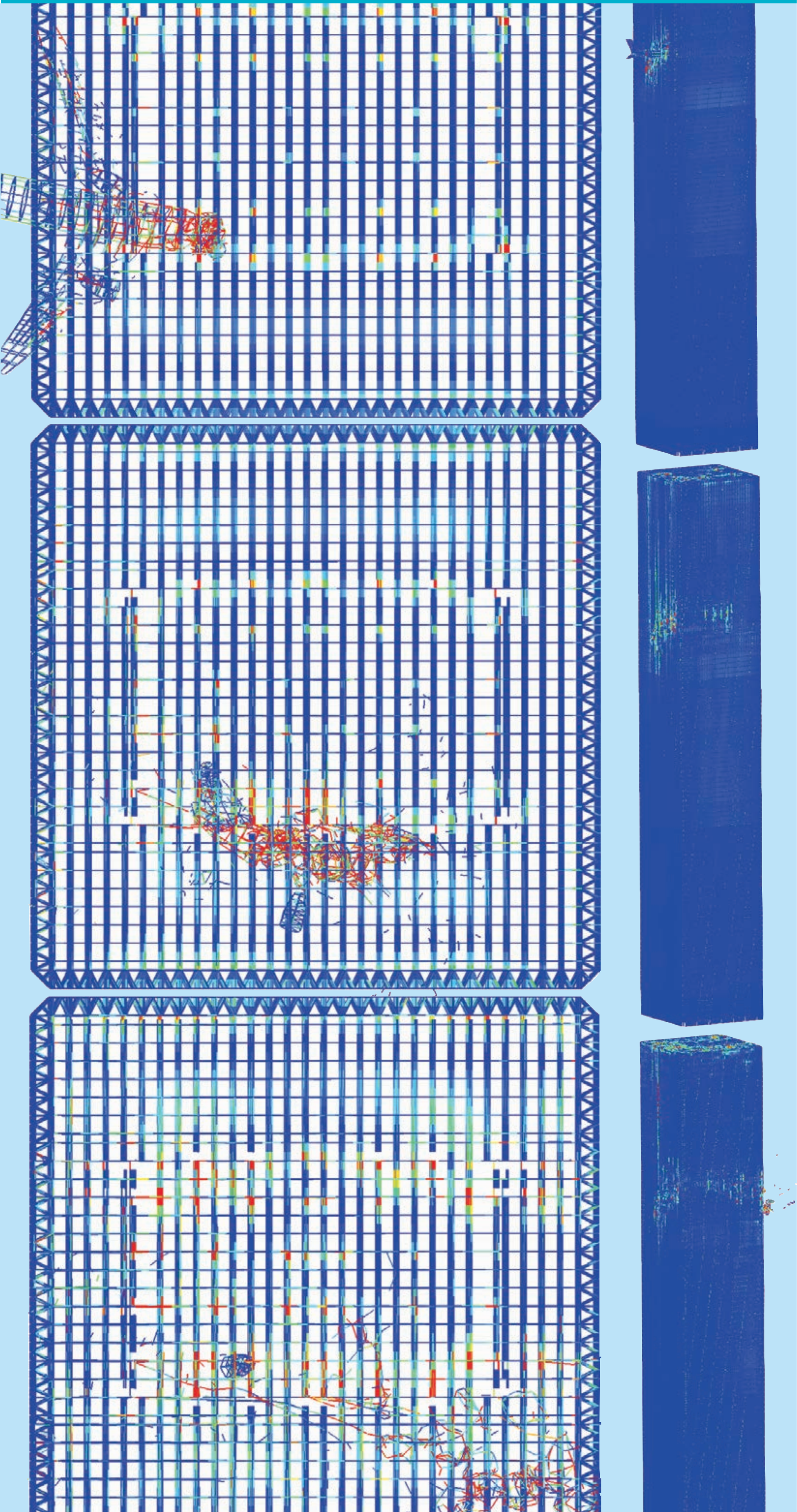
iacm

expressions



Bulletin for
The International Association
for Computational Mechanics

Nº 42
January 2018

Executive Council

President: **Wing Kam Liu** U.S.A.
Past Presidents: **T. Hughes** U.S.A, **J.T. Oden** U.S.A., **E.Oñate** Spain, **G. Yagawa** Japan
A. Samuelsson† Sweden, **O.C. Zienkiewicz**† U.K.
Vice President (Americas): **S. Idelsohn** Argentina
Vice President (Asia-Australia): **K. Terada** Japan
Vice President (Europe-Africa): **P. Wriggers** Germany
Secretary General: **A. Huerta** Spain
Members: **O. Allix** France, **R. de Borst** U.K., **J.S. Chen** U.S.A., **A. Coutinho** Brazil, **J. Dolbow** U.S.A., **Farhat** U.S.A., **K. Kashiyama** Japan, **T. Laursen**, UAE, **N. Moës,** France, **D.R.J. Owen**, U.K.,**M. Papadrakakis** Greece, **W. Wall** Germany, **S-K. Youn** Korea, **S. Yoshimura** Japan, **M. Yuan** China

IACM Honorary Members

E. Alarcon Spain, **E. de Arantes e Oliveira** Portugal**,** **T. Belytschko** U.S.A.**,** **J. Besseling** Netherlands, **Y.K. Cheung** China, **C.K. Choi** Korea, **R. Dautray** France, **C.S. Desai** U.S.A., **S.J. Fenves** U.S.A., **R. Glowinski** U.S.A., **A. Jameson** U.S.A., **T. Kawai** Japan, **M. Kleiber** Poland, **P.K. Larsen** Norway, **C. Mota Soares** Portugal, **J. Périaux** France, **O. Pironneau** France, **K.S. Pister** U.S.A., **E. Stein** Germany, **G. Strang** U.S.A., **C.W. Trowbridge** U. K., **S. Valliappan** Australia, **Wilson** U.S.A., **W. Wunderlich** Germany, **G. Yagawa** Japan, **Y. Yamada** Japan, **Y. Yamamoto** Japan, **W. Zhong** China

IACM General Council

O. Allix *France*
J. Ambrósio *Portugal*
T. Aoki *J apan*
I. Arias *Spain*
P. Ariza *Spain*
H. Askes *UK*
F. Auricchio *Italy*
J. Baiges *Spain*
P. Barbosa Lourenço *Portugal*
F. Bruzzi Barros *Brazil*
Z. P. Bar-Yoseph *Israel*
Y. Bazilevs *United States*
H. Ben Dhia *France*
M. Behr *Germany*
T. Burczynski *Poland*
D. Camotim *Portugal*
A. Cardona *Argentina*
D. Celentano *Chile*
J-S. Chen *United States*
P. Chen *China*
D. Chen *Taiwan*
M. Cho *Republic of Korea*
I. Colominas *Spain*
M. Cruchaga *Chile*
F.S. Cui *Singapore*
P. de Mattos Pimenta *Brazil*
L. Demkowicz *Poland*
P. Díez *Spain*
J. Dolbow *United States*
J.L. Drummond Alves *Brazil*
C. A. Duarte *United States*
A. Düster *Germany*
E. N. Dvorkin *Argentina*
G. Etse *Argentina*
G. Farias Moita *Brazil*
F. Feyel *France*
N. Filipovic *Serbia*
K. Fujii *Japan*
K. Garikipati..*United States*
V. Gavini *United States*
R. G. Ghanem *United States*
S. Ghosh *United States*
L. Godoy *Argentina*
A. Gravouil *France*
Y.T. Gu *Australia*
S. Hagihara *Japan*
I. Hagiwara *Japan*
X. Han *China*
I. Harari *Israel*
T. J. R. Hughes *United States*
A. Iafrati *Italy*
A. Ibrahimbegovic *France*
S. Idelsohn *Spain*
I. Iordanoff *France*
D. Isobe *Japan*
K. Kashiyama *Japan*
C. Kim *Republic of Korea*
Y-Y. Kim *Republic of Korea*
M. Kleiber *Poland*
S. Klinkel *Germany*
T. Kobayashi *Japan*
J. Korelc *Slovenia*
S. Koshizuka *Japan*
E. Kuhl *United States*
O. J. Kwon *Republic of Korea*
P. Ladevèze *France*
O. Laghrouche *U.K.*
C-O. Lee *Republic of Korea*
H. K. Lee *Republic of Korea*
T. H. Lee *Republic of Korea*
S. Leyendecker *Germany*
A. Lew *United States*
G. Li *China*
Q. Li *Australia*
S. Li *United States*
Z. Liu *China*
C.W. Lim *Hong Kong*
T. A. Lodygowski *Poland*
P. R. M. Lyra *Brazil*
S. Marfia *Italy*
A. Marsden *United States*
J. Matsumoto *Japan*
Y. Matsumoto *Japan*
A. Menzel *Germany*
G. Meschke *Germany*
N. Miyazaki *Japan*
N. Moës *France*
J. Murín *Slovakia*
T. Münz *Germany*
T. Nagashima *Japan*
K. Nakajima *Japan*
I. Narra Figuereido *Portugal*
R. N. Jorge *Portugal*
T. Y. Ng *Singapore*
N. Nishimura *Japan*
S. Nishiwaki *Japan*
T. Nomura *Japan*
S. Obayashi *Japan*
J. T. Oden *United States*
R. Ohayon *France*
H. Okada *Japan*
S. Okazawa *Japan*
H. Okuda *Japan*
X. Oliver *Spain*
J. Orkisz *Poland*
M. Oshima *Japan*
J. Pamin *Poland*
H. S. Park *United States*
C. Pearce *U. K.*
J.C.F. Pereira *Portugal*
C.B. Pina *Portugal*
J-P. Ponthot *Belgium*
F. G. Rammerstorfer *Austria*
A. Reali *Italy*
I. Romero *Spain*
J. Schröder *Germany*
L. J. Sluys *Netherlands*
C. Song *Australia*
J. Soric *Croatia*
G. E. Stavroulakis *Greece*
G. Steven *Australia*
J. Stewart *United States*
N. Sukumar *United States*
K. Suzuki *Japan*
N. Takano *Japan*
N. Takeuchi *Japan*
M. N. Tamin *Malaysia*
V. B. C. Tan *Singapore*
J. A. Teixeira de Freitas *Portugal*
T. Tezduyar *United States*
R. Tian *China*
G. J. van Heijst *Netherlands*
W. Wall *Germany*
D. Wang *China*
H. Watanabe *Japan*
M. Xie *Australia*
T. Yabe *Japan*
G. Yagawa *Japan*
T. Yamada *Japan*
M. Yamamoto *Japan*
S. Yoshimura *Japan*
K. Yuge *Japan*
J. Yvonnet *France*
Q. Zhang *China*
J. Zhang *United States*
Y. Zheng *China*
T. Zohdi *United States*

Members of the Executive Council, Honorary Members & Presidents of Affiliated Associations are also members of the General Council

IACM Membership - Fee

The annual fee for direct individual membership of IACM is 25 US dollars. For affiliated organisations the membership fee is reduced to 10US dollars. The Bulletin and a discount on IACM supported activities (congress, seminars, etc.) are some of the benefits of the membership.

IACM members are invited to send their contributions to the editors.
Views expressed in the contributed articles are not necessarily those of the IACM.

IACM Affiliated Associations and Presidents

Argentina	(AMCA)	*V. Fachinotti*	*Asociación Argentina de Mecánica Computacional*
Australia	(AACM)	*N. Khalili*	*Australian Association of Computational Mechanics*
Belgium	(NCTAM)	*J-P. Ponthot*	*Belgian National Committee for Theoretical & Applied Mechanics*
Brazil	(ABMEC)	*E. de Morais Barreto Campello*	*Brazillian Association for Comp. Methods in Engineering*
Austria, Croatia, Poland, Slovakia, Slovenia, The Czech Republic, Bosnia & Herzegovina	(CEACM)	*B. Pichler*	*Central-European Association for Comp. Mechanics*
Chile	(SCMC)	*C. Rosales*	*Sociedad Chilena de Mecánica Computacional*
PR China	(CACM)	*Z. Zhuang*	*Chinese Association of Computational Mechanics*
France	(CSMA)	*F. Chinesta*	*Computational Structural Mechanics Association*
Germany	(GACM)	*M. Kaliske*	*German Association of Computational Mechanics*
Greece	(GRACM)	*M. Papadrakakis*	*The Greek Association of Computational Mechanics*
Hong Kong	(HKACM)	*A.Y.T. Leung*	*Hong Kong Association of Computational Mechanics*
Israel	(IACMM)	*Z. Yosibash*	*Israel Association of Computational Methods in Mechanics*
Italy	(GIMC/AIMETA)	*A. Pandolfi*	*Italian Group of Computational Mechanics*
Japan	(JSCES)	*K. Terada*	*Japan Society for Computational Engineering and Science*
Japan	(JACM)	*S. Yoshimura*	*Japan Association for Computational Mechanics*
Korea	(KACM)	*H-G. Kwak*	*Korean Association on Computational Mechanics*
Korea	(KSCM)	*S.W. Chae*	*Korean Society of Computational Mechanics*
Malaysia	(MACM)	*A.K. Ariffin*	*Malaysian Association for Computational Mechanics*
Mexico	(AMMNI)	*S. Botello*	*Asociación Mexicana de Métodos Numéricos en Ingeniería*
Netherlands	(NMC)	*G-J.van Heijst*	*Netherlands Mechanics Committee*
Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden	(NoACM)	*T. Kvamsdal*	*The Nordic Association for Computational Mechanics*
Poland	(PACM)	*M. Kuczma*	*Polish Association for Computational Mechanics*
Portugal	(APMTAC)	*J. C. de Sá*	*Portuguese Society of Theoretical, Applied & Computational Mechanics*
Serbia	(SSCM)	*M. Kojic*	*Serbian Association for Computational Mechanics*
Singapore	(SACM)	*Z.S. Liu*	*Singapore Association for Computational Mechanics*
Spain	(SEMNI)	*E. Cueto*	*Sociedad Española de Métodos Numéricos en Ingeniería*
Taiwan	(ACMT)	*Y.B. Yang*	*Taiwan Association for Computational Mechanics Taiwan*
Thailand	(TSCE)	*W. Kanok-Nukulchai*	*Thailand Society of Computational Engineering*
U.K.	(UKACM)	*C. Augarde*	*Association for Computer Methods in Engineering*
U.S.A.	(USACM)	*L. Demkowicz*	*United States Association for Computational Mechanics*
Venezuela	(SVMNI)	*M. Cerrolaza*	*Venezuelan Society for Numerical Methods in Engineering*

IACM Expressions

Published by: (IACM)
The International Association for Computational Mechanics
Editorial Address:
IACM Secretariat, Edificio C1, Campus Norte UPC,
Gran Capitán s/n, 08034, Barcelona, Spain.
Tel: (34) 93 - 405 4697
Fax: (34) 93 - 205 8347
Email: secretariat@iacm.info
Web: www.iacm.info
Editor: Eugenio Oñate
Production Manager: Diane Duffett
Email: diane.duffett@telefonica.net
Advertising: For details please contact Diane Duffett at the IACM Secretariat

contents

editorial

Recent trends in computational mechanics research have increased the popularity of terms such as multiscale, multi-physics, real-time, model reduction, big data and high performance computing (HPC), among others. These contemporary research topics are related to the numerical solution of most multidisciplinary problems in engineering and applied sciences. As some examples, the accurate study of flow details in the aerodynamics of a vehicle, the simulation of particulate environmental flows and their interaction with constructions and the landscape, and the optimum design of new functional materials or enhanced industrial manufacturing processes require a combination of some, or even all, the above computational technologies, together with leading-edge HPC hardware.

An emerging research area in bio-medical sciences is the design of miniature devices for reconstructing tissues and organs by combining cells and nanotechnology. The so-called lab-on-a-chip devices (https://en.wikipedia.org/wiki/Lab-on-a-chip) aim to reproducing living systems on a chip. The goal is that the behavior of biological systems such as liver or gut can be reproduced by equivalent "organs on chips" in order to speed tests of drugs and toxicity, for instance. Clearly the numerical analysis of such extremely small and complex devices requires state-of-the-art XXI century computational techniques, such as those mentioned above.

Atomistic modelling at experimental timescales, a feature article in this bulletin by Prof H.S. Park from Boston University in the US, is another example of the need for radical computational techniques for molecular dynamics simulations capable of resolving in time the vibration frequency of an atom, a challenge still far of being feasible today even with the faster supercomputers. Quoting Prof. Park, "the ability to model physical phenomena with atomic scale resolution at experimentally-relevant timescales is one of the key unresolved challenges in computational materials science".

Similar computational challenges are common in multi-field problems such as, for example, electro-thermo-mechanical coupled problems or fluid-soil-structure interaction situations, among many others. Here the use of partition solution strategies can help to get useful numerical results for such complex problems, as described in the article of A. Dürste, M. König and L. Radtke in the pages of this issue of Expressions.

Clearly, the demand for ingenious numerical methods, as well as for innovative software and hardware technologies, capable of solving with the required accuracy and readiness the space and time scales of interest to most multidisciplinary problems increases continuously. This poses a permanent challenge to researchers on computational mechanics.

As a reference to the important activity of the IACM community, it is worth pointing out the 45 international conferences on a variety of topics related to computational mechanics that have taken place worldwide on 2017, after the initiative of many scientists and engineers supported by the IACM affiliated associations.

On the other hand, on 22-27 July 2018 the 13th World Congress on Computational Mechanics will be jointly organized with the 2nd Pan American Congress on Computational Mechanics in the city of New York. I recommend you not to miss what is promised to be a memorable IACM event from the scientific, social and cultural points of view. See you in New York.

Eugenio Oñate
Editor of IACM Expressions

Atomistic Modeling at Experimental Timescales

by
Harold S. Park
Boston University, U.S.A.
parkhs@bu.edu

Classical molecular dynamics (MD) simulations have enabled significant insights into the behavior and properties of materials. MD simulations are conceptually straightforward, and involve the numerical solution of Newton's equations of motion for a collection of particles, or atoms. The issue in the numerical solution is that, for the time integration of the Newton equations to be stable, the time step must be small enough to resolve the vibrational frequency of an atom, which is typically on the order of femtoseconds (10^{-15} seconds). This restriction on the time step explains why most MD simulations, even on the fast supercomputers available today, can typically only reach to the microsecond (10^{-6} seconds) time scale, which is orders of magnitude shorter than what is typically observed in a laboratory setting. A further consequence of this time step restriction is that, for interesting behavior to be observed (i.e. significant mechanical deformation and plasticity) on a microsecond time scale, the strain rate must be very high, and in fact is typically of the order 10^8 1/s in an MD simulation, which is again ~10 orders of magnitude larger than what is used in laboratory experiments. The ability to model physical phenomena with atomic scale resolution at experimentally-relevant timescales is thus one of the key unresolved challenges in computational materials science [1–6].

Self-Learning Metabasin Escape Algorithm

We have recently developed a novel approach to accessing experimentally-relevant time scales and strain rates in atomistic simulation. Specifically, we have developed the self-learning metabasin escape (SLME) algorithm [16]. This approach differs from conventional MD in that we do not solve Newton's equations of motions to determine the positions of atoms. Instead, as illustrated in *Figure 1*, we utilize potential energy surface exploration to explore the potential energy landscape by boosting the system out of energy wells by application of penalty functions[7]. Transition state theory is then utilized to draw a connection between the height of the energy barriers crossed on the potential energy landscape, and the corresponding strain rate [8–10].

Examples:

I now present two examples of problems where the SLME method has been instrumental in revealing new physical insights not available due to the timescale limitations intrinsic to classical MD.

