

Integrated Earthquake Simulation

Muneo Hori

Architected Materials - a Playground for Computational Mechanics

D.M. Kochmann

Introduction to Numerical Methods for Variational Problems

by

Hans Petter Langtangen
& Kent-Andre Marda

Book Review

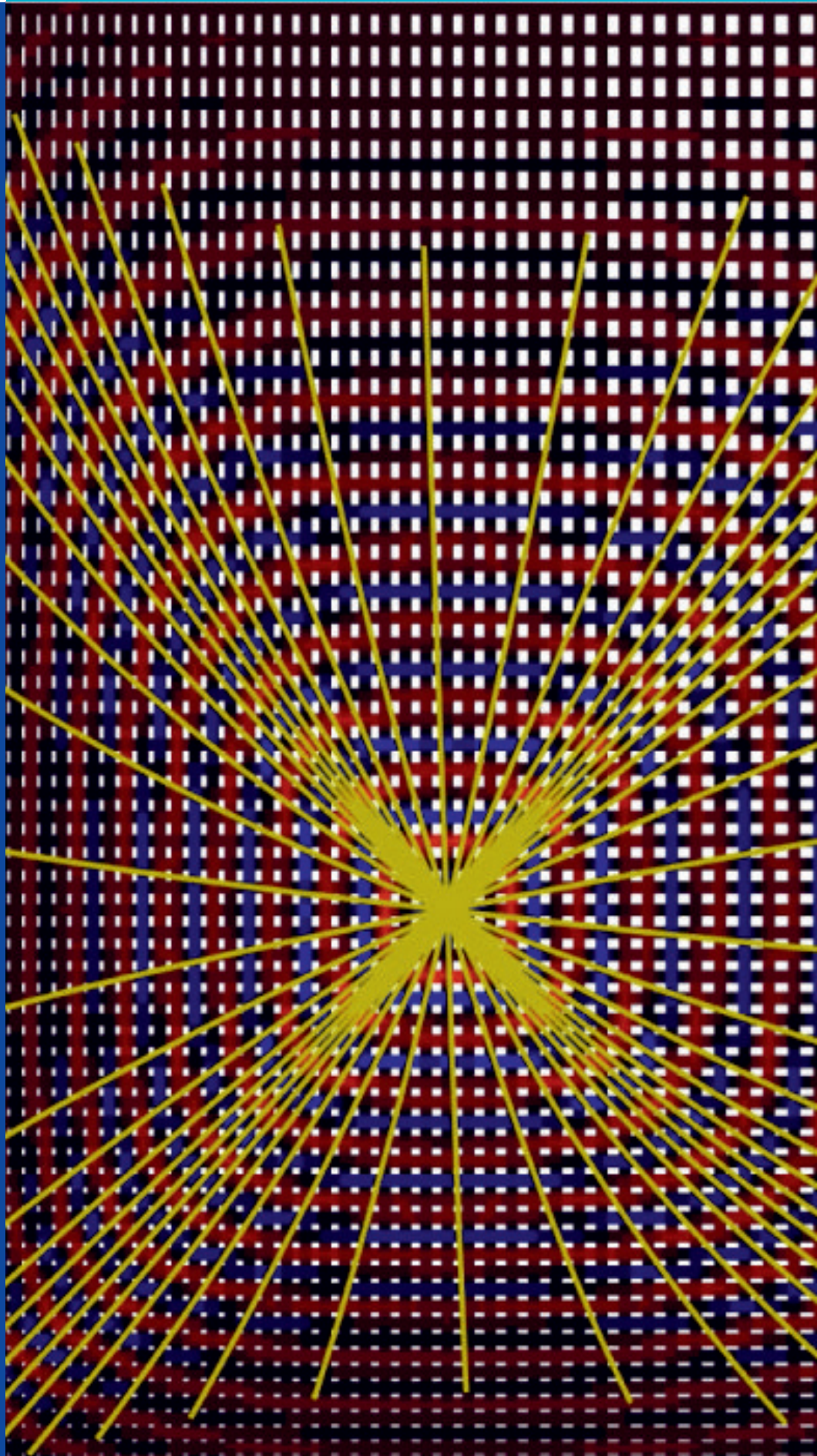
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*Bulletin for
The International Association
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Nº 51
December 2022



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Integrated Earthquake Simulation

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“ ... IES is the foundation of developing the digital twin for natural disasters. ”

Introduction

The estimation of earthquake hazard and disaster is the first step toward the disaster mitigation. A set of empirical equations are used for this estimate; the relation between an epicenter distance and a ground motion index and the relation between a ground motion index and a structural damage probability are typical empirical equations. A better tool is needed for more reliable estimation since the empirical relations are based on past data and cannot make an accurate estimate.

A candidate for such a better tool is a high-resolution physics-based simulation of hazard and disaster processes for a given earthquake scenario. This simulation is called integrated earthquake simulation, IES. High-resolution numerical analysis has been used to design an important facility, such as a high-rise building or a long-span bridge. IES is aimed at applying high-resolution numerical analysis to all structures located in a target area. We can estimate earthquake hazard and disaster at the same level of seismic design.

IES consists of two parts, earthquake wave propagation and seismic structural responses; see *Figure 1*. The former, which is regarded as Earth Science simulation, includes earthquake generation on a source fault of an earthquake and amplification of ground motion in shallow grounds. The latter, which is regarded as earthquake engineering simulation, is applied to various kinds of structures, for each of which a specific numerical analysis method is

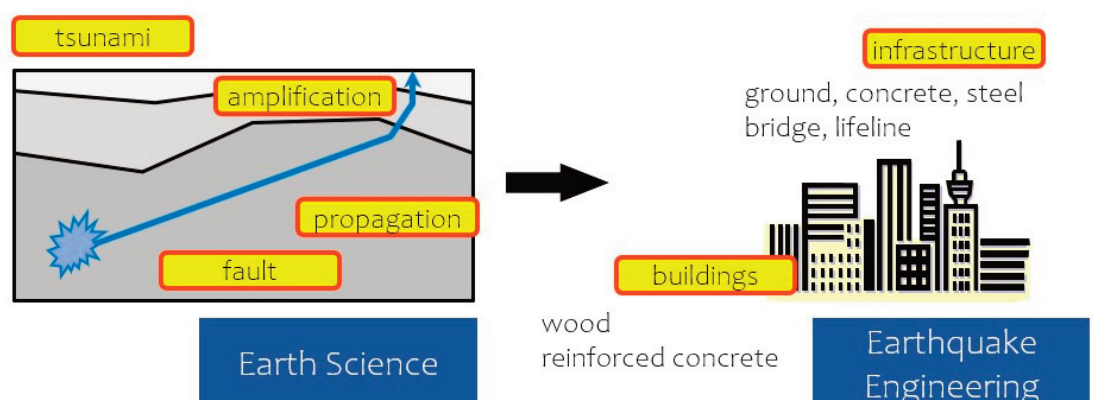
developed. All the simulations are implemented into IES for the estimate of earthquake hazard and disaster.

There are two major difficulties to develop IES. The first difficulty is large-scale numerical computation since the high-resolution simulation is made for a large area; the required spatial and temporal resolutions are 1 m and 0.1 s or less, respectively. High-Performance Computing (HPC) is applied as a solution of this difficulty. The second difficulty is analysis models for ground and structures. Automated Model Construction (AMC) is developed to solve this difficulty.

Use of HPC

The physics-based simulation of earthquake hazard and disaster solves a solid wave equation for ground and structures. The equation becomes non-linear if the deformation is large, and an analysis model of high fidelity ought to be used to accurately estimate the earthquake wave propagation and seismic structural responses. Finite Element Method (FEM) is a de-facto standard to solve the wave equation for a body of complicated configuration. Most of the numerical computation is spent to solve a matrix equation in FEM; the dimension of the matrix exceeds 1,000,000,000 for a large-scale numerical analysis model of highest fidelity. Therefore, it is necessary to enhance this solver with HPC capability.

Figure 1:
Overview of IES



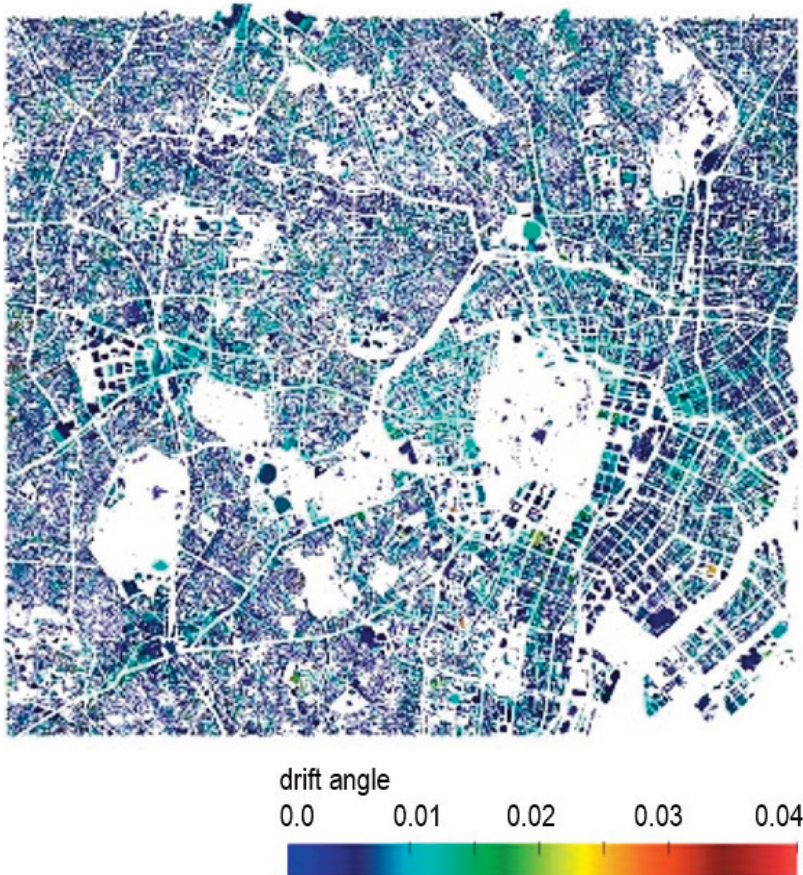


Figure 4:
*Distribution of structural responses computed in IES
for Tokyo Metropolis Earthquake*

scenario, IES computes earthquake wave propagation and seismic structural responses in the entire Tokyo region.

A three-dimensional numerical analysis model is constructed for the shallow surface ground of central Tokyo of 10 km x 10 km. IES produces ground motion distribution in 1 m resolution, and, due to the topographical effects, spatial concentration of strong ground motion is obtained. IES computes seismic responses of 300,000 residential buildings located in this area, constructing a numerical analysis model for each and inputting synthesized ground motion at the site. As expected, structural seismic responses differ for each structure; see Figure 4. The responses are determined by the natural frequency of the structure and the dominant frequency components of input ground motion.

The second example is Nankai Trough Earthquake. These earthquake scenarios are given, and IES computes the resulting earthquake hazard and disaster in Kansai Region, which includes Osaka, Kobe, Nara, Hyogo, and Kyoto.

For each residential building in this region, IES constructs a set of a one-dimensional stratified underground model for the surface ground and a multi-degree-of-freedom model for the structure. The number of the sets is 1,266,706; see Figure 5. It also computes structural seismic responses of infrastructures such as a road network, lifelines of energy, communication, water, and sewage, using empirical relations; numerical analysis of the infrastructure is not implemented in IES. The spatial distribution of structure damages are obtained for each earthquake scenario; the location and degree of heavily damaged area change depending on the scenario.

The physics-based simulation of IES can make high-resolution estimations of structural damages in Kansai Region. The estimation is useful, as it can be used for the estimate of post-disaster responses.

The following three post-disaster response simulations are implemented into IES:

- 1) mass evacuation simulation;
- 2) traffic demand and flow simulation; and
- 3) economic activity recovery simulation.

As for Nankai Trough Earthquake, the estimate of the traffic demand and flow simulation is interesting as it shows the occurrence of severe traffic congestion in several places in Kansai Region; see Figure 6. It is more difficult to assure the quality of the post-disaster response, which is regarded as social science simulation, compared with the physics-based simulation. Still, the estimate of the post-disaster response is essential for a fast and efficient recovery from the earthquake disaster. The development of a more reliable post-disaster response simulation is needed.

Concluding Remarks

IES is developed to carry out physics-based simulations of earthquake hazard and disaster, and it is applied to two earthquakes presumed in Japan, and its potential usefulness is demonstrated. A similar physics-based simulation is expected for floods, high tides, and volcano eruptions. It is thus necessary to enhance numerical analysis methods with HPC capability and to improve an AMC system that can process more data.

Better preparedness and resilience for natural disasters can be achieved by developing a digital twin of cities and

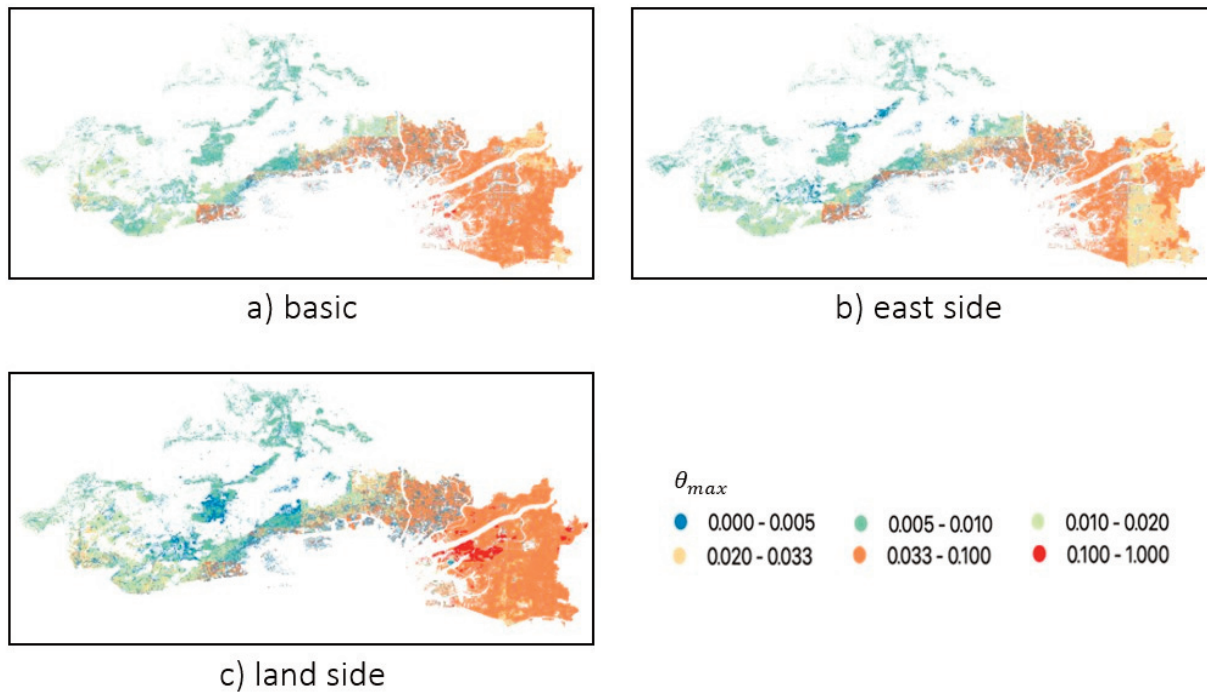


Figure 5:
Distribution of structural damage responses computed in IES for three scenarios of Nankai Trough Earthquake

regions. Various scenarios of natural disasters as well as mitigation plans and recovery strategies are examined using the digital twin. Integrated simulation system such as IES is the foundation of developing the digital twin for natural disasters. ●

References

- [1] M. Hori, **Introduction to computational earthquake engineering (3rd edition)**, World Scientific, 2018.
- [2] M. Hori, T. Ichimura and L. Maddegedara, **Integrated Earthquake Simulation**, CRC Press, 2022.
- [3] T. Ichimura, K. Fujita, R. Kusakabe, K. Koyama, S. Murakami, Y. Kikuchi, T. Hori, M. Hori, H. Inoue, T. Nose, T. Kawashima, and M. Lalith, **Extreme Scale Earthquake Simulation with Uncertainty Quantification**, 2022 SC22: International Conference for High Performance Computing, Networking, Storage and Analysis (SC), 37-47, 2022.

