Soheil Kolouri, Ph.D., IEEE Senior Member

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Research Interests

I am interested in high-impact multidisciplinary problems at the interface of Machine Learning (ML), Computer Vision (CV), and Signal Processing, focusing on real-world applications. Moreover, I have a standing interest in computational Optimal Transport and geometry-aware probability distances.

Professional Appointments

06/2016-PRESENT **HRL Laboratories, LLC, Malibu, CA**
Research Scientist in Information & Systems Sciences Lab
Role: Principle Investigator on current and past Defense Advanced Research Projects Agency (DARPA) programs including, *Learning with Less Labels (LwLL)*, *Lifelong Learning Machines (L2M)*, and *Real-World Adversarial Attacks on AI (RWA^3).*

06/2015-05/2016 **Carnegie Mellon University, Pittsburgh, PA**
Postdoctoral Research Assistant
Role: Postdoctoral researcher focusing on transport-based pattern recognition and image modeling approaches for automated analysis of histopathology, MRI, and fMRI images.

01/2016-05/2016 **Smoke Detective (Startup company), Pittsburgh, PA**
Algorithm Development Engineer
Role: Computer vision software developer for smoke detection based on video input.

Education

08/2012-05/2015 **Carnegie Mellon University (CMU), Pittsburgh, PA**
Ph.D. in Biomedical Engineering
Dissertation: *Transport-Based Pattern Recognition and Image Modeling*
Committee: Gustavo K. Rohde (Advisor), Dejan Slepčev, Jelena Kovačević, Robert F. Murphy, and Ryan Tibshirani
Research: Theory of optimal mass transportation and its ML applications in biomedical signal/image analysis
Notes: Completed my PhD degree in less than 3 years and received the best thesis award

08/2010-05/2012 **Colorado State University (CSU), Fort Collins, CO**
M.Sc. in Electrical and Computer Engineering
Thesis: *Acoustic Tomography of the Atmosphere via Unscented Kalman Filter*
Committee: Mahmood R. Azimi-Sadjadi (Advisor), Edwin K. P. Chong, and Dan Cooley
Research: ML algorithms in tomography and state-space modeling

08/2006-05/2010 **Sharif University of Technology (SUT), Tehran, Iran**
B.Sc. in Electrical Engineering
Thesis: *Markov Random Fields in Image Processing*
Committee: Emad Fatemizadeh (Undergraduate advisor)
Research: Signal and image processing

Research Grants

I have contributed to numerous DARPA proposals in ML, and have successfully secured a total of nearly $15M in funding as a principal investigator.

09/2019 PI - DARPA Real-World Adversarial Attacks on AI program (∼$600K)
Contract number No. FA8750-19-C-0025

08/2019 PI - DARPA Learning with Less Labels program ($4M)
Contract number No. FA8750-19-C-0098

05/2018 Co-PI - DARPA Lifelong Learning Machines program (∼$10M)
Contract number No. FA8750-18-C-0103,

Teaching Experience

SPRING 2015 & 16 BME 03-712: Computational Methods for Biological Modeling and Simulation
CMU *Co-instructor with Gustavo K. Rohde. (***Evaluation score: 4.7/5.0***)*

FALL 2015 BME 42-672: Fundamentals of Biomedical Imaging and Image Analysis
CMU *Co-instructor with Gustavo K. Rohde.* (**Evaluation score: 4.7/5.0**)

SPRING 2014 BME 03-712: Computational Methods for Biological Modeling and Simulation
CMU *Teaching Assistant*

FALL 2013 & 14 BME 42-672: Fundamentals of Biomedical Imaging and Image Analysis
CMU *Teaching Assistant*

Awards and Honors

06/2018 IR&D Research Award - Deep Sense Learning, HRL

06/2017 IR&D Research Award - Zero Shot Learning, HRL

05/2015 Outstanding Dissertation Award, CMU

01/2014 Bertucci Fellowship Award (Outstanding Graduate Student), CMU

08/2011 Colorado State Graduate Fellowship, CSU

Invited Talks and Tutorials

09/2020 Department of Electrical and Computer Engineering, University of Virginia
Invited talk: *Sliced Probability Metrics for Next Generation Machine Learning*

04/2019 Department of Applied Mathematics and Theoretical Physics, University of Cambridge
Tutorial: *Optimal Transport and its Applications in Deep Learning.*

02/2019 ECE Seminar, Carnegie Mellon University
Tutorial: *Generalized sliced Wasserstein distances*

04/2018 IEEE International Symposium on Biomedical Imaging (ISBI)
Tutorial: *Optimal transport in biomedical imaging*