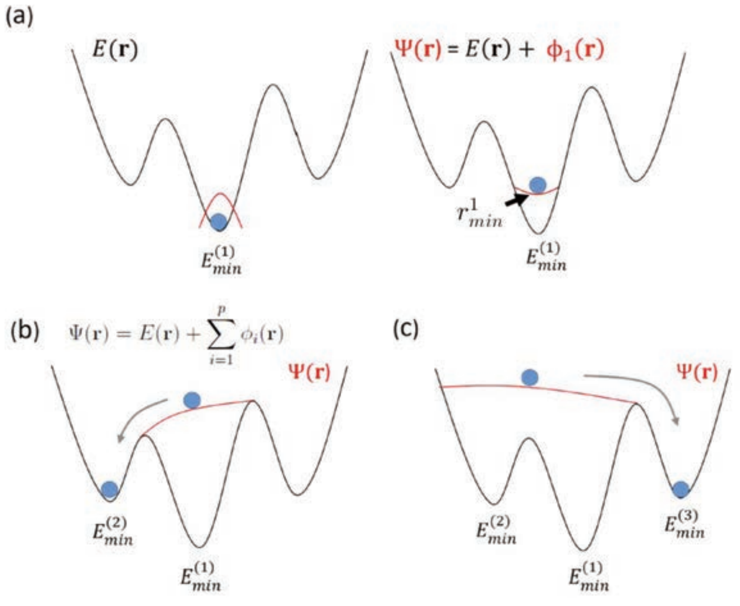


Figure 1: *Illustration of basin filling with penalty functions in the SLME method. NOTE: this image is from reference 5*

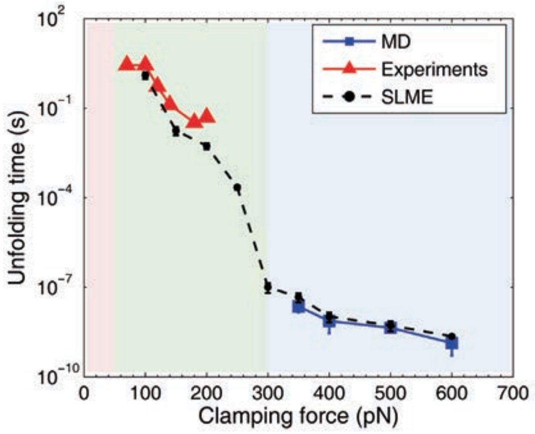


Figure 2: *Unfolding time as a function of the clamping force for ubiquitin as obtained experimentally, and also using the SLME method, and steered MD simulations. NOTE: image taken from reference 5*

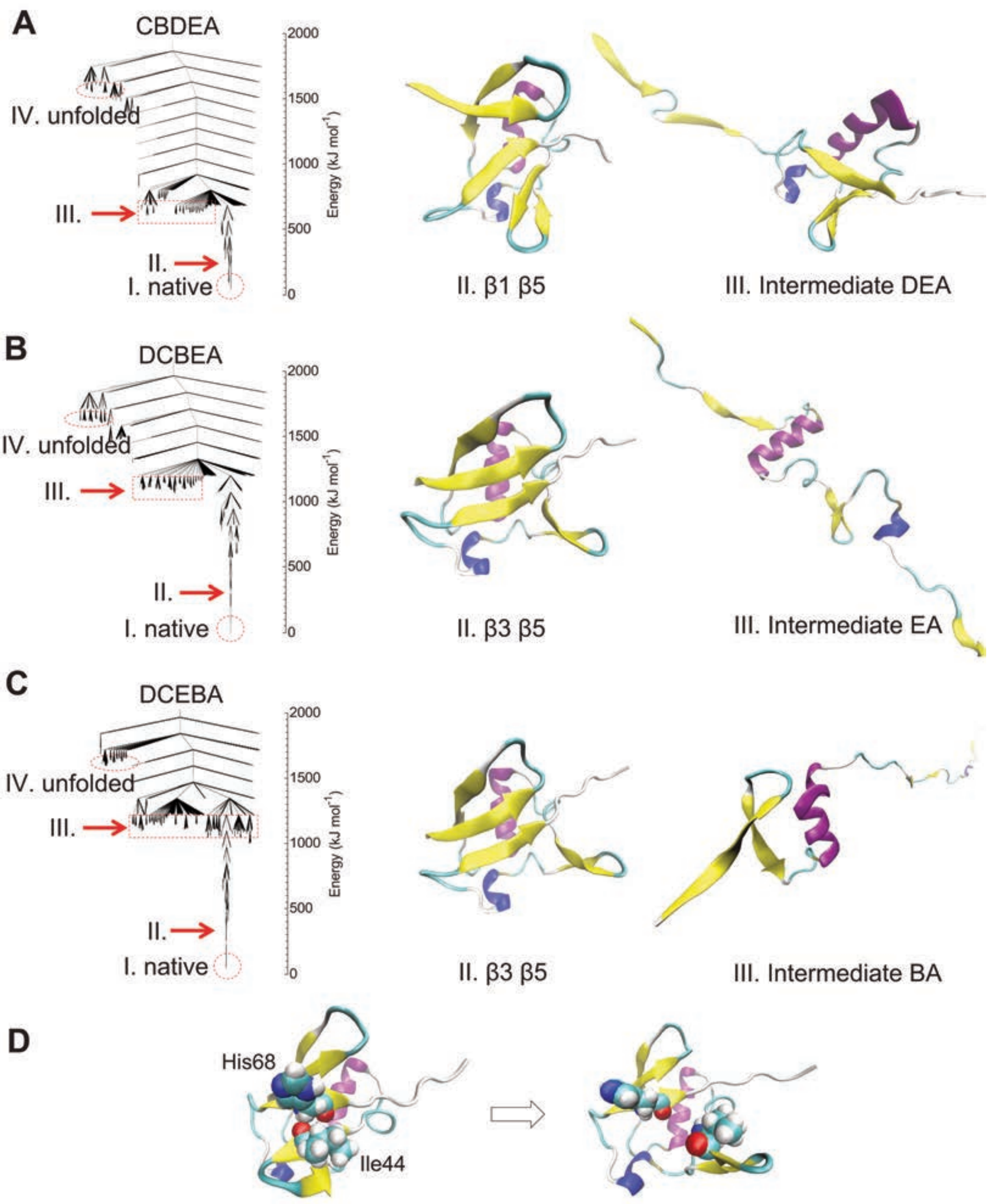


Figure 3:
(a-c) Disconnectivity graphs (left) of ubiquitin unfolding at 100 pN, and the molecular structures (middle, right) for the first unfolding event and the resulting intermediate configuration.
(d) Demonstration of new unfolding pathway involving the Ile44 residue.
NOTE: image taken from reference 11

1. Protein Unfolding

The first example is the unfolding of proteins [11,12]. Specifically, the force-induced unfolding of proteins has been extensively studied in recent years due to recent experimental advances based on force clamping techniques using the atomic force microscope (AFM), and optical tweezers, which can apply a constant force to each end of a protein to obtain force-dependent unfolding time distributions. The experiments have also been used to examine if the unfolding configurations can be correlated to those seen due to chemical denaturation. However, a key shortcoming of such single molecule pulling experiments is the lack of atomistic detail with regards to the unfolding pathways, as well as the structure of the intermediate configurations.

Figure 2 demonstrates the force-induced unfolding times across a range of forces for the small protein ubiquitin [11], compared with available experimental data [13]. Importantly, the SLME results enable us to bridge the unfolding times between those that are accessible via MD, which are on the order of nanoseconds, to those that were observed experimentally, which are on the order of milliseconds to seconds.

The SLME method further enabled us to get direct atomistic information about the structure of the intermediate configurations that ubiquitin passes through during the unfolding process. Specifically, as shown in *Figure 3*, we were able to determine multiple intermediate configurations, while predicting new mechanisms involving the binding site of ubiquitin, Ile44, on the unfolding process.

> *“ The ability to resolve atomistic processes at laboratory time scales may lead to new insights for scientists and engineers as to how materials evolve and respond to external stimuli.”*

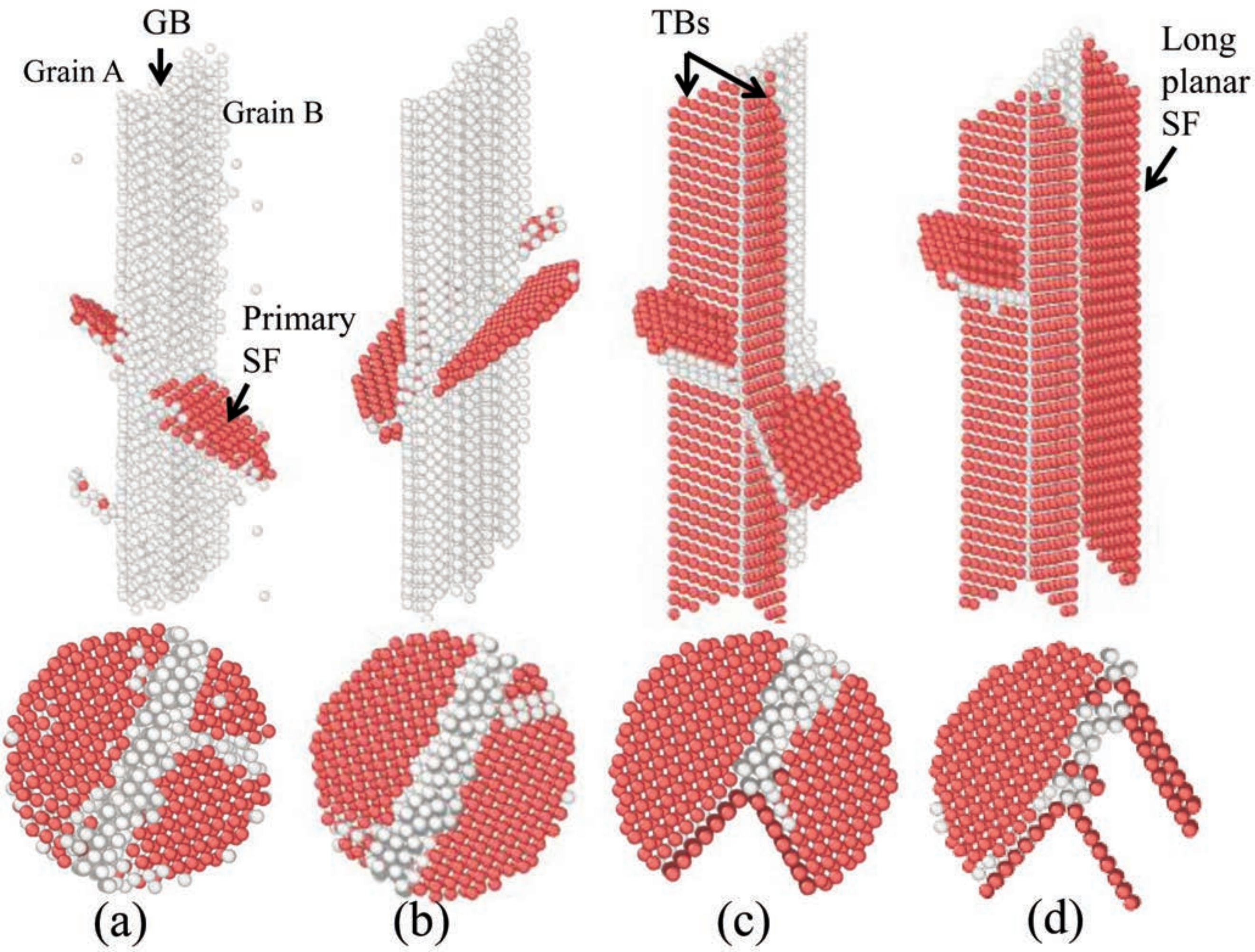


Figure 4:
(Top images): atomic configurations immediately after yielding (a) from MD simulations at stress of 5.23 GPa and from SLME simulations at stresses of (b) 5.23 GPa, (c) 4.29 GPa, and (d) 3.06 GPa. Bottom images: atomic structure looking down the [110] nanowire axis. In all cases planar defects are visualized using the following color convention: gray planes – grain boundaries; single red plane – twin boundary; two adjacent red planes – stacking fault

2. Plasticity Transitions at Experimental Strain Rates

Another key scientific challenge with regards to atomistic modeling are the mechanical properties and deformation mechanisms of nanostructured materials, such as nanowires. Specifically, one of the important yet unresolved problems in this field is to bridge the gap in properties and deformation mechanisms reported for slow strain rate experiments (~10^{-2} s^{-1}), and high strain rate MD simulations (~10^{8} s^{-1}) such that a complete understanding of strain rate effects on defect nucleation can be obtained.

Figure 4 shows the yielding mechanisms of 3 nm diameter bicrystalline copper nanowires a different uniaxial stress states. As can be seen, a transition from partial dislocations at high stresses in *Figure 4(a)* to the nucleation of twin boundaries that results in removal of the original grain boundary at lower stresses in *Figures 4(c)* and *(d)* [14].

By calculating the activation energy barriers that are crossed to obtain the yielding mechanisms shown in *Figure 4*, we can calculate the yield stress as a function of strain rate as shown in *Figure 5*. As can be seen, the transition in the yield stress occurs at a strain rate of about 1 s^{-1}, where an increased sensitivity to strain rate begins to manifest itself. This transition strain rate is on the same order with previous experimental studies on bicrystalline silver nanowires, where a critical transition strain rate dividing regions of high and low strain rate sensitivity of about 0.2 s^{-1} was observed [15]. Importantly, these strain rates shown in *Figure 5* are far slower than those that are accessible in conventional MD simulations.

Conclusions

The ability to resolve atomistic processes at laboratory time scales may lead to new insights for scientists and engineers as to how materials evolve and respond to external stimuli. While there are many important issues to be resolved within the field of long timescale atomistic modeling it is hoped that the examples shown here demonstrate the potential benefits of such methodologies.

Acknowledgements

The author appreciates the support from the Mechanical Engineering department at Boston University, and the support of NSF grant CMMI-1234183. The author also acknowledges the contributions of Prof. Xi Lin, Dr. Penghui Cao, Dr. Gwonchan Yoon, Prof. Kilho Eom, and Weiwei Tao to the SLME methodology and its applications. ●

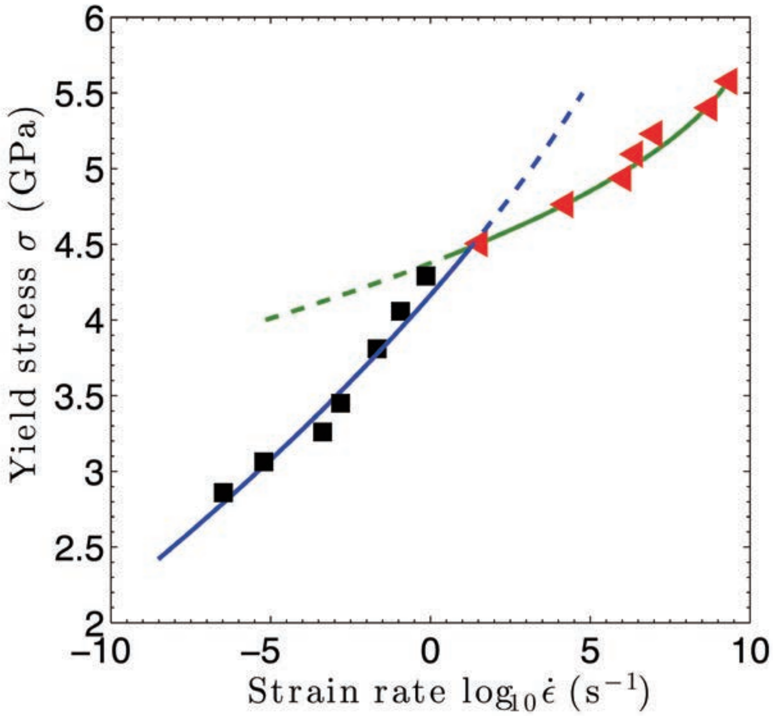


Figure 5:
Yield stress as a function of strain rate at room temperature

References

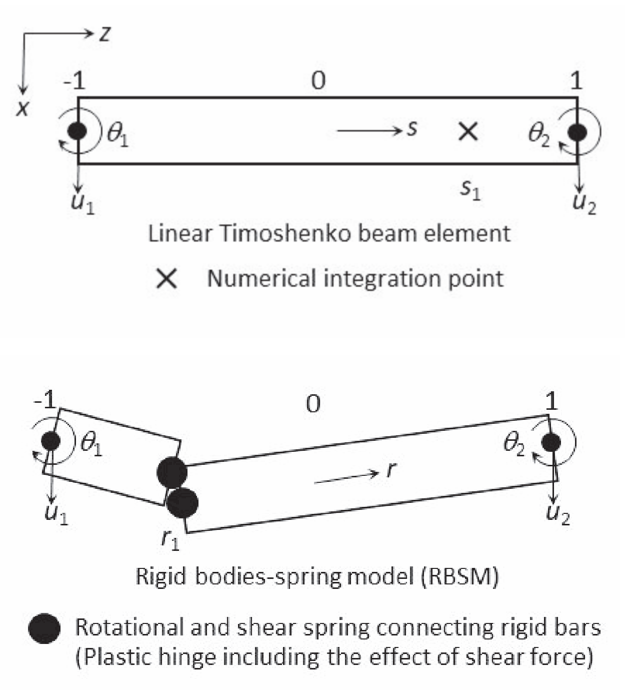
1. *Perez, D., Uberuaga, B. P., Shim, Y., Amar, J. G. & Voter, A. F.* **Accelerated Molecular Dynamics Methods Introduction and Recent Developments**. Annual Reports in Computational Chemistry 5, (Elsevier, 2009).
2. *Perez, D., Uberuaga, B. P. & Voter, A. F.* **The parallel replica dynamics method – Coming of age**. Comput. Mater. Sci. 100, 90–103 (2015).
3. *Voter, A. F., Montalenti, F., Germann, T. C. & Carlo, M*. **Extending the time scale in atomistic simulation of materials**. Annu. Rev. Mater. Res. 32, 321–346 (2002).
4. *Miron, R. A. & Fichthorn, K. A.* **Accelerated molecular dynamics with the bond-boost method Accelerated molecular dynamics with the bond-boost method**. J. Chem. Phys. 119, 6210–6216 (2003).
5. *Yan, X, Cao, P, Tao, W, Sharma, P, Park, H. S.* **Atomistic modeling at experimental strain rates and timescales**. J. Phys. D. Appl. Phys. 49, 493002 (2016).
6. *Laio, A. & Gervasio, F. L.* **Metadynamics: a method to simulate rare events and reconstruct the free energy in biophysics, chemistry and material science.** Reports Prog. Phys. 71, 126601 (2008).
7. *Cao, P., Li, M., Heugle, R. J., Park, H. S. & Lin, X.* **A self-learning metabasin escape algorithm and the metabasin correlation length of supercooled liquids**. Phys. Rev. E 86, 16710 (2012).
8. *Cao, P., Lin, X. & Park, H. S*. **Surface Shear Transformation Zones in Amorphous Solids**. Phys. Rev. E 90, 12311 (2014).
9. *Cao, P., Park, H. S. & Lin, X*. **Strain-rate and temperature-driven transition in the shear transformation zone for two-dimensional amorphous solids**. Phys. Rev. E 88, 42404 (2013).
10. *Cao, P., Lin, X. & Park, H. S*. **Strain-rate and temperature dependence of yield stress of amorphous solids via self-learning metabasin escape algorithm**. J. Mech. Phys. Solids 68, 239–250 (2014).
11. *Cao, P., Yoon, G., Tao, W. W., Eom, K. & Park, H. S*. **The Role of Binding Site on the Mechanical Unfolding Mechanism of Ubiquitin**. Sci. Rep. 5, 8757 (2015).
12. *Tao, W., Yoon, G., Cao, P., Eom, K. & Park, H. S*. **Beta-Sheet-Like Formation During the Mechanical Unfolding of Prioni Protein**. J. Chem. Phys. (2015).
13. *Schlierf, M., Li, H. & Fernandez, J. M.* **The unfolding kinetics of ubiquitin captured with single-molecule force-clamp techniques**. Proc. Natl. Acad. Sci. 101, 7299–7304 (2004).
14. *Tao, Weiwei; Cao, Penghui; Park, H*. **Atomistic observation of incipient plasticity and yield stress transitions at experimental strain rates in bicrystalline metal nanowires**. Submitt. Publ. (2017).
15. *Ramachandramoorthy, R., Gao, W., Bernal, R. & Espinosa, H*. **High Strain Rate Tensile Testing of Silver Nanowires: Rate- Dependent Brittle-to-Ductile Transition**. Nano Lett. 16, 255–263 (2016).
16. *X. Yan, P. Cao, W.W. Tao, P. Sharma and H.S. Park*. **“Atomistic Modeling at Experimental Strain Rates and Time Scales”**, Journal of Physics D: Applied Physics, 2016; 49:493002.

A Finite Element Approach for Structural Collapse Analysis of Buildings

by
Daigoro Isobe
University of Tsukuba, Japan
isobe@kz.tsukuba.ac.jp

Structural designers usually do not expect a loss of structural members in buildings, but these unexpected events do occur from time to time. However, structural collapse phenomena of buildings are very difficult to reproduce in experiments. They are also difficult to be simulated numerically, since they are packed with many mechanical interactions and strong nonlinear behaviors.

Figure 1:
Linear Timoshenko beam element and its physical equivalence to RBSM

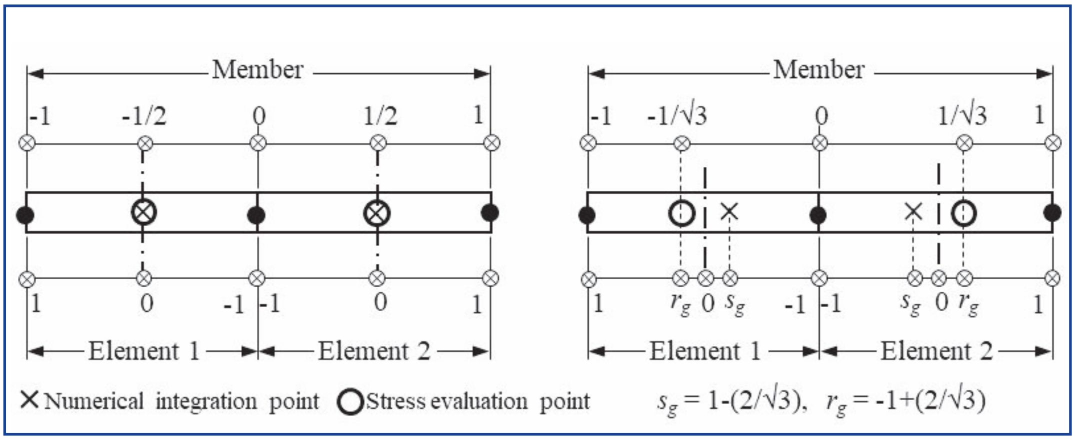


The possibilities of simulations considering a loss of structural members are immeasurable, because the risk of lives often depend on the behaviors of structures after they had lost their strengths. From these strong demands, new techniques are introduced into a finite element code utilizing linear Timoshenko beam elements to cope with such discontinuous problems. The main technique adopted in the code is called the adaptively shifted integration (ASI) – Gauss technique [1]; it can drastically reduce the computational cost without losing high levels of accuracy, and, at the same time, can handle fractured sections in structural components of buildings.

ASI-Gauss Technique

In the ASI-Gauss technique, high accuracy with small number of element subdivision is achieved by shifting numerical integration points in beam elements adaptively, when a fully plastic section is determined in the element, in order to express a plastic hinge exactly at that section in the element. This shifting is operated according to a relation between the locations of a numerical integration point and a plastic hinge [2], which is obtained by considering the equivalence conditions between the strain energy approximations of a linear Timoshenko beam element and a rigid-body-spring-model (RBSM) (*Figure 1*).

