HAMID REZA KARBASIAN

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Academic Experience

Postdoctoral Research Associate *Feb. 2023 ∼ present*
Dept. of Mechanical Engineering, Massachusetts Institute of Technology Cambridge, MA

- Algorithm development for solving PDEs in the FSI problems – parallel programming for high-fidelity simulation of multi-phase problems using immersed interface method (funded by the Department of Energy, DOE).
- Inverse design of deformable wing using deep neural networks – multi-objective optimization of an aeroelastic airfoil with extension to 3D problems in future work (preparing proof of concepts for writing a proposal and extending the research fund).
- Development of a digital twin framework for prediction of vortex dynamics in the wake, with application in the design and control of wind turbine – prediction of the flow structures in the wake of a flapping foil using deep learning.

Postdoctoral Research Fellow *Oct. 2022 – Feb. 2023*
Department of Mechanical Engineering, Polytechnique Montreal Montreal, Canada

- Physics-Informed Neural Networks (PINNs) for aeroelasticity – building a digital twin framework coupled with an experimental setup in the wind tunnel to test the behavior of a flexible slender plate (partnership with Hydro-Québec).
- Reduced order model development – a combination of PINNs with the Galerkin projection of Navier-Stokes equations for FSI modeling of a flexible pipe conveying flow. Experiments are also done to validate the model for different unsteady conditions (in collaboration with Maya HTT).

Fields CQAM Postdoctoral Research Fellow *Sep. 2021 – Aug. 2022*
Fields Institute, University of Toronto Toronto, Canada

- Member of AI-for-Design (AI4D) team at National Research Council Canada (NRC).
- Development of a physics-based deep learning framework for thermal analysis of multi-phase flow problems – transient modeling of fluid-solid interaction of particles using LSTM (in partnership with NRC).
- Mathematical modeling of non-newtonian melted metals in friction stir welding – solver development for simulation of particles using Smoothed Particle Hydrodynamics (SPH).

Research Assistant *Sep. 2017 – Aug. 2021*
Dept. of Mechanical & Aerospace Engineering, Concordia University Montreal, Canada

- Design of novel architectures for solving physics using physics-based machine learning (funded by Natural Sciences and Engineering Research Council of Canada).
- Model discovery and Hyper-Reduction using deep-learning neural networks.
- Large-scale constrained optimization using Multi-disciplinary Design Optimization (MDO).
- Design and development of non-linear reduced-order model for complex physics.
- System identification and controller design using Koopman operator formalism.
- Advanced software development, scientific computing, and parallel programming.

Research Assistant *Sep. 2015 – Aug. 2017*
Department of Mechanical Engineering, Pusan National University Busan, South Korea

- Flow measurements using Particle Image Velocimetry (PIV) in the wind tunnel (funded by BK21+).
- Turbulent flow analysis of a novel cooling fan (sponsored by LG).

- Optimal design and analysis of a mixing head (in partnership with DUT-Korea).
- Design and analysis of a novel apparatus applied to the oil industry to reduce gas emission (in collaboration with R&D team at Tanktech Co).
- Collaboration with Fluid Mechanics Key Laboratory of Education Ministry at Beihang University, China.

Education

Ph.D., Mechanical Engineering *Sep. 2017 – Aug. 2021*
Concordia University Montreal, Canada
Thesis: Aerodynamic optimization using high-fidelity computational fluid dynamics
Advisor: Brian C. Vermeire

M.Sc., Mechanical Engineering *Sep. 2015 – Aug. 2017*
Pusan National University Busan, South Korea
Thesis: Analysis of unsteady vortex structures around a moving foil under deep dynamic stall condition
Advisor: Kyung Chun Kim

B.Sc., Chemical Engineering *Mar. 2008 – Sep. 2012*
Ferdowsi University / Urmia University of Technology Mashhad, Iran / Urmia, Iran
Thesis: Mechanical gill for underwater breathing.