03/2018 Office of Naval Research (ONR), AI Sprint Team
Invited Talk: *Multi-sensory transfer learning and domain Adaptation*

09/2016 IEEE International Conference on Image Processing (ICIP)
Tutorial: *Transport and other Lagrangian transforms*

04/2016 HRL Laboratories, LLC
Invited talk: *Machine Learning and Nonlinear Embeddings*

01/2016 MIT Computer Science and Artificial Intelligence Laboratory (CSAIL)
Invited talk: *Optimal Transport-Based Morphometry*

Publications

BOOKS AND BOOK CHAPTERS

Zachary Murez*, **Soheil Kolouri***, David Kriegman, Ravi Ramamoorthi, and Ken Kim. *Chapter 7: Domain Adaptation via Image to Image Translation*, in Domain Adaptation in Computer Vision with Deep Learning. Springer, 2020.

Gustavo K. Rohde, **Soheil Kolouri**, and Saurav Basu, *Introduction to biomedical imaging and image analysis*, Manuscript under preparation. Accepted for publication by Cambridge University Press.

MAGAZINE ARTICLES

Soheil Kolouri, Xuwang Yin, and Gustavo Rohde. *Neural Networks, Hypersurfaces, and Radon Transforms [Lecture Notes].* in IEEE Signal Processing Magazine, vol. 37, no. 4, pp. 123-133, July 2020.

Soheil Kolouri, Serim Park, Matthew Thorpe, Dejan Slepčev, and Gustavo K. Rohde. *Optimal mass transport: signal processing and machine-learning applications.* IEEE Signal Processing Magazine, 34(4), pp.43-59, 2017.

JOURNAL ARTICLES

Xinyun Zou, **Soheil Kolouri**, Praveen K. Pilly, and Jeffrey L. Krichmar. *Neuromodulated attention and goal-driven perception in uncertain domains.* Neural Networks, 2020.

Mohammad Rostami, **Soheil Kolouri**, Eric Eaton, and Kyungnam Kim. *Deep transfer learning for few-shot sar image classification.* Remote Sensing 11, no. 11 (2019): 1374.

Shinjini Kundu, **Soheil Kolouri**, Kirk I. Erickson, Arthur F. Kramer, Edward McAuley, Gustavo K. Rohde. *Discovery and Visualization of Structural Biomarkers from MRI using Transport-Based Morphometry.* NeuroImage, pp. 256-275, 2018.

Serim Park, **Soheil Kolouri**, Shinjini Kundu, and Gustavo K. Rohde. *The Cumulative Distribution Transform and Linear Pattern Classification.* Applied and Computational Harmonic Analysis, 2017.

Soheil Kolouri, Serim Park, and Gustavo K. Rohde. *The Radon Cumulative Distribution Transform and its Application to Image Classification.* IEEE Transactions on Image Processing, 25(2), pp.920-934, 2016.

Soheil Kolouri, Akif B. Tosun, John A. Ozolek, and Gustavo K. Rohde. *A Continuous Linear Optimal Transport Approach for Pattern Analysis in Image Datasets.* Pattern Recognition, 51, pp.453-462, 2016.

Matthew Thorpe, M., Serim Park, **Soheil Kolouri**, Gustavo K. Rohde, and Dejan Slepčev. *A Transportation L^p Distance for Signal Analysis.* Journal of Mathematical Imaging and Vision, pp.1-24, 2016.

Akif B. Tosun, Oleksandr Yergiyev, **Soheil Kolouri**, Jan F. Silverman, and Gustavo K. Rohde. *Detection of Malignant Mesothelioma using Nuclear Structure of Mesothelial Cells in Effusion Cytology Specimens.* Cytometry Part A, 87(4), 326-333, 2015.

Adrianna Shembel, **Soheil Kolouri**, Hongming Xu, and Katherine V. Abbott. *Quantification of Respiratory Laryngeal Morphometry: Comparison of Laryngeal Lumen Angle Estimate Methods.* Journal of Voice, 2015.

Saurav Basu*, **Soheil Kolouri***, and Gustavo K. Rohde. *Detecting and Visualizing Cell Phenotype Differences from Microscopy Images using Transport-Based Morphometry.* Proceedings of the National Academy of Sciences (PNAS), 111(9), pp.3448-3453, 2014.

John A. Ozolek, Akif B. Tosun, Wei Wang, Cheng Chen, **Soheil Kolouri**, Saurav Basu, Hu Huang, and Gustavo K. Rohde. *Accurate Diagnosis of Thyroid Follicular Lesions*

from Nuclear Morphology using Supervised Learning. Medical Image Analysis, 2014.