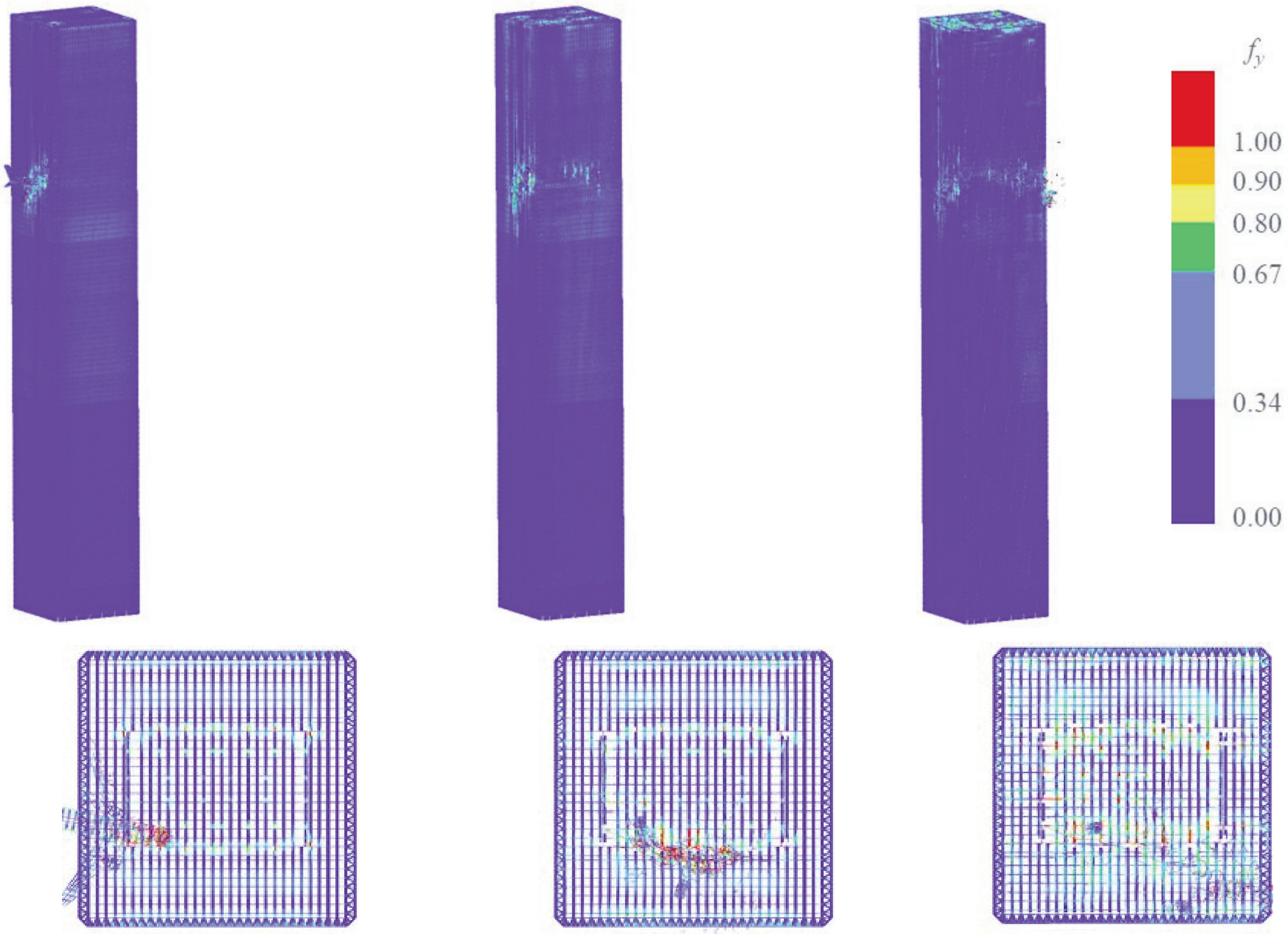
Figure 2:
Locations of the numerical integration and stress evaluation points in the elastic range



(a) Conventional FEM

(b) ASI-Gauss technique

Figure 3:
Bird view and upper view of the WTC 2 during aircraft collision



(a) 0.12 s after impact *(b) 0.28 s after impact* *(c) 0.56 s after impact*

When the plastic hinge is determined to be unloaded, the corresponding numerical integration point is shifted back to its initial location. By these processes, the plastic behavior of the element is simulated appropriately, and the converged solution can be obtained with a small number of elements per member. It should be noted here, that the initial location of the numerical integration point in the conventional finite element method (FEM) utilizing linear Timoshenko beam element is at the midpoint, and is always at the midpoint regardless of the present characteristic phase of the member (*Figure 2(a)*). The location is considered to be optimal for one-point integration when the entire region of the element behaves elastically. However, the bending deformations in the elastic range are less accurate when the number of elements per member is small, since the displacement functions of the finite element are defined by linear functions. Therefore, a simple means is implemented to improve the accuracy for the elastically deformed member in the ASI-Gauss technique; two consecutive elements are considered as a subset as shown in *Figure 2(b)*, and the numerical integration points of an elastically deformed member are placed such that the stress evaluation points coincide with the Gaussian integration points of the member. This means that the stresses and strains are evaluated at the Gaussian integration points of the elastically deformed members. These locations are optimal for two-point integration in the Gaussian quadrature, and the accuracy of the bending deformation defined by a cubic function is mathematically guaranteed. In this way, the ASI-Gauss technique takes advantage of two-point integration while using one-point integration per element in the actual calculations. Please refer to book [3] and papers [4-11] for further details on member fracture and elemental contact algorithms, and some verification and validation results.

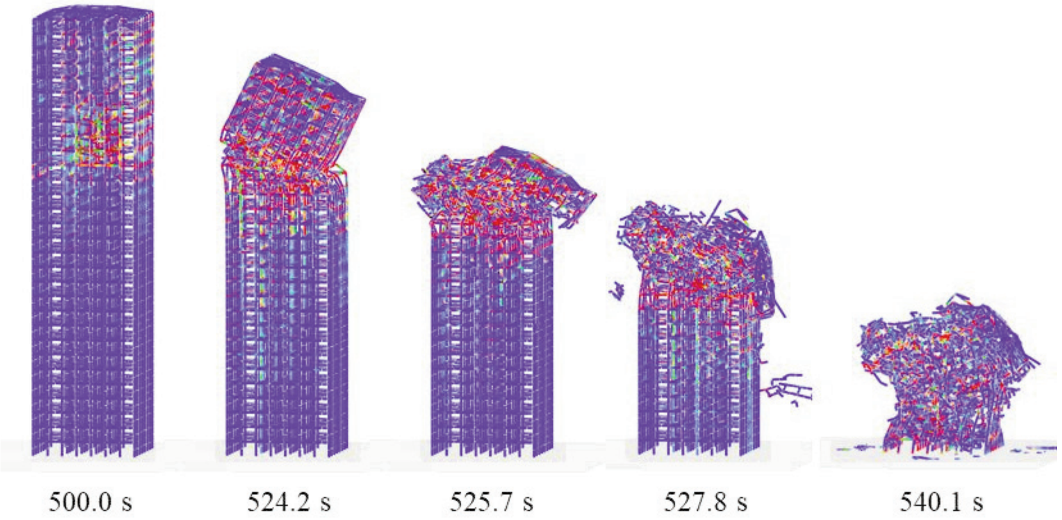


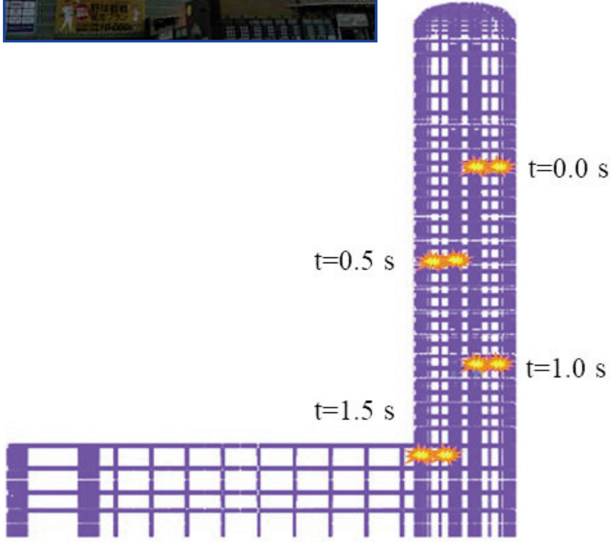
Figure 4:
Progressive collapse sequence of a high-rise tower with an outrigger truss system

Applications

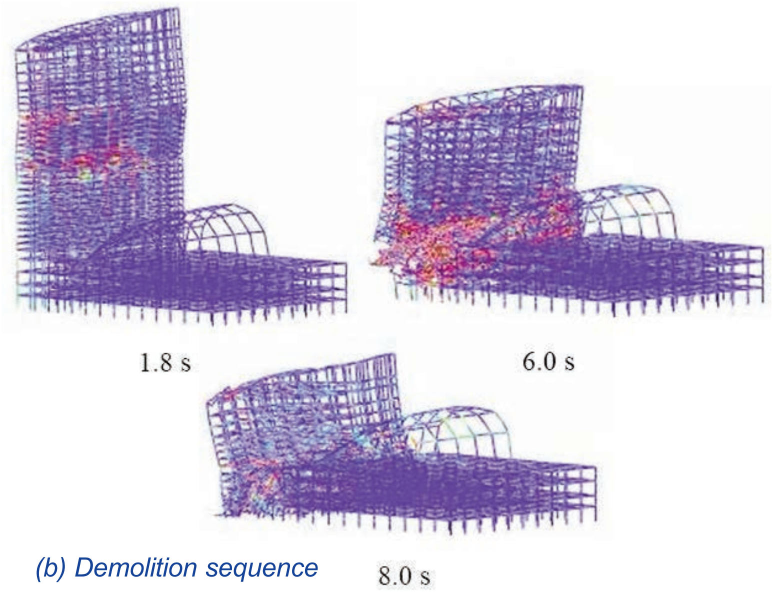
Several numerical simulations of high-rise buildings were conducted using the numerical code utilizing the ASI-Gauss technique to identify the specific structural cause of the high-speed total collapse of the World Trade Center (WTC) towers, which occurred during the 9.11 terrorist attacks. *Figure 3* shows the numerical result on full-scale aircraft impact simulation of the WTC tower 2. The colors in the figure indicate yield function values with red color indicating that the element is yielded. The simulation was conducted to examine the damage and the dynamic unloading phenomena, a so called “spring-back phenomena”, that occurred in the core columns during the impact. The spring-back phenomena might have caused the destruction of the splices between column sections, and consequently, triggered the following total collapse of the tower with a high possibility.

A fire-induced progressive collapse analysis of high-rise buildings with outrigger truss systems was carried out to qualitatively demonstrate the effects of fire

Figure 5:
Blast demolition sequence of a high-rise tower



(a) Blast plan



(b) Demolition sequence

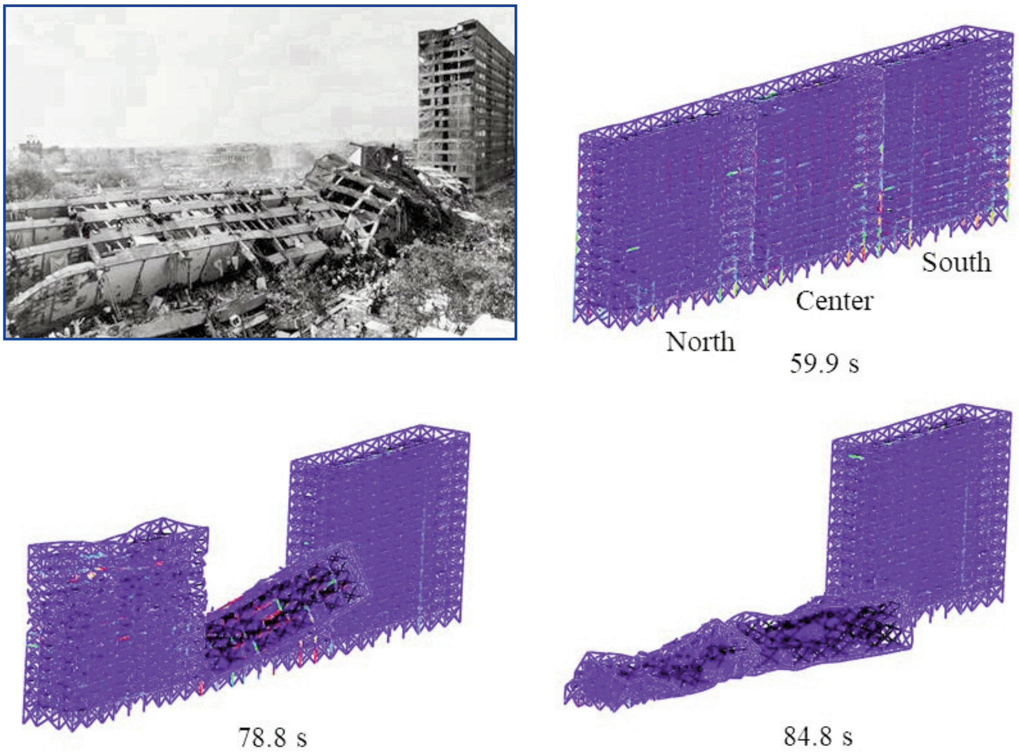
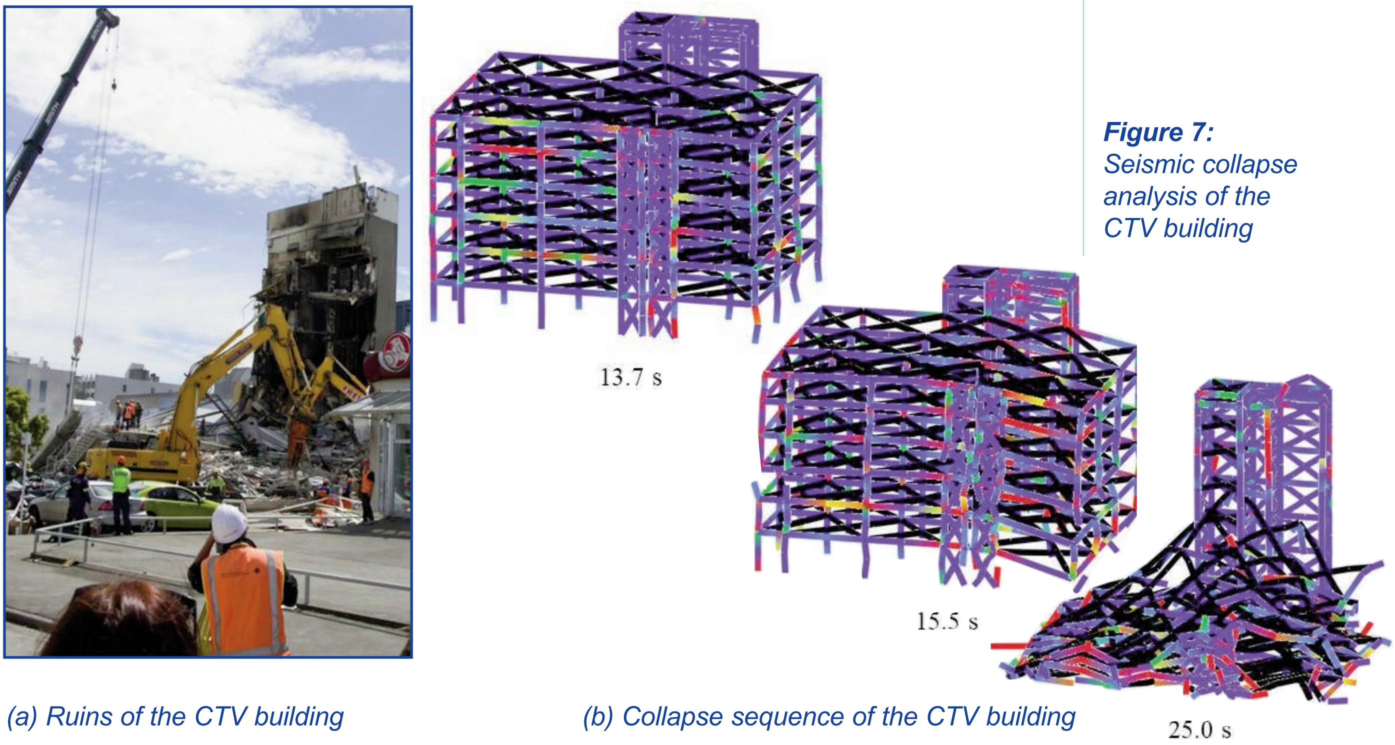


Figure 6:
Collapse behaviors of the Nuevo Leon buildings under long-period ground motion



(a) Ruins of the CTV building

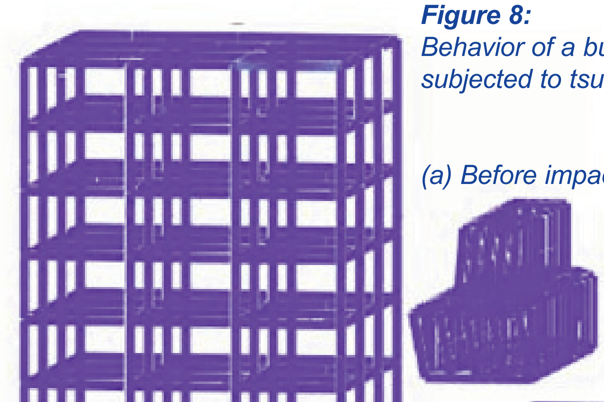
(b) Collapse sequence of the CTV building

Figure 7:
Seismic collapse analysis of the CTV building

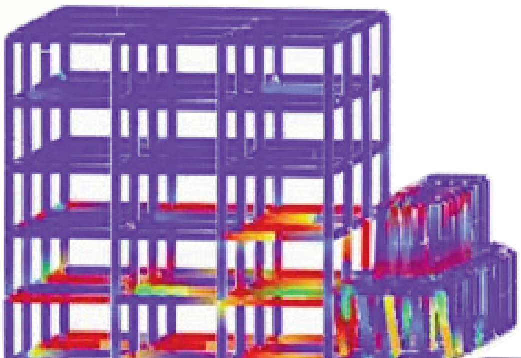
patterns and structural parameters on the progressive collapse behaviors of buildings *(Figure 4)*. The effects of fire patterns and structural parameters on the redundant strengths were surveyed by observing the collapse initiation time: the duration from the beginning of the fire until collapse initiation. It was confirmed that collapse initiation times were significantly affected by the member joint strengths if the axial force ratio was small on the condition that the fire pattern was nearly symmetrical, and the load paths to and from the outrigger truss system were sufficiently protected.

Figure 5 shows an example of blast demolition analysis conducted using the code. The building was planned to be demolished in its own wake, by carefully selecting the blast time interval and the columns of specific floors to be removed. Half of the columns on either side of the floors were removed sequentially from the

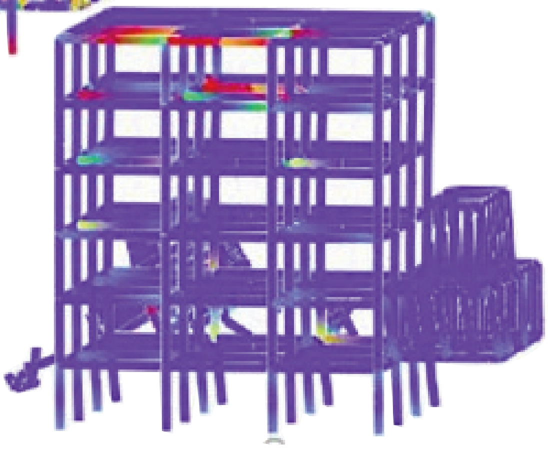
Figure 8:
Behavior of a building without walls under the water line subjected to tsunami and debris collision



(a) Before impact



(b) After impact



(c) Disintegration of debris

upper floor with a time interval of 0.5 s; 27F (t=0.0 s), 19F (t=0.5 s), 11F (t=1.0 s), 4F (t=1.5 s). As can be seen from the figure, it is successfully demolished without giving any damages to the concourse area which stands next to the building. However, there are some remains piled up higher on its wake, which may become a serious problem when clearing up the area.

A seismic pounding analysis was performed on a full model of the Nuevo Leon buildings, which consisted of three similar buildings built consecutively with narrow expansion joints between the buildings, and collapsed completely with one building remaining in the 1985 Mexican earthquake. It was aimed to understand the impact and collapse behavior of structures, built near each other, under long-period ground motion. It can be told from the numerical results that the difference of natural periods between the adjacent buildings caused by previous earthquakes may have triggered the collisions and the collapse *(Figure 6).*

An investigation was conducted on the factors that caused the collapse of the Canterbury Television (CTV) building during the Lyttelton aftershock on February 22nd, 2011, in New Zealand, which collapsed with only the north wall complex left standing. The collapse behavior with a clear twist mode vibration around the north wall complex was observed by carrying out a seismic collapse analysis *(Figure 7)*. The period of the twist mode vibration at the south-east corner of the building coincidentally matched the predominant period of the seismic wave in EW direction, which might had led to the deterioration of the columns at the location.

Figure 8 shows a behavior of a steel frame building in tsunami, which was obtained by applying seismic ground motion, fluid forces and debris collision, continuously in a single simulation. Since there are no walls under water, the building withstands the fluid force of tsunami and the following impact force applied by the debris. These results can provide information on appropriate design for tsunami refuge buildings and can also lift up a discussion to avoid the approach of large debris to such buildings.

Conclusions

The ASI-Gauss code can practically simulate the collapse behaviors of buildings with very low computational cost, and the most attractive point of this code is that it can be used in any personal computers with smaller memory resources. Although member fracture, contact and release are not considered, the developed numerical codes can be downloaded from the author's website [12, 13].

Some of the applications described here belong to real events occurred in the past. The observed data, if present, are valuable for the validation of the numerical code. One must always realize that validations are mostly important for these kinds of phenomena with strong non-linearity, because they are packed with unexpected mechanical interactions. However, it is evident that the numerical code based upon a finite element approach can provide useful information such as sectional forces acting in each member, deformation occurring in the structures, and so on, of which other methods based upon non-continuum mechanics cannot. The applicable field of the numerical code is now expanding from collapse analysis of structures to motion analysis of indoor non-structural components, and it is expected to expand further more. ●

> *" ...it is evident that the numerical code based upon a finite element approach can provide useful information ... deformation occurring in the structures ... of which other methods based upon non-continuum mechanics cannot."*

References

[1] *K.M. Lynn and D. Isobe*. **Finite Element Code for Impact Collapse Problems of Framed Structures**, International Journal for Numerical Methods in Engineering, Vol. 69, No. 12, pp. 2538-2563, 2007.

[2] *Y. Toi*. **Shifted Integration Technique in One-Dimensional Plastic Collapse Analysis Using Linear and Cubic Finite Elements**, International Journal for Numerical Methods in Engineering, Vol. 31, pp. 1537-1552, 1991.

[3] *D. Isobe*. **Progressive Collapse Analysis of Structures: Numerical Codes and Applications**, Elsevier, eBook ISBN: 9780128130421, Paperback ISBN: 9780128129753, 2017.