Industry Experience

Aerospace Engineer (Team Lead) *Jul. 2021 – Jan. 2023*
The Limosa Inc. Montreal, Canada

- Managing aerodynamic designs and mentoring team members, including two postdoctoral fellows.
- Preparing proposals and contributing to business development (funded two proposals by MITACS, and accepted into the Centech "Acceleration Program").
- Conceptual design and analysis of electric aircraft – considered more detailed designs of the propellers, wings, and fuselage after preliminary theoretical analysis. Moreover, several CFD simulations are performed for the initial validation of procedures.
- Fabrication of scaled model (drone version) of the LimoConnect and performing flight test in collaboration with the control team – implemented an experimental setup for testing aerodynamic performance and stability of the drone in the hover condition.

Research & Development Engineer *Mar. 2012 – Mar. 2015*
Sun-Air Research Institute Mashhad, Iran

- Conceptual and detailed aerodynamic design and analysis of 100kW horizontal-axis wind turbine – participated in the design and manufacturing process.
- Turbulent flow analysis and aerodynamic load prediction of various airfoil families – built a data library for different airfoils used in other wind turbines.
- Numerical simulation of unsteady aerodynamics and dynamic stall (funded by the Center of Excellence on Modeling and Control Systems).

Grants

1. **MITACS Thematic Elevate – 2022**.
   Subject: Application of computational fluid dynamics to urban air mobility
   PI: Brian Vermeire, Concordia University
   Co-PI: **H.R. Karbasian**, Limosa Inc.
   Total amount: $320,000
   Duration: 2022 – 2024
   Status: Awarded

2. **COVID Research Grant, Concordia University – 2020**.
   Subject: High-order computational fluid dynamics for turbulent flows
   PI: Brian Vermeire, Concordia University
   Recipient: **H.R. Karbasian**, Concordia University.
   Total amount: $5,000
   Duration: 2020 – 2021
   Status: Awarded

Honors & Awards

1. Fields CQAM Postdoctoral Fellowship, Fields Institute, Canada (2021)
2. Accelerator Award, Concordia University, Canada (2021)
3. Graduate Fellowship, Concordia University, Canada (2017)
4. International Tuition Award of Excellence, Concordia University, Canada (2017)
5. 2^{nd} place among the M.Sc. students, Pusan National University, South Korea (2017)
6. Brain Korea (BK21+) Scholarship, Korean government for graduate students, South Korea (2015)
7. Foreign Graduate Scholarship, Pusan National University, South Korea (2015)
8. 2^{nd} place (Silver medal), International Iran-Open RoboCup, Iran (2013)
9. Undergraduate Scholar (fully-funded), Ministry of Science & Research, Iran (2008)

Mentoring (Co-supervising)

Postdoc

1. Ramin Ghoreishi, *Aerodynamic optimization of eVTOL rotors*, Department of Mechanical Engineering, Concordia University (joint by Limosa Inc.), Aug. 2022–present.

2. Firoozeh Yeganehdoost, *Acoustic impact analysis of optimized eVTOL rotor designs*, Department of Mechanical Engineering, Concordia University (joint by Limosa Inc.), Aug. 2022–present.

MSc. Students

1. Omar Tazi Labzour, *Modeling FSI with physics-informed neural network using modal decomposition*, Department of Mechanical Engineering, Polytechnique Montreal, Oct. 2022–2023.

2. Theo Takla, *Development of the adjoint solver for sensitivity analysis using Automatic Differentiation*, visiting student at the Department of Mechanical Engineering, Massachusetts Institute of Technology, Aug. 2022–Feb. 2023.

3. Adriana Orta, *Optimization of Vertical-Axis Wind Turbine (VAWT) using high-fidelity computational fluid dynamics*, Department of Mechanical, Industrial and Aerospace Engineering, Concordia University, 2021.

4. Anthony Aubrey, *High-fidelity optimization of gas turbine cascades*, Department of Mechanical, Industrial and Aerospace Engineering, Concordia University, 2019-2021.

