Multidisciplinary Design Optimization

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: 978-1-7138-5399-2

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

AERODYNAMIC DESIGN: OPTIMIZATION I

Aerodynamic Optimization with Large Shape and Topology Changes Using Embedded Boundary Method 1
Jonathan B. Ho, Charbel Farhat

Investigations with Generic Modal Design Variables for Inviscid Wing Shape Optimisation..... 22
Laurence Kedward, Christian B. Allen, T. Rendall, Daniel J. Poole

Steady Aerodynamics of Airfoils with Porosity Gradients with Nonlinear Boundary Conditions..... 41
Robin Boitte, Rozhin Hajian, Lorna Ayton

Coupled Wing-Propeller Aerodynamic Optimization Using the Adjoint Method 58
Heyecan Koyuncuoglu, Ping He

Aerodynamic Optimization of Mach 0.8 Transonic Truss-Braced Wing Aircraft Using Variable Camber Continuous Trailing Edge Flap 81
Juntao Xiong, Nhan T. Nguyen, Robert E. Bartels

METAMODELING, REDUCED ORDER MODELS, AND APPROXIMATION METHODS I

Discrete Empirical Interpolation Based Hyper-Reduced Order Model for Steady Hypersonic Flows..... 95
Susmit S. Joshi, Rachit Prasad, Seongim Choi

Airfoil Unsteady Aerodynamic Analysis Using a Galerkin Reduced-Order Modeling Approach..... 107
Zilong Li, Ping He

Multidisciplinary Design Optimization with Mixed Categorical Variables for Aircraft Design..... 129
Paul Saves, Nathalie Bartoli, Youssef Diouane, Thierry Lefebvre, Joseph Morlier, Christophe David, Eric Nguyen Van, Sébastien Defoort

AERODYNAMIC DESIGN: OPTIMIZATION II/APPLICATION OF MDO FOR VEHICLE DESIGN I

Overset Adjoint-Based Sensitivity Analysis for Supersonic Jet Noise..... 153
Enrico Fabiano, Asitav Mishra, Zhi Yang, Dimitri J. Mavriplis

Optimization of an Actuation System for Articulated Missiles..... 172
Mackenzie Tidball, Richard Beblo, Tizoc Cruz-Gonzalez, Geoffrey Frank

Biomimetic Design Validation of Green Portable Manned Glider Wing with Plasma Boosters..... 190
Chesler Thomas , Shivangi Singh, Yukta Sharma

Optimal Design of Hovering Contra-Rotating Propulsion System..... 191
Ohad Gur, Jonathan Silver, Radovan Dítě, Raam Sundhar

Optimization of Spacecraft Structure Under Mechanical, Thermal and Acoustic Loads..... 216
Pranav Borwankar, Rakesh K. Kapania, Daisaku Inoyama, Tom G. Stoumbos

APPLICATION OF MDO FOR VEHICLE DESIGN II

Development of a Lunar Lander Modeling and Simulation Capability 237
Eugina Mendez Ramos, Bradford E. Robertson, Manuel J. Diaz, Dimitri N. Mavris

Multiscale Optimization of Resonant Frequencies in a Payload Attach Fitting Using a Metamaterial Lattice Approach 255
Morgan D. Nightingale, Robert Hewson, Matthew J. Santer, Martin Muir

Aerostructural Wing Design Optimization Considering Full Mission Analysis 265
Eytan Adler, Joaquim R. Martins

Optimization of Nacelle Design and Integration on the Eclipse Business Jet 281
Christopher C. Nelson, Aaron Godfrey, Durrell K. Rittenberg, Jason Borden

PHYSICS INFORMED MACHINE LEARNING: METHODS AND APPLICATIONS

Efficient Training of Transfer Mapping in Physics-Infused Machine Learning Models of UAV Acoustic Field 299
Rayhaan Iqbal, Amir Behjat, Revant Adlakha, Jesse Callanan, Mostafa Nouh, Souma Chowdhury

Adaptive Learning of Emulator Embedded Neural Networks for Multi-Fidelity Conceptual Design Studies 317
Atticus J. Beachy, Harok Bae, C C. Fischer, Ramana V. Grandhi

Application of Transfer Learning for Multi-Fidelity Regression Using Physics-Informed Neural Network on an Airfoil 337
Kohei Harada, Dushhyanth Rajaram, Dimitri N. Mavris