[4] *Y. Toi and D. Isobe*. **Adaptively Shifted Integration Technique for Finite Element Collapse Analysis of Framed Structures**, International Journal for Numerical Methods in Engineering, Vol. 36, pp. 2323-2339, 1993.

[5] *Y. Toi and D. Isobe*. **Finite Element Analysis of Quasi-Static and Dynamic Collapse Behaviors of Framed Structures by the Adaptively Shifted Integration Technique**, Computers and Structures, Vol. 58, No. 5, pp. 947-955, 1996.

[6] *D. Isobe and Y. Toi*. **Analysis of Structurally Discontinuous Reinforced Concrete Building Frames Using the ASI Technique**, Computers and Structures, Vol. 76, No. 4, pp. 471-481, 2000.

[7] *D. Isobe and M. Tsuda*. **Seismic Collapse Analysis of Reinforced Concrete Framed Structures Using the Finite Element Method**, Earthquake Engineering and Structural Dynamics, Vol. 32, No. 13, pp. 2027-2046, 2003.

[8] *D. Isobe, L. T. T. Thanh and Z. Sasaki.* **Numerical Simulations on the Collapse Behaviors of High-Rise Towers**, International Journal of Protective Structures, Vol. 3, No. 1, pp. 1-19, 2012.

[9] *D. Isobe, T. Ohta, T. Inoue and F. Matsueda.* **Seismic Pounding and Collapse Behavior of Neighboring Buildings with Different Natural Periods**, Natural Science, Vol. 4, No. 8A, pp. 686-693, 2012.

[10] *D. Isobe, W.S. Han and T. Miyamura*. **Verification and Validation of a Seismic Response Analysis Code for Framed Structures using the ASI-Gauss Technique**, Earthquake Engineering and Structural Dynamics, Vol. 42, No. 12, pp. 1767-1784, 2013.

[11] *D. Isobe*. **An Analysis Code and a Planning Tool Based on a Key Element Index for Controlled Explosive Demolition**, International Journal of High-Rise Buildings, Vol. 3, No. 4, pp. 243-254, 2014.

[12] *Website of ASIFEM.* **Finite element code for framed structures using ASI-Gauss technique**, http://www.kz.tsukuba.ac.jp/~isobe/asifem_e.html.

[13] *Website of ASIRES*. **Seismic response analysis code for framed structures using ASI-Gauss technique**, http://www.kz.tsukuba.ac.jp/~isobe/asires_e.html.

A Partitioned Solution Strategy for Strongly Coupled Multifield Problems

by
Alexander Düster,
Marcel König,
Lars Radtke
Hamburg University of Technology
alexander.duester@tuhh.de

Multifield problems are of increasing interest in various disciplines of science and engineering. In recent years, numerical simulations have evolved as an important means to support the modeling process and to enable a more profound understanding of these complex physical phenomena. In addition, simulations help to reduce the number of time-consuming and expensive experiments. Typical examples for multifield problems range from fluid-structure interaction (FSI) [1, 2] to applications including interactions between more than two fields – such as, for example, electro-thermo-mechanical coupled problems [3, 4]. Although the available computational resources are increasing steadily, multifield problems still pose a big challenge in terms of numerical effort. This is due to the individual requirements of the different fields, potentially involving different length and time scales.

In general, there are two different approaches to solve coupled multifield problems. **Monolithic schemes** serve to solve the entire physical system at once within one time step. When combined with implicit integration, these schemes have the advantage of exhibiting good stability characteristics. However, the linearization of the coupled problem introduces rather large unsymmetric matrices due to the cross derivatives of the individual fields with respect to the unknowns of the other fields. On the contrary, in a **partitioned approach**, the entire problem is subdivided into several subproblems, which can be solved separately.

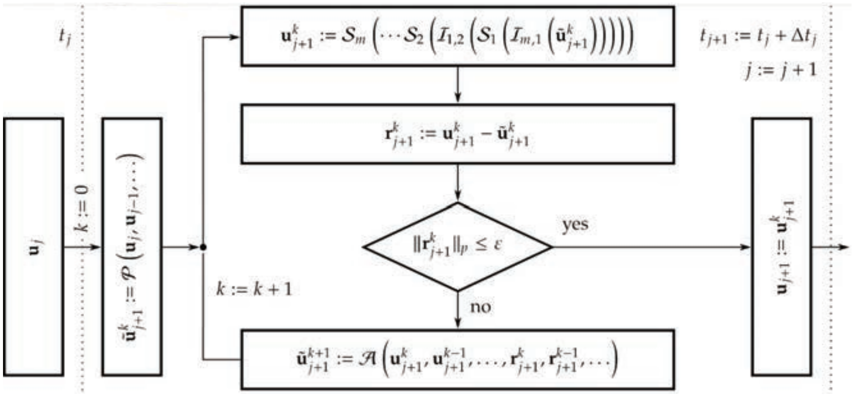


Figure 1: *Representative time step in the generic partitioned solution algorithm [5]*

Consequently, the resulting subsystems are significantly smaller, and different spatial and temporal discretization schemes may be applied for each of the subproblems. Moreover, existing specialized and fast black-box solvers can be used to solve the subproblems. This does not only enhance software modularity and re-usability, but also boosts performance. Yet, special care has to be taken in order to maintain the stability of a partitioned solution procedure. To this end, effective predictor and convergence acceleration schemes are utilized – not only to retain stability, but also to enhance the convergence behaviour.

In this contribution, we briefly summarize the partitioned solution approach and demonstrate its flexibility by means of several applications.

Partitioned solution approach

Coupled multifield problems can be categorized into **surface- and volume-coupled problems**. In surface-coupled problems, the subdomains share a common interface, whereas the corresponding subdomains overlap each other in volume-coupled problems. Both surface- and volume-coupled problems can be solved using the generic partitioned solution algorithm presented in [5]. *Figure 1* sketches a representative time step of this algorithm for an m-field problem, with u denoting the primary coupling quantity. In every new time step, a **predictor** $\mathcal{P}$ is applied to generate a reasonable initial iterate $\tilde{\mathbf{u}}^0_{j+1}$ from the converged results of the previous time steps (if available). From numerical tests conducted in [5, 6], for example, it turns out that polynomial as well as adaptive predictors, which solve a minimization problem in every time step, are most effective to retain the stability of the solution procedure and reduce the number of required implicit iterations. Since the subproblem discretizations are generally non-matching, an **interpolation** or **mapping operator** $\mathcal{I}_{ij}$ needs to be used to interpolate the quantities from the ith to the jth subfield discretization [5]. Whenever possible, we apply mesh-dependent interpolation schemes, which

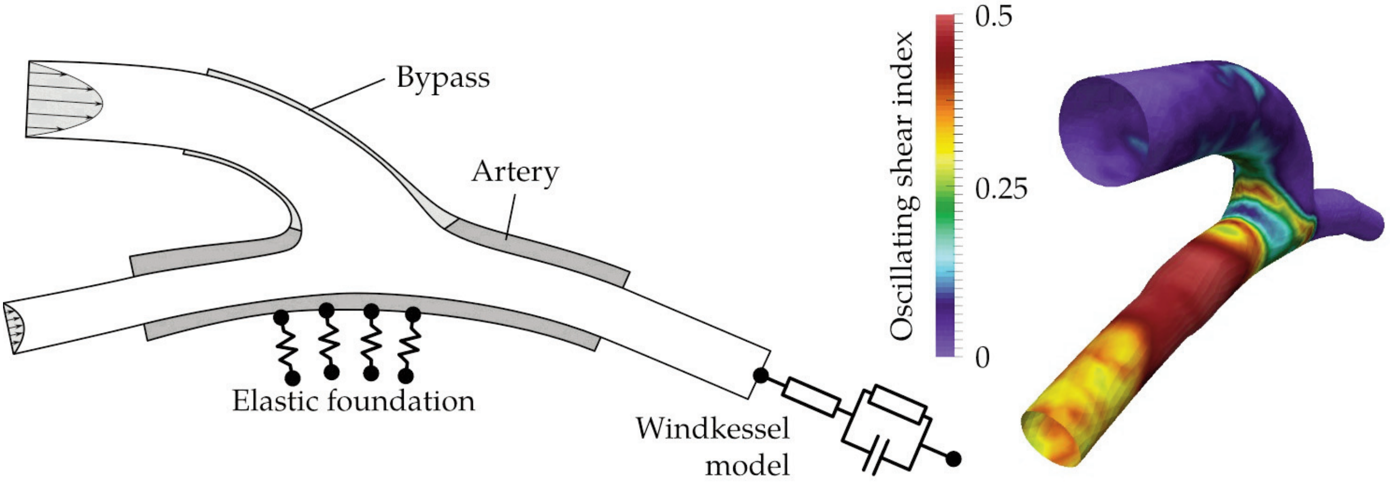


Figure 2: *Schematic model of an end-to-side anastomosis and oscillating shear index distribution [14]*

take the geometrical information of the existing discretizations into account to perform an accurate data transfer between the subfields. Subsequent to interpolating the initial iterate $\tilde{\mathbf{u}}^{0}_{j+1}$ from the mth to the first subfield, we supply the result to the first subfield solver $\mathcal{S}_1$. The cycle continues until the mth subfield solver computes the solution $\mathbf{u}^{k}_{j+1}$, which is then used to evaluate the residual $\mathbf{r}^{k}_{j+1} := \mathbf{u}^{k}_{j+1} - \tilde{\mathbf{u}}^{k}_{j+1}$. Provided that the p-norm of the residual $\| \mathbf{r}^{k}_{j+1} \|_p$ falls below a prescribed tolerance ε, we proceed to the next time step. Otherwise, an updated solution $\tilde{\mathbf{u}}^{k+1}_{j+1}$ is computed by applying a convergence acceleration scheme $\mathcal{A}$. A vast range of different convergence acceleration methods is available from the literature, and the reader is referred to [7] for an overview. The classical Aitken method [8] has been applied for FSI problems, for example, in [9]. Alternative acceleration schemes are based on variants of the quasi-Newton least squares (QNLS) method [10-12] that serve to approximate the inverse of the Jacobian matrix of the residual at the interface.

The proposed generic partitioned solution algorithm was implemented in our versatile C++ library *comana* [5], which allows to easily integrate different solvers in a partitioned solution strategy. Code adapters, which equip a solver with the ability to participate in a partitioned solution process, are readily provided for numerous different in-house, commercial, or open source solvers for fluid, structural, or thermodynamical problems supporting different discretization schemes such as the finite volume method (FVM), the finite element method (FEM), or the boundary element method (BEM). It requires only little effort to implement code adapters that are not yet available.

Applications

In this section, we present several applications involving strongly coupled multifield problems, which are solved using a partitioned approach. Exploiting the full flexibility of a partitioned solution strategy, we employ different spatial and temporal discretization schemes for the subproblems and use dedicated, existing solvers for their solution. If not mentioned otherwise, we employ a second-order polynomial predictor to generate an initial iterate at the beginning of each time step and the QNLS method [10] for the sake of convergence acceleration.

Blood flow through arteries

Cardiovascular diseases are one of the major causes of death in the world. If a blood vessel is occluded, a bypass graft may be implanted to restore the blood supply of the respective parts in the circulatory system. However, the distal connection of the graft and the artery (anastomosis) is prone to developing intimal hyperplasia (IH), a secondary disease that can lead to renewed occlusion. IH has been found to be triggered by abnormal wall shear stresses (WSS) in the anastomosis region. Among other criteria, the oscillating shear index (OSI, a measure for the direction change of the WSS over one beat of the heart) has been correlated with the development of IH.

Numerical simulations can provide a deeper insight into how dependent these criteria are on the shape of the anastomosis and the properties of the graft material, as well as on the prevalent flow and pressure conditions. To obtain realistic results in such investigations, the interaction between the blood and the vessel wall needs to be taken into account. We use state-of-the-art material models for the arterial tissue and make use of high-order finite elements to discretize the structural subproblem efficiently [13]. Using a modified version of the QNLS method introduced in [12], a partitioned solution approach can be used to solve this FSI problem. Further, the surrounding tissue as well as the vessel network distal to the anastomosis region have to be included using reduced order models. As shown in *Figure 2*, an elastic foundation and a windkessel model are included in the FSI problem, such that a four-field problem is obtained. A partitioning like this allows for the use of standard structural and fluid solvers without the need to implement special boundary conditions [14]. The OSI distribution shown along with the schematic model in *Figure 2* is in qualitatively good agreement with the experimental findings in [15]. Future investigations could combine the simulation approach with an optimization procedure to improve the performance of vascular bypass grafts.

Figure 3: *Deformed fender during the berthing operation [16]*

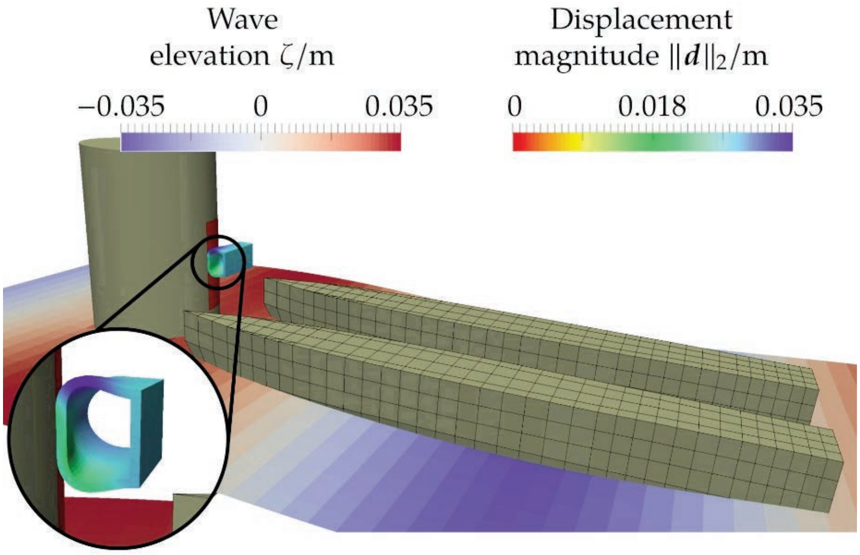
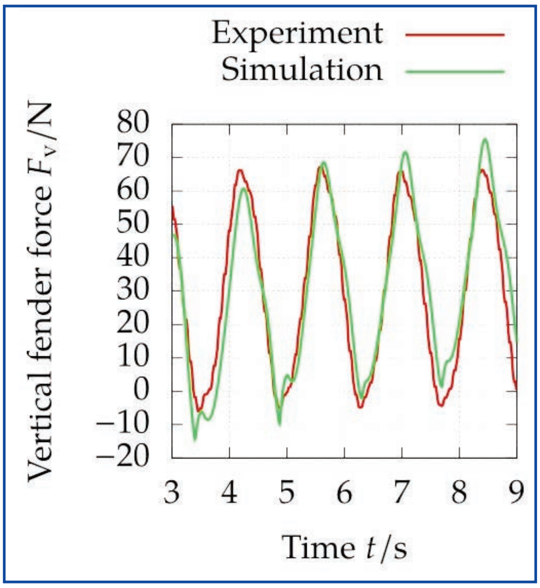


Figure 4: *Experimental and numerical results for the vertical fender force [16]*



Berthing manoeuvre of service ships to offshore wind turbines

Offshore wind turbines require scheduled maintenance and occasional repair to operate safely and reliably. Crew transfer vessels are utilized to transfer technicians from the shore to the offshore wind turbine. In order to ensure that the servicing staff can safely disembark from the ship, the relative motion between the ship and the offshore structure should be kept to a minimum. By means of numerical simulations, we study the limit conditions, under which a safe crew transfer is still possible. To this end, a coupled simulation involving three subproblems – the wave field, the motion of the rigid service vessel, and the contact between the fender and the boat landing – is performed [16], see *Figure 3*. For the fluid field, we assume a potential flow, which is efficiently solved using the BEM implemented in the first-order panel code *pan*MARE [17]. The motion of the rigid service vessel is covered by a six-degree-of-freedom description integrated with the implicit Euler method. Lastly, the contact problem between the hyperelastic fender and the boat landing is treated using the FEM and an augmented Lagrangian contact formulation implemented in the commercial software ANSYS [18]. For validation purposes, we conducted several model-scale towing tank experiments with different wave lengths and heights. It was found that the numerical results for the motion behaviour of the service vessel and the fender force (*see Figure 4*) are in good agreement with the experimental observations [16], demonstrating the suitability of the chosen coupling approach for this sophisticated problem.

Floating offshore wind turbine

Recently, floating offshore wind turbines (OWTs) evolved as an interesting competitor to conventional fixed-foundation turbines, which are limited to on- or near-shore areas. Floating OWTs may, on the contrary, also be installed in greater water depths, thus allowing to harvest the stronger and more constant wind further away from the coast. Moreover, modern floating OWTs can be produced in shipyards at quite a reasonable price – and, afterwards, be installed on site easily. Thus, floating OWTs appear to be an attractive solution, both technically and economically.

In order to assess the performance and ensure the structural integrity of the floating OWT under different loading conditions, it is essential to take the FSI into account and to analyse the hydro- and aerodynamic forces and their impact on the motion behaviour of the floating structure and the stresses inside. In the scope of the joint project "Hydrodynamic and structural optimization of a floating platform for offshore wind turbines" (HyStOH), which is financed by the German Federal Ministry of Economic Affairs and Energy (BMWi), we simulate the FSI of an innovative fully weather-vaning 6 MW downwind turbine that is mounted on a single-point moored, symmetric floating platform equipped with four floaters to provide the required hydrostatic lift [19]. Thanks to the flexibility of the partitioned solution approach, it is possible to compute the coupled problem as a three-field problem involving the hydro- and aerodynamic and the structural problem. In the implicit solution procedure, we first solve the hydro- and then the aerodynamic problem before applying the resulting fluid tractions on the structure to evaluate its motion response. Depending on the particular objective of the simulation, it is possible to consider parts of the structure as rigid or elastic. *Figure 5* depicts the simulation results for a JONSWAP spectrum, where all the components of the floating offshore wind turbine except for the mooring were considered as rigid in order to investigate the overall motion behaviour of the complete structure.

Field-assisted sintering technology

The field-assisted sintering technology (FAST), see *Figure 6*, is a sintering technique that represents an electro-thermo-mechanically coupled process [3]. Due to the applied electric field, the copper powder heats up and is compressed under high pressure at the same time. Since the tools are located inside a chamber, the heat exchange between the FAST tools and the chamber walls has to be taken into account as well. In [4], it is demonstrated that the application of a radiation solver can lead to significantly better results when being compared to classical radiation boundary conditions. The temperature distribution resulting from the solution of the four-field problem involving the electric, thermal, radiation, and mechanical field is depicted in *Figure 7*. Applying the Aitken method for convergence acceleration leads to an average number of iterations per time step in the range from 3.67 to 4.37, depending on the radiation model.

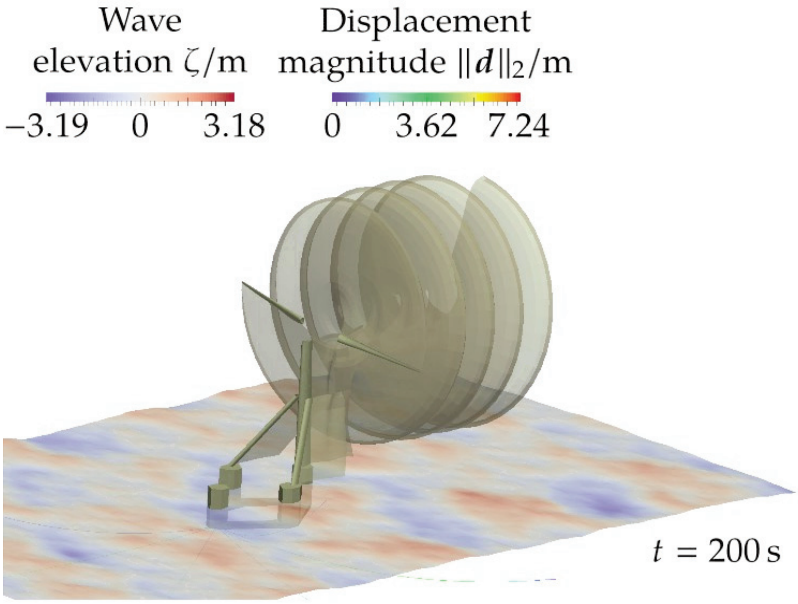


Figure 5:
Motion behavior of the floating OWT in a JONSWAP spectrum

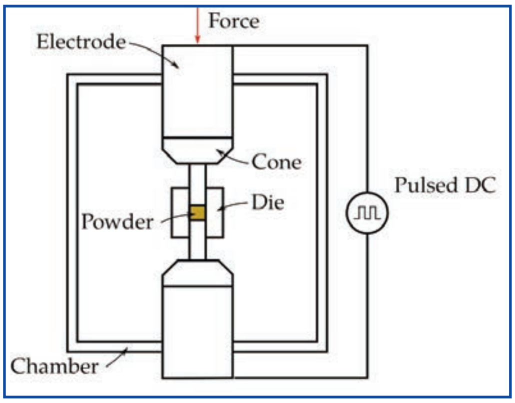


Figure 6:
Schematic sketch of the FAST process

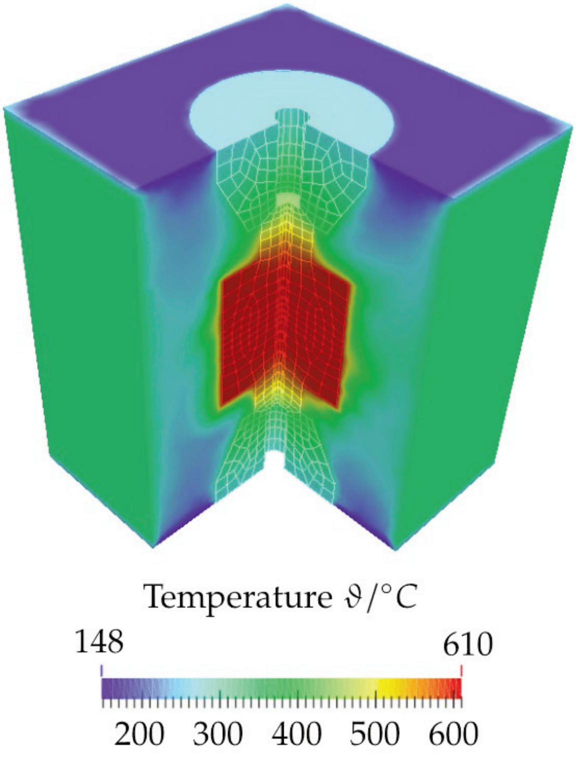


Figure 7:
Temperature distribution in the entire model

Conclusions

In this work, we presented a general partitioned solution approach that was applied to different strongly coupled multifield problems. Due to the black-box nature of the approach, different models and dedicated discretization methods can be applied to solve the individual problems. Future research will focus on the further development of the approach to tackle challenging engineering problems. In addition, we plan to undertake several experiments to validate our numerical results and adjust the numerical models for the involved subproblems if necessary. ●

References

[1] *H. J. Bungartz, M. Mehl, M. Schäfer (Eds.)*. **Fluid-structure interaction II, Modelling, Simulation, Optimization.** Springer, 2010.

