Kamila Zdybał, Ph.D.

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LinkedIn | Google Scholar | Personal website | GitHub | YouTube

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In my research, I develop tools and algorithms that help **understand high-dimensional datasets** and **model high-dimensional systems** with computational efficiency.

I am passionate about science outreach, creating educational content, academic writing, and developing open-source scientific software.

Education

- May 2023 – Sep 2023, F.R.S.-FNRS Aspirant Research Fellow, Université Libre de Bruxelles, Brussels, Belgium
- Sep 2018 – Apr 2023, Ph.D. student, Université Libre de Bruxelles, Brussels, Belgium
    - Jan 2020 – Apr 2020, research stay at the University of Utah, Salt Lake City, UT, USA

    Advisors: 🎓 **Prof. Alessandro Parente** and 🎓 **Prof. James C. Sutherland**
    Dissertation: *Reduced-order modeling of turbulent reacting flows using data-driven approaches.*
    📄 https://doi.org/10.13140/RG.2.2.18843.95521
- Jul 2016 – Sep 2016, Research student, the von Karman Institute for Fluid Dynamics, Rhode-Saint-Genèse, Belgium
    Advisor: 🎓 **Prof. Miguel A. Mendez**
    Report: *POD and DMD decomposition of numerical and experimental data.*
    📄 https://doi.org/10.13140/RG.2.2.34150.91201
- Mar 2015 – Sep 2016, Master degree in Civil Engineering, Cracow University of Technology, Cracow, Poland
    Thesis: *Quasi-static model of wind action in flutter of bridge structures.*
- Oct 2010 – Feb 2014, Bachelor degree in Civil Engineering, Cracow University of Technology, Cracow, Poland
    Thesis: *Analysis of wind action on a support structure of a dual-rotor wind turbine.* Graduated with honors.

Work experience

- Feb 2017 – Aug 2018, Software test engineer, Nokia, Cracow, Poland
    - Automating regression tests in Elixir language and manual black-box tests of base station software in the Long Term Evolution (LTE) standard, Python scripting, tutoring team members, writing *know-how* documentation, setup works of telecom laboratory equipment.
- May 2014 – Dec 2014, Civil structures intern, BMT Fluid Mechanics, Teddington, United Kingdom
    - Taking part in all stages of commercial wind tunnel tests of high-rise buildings and offshore structures. This included determining cladding pressures, forces and moments on structures, assessing pedestrian wind comfort, assisting in wind environment workshops with the clients, drawing 3D CAD models and communicating with the modeling team.

Academic awards & grants

- 2023, 39th ISOC Distinguished Paper Award for Numerical Combustion
- 2023, Student Travel Award for the SIAM Conference on Computational Science and Engineering ($700)
- 2022, Student Travel Award for the SIAM Conference on Mathematics of Data Science ($800)
- 2020, Funding for an abroad research stay, CCCI, Université Libre de Bruxelles (€4,500)
- 2019, F.R.S.-FNRS Aspirant Research Fellow grant & grant renewal in 2021
- 2018, Scholarship for the first year of my Ph.D., Université Libre de Bruxelles
- 2016, Funding for an abroad research stay, Erasmus+ (€500)
- 2016, Dean's scholarship for the best students, Cracow University of Technology
- 2012, GE Foundation Scholar Leaders scholarship (€3,000)

Peer-reviewed journal articles (6)

2023 K. Zdybał, E. Armstrong, A. Parente, and J. C. Sutherland. PCAfold 2.0—novel tools and algorithms for low-dimensional manifold assessment and optimization. *SoftwareX*, 23:101447, 2023.
  </> https://gitlab.multiscale.utah.edu/common/PCAfold
  ▤ https://doi.org/10.1016/j.softx.2023.101447
  ◼ https://www.youtube.com/watch?v=oVF4QaLpc6k

2023 K. Zdybał, G. D'Alessio, A. Attili, A. Coussement, J. C. Sutherland, and A. Parente. Local manifold learning and its link to domain-based physics knowledge. *Applications in Energy and Combustion Science*, 14:100131, 2023.
  </> https://github.com/kamilazdybal/local-manifold-learning
  ▤ https://doi.org/10.1016/j.jaecs.2023.100131