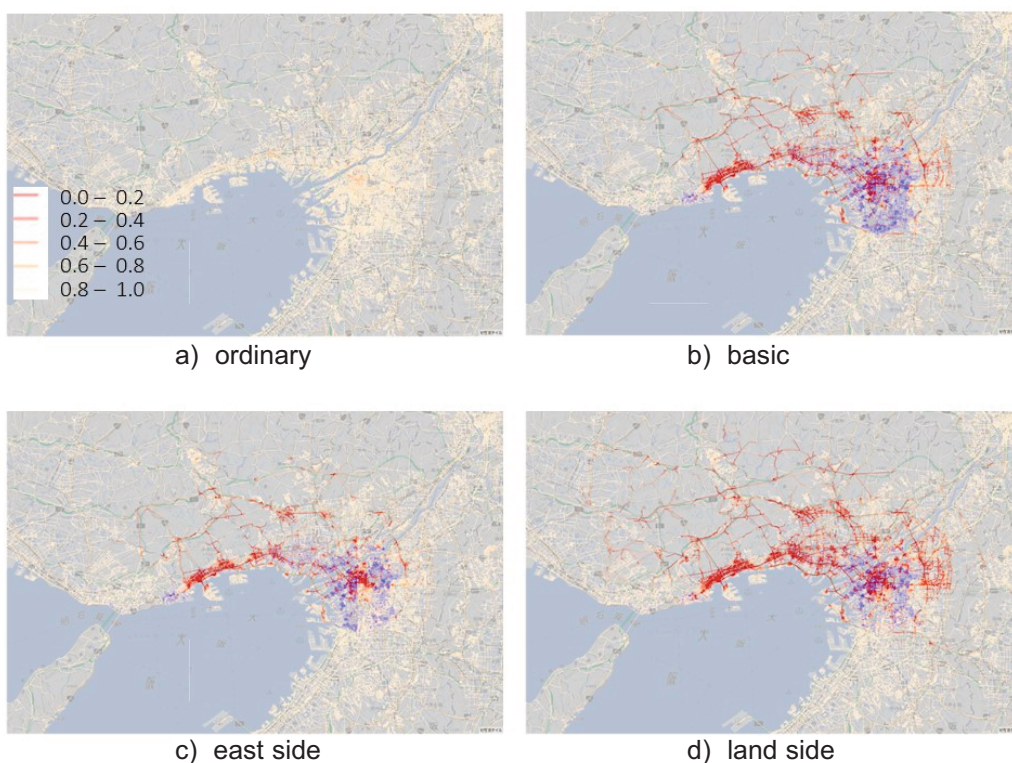


Figure 6:
Distribution of degree of traffic congestions computed from traffic demand and flow simulation

Architected Materials

– a Playground for Computational Mechanics

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Architected Materials

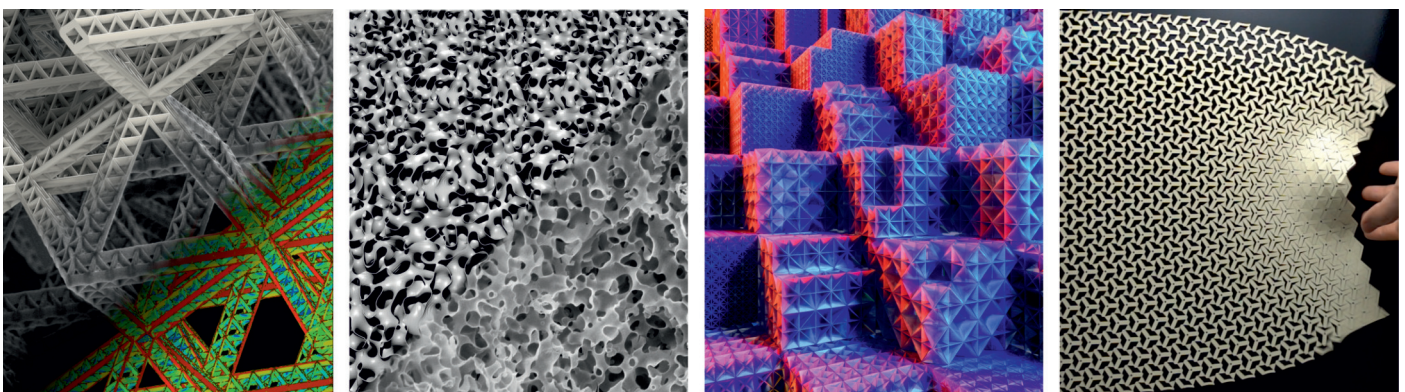
Architected materials have gained tremendous popularity over the past decade, enabled by advances in additive manufacturing down to the nanoscale as well as the enormous material property space that has been unlocked by the careful structural design across scales. The recent surge in truss-, plate-, and shell-based architected materials – with periodic or random arrangements of their structural features – is only the tip of the iceberg of the available design space (see Figure 1). Towards a successful exploration of such cellular solids (especially towards real-life applications), it is key to understand the link between the vast structural design space on the microscale and the resulting effective property space on the macroscale. (Note that *micro* and *macro* here do not refer to specific length scales but merely to those scales of small-scale features and effective properties, respectively.) This calls for computational approaches that allow us to address the two primary modeling challenges: *forward homogenization* aims at extracting the effective material properties from a known microstructural architecture, whereas *inverse homogenization* (or inverse design) seeks to identify microstructures that possess a given target property combination. Although we focus on mechanical properties here, this extends far beyond mechanics (including thermal, chemical, optic, electro-magnetic, and other material properties of interest).

The field of computational mechanics has, of course, pursued many strategies to address the aforementioned challenges – from computational homogenization and FE^2 to topology optimization – as well as tools for material modeling – from molecular dynamics (MD) to the finite element method (FEM). Many of the methods originally developed for ‘conventional’ materials have been adopted for architected materials. Yet, architected materials have posed new challenges – and they have rejuvenated and simplified some existing approaches. They also provide new opportunities for engineering the effective properties of materials with, e.g., exceptionally high stiffness-to-weight or strength-to-weight ratios [1] as well as energy absorbing or wave guiding capabilities [2].

Homogenization Approaches

Computational homogenization with periodic boundary conditions applied to a representative volume element (RVE) has proven well suited for efficiently obtaining, e.g., the effective stiffness or stress-strain response of a periodic architected material [3]. Caution is required when modeling large deformation, since low-density structural architectures promote buckling, which requires to perform stability analysis on the fly or a careful choice of the RVE [4]. Especially when using a structural representation (such as beam or discrete elastic rod elements for trusses), the problem to be solved is computationally inexpensive.

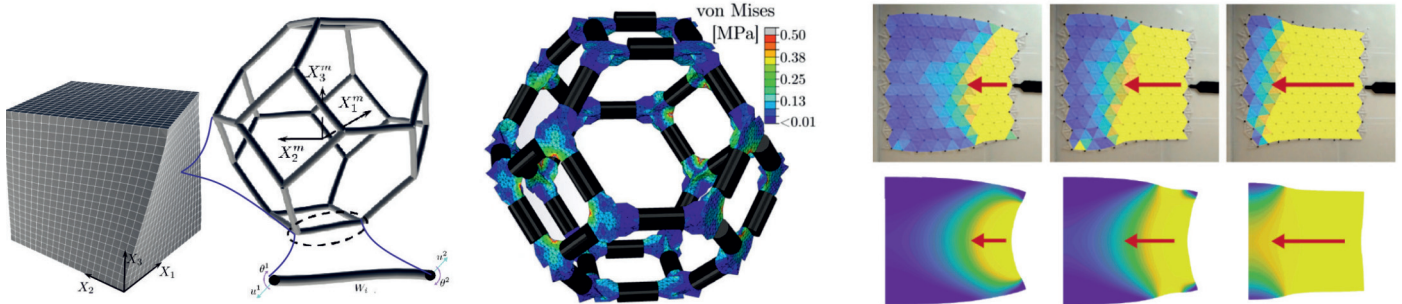
Figure 1:
Examples of architected materials to be modeled (from left to right): hierarchical truss shown by CAD, SEM, and FEM [9], shell-based spinodal architectures in simulations and experiments [21], plate-based architected materials [23], and multistable, shape-morphing structures [11]



For the same reason, FE^2 -type formulations have gained popularity [5] (see Figure 2). What makes FE^2 efficient in this setting is the small number of degrees of freedom required at the level of the RVE: compared to a solid element representation as in classical materials (e.g., when homogenizing composites or polycrystals), the description of truss networks through the displacements and rotations of a small number of nodes (e.g., having a few beam elements per strut) makes it affordable to homogenize on the fly in a general, nonlinear FE^2 setting. With a sufficiently large RVE, this works not only for elastic deformation (including buckling and localization) but also for inelastic base material behavior, e.g., to model visco-elastic trusses [6]. Using the analytical consistent tangent for iterative solvers makes for efficient two-scale simulations [5]. Note that an RVE composed of beam elements requires both translational and rotational degrees of freedom, which has been dealt with in different ways (connecting both translations and rotations [4-6] or only translations [7] to the macroscale) – and which can

vibrations during stereolithography) drastically reduces the effective stiffness of hierarchical truss-based architected materials (which could be predicted by FEM quite accurately when accounting for waviness of the right amplitude and wavelength) [9].

Homogenization techniques have also been applied to reconfigurable or shape-morphing structures with applications from soft robotics to mechanical logic and signal processing. The reconfigurable unit cell, typically having two or more stable equilibrium configurations, is the analog of a phase-transforming atomic unit cell – and the effective response of the reconfigurable architecture can be conveniently described as a phase-transforming continuum [10-11]. Without having to do on-the-fly numerical homogenization, even analytical homogenization approaches based on experimentally or numerically calibrated multi-well effective energy densities proved sufficient to reproduce various responses, e.g., in periodic multistable structures with pre-programmed defects (Figure 2) [11].



naturally lead to strain-gradient effects or micropolar-type continua [4]. The combination of translational and rotational unknowns furthermore furnishes the homogenized continuum with an intrinsic length scale, which becomes apparent when modeling structures undergoing localized instability [4].

Of course, the devil is in the detail. Struts in reality are rarely slender; strut junctions are neither compliant (as in trusses) nor rigid (as in frames) – which has promoted hybrid approaches of, e.g., fully refined junctions connected by beam elements [8] (Figure 2), or the a-priori computation of the effective response of strut segments and junctions in hierarchical trusses [9]. Imperfections, of increasing importance at decreasing length scales, render deterministic approaches often inappropriate and can significantly affect the effective response. We showed, e.g., how strut waviness (introduced by mechanical

Figure 2: Homogenization-based and hybrid modeling (from left to right): FE^2 -type modeling of inelastic beam networks [6], hybrid approach with fully resolved truss nodes and efficient beam representations in between [8], and continuum modeling of reconfigurable structures compared to experiments [11]

Spatial Grading

The above concepts of computational homogenization extend beyond periodic structures. They are equally applicable to spatially graded designs, as long as the spatial grading is relatively smooth (i.e., changes in unit cell topology and/or geometry must be smooth compared to the characteristic fields of the macroscale boundary value problem). This can be exploited, e.g., for the topology optimization of complex truss networks. We have pursued a two-scale approach [12], in which an inexpensive continuum problem is formulated on the macroscale, which uses FE^2 and

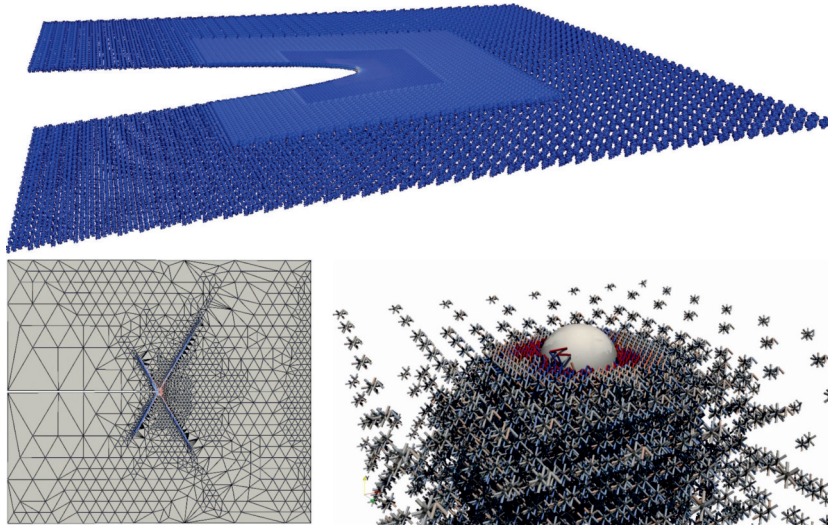


Figure 3:

Fracture simulations based on a truss quasicontinuum (TrussQC) formulation [16], retaining full resolution (i.e., discrete structural representation) near the crack tip while coarse-graining into a homogenized continuum away from the crack. Adaptive refinement tracks stress bands and ensures sufficient resolution during impact

defines for each quadrature point on the macroscale a distinct truss RVE on the small scale (Figure 4). When describing the RVE architecture by a number of design parameters (such as strut thicknesses or topological information such as connectivity or Bravais basis vectors), we can solve the macroscale optimization problem by adjusting the design parameters in each quadrature point (whose effective response on the macroscale is obtained from on-the-fly homogenization). We finally project

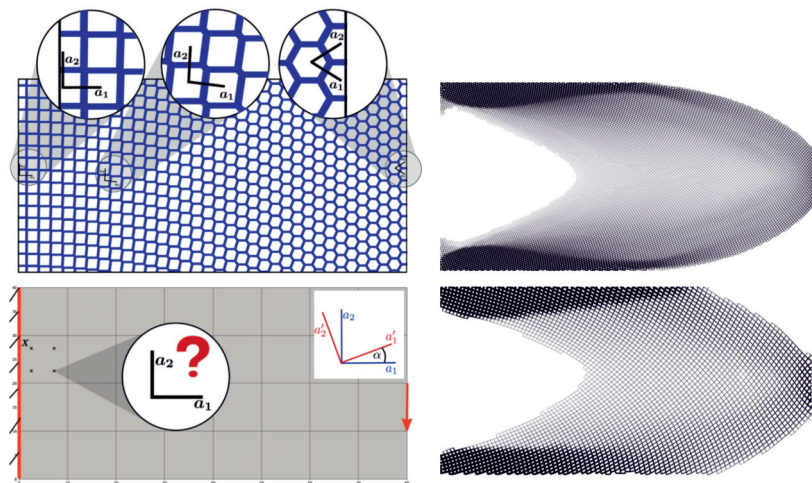


Figure 4:

(left) Spatial grading of the truss varies the local effective properties [12]. Two-scale topology optimization of spatially grade trusses uses on on-the-fly homogenization in every quadrature point on the macroscale; (right) projection leads to graded trusses with adjustable length scale

the resulting distribution of the design parameters onto a discrete truss with a pre-defined characteristic length scale. This effectively decouples the macroscale optimization problem from the fine-scale truss generation and hence gains efficiency over single-scale approaches.