[2] *Y. Bazilevs, K. Takizawa, T. E. Tezduyar*. **Computational fluid-structure interaction: methods and applications**. John Wiley & Sons, 2013.

[3] *S. Hartmann, S. Rothe, N. Frage*. **Electro-thermo-elastic simulation of graphite tools used in SPS processes, in: Generalized Continua as Models of Materials**, edited by H. Altenbach, S. Forest, and A. Krivtsov, Advanced Structured Materials Vol. 22, pp. 14-163, Springer, 2013.

[4] *G. Wendt, P. Erbts, A. Düster*. **Partitioned coupling strategies for multi-physically coupled radiative heat transfer problems**. Journal of Computational Physics, 300:327-351, 2015.

[5] *M. König, L. Radtke, A. Düster*. **A flexible C++ framework for the partitioned solution of strongly coupled multifield problems**. Computers & Mathematics with Applications, 72:1764-1789, 2016.

[6] *T. Gallinger*. **Effiziente Algorithmen zur partitionierten Lösung stark gekoppelter Probleme der Fluid-Struktur-Wechselwirkung**, PhD thesis, Technische Universität München, Munich, Germany, 2010.

[7] *I. Ramière, T. Helfer.* **Iterative residual-based vector methods to accelerate fixed point iterations**, Computers and Mathematics with Applications, 70:2210-2226, 2015.

[8] *B. M. Irons, R. C. Tuck*. **A version of the Aitken accelerator for computer iteration**. International Journal of Numerical Methods in Engineering, 1:275-277, 1969.

[9] *U. Küttler, W. A. Wall*. **Fixed-point fluid-structure interaction solvers with dynamic relaxation**, Computational Mechanics, 43:61-72, 2008.

[10] *J. Degroote, K.-J. Bathe, J. Vierendeels*. **Performance of a new partitioned procedure versus a monolithic procedure in fluid-structure interaction**, Computers and Structures, 87:793-801, 2009.

[11] *R. Haelterman, A. E. J. Bogaers, K. Scheufele, B. Uekermann, M. Mehl*. **Improving the performance of the partitioned QN-ILS procedure for fluid-structure interaction problems: Filtering**, Computers and Structures, 171:9-17, 2016.

[12] *L. Radtke, A. Larena-Avellaneda, E.S. Debus, A. Düster*. **Convergence acceleration for partitioned simulations of the fluid-structure interaction in arteries**. Computational Mechanics, 57:901-920, 2016.

[13] *L. Radtke, M. König, A. Düster*. **The influence of geometric imperfections in cardiovascular FSI simulations**. Computers & Mathematics with Applications, 74:1675-1689, 2017.

[14] *L. Radtke, A. Larena-Avellaneda, E.S. Debus, A. Düster.* **Simulation der Fluid-Struktur-Interaktion in arteriellen Bypässen**. Gefäßchirurgie, 22(6):400-406, 2017.

[15] *H. Haruguchi, S. Teraoka*. **Intimal hyperplasia and hemodynamic factors in arterial bypass and arteriovenous grafts: a review**. Journal of Artificial Organs, 6(4):227-235, 2003.

[16] *M. König, D. Ferreira González, M. Abdel-Maksoud, A. Düster.* **Numerical investigation of the landing manoeuvre of a crew transfer vessel to an offshore wind turbine.** Ships and Offshore Structures, 12(1):115-133, 2017.

[17] *M. Bauer, M. Abdel-Maksoud*. **A 3D potential based boundary element method for the modelling and simulation of marine propeller flows**. 7th Vienna Conference on Mathematical Modelling. Vienna, Austria, 2012.

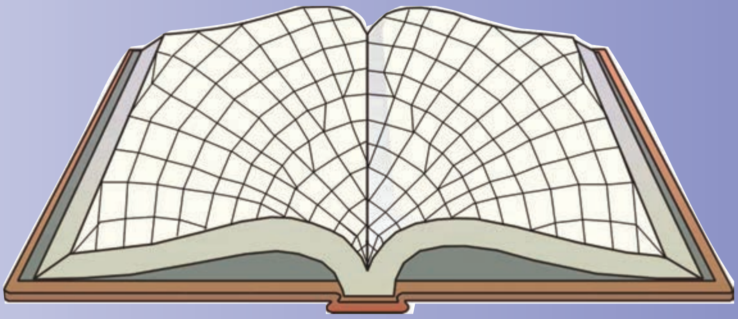
[18] *ANSYS, Inc*. **ANSYS Academic Research**, Release 17.0. Canonsburg, PA, 2017.

[19] *J. Cruse*. **Floating wind turbine promises cost reductions**. HANSA International Maritime Journal, 153. Jahrgang, 9:173, 2016.

> *“we … summarize the partitioned solution approach and demonstrate its flexibility by means of several applications.”*

DATA ASSIMILATION: METHODS, ALGORITHMS, AND APPLICATIONS

Mark Asch, Marc Bocquet and Maëlle Nodet
SIAM, Philadelphia, 2017



BOOK REVIEW

ISBN: 978-1-611974-53-9, 324 pages, soft cover, $84 (List Price).

Contents: Preface; Part I: Basic methods and algorithms for data assimilation; 1: Introduction to data assimilation and inverse problems; 2. Optimal control and variational data assimilation; 3. Statistical estimation and sequential data assimilation; Part II: Advanced methods and algorithms for data assimilation; 4. Nudging methods; 5. Reduced methods; 6. The ensemble Kalman filter; 7. Ensemble variational methods; Part III: Applications and case studies; 8. Applications in environmental sciences; 9. Applications in atmospheric sciences; 10. Applications in geosciences; 11. Applications in medicine, biology, chemistry, and physical sciences; 12. Applications in human and social sciences; Bibliography; Index

This excellent book is included in the SIAM series Fundamentals of Algorithms. It is a modern mathematical treatise of PDE-based Data Assimilation (DA). The area of DA is not new, but has seen a lot of exciting developments during the last decade. On a personal note, many years ago I took a course on numerical weather prediction and was exposed for the first time to DA. While the importance of this subject is obvious, my impression was that there was no deep methodology and rigorous mathematics behind it. All this changed when I heard a fascinating talk by Tony Patera from MIT (known in our circles as the inventor of spectral elements) on variational DA three years ago.

The basic problem of DA can be described as follows: Given a mathematical / computational model (whose solution inevitably contains some error) and physical measurements of related quantities (which inevitably contain some noise), how can one combine these two sources of information to obtain a result which is more accurate or complete than either of them? Or better still – what is the optimal (in some chosen norm) way to combine these two?

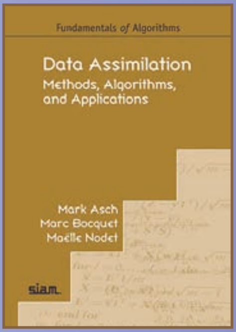
The book is divided into three parts: Part I describes the basic tools for analyzing this problem, Part II discusses more advanced tools, and Part III describes various applications of DA. I found the style of writing to be very appealing: interesting, focused on the important points, clear, not dry at all, sometimes even humorous. As the authors write in the Preface, "we observe a maximum of mathematical rigor but with a minimum of formalism." A truly min-max approach! The big picture is described before the small details are discussed. Illustrations and examples aid in understanding the ideas. In the reference list, page numbers where each reference is mentioned are indicated, a nice touch which I do not remember seeing in other books. The 15 algorithms discussed in the book are summarized in special "boxes". A typical member of the computational mechanics (CM) community would read the book and benefit from it with no difficulty. And I dare say – would enjoy it.

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

Mark Asch

Marc Bocquet

Maëlle Nodet



Fundamentals of Algorithms

Data Assimilation
Methods, Algorithms,
and Applications

Mark Asch
Marc Bocquet
Maëlle Nodet

siam

There are various approaches for viewing and analyzing the fundamental problem of DA mentioned above. The book places DA in the framework of *inverse problems*, and draws from the computational methods used to solve such problems. It covers two approaches within this framework: variational DA and statistical (or probabilistic) DA, whose main mathematical tools are the adjoint method and the Kalman Filter (KF), respectively. Probably, the vast majority of CM readers will prefer the variational DA approach, since it is well connected to major themes in CM. The book discusses also hybrid methods which combine the two general approaches. As the Preface asserts, "this book is about building bridges – bridges between inverse problems and DA, bridges between variational and statistical approaches, bridges between statistics and inverse problems." Related topics, like optimal control, optimization and Uncertainty Quantification (UQ) are also shown to be connected to DA.

Chapter 1 gives a bird view introduction to DA. The connection to inverse problems is explained, along with the definition of well- and ill-posedness. Examples for inverse problems are given, and the need for regularization is discussed. Then the distinction between variational and statistical DA is described. Both are based on minimization: in the variational approach the goal is to minimize an appropriate cost (or error) function, while in the statistical approach it is (for example) to minimize the relevant variance. The two approaches are developed, without giving yet the full details of the theory, for very simple examples, in order to demonstrate the crucial ideas. The basics of the KF (for statistical DA) and of the adjoint method (for variational DA) are very nicely explained. The 3D-Var and 4D-Var algorithms (variational schemes for space and space-time problems, respectively) are outlined.

As mentioned above, most members of the CM community would prefer the variational approach (and therefore I will relate to it much more in this review). Moreover, some of us would not possess the required background in statistics to feel at ease with statistical DA. For example, the authors use the concept of ensemble average, denoted by < … >, without explanation, and refer the reader to "a good book on probability and statistics". If a second edition of this book is to be published one day, my suggestion is to include an appendix with a brief description of necessary statistical concepts.

Chapter 1 includes a section on the notation convention to be used. This is a good idea, and the notation itself makes a lot of sense. The only trouble is that the consistent use of this notation is not always kept throughout the book. For example, according to the notation convention, the superscript o is to be used for "observation", but on p. 33 the authors use u^{obs} instead of u^o, and on p. 53 they use y instead of x^o. This and other such inconsistencies are by no means serious, and do not reduce from the clarity of the exposition.

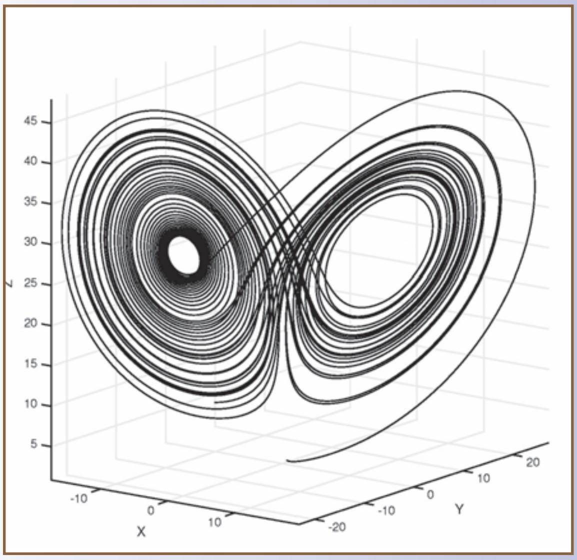


Figure 1:
Phase diagram for the chaoticLorenz system. This is Fig. 2.5 in the book

Chapter 2 elaborates on variational DA. There is a brief introduction to the calculus of variations, and then the powerful concept of the adjoint method is presented. The adjoint method is a technique to efficiently calculate the gradient G of a cost function in the context of inverse problems. A straight forward calculation would require the solution of N forward problems to find G in each iteration, N being the number of design variables. In the adjoint method, a single forward problem has to be solved in each iteration to find G.

Two ways are described to derive the adjoint equation associated with a given inverse problem: (1) using a Lagrange multiplier, and (2) using the tangent linear model (TLM), which amounts to " differentiating" the original equation with respect to the unknown parameters. I find the TLM derivation clearer and more appealing. The Lagrange multiplier approach is based on writing the constrained minimization problem using a Lagrange multiplier p, and then choosing p to satisfy some conditions in order to "kill terms", as the authors write. Since in constrained minimization the Lagrange multiplier is not arbitrary, but is an additional unknown of the problem, it is not obvious that the enforcement of such extra conditions on it is mathematically justified. The resolution of this paradox is that p is not truly a Lagrange multiplier in the usual sense, even though it appears to be. The derivation *is* correct, and it leads to the correct result (which is identical to that of the TLM). In any event, one may feel on a more solid ground using the TLM. Moreover, the authors remark (p. 35) that the TLM approach is more general.

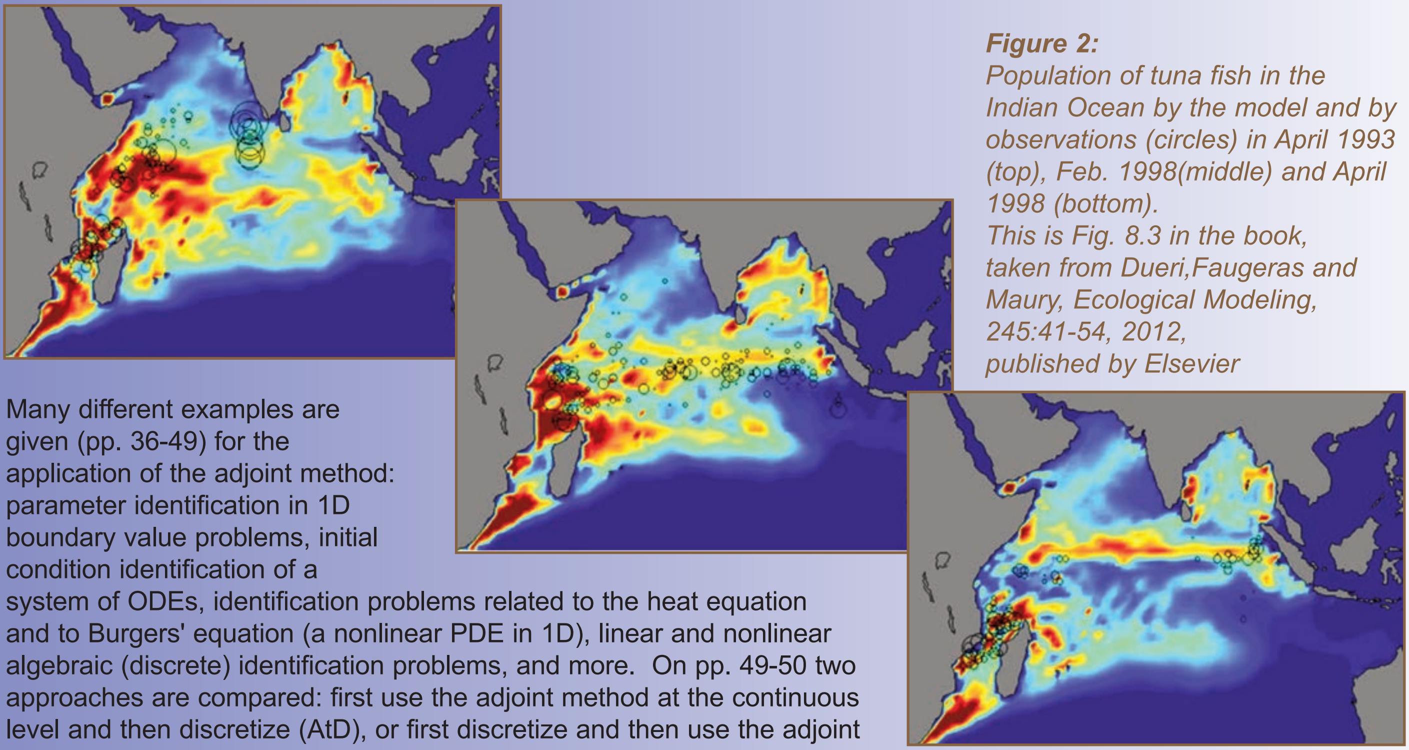
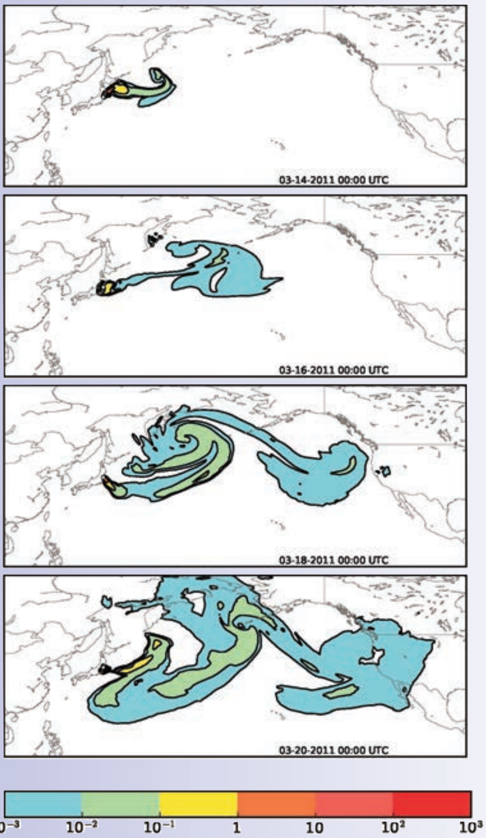


Figure 2: *Population of tuna fish in the Indian Ocean by the model and by observations (circles) in April 1993 (top), Feb. 1998(middle) and April 1998 (bottom). This is Fig. 8.3 in the book, taken from Dueri,Faugeras and Maury, Ecological Modeling, 245:41-54, 2012, published by Elsevier*

Many different examples are given (pp. 36-49) for the application of the adjoint method: parameter identification in 1D boundary value problems, initial condition identification of a system of ODEs, identification problems related to the heat equation and to Burgers' equation (a nonlinear PDE in 1D), linear and nonlinear algebraic (discrete) identification problems, and more. On pp. 49-50 two approaches are compared: first use the adjoint method at the continuous level and then discretize (AtD), or first discretize and then use the adjoint method at the discrete level (DtA). The authors point out that there are mixed opinions on which is better. Their stand is that AtD is in principle preferable, but is sometimes difficult to apply. I agree, since I believe that as a rule it is preferable to delay the approximation as much as possible. In DtA the approximation is made right in the beginning.

The authors then build upon the adjoint method to present the techniques of variational DA. The cost function to be minimized involves two error covariance matrices, which reflect the uncertainties in the model and in the measurements, respectively (thus, even variational DA involves a small statistical ingredient). The 3D-var and 4D-var algorithms are described in their full glory. In showing these two algorithms in the same chapter, the authors made the choice to treat the static (elliptic) case and the dynamic (time-dependent) case together, rather than to explain everything for the former and then, in another chapter, extend to the latter. I find this choice sensible. The examples given at the end of the chapter include a demonstration of DA for the chaotic Lorenz system; see *Figure 1*.

Figure 3: *Simulation, using DA techniques, of the radioactive plume emitted from the Fukushima-Daiichi nuclear power plant, following the accident in March 2011. This is Fig. 9.3 in the book*



Chapter 3 discusses statistical DA, estimation and the KF, from a Bayesian point of view. Section 3.1.3 makes a nice distinction between "prediction" and "forecast". Section 3.2 is devoted to statistical estimation theory, and is written in a more formal style than the rest of the book, with definition-theorem-remark sequences. The chapter includes a MATLAB code for the estimation of a scalar.

Part II discusses more advanced related topics, such as nudging methods (chapter 4), including the idea of Back & Forth Nudging; reduced methods (chapter 5), which may mean either the reduction of the model or of the DA method itself; ensemble KF (chapter 6), including several state-of-the-art algorithms; and ensemble variational methods (chapter 7), including the hybridization of variational DA and ensemble KF.

Part III (chapters 8-12) discusses various applications of DA, including applications in geophysics, environmental acoustics, medical imaging, urban planning, economics and more. See *Figures 2 and 3*, taken from the book.

In summary, this is a highly recommended book on PDE-based DA, covering important subjects in an effective and accessible manner. It can be used either as a reference book for the more experienced or as a textbook for those wishing to plunge for the first time into the fascinating world of DA. ●

The Japan Society for Computational Engineering and Science

JSCES Autumn School 2017 on Nonlinear Finite Element Method for Elastoplastic Analysis

A three-day course entitled "JSCES Autumn School 2017 on Nonlinear Finite Element Method for Elastoplastic Analysis" was held during October 4-6, 2017, at Arata Hall in Joining and Welding Research Institute, Osaka University. The aims of this course are to promote the spread of fundamental and up-to-date technologies of nonlinear finite element method for solids and structures, and to support engineers, researchers, and students for their improvement of technical knowledge toward higher expertise.

Figure 1: Lecture by Prof. Kenjiro Terada (Tohoku Univ., President of JSCES)

The course has been held consecutively every year since 2013 (2013 in Tokyo, 2014 in Nagoya, 2015 and 2016 in Tokyo, and 2017 in Osaka); each course has been attended by about 60 to over 100 participants. The Autumn School 2017 was attended by 65 participants, including engineers and researchers engaged in a broad range of industry and engineering, as well as researchers and students of universities and colleges.