2023 A. C. Ispir, K. Zdybał, B. H. Saracoglu, T. Magin, A. Parente, and A. Coussement. Reduced-order modeling of supersonic fuel-air mixing in a multi-strut injection scramjet engine using machine learning techniques. *Acta Astronautica*, 202:564–584, 2023.
  ▤ https://doi.org/10.1016/j.actaastro.2022.11.013

2022 K. Zdybał, E. Armstrong, J. C. Sutherland, and A. Parente. Cost function for low-dimensional manifold topology assessment. *Scientific Reports*, 12:14496, 2022.
  </> https://github.com/kamilazdybal/cost-function-manifold-assessment
  ▤ https://doi.org/10.1038/s41598-022-18655-1

2022 K. Zdybał, J. C. Sutherland, and A. Parente. Manifold-informed state vector subset for reduced-order modeling. *Proceedings of the Combustion Institute*, 39(4):5145–5154, 2023.
  This paper has received the Distinguished Paper Award from The Combustion Institute.
  </> https://github.com/kamilazdybal/manifold-informed-state-vector-subset
  ▤ https://doi.org/10.1016/j.proci.2022.06.019

2020 K. Zdybał, E. Armstrong, A. Parente, and J. C. Sutherland. PCAfold: Python software to generate, analyze and improve PCA-derived low-dimensional manifolds. *SoftwareX*, 12:100630, 2020.
  </> https://gitlab.multiscale.utah.edu/common/PCAfold
  ▤ https://doi.org/10.1016/j.softx.2020.100630

Book chapters (2)

2023 K. Zdybał, G. D'Alessio, G. Aversano, M. R. Malik, A. Coussement, J. C. Sutherland, and A. Parente. Advancing reactive flow simulations with data-driven models. In M. A. Mendez, A. Ianiro, B. R. Noack, and S. L. Brunton, editors, *Data-Driven Fluid Mechanics: Combining First Principles and Machine Learning*, chapter 15, pages 304–329. Cambridge University Press, 2023.
  ▤ https://doi.org/10.1017/9781108896214.022
  ▤ https://doi.org/10.48550/arXiv.2209.02051

2023 K. Zdybał, M. R. Malik, A. Coussement, J. C. Sutherland, and A. Parente. Reduced-order modeling of reactive flows using data-driven approaches. In N. Swaminathan and A. Parente, editors, *Machine Learning and Its Application to Reacting Flows: ML and Combustion*, chapter 9, pages 245–278. Springer, 2023.
  </> https://github.com/kamilazdybal/ROM-of-reacting-flows-Springer
  ▤ https://doi.org/10.1007/978-3-031-16248-0_9

Software development

- **PCAfold** – a Python software package for generating, analyzing and improving low-dimensional manifolds
  </> https://pcafold.readthedocs.io

- **multipy** – an educational Python library for multicomponent mass transfer
  </> https://multipy-lib.readthedocs.io

- **reduced-order-modelling** – a collection of MATLAB® tools for data pre-processing, reduced-order modeling and results visualization
  </> https://github.com/burn-research/reduced-order-modelling

- **plotting** – a collection of MATLAB® functions for automating plotting scientific results in our research group
  </> https://github.com/burn-research/plotting

- **POD-DMD-GUI** – a MATLAB® GUI for POD and DMD decomposition of experimental or numerical data
  </> https://github.com/kamilazdybal/POD-DMD-decompositions

Contributions to teaching & science outreach

- 2023–present, Creating YouTube tutorials for our open-source Python software, **PCAfold**
  🎥 YouTube playlist: PCAfold tutorials
- 2023–present, Creating YouTube tutorials *Python for Academics*
  🎥 YouTube playlist: Python for Academics
  </> https://github.com/kamilazdybal/python-for-academics
- 2022, Contributing to the course *Data-driven engineering*, Université Libre de Bruxelles
  </> https://github.com/burn-research/data-driven-engineering-course

