

ERIC NEIVA

POSTDOC ON FEM FOR CELL MORPHOGENESIS AT TURLIERLAB – CIRB – COLLÈGE DE FRANCE & CNRS

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PROFESSIONAL EXPERIENCE

- **Postdoctoral researcher** – Dr. Hervé Turlier laboratory 01/11/21 – Present
Centre Interdisciplinaire de Recherche en Biologie, Collège de France, CNRS Paris, France
- **Postdoctoral researcher** – Prof. Santiago Badia laboratory 08/10/20 – 31/10/21
International Centre for Numerical Methods in Engineering, CIMNE Barcelona, Spain
- **Visiting predoctoral researcher** – Prof. Santiago Badia laboratory 01/11/19 – 31/03/20
School of mathematics, Monash University Melbourne, Australia
- **Predocctoral researcher** – Profs. Santiago Badia and Michele Chiumenti laboratories 16/04/16 – 07/10/20
International Centre for Numerical Methods in Engineering, CIMNE Castelldefels, Spain
- **Research intern** – Prof. Michele Chiumenti laboratory 09/10/15 – 16/04/16
International Centre for Numerical Methods in Engineering, CIMNE Barcelona, Spain

EDUCATION

- **Ph.D. in civil engineering** 07/10/20
Universitat Politècnica de Catalunya Barcelona, Spain
Large-scale tree-based unfitted finite elements for metal additive manufacturing
Supervised by Profs. Santiago Badia and Michele Chiumenti
Obtained with highest honours and an international doctorate mention
- **M.Sc. in numerical methods in engineering** 21/10/16
School of civil engineering, Universitat Politècnica de Catalunya Barcelona, Spain
- **B.Sc. and M.Sc. in civil engineering** 16/06/15
School of civil engineering, Universitat Politècnica de Catalunya Barcelona, Spain
- **B.Sc. and M.Sc. in mathematics** 23/07/14
School of mathematics and statistics, Universitat Politècnica de Catalunya Barcelona, Spain

PUBLICATIONS

In peer-reviewed journals.

8. S. Badia, E. Neiva, and F. Verdugo, “Robust high-order unfitted finite elements by interpolation-based discrete extension”, *Computers & Mathematics with Applications*, vol. 127, p. 105-126, 2022.
DOI: 10.1016/j.camwa.2022.09.027
Scientific significance: We expose that finite element (FE) bases used in the seminal work of AgFEM by Badia et al., *CMAME* 336:553 (2018), are ill-conditioned in high-order approximations. We propose a new type of FE basis which is suitable for high-order. *G. Scholar citations:* 16
7. S. Badia, E. Neiva, and F. Verdugo, “Linking ghost penalty and aggregated unfitted methods”, *Computer Methods in Applied Mechanics and Engineering*, vol. 388, p. 114232, 2022. DOI: 10.1016/j.cma.2021.114232
Scientific significance: We introduce the *weak* aggregated unfitted FE method. It is an unfitted method of ghost penalty type that converges to the usual AgFEM when the penalty parameter goes to infinity. Hence, we discover how ghost penalty and aggregated unfitted methods are related to each other. *G. Scholar citations:* 34
6. S. Badia, A. F. Martín, E. Neiva, and F. Verdugo, “The aggregated unfitted finite element method on parallel tree-based adaptive meshes”, *SIAM Journal on Scientific Computing*, vol. 43, no. 3, pp. C203–C234, 2021.
DOI: 10.1137/m1344512
Scientific significance: We explain how to combine AgFEM and hanging node linear algebraic constraints in distributed memory FE codes, which allows us to formulate *h*-adaptive aggregated FE methods in parallel tree-based adaptive meshes. *G. Scholar citations:* 22