The lecturers, Prof. Kenjiro Terada, Dr. Isao Saiki, Dr. Yuki Yamakawa (Tohoku Univ.), Dr. Tateki Ishii (National Institute of Technology, Kisarazu College), Dr. Mao Kurumatani (Ibaraki Univ.), and Dr. Kazumi Matsui (Yokohama National Univ.) delivered lively lectures on the wide spectrum of issues including the following topics: basics of continuum mechanics for small and large deformations, general framework of nonlinear finite element analysis, constitutive theory and numerical scheme for inelastic materials involving finite strains, and practical techniques for numerical implementation *(Figure 1).* ●

by: Yuki Yamakawa

Summer Short Course: Finite Elements in Flow Problems

Figure 2: A view of a lecture in the summer school

The 7th summer school of finite elements in flow problems was held during August 7-9, 2017, which is a series that has been hosted by JSCES since 1995. This summer school was held at CST Hall of Nihon University in Tokyo, Japan, and about 100 participants attended *(Figure 2)*.

Invited special lectures for this summer school were given by Professors T.J.R. Hughes (University of Texas at Austin) and T.E. Tezduyar (Rice University) *(Figure 3)*. Other lectures were given by K. Takizawa (Waseda U), S. Fujima (Ibaraki U), S. Tanaka (U of Tsukuba), K. Kashiyama (Chuo U), J. Matsumoto (AIST), H. Hasebe (Nihon U), T. Nomura (Nihon U), H. Watanabe (MSC Software Co., Ltd), T. Sawada (AIST), C. Kato (U Tokyo), and M. Oshima (U Tokyo). Each lecture was about 60-90 minutes including exchanging questions and answers with participants.

Figure 3: *Special guest lectures: Profs. T.J.R. Hughes & T.E. Tezduyar*

The topics of the summer school ranged from the fundamental to advanced finite element methods in flow problems; the stabilized finite element formulation, programming with thread parallel computing, ALE and Space-Time technique, and X-FEM for the moving boundary problems such as free surface flow problem and fluid structure interaction (FSI). Recent advanced computing methods were covered in lectures on the variational multi-scale (VMS) method for turbulent flow, and isogeometric analysis technique. An original textbook was compiled for this summer school and it was published by Maruzen Publisher Co., Ltd. ●

by: Seizo Tanaka

20th Int. PSE (Problem Solving Environment) Workshop in London

The 20th International PSE (Problem Solving Environment) Workshop, chaired by the PSE Research Group in JSCES, was held during August 29 – 31, 2017, at the Baker Street Office of Fujitsu Services in London, UK. The 1st PSE Workshop was held in 1998 at Kanazawa, Japan. It has been held each year. PSE is an emerging scientific and technological active area in computing science. PSEs provide innovative computational facilities for easy incorporation of novel solution methods to solve a target class of problems in computing environments, distributed and heterogeneous resources, and collaborative environments. Key issues addressed in PSE studies include PSE for Cloud environment, PSE for collaborations, PSE for heterogeneous distributed system management, PSE for application developments, PSE for scientific computing and PSE for education, as well as PSEs for eScience-relating issues.

Figure 4:
Prof. Zheng-Ming Sheng presents his keynote speech

In this year, we had one beautiful keynote speech by Prof. Zheng-Ming Sheng, University of Strathclyde, Glasgow, UK / Shanghai Jiao Tong University, Shanghai, China, on "Challenges for numerical simulations in relativistic laser-plasma physics and applications: from attosecond pulse generation to laser fusion" *(Figure 4)*. Dr. S. Furuya, a research fellow of Fujitsu Laboratories of Europe presented her invited special talk on “Engineering Cloud”, and Dr. H. Kobashi, another research fellow of Fujitsu Lab. Europe showed us a new idea on knowledge connection by his impressive talk on "Dixiter: A Hineri engine". In addition, we had other interesting presentations on an education support PSE, a visualization support PSE, PSE for IoT (Internet of Things) and a review of PSE studies. On the second day of the workshop, we had a workshop tour to the Bletchley park *(Figure 5)*, following Alan M. Turing. Fruitful discussions were exchanged among attendees. ●

by: Shigeo Kawata

Figure 5:
Workshop tour following Alan M. Turing and EDSAC (replica) in Bletchley park

Summer Camp for Students

“The summer camp for students 2017” hosted by JSCES was held at the lakeside of Lake Kawaguchi during September 23-24, 2017 to enhance mutual friendship among the graduate students as the candidate of young researchers in the field of computational mechanics. The Lake Kawaguchi is one of the famous summer resorts in Japan, which is located at the foot of Mt. Fuji.

During this camp, 6 keynote speakers gave talks about their research backgrounds; also 18 students presented their ongoing researches. The best presentation awards were given to two students *(Figure 6)*. All attendees enjoyed exchanging their experience and idea in a beautiful late summer atmosphere *(Figure 7)*. ●

by: Yuichi Shintaku

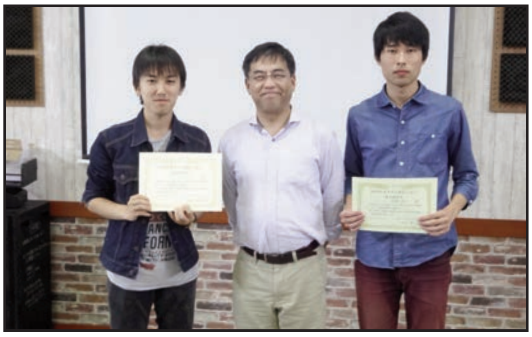


Figure 6:
Winners of the best presentation awards
Mr. Keita Imai (left) and Mr. Naoto Harasawa, Prof. Takahiro Yamada, Vice-president of JSCES (center)

Figure 7:
Participants of the JSCES summer camp 2017

JACM 日本計算力学連合

Japan Association for Computational Mechanics

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

The JACM is a union of researchers and engineers working in the field of computational mechanics mainly in Japan. JACM is a loosely coupled umbrella organization covering 29 computational mechanics related societies in Japan through communication with e-mail and web page (**http://www.sim.gsic.titech.ac.jp/jacm/index-e.html**). The number of individual members is about 310. JACM members actively participate the IACM activities. For example, the members organized 12 minisymposia at upcoming **WCCM XIII & PANACM II**, New York, USA, 22-27 July, 2018 and 7 minisymposia at **COMPSAFE 2017** in Chengdu, China in October 2017.

On July 19th, 2017, the 2017 JACM annual meeting and award ceremony were held on the occasion of the USNCCM 14, Montreal, Canada *(Figure 1)*. In the award ceremony, the award winners received their certificates from Prof. S. Yoshimura (President of JACM, *Figure 2*). The other award winners are presented with their photographs *(Figures 3 and 4)*. In 2017, The JACM Computational Mechanics Awards were presented to Profs. G. R. Liu (University of Cincinnati), T. Kitamura (Kyoto University) and K. Takizawa (Waseda University). At the annual meeting, the JACM members discussed the current state of the JACM and future plans and events such as WCCM XIII & PANACM II in July 2018 and COMPSAFE2017 (2nd International Conference on Computational Engineering and Science for Safety and Environmental Problems, an APACM Thematic Conference & IACM Special Interest Conference) in Chengdu, China, held in October 2017.

Figure 1:
2017 JACM annual meeting group photo

The JACM supports a variety of international and domestic activities related to computational mechanics. The members are actively involved in such activities. A typical example is their cooperation in the activities of the Science Council of Japan (SCJ). The function of SCJ is defined as “The Science Council of Japan was established in 1949 as a “special

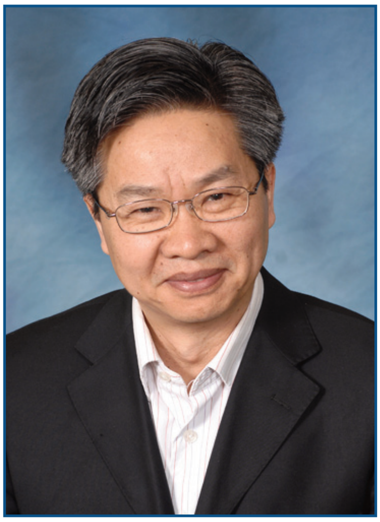
Figure 2:
JACM award winners with Prof. S. Yoshimura in the award ceremony

(a) Prof. H. Kawai of Toyo Uiniversity (JACM Fellows Award)

(b) Prof. H. Fujii of the University of Tokyo (JACM Young Investigator Award)

(c) Dr. M. Suzuki of JAXA (Japan Aerospace Exploration Agency) (JACM Young Investigator Award)

Figures 3:
Computational Mechanics Award


(a) Prof. G. R. Liu (University of Cincinnati)


(b) Prof. T. Kitamura (Kyoto University)


(c) Prof. K. Takizawa (Waseda University)

organization" under the justification of the Prime Minister, operating independently of the government for the purpose of promoting and enhancing the field of science, and having science reflected in and permeated in administration, industries and people's lives. It represents Japan's scientists both domestically and internationally" (**http://www.scj.go.jp/en/scj/index.html**).

SCJ published a new report "A point of reference in curriculum - Design/development for disciplinary quality assurance in university education - Computational Mechanics" on August 8th, 2017 (**http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-23-h170808.pdf**; only a Japanese version, a report for the Mechanical Engineering discipline can be found at: **http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-22-h130819-en.pdf#page=1**, in English). This report defines the direction of disciplinary curriculum-design and development in the field of computational mechanics, as a method of disciplinary quality assurance in university education. "A point of reference in curriculum - Design/development for disciplinary quality assurance in university education - Computational Mechanics" is consisting of six major chapters and they are:
1) Introduction,
2) Definition of Computational Mechanics,
3) Characteristics Specific to Computational Mechanics,
4) Basic grounding all students learning Computational Mechanics should aim to acquire,
5) Basic principles related to learning methods and the evaluation method for learning outcomes and
6) A liberal arts education in which experts and generality are combined.
The report was assembled by SCJ Committee on Computational Science and Engineering and Its Application to Engineering Design, whose chair is Prof. S. Yoshimura and vice chair is Prof. I. Higiwara (Meiji University). Some other members of JACM actively cooperated in the activities of the committee. ●

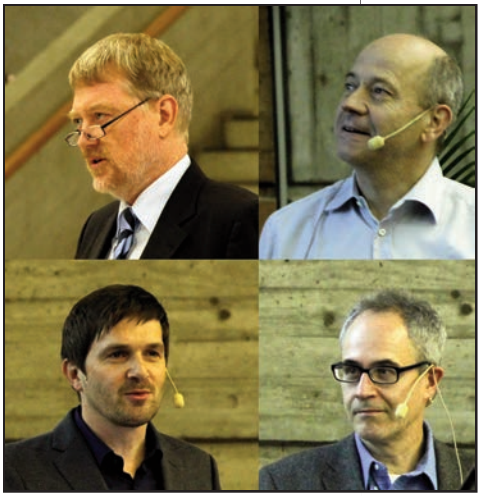

Figures 4:
Fellows Award: Prof. T. Takaki (Kyoto Institute of Technology).

7th GACM Colloquium on Computational Mechanics

11-13 October 2017 in Stuttgart

The 7th GACM Colloquium on Computational Mechanics for Young Scientists from Academia and Industry was hosted by the Institute for Structural Mechanics and the Institute of Applied Mechanics of the University of Stuttgart in collaboration with DYNAmore GmbH.

Figure 1: *The GACM president Michael Kaliske and the 3 plenary speakers: Paul Steinmann, Ralph Lohner & Kurt Maute*



Around 260 participants from 21 countries including doctoral students, post-docs, professors and students created a lively and warm atmosphere with many fantastic talks and even more fruitful discussions. Over 200 presentations in 42 parallel sessions were organized in 18 mini-symposia and seven contributed sessions.

The contributions from young researchers were supplemented by three plenary lectures from renowned experts from academia and industry. These were Paul Steinmann giving an inspiring lecture on the thermo-mechanics of additive manufacturing, Ralph Lohner from Hilti AG talking about various challenges in industrial applications and Kurt Maute speaking about the many facets of topology optimization. In addition, the four GACM Best Ph.D. Award winners of the years 2015 and 2016 could present their Ph.D. thesis to the plenary auditorium. During the poster session including 30 seconds poster flash presentations, the three GACM Best Poster Award winners were nominated in a thorough evaluation process.

The scientific program was surrounded by social events to foster the dialogue and the networking between the young investigators. During the reception on the first

GACM Best PhD Awards

It is a great pleasure for us to announce that the two outstanding doctoral theses of **Dr.-Ing. Tobias Gleim** and **Dr.-Ing. Vladimir Statnikov** were honored with the GACM Best PhD Award 2016 on the occasion of the 7th GACM Colloquium on Computational Mechanics in Stuttgart. Dr. Gleim's thesis on **"Simulation of Manufacturing Sequences of Functionally Graded Structures"** was supervised by Prof. Detlef Kuhl at the University of Kassel. Dr. Statnikov conducted his work on **"Numerical Analysis of Space Launcher Wake Flows"** at RWTH Aachen under the academic supervision of Prof. Wolfgang Schröder.

Dr.-Ing. Tobias Gleim: "Simulation of Manufacturing Sequences of Functionally Graded Structures"

The present thesis establishes an axisymmetric model for an inductive heating process. Therein, the fully coupled MAXWELL equations are combined with the nonlinear heat conduction equation, assuming temperature dependent electromagnetic and thermal material parameters, to yield a monolithic solution strategy. This is based on a consistent linearization together with a high-order finite element discretization using GALERKIN's method in space. For the temporal discretization, the generalized NEWMARK-α methods, high-order RUNGE-KUTTA methods, and discontinuous and continuous GALERKIN methods are used. Furthermore, the residual error is introduced to open an alternative way to obtain a numerically efficient estimation of the time integration accuracy. Simulation results of the electric, magnetic and thermal fields are provided, together with parameter studies concerning spatial

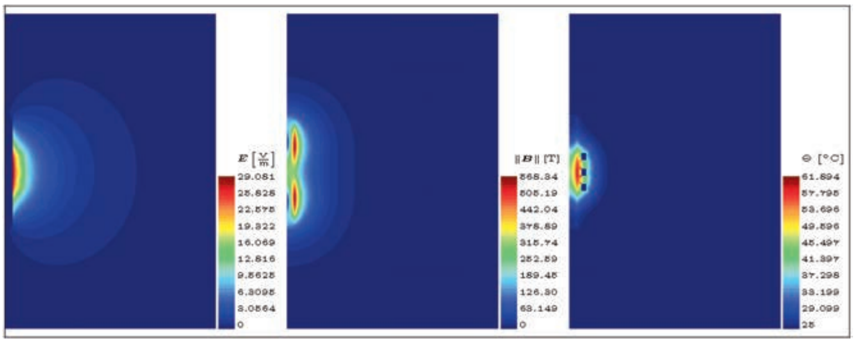


Figure 2:
The four GACM Best Ph.D. Award winners 2015 & 2016: Richard Ostwald, Ursula Rasthofer, Vladimir Statnikov & Tobias Gleim

evening, the GACM Best Poster Awards were handed over to Oliver Kunc, Metin Cakircali and Markus Klassen by the GACM president Michael Kaliske. The banquet was held in the historical Kursaal Cannstatt and was devoted to the region: traditional local Swabian food was served and in his very entertaining dinner speech, Ekkehard Ramm explained the peculiarities of the Swabians.

Overall, the 7th GACM Colloquium on Computational Mechanics in Stuttgart was a great success and will be succeeded by the 8th Colloquium to be held in Kassel in 2019. ●

Malte von Scheven, Marc-André Keip & Nils Karajan

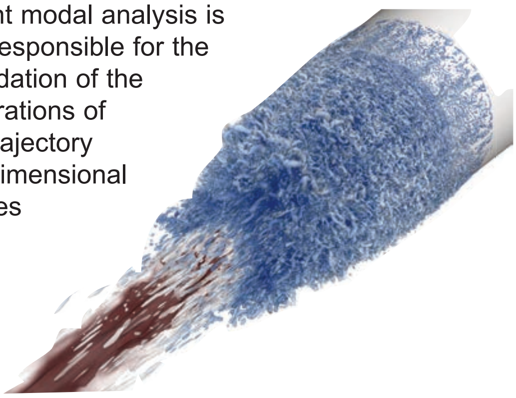
Figure 3:
The conference banquet in the historical Kursaal Cannstatt

Figure 4:
The three conference chairmen: Marc-André Keip, Nils Karajan & Malte von Scheven

discretization, frequency dependence and penetration depth of the heating zone. Another topic analyzed is the residual error and its estimation quality regarding polynomial degree and time step size. A further aspect of this work is the investigation of the thermal fluid-structure interaction with respect to functionally graded materials. Different coupling strategies for the acceleration of the fixed-point iteration between the fluid and solid code in each time step is the main aspect of the study. Relaxation methods as well as extrapolation methods make it possible to significantly reduce the number of fixed point iterations. At the same time, an adaptive strategy with high-order RUNGE-KUTTA methods can provide a further advantage in combination with acceleration methods.

Dr.-Ing. Vladimir Statnikov: "Numerical Analysis of Space Launcher Wake Flows"

This thesis focuses on a numerical analysis of turbulent wake flows of generic space launcher configurations at transonic and supersonic freestream conditions using a combination of zonal turbulence modeling and dynamic mode decomposition (DMD). The zonal simulation approach is applied to efficiently obtain time-resolved high-fidelity flow field data. The objective of the subsequent modal analysis is to extract and scrutinize the underlying spatio-temporal modes that are responsible for the characteristic dynamic phenomena . After a detailed description and validation of the complementary methodology, it is exemplarily applied to generic configurations of an Ariane 5-like space launcher. For two selected, dynamically crucial trajectory stages, i.e., $M_\infty = 0.8$ and $M_\infty = 6$, previously unknown coherent three-dimensional modes are extracted and attributed to the single characteristic frequencies and wave lengths, which are responsible for critical side loads on the nozzle structure. As conclusive remarks, the transferability of the obtained findings to other space launcher systems is discussed accompanied by an outlook for future investigations of space launcher wake flows and their controllability. ●



SEMNI celebrates its biennial congress

Valencia, Spain

The Congress on Numerical Methods in Engineering takes place biennially and is jointly organized by the Spanish Society on Numerical Methods in Engineering (SEMNI, Spain) and the "Associação Portuguesa de Mecânica Teórica, Aplicada e Computacional" (APMTAC, Portugal). The 2017 edition, CMN 2017; was held in the Campus de Vera of the Universitat Politècnica de València (UPV) from 3rd to 5th July, organized by the members of the Mechanical Engineering Research Center (CIIM).

The conference was inaugurated by the UPV Rector, Francisco J. Mora together with the president of SEMNI, Elías Cueto, the president of APMTAC José César de Sa, the APMTAC member of the organizing committee, Paulo Lourenço, and the SEMNI member of the organizing committee and president of the local organizing committee, Manuel Tur. The organizing committee expressed its appreciation to all thematic session organizers, to all the staff who managed the different aspects of the Congress and to all the contributing authors and participants.

It was a successful conference with over 320 participants including 6 plenary speakers (Marino Arroyo, Manuel Casteleiro, Francisco Chinesta, Joao Miguel Nobrega, Jean-François Remacle and Nuno Silvestre), and 52 thematic sessions in parallel to host more than 300 presentations by experts in computational mechanics from Spain, Portugal and 25 other countries around the world, including Brazil, Mexico, Colombia and France. The CMN 2017 and SEMNI made a great effort to encourage participation of young researchers offering them grants and reduced congress fees. Finally, more than half of the participants were young researchers.

Figure 1: *CMN2017 opening ceremony at the Universitat Politècnica de València*

The conference delegates had the opportunity exchange ideas in a relaxed ambient during the welcome reception held in the Centre Cultural la Beneficència, located in the old city center.

The Young Researchers Section of SEMNI (SJIS) organized poster sessions that took place during the morning coffee breaks and a football match after the parallel sessions.

Figure 2: *Relaxing welcome reception at the city centre*

The congress banquet was held at the Veles e Vents building located close to the canal of the Marina Real Juan Carlos I of Valencia.

The ceremony of SEMNI awards 2016 and 2017 took place during the banquet:
The Juan Carlos Simó award for Young Reserachers 2016 was granted to Xesús Nogueira and 2017 ex-aecuo to Pavel Ryzhakov and Ester Reina. The best PhD Thesis award 2016 was given to Héctor Espinoza y Alessandro Franci, ex-aecuo and the 2017 best PhD Thesis award to Ernesto Castillo and Guillermo Vilanova. Manuel Casteleiro received the 2017 SEMNI OC Zienkiewicz award to the best Research Trajectory.

The following conference, which is to be held in Guimaraes (Portugal), was announced after the event **(http://www.civil.uminho.pt/cmn2019/)**. ●

Figure 3: *Young Researchers Section of SEMNI participating in a football match*

Figure 4: *SEMNI OC Zienkiewicz award received by Manuel Casteleiro*

Figure 5: *(below) Some of the awardees during the ceremony. From left to right, Xesus Nogueira, Esther Reina and Pavel Ryzhakov*

USACM 14th U.S. National Congress on Computational Mechanics

Montréal, Québec, Canada

The 14th **U.S. National Congress on Computational Mechanics** was held in **Montréal**, **Québec**, **July 17-20, 2017** at the Palais des Congrès de Montréal nearby the Old Town. The congress was co-chaired by S. Dufour, M. Laforest, and S. Prudhomme from Ecole Polytechnique Montréal. For its first edition outside of the US borders, over 1000 delegates, including about 100 from Canada, participated in 81 minisymposia over the four day period. It also featured four plenary speakers (M. Ainsworth, A. Patera, A. Stuart , and T. Zohdi), and six semi-plenary speakers (M. Arroyo, M. Gerritsen, E. Haber, R. Miller R. Tempone, B. Wingate). USACM Awards were presented during the opening session.

Figure 1:
Professor Mark Shephard

Following the format of previous editions, the congress was preceded by several short courses and featured a poster session, sponsored by AHPCRC, in which over 90 graduate students and young researchers participated. It hosted the Women's Networking Event, sponsored by John Wiley and USACM, which was attended by about 50 female researchers. A special talk on "Mechanics Opportunities at NSF" was also offered by Program Manager, Dr. Siddiq Qidwai. In addition, an honorary minisymposium marked the 65th birthday of Prof. Mark Shephard of Rensselaer Polytechnic Institute.

The banquet was held on Wednesday evening at the Palais des Congrès during which the USACM awards for the best poster, and the Computers & Mathematics with Applications awards for the most mathematically oriented posters, were announced.