  - Preparing and delivering exercise sessions for students using Jupyter notebooks
  - Delivering seminar talks on my research
- 2021, Developing Python software for a graduate course on multicomponent mass transfer
- 2019, Teaching *Fluid mechanics and transport phenomena* class, Université Libre de Bruxelles
- 2018–present, Developing open-source educational materials
  https://kamilazdybal.github.io
- 2018–present, Co-organizing annual *Pinguino Lecture Series* for fellow PhD students and academics
- 2016–2017, Leading *Arduino Study Group*, Jagiellonian University

  - 2017, A tutorial for one of our projects that uses Arduino and C++ can be found below:
    📄 https://github.com/kamilazdybal/objectif-morse/
- 2013–2015, Developing online materials in STEM for high school students as part of the GE Foundation Scholar Leaders voluntary experience
  https://wszechswiatnauki.wordpress.com

  - 2016, One of my educational articles is published in *Neutrino*, a popular science magazine issued by the Physics Department at the Jagiellonian University
    📄 http://www.neutrino.if.uj.edu.pl/archiwum/2016/33

Articles currently under review (1)

2023 K. Zdybał, A. Parente, and J. C. Sutherland. Improving reduced-order models through nonlinear decoding of projection-dependent outputs. *Under review in Patterns*, 2023.
</> https://github.com/kamilazdybal/nonlinear-decoding

Articles in preparation (2)

2023 K. Zdybał, A. Parente, and J. C. Sutherland. Improving reduced-order models of turbulent combustion: Quantity of interest (QoI)–aware data projections and the effect of manifold topology. *In preparation for Combustion and Flame*, 2023. (**To be submitted in Aug 2023.**)

2023 K. Zdybał, A. Procacci, M. A. Mendez, T. Grenga, A. Coussement, and A. Parente. Advances in dimensionality reduction and manifold learning for parametrization and modeling of large combustion systems: A review. *In preparation for Progress in Energy and Combustion Science*, 2023. (**To be submitted in Oct 2023.**)

Invited talks (8)

2023 K. Zdybał. Learning from high-dimensional data. In *Stanford University, School of Medicine*, Online, 2023. Seminar at Bendall Lab.

2023 K. Zdybał. How to project data? In *Université Libre de Bruxelles*, Brussels, Belgium, 2023. Seminar.

2023 K. Zdybał. Introduction to machine learning and artificial neural networks. In *The University of Utah*, Online, 2023. Guest lecture in the undergraduate course CHEN-2450 – Numerical Methods.
🎥 https://www.youtube.com/watch?v=wPL2l1K6KPM

2023 K. Zdybał. Improving reduced-order models, one manifold at a time. In *The von Karman Institute for Fluid Dynamics*, Rhode-Saint-Genese, Belgium, 2023. Research Master seminar.

2023 K. Zdybał. Modeling turbulent reacting flows: Data science to the rescue. In *University of Utah*, Online, 2023. Graduate seminar at the Department of Chemical Engineering.

2022 K. Zdybał. Adventures in low-dimensional manifolds and reduced-order modeling. In *Université Libre de Bruxelles*, Brussels, Belgium, 2022. Seminar.

2022 K. Zdybał. Cost function for low-dimensional manifold topology optimization. In *The von Karman Institute for Fluid Dynamics*, Rhode-Saint-Genese, Belgium, 2022. Seminar.
◼◖ https://www.vki.ac.be/index.php/vki-seminars

2018 K. Zdybał. Principal Component Analysis for chemistry reduction. In *Pinguino Lecture Series*, Brussels, Belgium, 2018. Talk.

Conference presentations (15)

2023 K. Zdybał, J. C. Sutherland, and A. Parente. On the effect of manifold topology in reduced-order modeling of turbulent combustion. In *Joint Meeting of the Belgian and Italian Sections of the Combustion Institute*, Florence, Italy, 2023.

2023 H. Dave, M. R. Malik, K. Zdybał, H. G. Im, and A. Parente. On the use of projection to latent structures (PLS) and gaussian process regression (GPR) to reduce combustion chemistry. In *Joint Meeting of the Belgian and Italian Sections of the Combustion Institute*, Florence, Italy, 2023.