As a second example, spatial grading has been exploited to guide elastic waves in trusses [13]. Borrowing from atomic-level concepts, the wave dispersion in periodic trusses is well described by classical Bloch wave analysis, assuming a propagating plane wave and solving the dynamic eigenvalue problem on an irreducible unit cell with Bloch boundary conditions (Figure 5). Spatially graded trusses, by contrast, offer a much richer design space. Instead of uniform wave dispersion, waves can be guided or attenuated along pre-defined paths by locally adjusting the truss architecture. As discrete structural calculations become prohibitively expensive when considering large structures (especially when interested in iterative design optimization), we have adopted ray tracing – classically known, e.g., from seismic waves or photonics – to the field of graded architected materials [13]. Unlike for seismic waves, here not only the effective elastic properties change from point to point but also the dispersion relations. Compared to optics and photonics, the mechanical problem is richer due to the vector-valued displacement field (the former two deal with scalar-valued fields). The resulting ray tracing machinery assumes a locally periodic architecture, so that the local effective wave dispersion can be obtained, as before, from Bloch wave analysis but is modulated by the spatial grading in the truss architecture [13].

Discrete-to-Continuum Coupling

Computing the fracture toughness is a good example of where an architected material cannot be described as a homogenized continuum [14]. For a conventional linear elastic material, linear elastic fracture mechanics predicts the stress and strain fields around the crack tip under remote loading, admitting the definition of a fracture toughness from the scaling of the stress fields around the crack tip. Consider, by contrast, a periodic truss made of linear elastic struts. The effective elastic response is characterized by homogenized elastic moduli, yet the fracture toughness requires considering the discrete nature of the crack tip: fracture occurs when the strut with the maximum stress reaches its limit.

This in turn requires a discrete representation at the crack tip – and the exact structural arrangement near the crack tip is essential. For example, triangular or hexagonal truss lattices in 2D have an effective isotropic stiffness (so that homogenizing the architected material around the crack tip would show no orientation dependence). Yet, their fracture toughness depends strongly on the orientation of the crack tip with respect to the truss architecture [14,15]. Discrete calculations, unfortunately, reach their limits when large 3D trusses are to be simulated, especially when long-range stress bands emanate from the crack tip.

To this end, we have borrowed the quasicontinuum technique from atomistic modeling, which retains full discrete resolution where needed while efficiently coarse-graining in the far-field (*Figure 3*). Atoms and representative atoms in the atomistic context become, respectively, truss unit cells and representative unit cells in this new context [16]. As a specialty, we coarse-grain not based on truss nodes (as this would lead to an overly stiff interpolation of the effective mechanics within coarse-grained regions) but based on unit cells. Hence, every ‘node’ in the QC setting carries the degrees of freedom of an entire unit cell. This not only admits the seamless transition between fully resolved discrete and homogenized continuum regions, but it also allows capturing the effective truss response in the latter regions efficiently albeit accurately, as it does not assume an affine deformation (as in the classical local QC method). Finally, adaptive remeshing (based on a local strain criterion) enables the efficient tying of high resolution to evolving regions of interest – such as the stress bands emerging from a crack tip under remote loading, or the growing damage zone underneath an indenter or impactor (*Figure 3*).

Of course, reality is more complex than this simple example – plasticity at the strut level, material size effects at the nanoscale, localized failure at strut junctions, etc. all contribute to the effective fracture behavior. Moreover, real-world trusses are never infinite, and the finite size gives rise to surface effects that may dominate the fracture response even in assemblies of millions of truss unit cells (see the recent work in [17]). This is where coarse-grained approaches can help.

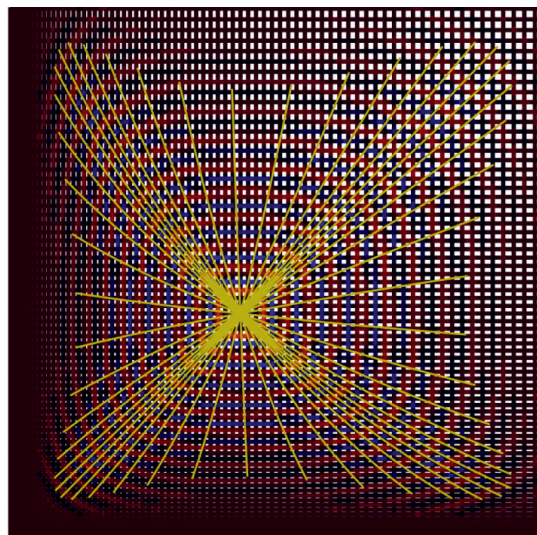


Figure 5:
Wave paths are being bent by the spatial grading of a 2D truss, simulated by ray tracing [13]

Inverse Design

Topology optimization was introduced to deal with the inverse challenge of finding optimal architectures with target properties. As an efficient alternative we have explored ways to use machine learning (ML) for the inverse design of, e.g., truss-based and spinodoid architected materials with as-designed 3D anisotropic stiffness [18,19]. While the forward homogenization approach (discussed above) is usually well-posed, the inverse design challenge is generally ill-posed. Simply put, for a given (deterministic) architecture one can predict its unique effective properties. However, a given set of target properties may be associated with many different architectures (e.g., consider the vast amount of architectures that result in isotropic elastic moduli). This is both a challenge (see, e.g., classical topology optimization’s dependence on the initial guess) and an opportunity (receiving many candidate architectures with (close to) identical effective properties).

For given design parameters, we generate a rich dataset of distinct design realizations along with their associated effective properties obtained from computational homogenization. This dataset is used to train a neural network, whose loss is given by the distance between the queried properties and the effective properties of the predicted design [18] (e.g., the norm between two fourth-order stiffness tensors for the elastic properties, or the difference in principal components of a stress-strain response). As the property prediction

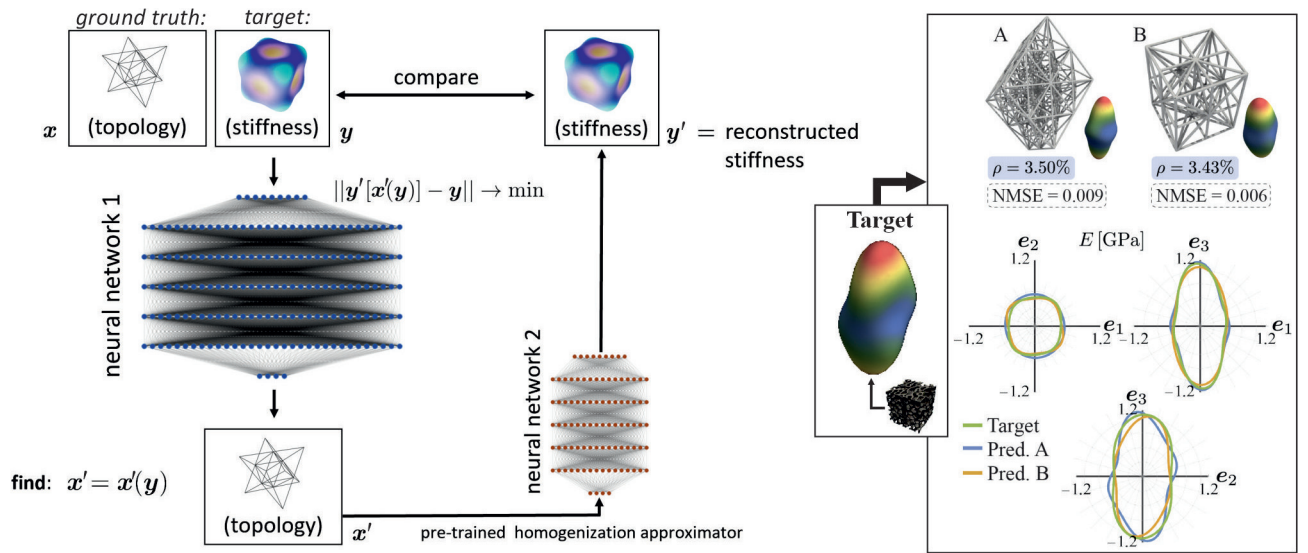


Figure 6:

Inverse design of spinodoids [18] and of truss-based [19] architected materials by machine learning, with application to bio-mimetic bone implants having target anisotropic 3D stiffness

involves a computationally expensive homogenization step, we bypass the latter by a second, a-priori trained neural network, which serves as a homogenization approximator (and can also be used individually for efficient forward homogenization). This ML strategy has been applied to both truss-based architectures [19] and spinodal-type stochastic cellular networks [18] (Figure 6). In both cases, a low-dimensional parameterization of the design space is key to efficient and accurate predictions (this is a key advantage over, e.g., image-based approaches, which use the full pixel information as design parameters). Through this framework we have found, among others, cellular designs that match the 3D anisotropic stiffness of bone samples, providing a route to patient-specific, biomimetic bone implants.

Concluding Remarks and Open Challenges

The above description is, of course, not exhaustive. Many multiscale modeling and optimization techniques have been proposed for architected material design across scales [3]. At the same time, the list of open challenges in the context of modeling architected materials is long and growing. A key challenge has been the property prediction and inverse design of architected materials with imperfections [20]. Fabrication-induced imperfections (ranging from variations in the structural geometry and the base material properties to topological defects) break the periodicity and symmetry and are stochastic in nature, hence calling for statistical approaches.

Especially at small scales, size effects were shown to dominate the effective mechanical response (including, e.g., defect starvation mechanisms in nanoscale structures, base material hardening in nano-crystalline base materials, and plastic size effects in metals). Taking these into account requires accurate models at the smallest scales, where continuum mechanics ceases to apply and atomistic techniques such as MD are required (which, however, come with severe spatial and temporal limitations). Moreover, modeling the fabrication process of architected materials by methods of additive manufacturing could enable a more holistic optimization route of the as-fabricated effective properties. Although imperfections have been accounted for, e.g., in topology optimization or forward homogenization, the state of the art is still far from modeling the full fabrication process at realistic scales. When it comes to the inverse design, optimizing for linear properties such as the elastic stiffness or wave motion is only the beginning, and recent work has started to address inverse designing inelastic effective behavior (including plasticity, damage and failure, friction, and contact). The same holds for the (forward and inverse) homogenization of nonlinear dynamic behavior [22]. Finally, the availability of codes is another bottleneck, as many of the approaches mentioned above are ‘home-grown’ and few open-source codes are available.

Acknowledgements

I sincerely thank all those team members (past and present) as well as collaborators who have contributed to the work presented here. This includes, in particular, Jan-

Hendrik Bastek, Charlie Dorn, Raphael Glaesener, Vignesh Kannan, Romik Khajehtourian, Sid Kumar, Helen Le Clézio, Claire Lestringant, Greg Phlipot, Carlos Portela, Kaoutar Radi, Bastian Telgen, Alex Zelhofer, Li Zheng, and collaborators Julia R. Greer and Ole Sigmund. (A big apology to all those whose names I forgot to mention here). Funding from the U.S. Office of Naval Research, National Science Foundation, Army Research Office, the ERC Horizon 2020 Program, and ETH Zurich is gratefully acknowledged.

Codes

Our codes for the homogenization of elastic properties and the calculation of dispersion relations for periodic structures are freely available from www.ae108.ethz.ch. For a list of other available codes (e.g., for the ML-based inverse design), visit <https://mm.ethz.ch/facilities-and-codes/codes.html>. ●

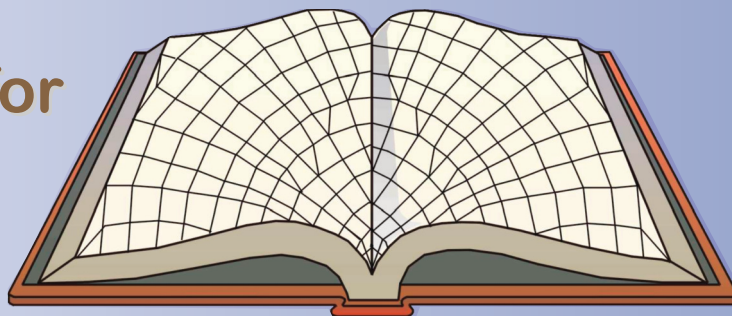
References

- [1] *L.R. Meza, G.P. Phlipot, C.M. Portela, A. Maggi, L.C. Montemayor, A. Comella, D.M. Kochmann, J.R. Greer, Reexamining the mechanical property space of three-dimensional lattice architectures*, Acta Mater., 140:424-432, 2017.
- [2] *M.I. Hussein, M.J. Leamy, M. Ruzzene, Dynamics of Phononic Materials and Structures: Historical Origins, Recent Progress, and Future Outlook*, Appl. Mech. Rev., 66:040802, 2014.
- [3] *D.M. Kochmann, J.B. Hopkins, L. Valdevit, Multiscale modeling and optimization of the mechanics of hierarchical metamaterials*, MRS Bulletin, 44:773-781, 2019.
- [4] *R.N. Glaesener, E.A. Träff, B. Telgen, R.M. Canonica, D.M. Kochmann, Continuum representation of nonlinear three-dimensional periodic truss networks by on-the-fly homogenization*, Int. J. Solids Struct., 206:101-113, 2020.
- [5] *R.N. Glaesener, C. Lestringant, B. Telgen, D.M. Kochmann, Continuum models for stretching- and bending-dominated periodic trusses undergoing finite deformations*, Int. J. Solids Struct., 171:117-134, 2019.
- [6] *R.N. Glaesener, J.-H. Bastek, F. Gonon, V. Kannan, B. Telgen, B. Spöttling, S. Steiner, D.M. Kochmann, Viscoelastic truss metamaterials as time-dependent generalized continua*, J. Mech. Phys. Solids, 156:104569, 2021.
- [7] *A. Vigliotti, V.S. Deshpande, D. Pasini, Non-linear constitutive models for lattice materials*, J. Mech. Phys. Solids, 64:44-60, 2014.
- [8] *C.M. Portela, J.R. Greer, D.M. Kochmann, Impact of node geometry on the effective stiffness of non-slender three-dimensional truss lattice architectures*, Extr. Mech. Lett., 22:138-148, 2018.
- [9] *L. Meza, A.J. Zelhofer, N. Clarke, A.J. Materos, D.M. Kochmann, J.R. Greer, Resilient 3D hierarchical architected metamaterials*, PNAS, 112:11502-11507, 2015.
- [10] *R. Khajehtourian, D.M. Kochmann, A continuum description of substrate-free dissipative reconfigurable metamaterials*, J. Mech. Phys. Solids, 147:104217, 2021.
- [11] *L. Jin, R. Khajehtourian, J. Mueller, A. Rafsanjani, V. Tournat, K. Bertoldi, D.M. Kochmann, Guided transition waves in multistable mechanical metamaterials*, PNAS, 117:2319-2325, 2020.
- [12] *B. Telgen, O. Sigmund, D.M. Kochmann, Topology Optimization of Graded Truss Lattices Based on On-the-Fly Homogenization*, J. Appl. Mech. 89:061006, 2022.
- [13] *C. Dorn, D.M. Kochmann, Ray theory for elastic wave propagation in graded metamaterials*, J. Mech. Phys. Solids, 168:105049, 2022.
- [14] *N. Fleck, X.M. Qiu, The damage tolerance of elastic-brittle, two-dimensional isotropic lattices*, J. Mech. Phys. Solids, 55:562-588, 2007.
- [15] *F. Lipperman, M. Ryvkin, M.B. Fuchs, Fracture toughness of two-dimensional cellular material with periodic microstructure*, Int. J. Fract., 146:279-290, 2007.
- [16] *G.P. Phlipot, D.M. Kochmann, A quasicontinuum theory for the nonlinear mechanical response of general periodic truss lattices*, J. Mech. Phys. Solids, 124:758-780, 2019.
- [17] *A.J.D. Shaikeea, H. Cui, M. O'Masta, Z.R. Zheng, V.S. Deshpande, The toughness of mechanical metamaterials*, Nat. Mater., 21:297-304, 2022.
- [18] *S. Kumar, S. Tan, L. Zheng, D.M. Kochmann, Inverse-designed spinodoid metamaterials*, npj Comput. Mater., 6:73, 2020.
- [19] *J.-H. Bastek, S. Kumar, B. Telgen, R.N. Glaesener, D.M. Kochmann, Inverting the structure-property map of truss metamaterials by deep learning*, PNAS, 119:e21111505119, 2021.
- [20] *D. Pasini, J.K. Guest, Imperfect architected materials: Mechanics and topology optimization*, MRS Bulletin, 44:766-772, 2019.
- [21] *C.M. Portela, A. Vidyasagar, S. Krödel, T. Weissenbach, D.W. Yee, J.R. Greer, D.M. Kochmann, Extreme mechanical resilience of self-assembled nanolabyrinthine materials*, PNAS 117:5686-5693, 2020.
- [22] *K. Pham, V.G. Kouznetsova, M.G.D. Geers, Transient computational homogenization for heterogeneous materials under dynamic excitation*, J. Mech. Phys. Solids, 61:2125-2146, 2013.
- [23] *T. Tancogne-Dejean, M. Diamantopoulou, M.B. Gorji, C. Bonatti, D. Mohr, 3D Plate-Lattices: An Emerging Class of Low-Density Metamaterial Exhibiting Optimal Isotropic Stiffness*, Adv. Mater. 30:1803334, 2018.