Soheil Kolouri, Mahmood R. Azimi-Sadjadi, and Astrid Ziemann. *Acoustic Tomography of the Atmosphere Using Unscented Kalman Filter.* IEEE Transactions on Geoscience and Remote Sensing (TGRS), 52(4), pp.2159-2171, 2014.

Soheil Kolouri, Mahmood R. Azimi-Sadjadi, and Astrid Ziemann. *A Statistical-Based Approach for Acoustic Tomography of the Atmosphere.* The Journal of the Acoustical Society of America, 135(1), pp.104-114, 2014.

CONFERENCE PAPERS

Kimia Nadjahi, Alain Durmus, Lenaic Chizat, **Soheil Kolouri**, Shahin Shahrampour, and Umut Simsekli. "Statistical and topological properties of sliced probability divergences." Accepted to Advances in NeurIPS, 2020.

Soheil Kolouri, Aniruddha Saha, Hamed Pirsiavash, and Heiko Hoffmann. *Universal Litmus Patterns: Revealing Backdoor Attacks in CNNs.* In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2020.

Joseph F. Comer, Reed W. Andrews, Navid Naderializadeh, **Soheil Kolouri***, and Heiko Hoffman*. *SAR automatic target recognition with less labels.* In Automatic Target Recognition XXX, International Society for Optics and Photonics, 2020.

Soheil Kolouri, Nicholas A. Ketz, Andrea Soltoggio, and Praveen K. Pilly. *Sliced Cramer synaptic consolidation for preserving deeply learned representations.* In International Conference on Learning Representations (ICLR), 2020.

Mohammad Rostami, **Soheil Kolouri**, James McClelland, and Praveen Pilly. *Generative Continual Concept Learning.* The 34th AAAI Conference on AI, 2020.

Soheil Kolouri, Kimia Nadjahi, Umut Simsekli, Roland Badeau, Gustavo K. Rohde. *Generalized Sliced-Wasserstein Distances.* In Advances in NeurIPS, pp. 261-272, 2019.

Phillip E. Pope*, **Soheil Kolouri***, Mohammad Rostami, Charles E. Martin, Heiko Hoffmann. *Explainability Methods for Graph Convolutional Neural Networks.* In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 2019.

Javad Mohammadi, and **Soheil Kolouri**. *Collaborative Learning Through Shared Collective Knowledge and Local Expertise.* In 2019 IEEE 29th International Workshop on Machine Learning for Signal Processing (MLSP), pp. 1-6. IEEE, 2019.

Alex J. Gabourie, Mohammad Rostami, Phillip E. Pope, **Soheil Kolouri**, Kyungnam Kim. *Learning Domain-Invariant Embedding for Unsupervised Domain Adaptation Using Sliced-Wasserstein Distance.* In 2019 57th Annual Allerton Conference on Communication, Control, and Computing (Allerton), pp. 352-359. IEEE, 2019.

Mohammad Rostami, **Soheil Kolouri**, and Praveen K. Pilly. *Complementary learning for overcoming catastrophic forgetting using experience replay.* Proceedings of the Twenty-Eighth International Joint Conference on Artificial Intelligence, IJCAI, 2019.

Soheil Kolouri, Phillip E. Pope, Charles E. Martin, Gustavo K. Rohde. *Sliced-Wasserstein Auto-Encoder.* In International Conference on Learning Representations (ICLR), 2019.

Soheil Kolouri, Gustavo K. Rohde, Heiko Hoffmann. *Sliced-Wasserstein Distance for learning Gaussian Mixture Models.* In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (*CVPR*), pp. 3427-3436, 2018.

Zak Murez, **Soheil Kolouri**, David Kriegmann, Ravi Ramamoorthi, Kyungnam Kim.

Image-to-Image Translation for Domain Adaptation. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (*CVPR*), pp. 4500-4509, 2018.

Soheil Kolouri, Mohammad Rostami, Yuri Owechko, and Kyungnam Kim. *Joint dictionaries for zero-shot learning.* The 32nd AAAI Conference on AI, 2018.

Mohammad Rostami, **Soheil Kolouri**, Kyungnam Kim, and Eric Eaton. *Multi-agent distributed lifelong learning for collective knowledge acquisition.* In Proceedings of the 17th International Conference on Autonomous Agents and MultiAgent Systems (*AAMAS-18*),

Shay Deutsch, **Soheil Kolouri**, Kyungnam Kim, Yuri Owechko, and Stefano Soatto. *Zero shot learning via multi-scale manifold regularization.* In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (*CVPR*), pp. 7112-7119, 2017.

Soheil Kolouri, Yang Zou, and Gustavo K. Rohde. *Sliced Wasserstein kernels for probability distributions.* In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (*CVPR*), pp. 7113-7119, 2016.