5. E. Neiva and S. Badia, “Robust and scalable h-adaptive aggregated unfitted finite elements for interface elliptic problems”, *Computer Methods in Applied Mechanics and Engineering*, vol. 380, p. 113 769, 2021.
DOI: 10.1016/j.cma.2021.113769
Scientific significance: We give first insight on how to formulate AgFEM in large-scale multiphase/multiphysics problems, by introducing and analysing a new robust and highly-scalable *h*-adaptive AgFEM for interface elliptic problems. *G. Scholar citations:* 27
4. S. Badia, A. F. Martín, E. Neiva, and F. Verdugo, “A generic finite element framework on parallel tree-based adaptive meshes”, *SIAM Journal on Scientific Computing*, vol. 42, no. 6, pp. C436–C468, 2020.
DOI: 10.1137/M1328786
Scientific significance: Reproducing algorithms implementing FE methods in parallel, distributed-memory, tree-based adaptive meshes was hindered by lacking rigorous mathematical proofs that they were correct, until this work provided the missing proofs. *G. Scholar citations:* 19
3. E. Neiva, M. Chiumenti, M. Cervera, E. Salsi, G. Piscopo, S. Badia, A. F. Martín, Z. Chen, C. Lee, and C. Davies, “Numerical modelling of heat transfer and experimental validation in powder-bed fusion with the virtual domain approximation”, *Finite Elements in Analysis and Design*, vol. 168, p. 103 343, 2020.
DOI: 10.1016/j.finel.2019.103343
Scientific significance: We formulate and experimentally validate a new physics-based thermal contact model for powder-bed 3D printing FE models. It yields greater accuracy than naive state-of-the-art approaches (e.g. constant heat transfer coefficient), without an overall increment of the computational cost. *G. Scholar citations:* 38
2. E. Neiva, S. Badia, A. F. Martín, and M. Chiumenti, “A scalable parallel finite element framework for growing geometries. Application to metal additive manufacturing”, *International Journal for Numerical Methods in Engineering*, vol. 119, no. 11, pp. 1098–1125, 2019. DOI: 10.1002/nme.6085
Scientific significance: We propose the first fully parallel FE framework to simulate metal 3D printing processes by powder-bed fusion. The key ingredient is a new parallel search algorithm to adapt the mesh resolution and track the heat input by the laser during the simulation. *G. Scholar citations:* 57
1. M. Chiumenti, E. Neiva, E. Salsi, M. Cervera, S. Badia, J. Moya, Z. Chen, C. Lee, and C. Davies, “Numerical modelling and experimental validation in selective laser melting,” *Additive manufacturing*, vol. 18, pp. 171–185, 2017. DOI: 10.1016/j.addma.2017.09.002
Scientific significance: In FE models of metal 3D printing processes, time-lumping is widely used by engineers and researchers to cut simulation times, but the approach was not backed by exhaustive numerical assessment, sensitivity analysis and contrast with experimental evidence, especially for large printing sizes. We addressed this limitation here. *G. Scholar citations:* 221

In preparation.

- E. Neiva and H. Turlier, “Modelling coupled surface-bulk viscous flows in animal cells with unfitted finite elements”.
- I. Hammer, E. Neiva, and A. Massing, “Unfitted finite element methods for the biharmonic and Cahn-Hilliard problem in primal form”.

ORGANISATION OF SCIENTIFIC EVENTS

International workshops.

1. **Finite Elements for Cell and Tissue Morphogenesis 2024** Fréjus, France, 9-13/09/24
Main organiser of a first-of-its-kind workshop, that gathered leading experts and researchers in *finite elements and morphogenesis for animal and plant systems* (35 participants from 11 countries in Europe and North America). The event was co-organised with Dr. Hervé Turlier (Collège de France) and Dr. Gabriella Mosca (Universität Tübingen). It received financial support from the European Union and the Franco-German University.

Minisymposia.

1. **Recent Advances in Numerical Methods for Mixed-dimensional PDEs** Vancouver, Canada, 22/06/24
At the XVI World Congress on Computational Mechanics and IV Pan American Congress on Computational Mechanics. Main organiser. Co-organised with Oriol Colomés (TU Delft) and André Massing (Norwegian University of Science and Technology).

SCIENTIFIC PRESENTATIONS

Invited talks at conferences.

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| 5. IX Biennial European Cell Mechanics Meeting | Marseille, France, 27/09/23 |
| 4. XXII IACM Computational Fluids Conference | Cannes, France, 25/04/23 |
| 3. IX International Conference on Computational Methods for Coupled Problems in Science and Engineering, COUPLED PROBLEMS 2021 | Online event, 13/06/21 |
| 2. XIV World Congress on Computational Mechanics and ECCOMAS Congress | Online event, 11/01/21 |
| 1. II International Conference on Simulation for Additive Manufacturing | Pavia, Italy, 11/09/19 |

Selected talks at conferences.

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| 7. XVI World Congress on Computational Mechanics and PANACM Congress | Vancouver, Canada, 22/07/24 |
| 6. The 8 th annual JuliaCon 2021 | Online event, 30/06/21 |
| 5. I Monash workshop on Numerical Differential Equations and Applications | Melbourne, Australia, 12/02/20 |
| 4. IX International Congress on Industrial and Applied Mathematics | Valencia, Spain, 16/07/19 |
| 3. Additive Manufacturing Benchmarks 2018 | Washington, USA, 18/06/18 |
| 2. I International Conference on Simulation for Additive Manufacturing | Munich, Germany, 12/10/17 |
| 1. XIV International Conference on Computational Plasticity | Barcelona, Spain, 07/10/15 |

Invited talks at seminars.

