Malik Hassanaly

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EDUCATION

PhD University of Michigan, USA
Aerospace Engineering - Dissertation:"Extreme Events in Turbulent Combustion"
GPA: 4.0
August 2019

MSE University of Texas at Austin, USA
Aerospace Engineering - Master Thesis:"Large-eddy simulations of boundary layer flashback"
GPA: 3.79
January 2015

MSE Ecole Centrale de Lille, France
General Engineering - Thesis project:"Design and testing of a new tidal turbine"
GPA: 3.89
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. *Data-Centric Engineering*, 2023, ⭕

- **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 ⭕

- **Synergistic activities**: Developed a variety of funding proposals for solving inverse problems, data reduction, parameter estimation and extreme event prediction. Mentored two summer interns.

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.
  Used experimental observations in swirl-combustors to formulate a predictive model for flame lift-off and access state variables non-measurable.
  ↱ Experimental Data Based Reduced Order Model for Analysis and Prediction of Flame Transition in Gas Turbine Combustors, S. Barwey, M. Hassanaly et al. *Combustion Theory and Modelling*, 2019.
- ○ **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

- **Bi-fidelity Modeling of Uncertain and Partially Unknown Systems using DeepONets**: S. De, M. Reynolds, M. Hassanaly et al. *Computational Mechanics*, 2023
- **An Approximate Inertial Manifold (AIM) Based Closure for Turbulent Flows**: M. Akram, M. Hassanaly et al. *AIP Advances*, 2022
- **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
- **Probabilistic Modeling of Forced Ignition of Alternative Jet Fuels**: Y. Tang, M. Hassanaly et al. *Proceedings of the Combustion Institute*, 2021
- **Data-driven Classification and Modeling of Combustion Regimes in Detonation Waves**: S. Barwey, S. Prakash, M. Hassanaly et al. *Flow Turbulence and Combustion*, 2020
- **A priori analysis of reduced description of dynamical systems using approximate inertial manifolds**: M. Akram, M. Hassanaly et al. *Journal of Computational Physics*, 2020
- **Data-based analysis of multimodal partial cavity shedding dynamics**: S. Barwey, H. Ganesh, M. Hassanaly et al. *Experiments in Fluids*, 2020
- **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
- **Using Machine Learning to Construct Velocity Fields from OH-PLIF Images**: S. Barwey, M. Hassanaly et al. *Combustion Science and Technology*, 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

HONORS AND AWARDS

- 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"