METAMODELING, REDUCED ORDER MODELS, AND APPROXIMATION METHODS II

Composite Kernel Functions for Surrogate Modeling Using Recursive Multi-Fidelity Kriging 350
Pramudita S. Palar, Lucia Parussini, Luigi Bregant, Koji Shimoyama, Muhammad F. Izzaturrahman, Febrian A. Baehaqi, Lavi Zuhal

Navigating Kernel Selections in Kernel-Based Methods: The Issues and Possible Solutions 368
Kehinde Sikirulai Oyetunde, Rhea P. Liem

Surrogate Unsteady Aerodynamic Modeling with Autoencoders and LSTM Networks 402
Huseyin E. Tekaslan, Yusuf Demiroglu, Melike Nikbay

DESIGN UNDER UNCERTAINTY I

Design of a Conceptual Firefighting Airtanker Vehicle Using Reliability-Based Design Optimization 416
Daniel L. Clark, Jason Y. Kao, Cale Zeune, Scott A. Burton, Edwin E. Forster

Inverse Design Under Uncertainty Using Conditional Normalizing Flows 433
Panagiotis Tsilifis, Sayan Ghosh, Valeria Andreoli

Reliability-Based Design Optimization of Tow-Steered Composite Plates Employing High-Order CUF-Based Finite Elements 448
Alberto Racionero Sanchez-Majano, Alfonso Pagani

Modelling Material Uncertainties Using Random Irregularities in Lattice Based Multiscale Optimization 459
Dilaksan Thillaithevan, Paul J. Bruce, Matthew J. Santer

MACHINE LEARNING AND OPTIMIZATION I/PHYSICS INFORMED MACHINE LEARNING: METHODS AND APPLICATIONS

Deep Neural Network for Airfoil Optimization 473
Wenhui Peng, Yao Zhang, Michel Desmarais

Topology Optimization Integrated Deep Learning for Multiphysics Problems 481
Hesaneh Kazemi, Carolyn Seepersad, H. Alicia Kim

Multifidelity Data Fusion in Convolutional Encoder/decoder Assembly Networks for Computational Fluid Dynamics 495
Lauren Partin, Ahmad A. Rushdi, Daniele E. Schiavazzi

Underhood Spatial Packing and Routing of an Automotive Fuel Cell System (AFCS) Using 2D Geometric Projection 513
Waheed B. Bello, Satya R T Peddada, Anurag Bhattacharyya, Mark Jennings, Sunil Katragadda, Kai A. James, James T. Allison

Adaptive Sampling-Based Artificial Neural Network for Surrogate Modeling 530
Subham Gupta, Achyut Paudel, Mishal Thapa, Sameer B. Mulani, Robert Walters

DESIGN UNDER UNCERTAINTY II

Multifidelity Gaussian Processes for Failure Boundary and Probability Estimation 544
Ashwin Renganathan, Vishwas Rao, Ionel Navon

Inverse Design of 2D-Mechanical Metamaterials with Spinodal Topologies Under Uncertainty 563
Kiara L. McMillan, Doğacan S. Öztürk, Pinar Acar

A Novel Tolerance Analysis Method Based on the "reverse Model" Considering Robustness 577
Linjun Zhong, Yang Yang, Leshi Shu, Ping Jiang, Hua Wei

MAGE: Alleviating Uncertainty in Real-Time Decision-Making as a Function of Problem Complexity 583
Natalia Alexandrov

STRUCTURAL OPTIMIZATION AND MULTISCALE MODELING I

Inverse Multiscale Design of Cellular Mechanical Metamaterials 591
Sheng Liu, Pinar Acar

Optimization of the Compartment Layout in an Inflatable Airfoil 603
Sohrab R. Mistri, Rajkumar S. Pant, Anirban Guha, Chandra S. Yerramalli

Shape Optimization of a Sandwich Composite Plate with Low-Velocity Impact Loading and Effect of Finite Difference Sensitivity Analysis 615
Utsav B. Shah, Mandar D. Kulkarni, Naresh L. Ahuja

Towards the Optimal Partitioning of 3D Printed Multi-Material Models 640
Asa E. Palmer, Alexander M. Pankonien, Gregory W. Reich, Eliot S. Rudnick-Cohen, Markus P. Rumpfkeil

VOLUME 2

Multiscale Design Optimization with Integrating Overhang Constraints for Additively Manufactured Lattice Structures 669
Jackson G. Reid, Mostafa S. ElSayed

