

# Malik Hassanaly

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🏆 R<sup>e</sup> in

## EDUCATION

- **PhD University of Michigan, USA** GPA: 4.0  
*Aerospace Engineering - Dissertation: "Extreme Events in Turbulent Combustion"* August 2019
- **MSE University of Texas at Austin, USA** GPA: 3.79  
*Aerospace Engineering - Master Thesis: "Large-eddy simulations of boundary layer flashback"* January 2015
- **MSE Ecole Centrale de Lille, France** GPA: 3.89  
*General Engineering - Thesis project: "Design and testing of a new tidal turbine"* January 2015

## SKILLS

- **Programming:** Python, C++, Fortran, Bash, Git
- **ML Libraries:** TensorFlow, PyTorch
- **Physics modeling tools:** OpenFOAM, Paraview
- **Languages:** English (Fluent), French (Native), Spanish (Intermediate)

## EXPERIENCE

- **National Renewable Energy Laboratory (NREL), USA** September 2019 - Current  
*Researcher - Computational Science and Machine Learning*
  - **Data augmentation for atmospheric modeling and probability estimation:** Developed a method that estimates the amount of diversity that must be observed when super-resolving atmospheric data. The a priori diversity is used to evaluate and regularize Generative Adversarial Networks (GANs).  
🔗 Adversarial sampling of unknown and high-dimensional conditional distributions, M. Hassanaly et al. *Journal of Computational Physics*, 2022 🌐  
Scaled up the conditional moment estimation method to large spatiotemporal atmospheric datasets.  
🔗 Coarse-graining uncertainty in atmospheric spatio-temporal super-resolution 🌐  
The method is also useful when multiple realizations need to be generated. I demonstrated that it reduces the variance of rare-event probability estimators when using importance splitting.  
🔗 GANISP: a GAN-assisted Importance Splitting Probability Estimator, M. Hassanaly et al. *AAAI-ADAM*, 2022, 🌐
  - **Downsampling of large and high-dimensional datasets:** Developed a method to downsample large datasets while incurring minimal information loss. The method first estimates the probability density of a high-dimensional and large dataset with a normalizing flow and uses it to decide how aggressive downsampling needs to occur. An iterative treatment helps mitigate errors in low-probability regions. The method achieves uniform-in-phase space sampling even in high dimensions and outperforms SOTA for combustion modeling.  
🔗 Uniform-in-phase-space data selection with iterative normalizing flows, M. Hassanaly et al. *Under-review*, 2022, 🌐
  - **Physics-informed surrogate model of Li-ion batteries:** Accelerate Bayesian calibration of Li-ion battery parameters to help diagnose the cause of battery degradation and formulate degradation models for parameters. The surrogate model is constructed with a physics-informed neural network that uses sparse available data. The method accelerates inverse problem solving by at least two orders of magnitude.  
🔗 Physics-Informed Neural Network Modeling of Li-Ion Batteries, M. Hassanaly et al. *242nd ECS Meeting*, 2022
  - **Analytically reduced chemistry for heterogeneous high-performance computing (HPC):** Generation of chemical Jacobian for analytically reduced chemistry. The Jacobian is symbolically encoded allowing to automate memory-efficient pre-computations to balance memory and register pressure on CPU/GPU architectures. The method has been successfully deployed on exascale machines 🌐
  - **Uncertainty propagation of data-driven models:** Estimate reducible and non-reducible uncertainties with Bayesian neural networks. Developed a method for including extrapolative uncertainty in regression models.
  - **Optimization of deposition reactors:** Developed a chemistry surrogate model for accelerating numerical simulations of III-V deposition reactors used for solar cell manufacturing. The chemistry model was calibrated with a Bayesian approach. The model was used to optimize the reactor geometry and the reactant injection scheme.  
🔗 Surface chemistry models for GaAs epitaxial growth and hydride cracking using reacting flow simulations, M. Hassanaly et al. *Journal of Applied Physics*, 2021
- **University of Michigan, USA** January 2015 - August 2019  
*Graduate Research Assistant*
  - **Chaotic dynamics of turbulent combustion:** Characterized the dynamics of turbulent flames using Lyapunov exponent (LE). I identified that extinction and reignition in turbulent flames mainly participated in the amplification of perturbations. In absence of combustion, perturbation amplification is mostly localized near strong vortices. I provided the first estimate of the attractor dimension of turbulent flames.

✂ Ensemble-LES Analysis of Perturbation Response of Turbulent Partially-Premixed Flames, M. Hassanaly et al. *Proceedings of the Combustion Institute*, 2019

I adapted the LE computation algorithm to variable density low-Mach CFD solvers and rigorously assessed the convergence properties of the algorithm.

