Rimple Sandhu, Ph.D.

Contact

Research Scientist, Computational Science Center
National Laboratory of the Rockies (NLR) - A U.S. Department of Energy Research Institution
15013 Denver West Parkway, Golden, CO 80401, USA
Email (Personal): rimple.sandhu@outlook.com
Email (Work): rimple.sandhu@nrel.gov
Web pages: NLR, Google Scholar, LinkedIn, Orcid

Research Profile

Machine learning (ML) for scientific applications (Probabilistic ML, AI for science)
Energy-efficient computing (Reservoir computing, dimensionality reduction, sparse learning)
Decision-making under uncertainty (Bayesian methods, control theory, active inference)
Uncertainty quantification (Inverse problems, Kalman filtering, model selection, sensitivity analysis)

Positions

Research Scientist, National Laboratory of the Rockies, Golden, CO, USA — 2022-present
Data Analysis and Visualization Group, Computational Science Center

Postdoctoral Researcher, National Laboratory of the Rockies, Golden, CO, USA — 2020-2022
Wind Energy Science Group, National Wind Technology Center

Visiting Research Scholar, National Research Council, Ottawa, ON, Canada — 2018-2020
Aerospace Research Center; Joint appointment with *Royal Military College of Canada*

Research Associate, Carleton University, Ottawa, ON, Canada — 2012-2014
Department of Civil and Environmental Engineering

Research/Teaching Assistant, Carleton University, Ottawa, ON, Canada — 2010-2012, 2014-2017
Department of Civil and Environmental Engineering

Education

Doctor of Philosophy, Civil Engineering — 2014-2019
Carleton University, Ottawa, ON, Canada

- Thesis titled: *Model Comparison and Sparse Learning of Nonlinear Physics-Based Models Using Bayesian Inference* [Link]
- Thesis supervisors: Prof. Abhijit Sarkar (Carleton University), Prof. Dominique Poirel (Royal Military College of Canada), Prof. Chris Pettit (US Naval Academy)

Master of Applied Science, Civil Engineering — 2010-2012
Carleton University, Ottawa, ON, Canada

Bachelor of Technology, Civil Engineering — 2006-2010
Indian Institute of Technology Bombay, Mumbai, India

Journal Publications

1. **R. Sandhu**, C. Tripp, E. Quon, R. Thedin, C.J. Farmer, T. A. Miller, M.A. Braham, and T. Katzner. Movement models to predict low-altitude flight of soaring birds using look-ahead environmental factors. Ecology and Evolution, Accepted for publication.
2. F. Mir, **R. Sandhu**, S. Young, Q. Wang, D. Sines and Z. Sosa. Infrastructure Perception and Control: Multi-Sensor Object Tracking Dataset. IEEE Data Descriptions, 2:459-467, 2025.
3. R. Thedin, D. Brandes, E. Quon, **R. Sandhu**, and C. Tripp. A three-dimensional model of terrain-induced updrafts for movement ecology studies. Movement Ecology, 12-25, 2024.
4. **R. Sandhu**, B. Robinson, M. Khalil, C.L. Pettit, D. Poirel and A. Sarkar. Encoding nonlinear and unsteady aerodynamics of limit cycle oscillations using nonlinear sparse Bayesian learning. Journal

of Sound and Vibration, 117816, 2023.