Introduction to Numerical Methods for Variational Problems

Hans Petter Langtangen
& Kent-Andre Mardal

Springer Nature, Cham, Switzerland, 2019



BOOK REVIEW

ISBN: 978-3-030-23787-5, 405 pages, soft cover, €50 (List Price)

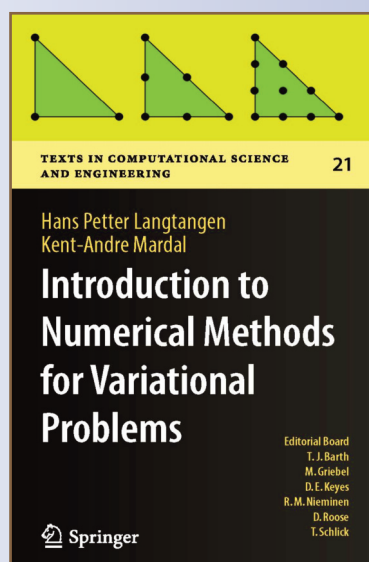
Contents: Preface; 1: Quick Overview of the Finite Element Method; 2: Function Approximation by Global Functions; 3: Function Approximation by Finite Elements; 4: Variational Formulations with Global Basis Functions; 5: Variational Formulations with Finite Elements; 6: Time-Dependent Variational Forms; 7: Variational Forms for Systems of PDEs; 8: Flexible Implementations of Boundary Conditions; 9: Nonlinear Problems; 10: Variational Methods for Linear Systems; Appendix A: Useful Formulas; References; Index.

The first author, Hans Petter Langtangen, a professor of scientific computing at the University of Oslo, died before this book was completed. The second author, Kent-Andre Mardal, a professor of mechanics in the department of mathematics at that university, finalized the task. The book was published as part of the Springer series “Texts in Computational Science and Engineering”.

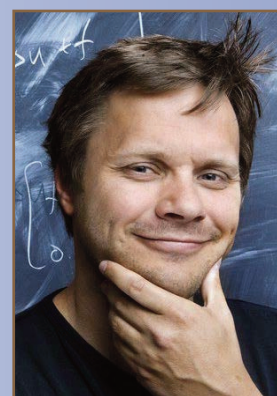
As the authors write in the Preface, this is “essentially a book on the finite element method, although we discuss many other choices of basis functions and other applications than PDEs.”

There are a number of things that I like about this book, and in particular the subjects that it covers. In addition to the basics of FEM, the reader can find a thorough discussion on projection methods in general, and on using the Galerkin method with other basis functions than FE shape functions. Non-standard material includes a nice discussion on the Runge phenomenon and on ways to overcome it, e.g., by the use of the Bernstein polynomial basis (chapter 2); see figures below.

Chapter 6 is about time-dependent problems, where time discretization is performed before space discretization. Chapter 8 is also non-standard, discussing special treatment of boundary conditions, using a Lagrange multiplier method, a penalty method, the Nitsche method, and more. Chapter 9 on nonlinear problems is also rarely found in basic books on the FEM.



H.P. Langtangen



K.A. Mardal

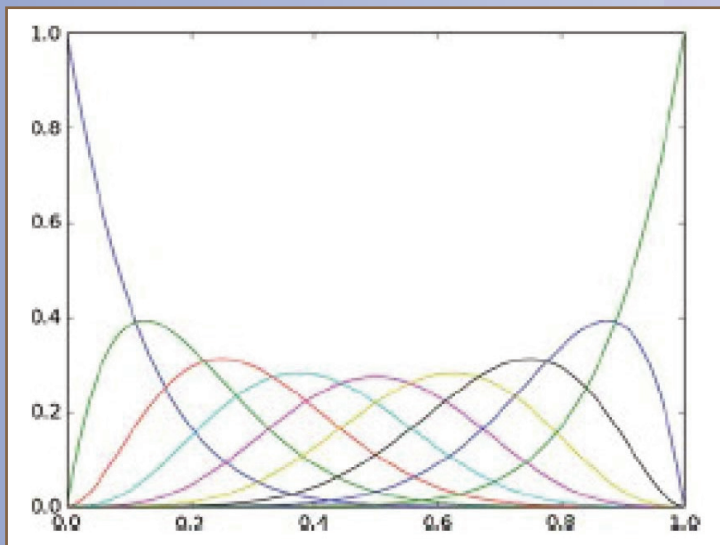
by
Dan Givoli
Technion -
Israel Institute of
Technology
givolid@technion.ac.il

In addition, the book includes many clear figures, a set of nice exercises at the end of each chapter, and many FEniCS code segments throughout the book for the various algorithms discussed.

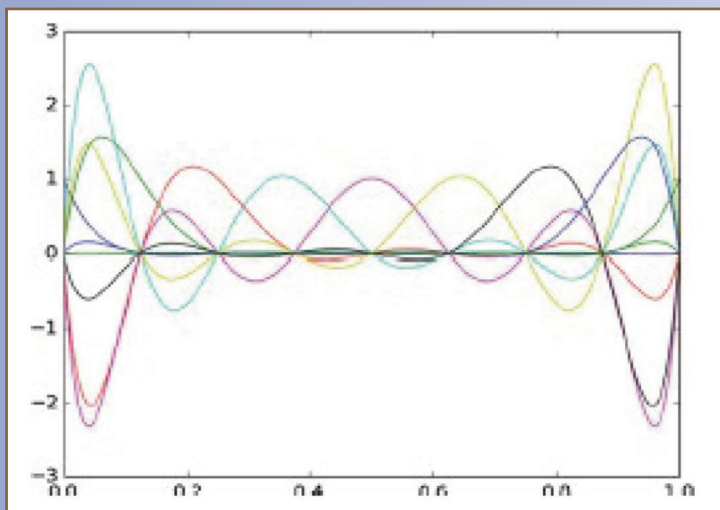
On the other hand, the book suffers from serious lack of proper proof-reading, and thus contains many mistakes, both in the text and in the equations. Chapter 1 in particular is full of awkward English phrasings, and looks as if it was never carefully read by anyone before publication. In addition, the explanations in this chapter are very confusing. As an example, in eq. (1.4), the PDE is multiplied by a test function and is integrated over a single element (why?), and this is followed by the statement that eq. (1.5) (which is a mistake in the equation number) gives rise to $N+1$ linearly independent equations, where $N+1$ is the total number of unknowns in the problem. The equations that follow also consist of integrals over element domains, but the text continues to talk about the global problem. In Chapter 2, p. 8., the local support of basis functions is explained by the words “each function is nonzero except in a small part of the domain.” Of course, “nonzero” should be “zero”. These and many other mistakes, scattered throughout the book, will make reading the book a frustrating experience for the average reader.

In addition, I did not like some of the notation and example choices made by the authors, although this may be a matter of taste. As an extreme example, in Chapter 3, p. 80, a vector with entries such as 2-h (a pure number minus the element length) appears. This is either an “anti-educational” mixture of numbers and symbols, or simply another typographical mistake.

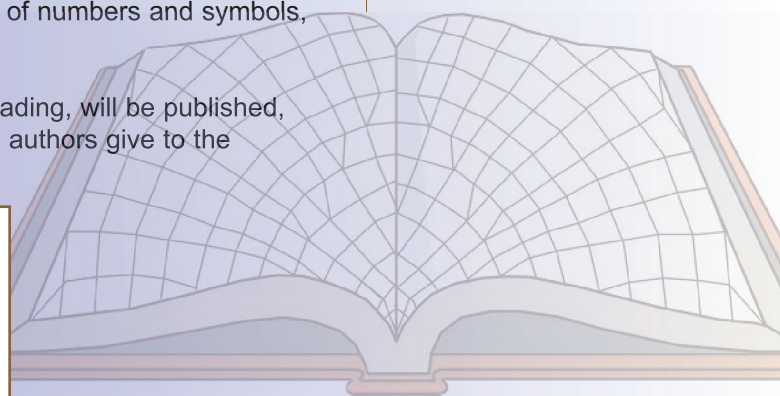
Hopefully, a second edition of this book, with careful proofreading, will be published, so as to allow the readers to fully enjoy the original view the authors give to the FEM and related topics. ●



The 9 Bernstein basis functions of order 8
(this is Fig. 2.16 in the book)



The 9 Lagrange basis functions of order 8
(this is Fig. 2.17 in the book)



CMM-SolMech 2022

On 5-8 September 2022, a joint scientific event including the **24th International Conference on Computer Methods in Mechanics** and the **42nd Solid Mechanics Conference (CMM-SolMech 2022)** was held in Świnoujście, a city located at the Baltic Sea coast in north-western Poland. The CMM-SolMech 2022 Conference was co-organized by the Polish Association for Computational Mechanics (PACM), Institute of Fundamental Technological Research of the Polish Academy of Sciences (IPPT PAN) and the West Pomeranian University of Technology in Szczecin (ZUT).

The series of CMM conferences is organized by the PACM. Started in 1973, the CMM conference series is dedicated to numerical methods and their applications to the mechanics-based problems. The series of SolMech conferences have been organized by the Institute of Fundamental Technological Research, Polish Academy of Sciences (IPPT PAN) since 1953 and cover all aspects of solid mechanics. Due to the unusual situation caused by COVID-19, it was decided to organize a joint conference – CMM-SolMech 2022 – gathering the two communities.

Prof. Michał Kleiber (PACM, IPPT PAN) acted as the Conference President. The Scientific Committee was chaired by Prof. Tadeusz Burczyński (PACM, IPPT PAN) and the Organizing Committee was co-chaired by Prof. Ryszard Buczkowski from the West Pomeranian University of Technology in Szczecin and Prof. Stanisław Stupkiewicz from IPPT PAN.

The scientific programme of the CMM-SolMech 2022 conference was composed of 8 plenary lectures, 17 thematic sessions and one poster session. There were nearly 300 participants from Poland and 23 other countries. The following distinguished scientists held the interesting plenary lectures on current research topics:

- **Matthew Gilbert**, University of Sheffield, UK, *Application of layout optimization methods in engineering analysis and design*
- **Dennis Kochmann**, ETH Zürich, Switzerland, *Microstructure of ferroelectric ceramics: simulation meets experiment*
- **Jože Korelc**, University of Ljubljana, Slovenia, *Sensitivity analysis based computational modeling*
- **Laura De Lorenzis**, ETH Zürich, Switzerland, *EUCLID – Efficient Unsupervised Constitutive Law Identification and Discovery*
- **Dariusz Łydźba**, Wrocław University of Science and Technology, Poland, *Overall microstructure response function and its application to recovery of microstructure*
- **Thomas Pardoen**, Université Catholique de Louvain, Belgium, *On-chip fracture mechanics to explore fracture toughness of freestanding ultra-thin films from brittle to ductile, down to 2D materials*
- **Jacek Tejchman**, Gdańsk University of Technology, Poland, *Application of a coupled DEM–CFD approach to engineering problems*
- **Tarek Zohdi**, University of California, Berkeley, USA, *Modeling and simulation tools for industrial and societal research applications: digital twins and genome-based machine-learning*

It has become a 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 congress opening. The 2022 laureates of the O.C. Zienkiewicz Medal are:

- **Prof. Jacek Tejchman** in the category for the whole of activity,
- **Prof. Jože Korelc** in the category for foreign scientists of particular merit for the development of computational mechanics in Poland.

The awards were presented by Prof. Michał Kleiber (Commander of the Medal Chapter) and Prof. Tadeusz Burczyński (Chancellor of the Medal Chapter), during the ceremony conducted by Prof. Jerzy Rojek (President of PACM).

During the conference there was also held the Jan Schmelter competition for young scientists. Jury of the competition led by prof. Ewa Błazik-Borowa (Lublin University of Technology) awarded three prizes to the following young scientists:

- 1st place: **Vishnu Ambikadevi Rajasekharan** – Uni. Carlos III of Madrid, Spain
- 2nd place: **Rabea Sondershaus** – Technical University of Darmstadt, Germany
- 3rd place *ex aequo*: **Monika Zielińska** – AGH Uni. of Science & Technology, Poland
Agata Mrozek – Poznan Uni. of Technology, Poland

The General Assembly of PACM was held during the conference. At the meeting, PACM president Jerzy Rojek presented a report on PACM activities and achievements during the last term 2019-2022. The report was accepted unanimously. A new Managing Board of the PACM was elected for the next term 2022-2024. Prof. Wojciech Sumelka from Poznan University of Technology was elected the new President of PACM.

The CMM-SolMech 2022 conference was a successful, well-organized scientific event. More details on CMM-SolMech 2022 conference can be found at the conference web site: <http://cmm-solmech.ippt.pan.pl/>. The next, 25th International Conference on Computer Methods in Mechanics will be organized together with the 5th Polish Congress of Mechanics. The joint PCM-CMM 2023 conference will be held in Gliwice (Upper Silesia) on 4-7 September 2023.