The winners of the USACM awards were B. Dortdivanlioglu (3rd), C. Peco (2nd) and G. Weber (1st). The CAWMA awards were given to K. Dunn (3rd), B. Keith (2nd), and K. Kergrene (1st). The banquet was followed by the viewing of the Pyro Rhapsody fireworks of the Festival de l'International des Feux on the rooftop terrace of the Palais. ●

Figure 2:
Women's Networking Event

Figure 3:
USNCCM14 Registration Area

USACM Upcoming Events

further details at usacm.org/conferences

- ❍ **Nonlocal Methods in Fracture,** January 15-16, 2018, Austin, TX; http://nmf2018.usacm.org/
- ❍ **Isogeometric Analysis (IGA2018),** October 10-12, 2018, Austin, TX (website available soon) ●

USACM Announces 2017 Awards and Honors

USACM presented several awards at the 14^{th} **U.S. National Congress**, held in July 2017 in Montreal. They are as follows:

- *John von Neumann Medal*
  J.N. Reddy
  Texas A&M University

For pioneering and sustained contributions on shear deformation and layerwise theories of composite structures, development of finite element methods for solids, geophysical phenomena, incompressible fluids and authorship of highly-cited books

- *Belytschko Medal*
  Jiun-Shyan (JS) Chen
  University of California, San Diego

For seminal contributions to the development of stabilized Galerkin and collocation meshfree methods, and their applications to multiscale materials modeling of solids and structures subjected to extreme loading conditions

- *Thomas J.R. Hughes Medal*
  Pavel Bochev
  Sandia National Laboratories

For fundamental contributions to numerical partial differential equations, especially advances in the development and analysis of new stabilized and compatible finite element methods, and software design for advanced discretizations

- *J. Tinsley Oden Medal*
  Narayana Aluru
  University of Illinois at Urbana-Champaign

For outstanding contributions to multiphysics and multiscale analysis of micro and nanoelectromechanical systems (MEMS & NEMS) and micro and nanofluids, and for leadership in computational science and engineering education

- *Gallagher Young Investigator Medal*
  Hector Gomez
  Purdue University

For outstanding contributions to integration of phase field models with isogeometric analysis in computational mechanics

- *USACM Fellows*
  Suvranu De
  Rensselaer Polytechnic Institute
  C. Armando Duarte
  University of Illinois at Urbana-Champaign

Congratulations to all these on their awards! ●

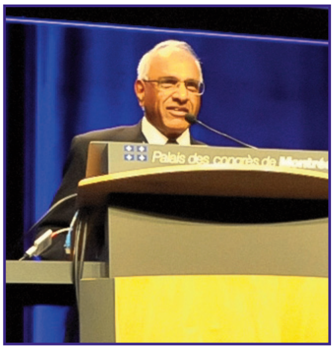


Figure 4:
J.N. Reddy, recipient of the John von Neumann Medal, addresses the congress participants

Figure 5:
Jiun-Shyan (JS) Chen, recipient of the Belytschko Medal

Figure 6:
Pavel Bochev, recipient of the Thomas J.R. Hughes Medal

Figure 7:
Narayana Aluru, recipient of the J. Tinsley Oden Medal

Figure 8:
Hector Gomez, recipient of the Gallagher Young Investigator Medal

Figure 9:
Suvranu De, USACM Fellow

Figure 10:
C. Armando Duarte, USACM Fellow

French Comutational Structural Mechanics Association

13th National Conference on Computational Structural Mechanics

From **May 14 to 19, 2017**, CSMA organised its biannual conference. For more than 20 years, it has been held in the Giens peninsula (on the French Riviera) to both ensure beautiful weather conditions, and feel the pulse of research in the field of computational mechanics

The conference was co-organised by a consortium of Parisian laboratories under the supervision of **Patrick Le Tallec** *(LMS)* and **Patrick Massin** *(IMSIA)* with laboratories **LMS, IMSIA, ONERA**. It is therefore easy to understand that optimisation and lifetime duration should be key players of general preoccupations. Hence the key topics: "Reduction of Models", "Structural Dynamics", "Numerical methods", "Modelisation identification of Behaviour Laws", "Contact-Friction", "Biomechanics", "Multiscale's Approach and Homogenisation", "Fluid-Structure Interaction", "Inverse Problems", "Manufacturing Processes". In addition, there were five symposia organised by the researchers in order to throw light onto some major trends: "Fatigue", "Damage, Rupture", "Non-Linear Vibrations", "Shape Optimisation", "Staggering Simulations in Structural, Fluid or Material Mechanics", "Test-Simulation Dialog". The conference also included seven plenary sessions, plus one centred on our best young researchers (CSMA's best PhD), another dedicated to software demonstration and yet another gathering about fifty poster presentations. Not to mention what is so delightful about Giens: the emphasis on friendliness and social interactions. The conference programme was established with almost 250 proposals selected by a panel chaired by **O. Allix** *(LMT-Paris Saclay)* attended by an industrialist, **L. Rota** *(PSA*), **P. Le Tallec** *(LMS-Palaiseau)* & **P. Massin** *(IMSIA-Palaiseau)* representing the organisation laboratories. The 2017 conference gathered almost 350 participants and received support from the following companies: DS Simulia, AREVA, ALTAIR, ANDRA, CEA, EDF, MICHELIN, ONERA, PHIMECA, POLYTECH, SAFRAN, SIXENSE, SNCF, SOCOTEC.

Figure 1: *Views of the stunning Giens Peninsula*

CSMA Juniors: The very promising novelty of this edition with a set of six presentations dedicated to more than 70 young researchers (up to 40) on the theme of the key topics of the congress. It is the first meeting of the CSMA juniors' group which plans the organization of an event once a year. The team of organizers leaded by **L. Chamoin** *(LMT-Paris Saclay)*.

Figure 2: *A presentation during CSMA juniors' workshop*

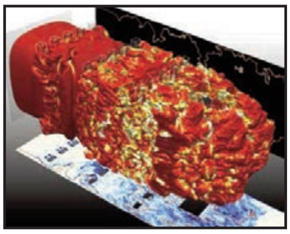


Figure 3: *From S. Candel's presentation on Staggering Simulations in combustion*

Figure 4: *From S. Conti's presentation on Variational modeling of pattern formation in thin elastic films under compression*

Plenary Sessions: The presentation of **G. Allaire**(*CMAP-Palaiseau)*, *On some recent developments of topology optimization of structures for additive manufacturing* explained how some limitations of additive manufacturing can be taken into account in a topology optimization algorithm, the so-called level set method (compared to the popular SIMP algorithm), which is a very attractive tool by its capacity of defining a clear notion of boundary for the admissible shapes. **S. Conti** *(Bonn University)* presented *Variational modeling of pattern formation in thin elastic films under compression and discusses mathematical progress in the area of elastic thin sheets under compression* focusing on specific concrete examples like: crumpled sheet of paper with a flat or conical reference configuration. The president of Science's Academy **S. Candel** *(EM2C-Chatenay-Malabry)* handled, i*n Staggering Simulations in combustion* more specially progress realized in simulation of large eddy simulations scales to analyze problems of turbulent combustion and dynamics of the combustion. The progress and the challenges are examined and illustrated by means of examples of very extreme calculations (over 1 million of CPU-hours). The presentation of **J.-J. Sinou** *(LTDS-Lyon), Experimental approaches and numerical simulations in not linear dynamics of the structures with frictional interfaces*, reminded that, the simulation goes hand in hand with an understanding of the observed physical phenomena and a mastered modelling and the closest possible of the reality. The experiment feeds the models and consequently the simulation, especially on the problems where engineering meets non-linear dynamics. In his presentation *Building materials in the new environmental contexts: impacts on the characterization and the modelling,* **A. Delaplace** *(LafargeHolcim)* showed that the progress of the models and the increase of the computing power allow to represent the main physical phenomena connected to the behavior of cementitious materials even if there is no predictive model today allowing from used raw materials to predict the complete behavior of the hardened material. For **B. Capra** *(Oxand)* who presented *Behavior of the works in service: numerical simulation and decision-making support*, it is necessary to implement strategies of modelisation adapted to the contracting authority. These strategies owe be the most relevant possible towards the constraints by representing all the multi-physical phenomena in a simple but not simplistic way and by integrating at best the real data (uncertainties on the initial state, impact of the lifetime duration…). **F. Hild** *(LMT-Paris Saclay)* aimed, in *On the integration of measured datas in the numerical simulation* to illustrate the integration of the data of sensors and imaging in numerical procedures for purposes of identification of laws of behavior and their validation which are discussed for various scales of modelling. The feasibility of such approaches is shown in the in-situ context of follow-up trials by tomography or laminography. A non-intrusive procedure is developed in which the fields of sensibility are obtained with FE codes (commercial or academic).

Mini-Symposia & Thematic Sessions: The amount of presentations (more than 200 of them, many of which of very high quality) reflects us the energy and openness of our laboratories.

"Shape Optimisation" Symposium: L. Rota (PSA), P.-A. Boucard (LMT-Paris Saclay), - 16 conferences distributed in 5 sessions.

"Test-Simulation Dialog" Symposium: V. Chiaruttini (ONERA) & J. Rethore (GEM-Nantes). - 10 conferences distributed in 3 sessions.

"Non Linear Vibrations" Symposium: C. Touze (IMSIA-Paris Saclay), O. Thomas (LMSSC-Paris), and has gathered 18 conferences distributed in 6 sessions. This symposium shown researchers' contributions in the

"Fatigue, Damage, Rupture" Symposium: H. Maitournam (IMSIA-Paris Saclay), P. Le Tallec (LMS-Palaiseau), has gathered 30 conferences distributed in 9 sessions.

"Staggering Simulations in Structural, Fluid or Material Mechanics" Symposium: P. Massin (IMSIA-Paris Saclay), P. Gosselet (LMT-Paris Saclay), and has gathered 11 conferences distributed in 3 sessions.

Ten thematic Sessions: Gathered by the Scientific Committee: "Reduction of Models" (17 conferences), "Structural Dynamics" (14), "Numerical methods" (14), "Modelisation, identification of Behaviour Laws" (11), "Contact-Friction" (8), "Biomechanics" (7), "Multiscale's Approach and Homogeneisation" (7), "Fluid-Structure Interaction" (6), "Inverse Problems" (5), "Manufacturing Processes" (5).

CSMA Prize: The best two PhDs defendes in 2016 are **A. Cattabiani** *(LMT-Paris Saclay)* for *Simulation of low- and mid-frequency response of shocks with a frequency approach* and **M. Shakoor** *(CEMEF-Sophia)* for *Three-dimensional numerical modeling of ductile fracture mechanisms at the microscale*. Those two prize-winners come after those of 2015 **T.-T. Nguyen** *(MSME-Marne-la-Vallée)* for *Modeling of complex microcracking in cement based materials by combining numerical simulations based on a phase-field method and experimental 3D imaging* and **L. Xia** *(Roberval-Compiègne)* for *Towards Optimal Design of Multiscale Nonlinear Structures*. Reduced-Order Modeling Approaches (see IACM Expressions 39/16 p. 22).

Software Session: About twelve research softwares were presented. In an atmosphere of excitement, the champions of the field gave demos: CAST3M, LMGC90, SALOME-MECA, SIMULIA, ALTAIR. More specific tools were also presented.

Poster Session: Introduced by **P. Le Tallec** *(LMS-Palaiseau)*, this session allowed one to communicate research in a new way: the classical 20 minutes' presentation was replaced by a 2 hour question time where the researcher answered questions. This year, the organisers decided to give three prices: *Instability of MRE film – substrate block under magneto-mechanical loadings* by **E. Psarra** *(PhD student at LMS-Palaiseau)*, *Adaptive Finite Elements for the simulation of interfacial phenomenas with change phase* by **C. Bahbah** *(PhD student at CEMEF-Sophia)*, *Rod Model with Flexible Thin-Walled Cross Sections for the behaviour of the tape springs: Numerical Aspects Linked to the Non-Convexity of the Strain Energy* by **M. Martin** *(PhD student at LMA-Marseille)*.

Social Interaction: It is part and parcel of the conference and hugely contributes to the delight and the warmth enjoyed by everyone: the residence, the opening and closing cocktail receptions, the dinner, the day trip to Porquerolles are the little side orders without which the taste of Giens wouldn't be the same! And they facilitate studious conversations that sometimes last very long over a drink shared by PhD students, assistant professors and professors. ●

Prospects

2019 Conference: The organizing committee will be a Parisian team located on the Paris-Saclay Campus et gathering the new IMSIA (CEA, EDF, ENSTA), ONERA and the LMS, The 14th conference will be organized by LEM3 in Metz. This 14th edition will be held in Giens during May 2019.

AMSES Journal: In June 2012, the CSMA launched a new international journal: AMSES , "Advanced Modeling and Simulation in Engineering Sciences". The first paper was published on January 2014. Quickly published, this open-access peer-reviewed scientific journal, is published by Springer and widely funded by CSMA. It shall encompass issues of modelisation, simulation, but also interactions with trials, which are essential to modelisation, characterisation and validation – not to mention related subjects. The ambition of AMSES is always to become as quickly as possible, one of the reference's journal in the field of computational mechanics with already more than 90 papers. (see iacm expressions 40/17 p. 40)

As a Conclusion: The Giens conference has long been a must-go event which displays the dynamism in computational mechanics research by gathering the younger researchers, scientific leaders and the industry. Even hiding itself behind fundamental presentations, application is the fuel of research, supporting most of the fields tackled in Giens. Now it is sure that CSMA is totally mobilized with its partners to organize WCCM and ECCOMAS joint conference in 2020 in Paris ! ●

The 22nd International Conference on Computer Methods in Mechanics - CMM2017

On **September 13-16 2017**, the 22nd International Conference on Computer Methods in Mechanics - CMM2017 was held at the Faculty of Civil Engineering & Architecture, Lublin University of Technology. The CMM conference series is devoted to numerical methods and their applications of the various phenomena in mechanics. The conferences are organized every two years, starting in 1973 by PACM and various universities in Poland.

The CMM2017 topics include: *adaptive materials systems, structures & smart materials, artificial intelligence methods, biomechanics, contact mechanics, computational intelligence, concrete, ceramic & geomaterials, coupled field problems, dynamics of multibody systems, experimental mechanics, fluid mechanics, including modeling of blood flow, fracture mechanics, geophysics, growth phenomena & evolution of microstructures, heat transfer, industrial applications, inverse problems & optimization, mechanics of multiphase and porous materials, mechanics of plates and shells, meshless & related methods, multiscale problems & nanomechanics, numerical analysis of the initial and boundary value problems in mechanics, parallel computing, response of structures to extreme actions, soft computing, solid mechanics, structural & composite mechanics.*

The Scientific Committee was chaired by **Prof. Tadeusz Burczyński** (Institute of Fundamental Technological Research, Polish Academy of Sciences) and the vice chairmen of the committee were **Prof. Mieczysław Kuczma** from Poznan University of Technology (President of PACM) and **Prof. Jerzy Warmiński** from the Faculty of Mechanical Engineering Lublin University of Technology. The local Organizing Committee at Lublin University of Technology was chaired by **Prof. Jerzy Podgórski** and two vice chairmen **Prof. Ewa Błazik-Borowa** and **Prof. Andrzej Teter**.

The honorary patronage of the conference: Minister of Science and Higher Education Republic of Poland, Committee on Mechanics of the Polish Academy of Sciences, Committee on Civil Engineering and Hydroengineering of the Polish Academy of Sciences, Committee on Informatics of the Polish Academy of Sciences and Rector of Lublin University of Technology.

The following distinguished scientists held the interesting plenary lectures on current research topics: **Herbert A. Mang**: *Evolution and verification of a kinematic hypothesis for splitting of the strain energy*, **Gaëtan Kerschen**: *Nonlinear normal modes & resonances of mechanical systems*, **Błażej Skoczeń**: *Constitutive modelling of strain induced coupled phenomena in engineering materials applied at cryogenic temperatures*, **René de Borst**: *Isogeometric analysis of damage & fracture in thin-walled structures*, **Celso Grebogi**: Compressive sensing based prediction of complex dynamics and complex networks, **Holm Altenbach, Daniel Juhre**: *New trends in continuum mechanics & challenges for numerical mechanics*, **Stefano Lenci, Pierpaolo Belardinelli**: *A new computational approach to improve the global analysis of dynamical systems*, **Balakumar Balachandran**: *GPU based computational dynamics*, **Ewa Majchrzak**: *Selected problems of bioheat transfer modelling*, **Giuseppe Rega**, **Valeria Settimi**: *Nonlinear dynamics & control in macro- & micro-mechanics: some computational issue*.

Figure 1: *Group photo of CMM2017 participants*

The papers delivered by the participants of the conference took place within 14 mini-symposia in which the organization was attended by researchers from many scientific centers in Poland and abroad. Within these sessions, 237 papers were delivered. The participants of the conference were 291 researchers from Poland and 18 countries from Europe, Asia and North America.

It has become tradition that during the CMM conferences the O.C. Zienkiewicz Medal Awarding Ceremony takes place to honour outstanding researchers in the field of computational mechanics. This year's awarding ceremony was held during the conference gala in the Lublin Philharmonic Hall. The 2017 laureates of the O.C. Zienkiewicz Medal are: **Prof. Ewa Majchrzak** & **Prof. Maciej Pietrzyk**: category: for the whole of activity, **Prof. René de Borst**: category: for foreign scientists of particular merit for the development of computational mechanics in Poland.

During the conference there was also held a Jan Schmelter competition for young scientists. Jury of the competition led by Prof. Adam Borkowski (IFTR PAS) awarded 3 prizes and 3 distinctions to the following young scientists; *Prizes*: 1st: **Witold Ogierman** – Silesian University of Technology, 2nd: **Waldemar Mucha** – Silesian University of Technology, 3rd: **Tomasz Gajewski** – Poznan University of Technology *Distinctions*: :**Brubeck Freeman** – Cardiff University, **Bartłomiej Pokusiński** – Lodz University of Technology, **Marcin Hatłas** – Silesian University of Technology.

The General Assembly of PACM was hold during the conference. After two fruitful terms as president of PACM, Prof. Kuczma stepped down. Prof. Jerzy Rojek from IFTR PAS was elected new president of PACM.

The CMM2017 conference was a successful, well-organized scientific event. The next, 23rd International Conference on Computer Methods in Mechanics will be held as a joint event of the 23rd CMM and the 4th Polish Congress of Mechanics in Cracow on September 8-12, 2019.

More details on CMM2017 can be found at the conference web site: **http://cmm2017.pollub.pl/.** ●

Figure 2:
Opening ceremony. From left to right: T. Burczyński (Chairman of CMM2017), J. Warmiński (Vice-chairman of CMM2017), M. Kuczma (President of PACM), P. Kacejko (Rector of Lublin UT), M. Kleiber (President of ECCOMAS), H. Mang (past President of ECCOMAS)

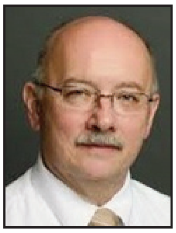
Figure 3:
O.C. Zienkiewicz Medal Award Ceremony. From left to right: M. Kuczma – President of PACM, Maciej Pietrzyk, Ewa Majchrzak, Rene de Borst – recipients of Medal, M. Kleiber – President of ECCOMAS, T. Burczyński – Chairman of CMM2017 Scientific Committee

PACM 25th Anniversary

ptmkm 25 YEARS pacm
SILVER JUBILEE
PTMKM/PACM – founded on May 6, 1991
– member of ECCOMAS & IACM, CEACM

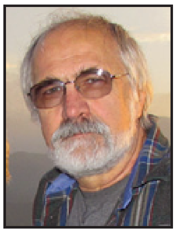
On the occasion of the conference **CMM2017**, the Polish Association for Computational Mechanics celebrated its **25th Anniversary**. It was was founded on May 6, 1991 on the initiative of Professors: **Leszek Demkowicz**, **Michał Kleiber**, **Tadeusz Liszka**, **Janusz Orkisz** and **Zenon Waszczyszyn**.

Founders of the PACM:



L. Demkowicz

M. Kleiber

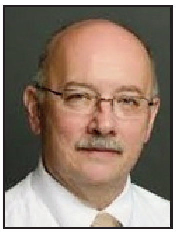


T. Liszka

J. Orkisz

Z. Waszczyszyn

Presidents of PACM (1991-2017):



L. Demkowicz
1991-1993

A. Garstecki
1993 - 1997

M. Witkowski
1997 - 1999

T. Burczyński
1999 - 2009

J. Pamin
2009 - 2013

M. Kuczma
2013 - 2017

Since our last report (IACM Expressions No. 40) the Israel Association for Computational Methods in Mechanics (IACMM) held two symposia.

41st Israel Symposium on Computational Mechanics (ISCM-41)

The **41st Israel Symposium on Computational Mechanics (ISCM-41)** was held in October 2016 at the Shamoon College of Engineeing in Beer-Sheva, organized by Drs. Nir Trabelsi and Elad Priel (*Figure 1*).

Figure 1:
The two organizers of ISCM-41.
Left : Dr. Elad Priel the editor of the IACMM bulletin at the opening of ISCM-41.
Right: Dr. Nir Trabelsi in a discussion during the coffee break at ISCM-41, SCE, Beer-Sheva

Prof. Gideon Sahar, head of the Cardio-thoracic surgery department at Soroka hospital was the invited speaker, delivering an interesting opening lecture on "New horizons in the treatment of coronary artery disease". In his talk Prof. Sahar showed an example of the interaction of clinical procedures with computational mechanics. *Figure 2* shows Prof. Sahar lecturing. The symposium included 11 other lectures, presented by practitioners and researchers from industry and academia. These included among others talks by Prof. Slava Krylov (Elasto-plastic behavior of micro strings loaded by distributed electrostatic force), Dr. Adi Ditkowski (New approach for using the generalized polynomial chaos method with dependent parameters) both from Tel Aviv University and Dr. Idit Avrahami (The impact of flow through aortic valve on the coronary perfusion), from Ariel University. The other talks were on computational material engineering, development of FE methods and singularities. The winner of the ISCM-41 competition for the best presentation was Mr. Tomer Levin (Obstacle identification using the TRAC algorithm), a graduate student of Prof. Eli Turkel at Tel-Aviv University. *Figure 3* shows Mr. Levin during his presentation.