DESIGN UNDER UNCERTAINTY III

Uncertainty Quantification and Sensitivity Analysis for In-Plane Thermo-Mechanical Properties of 3-D Textile Composites 684
Muhammad Ridlo Erdata Nasution, Pramudita S. Palar, Bambang K. Hadi, Djarot Widagdo, Lavi Zuhal, Arief Yudhanto

On Physics-Informed Deep Learning for Solving Navier-Stokes Equations 700
Cahya Amalinadhi, Pramudita S. Palar, Rafael Stevenson, Lavi Zuhal

Accuracy Improvement Technique of DNN for Accelerating CFD Simulator 718
Yukito Tsunoda, Toshihiko Mori, Tsuguchika Tabaru, Akira Oyama

Microstructure-Sensitive Stochastic Design of Polycrystalline Materials for Quasi-Isotropic Properties with Applications to Aerospace Systems 730
Md Mahmudul Hasan, Pinar Acar

EMERGING METHODS, ALGORITHMS, AND SOFTWARE DEVELOPMENT IN MDO

Constraint Enforcement to Guarantee Strictly Feasible Solutions in a Surrogate Based Optimizer 745
Ahmed Abouhussein, Nusrat Islam, Yulia Peet

Aerothermoelastic Analysis and Optimization of Stiffened Thin-Walled Structures 754
Lenard J. Halim, Sejal Sahu, Graeme Kennedy, Marilyn J. Smith

Inexact Linearization of Fixed Point Iterations in the Piggy-Back Iterations of the One-Shot Adjoint 772
Emmett Padway, Dimitri J. Mavriplis

A Hybrid Architecture for Large-Scale System Design Optimization of PDE-Based Models 796
Anugrah Jo Joshy, Jiayao Yan, John T. Hwang

AERODYNAMIC DESIGN: OPTIMIZATION III

Constructing Geometry for Aerodynamic Shape Optimisation Using Volume of Solid Driven Cellular Automata 812
Maximilian J. Wood, T. Rendall, Christian B. Allen, Laurence Kedward, Nigel J. Taylor, James Fincham, Nick E. Leppard

An Explicit Level-Set Formula to Approximate Geometries 842
Jason E. Hicken, Sharanjeet Kaur

Subdivision Multi-Resolution Systems for Three-Dimensional Aerodynamic Optimisation..... 859
Maximilian J. Wood, T. Rendall, Christian B. Allen, Laurence Kedward, Nigel J. Taylor, James Fincham, Nick E. Leppard

Investigation of a Smooth Local Correlation-Based Transition Model in a Discrete-Adjoint Aerodynamic Shape Optimization Algorithm 881
Michael G. Piotrowski, David W. Zingg

MDO/SENSITIVITY ANALYSIS WITH AEROELASTICITY/FLUID-STRUCTURE INTERACTION I

Effectiveness of Flutter-Based Piezoelectric Energy Harvesters with the Presence of Freeplay and Aerodynamic Nonlinearities..... 898
Adam Bouma, Rui Vasconcellos, Abdessatar Abdelkefi

Level Set Topology Optimization for Fluid-Structure Interactions..... 908
Andreas Neofytou, Feimi Yu, Lucy Zhang, H. Alicia Kim

High-Fidelity Gradient-Based Wing Structural Optimization Including a Geometrically Nonlinear Flutter Constraint..... 928
Eirikur Jonsson, Cristina Riso, Bernardo Bahia Monteiro, Alasdair C. Gray, Joaquim R. Martins, Carlos E. Cesnik

Supporting Expensive Physical Models with Geometric Moment Invariants to Accelerate Sensitivity Analysis for Shape Optimisation..... 951
Shahroz Khan, Panagiotis Kaklis, Andrea Serani, Matteo Diez

Aeroelastic Analysis and Optimization Using FUNtoFEM of an Efficient Supersonic Air Vehicle 961
Markus P. Rumpfkeil, Philip S. Beran

SHAPE AND TOPOLOGY OPTIMIZATION/AERODYNAMIC DESIGN: OPTIMIZATION IV/APPLICATION OF MDO FOR VEHICLE DESIGN III

Efficient Multi-Objective Shape Optimization Using Dimension Reduction Technology..... 972
Wataru Yamazaki