✂ Numerical convergence of the Lyapunov spectrum computed using low Mach number solvers, M. Hassanaly et al. *Journal of Computational Physics*, 2019

- **Information extraction from large datasets:** Identify turbulent features that influence ignition of jet fuels using data from numerical simulations.

✂ Data-driven Analysis of Relight variability of Jet Fuels induced by Turbulence, M. Hassanaly et al. *Combustion and Flame*, 2021.

- **Efficient numerical solvers for variable density flows:** Developed a numerical solver that reduces the amount of numerical dissipation and mass conservation inaccuracies in variable density low-Mach solvers. The solver has been used by 4 corporations and 15 universities.

✂ A minimally-dissipative low-Mach number solver for complex reacting flows in OpenFOAM, M. Hassanaly, *Computer and Fluids*, 2018.

- **Maïa Eolis (now Engie Green), France** November 2012 - May 2013  
*Physics Modeling Intern*
  - Computational fluid dynamics modeling of wind turbine blades. I quantified the mechanical stress induced by a novel blade spoiler.
- **RTE (French Electrical Grid), France** May 2012 - November 2012  
*Software Development Intern*
  - Developed of a generic gateway from a UML model to a C++ library used in a large-scale power grid code.

## OTHER JOURNAL PUBLICATIONS

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### Data-driven modeling

- **Bi-fidelity Modeling of Uncertain and Partially Unknown Systems using DeepONets:** S. De, M. Reynolds, M. Hassanaly et al. *Computational Mechanics*, 2023
- **Data-driven Classification and Modeling of Combustion Regimes in Detonation Waves:** S. Barwey, S. Prakash, M. Hassanaly et al. *Flow Turbulence and Combustion*, 2020
- **Data-based analysis of multimodal partial cavity shedding dynamics:** S. Barwey, H. Ganesh, M. Hassanaly et al. *Experiments in Fluids*, 2020

### Information Extraction

- **Using Machine Learning to Construct Velocity Fields from OH-PLIF Images:** S. Barwey, M. Hassanaly et al. *Combustion Science and Technology*, 2019
- **Experimental Data Based Reduced Order Model for Analysis and Prediction of Flame Transition in Gas Turbine Combustors:** S. Barwey, M. Hassanaly, Q. An, V. Raman, A. Steinberg *Combustion Theory and Modelling*, 2019.

### Reacting flows modeling

- **Surface chemistry models for GaAs epitaxial growth and hydride cracking using reacting flow simulations:** M. Hassanaly et al. *Journal of Applied Physics*, 2021
- **Probabilistic Modeling of Forced Ignition of Alternative Jet Fuels:** Y. Tang, M. Hassanaly et al. *Proceedings of the Combustion Institute*, 2021
- **Emerging Trends in Numerical Simulations of Combustion Systems:** V. Raman, M. Hassanaly, *Proceedings of the Combustion Institute*, 2019
- **A Comprehensive Modeling Procedure for Estimating Statistical Properties of Forced Ignition:** Y. Tang, M. Hassanaly et al. *Combustion and Flame*, 2019
- **Large Eddy Simulation of Pressure and Dilution Jet Effects on Soot Formation in a Model Aircraft Swirl Combustor:** S. T. Chong, M. Hassanaly et al. *Combustion and Flame*, 2018
- **Large Eddy Simulation of Soot Formation in a Model Gas Turbine Combustor:** H. Koo, M. Hassanaly et al. *Journal of Engineering for Gas Turbines and Power*, 2017

### Turbulence modeling

- **A priori analysis of reduced description of dynamical systems using approximate inertial manifolds:** M. Akram, M. Hassanaly et al. *Journal of Computational Physics*, 2020
- **An Approximate Inertial Manifold (AIM) Based Closure for Turbulent Flows:** M. Akram, M. Hassanaly et al. *AIP Advances*, 2022

### Chaotic dynamics

- **Classification and Computation of Extreme Events in Turbulent Combustion:** M. Hassanaly et al. *Progress in Energy and Combustion Science*, 2021
- **A self-similarity principle for the computation of rare event probability:** M. Hassanaly et al. *Journal of Physics A: Mathematical and Theoretical*, 2019
- **Lyapunov spectrum of forced homogeneous isotropic turbulent flows:** M. Hassanaly et al. *Physics Review Fluids*, 2019

## HONORS AND AWARDS

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- 2019: Richard and Eleanor Towner Prize for Distinguished Academic Achievement
- 2022: Milton Van Dyke Video Award, “Simulation of an RCCI Engine Using the Pele Suite of Exascale Codes”