Malik Hassanaly

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  R⁶ 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

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

- 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"