Simultaneous 3D Component Packing and Routing Optimization Using Geometric Projection 989
Anurag Bhattacharyya, Satya R T Peddada, Waheed B. Bello, Lawrence E. Zeidner, James T. Allison, Kai A. James

Multiobjective Multidisciplinary Optimization of Low-Boom Supersonic Transports Using Multifidelity Models..... 1008
Wu Li, Karl Geiselhart

Deep Gaussian Process and Deep Sigma Point Process Applied to Aerodynamic Optimization Problem 1028
Kaoruko Eto, Satoshi Takanashi, Shinsuke Nishimura

Multi-Objective Multi-Fidelity Aerodynamic Optimization of Helicopter Rotor 1047
Onur Okumus, Murat Senipek, Alper Ezertas

MDO/SENSITIVITY ANALYSIS WITH AEROELASTICITY/FLUID-STRUCTURE INTERACTION II

Aeroelastic Wing Design Sensitivity Analysis with SU2-Nastran Coupling in OpenMDAO 1069
Harsh C. Patel, David J. Neiferd, Juan J. Alonso, Joshua D. Deaton, James Akkala, John W. Gallman

Aeroservoelastic Wing Sizing Using Integrated Structural and Control (co-Design) Optimization 1090
Emmeline Faïsse, Robin Vernay, Fabio Vetrano, Joseph Morlier, Daniel Alazard

Topology Optimization with Natural Frequency Constraints Using a Quadratic Approximation of a Spectral Aggregate 1104
Graeme Kennedy, Yicong Fu

Topology Optimization for Buckling Via Geometry Projection 1118
Hollis A. Smith, Julian A. Norato, Joshua D. Deaton, Raymond M. Kolonay

MACHINE LEARNING AND OPTIMIZATION

Aerodynamic Shape Optimization Using Gradient-Enhanced Multifidelity Neural Networks 1130
Jethro R. Nagawkar, Leifur T. Leifsson, Ping He

Learning Airfoil Manifolds with Optimal Transport 1147
Qiuyi Chen, Phillip Pope, Mark Fuge

Critical Investigation of Failure Modes in Physics-Informed Neural Networks 1160
Shamsulhaq Basir, Inanc Senocak

MDO WITH MODEL-BASED DESIGN ENGINEERING

Surrogate Finite-Element Modelling for Launch Vehicle Multidisciplinary Optimization 1172
Lucandrea Mancini, Leandro Lucchese, Francesco Saltari, Franco Mastroddi, Agostino Neri

Exergy-Based Analysis and Optimization of Complex Aircraft Thermal Management Systems 1187
Marcin Glebocki, William A. Malatesta, Kevin McCarthy, Neera Jain

Voxel-Based Topology Optimization of Heat Exchanger Fins 1203
Bashir S. Mekki, Stephen P. Lynch

METAMODELING, REDUCED ORDER MODELS, AND APPROXIMATION METHODS III

Local Non-Intrusive Reduced Order Modeling Using Isomap 1218
Rakesh Halder, Krzysztof Fidkowski, Kevin Maki

Parametric Model Order Reduction for Buckling Constraint Evaluation in Structural Optimization 1230
Varakini Sanmugadas, Rakesh K. Kapania

The Nonlinear Fluid Modal Method for Efficient Dynamic Aeroelastic Simulation 1240
Hong Q. Yang, Timothy Wray, Simon Yang, Henry Ran

Dimensionality Reduction of Embedded Boundary Models for Problems with Large Shape Changes 1255
Noah Youkilis, Philip Avery, Charbel Farhat

Nonlinear Modeling and Effective Design of Dual-Functional Piezoelectric Energy Harvesting Microgyroscopes 1273
Manuel Serrano, Kevin Larkin, Mehdi Ghommem, Sergei Tretiak, Abdessatar Abdelkefi

STRUCTURAL OPTIMIZATION AND MULTISCALE MODELING II

Heterogeneous Beam Element for Multiscale Modeling of Composite Beam-Like Structures Featuring Spanwise Heterogeneity 1282
Rong Chiu, Wenbin Yu

Optimization of Rover Wheel Geometries for Planetary Missions 1297
Nikita A. Amberkar, Mandar D. Kulkarni

On Development of an Accessible and non-Intrusive Level-Set Topology Optimization Framework Via the Discrete Adjoint Method..... 1310
Jaeyub Hyun, Carolina Jauregui, H. Alicia Kim, Andreas Neofytou

Author Index