

# Rene Hiemstra

POSTDOCTORAL RESEARCHER

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## Research Profile

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My research interests and focus are on the development and implementation of new methods that overcome limitations of today's computational techniques in the fields of numerical simulation, machine learning and geometry processing. I have developed finite element exterior calculus techniques for incompressible flow, advanced quadrature, formation, assembly and solution procedures for finite element methods, investigated improved mathematical representations for splines and worked on algorithmic improvements for PDE-based surface parameterization and mesh generation. In my current postdoctoral studies, I am continuing and extending these lines of research, supervise four Ph.D. students, and am leading our research group's software development initiative.

## Education

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### Oden Institute for Computational Engineering and Sciences University of Texas at Austin

Austin, TX, USA

PH.D. IN COMPUTATIONAL SCIENCE, ENGINEERING AND MATHEMATICS

19/08/2019

*Advisor: Prof. Dr. Thomas J.R. Hughes*

*Thesis: Enabling Higher Order Isogeometric Analysis for Applications in Solid Mechanics*

### Oden Institute for Computational Engineering and Sciences University of Texas at Austin

Austin, TX, USA

M.SC. IN COMPUTATIONAL SCIENCE, ENGINEERING AND MATHEMATICS

17/12/2016

### Department of Maritime Technology Delft University of Technology

Delft, Netherlands

M.SC. IN MARITIME TECHNOLOGY (CUM-LAUDE)

11/06/2011

B.SC. IN MARITIME TECHNOLOGY

30/05/2009

## Professional Experience

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### Institute of Mechanics Technical University of Darmstadt

Darmstadt, Germany

POST-DOCTORAL RESEARCHER

01/01/2022 - present

SUPPORTED BY THE GERMAN RESEARCH FOUNDATION

- R&D in computational methods for geometry and physics simulation
- Supervision of several Ph.D. Students
- Leading the group's software development initiative

### Institut für Baumechanik und Numerische Mechanik Leibniz Universität Hannover

Hannover, Germany

POST-DOCTORAL RESEARCHER

01/10/2019 - 31/12/2021

SUPPORTED BY THE GERMAN RESEARCH FOUNDATION

- R&D in computational methods for geometry and physics simulation
- Supervision of several Ph.D. Students
- Leading the group's software development initiative

### Oden Institute for Computational Engineering and Sciences University of Texas at Austin

Austin, TX, USA

GRADUATE RESEARCH ASSISTANT

21/01/2013 - 08/08/2019

SUPPORTED BY GRADUATE SCHOOL FELLOWSHIPS, NATIONAL SCIENCE FOUNDATION, AND THE UNITED STATES ARMY

- R&D in isogeometric analysis methods

## Basque Center for Applied Mathematics (BCAM)

VISITING SUMMER RESEARCHER

SUPPORTED THROUGH A BCAM VISITING FELLOW GRANT

- R&D in efficient quadrature and assembly for isogeometric analysis

*Bilbao, Spain*

*01/07/2018 - 30/08/2018*

## Department of Maritime Engineering Delft University of Technology

RESEARCH SCIENTIST

- R&D in finite element exterior calculus

*Delft, Netherlands*

*01/09/2011 - 30/11/2012*

## Teaching & Supervising

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### Leibniz Universität Hannover

INSTRUCTOR

- Geometric modeling and isogeometric analysis (2 lectures - Summer 2020)
- Stabilized Finite Element Methods for Computational Fluid Mechanics (4 lectures - Spring 2020)
- Test driven development in Julia (8 lectures - Spring 2020)
- Co-supervision of 4 Ph.D. students

*Hannover, Germany*

*2019-2021*

### University of Texas at Austin

GRADUATE TEACHING ASSISTANT

- Stabilized and variational multiscale methods
- Non-linear Static and Dynamic Finite Element Analysis

*Austin, TX, USA*

*2015-2018*

## Research Interests

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computational geometry · physics simulation · machine learning · surface parameterization · mesh generation · geometric discretization · discrete exterior calculus · finite element exterior calculus · isogeometric analysis

## Presentations

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### INVITED TALKS

<b>Dagstuhl Workshop Geometric Modeling: Interoperability and New Challenges</b> , Schloss Dagstuhl, Germany	2021
<b>INdAM Workshop Geometric Challenges in Isogeometric Analysis</b> , Rome, Italy	2020
<b>Isogeometric Splines: Theory and Applications (19w5196)</b> , Banff, Canada	2019
<b>Institut für Baumechanik und Numerische Mechanik</b> , Leibniz University Hannover, Hannover, Germany	2019
<b>Department of Civil Engineering and Architecture (DICaR)</b> , University of Pavia, Pavia, Italy	2015