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| 4. Fluid Mechanics Department Seminar @ EEBE UPC | Barcelona, Spain, 28/10/24 |
| 3. COMMEDIA Seminar @ INRIA Paris | Paris, France, 13/05/24 |
| 2. InvBlastula ANR Meeting @ Institut de la Mer de Villefranche | Villefranche-sur-Mer, France, 14/11/23 |
| 1. Warwick Applied Mathematics Seminar @ Warwick University | Coventry, UK, 25/11/22 |

AWARDS AND FELLOWSHIPS

- ▶ **2022 special doctoral award** of the Universitat Politècnica de Catalunya (UPC) 23/06/22
Awarded to the best doctors graduated at the UPC in the graduation year 2019-2020
- ▶ **ECCOMAS scholarship for participation at WCCM-ECCOMAS 2020** 05/11/20
Covering the registration fee to the XIV World Congress in Computational Mechanics and ECCOMAS Congress
- ▶ **Financial support for the IX International Congress on Industrial and Applied Mathematics** 29/03/19
Covering registration fees, travel and accommodation expenses
- ▶ **Ajuts Joan Oró (FI-AGAUR) predoctoral fellowship** 01/04/17 – 31/03/20
Competitive funding awarded by the Agència de Gestió d'Ajuts Universitaris i de Recerca and the Departament d'Innovació, Universitats i Empresa of the Government of Catalonia (Grant Id. 2017 FI B00219).
- ▶ **Centre de Formació Interdisciplinària Superior (CFIS) scholarship** 15/09/08 – 16/06/14
Covering the tuition fees of my degree in mathematics

PARTICIPATION IN INTERNATIONAL RESEARCH PROJECTS

- ▶ **Computer Aided Technologies for Additive Manufacturing (CAxMan)** 01/09/15 – 31/08/18
Funded under the programme H2020-EU.2.1.1. (Grant Id. 680448)
Contribution: Development of research and innovation content of the project, writing of deliverables, coordination with the rest of participants through follow-up periodical meetings.
- ▶ **Efficient Manufacturing for Aerospace Components Using Additive Manufacturing, Net Shape HIP and Investment Casting (EMUSIC)** 01/04/16 – 31/03/19
Funded under the programme H2020-EU.3.4. (Grant Id. 690725)
Contribution: Development of research and innovation content of the project.

SOFTWARE PROJECTS

- **Gridap.jl contributor** – github.com/gridap Since 2020
Gridap.jl is a feature-rich open-source FE software ecosystem written 100% in Julia. I am currently the lead maintainer of GridapEmbedded.jl, the subpackage of Gridap.jl for immersed/unfitted FE methods such as aggregated and trace FEM. I have implemented missing features in Gridap.jl and GridapEmbedded.jl for works 7-8 above. I am currently working on GridapEmbedded.jl to simulate fluid-deformable surfaces and coupled surface-bulk problems with dynamic surfaces. Gridap.jl is publicly hosted in *GitHub*.
- **FEMPAR contributor** – github.com/fempar 2016 – 2020
FEMPAR is an open-source scientific software for massively-parallel simulations of multiphysics problems governed by PDEs. Implemented in hybrid OpenMP/MPI object-oriented FORTRAN200X. I have implemented in FEMPAR all the missing FE needed for publications 1-6 above. FEMPAR is publicly hosted in *GitHub*.

ACADEMIC COLLABORATIONS

Current.

- **Dr. Marie-Hélène Verlhac & Dr. Marie-Émilie Terret, CIRB, France** 01/11/23 – Present
Modelling surface-bulk couplings in stiff mouse oocytes to determine its viability to develop into an embryo.
- **Prof. André Massing, Norwegian University of Science and Technology, Norway** 01/09/23 – Present
Working together on unfitted FE methods for dynamic surfaces and coupled surface-bulk problems.

Past.

- **Prof. Christopher Davies and Dr. Zhuoer Chen, Monash University and Monash Centre for Additive Manufacturing, Melbourne, Australia** 16/04/16 – 31/03/20
Prof. Davies and Dr. Chen provided the expertise in material science and manufacturing engineering and were in charge of the experimental measurements contributing to publications 1. and 3. above.

