Kamila Zdybał, Ph.D.

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Google Scholar | Personal website | GitHub | LinkedIn | YouTube

In my research, I develop computationally-efficient and adaptive data-driven models of **high-dimensional dynamical systems** using **machine learning** and **numerical optimization**. I am also dedicated to developing open-source scientific software.

Academic appointments

- Feb 2024 – Jan 2026, Postdoctoral researcher, Computational Engineering laboratory, Empa – Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland
  PI: **Dr. Ivan Lunati**

- May 2023 – Jan 2024, Postdoctoral researcher, Université Libre de Bruxelles, Brussels, Belgium
  PI: **Prof. Alessandro Parente**

Education

- 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.

Teaching

- September 9–11 2024, Training school instructor for *Machine Learning for Reacting Flows* with ≈40 participants, Thessaloniki, Greece.
- Spring semester 2022, Master-level: *Data-driven engineering*, Exercise sessions for ≈40 students, Université Libre de Bruxelles
  https://github.com/burn-research/data-driven-engineering-course
- Fall semester 2019, Master-level: *Fluid mechanics and transport phenomena*, Exercise sessions for ≈40 students, Université Libre de Bruxelles

Graduate students supervised

- 2024-2028 (Ph.D.) **Grégoire Corlùy**, in collaboration with Université Libre de Bruxelles

Work experience

- Feb 2017 – Aug 2018, Software test engineer, Nokia, Cracow, Poland
- May 2014 – Dec 2014, Civil structures intern, BMT Fluid Mechanics, Teddington, United Kingdom

Academic awards & grants

- 2023, Winner of the **18th ERCOFTAC da Vinci Competition** – Awarded for the best European Ph.D. thesis in flow, turbulence and combustion, and outstanding scientific contributions with engineering relevance (**€1,000**)
- 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 (**€125,000** + **€10,000** ancillary costs)
- 2018, Scholarship for the first year of my Ph.D., Université Libre de Bruxelles (**€25,000** + **€3,000** ancillary costs) Granted to Ph.D. students who scored just below the threshold for obtaining a F.R.S.-FNRS grant in 2018 to encourage another application to F.R.S.-FNRS the following year.
- 2016, Funding for an abroad research stay, Erasmus+ (**€500**)
- 2016, Dean's scholarship for the best students, Cracow University of Technology (approx. **€800**)
- 2012, GE Foundation Scholar Leaders scholarship (**€3,000**)

Peer-reviewed journal articles (10)

2025 C. Mucignat, **K. Zdybał**, and I. Lunati. Improving the performance of a lightweight convolutional neural network for particle image velocimetry through hyper-parameter and padding optimization. *Physics of Fluids*, 37:105112, 2025.
https://doi.org/10.1063/5.0283779

2025 **K. Zdybał**, C. Mucignat, and I. Lunati. pykitPIV: A framework for flexible and reproducible virtual training of machine learning models in optical velocimetry. *SoftwareX*, 31:102356, 2025.
https://github.com/kamilazdybal/pykitPIV
https://doi.org/10.1016/j.softx.2025.102356

2025 **K. Zdybał**, J. C. Sutherland, and A. Parente. Optimizing progress variables for ammonia/hydrogen combustion using encoding-decoding networks. *Combustion and Flame*, 276:114152, 2025.
https://github.com/kamilazdybal/pv-optimization
https://doi.org/10.1016/j.combustflame.2025.114152
https://youtu.be/Ux70wlXQ4_M

2023 **K. Zdybał**, A. Parente, and J. C. Sutherland. Improving reduced-order models through nonlinear decoding of projection-dependent outputs. *Patterns*, 4:100859, 2023.
https://github.com/kamilazdybal/nonlinear-decoding
https://doi.org/10.1016/j.patter.2023.100859
https://youtu.be/ZEB46rEknvU

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://youtu.be/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
https://youtu.be/MMldWMduCp0

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

Articles to be submitted in 2025 (2)

2025 G. Corlùy, **K. Zdybał**, and A. Parente. Progress variable optimization in a hydrogen flame for reduced-order modeling using an encoder-decoder. *In preparation for Energy and AI*, 2025.

2025 A. Procacci, **K. Zdybał**, 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*, 2025.

Software development

I am **the main developer** of the following packages:

- **`pykitPIV`** – a Python library for kinematic training of machine learning algorithms in particle image velocimetry
  https://pykitpiv.readthedocs.io
- **`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
  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

I am **a contributor** to the following package:

- **`LIMA`** – Lightweight Image Matching Architecture for velocimetry

Contributions to 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
- 2018–present, Developing open-source educational materials
  https://kamilazdybal.github.io
- 2021, Developing Python software for a graduate course on multicomponent mass transfer
- 2018–2021, 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

Invited talks (15)

2025 **K. Zdybał**. Convolutions and particles: How can machine learning support PIV? In *Machine Learning for Complex Flows, ETSIAE-UPM*, Madrid, Spain, 2025.