The 42nd Israel Symposium on Computational Mechanics (ISCM-42)

The 42nd Israel Symposium on Computational Mechanics (ISCM-42) was held in March 2017 at the Technion in Haifa, organized by Profs. Pinhas Bar Yoseph and Mahmood Jabareen. The delightful opening lecture was given by the international

Figure 2:
Prof. Sahar delivering the invited lecture of the ISCM-41, Oct 2016, SCE, Beer-Sheva

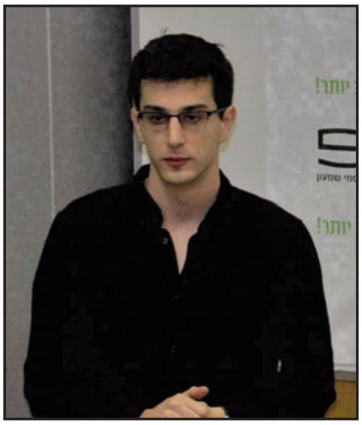


Figure 3:
Mr. Tomer Levin (graduate student of Prof. Turkel) the winner of the ISCM-41 best presentation, during an answer to a question from the audience

Figure 4:
Prof. Natarajan Sukumar at the opening lecture of the ISCM-42, March 2017, Technion, Haifa

Figure 7:
Group photo of IACMM council and international speakers at ISCM-42, at the Technion.
Left to Right: J. Tal, Z. Yosibash, N. Sukumar, A. Herszage, D. Givoli, S. Krylov, I. Harari, T. Saksala, M. Jabareen, P. Bar-Yoseph

invited speaker Prof. Natarajan Sukumar from the University of California at Davis, USA, titled “Maximum-entropy meshfree methods in computational mechanics”. This overview talk presented maximum-entropy methods and X-FEMs. *Figure 4* shows Prof. Sukumar lecturing. *Figure 5* is a group photo of the Invited speaker with the IACMM executive council. Ten additional presentations were given at ISCM-42, including a talk by Prof. Timo Saksala from the Tempre University of Technology, Finland, and a very interesting and well explained tutorial by Prof. Oded Amir, (shown in *Figure 6*) from the Technion on Topology Optimization. The morning session was devoted to computational biomechanics topics with lectures by Profs. Netanel Korin, Sefi Givli and Daphne Weiss from the Technion. The other talks were on fluid dynamics and finite elements methods. Mr. Hanan Amar, a graduate student of Prof. Dan Givoli was the winner of the ISCM-42 competition for the best presentation – the title of his talk was "Mixed-dimensional modeling of time-dependent wave problems using the Nitsche method". *Figure 6* shows Mr. Amar during his talk.

The winner of the best presentation in 2016 (ISCM-40, and ISCM-41), Mr. Lior Medina was financially supported by the IACMM to present his talk at the COMPDYN 2017 conference held in June 2017 in Rhodes Island, Greece. Mr. Medina and the second prize winner for the best presentation in 2016, Mr. Tomer Levin, received an IACMM certificate awarded by IACMM's president Prof. Zohar Yosibash during the assembly meeting of IACMM held at ISCM-42 as shown in *Figure 8*.

The PhD thesis of Dr. Alexander Kleiman, supervised by Prof. Oded Gottlieb from the faculty of mechanical engineering at the Technion was selected as the best PhD thesis in computational mechanics in Israel in 2016. ●

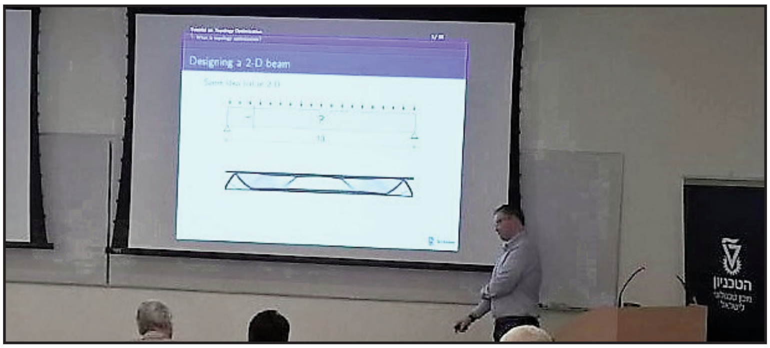


Figure 7:
Prof. Oded Amir delivering the tutorial on topological optimization at ISCM-42

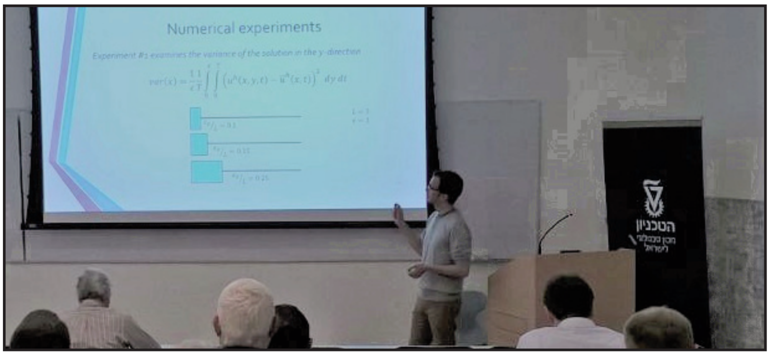


Figure 7:
Mr. Hanan Amar (graduate student of Prof. Dan Givoli) the winner of the ISCM-42 best presentation, during his talk

Figure 8:
Mr. Lior Medina (left) and Mr. Tomer Levin (right) receiving the certificate on best and second best presentations in 2016
from Prof. Yosibash (president of IACMM) during the General Assembly of the IACMM at ISCM-42

ENIEF 2017
XXIII Congress on Numerical Methods and their Applications

La Plata, Argentina
7-10 November 2017

The XXIII Congress on Numerical Methods and their Applications (ENIEF 2017) took place from November 7 through November 10, 2017, in the city of La Plata, Argentina. This new edition of the annual AMCA Congresses was organized by the School of Engineering of the National University of La Plata.

Figure 1: *ENIEF 2017 opening ceremony: V. Sonzogni (AMCA President), F. Tauber (UNLP Vice-President), A. Scarabino (ENIEF Chairman)*

The organizing committee was chaired by Prof. Ana Scarabino and integrated by: Federico Bacchi, Mariano Martínez, Juan Ignacio Villar, Yen Kun Ho, Julio Marañón Di Leo, Juan Sebastián Delnero, Patricia Gauzellino, Victoria Vampa, María Teresa Martín and Juan Diego Lavirgen. The Scientific Committee was chaired by Prof. Martin I. Idiart.

The Congress included six invited plenary lectures by Prof. Sergio R. Idelsohn (CIMNE-UPC, Spain), Prof. Rainald Löhner (George Mason University, USA), Prof. Julián J. Rímoli (Georgia Institute of Technology, USA), Prof. Oscar Lopez-Pamies (University of Illinois at Urbana-Champaign, USA), Dr. Jaime Klapp (National Institute of Nuclear Research, Mexico), and Prof. Alejandro Otero (University of Buenos Aires/CONICET, Argentina).

Figure 2: *Participants ENIEF 2017*

CALL FOR PAPERS

MECOM 2018

XII Argentine Congress on Computational Mechanics
Tucuman, Argentina, 6 - 9 November 2018

The Argentine Association for Computational Mechanics (AMCA) announces the XII Argentine Congress on Computational Mechanics, which will be held in Tucuman, Argentina, organized by the Faculty of Exact Sciences and Technology, of the National University of Tucuman.

www.facet.unt.edu.ar/mecom2018 ●

Figure 3:
Organizing Committee ENIEF 2017

The Congress was attended by 290 professionals and students of the field. Full-length papers were submitted to a review process prior to publication. From them, 241 papers were accepted and published in the proceedings which are openly available at the website http://www.amcaonline.org.ar/mcamca

A special session was devoted to undergraduate students, with awards for the best posters. The awards were granted to:
1) *Agustina Ravettino* (National University of La Plata, Argentina);
2) *Nahuel Volpe* and *Federico Zeitler* (UTN, FR Santa Fe, Argentina); and
3) *Andrés Maximiliano Pereyra* (National University of La Plata, Argentina).

The Congress also included other activities: group meetings on OpenFOAM and EFD Codes, and the AMCA Annual Assembly. . ●

Figure 4:
A break at ENIEF 2017

Figure 5:
Lecturers ENIEF 2017: S. R. Idelsohn; R. Löhner; O. Lopez-Pamies; J. Rimoli; J. Klapp and A. Otero

New Executive Council for the AMCA

A new Executive Council has been elected by the Argentine Association for Computational Mechanics (AMCA) for the period 2018-2019.

It is formed by: **Victor Fachinotti** (president), **Pablo Kler** (secretary), **Jorge D'Elía** (treasurer), and the members: **Enzo Dari**, **Victor Cortinez**, **Sebastian Giusti**, **Anibal Mirasso**, **Oscar Moller**, **Ana Scarabino**, **Marcelo Venere** and **Sonia Vrech**, while **Axel Larreteguy** and **Diana Bambill** are the auditors. ●

Figure 6:
Victor Fachinotti, Pablo Kler and Jorge D'Elía: president, secretary and treasurer of AMCA, respectively

Compsafe2017
successfully held in
Chengdu, China
October 15-18, 2017

The 2nd International Conference on Computational Engineering and Science for Safety and Environmental Problems (Compsafe2017) was successfully held in Chengdu, China, on October 15-18, 2017, which was also an APACM Conference & IACM Special Interest Conference. This conference was organized by Chinese Society of Theoretical and Applied Mechanics (CSTAM). The Chinese Association for Computational Mechanics (CACM) hosted Compsafe2017, which was co-chaired by President of CACM, Prof. Zhuo Zhuang and former President of CACM, Prof. Mingwu Yuan. The local support was received from Southwest Jiaotong University, China (SWJTU). There were about 230 people, including 100 students, attended the conference represented more than 10 countries and regions, like China, Japan, USA, UK, Germany, Korea, Singapore, China Taiwan, China Hong Kong and so on.

Figure 1: *Prof. Zhuo Zhuang at opening ceremony of Compsafe2017*

The huge scale natural disasters occurred worldwide due to global warming, earthquake, tsunami, land slid, sandstorm, and so on. Since the rare numerous vulnerable areas and densely inhabited district in Asian-Pacific regions, such failures can be catastrophic and lead to a large loss of life as well as major economic loss. To describe and evaluate, as well as finally to prevent from these disasters is the critical work for local government and human society, which is required the scientists and engineers to work together in these fields. The simulation-based engineering and science may play a key role in solving such problems.

The first international conference, Compsafe2014 was successfully held in Sendai, Japan, on April, 2014 to gather the scientific researchers and engineers to carry out the computational mechanics research and innovation, as well as engineering application to give the powerful tool for solving complicated safety-related and environment problems.

This was the second Compsafe conference. The conference topics are computational mechanics, and computational engineering and science technologies, and their applications which are safety/risk-related, disaster-preventing including various types of natural hazards, any kinds of accidents and failures of engineering artifacts, environmental and social problems.

The conference proceedings contained about 210 extended abstracts. Those were presented at 6 plenary lectures, 10 semi-plenary lectures and 23 mini-symposia.
The plenary lectures were given by:
Prof. Xiaojing Zheng, China: Trans-Scale Simulation of Aeolian Sand/Dust Transport and Landform Evolution Process";
Prof. Muneo Hori, Japan: Development of Integrated Earthquake Simulation Enhanced with High Performance Computing;

Prof. Jiun-Shyan Chen, USA: Recent Advances in Accelerated and Stabilized Meshfree Method for Modeling Man-made and Natural Disasters;
Prof. Shinobu Yoshimura, Japan: Petascale Finite Element Simulation Based Investigation on Structural Integrity of Nuclear Power Plant Attacked by Strong Earthquake;
Prof. Shi Gen-hua, China: Stability Analysis Based on Inequality Equations;
Prof. Wing-Kam Liu, USA: Microstructural Material Database for Self-Consistent Clustering Analysis of Strain Softening Materials.

All lectures and MS reports were focus on the key problems of computational mechanics and cross areas. There were rich in contents accepted by representatives participating in the conference with interaction hotness.

During the conference, the organizers arranged a conference tour to the site of Wenchuan earthquake museum, old Beichuan County and the rebuilt new Beichuan County, where is 150 km away from Chengdu City. We hope this conference will set up a corporation network and push forward the researches and technologies in those safety and environmental fields.

by
***Zhuo Zhuang**, CACS*

Figures 2:
Plenary lecture given by
Prof. Wing-Kam Liu, USA

Figures 3:
Plenary lecture given by
Prof. Xiaojing Zheng, China

Figures 4 a & b:
The rich in contents were accepted by representatives participating in the conference with interaction hotness

20 anos
1997 - 2017
abmec
Associação Brasileira de
Métodos Computacionais
em Engenharia

From **November 5 to 8, 2017**, in the charming island city of Florianópolis, Brazil, the Brazilian Association for Computational Methods in Engineering (ABMEC) promoted the 38th edition of **CILAMCE**, the **Ibero-Latin-American Congress on Computational Methods in Engineering**. The congress was organized by the Federal University of Santa Catarina, under the lead of Prof. Patricia Faria (chairwoman), from the Department of Civil Engineering. CILAMCE-2017 was a tremendous success in all respects. We had over 750 participants from all over Brazil and Latin America, and also a crew of more "international" colleagues from farther abroad. This truly expressed the very spirit of CILAMCE. A few pictures of the congress can be seen below (more at the congress photo gallery https://www.flickr.com/photos/cilamce2017).

During CILAMCE-2017, ABMEC celebrated its 20th anniversary. To mark this special date in our history, we invited our members to say "Saúde!" (Cheers!) to ABMEC on a casual cocktail served on the night of November 6, immediately after our General Assembly meeting. Some pictures of this gathering are here, including one which showcases all former presidents of ABMEC – except for Prof. Phillipe Devloo, who unfortunately couldn´t come to CILAMCE this year (the good side of this was that there was more champagne left for the party). All participants wished many more years of success and accomplishments to ABMEC in its mission of fostering the use and advancement of computational methods in engineering and related sciences in Brazil.

1st German-Brazilian Workshop on Computational Mechanics
February 19th - 20th, 2018
Polytechnic School at University of São Paulo

During ABMEC´s General Assembly meeting, the final program of the 1st German-Brazilian Workshop on Computational Mechanics, to be held in São Paulo next February, was shown. This initiative is a result of a long history of collaboration between several research groups from both countries, and is being fully supported by ABMEC (more details can be found at www.gbwcm2018.com). Also, the bid for organizing the next

Figure 1:
CILAMCE-2017.
Opening Ceremony:
Prof. Patricia Faria, Chairwoman, welcomes all participants

Figure 2:
CILAMCE-2017. The Local Organizing Committee stands for the Brazilian National Anthem

Figure 3:
CILAMCE-2017. Plenary Speaker Eurípedes Vargas Jr

Figure 4:
CILAMCE-2017.
Plenary Speaker Tarek Zohdi

Figure 5:
CILAMCE-2017. Some of the delegates from Minas Gerais, the biggest delegation at CILAMCE-2017, with over 100 participants

Figure 6:
CILAMCE-2017. The Local Organizing Committee at the entrance of the main building

Figure 7:
ABMEC´s 20th Anniversary Celebration: past presidents Paulo Pimenta, Gray F. Moita, current president Eduardo M. B. Campello, CILAMCE-2017´s Chairwoman Patricia Faria, and past presidents Estevam Las Casas, José Luis D. Alves and Paulo R. M. Lyra

Figure 8:
ABMEC´s current Board of Directors Felício B. Barros (Vice-President), Eduardo M. B. Campello (President) and André T. Beck (First-Secretary)

Figure 9:
Past president Paulo R. M. Lyra´s honorary speech in celebration of ABMEC´s 20 years

Figure 10, 11 & 12:
ABMEC´s 20th Anniversary Celebration.
Colleagues and members of the Executive Council saying Cheers to ABMEC

year´s edition of CILAMCE was presented and approved. Accordingly, **CILAMCE-2018** will be held in **Paris, France**, with professors Adnan Ibrahimbegovic (IUF/Sorbonne/UT-Compiégne) and Ivo Maday (Université Pierre-Marie Curie) as the chairmen, and Prof. Paulo Pimenta (University of São Paulo) as co-chairman. The tentative dates are November 12 to 16, 2018. The congress activities will take place at UT-Compiègne campus (in Compiègne) as well as at the historical building of the École Polytechnique (in Quartier Latin, Paris). This will be the first time, since its inception, that CILAMCE will be held outside Brazil, Argentina, Portugal, Italy or Spain. We are very excited for this innovation and opportunity. We invite all IACM members and enthusiasts of computational mechanics to participate in the 39th edition of our CILAMCE series of congresses. Hope to see you there!

Warmest regards, and Saúde!

***Prof. Eduardo M. B. Campello**, ABMEC President (University of São Paulo)*
***Prof. Felício B. Barros**, ABMEC Vice-President (Federal University of Minas Gerais)*

39th CILAMCE – Ibero-Latin-American Congress on Computational Methods in Engineering
Paris

Tentative dates: November 12-16, 2018

Chairs: Prof. Adnan Ibrahimbegovic (IUF/Sorbonne/UTC) and Ivo Maday (UPMC)
Co-chair: Paulo Pimenta (USP)

SORBONNE UNIVERSITÉS utc Université de Technologie Compiègne USP

Figure 13:
Announcement of CILAMCE-2018. Paulo Pimenta announces CILAMCE-2018 during the CILAMCE-2017 Congress Banquet

conference diary planner

15 - 16 Jan. 2018 **NMF2018 - Nonlocal Methods in Fracture**
Venue: Austin, TX, USA *Contact:* http://nmf2018.usacm.org/

12 - 14 Feb. 2018 **ACCM-3 - 3rd Australian Conference on Computational Mechanics**
Venue: Melbourne, Australia *Contact:* *http://www.deakin.edu.au*

26 - 29 March 2018 **CMBBE2018 - 15th Int. Symp. Computer Methods in Biomechanics & Biomedical Engineering**
Venue: Lisboa, Portugal *Contact:* http://cmbbe2018.tecnico.ulisboa.pt

8 - 11 April 2018 **ICVRAM-ISUMA-Uncertainties 2018**
ICVRAM - International Conference on Vulnerability & Risk Analysis and Management
ISUMA - International Symposium on Uncertainty Modeling and Analysis
UNCERTAINTIES - International Symposium on Uncertainty Quantification & Stochastic Modeling
Venue: São Paulo, Brazil *Contact:* http://icvramisuma2018.org/

16 - 18 May 2018 **CMIS2018 - 9th Contact Mechanics International Symposium**
Venue: Biella, Italy *Contact:* http://conference.unisalento.it/ocs/index.php/cmis/cmis2018

21 - 24 May 2018 **ACSMO2018 - The Asian Congress of Structural and Multidisciplinary Optimization 2018**
Venue: Dalian, China *Contact:* http://www.acsmo2018.org/

5 - 9 June 2018 **USCTAM 2018 - 18th U.S. National Congress of Theoretical & Applied Mechanics**
Co-Organized with **the Chinese Society of Theoretical & Applied Mechanics**
Venue: Chicago, Illinois, USA *Contact:* http://sites.northwestern.edu/usnctam2018/

11 - 15 June 2018 **ECCM - ECFD Conference 2018 - 7th European Conference on Computational Fluid Dynamics & 6th European Conference on Computational Mechanics**
Venue: Glasgow, UK *Contact:* www.eccm-ecfd2018.org

25 - 29 June 2018 **DSL2018 – 14th International Conference on Diffusion in Solids and Liquids Amsterdam,**
Venue: Amsterdam, The Netherlands *Contact:* www.dsl-conference.com

01 - 05 July 2018 **ACE-X2018 – 12th Int. Conference on Advanced Computational Engineering & Experimenting**
Venue: Amsterdam, The Netherlands *Contact:* www.acex-conference.com

02 - 06 July 2018 **ESMC 2018 - The 10th European Solid Mechanics Conference**
Venue: Bologna, Italy *Contact:* www.esmc2018.org

11 - 15 July 2018 **ECCM VI - 6th European Conference on Computational Mechanics**
Venue: Glasgow, U.K. *Contact:* www.eccm-ecfd2018.org

11 - 15 July 2018 **ECFD VII - 7th European Conference on Computational Fluid Dynamics**
Venue: Glasgow, U.K. *Contact:* www.eccm-ecfd2018.org

22 - 27 July 2018 **WCCM-XIII - PANACM-II : 13th World Congress on Computational Mechanics** jointly organized with the **2nd Pan American Congress on Computational Mechanics**
Venue: New York, USA *Contact:* http://www.wccm2018.org/

10 - 12 Oct. 2018 **IGA2018 - Isogeometric Analysis**
Venue: Austin, TX *Contact:* http://congress.cimne.com

6 - 9 Nov. 2018 **MECOM 2018 - XII Argentine Congress on Computational Mechanics**
Venue: Tucuman, Argentina *Contact:* www.facet.unt.edu.ar/mecom2018

9 - 11 April 2019 **AM2018 - 20th International Conference on Applied Mechanics 2018**
Venue: Myslovice, Czec Republic *Contact:* https://am2018.zcu.cz/index.html

1 - 6 Sept. 2019 **YIC 2019 - Eccomas Young Investigators Conference**
Venue: Cracow, Poland *Contact:* http://www.ptmkm.pl/pl/node/134

8 - 12 Sept. 2019 **PCM-CMM 2019 - 4th Polish Congress of Mechanics & 23rd International Conference on Computer Methods in Mechanics**
Venue: Krakow, Poland *Contact:* http://pcm-cmm2019.com/

18 - 21 Dec. 2019 **APCOM 2019 - 7th Asian Pacific Congress on Computational Mechanics**
Venue: Taipei, Taiwan *Contact:* http://www.apcom2019.org/

19 - 24 July 2020 **ECCOMAS CONGRESS 2020** jointly organized with the
WCCM XIV - 14th World Congress on Computational Mechanics (IACM)
Venue: Paris, France *Contact:* http://www.eccomas.org/