Malik Hassanaly

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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 Summary

- **Programming**: Python, C_{++}, Fortran, Bash, Git
- **Libraries**: TensorFlow, sympy, matplotlib, numpy, MPI, PETSc, Flask
- **Physics Modeling tools**: OpenFOAM, Paraview
- **Languages**: English (Fluent), French (Native), Spanish (Intermediate)

Experience

- **National Renewable Energy Laboratory (NREL), USA** September 2019 - Current
  Researcher
  - **Data augmentation for atmospheric modeling and probability estimation**: Developed a method that estimates the amount of diversity that must be observed with continuous datasets. I used the method to evaluate and regularize Generative Adversarial Networks (GANs) so that they generate the expected amount of diversity. The method is the first one that can reliably measure and enforce a priori diversity.
    Adversarial sampling of unknown and high-dimensional conditional distributions, M. Hassanaly, et al. *Journal of Computational Physics*, 2022
    The method is also useful when multiple realizations need to be generated. I demonstrated that it reduces the rare-event probability estimator variance compared to other naive sampling methods.
    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)**: Developped a code that functions on GPU/CPU architectures for Quasi-Steady state chemistry mechanisms. The method includes a reliable chemistry Jacobian generation by symbolically encoding the chemistry mechanism. Memory-efficient precomputations are used for further acceleration on GPU. 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
  - **Synergestic activities**: Developped a variety of funding proposals for solving inverse problems, data reduction, and parameter estimation. Mentored interns over the summers.
- **University of Michigan, USA** January 2015 - August 2019
  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 dataset**: Used data from numerical simulations to identify the turbulent features that influenced the ignition of different jet fuels.
  ☞ 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 significantly 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 Publications

- **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
- **An Approximate Inertial Manifold (AIM) Based Closure for Turbulent Flows**: M. Akram, M. Hassanaly et al., *AIP Advances*, 2022

Honors and Awards

- 2019: Richard and Eleanor Towner Prize for Distinguished Academic Achievement