Figure 1:
Awarding Ceremony of the O.C. Zienkiewicz Medal. From left to right: Michał Kleiber – Commander of the Medal Chapter, Tadeusz Burczyński – Chancellor of the Medal Chapter, Joze Korelc – recipients of the Medal in the category for foreign scientists of particular merit for the development of computational mechanics in Poland, Jerzy Rojek – President of PACM



Figure 2:
Awarding Ceremony of the Jan Schmelter competition for young scientists. From left to right: Michał Kleiber – President of the CMM-SolMech 2022 Conference, Stanisław Stupkiewicz – Co-chairman of the Organizing Committee, Jerzy Rojek – President of PACM, Vishnu Ambikadevi Rajasekharan – winner of the Jan Schmelter competition for young scientists, Ewa Błazik-Borowa – chair of the jury of the Jan Schmelter competition, Maciej Taczala, West Pomeranian University of Technology in Szczecin

Advanced FEM Course

A two day short course titled: **Implementation of the DPG Method in a FE Code Supporting H1, H(curl), H(div) and L2-Conforming Finite Elements** was held at the Poznan University of Technology on 14-15 June 2022. The course was organized by the PACM and the Polish Section of GAMM. The lectures were delivered by Professor Leszek Demkowicz and his former PhD student, Dr Stefan Henneking, both from the Oden Institute at the University of Texas at Austin, USA. The presentation focused on three topics: a) fundamentals of hp3D, a parallel MPI/openMP 3D Finite Element code supporting discretization of arbitrary variational formulations set up in the exact energy spaces on hybrid meshes (tets+hexas+prisms+pyramids), b) fundamentals of the Discontinuous Petrov-Galerkin (DPG) method, and c) implementation of the DPG method within the hp3D code. The hp3D library along with a documentation is available in the public domain. The technology was illustrated with a simulation of Transverse Mode Instabilities (TMS) in optical amplifiers. The problem consists of a system of two nonlinear time-harmonic Maxwell equations coupled with a transient heat equation; the simulation of up to 10 million wavelengths involves solution of linear systems with 2 billion degrees-of-freedom and elements of order 8. The course was attended by PhD students from Poznań University of Technology and partner universities from Germany. ●

Figure 3:
Participants of the Advanced FEM Course, in the middle, lecturer Prof. Leszek Demkowicz



UKACM 2022 Conference

The 2021 conference took place on 20th-22nd of April 2022. Organised by Dr Jelena Ninic, Dr Matteo Icardi, Dr Kristoffer Van Der Zee and Dr Fangying Wang (University of Nottingham), the conference followed an in-person format, with 84 participants delivering talks.

UKACM School

As it is tradition in UKACM, a School was organised before the start of the conference. This year the following topics were covered in the UKACM School:

- **Computational Phase-field Modelling.** (Dr Kris van der Zee, University of Nottingham)
- **Cut Finite Element Methods** (Prof Dominik Schillinger, Technische Universität Darmstadt, Germany)
- **Optimisation Using Metaheuristics** (Prof Ender Özcan, University of Nottingham)

UKACM Plenary Speakers

Four plenary lectures at the conference were delivered by the following distinguished researchers:



René de Borst, University of Sheffield, UK

Fracture and fluid flow in porous media: A multiscale approach and isogeometric discretisation



Dominik Schillinger, Technische Universität Darmstadt, Germany

Thermodynamically consistent concurrent material and structure optimization of elastoplastic multiphase hierarchical systems



Stefanie Elgeti, TU Wien, Austria

Numerical Design of Engineering Components and their Production Processes



Emilio Martínez-Pañeda, Imperial College London, UK

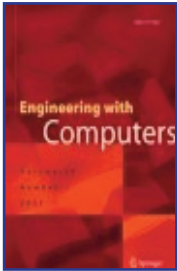
Phase field modelling of fracture and multi-physics material degradation phenomena

In addition, **Dr Robert Bird** delivered the closing lecture, entitled “On the highly accurate computation of crack paths using the hp-adaptive finite element method”, as winner of the 2021 Roger Owen PhD Thesis Award.

UKACM Conference Awards

The following delegates received the three UKACM conference awards:

- **Arnaud Vadeboncoeur** from University of Cambridge received the Mike Crisfield Prize for the paper “Efficient sampling through active learning projected surrogates: ALPS-SVG”.
- **James D. Elgy** from Keele University received the prize to the best presentation by a post-doctoral researcher for the paper “Computation of the magnetic polarizability tensor for dictionaries of objects with varying materials”.
- **Manuela Cabrera** from the University of Nottingham received the prize to the best presentation by a PhD student for the paper “Machine learning-based fusion of experimental and synthetic data for reliable prediction of steel connection stiffness”.

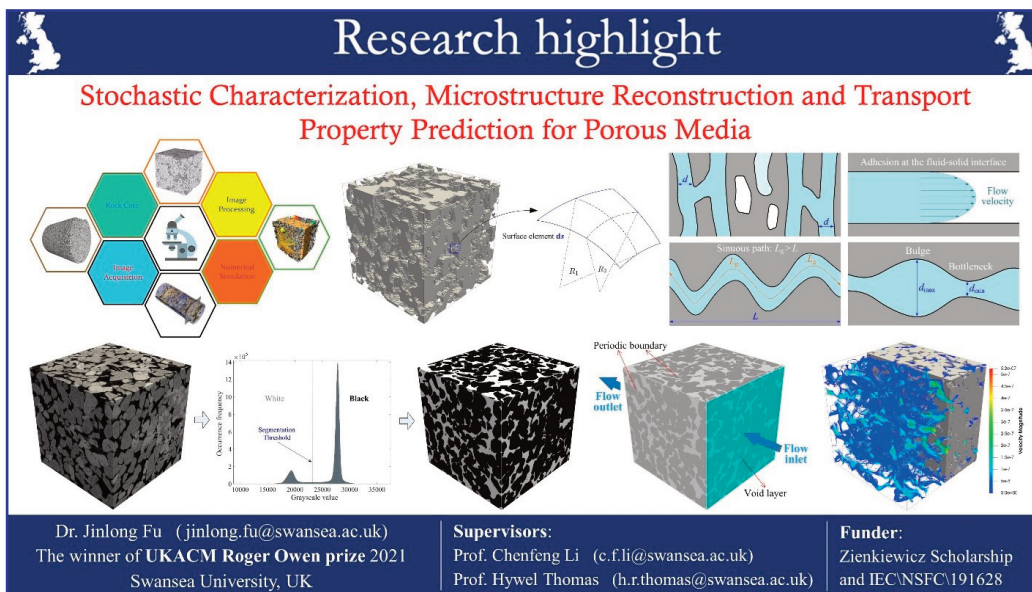


UKACM 2022 special issue in Engineering with Computers

Attendees to the 2022 UKACM conference have been invited to submit a paper to a special issue in Engineering with Computers entitled “Advanced in Computational Mechanics”. The issue is expected to be published in 2023.

2022 Roger Owen PhD Thesis Award

The winner of the 2022 Roger Owen PhD Thesis Award was Dr Jinlong Fu.



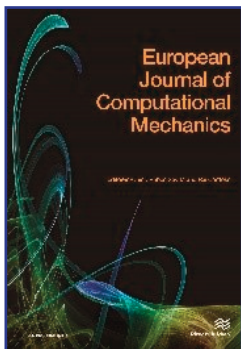
UKACM 2023 Conference

The 2022 UKACM conference will be organised by Dr Mohaddeseh Mousavi Nezhad, from the University of Warwick. The Conference and School will take place between 19th-21st of April 2023.

This conference will also mark the end of the 30th Anniversary of UKACM.

Agreement with River Publishers

UKACM has recently signed an agreement with the European Journal of Computational Mechanics, owned by River Publishers.



The agreement, signed during the 30th Anniversary of both UKACM and the European Journal of Computational Mechanics, will provide free access to the journal to UKACM members and a sponsorship for all the UKACM conference awards.

UKACM would like to take this opportunity to encourage submissions to the European Journal of Computational Mechanics and the organisation of special issues in relevant topics. ●

USACM Thematic Conference on Uncertainty Quantification for Machine Learning Integrated Physics Modeling (UQ-MLIP)

The USACM Technical Thrust Area (TTA) on Uncertainty Quantification and Probabilistic Modeling organized an in-person thematic conference on UQ for Machine Learning Integrated Physics Modeling (UQ-MLIP) on August 18-19, 2022, in Crystal City, Arlington, Virginia. Machine Learning, and in particular neural network-based methods, are being increasingly embedded in modeling and simulation methods of complex physical systems – starting from the observation/data collection to the formulation and evaluation of different scales/levels of modeling and finally prediction. While uncertainty quantification methods for “classical” modeling and solution methods are now well understood, though often still intractable, methods for UQ of ML integrated models are crucial but pose many new challenges!

The conference program attracted several excellent speakers and posters. Keynote speakers brought up key challenges and presented some innovative ideas. An early career panel with panelists from several federal science agencies was well received as it engaged early career scientists in the audience. Successful early/mid-career scientists brought up challenges they have been faced with and strategies they have used to navigate them. A panel on open research challenges and opportunities at the end of the meeting brought up new ideas for future efforts of the community.

Figure 1:
Technical session
at UQ-MLIP



The meeting was partially supported by the National Science Foundation and Sandia National Laboratories. Funds were used to support travel expenses of students and early career scientists. We thank the 95 participants for their time and effort, the NSF and Sandia National Laboratories for their financial support, and gratefully acknowledge the involvement of program managers A. Sussman (CISE/OAC) and S. Qidwai (ENG/MOM) at the NSF, S. Lee at the DOE, and F. Fahroo at the AFOSR. Further information about the event may be found at <https://sites.google.com/usacm.org/uq-mlip/home>.

USACM Thematic Conference on Meshfree and Novel Finite Element Methods with Applications (MFEM)

The USACM Novel Methods in Computational Engineering and Sciences TTA, with support from Ansys, Oak Ridge National Laboratory, K&C, Sandia National Laboratories, Moldex3D and JSOL hosted an in-person conference on Meshfree and Novel Finite Element Methods with Applications in Berkeley, California September 25-27, 2022 to focus on the post-pandemic academia-industry engagement, industrial trends and challenging applications.

Organized by Drs. C. T. Wu, Zhen Chen, C. Armando Duarte, Sanjay Govindjee, Jacob Koester and Shaofan Li, the conference brought together over 100 participants in academia and industry from the US, Europe and Asia to develop a two-way engagement that is about the people who can engage to create and utilize the Computational Mechanics technology to meet the industry’s needs, follow the industrial trends, and focus on emergent industrial applications. Through eighty-four technical presentations in twelve minisymposia as well as four plenary lectures and four semi-plenary lectures, the participants were able to engage to identify challenges and barriers in industrial applications, and showcase ideas, resources, and success stories. Further information about the event may be found at <http://mfem2020.usacm.org>.

10th International Conference on Isogeometric Analysis

The 10th International Conference on Isogeometric Analysis was held November 6-9 in Banff, Alberta, Canada at the world famous Banff Spring Fairmont hotel. With over 130 in attendance and organized by the USACM Technical Thrust Area on Isogeometric Analysis and with sponsorship from Coreform, the conference featured four plenary speakers and two semi-plenary speakers as well as an industry panel. There were 11 minisymposia covering the following topics: IGA for Biomedical Applications, Industrial Applications for IGA, Unstructured Spline Technologies, Adaptive Spline Technologies, IGA for Fluids and FSI, IGA for Solids and Structures, Mathematical Foundation of IGA, Fast Formation and Solution Techniques, Design Space Exploration, Optimization and Uncertainty Quantification, New Frontiers in IGA, and Isogeometric Boundary Element Methods.

Organized by Professors Artem Korobenko (University of Calgary), Ming-Chen Hsu (Iowa State University) and John Evans (University of Colorado, Boulder), the conference was the first IGA conference to be held in Canada and the first in-person conference since the 2019. Participants enjoyed not only the talks, but free time for informal discussions with colleagues. More information may be found on the website at <http://iga2022.usacm.org>.

Figure 2:
A. Korobenko,
M-C. Hsu & J. Evans



TTA Virtual Seminars

Several TTAs of the USACM have been holding monthly virtual seminars which have featured guest speakers and discussions on various topics of importance to their field. Videos of the talks may be found at usacm.org/ttas under the TTA of interest. The following talks have taken place this summer/fall:

TTA on Computational Fluid Dynamics and Fluid Structure Interaction

Kenji Takizawa (Waseda University), *Space-Time Isogeometric Analysis of Heart Valves*

TTA on Large Scale Structural Systems and Optimal Design

Brendan Keith (Brown University), *Adaptive Sampling for Constrained Optimization under Uncertainty*

Hayoung Chung (Ulsan National Institute of Science and Technology), *Understanding Multifunctional Behaviors using Sequential Multiscale Approaches*

Xingsheng Sun (University of Kentucky), *Rigorous Multiscale Quantification of Material Uncertainties*

TTA on Nanotechnology and Lower Scale Phenomena

Alejandro Strachan (Purdue University), *Enhancing Physics-Based Modeling and Extracting Physical Insight from Data Using Machine Learning*

Markus Hütter (Eindhoven University of Technology), *Molecular Approach to Plasticity in Polymer Glasses: A Journey*

Michael Falk (Johns Hopkins University), *Questing for Structural Predictors of Plastic and Failure Response in Glasses*

Michael Shields (Johns Hopkins University), *The Intersection of Machine Learning & Uncertainty Quantification in Physics-Based Modeling for Materials Systems*

Steve WaiChing Sun (Columbia University), *Geometric Learning for Discovering Complex Material Behaviors of Microstructures*

Stefanie Reese (RWTH Aachen University), *Data-Driven Mechanics for Elastic and Inelastic Problems Including Uncertainty Quantification* ●

USACM Upcoming Events

○ 17th U.S. National Congress on Computational Mechanics

July 23-27, 2023, Albuquerque, New Mexico (17.usnccm.org)

Information on other upcoming conferences may be found at www.usacm.org/conferences. ●

9th GACM Colloquium on Computational Mechanics for Young Scientists from Academia and Industry

The successful 9th GACM Colloquium on Computational Mechanics for Young Scientists from Academia and Industry took place with 279 participants from 20 countries from September 21 to 23, 2022, in Essen, Germany!

Follow GACM



After the motivating opening by GACM President Marek Behr and the kind welcome to the University Duisburg-Essen by Vice-Rector Jörg Schröder, all participants could follow the first scientific talk on Wednesday. Exciting plenary lectures were given by Swantje Bargmann on "Core-Shell Metamaterials Based on Triply Periodic Minimal Surfaces" and Otto von Estorff on "Computational Methods in Acoustics: Challenges in Theory and Practice." Each plenary talk was followed by impressive presentations of the winners of the Best Ph.D. Award 2019, first Tobias Kaiser on "Computational Modelling of Non-Simple and Anisotropic Materials," followed by Bettina Römer on "Consistent Higher Order Accurate Time Discretization Methods for Inelastic Material Models." The two contributed sessions with eight tracks in the afternoon already showed an active and innovative community with numerous talents.

The second day started with a fascinating plenary lecture by Karl Steeger of CPI Vertex Antennentechnik on "How Numerical Methods Support the Development of Antennas." After his talk, the winner of the GACM Best Ph.D. Award 2020, Maximilian Grill presented his remarkable work on "Computational Models and Methods for Molecular Interactions of Deformable Fibers in Complex Biophysical Systems." The morning was closed by another exciting plenary lecture on "Multiscale Modeling Of Materials With Microstructure -- From Smart And Soft To Light And Stiff" by Marc-André Keip. In the afternoon, very lively discussions were held during the poster session. The scientific part of the day was again concluded by a contributed session, with many talks covering the whole spectrum of Computational Mechanics.

After enjoying a delicious dinner in a great atmosphere on Thursday evening, the scientific program on Friday was again very inspiring. The day started with a seven-track contributed session before Laura De Lorenzis gave the final plenary talk on "EUCLID: Efficient Unsupervised Constitutive Law Identification and Discovery." Like all previous plenaries, this one was very impressive. After lunch, the winner of the Best Ph.D. Award 2021, Tobias Bode gave an outstanding talk on "Peridynamic Galerkin Methods For Nonlinear Solid Mechanics." The research program was concluded with a final contributed session with five tracks in the afternoon. During the closing session, Marek Behr summarized the event's success along with some statistics and announced that the 10th GACM Colloquium, celebrating the 30th anniversary of the German Association for Computational Mechanics, will take place from September 11 to 13, 2023, in Vienna!