### TALKS AT INTERNATIONAL CONFERENCES

<b>Virtual Isogeometric Analysis 2020 (VIGA2020)</b> , Virtual	2020
<b>International Conference on Isogeometric Analysis (IGA2018)</b> , Austin, TX, USA	2018
<b>International Conference on Isogeometric Analysis (IGA2017)</b> , Pavia, Italy	2017
<b>IACM 19th International Conference on Finite Elements in Flow Problems (FEF-2017)</b> , Rome, Italy	2017
<b>USACM Conference on Isogeometric Analysis and Meshfree Methods (IGA2016)</b> , La Jolla, California, USA	2016
<b>European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS2016)</b> , Crete, Greece	2016
<b>15th International Conference on Approximation Theory</b> , San Antonio, Texas, USA	2016
<b>International Conference on Isogeometric Analysis (IGA2015)</b> , Trondheim, Norway	2015
<b>Finite Element Rodeo 2014</b> , Austin, Texas, USA	2014
<b>International Conference on Isogeometric Analysis (IGA2014)</b> , Austin, Texas, USA	2014
<b>11th. World Congress on Computational Mechanics (WCCM XI)</b> , Barcelona, Spain	2014
<b>12th US National congress on Computational Mechanics (USNCCM12)</b> , Raleigh, North Carolina, USA	2013
<b>Advances in Computational Mechanics (ACM 2013)</b> , San Diego, California, USA	2013
<b>6th European Congress on Computational Methods in Applied Science and Engineering (ECCOMAS2012)</b> , Vienna, Austria	2012
<b>International Conference On Spectral And High Order Methods (ICOSAHOM2012)</b> , Gammarth, Tunisia	2012
<b>2011 Woudschoten Conference</b> , Woudschoten, Netherlands	2011

# Publications

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## PEER REVIEWED JOURNAL ARTICLES

1. Nguyen, T.H., **Hiemstra, R.R.**, Stoter, S.K.F., Schillinger, D., (2022). "A variational approach based on perturbed eigenvalue analysis for improving spectral properties of isogeometric multipatch discretizations." *Computer Methods in Applied Mechanics and Engineering*, 392, p. 114671
2. Nguyen, T.H., **Hiemstra, R.R.**, Schillinger, D., (2022). "Leveraging spectral analysis to elucidate membrane locking and unlocking in isogeometric finite element formulations of the curved Euler–Bernoulli beam." *Computer Methods in Applied Mechanics and Engineering*, 388, p.114240.
3. **Hiemstra, R.R.**, Hughes, T.J.R., Reali, A., Schillinger, D., (2021). "Removal of spurious outlier frequencies and modes from isogeometric discretizations of second- and fourth-order problems in one, two, and three dimensions." *Computer Methods in Applied Mechanics and Engineering*, 387, p.114115.
4. Mika, M.Ł., Hughes, T.J.R., Schillinger, D., Wriggers, P. and **Hiemstra, R.R.**, (2021). "A matrix-free isogeometric Galerkin method for Karhunen–Loève approximation of random fields using tensor product splines, tensor contraction and interpolation based quadrature." *Computer Methods in Applied Mechanics and Engineering*, 379, p.113730.
5. **Hiemstra, R.R.**, Shepherd, K.M., Johnson, M.J., Quan, L. and Hughes, T.J., (2020). "Towards untrimmed NURBS: CAD embedded reparameterization of trimmed B-rep geometry using frame-field guided global parameterization". *Computer Methods in Applied Mechanics and Engineering*, 369, p.113227.
6. **Hiemstra, R.R.**, Hughes, T.J.R., Manni, C., Speleers, H. and Toshniwal, D., (2020). "A Tchebycheffian Extension of Multidegree B-Splines: Algorithmic Computation and Properties." *SIAM Journal on Numerical Analysis*, 58(2), pp.1138-1163.
7. Toshniwal, D., Speleers, H., **Hiemstra, R.R.**, Manni, C. and Hughes, T.J., (2020). "Multi-degree B-splines: Algorithmic computation and properties." *Computer Aided Geometric Design*, 76, p.101792.
8. **Hiemstra, R.R.**, Sangalli, G., Tani, M., Calabrò, F., & Hughes, T.J.R. (2019). "Fast Formation and Assembly of Finite Element Matrices with Application to Isogeometric Linear Elasticity." *Computer Methods in Applied Mechanics and Engineering*, Volume 355, Pages 234-260.
9. Evans, J.A., **Hiemstra, R.R.**, Hughes, T.J.R., & Reali, A. (2018). "Explicit higher-order accurate isogeometric collocation methods for structural dynamics." *Computer Methods in Applied Mechanics and Engineering*. 338: 208-240.
10. Marussig, B., **Hiemstra, R.R.**, and Hughes, T.J.R. (2018). "Improved conditioning of isogeometric analysis matrices for trimmed geometries." *Computer Methods in Applied Mechanics and Engineering*. 334: 79-110.
11. Toshniwal, D., Speleers, H., **Hiemstra, R.R.**, & Hughes, T.J.R. (2017). "Multi-degree smooth polar splines: A framework for geometric modeling and isogeometric analysis." *Computer Methods in Applied Mechanics and Engineering*. 316: 1005-1061.
12. **Hiemstra, R.R.**, Calabrò, F., Schillinger, D., & Hughes, T.J.R. (2017). "Optimal and reduced quadrature rules for tensor product and hierarchically refined splines in isogeometric analysis." *Computer Methods in Applied Mechanics and Engineering*. 316: 966-1004.
13. Schillinger, D., Evans, J. A., Frischmann, F., **Hiemstra, R.R.**, Hsu, M.C., & Hughes, T.J.R. (2015). "A collocated  $C^0$  finite element method: Reduced quadrature perspective, cost comparison with standard finite elements, and explicit structural dynamics." *International Journal for Numerical Methods in Engineering*. 102: 576-631.
14. **Hiemstra, R.R.**, Toshniwal, D., Huijsmans, R.H.M., & Gerritsma, M.I. (2014). "High order geometric methods with exact conservation properties." *Journal of Computational Physics*. 257: 1444-1471.
15. Palha, A., Rebelo, P.P., **Hiemstra, R.R.**, Kreeft, J., & Gerritsma, M.I. (2014). "Physics-compatible discretization techniques on single and dual grids, with application to the Poisson equation of volume forms." *Journal of Computational Physics*. 257: 1394-1422.