Undergraduate Students

1. Matthieu Castaliho, *Low-Reynolds number flapping foil with different kinematic parameters.*, Department of Mechanical, Industrial and Aerospace Engineering, Concordia University, 2020.

2. Mohammad Houqe, *Aerodynamic load prediction using open-source PyFR CFD solver.*, Department of Mechanical, Industrial and Aerospace Engineering, Concordia University, 2017.

Teaching Experience

Teaching Certificate

Title: "University Teaching"
Licensed by: GradProSkill, Concordia University, 2021
Workshop duration: 35 hours

Lab Demonstrator: (Number of attendees: 👪)

Gas Dynamics (Aerospace Engineering, Concordia University)
Summer 2020 (∼90 👪)/ Fall 2020 (∼80 👪)/ Summer 2021 (∼80 👪)

Theoretical explanation of gas dynamics and analytical design of subsonic/sonic/supersonic nozzles. Implementation, testing, and validation of the analytical method using Computational Fluid Dynamics (CFD) software (Ansys Fluent and STAR CCM). Introduction to the design of different meshes for various converging-diverging nozzles. Solving stability issues at high Mach number flows using numerical techniques and simulation setup in the software.

Computational Fluid Dynamics (Mechanical Engineering, Concordia University)
Winter 2018 (∼12 👪)/ Winter 2019 (∼15 👪)/ Winter 2020 (∼20 👪)/ Winter 2021 (∼20 👪)

Fundamentals in CFD and numerical methods, including spatial discretization using the finite difference approach. Providing a preliminary introduction to code development using high-level languages, such as MATLAB. The advanced design of mesh (structured and unstructured) using Gmsh, an open-source software, and setting up SU2 software for solving 2D and 3D canonical aerodynamics problems. Advanced post-processing, such as planar plots, contours, rendering, developing scripts for mathematical calculations in Paraview, and providing technical consultations for code development and debugging.

Aerodynamics (Mechanical Engineering, Concordia University)
Fall 2017 (∼9 👪)/ Fall 2018 (∼35 👪)/ Fall 2019 (∼20 👪)

Teaching as a guest lecturer: panel method in theoretical aerodynamics and its mathematical formulations. Explaining different flow regimes around an arbitrary bluff body at different Reynolds numbers and flow conditions. A mathematical explanation of force calculations around a bluff body in inviscid flow and providing some examples. Advanced aircraft design and computational aerodynamic analysis using OpenVSP software.

Tutor:

Department of Mechanical Engineering, Concordia University
Thermodynamics, Turbomachinery & Propulsion, and Applied Ordinary Differential Equations.

Publications

Total number of peer-reviewed articles: 27
Total number of citations: 474
h-index: 12 | **i10-index: 14**

Book

1. *Computational Fluid Dynamics: An Open-Source Approach*, B.C. Vermeire, C.A. Pereira, **H.R. Karbasian**, Concordia University Press, 2020. [Link]

Thesis

1. **H.R. Karbasian**, *Aerodynamic optimization using high fidelity computational fluid dynamics*, PhD thesis, Concordia University, 2021. [Link]

2. **H.R. Karbasian**, *Analysis of unsteady flow and vortex structures around a moving foil under deep dynamic stall condition*, MSc thesis, Pusan National University, 2017. [Link]

Patent

1. *Mechanical respiratory system for underwater breathing (Mechanical gill)*, **H.R. Karbasian**, N. Saghatoleslami, No. 71062 B/ 390010253 App. Iranian Patent, 2011. [Link]

