

Non-Deterministic Approaches

Papers Presented at the AIAA SciTech Forum and Exposition
2022

San Diego, California, USA and Online
3-7 January 2022

Volume 1 of 2

ISBN: 978-1-7138-5402-9

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

The contents of this work are copyrighted and additional reproduction in whole or in part are expressly prohibited without the prior written permission of the Publisher or copyright holder. The resale of the entire proceeding as received from CURRAN is permitted.

For reprint permission, please contact AIAA's Business Manager, Technical Papers. Contact by phone at 703-264-7500; fax at 703-264-7551 or by mail at 12700 Sunrise Valley Drive, Suite 200, Reston, VA 20191, USA.

TABLE OF CONTENTS

VOLUME 1

PHYSICS INFORMED MACHINE LEARNING: METHODS AND APPLICATIONS

Efficient Training of Transfer Mapping in Physics-Infused Machine Learning Models of UAV Acoustic Field.....	1
<i>Rayhaan Iqbal, Amir Behjat, Revant Adlakha, Jesse Callanan, Mostafa Nouh, Souma Chowdhury</i>	
Adaptive Learning of Emulator Embedded Neural Networks for Multi-Fidelity Conceptual Design Studies	19
<i>Atticus J. Beachy, Harok Bae, C C. Fischer, Ramana V. Grandhi</i>	
Application of Transfer Learning for Multi-Fidelity Regression Using Physics-Informed Neural Network on an Airfoil	39
<i>Kohei Harada, Dushhyanth Rajaram, Dimitri N. Mavris</i>	

DESIGN UNDER UNCERTAINTY I

Design of a Conceptual Firefighting Airtanker Vehicle Using Reliability-Based Design Optimization.....	52
<i>Daniel L. Clark, Jason Y. Kao, Cale Zeune, Scott A. Burton, Edwin E. Forster</i>	
Inverse Design Under Uncertainty Using Conditional Normalizing Flows	69
<i>Panagiotis Tsilifis, Sayan Ghosh, Valeria Andreoli</i>	
Reliability-Based Design Optimization of Tow-steered Composite Plates Employing High-order CUF-Based Finite Elements	84
<i>Alberto Racionero Sanchez-Majano, Alfonso Pagani</i>	
Modelling Material Uncertainties Using Random Irregularities in Lattice Based Multiscale Optimization.....	95
<i>Dilaksan Thillaithevan, Paul J. Bruce, Matthew J. Santer</i>	

DESIGN UNDER UNCERTAINTY II

Multifidelity Gaussian Processes for Failure Boundary and Probability Estimation.....	109
<i>Ashwin Renganathan, Vishwas Rao, Ionel Navon</i>	
Inverse Design of 2D-Mechanical Metamaterials with Spinodal Topologies Under Uncertainty.....	128
<i>Kiara L. McMillan, Dogacan S. Ozturk, Pinar Acar</i>	
A Novel Tolerance Analysis Method Based on the "reverse Model" Considering Robustness	142
<i>Linjun Zhong, Yang Yang, Leshi Shu, Ping Jiang, Hua Wei</i>	
MAGE: Alleviating Uncertainty in Real-Time Decision-Making as a Function of Problem Complexity	148
<i>Natalia Alexandrov</i>	

VERIFICATION, VALIDATION, AND UNCERTAINTY QUANTIFICATION I

Modeling Non-Stationarity with Deep Gaussian Processes: Applications in Aerospace Engineering	156
<i>Muhammad F. Izzaturrahman, Pramudita S. Palar, Lavi Zuhail, Koji Shimoyama</i>	
Label Free Uncertainty Quantification	169
<i>Huiru Li, Jianhua Yin, Xiaoping Du</i>	
Regularizing Invertible Neural Networks for Airfoil Design Through Dimension Reduction	179
<i>Andrew Glaws, Jeffrey Hokanson, Ryan King, Ganesh Vijayakumar</i>	
Improving Multi-Model Trajectory Simulation Estimators Using Model Selection and Tuning	190
<i>Geoffrey Bomarito, Gianluca Geraci, James Warner, Patrick Leser, William Leser, Michael S. Eldred, John Jakeman, Alex Gorodetsky</i>	
Uncertainty Quantification by Convolutional Neural Network Gaussian Process Regression with Image and Numerical Data	208
<i>Jianhua Yin, Xiaoping Du</i>	