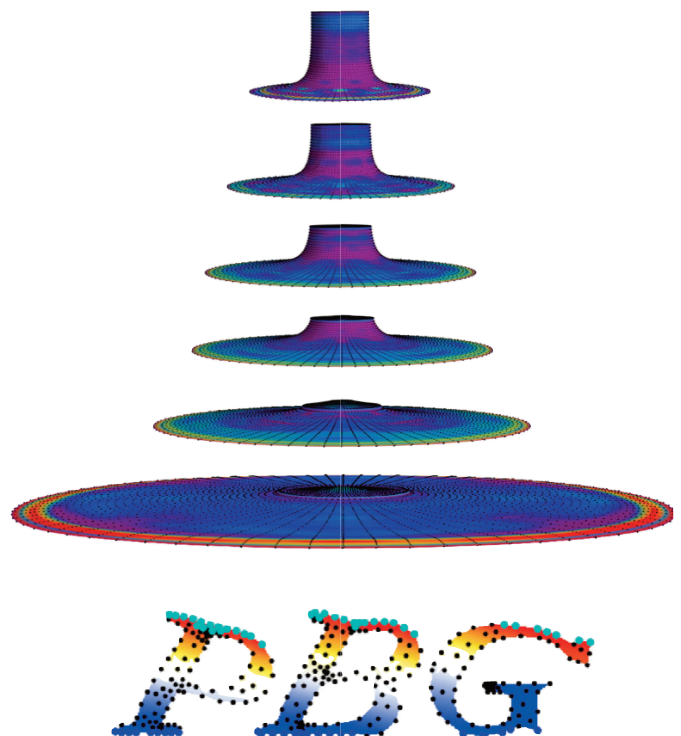
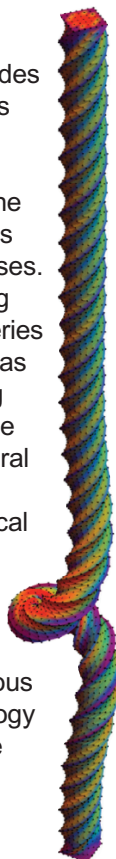
We want to take this opportunity to thank everyone involved in the conference. First, thanks to everyone who contributed to this conference by organizing a mini-symposium, giving a talk, or creating a poster! This is the only way a conference can ever be a success. Then we would like to thank the countless people working behind the scenes including student and administrative assistants. Without your work, such a conference cannot be held. Finally, special thanks to the event organizers: Dominik Brands, Hauke Gravenkamp, Richard Ostwald, Lisa Scheunemann, Alexander Schwarz, and Carina Schwarz. This has been a fantastic conference in a professional environment with a pleasant atmosphere! ●

GACM Best Ph.D. Award 2021

We are pleased to announce that the outstanding doctoral thesis of Tobias Bode was honored with the GACM Best Ph.D. Award 2021. His thesis, "Peridynamic Galerkin Methods for Nonlinear Solid Mechanics," was conducted at Leibniz Universität Hannover and has been performed under the academic supervision of Prof. Peter Wriggers.

Large deformations occur in additive manufacturing and many other engineering processes - such as forming or machining. These finite deformations lead to considerable mesh distortions in classical finite element methods, such that computationally expensive adaptive methods have been developed to obtain meaningful predictions with FEM of the process sequences. To reduce the complexity of FEM, new mesh-free methods have been increasingly developed in recent years, which allow the calculation of large deformations without the need to adjust meshes adaptively. One promising method is based on peridynamics, which uses an alternative approach to describe the partial differential equations of solid mechanics. The combination of particle discretizations and the so-called peridynamic correspondence principle provides a mesh-free simulation method, which is flexible but not robust in its original form.

This was the starting point of the work of Mr. Bode. He has improved the peridynamic correspondence formulation utilizing a Galerkin method, which provides new conditions for the choice of the shape functions and the application of the Dirichlet and Neumann boundary conditions. This method allows for stabilizations and enrichments, similar to those of the finite element method, to improve performance, thus enabling the calculation of complex forming processes. The applicability of peridynamics to real engineering problems is verified in the thesis by computing a series of challenging test examples. Thus, Tobias Bode has developed a new numerical method for engineering applications with finite deformations. In doing so, he developed a stable and efficient variant of the general peridynamic mesh-free discretization method. Mr. Bode contributed the thesis to both the theoretical and algorithmic formulations. Here, he had to break new ground and thus made significant contributions of his own, which have already been recognized in the scientific community and found their way into several publications in prestigious journals. This was possible because the methodology is new and has been considered in this form for the first time in an international context. ●



GIMC SIMAI YOUNG WORKSHOP

Pavia, 29-30 September 2022



The AIMETA Computational Mechanics Group (GIMC) is pleased to announce that the workshop had a great success:

Senior Plenary Lecturer

- Antonia Larese, University of Padua (ITALY)
- Giancarlo Sangalli, University of Pavia (ITALY)



Young Plenary Lecturers

- Francesco Regazzoni (SIMAI)
- Lorenzo Tentarelli (SIMAI)
- Alessia Patton (GIMC)
- Giulia Bertaglia (GIMC)

Thematic Minisymposia

19 minisymposia spanning a wide range of topics in applied mathematics and computational mechanics. ●



MINISYMPOSIUM GIMC
(Italian Group of Computational Mechanics)
at the AIMETA Congress, Palermo, 4-9 September 2022



The AIMETA Computational Mechanics Group (GIMC) is pleased to announce that the minisymposium GIMC was very successful and had a large turnout:

- 41 presentations and more than 80 participants, from Italian and foreign Universities. ●

GIMC GMA GBMA 2023
Reggio Calabria, 12-14 July 2023



The joint Conference of the AIMETA Groups GIMC (Computational Mechanics Group), GMA (Mechanics of Materials Group) and GBMA (Biomechanics Group) will be held at the Università Mediterranea di Reggio Calabria, during July 12-14, 2023.

The abstract submission deadline is April 1, 2023.

Further information is available at <http://www.gimc-gma-gbma-2023.unirc.it/> ●

10th International Congress of the Croatian Society of Mechanics 10th ICCSM

The Croatian Society of Mechanics is an association with the objective of promoting education, research and application in the field of fluid and solid mechanics. Within the framework of this Society, scientific gatherings have been organised in order to make an environment for the exchange of new ideas and achievements in mechanical sciences. The 10th International Congress of the Croatian Society of Mechanics (10th ICCSM) was held on September 28-30 in Pula, the city of the Istrian peninsula, and one of the Croatia's most popular tourist destination. The congress was co-organised by the Central European Association for Computational Mechanics (CEACM), under the auspices of the Croatian Academy of Sciences and Arts. The General Chairs of the congress were Zdenko Tonković, President of the Croatian Society of Mechanics (CSM) and Jurica Sorić, member of the Executive Committee of CSM and former CEACM President. The International Scientific Committee was composed of 57 prominent researches from 14 different countries.

More than 150 participants from 16 countries took part in this scientific event. Four plenary and 137 regular lectures were presented. The plenary lecturers were Ferdinando Auricchio (University of Pavia), Laura De Lorenzis (ETH Zuerich), Marc Geers (Eindhoven University of Technology) and Joerg Schroeder (University Duisburg-Essen). There were four organised sessions dealing with current research topics in mechanical

sciences. A special session entitled "Advanced Numerical Methods in Structural Analysis: Recent Developments and Future Challenges" was organised by the CEACM in honour of Professor Sorić on the occasion of his retirement, as recognition for his scientific contribution in the field of numerical mechanics, especially for his longtime activities in the CEACM. On behalf of the CEACM, the session co-organisers were Adnan Ibrahimbegovic, current CEACM President; Bernhard Pichler, Past-President and Zdenko Tonković, member of the CEACM Board. The extended abstracts of all the presentations were published in the Book of Abstracts.

During the congress dinner, the awarding ceremony of CEACM awards, conducted by Adnan Ibrahimbegović, took place. This year two CEACM awards were initiated to honour outstanding researchers in the field of computational mechanics: the CEACM Prof. Mang Award for senior scientists and the CEACM Best Thesis Award for young researchers. The laureates are Adnan Ibrahimbegović and Vladimir Kompiš for the CEACM Prof. Mang Award and Henrik T. Sykora for the CEACM Best Thesis Award.

After the dense days of fruitful scientific gathering, the congress participants enjoyed local hospitality, food, culture, and sight-seeing in the beautiful city of Pula. More details on the congress can be found at the website <http://www.iccsm2022.fsb.hr>. ●

Figure 1:

*Awarding Ceremony
of the CEACM Awards.*

From left to right:

*Adnan Ibrahimbegović
(CEACM President),
Zdenko Tonković
(member of CEACM
Scientific Board),
Janos Logo
(CEACM Vice-President)
& Bernhard Pichler
(CEACM Past-President)*



Figure 2:

*Participants at the
10th ICCSM
after Closing Ceremony*





SOCIEDAD CHILENA DE MECÁNICA COMPUTACIONAL

for all inclusions under **SCMC** please contact
**Marcela Cruchaga &
Jorge Hinojosa**
scmc.correo@gmail.com

The Chilean Society of Computational Mechanics (SCMC) established in 1995, is the entity that brings together researchers and engineers in the area of computational mechanics in Chile.

Since 2003, the SCMC, together with several Chilean Universities as hosts, organizes the Conference on Computational Mechanics (JMC), the main workshop/conference on the application and development of numerical methods for calculation and design in engineering and applied sciences in Chile.

During the year 2020, due to the pandemic, JMC was not held, but works were disseminated through videos carried out by Chilean students and their tutors, which were shared on social networks.

During 2021, also in a pandemic situation, the JMC was held virtually, organized by the Universidad Técnica Federico Santa María de Chile, where more than 100 papers were presented.

In the year 2022, the MC2022 was the 20th version of the Computational Mechanics Conference and was organized by the Austral University of Chile 100% in person, on October 6 and 7 in the city of Valdivia <https://jmc2022.web.app/>, with the participation of national and international undergraduate and postgraduate students and researchers and with the sponsorship of important companies in the area of computer simulation and providers of computer equipment such as ESSS and SIASA. Invited presentation were made by Professor Jean-Philippe Ponthot from University of Liege, Belgium, Professor Cristián Escauriaza from Pontificia Universidad Católica de Chile and Professor Franco Perazzo from Universidad Técnica Federico Santa María de Chile.



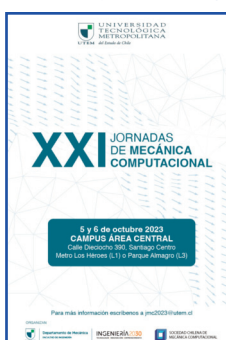
Figure 1:
Prof. Jean-Philippe Ponthot
University of Liege (Belgium)



Figure 2:
Prof. Cristián Escauriaza
Pontificia Universidad
Católica de Chile



Figure 3:
Prof. Franco Perazzo
Universidad Técnica
Federico Santa María
de Chile



The next Conference on Computational Mechanics XXI will be organized in the city of Santiago, by the Metropolitan Technological University on October 5 and 6, 2023, for more information contact jmc2023@utem.cl.

We cordially invite you to participate and spread this invitation. ●



In 1997, a visionary group of researchers and faculty members of several Brazilian universities decided to establish an association to foster the Computational Mechanics area in Brazil. It was September 15th, in a meeting held at LNCC (National Laboratory of Scientific Computation) in Rio de Janeiro. That was the foundation stone of ABMEC, the Brazilian Association for Computational Methods in Engineering. In 2022, ABMEC celebrates its 25th anniversary, with a modern webpage (www.abmec.org.br), promoting a very traditional and successful conference, the XLIII CILAMCE, in a fully face-to-face format, and renewed by the election of a new director board and half of its executive council.



Figure 1:
XLIII CILAMCE

The most important event promoted by ABMEC is the Ibero-Latin American Congress on Computational Methods in Engineering, CILAMCE. In 2020, the mini-symposia call was closing when WHO declared the COVID pandemic. The first option was to cancel CILAMCE. Despite all the uncertainties ahead, we took the support of the Brazilian Computation Methods community for granted, and CILAMCE was redesigned for a virtual format.

Thanks to the efforts of the organizing committee chaired by Prof. Aref Kazan (chairman) and Prof. André Torii (co-chairman) from UNILA (Federal University of the Latin-American Integration), the XLI CILAMCE became a huge success. The following year, we had an even more impressive challenge, organizing with IACM, the third edition of PANACM jointly with the XLII CILAMCE.



Figure 2:
Iguazu Falls

The format was still virtual, but a studio based in Rio de Janeiro was used to broadcast the live participation of the plenary speakers. Prof. Alvaro Coutinho (chairman) from UFRJ (Federal University of Rio de Janeiro), Prof. Eduardo Campello (co-chairman) from USP (University of Sao Paulo) and Prof. Sandra Malta (co-chairwoman) from LNCC were able to organize a successful event with a large number of pre-recorded talks, mini-symposia, and participants from Brazil and outside.

This year, from November 21 to 25, in a fully face-to-face format, the XLIII CILAMCE was held in Foz do Iguaçu. This city, where Brazil borders Argentina and Paraguay, is the gateway to Iguazu Falls, one of the New Seven Natural Wonders of the World. After two long years, the Brazilian community of Computational Methods was able to meet in person, making this conference unforgettable. The success of the event can be illustrated by the 413 approved complete papers, 37 mini-symposia, and 392 participants from Brazil, Latin America, North America, and Europe. Prof. Andre Torii (chairman) from UNILA and Prof. Marco Argenta (co-chairman) from UFPR (Federal University of Paraná) worked tirelessly to provide a remarkable and full of novelties conference. One of them was a mini-symposium conceived to present the practical application of Computational Methods for students from the high schools of Foz do Iguaçu.

It was a fantastic experience for the young students to be in contact with the research of some of our senior delegates. CILAMCE participants were presented

with five high-level plenary lectures, given by Prof. Junuthula N. Reddy from Texas A&M University, Prof. Emilio C. N. Silva from the University of São Paulo, Prof. Bruno Sudret from ETH Zürich, Prof. Silvana M. B. A. da Silva from the Federal University of Pernambuco and Prof. Peter Wriggers from Leibniz University at Hannover. Closing the conference, all participants gather to watch Brazil's victory over Serbia in the World Cup.

The year 2022 will be marked not only due to the new beginning of a face-to-face CILAMCE. Also, important changes were established by the election of the director board and half of the executive council. For the first time, our association will have as a president a woman, Prof. Suzana Avila from UnB (University of Brasília). This remarkable fact and the election of another woman, Prof. Silvana Silva from the UFPE (Federal University of Pernambuco), for the executive council highlight the increasing contribution of women to Computation Methods in Brazil.