5. B. Robinson, J.D. Edwards, T. Kendzerska, C.L. Pettit, D. Poirel, J.M. Daly, M. Ammi, M. Khalil, P.J. Taillon, **R. Sandhu**, S. Mills, S. Mulpuru, T. Walker, V. Percival, V. Dolean, and A. Sarkar. Comprehensive compartmental model and calibration algorithm for the study of clinical implications of the population-level spread of COVID-19: a study protocol. British Medical Journal Open, 12(3):e052681, 2022.
6. **R. Sandhu**, C. Tripp, E. Quon, R. Thedin, M. Lawson, D. Brandes, C.J. Farmer, T. A. Miller, C. Draxl, P. Doubrawa, L. Williams, A.E. Duerr, M.A. Braham, and T. Katzner. Stochastic agent-based model for predicting turbine-scale raptor movements during updraft-subsidized directional flights. Ecological Modelling, 466:109876, 2022.
7. P. Bisaillon, **R. Sandhu**, C. Pettit, M. Khalil, D. Poirel, C.S. Manohar, and A. Sarkar. Combined selection of the dynamic model and modeling error in nonlinear aeroelastic systems using Bayesian Inference. Journal of Sound and Vibration, 522:116418, 2022.
8. **R. Sandhu**, M. Khalil, C.L. Pettit, D. Poirel, and A. Sarkar. Nonlinear sparse Bayesian learning for physics-based models. Journal of Computational Physics, 426:109728, 2021.
9. W. Yuan, **R. Sandhu**, and D. Poirel. Fully coupled aeroelastic analysis of wing flutter applicable to complex aircraft configurations. Journal of Aerospace Engineering, 34(2):04020117, 2020.
10. **R. Sandhu**, C.L. Pettit, M. Khalil, D. Poirel, and A. Sarkar. Bayesian model selection using automatic relevance determination for nonlinear dynamical systems. Computer Methods in Applied Mechanics and Engineering, 320:237-260, 2017.
11. **R. Sandhu**, D. Poirel, C. Pettit, M. Khalil, and A. Sarkar. Bayesian inference of nonlinear unsteady aerodynamics from aeroelastic limit cycle oscillations. Journal of Computational Physics, 316:534-557, 2016.
12. P. Bisaillon, **R. Sandhu**, M. Khalil, C. Pettit, D. Poirel, and A. Sarkar. Bayesian parameter estimation and model selection for strongly nonlinear dynamical systems. Nonlinear Dynamics, 82:1061-1080, 2015.
13. **R. Sandhu**, M. Khalil, A. Sarkar, and D. Poirel. Bayesian model selection for nonlinear aeroelastic systems using wind-tunnel data. Computer Methods in Applied Mechanics and Engineering, 282:161-183, 2014.

Conference Publications

1. S. Young, E. Bensen, L. Zhu, C. Day, J. Lott, **R. Sandhu**, C. Tripp, and P. Graf. Concept of Operations of Next-Generation Traffic Control Utilizing Infrastructure-Based Cooperative Perception. International Conference on Transportation and Development, SP:93-104, 2022.
2. **R. Sandhu**, W. Yuan, and D. Poirel. Global sensitivity analysis of transonic flutter using a coupled CFD-CSD solver. 31st Congress of the International Council of the Aeronautical Sciences, 0037, 2018.
3. W. Yuan, **R. Sandhu**, O. Dias de Matos Jr., and D. Poirel. Methodology development for coupled aeroelastic analysis of wing flutter. 54th AIAA Aerospace Sciences Meeting, 2016-1550, 2016.
4. **R. Sandhu**, M. Khalil, D. Poirel, and A. Sarkar. Model Selection Methods for Nonlinear Aeroelastic Systems Using Wind Tunnel Data. 54th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, AIAA 2013-1938, 2013.
5. P. Bisaillon, **R. Sandhu**, M. Khalil, A. Sarkar, and D. Poirel. Model Selection for Strongly Nonlinear Systems. 54th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, AIAA 2013-1939, 2013.

Data and Software

1. **R. Sandhu** *et al.*, Multi-Sensor Object Detection Data from Infrastructure Sensors Deployed at Traffic Intersections in the City of Colorado Springs, Colorado, USA. NLR Data Catalog. Link.
2. **R. Sandhu** *et al.*, Stochastic Soaring Raptor Simulator (SSRS). Software, USDOE Office of Energy Efficiency and Renewable Energy (EERE), Renewable Power Office. Wind Energy Technologies Office, 10.11578/DC.20210903.2, 2021.

Projects

Biological Computing as Energy-efficient Alternative to Digital Computing 2025-Present
Funding: LDRD, U.S. Department of Energy
Skills: Python, Control theory, Active inference, Biochemical reactions, Synthetic biology
- Designing and testing optimal control strategies for control of oxygen concentration in bioreactors
- Reviewing and understanding other biological computing paradigms for energy efficiency benefits

Multisensor Data Fusion of Traffic Trajectory Data at Edge 2021-Present
Funding: LDRD, U.S. Department of Energy; SMART, U.S. Department of Transportation
Skills: Python, Design of experiments, Dynamical systems, Edge computing, Kalman Filtering
- As a subtask lead, spearheaded the field data collection effort to deploy camera, lidar and radar sensors at traffic intersections; processed and prepared the sensor data for subsequent modeling
- Designed and implemented an algorithmic framework to create a digital twin of traffic using heterogeneous sensor data at compute-constrained edge hardware.