Peer-reviewed Articles

1. **H.R. Karbasian**, W.M. van Rees, *A parametric LSTM neural network and its application to predicting flapping foil dynamics across a design space* (submitted).
2. **H.R. Karbasian**, W.M. van Rees, *A Deep-Learning Surrogate Model Approach for Optimization of Morphing Airfoils*, AIAA SCITECH, 2023. [Link]
3. **H.R. Karbasian**, B.C. Vermeire, *Application of physics-constrained data-driven reduced-order models to shape optimization*, Journal of Fluid Mechanics, 2022. [Link]
4. **H.R. Karbasian**, B.C. Vermeire, *Sensitivity analysis of chaotic dynamical systems using a physics constrained data-driven approach*, Physics of Fluids, 2022. [Link]
5. **H.R. Karbasian**, J.A. Esfahani, A.M. Aliyu, K.C. Kim, *Numerical analysis of wind turbines blade in deep dynamic stall*, Renewable Energy, 2022. [Link]
6. A. Aubrey, **H.R. Karbasian**, B.C. Vermeire, *High-fidelity gradient-free optimization of low-pressure turbine cascades*, Computers and Fluids, 2022. [Link]
7. **H.R. Karbasian**, B.C. Vermeire, *Gradient-free aerodynamic shape optimization using Large Eddy Simulation*, Computers and Fluids, 2021. [Link]
8. **H.R. Karbasian**, J.A. Esfahani, *Enhancement of propulsive performance of flapping foil by fish-like motion pattern*, Computers and Fluids, 2017. [Link]
9. **H.R. Karbasian**, D.Y. Kim, ..., *A new method for reducing VOCs formation during crude oil loading process*, Journal of Mechanical Science and Technology, 2017. [Link]
10. **H.R. Karbasian**, J.A. Esfahani, E. Barati, *The power extraction by flapping foil hydrokinetic turbine in swing arm mode*, Renewable Energy, 2016. [Link]
11. **H.R. Karbasian**, K.C. Kim, *Numerical investigations on flow structure and behavior of vortices in the dynamic stall of an oscillating pitching hydrofoil*, Ocean Engineering, 2016. [Link]
12. **H.R. Karbasian**, ..., K.C. Kim, *Numerical visualization of mixing in a circular chamber by two opposite impinging jets*, Journal of the Korean Society of Visualization, 2016. [Link]
13. **H.R. Karbasian**, J.A. Esfahani, E. Barati, *Effect of acceleration on dynamic stall of airfoil in unsteady operating conditions*, Wind Energy, 2016. [Link]
14. **H.R. Karbasian**, J.A. Esfahani, E. Barati, *Simulation of power extraction from tidal currents by flapping foil hydrokinetic turbines in tandem formation*, Renewable Energy, 2015. [Link]
15. J.A. Esfahani, **H.R. Karbasian**, E. Barati, *Proposed kinematic model for fish-like swimming with two pitch motions*, Ocean Engineering, 2015. [Link]
16. J.A. Esfahani, E. Barati, **H.R. Karbasian**, *Fluid structures of flapping airfoil with elliptical motion trajectory*, Computers and Fluids, 2015. [Link]
17. **H.R. Karbasian**, S.A.Moshizi, M.J. Maghrebi, *Dynamic stall analysis of S809 pitching airfoil in unsteady free stream velocity*, Journal of Mechanics, 2015. [Link]
18. J.A. Esfahani, E. Barati, **H.R. Karbasian**, *Effect of caudal on hydrodynamic performance of flapping foil in fish-like swimming*, Journal of Applied Ocean Research, 2013. [Link]

Invited Talks

1. **H.R. Karbasian**, *A novel reduced-order modeling for high-fidelity PDE-constrained aerodynamic optimization*, Department of Mechanical Engineering, Toronto Metropolitan University, Toronto, Canada, Jun. 2023.
2. **H.R. Karbasian**, *High-fidelity PDE-constrained aerodynamic optimization using reduced-order modeling*, Department of Mechanical Engineering, University of South Florida, USA, May. 2023.
3. **H.R. Karbasian**, *Design in Chaos: High-Fidelity Aerodynamic Optimization Using Novel Physics Constrained Machine Learning*, Department of Mechanical and Aerospace Engineering, University of California Davis, USA, Feb. 2022.
4. **H.R. Karbasian**, *Physics-constrained data-driven reduced-order modeling for large-scale optimizations*, National Research Council Canada, Canada, Dec. 2021.
5. **H.R. Karbasian**, *Sensitivity analysis and uncertainty quantification using novel physics-constrained machine learning*, Department of Mathematics and Statistics, Utah State University, USA, Sep. 2021.
6. **H.R. Karbasian**, B.C. Vermeire, *Design in Chaos*, University of Toronto Institute for Aerospace Studies, Canada, Apr. 2021.
7. **H.R. Karbasian**, *Design in Chaos*, Department of Mechanical Engineering, The University of British Columbia, Canada, Apr. 2021.
8. **H.R. Karbasian**, B.C. Vermeire, *Shadow of the Chaos*, University of Toronto Institute for Aerospace Studies, Canada, Nov. 2020