As the Christmas holidays approach, we would like to announce the XLIV CILAMCE that will be held in Porto City, Portugal, from November 13 to 16. Our hosts will be FEUP (Faculty of Engineering of the University of Porto) and ISEP (Superior Institute of Engineering of Porto). Then, have you all a Merry Christmas, and welcome to join us at Porto City for the upcoming XLIV CILAMCE 2023. ●

Warmest regards

Prof. Felício Bruzzi Barros
ABMEC President
(Federal University of Minas Gerais)

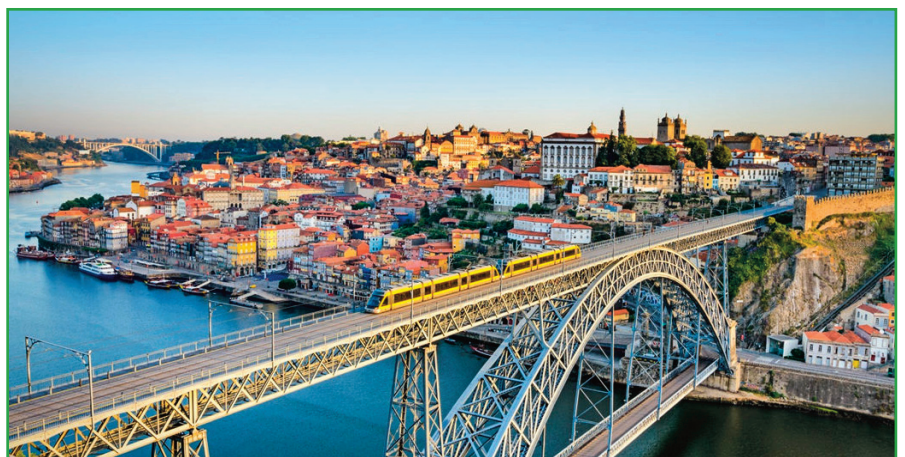
Figure 3:
Prof. Marco Argenta (co-chairman) & Prof. André Torri (chairman)



Figure 4:
CILAMCE participants celebrating the first goal of the Brazilian Team in the World Cup



Figure 5:
Porto City



Report from the Japan Association for Computational Mechanics

The Japan Association for Computational Mechanics (JACM) is a union of researchers and engineers working in the field of computational mechanics mainly in Japan. The JACM is a loosely coupled umbrella organization covering 29 computational mechanics related societies in Japan through communication with e-mail and web page (<https://ja-cm.org/index-e.html>). The number of individual members is about 330. JACM members actively participate in the IACM activities.



Figure 1:
Professor Hiroshi Okada, President of JACM,
reporting about the recent activities of JACM

On September 17, 2022, the 2022 JACM annual meeting and award ceremony were held in Morito Memorial Hall of Tokyo University of Science in Tokyo. The annual meeting celebrated the 20th anniversary of JACM. JACM was established on December 17, 2002. The main function of JACM has unchanged over the years. That is the bridge between researchers/engineers in the field of Computational Mechanics in Japan and the activities of IACM. The meeting was also broadcasted by Zoom to remote participants (Figure 1).



Figure 2:
Recipients of the 2022 JACM Computational
Mechanics Award, (a) Prof. Tomonari Furukawa (Uni.
of Virginia) (b) Prof. Seiya Hagihara (Saga Uni.) &
(c) Prof. Nobuyuki Oshima (Hokkaido Uni.)

In this year, JACM inducted eight new honorary members. Before the award ceremony, new honorary members were introduced. They have distinguished records of researches and services to computational mechanics related professional societies. The new honorary members are:

Professor Nobutada Ohno (Professor Emeritus, Nagoya University and Nagoya Industrial Science Research Institute),
Professor Kikuo Kishimoto (Professor Emeritus, Tokyo Institute of Technology and New Energy and Industrial Technology Development Organization),
Professor Michihisa Tsutahara (Professor Emeritus, Kobe University),
Professor Kazuhiro Nakahashi (Professor Emeritus, Tohoku University),
Professor Toshiaki Hisada (Professor Emeritus, The University of Tokyo, UT-Heart Inc),
Professor Kozo Fujii (Tokyo University of Science),
Professor Yoichiro Matsumoto (Professor Emeritus, The University of Tokyo) and
Professor Takami Yamaguchi (Professor Emeritus, Tohoku University).

Each of new honorary members gave a short speech, after their introductions.

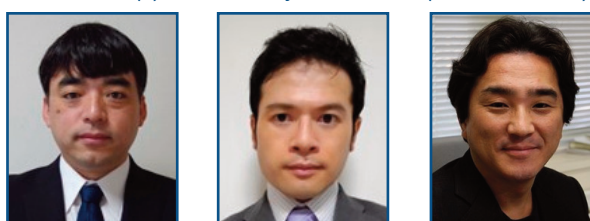


Figure 3:
Recipients of the 2022 JACM Fellows Award,
(a) Prof. Masao Ogino (Daido Uni.),
(b) Prof. Akihiro Takezawa (Waseda Uni.) &
(c) Prof. Satoyuki Tanaka (Hiroshima Uni.)



Figure 4:
Recipients of JACM Young Investigators Award,
(a) Prof. Yusuke Kuwata (Osaka Metropolitan Uni.),
(b) Prof. Hiroya Mamori (The Uni. of
Electro-Communications) &
(c) Prof. Tomohiro Otani (Osaka Uni.)

Following the introduction of the new honorary members, the award ceremony took place. There are three categories of JACM Awards. They are the JACM Computational Mechanics Award which is the highest award, JACM Fellows Award and the JACM Young Investigator Award.

Professor Tomonari Furukawa (University of Virginia),
Professor Seiya Hagihara (Saga University) and **Professor**

Nobuyuki Oshima (Hokkaido University) were awarded 2022 the JACM Computational Mechanics Award (*Figure 2*).

The recipients of the JACM Fellows Award were **Professor Masao Ogino** (Daido University), **Professor Akihiro Takezawa** (Waseda University) and **Professor Satoyuki Tanaka** (Hiroshima University) (*Figure 3*).

The winners of JACM Young Investigator Award were **Professor Yusuke Kuwata** (Osaka Metropolitan University), **Professor Hiroya Mamori** (The University of Electro-Communications) and **Professor Tomohiro Otani** (Osaka University) (*Figure 4*).

The second part of the annual meeting, **Professors Shinobu Yoshimura**, the former president of JACM and **Shu Takagi**, recipient of 2021 JACM Computational Mechanics Award, delivered special lectures for the occasion of the 20th anniversary of JACM (*Figure 5*).

Professor Yoshimura talked about the history of JACM. It included activities among the Japanese researchers just before JACM was established in 2002. **Professor Genki Yagawa**, Professor Emeritus the University of Tokyo and Toyo University, took the leading role. Then, JACM became almost its present form in two year. After 2005, JACM slowly evolved and grew over the years. **Professor Yoshimura** showed memorable photographs from the past JACM meetings.

Professor Shu Takagi of the University of Tokyo presented his work on computational fluid dynamics analysis on free-surface flow problems. We all enjoyed his presentation.

At the end of the 2022 JACM meeting, we took a group photo (*Figure 6*). ●

Figure 6:
Group Photo (All the participants)

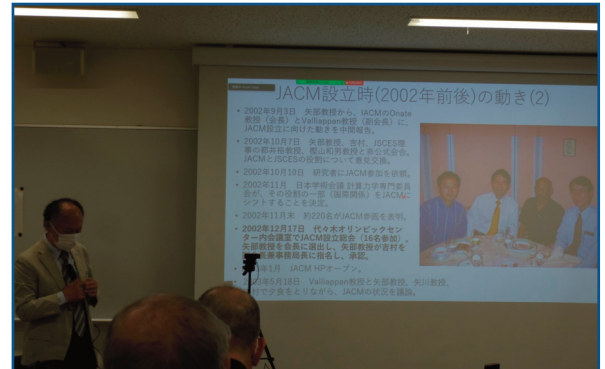
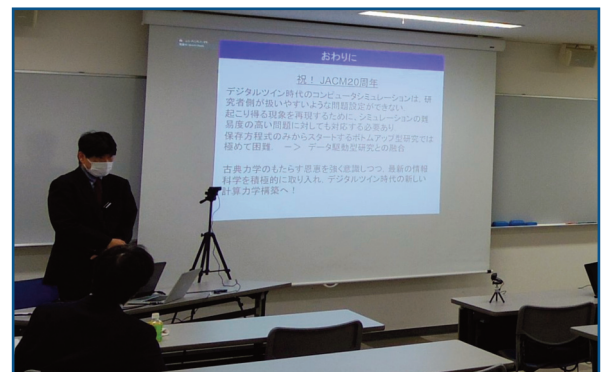


Figure 5: above & below
(above) Prof. Shinobu Yoshimura (The Uni. of Tokyo)
& (below) Prof. Shu Takagi (The Uni. of Tokyo)
delivering their talks



MECOM 2022

XXXVIII Argentine Congress on Computational Mechanics

Bahía Blanca, Buenos Aires, Argentina

The XXXVIII Argentine Congress on Computational Mechanics (MECOM 2022) took place from November **1st through November 4th, 2022**, in the city of Bahía Blanca, Buenos Aires, Argentina. This new edition of the annual AMCA Congresses was organized by the Applied Multiphysics Research Group (GIMAP), dependent on the Bahía Blanca Regional Faculty of National Technological University (UTN) and the National University of the South (UNS), together with the Argentine Association for Computational Mechanics (AMCA).

The Organizing Committee included Prof. Sebastián P. Machado (Chairman), Prof. Franco E. Dotti (Co-Chairmen), Prof. Carlos Vera, Dr. Santiago M. Osinaga and Dr. José Ramírez. The Scientific Committee was chaired by Prof. Mariano Febbo with Prof. Martín Saravia as Co-Chairmen.

Figure 1:

Opening Ceremony, from left to right: Prof. Sebastián Machado (chair of the congress), Prof. Mariano Febbo (scientific Committee), Prof. Daniel Vega (rector of UNS), Ana Scarabino (vocal of AMCA) & Alejandro Staffa (dean of UTN-FRBB)



The Congress hosted seven Invited Lecturers, Prof. Marcelo Savi (Department of Mechanical Engineering in Universidad Federal de Rio de Janeiro, Brasil), Prof. Rainald Löhner (George Mason University, USA), Prof. Tim Colonius (California Institute of Technology -Caltech, USA), Prof. Alper Erturk (Georgia Institute of Technology, USA), Prof. Elbio Palma (National University of the South, Argentina), Prof. Marian Wiercigroch (Aberdeen University, UK), Dr. Ricardo Lebenshon (Alamos National Laboratory's Theoretical Division, USA). Also, four Keynote Lectures were delivered by Prof. Marta Rosales (National University of the South, Argentina), Prof. Tomasz Kapitaniak (Technical University of Lodz, Poland), Adrian Lew (Stanford University, USA) and Prof. Ekaterina Pavlovskaja (Aberdeen University, UK).

Figure 2:

All conference participants at the UNS main entrance

Full-length papers were submitted to a peer review process prior to publication. Accepted papers have been published in the proceedings series "Mecánica Computacional", which are openly available at the following website:



<http://www.amcaonline.org.ar/mcamca>. The Conference consisted of 20 Technical Sessions with more than 220 papers presented.

A special session was devoted to undergraduate students, with awards for best posters, that were granted to:

1. **Delfina Criado**, from the Applied Multiphysics Research Group (GIMAP) of the National Technological University at Bahia Blanca, Argentina.
2. **José Fernández Palmieri** from the Applied Multiphysics Research Group (GIMAP) of the National Technological University at Bahia Blanca, Argentina.
3. **Lucas Donnet y Martín Zanatta**, from National Technological University (UTN) at Santa Fe, Argentina.

The Congress also included other activities like the X Meeting of OpenFOAM users, a short course about Piezoelectric energy harvesting by Alper Erturk and the special session to honor Prof. Marta Rosales and Diana Bambill for their retirement. ●



Figure 3:
Prof. Sergio Idelsohn receiving the AMCA Award from Prof. Victor Fachinotti



Figure 4:
Welcome cocktail



Figure 5:
Participants of the Congress during of a conference

Call for Papers

The Argentine Association for Computational Mechanics (AMCA) announces the XXXIX Argentine Congress on Computational Mechanics, and the first Argentine – Uruguay Congress on Computational Mechanics (MECOM 2023) to be held in **Concordia, Argentina, and Salto, Uruguay**, organized by Facultad Regional Concordia (FRCon), of the Universidad Tecnológica Nacional (UTN), Centro Universitario Regional Litoral Norte (CENUR LN), of the Universidad de la República, Uruguay, and AMCA.

<https://amcaonline.org.ar/mecom2023/> ●



KSCM 2022 2022 KSCM Conference on Computational Mechanics

The 2022 Annual KSCM Conference was held for 3 days in the Yongpyong Resort, 210 km east of Seoul, Gangwon-do, Korea, from 22 to 24 June, 2022. The conference organized by the Korean Society for Computational Mechanics aims to bring together Korean researchers and foreign graduate students in the field of computational mechanics and to encourage research exchange and networking. 72 professors and students registered and listened to research on the latest research topics on computational mechanics.

Figure 1:

*The photo of all participants
for the 2022 conference*



In the conference, the academic awards ceremony was also held and three types of awards and rewards were given to six professors. Yoon Young Kim (Seoul National University) received the KSCM Medal Award; Sungsoo Na (Korea University), Sang-Joon Shin (Seoul National University), and Jungwook Hong (KAIST) received KSCM Academic Award; Do-Nyun Kim (Seoul National University) and Jae Wook Kim (Seoul National University) won the Young Investigator Award. In addition, 3 graduate students (Mr. Park, Song, and Kim) received the Outstanding Poster Award.

Figure 2:

*The commemorative photo
of all participants' dinner*



Further information will be found at: <http://www.kscm-society.org/>.

2022 KSCM Year-end Workshop on Computational Mechanics

The 2022 KSCM Year-end Workshop will be held at the Sofitel Ambassador Hotel on December 29, 2022, Seoul, Korea. Three famous speakers from world class companies and university in Korea will give lectures on the latest technology trend. ●

A PMTAC, the Portuguese Association of Theoretical, Applied and Computational Mechanics and SEMNI, the Spanish Society of Computational Mechanics and Computational Engineering, had their joint **Congress on Numerical Methods, CMN 2022**, that took place in Las Palmas de Gran Canaria in Spain, in 12-14 September 2022. It was the eleventh congress of this series, which is celebrated every two years by the two societies since 2002, and where members of the two societies present and discuss their more recent research work. During the congress there was a special session in honour of **Prof. Manuel Casteleiro**, former president of SEMNI who has passed away recently. Manuel Casteleiro has been, for more than two decades, one of the promoters of the close relations between the two societies. On the occasion the organizers of the conference promoted a fruitful discussion on the future of Computational Mechanics, surely a fine way to honour his memory by not only remembering his scientific legacy, but also by looking at the future he helped to carve. The next common conference of the two societies will be held in September 2024 in Aveiro, Portugal.



Figure 1:
Session honouring
Manuel Casteleiro:
“A look into the future of
Computational Mechanics”

Some forthcoming international congresses in Portugal

- APMTAC is the main organizer of the next ECCOMAS CONGRESS 2024, <https://eccomas2024.org/>, the **9th European Congress on Computational Methods in Applied Sciences and Engineering**. The main motivation of APMTAC is to contribute to promote joint efforts of European Universities, Research Institutes and Industries which are active in the broader field of Numerical Methods and Computer Simulations in Engineering and Applied Sciences, but also to attract researchers from all over the world to this great event that will take place on 3-7 June 2024, in Lisbon, Portugal.
- The **7th ECCOMAS Young Investigators Conference (YIC2023)**, <https://yic2023.fe.up.pt/>, will be held at the Faculty of Engineering of the University of Porto (FEUP), Portugal, 19-21 June 2023. APMTAC supports this conference which organizing committee is composed of young researchers from the Mechanical and Civil Engineering Departments of FEUP, and INEGI, the Institute of Science and Innovation in Mechanical and Industrial Engineering. ●

Spanish-Portuguese Congress on Numerical Methods held in Las Palmas de Gran Canaria last September

Once the pandemic has been overcome, the Spanish and Portuguese societies of Computational Mechanics, SEMNI and APMTAC, have held their joint conference in a magnificent venue: Las Palmas de Gran Canaria, in the Canary Islands. The conference was held at the Alfredo Kraus conference centre of the city, with almost 200 participants.