ICME FOR MATERIALS, STRUCTURES, AND UQ I

Higher-Order Approximations for Stabilizing Zero-Energy Modes in Peridynamics Crystal Plasticity Models with Large Horizon Interactions	220
<i>Iman Javaheri, Jiangyi Luo, Aaditya Lakshmanan, Veera Sundararaghavan</i>	
Fiber Network Model for Reduced Order Composite Microstructural Models	246
<i>Scott E. Stapleton, Sagar Shah, Micheal Donovan</i>	
Materials Design Using an Active Subspace-Based Batch Bayesian Optimization Approach	255
<i>Daniel Khatamsaz, Raymundo Arroyave, Douglas L. Allaire</i>	

REDUCED-ORDER AND SURROGATE MODELS I

Reduced Order Modeling of Hypersonic Aerodynamics with Grid Tailoring	269
<i>David S. Ching, Patrick J. Blonigan, Francesco Rizzi, Jeffrey A. Fike</i>	
ROAM-ML: A Reduced Order Aerodynamic Module Augmented with Neural Network Digital Surrogates	317
<i>Daniel A. Martinez-Gonzalez, Dylan Jude, Andrew M. Wissink</i>	
Efficient Sampling Methods for Machine Learning Error Models with Application to Surrogates of Steady Hypersonic Flows	339
<i>Elizabeth H. Krath, David S. Ching, Patrick J. Blonigan</i>	

DESIGN UNDER UNCERTAINTY III

Uncertainty Quantification and Sensitivity Analysis for In-Plane Thermo-mechanical Properties of 3-D Textile Composites	354
<i>Muhammad Ridlo Erdata Nasution, Pramudita S. Palar, Bambang K. Hadi, Djarot Widagdo, Lavi Zuhail, Arief Yudhanto</i>	
On Physics-Informed Deep Learning for Solving Navier-Stokes Equations	370
<i>Cahya Amalinadhi, Pramudita S. Palar, Rafael Stevenson, Lavi Zuhail</i>	

Accuracy Improvement Technique of DNN for Accelerating CFD Simulator	388
<i>Yukito Tsunoda, Toshihiko Mori, Tsuguchika Tabaru, Akira Oyama</i>	

Microstructure-Sensitive Stochastic Design of Polycrystalline Materials for Quasi-Isotropic Properties with Applications to Aerospace Systems	400
<i>Md Mahmudul Hasan, Pinar Acar</i>	

SPECIAL SESSION: CFD VERIFICATION AND VALIDATION

Application of Error Transport Equations to Unsteady Flows	415
<i>William A. Jordan, Hongyu Wang, Christopher J. Roy</i>	

Simulation of Two Benchmark Cases: 2DB and 2DML from Turbulence Modeling Resource Using STAR-CCM+ and OpenFOAM	430
<i>Ranjith D. Janardhana, Mohamed Abuhegazy, Svetlana Poroseva</i>	

VOLUME 2

Validation Study of the Multi-Fidelity Toolkit	449
<i>Blake Lance, Aaron M. Krueger, Brian A. Freno, Ross M. Wagnild</i>	

ADAPTIVE MESHING, ERROR ESTIMATION, AND UNCERTAINTY QUANTIFICATION I

Enabling Metric-Based Mesh Adaptation for Advanced Compressible Flow Simulations Using US3D.....	463
<i>Dirk Ekelschot, Joesph Brock</i>	

Output-Based Mesh Adaptation Using Overset Methods for Structured Meshes	481
<i>Alexander Coppeans, Krzysztof Fidkowski, Joaquim R. Martins</i>	

RELIABILITY ANALYSIS: METHODS AND APPLICATIONS

A Refined Kriging Surrogate Model for Subset Simulation.....	496
<i>David Braun, Dalong Shi, Florian Schwaiger, Florian Holzapfel</i>	

Simulation-Based Multi-Vehicle Path Planning Under Uncertainty Using Physarum-Based Approach	517
<i>Yixuan Liu, Chen Jiang, Xiaoge Zhang, Zissimos P. Mourelatos, Zhen Hu, David Gorsich</i>	

Managing High Input Dimensionality in Kriging-Based Adaptive Reliability Analyses.....	529
<i>Gabriele Capasso, Christian Gogu, Christian Bes, Jean Philippe Navarro, Martin Kempeneers</i>	

VERIFICATION, VALIDATION, AND UNCERTAINTY QUANTIFICATION II

Transfer Learning Based Modeling of Industrial Turbine Airfoil Characteristics.....	541
<i>Sandipp Krishnan, Sayan Ghosh, Steven Atkinson, Valeria Andreoli, Thomas Vandeputte, Liping Wang</i>	

Multi-Scale Modeling for Texture and Grain Topology of Polycrystalline Microstructures Under Uncertainty	554
<i>Arulmurugan Senthilnathan, Pinar Acar</i>	

