structures
- Computational polymers and polymer composites
- Computational microtribology and micromechanics
- CAD, CAM and CAE
- Scientific visualization
- Data and signal processing
- Parallel computing
- Artificial intelligence and expert systems
- Meshless and wavelet methods
- Multiple-scale physics and computation

### *Key deadlines are:*

Submission of abstracts:	September 30, 2009
Acceptance of abstracts:	November 15, 2009
Submission of final papers:	March 31, 2010



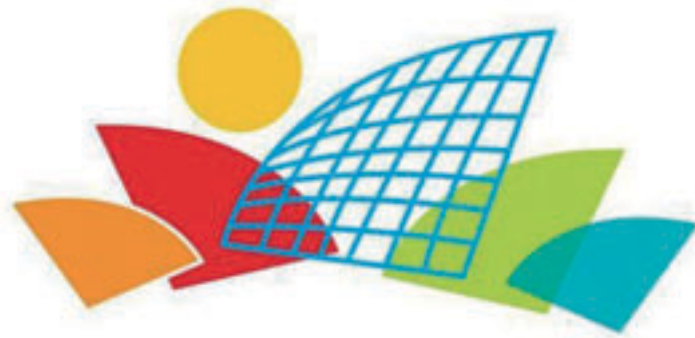
For further information, please contact  
Conference Secretariat at  
[www.wccm2010.com](http://www.wccm2010.com)