## PEER REVIEWED BOOK CHAPTERS

16. Mika, M.Ł., **Hiemstra, R.R.**, Schillinger D., Hughes, T.J.R., (2022). "A Comparison of Matrix-Free Isogeometric Galerkin and Collocation Methods for Karhunen–Loève Expansion." *Current Trends and Open Problems in Computational Mechanics*. Springer, Cham, 329-341.
17. **Hiemstra, R. R.**, and Gerritsma, M.I. (2014). "High order methods with exact conservation properties." *Spectral and High Order Methods for Partial Differential Equations-ICOSAHOM 2012*. Springer, Cham, 285-295.
18. Gerritsma, M. I., **Hiemstra, R. R.**, Kreeft, J., Palha, A., Rebelo, P., & Toshniwal, D. (2014). "The geometric basis of numerical methods." *Spectral and High Order Methods for Partial Differential Equations-ICOSAHOM 2012*. Springer, Cham, 17-35.

## Software

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**FEATHER**, Julia ecosystem of packages implementing, amongst others, the finite element analysis technology presented in the papers [2,6,10] [\(link\)](#)

**DolphinMesh**, C++20 halfedgemesh implementation with a C-API and bindings to C++11 and C# [\(link\)](#)

**ranges-next**, A ranges library for C++20 [\(link\)](#)

## Honors & Awards

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<b>Graduate School Continuing fellowship</b> , University of Texas at Austin	2017-2018
<b>Certificate of Outstanding Contribution in Reviewing</b> , Computer Methods in Applied Mechanics and Engineering	2017
<b>Graduate School recruitment fellowship</b> , University of Texas at Austin	2013-2014
<b>Best poster award, 3rd prize (Structure Preserving Isogeometric Methods)</b> , The 36th Woudschoten Conference	2011
<b>Cum Laude M.Sc. Marine Technology</b> , Delft University of Technology	2011

## Funding

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Eliminating spurious outlier frequencies and modes in IGA, DFG #SCH 1049/5-1 (2-year, 1FTE)

2021

## Service to Profession

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### Peer review (Journals / number of reviews),

Computer Methods in Applied Mechanics and Engineering	34
Journal of Computational and Applied Mathematics	1
Computers and Mathematics with Applications	1
Computational Mechanics	1
Computer Aided Design	1

### Peer review (Conferences / number of reviews),

ACM SIGGRAPH	1
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## Professional Skills

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**Expertise:** geometry processing, finite element analysis, computational fluid dynamics, isogeometric analysis, numerical analysis, scientific computing

**Communication:** Presented research insights at 16 international conferences (100+ attendees), 2 invited closed circle workshops and 2 invited seminars at research institutes; Published 6 first-author articles and co-authored 7 others in high-impact, internationally peer-reviewed journals (with 504 citations to date; h-index 12 (Google-Scholar)); Worked independently and in small, international teams

**Leadership:** Supervision of four Ph.D. students and several master students; lead developer of our research group's software development initiative

**Software:** C++ (expert); Julia (expert); C# (expert); MatLab (expert); C (intermediate); Python (intermediate); Version Control (Git); Continuous Integration / Deployment (Gitlab); Build systems / Packaging (cmake / conan); Containerisation (Docker); Microsoft Office; LaTeX; Adobe Acrobat and Illustrator; Rhinoceros 3D

**Languages:** English (fluent); Dutch (native); German (intermediate)

## References

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### Prof. Dr. Thomas J.R. Hughes

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The University of Texas at Austin

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### Prof. Dr. Dominik Schillinger

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### Prof. Dr. Carla Manni

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### Prof. Dr. Daniele Panozzo

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