2024 **K. Zdybał**. Representation learning in combustion and beyond. In *Machine Learning for Reacting Flows, CERTH - The Centre for Research & Technology, Hellas*, Thessaloniki, Greece, 2024.

2024 **K. Zdybał**. The beauty and pitfalls of t-SNE. In *Université Libre de Bruxelles*, Online, 2024. Guest lecture in the master-level course MECA-H419 – Data-Driven Engineering.
Part 1: https://youtu.be/tfk6Jo0pUQ8
Part 2: https://youtu.be/8fqk-3Z7J4Y

2024 **K. Zdybał**. Introduction to artificial neural networks. In *Université Libre de Bruxelles*, Online, 2024. Guest lecture in the master-level course MECA-H419 – Data-Driven Engineering.

2024 **K. Zdybał**. Introduction to machine learning and artificial neural networks. In *The University of Utah*, Online, 2024. Guest lecture in the undergraduate course CHEN-2450 – Numerical Methods.
https://www.youtube.com/watch?v=IGEWE81FWMA

2023 **K. Zdybał**. Efficient dimensionality reduction of combustion data. In *Machine Learning in Combustion*, Online, 2023. Technische Universität Darmstadt & RWTH Aachen University workshop.
https://www.nhr4ces.de/machine-learning-in-combustion/

2023 **K. Zdybał**. Modeling high-dimensional systems with data science and machine learning. In *Empa, Swiss Federal Laboratories for Materials Science and Technology*, Dübendorf, Switzerland, 2023. Talk.

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 (19)

2025 G. Corlùy, **K. Zdybał**, X. Wen, L. Berger, H. Pitsch, and A. Parente. Reduced-order modeling with an optimized progress variable for a hydrogen flame. In *Math to Product (M2P)*, Valencia, Spain, 2025.

2025 G. Corlùy, **K. Zdybał**, X. Wen, L. Berger, H. Pitsch, and A. Parente. Progress variable optimization of a hydrogen flame for reduced-order modeling using an encoder-decoder. In *AI and Fluid Mechanics*, Crete, Greece, 2025.

2024 **K. Zdybał**, C. Mucignat, and I. Lunati. Optimization of hyper-parameters and padding for a lightweight velocimetry network. In *APS Division of Fluid Dynamics Meeting*, Salt Lake City, UT, USA, 2024.

2024 J. C. Sutherland, **K. Zdybał**, and A. Parente. Optimizing progress variables for ammonia/hydrogen combustion using encoding-decoding networks. In *APS Division of Fluid Dynamics Meeting*, Salt Lake City, UT, USA, 2024.

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 J. C. Sutherland, **K. Zdybał**, and A. Parente. 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 (4)

2025 C. Mucignat, **K. Zdybał**, and I. Lunati. AuRos: An autonomous robotic system for agentic scientfic experimentation. In *Research Data in Materials Science, EMPA*, Dübendorf, Switzerland, 2025.

2025 C. Mucignat, **K. Zdybał**, and I. Lunati. LIMA: A lightweight CNN for fast and accurate image matching. In *Research Data in Materials Science, EMPA*, Dübendorf, Switzerland, 2025.

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 | Proceedings of the Combustion Institute | Data-Centric Engineering | Nonlinear Dynamics | International Journal of Hydrogen Energy | Applications in Energy and Combustion Science |

Society member

Belgian Section of the Combustion Institute | Society for Industrial and Applied Mathematics (SIAM) | American Physical Society (APS) |

Technologies used

Programming languages

Python (7 years of experience) | Elixir (1 year of experience) | Julia (beginner) | C/C++ (beginner) |

Other

Jupyter notebook | Jupyter lab | TensorFlow | TF-Agents | Keras | PyTorch | Sphinx | git | GitHub | GitLab | MATLAB® | Notion | LaTeX | texmaker | draw.io | ReadTheDocs | SLURM | Atom | PyCharm | Rhinoceros 3D | AutoCAD | SketchBook | Confluence | Jira | wandb |

Selected course certifications

- **The Basics of Transport Phenomena**, Delft University of Technology
- **Advanced Transport Phenomena**, Delft University of Technology
- **Learning Data Visualization**, LinkedIn Learning
- **Deep Learning Fundamentals with Keras**, IBM
- **Deep Learning with Tensorflow**, IBM
- **Being a Good Mentor**, LinkedIn Learning
- **Communicating through Disagreement**, LinkedIn Learning

Professional references

🎓 **Prof. Alessandro Parente**, Université Libre de Bruxelles
`Alessandro.Parente@ulb.be`

🎓 **Prof. James C. Sutherland**, The University of Utah
`James.Sutherland@utah.edu`

🎓 **Prof. Miguel A. Mendez**, The von Karman Institute for Fluid Dynamics
`Miguel.Alfonso.Mendez@vki.ac.be`

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