# conference diary planner

<b>04 - 08 January 2010</b>	<b>PACAM XI - Congresso Pan-Americano de Mecanica Aplicada</b> <i>Venue:</i> Foz do Iguazu, Brazil <i>Contact:</i> <a href="http://www.set.eesc.usp.br/docentes/aguiarar">http://www.set.eesc.usp.br/docentes/aguiarar</a>
<b>11 - 13 January 2010</b>	<b>SACAM - 7<sup>th</sup> Conference on Computational and Applied Mechanics</b> <i>Venue:</i> Pretoria, South Africa <i>Contact:</i> <a href="mailto:lizette.vandermerwe@up.ac.za">lizette.vandermerwe@up.ac.za</a>
<b>07 - 10 February 2010</b>	<b>NEMB2010 - 1<sup>st</sup> Global Congress on NanoEngineering for Medicine and Biology</b> <i>Venue:</i> Houston, Texas <i>Contact:</i> <a href="http://www.asmeconferences.org/nemb2010/">http://www.asmeconferences.org/nemb2010/</a>
<b>17 - 21 March 2010</b>	<b>REC2010 - Workshop on Reliable Engineering Computing</b> <i>Venue:</i> Singapore <i>Contact:</i> <a href="http://www.eng.nus.edu.sg/civil/REC2010">http://www.eng.nus.edu.sg/civil/REC2010</a>
<b>12- 16 April 2010</b>	<b>Nonlinear Computational Solid &amp; Structural Mechanics Theoretical Formulations, Technologies &amp; Computations</b> <i>Venue:</i> Pavia, Italy <i>Contact:</i> <a href="http://www.eucentre.it/nl10">http://www.eucentre.it/nl10</a>
<b>10 - 14 May 2010</b>	<b>Hughes - Belytschko Short Course on Nonlinear Finite Element Analysis</b> <i>Venue:</i> Berlin, Germany <i>Contact:</i> <a href="http://www.zace.com">http://www.zace.com</a>
<b>16 - 21 May 2010</b>	<b>ECCM 2010- 4<sup>th</sup> European Conference on Computational Mechanics</b> <i>Venue:</i> Paris, France <i>Contact:</i> <a href="http://www.eccm2010.org">www.eccm2010.org</a>
<b>17 -21 May 2010</b>	<b>22nd International Conference on Parallel Computational Fluid Dynamics 2010</b> <i>Venue:</i> Kaohsiung, Taiwan <i>Contact:</i> <a href="http://www.parcfd2010.tw/">http://www.parcfd2010.tw/</a>
<b>23- 25 May 2010</b>	<b>CWE2010 - 5<sup>th</sup> International Symposium on Computational Wind Engineering</b> <i>Venue:</i> North Carolina, USA <i>Contact:</i> <a href="http://www.cwe2010.org">www.cwe2010.org</a>
<b>31 May - 02 June 2010</b>	<b>ICTPMCS-2010 - Thermal Process Modeling &amp; Computer Simulation</b> <i>Venue:</i> Shanghai, China <i>Contact:</i> <a href="http://www.ictpmcs2010.sjtu.edu.cn/">http://www.ictpmcs2010.sjtu.edu.cn/</a>
<b>06- 11 June 2010</b>	<b>PANAM 2010 - Applied &amp; Computational Mathematics/Computational Science &amp; Engineering</b> <i>Venue:</i> Choroní, Venezuela <i>Contact:</i> <a href="http://www.csrc.sdsu.edu/csrc/panam/index.php">http://www.csrc.sdsu.edu/csrc/panam/index.php</a>
<b>06 -11 June 2010</b>	<b>IUTAM - Dynamics Modeling &amp; Interaction Control in Virtual &amp; Real Environments</b> <i>Venue:</i> Budapest, Hungary <i>Contact:</i> <a href="http://www.iutam2010.org">http://www.iutam2010.org</a>
<b>14 - 17 June 2010</b>	<b>CFD 2010 - 5<sup>th</sup> European Conference on Computational Fluid Dynamics,</b> <i>Venue:</i> Lisbon, Portugal <i>Contact:</i> <a href="http://www-ext.lnec.pt/APMTAC">http://www-ext.lnec.pt/APMTAC</a>
<b>21 - 24 June 2010</b>	<b>CMWR 2010 - XVIII Computational Methods in Water Resources</b> <i>Venue:</i> Barcelona, Spain <i>Contact:</i> <a href="http://congress.cimne.com/CMWR2010/">http://congress.cimne.com/CMWR2010/</a>
<b>22 - 25 June 2010</b>	<b>VECPAR 2010 - 9<sup>th</sup> Int. Meeting on High Performance Computing for Computational Science</b> <i>Venue:</i> Berkeley, USA <i>Contact:</i> <a href="http://vecpar.fe.up.pt/2010/">http://vecpar.fe.up.pt/2010/</a>
<b>19 - 23 July 2010</b>	<b>HEFAT2010 - 7<sup>th</sup> Int. Conference on Heat Transfer, Fluid Mechanics &amp; Thermodynamics</b> <i>Venue:</i> Antalya, Turkey <i>Contact:</i> <a href="http://www.hefat.net/">http://www.hefat.net/</a>
<b>19 - 23 July 2010</b>	<b>IX World Congress on Computational Mechanics</b> <b>III Asian Pacific Congress on Computational Mechanics</b> <i>Venue:</i> Sydney, Australia <i>Contact:</i> <a href="http://www.wccm2010.com.au">http://www.wccm2010.com.au</a>
<b>06 - 09 Sept. 2010</b>	<b>EngOpt2010 - 2nd International Conference on Engineering Optimization</b> <i>Venue:</i> Lisbon, Portugal <i>Contact:</i> <a href="http://www.engopt.org/">http://www.engopt.org/</a>
<b>06 - 10 Sept.2010</b>	<b>XXXIV Jornadas Sudamericanas de Ingeniería Estructural</b> <i>Venue:</i> San Juan, Argentina <i>Contact:</i> <a href="http://www.jornadas2010.unsj.edu.ar/">http://www.jornadas2010.unsj.edu.ar/</a>
<b>14 - 19 Sept. 2010</b>	<b>ECT2010 - 7<sup>th</sup> International Conference on Engineering Computational Technology</b> <i>Venue:</i> Valencia, Spain <i>Contact:</i> <a href="http://www.civil-comp.com/conf/ect2010.htm">http://www.civil-comp.com/conf/ect2010.htm</a>
<b>14 - 19 Sept. 2010</b>	<b>CST2010 - 10<sup>th</sup> International Conference on Computational Structures Technology</b> <i>Venue:</i> Valencia, Spain <i>Contact:</i> <a href="http://www.civil-comp.com/conf/cst2010.htm">http://www.civil-comp.com/conf/cst2010.htm</a>
<b>19 - 24 Sept. 2010</b>	<b>ICAS 2010 - International Council for the Aeronautical Science Congress</b> <i>Venue:</i> Nice, France <i>Contact:</i> <a href="http://www.icas.org/">http://www.icas.org/</a>
<b>16 - 19 Nov. 2010</b>	<b>2<sup>do</sup> Congreso Argentino de Ingeniería Mecánica</b> <i>Venue:</i> San Juan, Argentina <i>Contact:</i> <a href="http://www.caim2010.unsj.edu.ar">http://www.caim2010.unsj.edu.ar</a>





9th world congress on  
computational mechanics  
WCCM / APCOM 2010  
19-23 july 2010 | sydney | australia



[www.wccm2010.com](http://www.wccm2010.com)