TRAINING, SUPERVISION AND MENTORSHIP

- **Martina Gatti** – MSc student in Mathematical Engineering at Politecnico di Milano 01/04/24 – 31/12/24
Supervised her master thesis entitled *Modelling surface-bulk flows in migrating animal cells*.
- **Journée Gridap.jl** – Training session @ INRIA Saclay Palaiseau, France, 01/12/22
F. Verdugo and me were invited by *Groupe Calcul* from CNRS to teach basic and advanced features of Gridap.jl.
- **Pau Riera i Portillo** – *Google Summer of Code 2021* student developer 17/05/21 – 31/08/21
I mentored his GSoC project “Visualizing PDE approximations in Julia with Gridap.jl and Makie.jl”.
- **Balaje Kalyanamaran** – *Google Summer of Code 2021* student developer 17/05/21 – 31/08/21
I mentored his GSoC project “A fast finite element interpolator in Gridap.jl”.

Google Summer of Code is a global, online program focused on bringing new contributors into open source software development. GSoC Contributors work with an open source organisation on a 12+ week programming project under the guidance of mentors.

- **Joan Josep Moya** – Research intern at CIMNE 16/04/16 – 22/09/17
I mentored his internship and his work contributed to publication 1. above.

EXPERIENCE IN HIGH-PERFORMANCE SCIENTIFIC COMPUTING

I have experience in distributed-memory computing at the largest supercomputers of Spain and Australia *Marenostrum IV* (166k CPUs) and NCI's *Gadi* (155k CPUs), respectively. I have also employed smaller clusters, namely, *Acuario* (480 CPUs), hosted at CIMNE, *Titani* (120 CPUs), hosted at UPC, and *Coste* (324 CPUs), my supervisor's cluster hosted at Collège de France and maintained by its IT services. My biggest simulation run used 32.2k CPU cores and had 482.2M degrees of freedom. It was run in Marenostrum IV and is reported in publication 4. above.

I also have expertise using state-of-the-art scientific computing linear solvers and optimisation libraries such as MKL's Pardiso (direct solvers), PETSc (iterative solvers) and Dakota (parallel optimisation), which I interfaced to my computational models for calibration and validation against experiments in 1. and 3..

I also have prepared research proposals to access the supercomputer Marenostrum IV. Between 2019 and 2020, I have been a main contributor to four successful proposals related to my PhD thesis (FI-2019-1-0007, IM-2019-2-0007, IM-2019-3-0008 and IM-2020-1-0002). They were awarded altogether 1,075 Kh of computing hours.

SCIENTIFIC OUTREACH

- ▶ **Fête de la Science: Science Fair** – Collège de France. Paris, France, 05/11/24
Created a stand about interdisciplinary research in biology, physics and mathematics for the general public.
- ▶ **Els Grans Interrogants de la Ciència: Conference series** – Olot Cultura. Olot, Spain, 19/04/24
Gave the talk *Podem descobrir com es desenvolupen els éssers vius amb la matemàtica computacional?*
- ▶ **Déclics: Speed meetings with high-school students** – Lycée Claude Monet. Paris, 11/12/23
Meetings between researchers and high-school students to raise their interest in building knowledge.
- ▶ **Cartas com Ciência: Letter exchanges** São Tomé e Príncipe & Paris, 2022-23
Exchanging letters with a secondary school student at São Tomé e Príncipe to increase his science capital.
- ▶ **Skype a Scientist** – Fisher Middle School. Ewing, New Jersey, USA. Online event, 12/12/22
Skype a Scientist organises Q&A sessions between worldwide scientists and classrooms.
- ▶ **Déclics: Speed meetings with high-school students** – Lycée Gabriel Fauré. Paris, 07/12/22
Meetings between researchers and high-school students to raise their interest in building knowledge.
- ▶ **Skype a Scientist** – Pragati School. Ahmedabad, India. Online event, 23/08/22
Skype a Scientist organises Q&A sessions between worldwide scientists and classrooms.
- ▶ **Twitter account** – @ericnumerics Since February 2022
I inform about my research activities and announce new research outputs. I target people working in my research fields and the community of the Julia programming language.
- ▶ **V Interdisciplinary Meeting of Predoctoral Researchers, JIPI 2017** Barcelona, 09/02/17
PhD students in all research fields from all Catalan universities gather at JIPI for a day of talks, debates and net-working. I gave there the talk “3D Printing with metals: An exciting opportunity for the manufacturing industry”.

REVIEW ACTIVITY

- ▶ Additive Manufacturing
- ▶ Computer-Aided Design
- ▶ The Journal of Open Source Software (JOSS)