2023 K. Zdybał, A. Parente, and J. C. Sutherland. Reduced-order modeling of reacting flows with a regression-aware autoencoder. In *13th U.S. National Combustion Meeting*, Texas A&M University in College Station, TX, USA, 2023.

2023 J. C. Sutherland and K. Zdybał. Topological characteristics of low-dimensional manifolds in reduced-order modeling of turbulent combustion. In *SIAM Conference on Computational Science and Engineering*, Amsterdam, The Netherlands, 2023.

2023 K. Zdybał, A. Parente, and J. C. Sutherland. Reduced-order modeling with a regression-aware autoencoder. In *SIAM Conference on Computational Science and Engineering*, Amsterdam, The Netherlands, 2023.

2023 K. Zdybał. Reduced-order modeling using regression-aware autoencoder. In *Université Libre de Bruxelles and Vrije Universiteit Brussel BRITE workshop*, Brussels, Belgium, 2023. Talk.

2022 K. Zdybał, E. Armstrong, J. C. Sutherland, and A. Parente. Cost function for assessing the quality of low-dimensional manifolds. In *SIAM Conference on Mathematics of Data Science*, San Diego, CA, USA, 2022.

2022 K. Zdybał, J. C. Sutherland, and A. Parente. Manifold-informed state vector subset for reduced-order modeling. In *39th International Symposium on Combustion*, Vancouver, Canada, 2022.
◼◖ https://www.youtube.com/watch?v=MMldWMduCp0

2022 K. Zdybał, M. R. Malik, E. Armstrong, J. C. Sutherland, and A. Parente. Characterizing manifold topologies for reduced-order modeling. In *18th International Conference on Numerical Combustion*, La Jolla, CA, USA, 2022.

2022 A. Parente, L. Donato, K. Zdybał, A. Procacci, and M. Savarese. Data-enhanced analysis, parameterisation and reduced-order modelling of turbulent reacting flows. In *18th International Conference on Numerical Combustion*, La Jolla, CA, USA, 2022.

2022 K. Zdybał. Manifold-informed state vector subset for reduced-order modeling. In *26th Journees D'Etudes of the Belgian Section of the Combustion Institute*, Ghent, Belgium, 2022.

2022 K. Zdybał. Cost function for low-dimensional manifold topology optimization. In *Université Libre de Bruxelles and Vrije Universiteit Brussel BRITE workshop*, Brussels, Belgium, 2022. Talk.

2022 E. Armstrong, K. Zdybał, A. Parente, and J. C. Sutherland. A cost function for optimizing manifold topology in reduced-order modeling. In *2022 WSSCI Spring Technical Meeting*, Stanford, CA, USA, 2022.

2021 K. Zdybał, J. C. Sutherland, and A. Parente. Manifold-informed state vector subset for reduced-order modeling. In *Combura Symposium*, pages 39–40, Soesterberg, The Netherlands, 2021.

2019 G. D'Alessio, G. Aversano, K. Zdybał, A. Cuoci, and A. Parente. Feature extraction in combustion applications. In *17th International Conference on Numerical Combustion*, Aachen, Germany, 2019.

Posters (2)

2021 K. Zdybał, E. Armstrong, A. Parente, and J. C. Sutherland. PCAfold: Python software to generate, analyze and improve PCA-derived low-dimensional manifolds. In *Combura Symposium*, pages 88–89, Soesterberg, The Netherlands, 2021.
▤ Poster file

2019 K. Zdybał, M. R. Malik, and A. Parente. Nonlinear regression of chemical source terms using Deep Neural Networks. In *Tsinghua-Princeton-CI 2019 Summer School on Combustion*, Beijing, China, 2019.
▤ Poster file

Journal reviewer

Journal of Computational Physics

Professional references

👨‍🎓 **Prof. Alessandro Parente**, Université Libre de Bruxelles
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👨‍🎓 **Prof. James C. Sutherland**, The University of Utah
James.Sutherland@utah.edu

👨‍🎓 **Prof. Miguel A. Mendez**, The von Karman Institute for Fluid Dynamics
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