Arguments for the Generality and Effectiveness of “Discrete Direct” Model Calibration and Uncertainty Propagation Vs. Other Calibration-UQ Approaches.....	564
<i>Vicente J. Romero</i>	

Programming with Equadratures: An Open-Source Package for Uncertainty Quantification, Dimension Reduction, and Optimisation.....	602
<i>Pranay Seshadri, Chun Yui Wong, Ashley D. Scillitoe, Bryn N. Ubald, Barney Hill, Irene Viridis, Tiziano Ghisu</i>	

VERIFICATION, VALIDATION, AND UNCERTAINTY QUANTIFICATION III

Overview of Challenges in Performing Uncertainty Quantification for Fluids Engineering Problems.....	628
<i>Andrew W. Cary, John Schaefer, Earl P. Duque, Manas Khurana, Erin C. Decarlo</i>	

Bayesian Recurrent Neural Networks for Monitoring Rotorcraft Icing from Aeroacoustics Time-Series Data.....	649
<i>Hua Tong, Jeremiah M. Hauth, Xun Huan, Beckett Yx Zhou, Nicolas R. Gauger, Myles C. Morelli, Alberto Guardone</i>	

Exploring Design of Structures Under Uncertainty and Deterministic Design Using Allowables.....	662
<i>Edwin E. Forster, Daniel L. Clark, Philip S. Beran</i>	

Quantification of Uncertainty in Extrapolation of Charring Ablator Material Performance to Flight	675
<i>Przemyslaw Rostkowski, Marco Panesi</i>	

ADAPTIVE MESHING, ERROR ESTIMATION, AND UNCERTAINTY QUANTIFICATION II

Coupled Adjoint Solver and Turbulent Error Estimate for Anisotropic Mesh Adaptation for High-Fidelity RANS Simulations	692
<i>Francesco Clerici, Philippe Spalart, Frederic Alauzet</i>	

Initial Mesh Generation for Solution-Adaptive Methods Using Machine Learning	714
<i>Vivek Ojha, Guodong Chen, Krzysztof Fidkowski</i>	

Anisotropic Goal-Based Mesh Adaptation Metric Clarification and Development	731
<i>Dmitry S. Kamenetskiy, Joshua A. Krakos, Todd R. Michal, Francesco Clerici, Frederic Alauzet, Adrien Loseille, Michael A. Park, Stephen L. Wood, Aravind Balan, Marshall C. Galbraith</i>	

Quasi-Structured Anisotropic Quad-dominant Mesh Adaptation Using Metric-orthogonal Approach	755
<i>Lucille-Marie Tenkes, Adrien Loseille, Frederic Alauzet</i>	

FLOW QUALITY, DATA QUALITY, AND UNCERTAINTY QUANTIFICATION

Analysis and Uncertainty Quantification of a Hybrid Laminar Flow Control System.....	772
<i>Alexander Barklage, Ulrich Romer, Philipp Bekemeyer, Anna Bertram, Jan Himisch, Rolf Radespiel, Camli Badrya</i>	

Freestream Noise in the Purdue University Boeing/AFOSR Mach-6 Quiet Tunnel	793
<i>Derek Mamrol, Joseph S. Jewell</i>	

REDUCED-ORDER AND SURROGATE MODELS II

Nonlinear Reduced Order Modeling Using Domain Decomposition	810
<i>Nikhil Iyengar, Dushhyanth Rajaram, Kenneth Decker, Christian Perron, Dimitri N. Mavris</i>	
Adaptive Surrogate Models for Uncertainty Quantification with Partially Observed Information	835
<i>Yanwen Xu, Pingfeng Wang</i>	
Dimension Reduction for Efficient Surrogate Modeling in High-Dimensional Applications	845
<i>Berkcan Kapusuzoglu, Yulin Guo, Sankaran Mahadevan, Shunsaku Matsumoto, Miyagi Yoshitomo, Shunsuke Taba, Daigo Watanabe</i>	
Estimating Invariant Sets Using Physics-Informed Neural Networks	857
<i>Venkata Vaishnav Tadiparthi, Raktim Bhattacharya</i>	
Nondeterministic Parameter Space Characterization of the Damage Tolerance of a Composite/Metal Structure	865
<i>Corey M. Arndt, Stephanie C. Termaath</i>	

ICME FOR MATERIALS, STRUCTURES, AND UQ II

Uncertainty Dominated Phase Transitions of 2-D Magnetic Materials	885
<i>Md Mahmudul Hasan, Arulmurugan Senthilnathan, Pinar Acar</i>	
Effect of Fiber Waviness on Processing and Performance of Textile Composites	900
<i>Ryan S. Enos, Dianyun Zhang</i>	

Author Index