Conference Papers & Presentations (Refereed)

1. **H.R. Karbasian**, W. van Rees, *A parameterized LSTM deep neural network framework to model unsteady flow problems*, American Physical Society, Washington DC, USA, 2023.
2. Omar Tazi Labzour, **H.R. Karbasian**, Sebastien Houde, Frederick P. Gosselin, *Combining Reduced-Order Modeling and PINNs to model Fluid-Structure Interactions*, Canadian Society for Mechanical Engineering (CSME), Sherbrooke, Canada, 2023.
3. **H.R. Karbasian**, W. van Rees, *A Deep-Learning Surrogate Model Approach for Optimization of Morphing Airfoils*, AIAA SCITECH, National Harbor, USA, 2023.
4. **H.R. Karbasian**, W. van Rees, *Development of surrogate models for unsteady flow fields using a deep neural network*, American Physical Society, Indianapolis, USA, 2022.
5. **H.R. Karbasian**, B.C. Vermeire, *Advances in Multi-Disciplinary PDE-Constrained Optimization*, The 29^{th} Annual Conference of the CFD Society of Canada, St. Johns, Newfoundland, Canada, 2021.
6. **H.R. Karbasian**, B.C. Vermeire, *Aerodynamic Optimization of Unsteady Chaotic Flows*, AERO Conference at Canadian Aeronautics and Space Institute, Canada, 2021.
7. A. Aubry, **H.R. Karbasian**, B.C. Vermeire, *High-Fidelity Gradient-Free Optimization of Low-Pressure Turbine Cascades*, International Conference on Spectral and High Order Methods, Vienna, Austria, 2021.
8. A. Aubry, **H.R. Karbasian**, B.C. Vermeire, *High-Fidelity Gradient-Free Optimization of Low-Pressure Turbine Cascades*, AERO Conference at Canadian Aeronautics and Space Institute, Canada, 2021.
9. **H.R. Karbasian**, B.C. Vermeire, *Gradient-free high-fidelity airfoil optimization*, AERO Conference at Canadian Aeronautics and Space Institute, Laval, QC, Canada, 2019.
10. K.C. Kim, **H.R. Karbasian**, *Reynolds number effect on airfoil wake structures under pitching and heaving motion*, Bulletin of the American Physical Society, 70th Annual Meeting of the APS Division of Fluid Dynamics, Vol.62, Denver, CO, USA, 2017
11. **H.R. Karbasian**, K.C. Kim, *Unsteady Flow Features over Flapping Foil in Low Reynolds Number*, Proceedings of the Korean Society for Visualization, South Korea, 2016.

12. M. Kim, **H.R. Karbasian**, E. Yeom, K.C. Kim, *Large Eddy Simulation of* 45° *oblique round jet impingement onto a circular cylinder*, Proceedings of the Korean Society for Visualization, South Korea, 2017.
13. **H.R. Karbasian**, K.C. Kim, *Vortex structure and instability of flow over heaving and pitching foils*, 17th International Symposium on Flow Visualization, Gatlinburg, TN, USA, 2016
14. **H.R. Karbasian**, K.C. Kim, *Flow instabilities and its effect on power generation of horizontal axis wind turbine*, The 9th National Congress on Fluid Engineering, Daegu, South Korea, 2016
15. **H.R. Karbasian**, K.C. Kim, *Unsteady flow features over flapping foil in low Reynolds numbers", The Korean Society of Visualization*, Yongin, South Korea, 2016