Karen Willcox opened the conference with a brilliant plenary conference on reduced-order models, digital twins and predictive science. Also plenary lecturers were profs. Antonio Huerta, Renato Natal, Carlos Pina, Paulo Flores and Ricardo Vinuesa.

With a lot of special activities for our young researchers, the conference was an excellent place where we could finally meet in person after the pandemic. ●



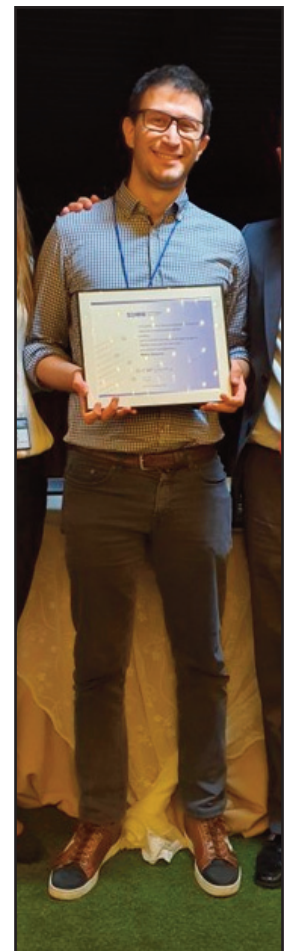
SEMNI awarded its annual prizes

On the occasion of the Conference on Numerical Methods held in the Canary Islands, and during the gala dinner of the congress, SEMNI awarded its prizes to their recipients.

These were **Rubén Ibañez** and **Alberto Badías**, awardees for the best thesis defended during 2019 and 2020 respectively, and **David Codony** for the best thesis defended during 2021. SEMNI's young research prize, the Juan C. Simó prize, was awarded to **Emilio Martínez-Pañeda**, from Imperial College, as the recipient of the 2020 award, **Marcos Latorre** of the 2021 award and **Matteo Giacomini**, as the recipient of the 2022 prize—exceptionally, and due to the pandemic, this year we awarded the prizes corresponding to three years. ●

Figures below:

Left to Right
Alberto Badías,
Emilio Martínez-Pañeda,
Marcos Latorre,
and **Matteo Giacomini**
receiving their respective
prizes



Antonio Huerta SEMNI's O. C. Zienkiewicz prize 2022

Finally, the award ceremony arrived at its most important moment, the one in which we awarded the O.C. Zienkiewicz prize to Prof. Antonio Huerta. The O. C. Zienkiewicz prize is the highest distinction awarded by SEMNI every two years and recognizes individuals for their lifelong contributions to science and our community. Congratulations, Antonio! ●



WCCM-APCOM YOKOHAMA2022

15th World Congress on Computational Mechanics &
8th Asian Pacific Congress on Computational Mechanics

The 15th World Congress on Computational Mechanics (WCCM-XV) and the 8th Asian Pacific Congress on Computational Mechanics (APCOM-VIII), WCCM-APCOM 2022, was held in a fully virtual format from July 31 to August 5, 2022, and successfully concluded.

Registration	Seoul 2016		New York 2018		Paris 2020		Yokohama 2022	
Asian Pacific	1391	67%	814	27%	433	14%	1257	54%
Americas	247	12%	1293	42%	489	16%	408	17%
Europe – Middle East – Africa	432	21%	937	31%	2096	69%	680	29%
Total	2070		3044		3018		2345	

The decision to host the WCCM in Yokohama was made in May 2018, and the first Organizing Committee meeting was held on January 23, 2020. However, a state of emergency was declared in Japan in April 2020 due to the global spread of the new coronavirus. Therefore, the policy was changed to hold the meeting in a hybrid format combining face-to-face and virtual sessions. However,

due to the repeated spread and containment of infection by mutant strains since then, the format was further changed to a fully virtual format in February 2022.

The fully virtual format at WCCM-APCOM 2022 was designed so that after presenters submitted their abstracts, they could create a video of their presentation and upload it to the video site prior to the conference, allowing conference participants to view it online and enter comments if they had questions. For the plenary/semi-plenary lectures, and mini-symposiums, live sessions were set up during the conference period to provide an opportunity to ask questions directly to the presenters, albeit virtually. Several Short Courses by the IACM and meetings by the Female Researchers Chapter were also held as Side Events.

Figure 1:
Number of all participants & the number of participants by region, together with data from the previous three WCCMs

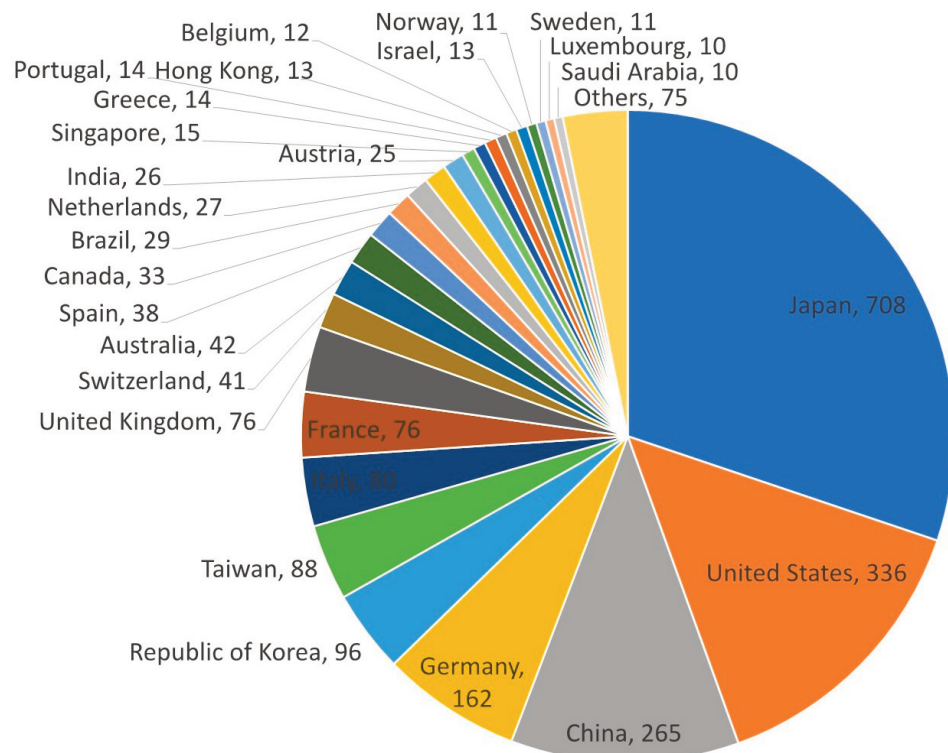


Figure 2:
Breakdown of registered participants by country

As a result of this format, statistical information shows that there were 6 plenary lectures, 15 semi-plenary lectures, 287 total mini-symposia, and 2,065 total abstract submissions.

In fact, while the number of abstract submissions as of the end of February 2022 was 3,061 in the declared hybrid event, the decision to hold the event completely virtual format means that more than 30% of the abstracts were canceled (as of August 8, 2022).

The number of participants was 2,345, slightly higher than the number of presentations. Table 1 shows the number of all participants and the number of participants by region, together with data from the previous three WCCMs. The breakdown of registered participants by country is also shown in *Figure 2*. It should be noted that the number of participants from the Asia-Pacific region, which accounted for half of the participants, exceeded the number of registrants for the previous WCCM-APCOM, which was held face-to-face in the same region.

With the help of many people in various phases of the event, from the invitation to the day of the event, we managed to successfully complete WCCM-APCOM 2022. I would like to express my sincere gratitude to all of you as the Congress Chair. ●

Junji Kato,
Deputy Secretary General
Kenjiro Terada
Secretary General
Seiichi Koshizuka
Congress Chair

JSCES Summer Camp for Students 2022

“The summer camp for students 2022,” a successful series hosted by JSCES from 2013, was held online. This event was held annually onsite through 2019, but was cancelled in 2020 due to COVID-19. Since 2021 we have launched online special events. This year, six video interviews were made available to members as the special online event (*Figure 3*). Three doctoral students presented their ongoing researches and their motivation for entering the doctor course, and three keynote speakers gave talks on their research experiences and their career in universities, national laboratories and industry. ●

Naoto Mitsume
Tsukuba University

Figure 3:
Homepage for the online special event and interview videos



conference diary planner

5 - 8 March 2023	KomPlas Tech 2023 - XXVIII Conference on Computer Methods in Materials Technology Venue: Poland Contact: https://www.eccomas.org/conferences/
30 - 31 March 2023	SYMCOMP 2023 - VI Int Conf on Numerical 6 Symbolic Computation: Dev & Applications Venue: Évora, Portugal Contact: https://www.eccomas.org/conferences/
19 - 21 April 2023	2022 UKACM conference - Uk Association for Computational Mechanics Venue: Warwick, U.K. Contact: https://ukacm.org/
25 - 28 April 2023	CFC 2023 - 22nd IACM Computational Fluids Conference Venue: Cannes, France Contact: https://cfc2023.iacm.info/
20 - 22 May 2023	CM3 – Transport 2023 Computational Multi Physics, Multi Scales and Multi Big Data Venue: Jyväskylä, Finland Contact: https://www.eccomas.org/conferences/
30 May - 1 June 2023	Math 2 Product (M2P) - 1st Emerging Tech in Comp Science for Industry, Sustainability & Innovation Venue: Taormina (Messina), Italy Contact: https://m2p2023.cimne.com/
1 - 3 June 2023	EUROGEN 2023 - 15th Int Conf on Evolutionary & Deterministic Methods for Design, Optimization & Control Venue: Chania, Crete, Greece Contact: https://www.eccomas.org/conferences/
5 - 7 June 2023	COUPLED PROBLEMS 2023 - Int Conf on Coupled Problems in Science & Engineering Venue: Chania, Crete Island, Greece Contact: https://coupled2023.cimne.com/
12 - 14 June 2023	COMPDYN 2023 - IX Int Conf on Comp Methods in Structural Dynamics & Earthquake Engineering Venue: Athens, Greece Contact: https://www.eccomas.org/conferences/
12 - 14 June 2023	UNCECOMP 2023 - V Int Conf on Uncertainty Quantification in Computational Sciences & Eng Venue: Athens, Greece Contact: https://www.eccomas.org/2022/04/01/thematic-conference-2023/
18 - 21 June 2023	YIC2023 - The 7th ECCOMAS Young Investigators Conference Venue: Porto, Portugal Contact: https://yic2023.fe.up.pt/
18 - 21 June 2023	IGA 2023 - IX International Conference on Isogeometric Analysis Venue: Lyon, France Contact: https://www.eccomas.org/conferences/
19 - 21 June 2023	ADMOS 2023 - International Conference on Adaptive Modeling & Simulation Venue: Gotheburg, Sweden Contact: https://admos2023.cimne.com/
21 - 23 June 2023	CFRAC 2023 - The 7th Int Conf on Comp Modeling of Fracture & Failure of Materials & Structures Venue: Prague, Prague, Czechia Contact: https://www.eccomas.org/conferences/
25 - 27 June 2023	MSF 2023 - 6th International Conference on Computational Methods for Solids & Fluids Venue: Sarajevo, Bosnia-Herzegovina Contact: https://eccomas.gf.unsa.ba/msf-2023/
27 - 29 June 2023	MARINE 2023 - X International Conference on Computational Methods in Marine Engineering Venue: Madrid, Spain Contact: https://marine2023.cimne.com/
25 - 27 June 2023	MSF 2023 - V International Conference on Computational Methods for Solids & Fluids Venue: Sarajevo, Bosnia-Herzegovina Contact: https://eccomas.gf.unsa.ba/msf-2023
3 - 6 July 2023	SMART 2023 - IX Conference on Smart Structures and Materials Venue: Patras, Greece Contact: https://www.eccomas.org/conferences/
5 - 7 July 2023	ICCCM 2023 - 7th International Conference on Computational Contact Mechanics Venue: Torino, Italy Contact: https://www.eccomas.org/conferences/
12 - 14 July 2023	AIMETA Groups - GIMC (Comp. Mechanics), GMA (Mechanics of Materials) & GBMA (Biomechanics) Venue: Calabria, Italy Contact: http://www.gimc-gma-gbma-2023.unirc.it/
18 - 21 July 2023	CMP4 2023 - Computational Modelling of Multi-Uncertainty & Multi-Scale Problems Venue: Porto, Portugal Contact: https://www.eccomas.org/conferences/
23 - 27 July 2023	17th U. S. National Congress on Computational Mechanics Venue: Albuquerque, NM, USA Contact: 17.usnccm.org
24 - 28 July 2023	MULTIBODY 2023 - ECCOMAS Thematic Conference on Multibody Dynamics Venue: Lisboa, Portugal Contact: https://www.eccomas.org/conferences/
25 - 29 July 2023	USNCCM16 - 16th U.S. National Congress on Computational Mechanics Venue: Chicago, Illinois Contact: http://16.usnccm.org/
26 - 28 July 2023	SIM-AM 2023 - IV International Conference on Simulation for Additive Manufacturing Venue: Munich, Germany Contact: https://www.eccomas.org/conferences/
20 - 23 Aug 2023	M-FET 2023 - III Modern Finite Element Technologies – Mathematical & Mechanical Aspects Venue: Mülheim, Germany Contact: https://www.eccomas.org/conferences/
28 - 30 Aug 2023	CSAI 2023 - Computational Sciences and Artificial Intelligence in Industry Venue: Trondheim, Norway Contact: https://www.eccomas.org/conferences/
4 - 7 Sept 2023	PCM-CMM 2023 - 25th International Conference on Computer Methods in Mechanics Venue: Gliwice, Poland Contact: http://cmm-solmech.ippt.pan.pl/
5 - 7 Sept 2023	COMPLAS 2023 - XVII Int. Conference on Computational Plasticity Venue: Barcelona, Spain Contact: https://complas2023.cimne.com/
11 - 13 Sepy 2023	10th GACM Colloquium - 30th Anniversary of the German Association for Computational Mechanics Venue: Vienna, Austria Contact: https://www.gacm.de/news
12 - 14 Sept 2023	COMPOSITES 2023 - IX Conference on Mechanical Response of Composites Venue: Trapani, Italy Contact: https://www.eccomas.org/conferences/
24 - 27 Sept 2023	2nd IACM Mechanistic Machine Learning & Digital Twins for Computational Science, Eng. & Technology Venue: El Paso, TX, USA Contact: https://www.utep.edu/engineering/mmlde/index.html
2 - 4 Oct 2023	Structural Membranes 2023 - XI Int Conference on Textile Composites & Inflatable Structures Venue: Valencia, Spain Contact: https://structuralmembranes2023.cimne.com/
9 - 11 Oct 2023	PARTICLES 2023 - VII International Conference on Particle-based Methods Venue: Milano, Italy Contact: https://congress.cimne.com/particles2023/
10 - 13 Oct 2023	CMCS 2023 - II Int Conf on Computational Modeling of Complex Materials Across the Scales Venue: Eindhoven, Netherlands Contact: https://www.eccomas.org/conferences/
13 - 16 Nov 2023	XLIV CILAMCE - Ibero-Latin American Congress on Computational Methods in Engineering Venue: Porto, Portugal Contact: https://cilamce.com.br/
3 - 7 June 2024	9th European Congress on Computational Methods in Applied Sciences and Engineering Venue: Lisbon, Portugal Contact: https://eccomas2024.org/
21 - 26 July 2024	WCCM/PANACM - 16th World Congress on Comp Mechanics & 4th PANACM Congress Venue: Vancouver, Canada Contact: https://www.cacse-acscg.ca/