Stochastic Movement Modeling of Soaring Raptors using Telemetry Data 2020-2023
Funding: Wind Energy Technologies Office, U.S. Department of Energy
Skills: Python, Model discovery, Data assimilation, Agent-based modeling, Scientific visualization
- Designed a stochastic model for soaring raptors and implemented this model into a public-facing software tool that predicts eagle movement patterns near wind energy facilities
- Led model discovery process involving cleaning and parsing a large amount of telemetry data to train and validate the proposed model, leading to 3 journal publications and 1 released software

Physics-informed Bayesian Learning of Nonlinear Dynamical Systems 2014-2019
Funding: NSERC, Canada; Ontario Graduate Scholarship; Carleton University
Skills: Python, Bayesian inference, Scientific ML, Dynamical systems, Inverse problems
- Developed novel Bayesian methodology for constructing predictive stochastic models for nonlinear dynamical systems with noisy observations and limited domain knowledge
- Implemented and validated the inverse modeling framework to aeroelastic systems, reducing model complexity by 60% while maintaining predictive accuracy, leading to 3 first-authored journal pubs

Surrogate-powered Sensitivity Analysis for High-fidelity Aeroelastic Simulations 2018-2019
Funding: National Research Council Canada
Skills: C++, Fluid dynamics, finite element analysis, HPC, Global sensitivity analysis
- Developed fully coupled aeroelastic solver for transonic flutter prediction in aircraft wings
- Designed a polynomial chaos expansion based sensitivity study to identify critical design variables

Media Coverage

- '*Driving Innovation in Traffic Optimization*' by Ty Burke, Carleton.ca, September 2023.
- '*Giving Vehicles a Safe Green Light – New Software Tool Helps Cars and Pedestrians Safely and Efficiently Share the Road* ' by Anya Breitenbach and Julia Thomas, NREL.gov, June 2022
- '*NREL Tool Aims To Predict Interactions Between Soaring Eagles and Wind Turbines*' by Laura Carter, NREL.gov, April 2022.

Awards and Recognitions

- President's Award – recognizes one-time exceptional staff achievement — NREL, 2023
- Leadership Choice Publication Award – for publishing high-quality journal paper — NREL, 2023
- Senate Medal – for outstanding thesis and publication record during PhD — Carleton, 2020
- Outstanding Singular Achievement – for successful conclusion of research project — NRC, 2019

Scholarships

- Ontario Graduate Scholarship — PhD, 2016-2019
- Civil Engineering Departmental Graduate Scholarship — PhD, 2014-2019
- Hamlin Graduate Fellowship — PhD, 2017
- Professor Jagmohan Humar Graduate Student Fellowship — PhD, 2016
- Doctoral Entrance Scholarship — PhD, 2014-2015
- Civil Engineering Departmental Graduate Scholarship — MS, 2010-2012
- Institute Merit-Cum-Means Scholarship — BTech, 2006-2010

Recent Talks

2024 Automatic Calibration of Infrastructure Sensors, IEEE 27th International Conference on Intelligent Transportation Systems (IEEE ITSC 2024), Edmonton, Alberta, Canada.

2024 Inverse UQ: Intro, Case Study and Bayesian Inference, and Application to Wake Modeling, IEA Wind Task 44 Work Package 2 Meeting. YouTube Link. *Virtual*.

2022 Decoding Golden Eagle Movement Behavior from High-Resolution, Variable-Rate Telemetry Data Through Bayesian Filtering, 14th Wind Wildlife Research Meeting, Kansas City, Missouri, USA.

2022 Simulation-Based Model for Facility-Scale Eagle Presence Mapping, Eagle Behavior and Risk Modeling for Wind Energy Workshop, NREL. *Virtual*.

2021 Bayesian State Space Modeling Framework for Understanding and Predicting Golden Eagle Movements Using Telemetry Data, Raptor Research Foundation Annual Conference. *Virtual*.

2021 Infrastructure Perception and Control (IPC): Creating a real-time digital twin of the traffic intersection, High-Definition Artificial Intelligence, Computing, Data and Cloud (HD-ACDC): Transportation Science and Mobility Electrification Workshop, NREL, Golden, CO, USA.

2021 Sparse Learning of Over-Parametrized Nonlinear Engineering Models, SIAM Conference on Computational Science and Engineering. *Virtual*.

2020 Quantifying Turbine-Level Risk to Golden Eagles Using a High-Fidelity Updraft Model and a Stochastic Behavioral Model, 13th Wind Wildlife Research Meeting. *Virtual*.

2020 Inference Of Model Sparsity In Nonlinear Dynamics Using Noisy Data, The 20th Biennial Computational Techniques and Applications Conference. *Virtual*.

Journal Reviewer

- Nonlinear Dynamics, Springer
- Mechanical Systems and Signal Processing, Elsevier
- American Institute of Aeronautics and Astronautics (AIAA) Journal
- Journal of Aerospace, MDPI.
- Journal of Applied Ecology, Wiley.
- Journal of the Royal Society Interface

References

Available upon request