Technical Reports

1. **H.R. Karbasian**, *AI4D bi-annual project progress update*, National Research Council Canada, 2021.
2. **H.R. Karbasian**, *Conceptual design of the LimoConnect eVTOL aircraft*, Limosa Inc., 2021.
3. **H.R. Karbasian** *Aerodynamic design of propellers for the LimoConnect*, Limosa Inc., 2021.
4. **H.R. Karbasian**, Y. Kim, K.C. Kim, *반대방향 충돌제트에 의한 원형 챔버 내 혼합거동에 대한 전산 가시화*, DUTKOREA Co., Ltd, 2016.
5. **H.R. Karbasian**, D.Y. Kim, S.Y. Yoon, J.H. Ahn, K.C. Kim, *유류운반선의 저장탱크에서 발생하는 VOC 회수시스템 개발*, Technical Research Department, Tanktech Co., Ltd, 2015.
6. **H.R. Karbasian**, A. Rasouli, *Possibility of higher power generation using 100KW Horizontal Axis Wind Turbine (HAWT)*, Aerodynamics group, Sun-Air Research Institute, 2014.
7. **H.R. Karbasian**, A. Rasouli, *Design of 1.5KW Stall turbine using Qblade and WT-Perf.*, Aerodynamics group, Sun-Air Research Institute, 2013.

Skills

Developer of scientific softwares:

- **OPTHiNOS** (**OP**timization **T**oolkit for **Hi**ghly **NO**n-linear **S**ystems) [Link]
  A physics-based machine learning framework for high-fidelity optimization problems. The main feature of this software is enabling complex optimization in the presence of highly non-linear and chaotic systems.
- **PyMADS**
  A python package for non-convex optimization using Mesh Adaptive Direct Search (MADS) algorithm. This package uses a novel CPU-GPU platform to accelerate optimization time by 30% $\sim$ 70%.
- **jFVS** (**j**ulia **F**inite **V**olume **S**olver)
  An in-house PDE solver developed to solve Navier-Stokes and Euler equations using Finite Volume Method (FVM). This solver is purely programmed in Julia with optimized algorithms suited for High Performance Computing (HPC).
- **HORUS** (**H**igh-**OR**der **U**nstructured **S**olver) as a team member
  An in-house high-order CFD solver developed at Computational Aerodynamics Lab.

Experimental skills:

- **FSI analysis:** deformation of a slender flat plate in the wind tunnel is studied for unsteady conditions when fluttering occurs. Finding different structural instability patterns and adding them to the digital twin framework.
- **Unsteady analysis of oscillating airfoils:** testing pure pitching and plunging airfoils at high oscillation frequencies in the wind tunnel and visualizing flow patterns using Particle Image Velocimetry (PIV).
- **Robotics:** using various sensors (accelerometer gyroscope, load cells, thermometer,...) and actuators (servo and stepper motors) for experimental setups. Participated in the fabrication and test of our designed drone (scaled size of LimoConnect).

Professional Activities

Journal Referee

Physics of Fluids (ASP) • AIAA • Energy (*Elsevier*) • Renewable Energy (*Elsevier*) • Ocean Engineering (*Elsevier*) • Applied Ocean Research (*Elsevier*) • Aerospace (MDPI) • Alexandria Engineering Journal (*Elsevier*) • Journal of Visualization (*Springer*) • International Journal of Aerospace Engineering (*Hindawi*).

Professional Memberships

- Canadian Aeronautics and Space Institute

Services

- Technical representative for Limosa Inc. (2022), International Aerospace Week, Montreal, Canada.
- Student volunteer (2018-2019), *Concordia University Student Parent Center*, Montreal, Canada.
- Technical staff (2017), *12th International Symposium on Particle Image Velocimetry*, Busan, South Korea
- Robot designer (2013-2015), *FUM Robotics Lab*, Mashhad, Iran
- Teacher (2014), *Scientific programming using MATLAB*, Ferdowsi University, Mashhad, Iran