Soheil Kolouri and Gustavo K. Rohde. *Transport-based single frame super resolution of very low resolution face images.* In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (*CVPR*), pp. 4876-84, 2015.

Soheil Kolouri, Dejan Slepčev, and Gustavo K. Rohde. *A symmetric deformation-based similarity measure for shape analysis.* In IEEE (*ISBI*), pp. 314-318, 2015.

Soheil Kolouri and Gustavo K. Rohde. *PCA-Based Super-Resolution in Transport Space.* In Computational Optical Sensing and Imaging, 2015.

Soheil Kolouri and Gustavo K. Rohde. *Temporal information inference from static high-content fluorescent microscopy.* In IEEE 40th Annual NEBEC, 2014.

Soheil Kolouri, Saurav Basu, and Gustavo K. Rohde. *Learning and visualizing statistical relationships between protein distributions from microscopy images.* In IEEE 11th International Symposium on Biomedical Imaging (ISBI), pp. 381-384, 2014.

Akif B. Tosun, Oleksandr Yergiyev, **Soheil Kolouri**, Jan F. Silverman, and Gustavo K. Rohde. *Novel computer-aided diagnosis of mesothelioma using nuclear structure of mesothelial cells in effusion cytology specimens.* In Medical Imaging, 2014.

Soheil Kolouri and Gustavo K. Rohde. *Quantifying and visualizing variations in sets of images using continuous linear optimal transport.* In Medical Imaging 2014: Image Processing, vol. 9034, p. 903438. International Society for Optics and Photonics, 2014.

Soheil Kolouri and Mahmood R. Azimi-Sadjadi. *Acoustic tomography of atmosphere using Unscented Kalman Filter.* In Proceedings of the 20th IEEE European Signal Processing Conference (EUSIPCO), pp. 2531-2535, 2012.

WORKSHOP PAPERS

Mohammad Rostami, **Soheil Kolouri**, Eric Eaton, and Kyungnam Kim. *SAR image classification using few-shot cross-domain transfer learning.* In CVPRW, 2019.

Soheil Kolouri, Charles E. Martin, and Heiko Hoffmann. *Explaining distributed neural activations via unsupervised learning*. In Computer Vision and Pattern Recognition Workshops (CVPRW), 2017.

Amir M. Rahimi, **Soheil Kolouri** and Rajan Bhattacharyya. *Automatic tactical adjustment.* In Computer Vision and Pattern Recognition Workshops (CVPRW), 2017.

UNDER REVIEW

Soheil Kolouri, Navid Naderializadeh, Gustavo K. Rohde, and Heiko Hoffmann. "Wasserstein Embedding for Graph Learning." arXiv preprint arXiv:2006.0943, 2020.

Mohammad Shifat-E-Rabbi, Xuwang Yin, Abu Hasnat Mohammad Rubaiyat, Shiying Li, **Soheil Kolouri**, Akram Aldroubi, Jonathan M. Nichols, and Gustavo K. Rohde. "Radon cumulative distribution transform subspace modeling for image classification," arXiv preprint arXiv:2004.03669, 2020.

Soheil Kolouri, Kimia Nadjahi, Umut Simsekli, and Shahin Shahrampour. "Generalized sliced distances for probability distributions." arXiv preprint arXiv:2002.12537, 2020.

Patents

ISSUED

Soheil Kolouri, Shankar R. Rao, and Kyungnam (Ken) Kim. "Zero shot machine vision system via joint sparse representations." U.S. Patent 10,755,149, issued August 25, 2020.

Soheil Kolouri, Amir M. Rahimi, and Rajan Bhattacharyya. "Prediction of multi-agent adversarial movements through signature-formations using Radon-CDT and canonical correlation analysis." U.S. Patent 10,755,424, issued August 25, 2020.

Soheil Kolouri, Charles E. Martin, and Heiko Hoffmann. "Machine-vision system for discriminant localization of objects." U.S. Patent 10,691,972, issued June 23, 2020.

Soheil Kolouri, Charles E. Martin, Ken Kim, and Heiko Hoffmann. "Machine vision system for recognizing novel objects." U.S. Patent 10,607,111, issued March 31, 2020.

Amir M. Rahimi, **Soheil Kolouri**, and Rajan Bhattacharyya. "Explicit prediction of adversary movements with canonical correlation analysis." U.S. Patent 10,583,324, issued March 10, 2020.

PENDING

Nicholas A. Ketz, Praveen K. Pilly, **Soheil Kolouri**, Charles E. Martin, and Michael D. Howard. "Autonomous system including a continually learning world model and related methods." U.S. Patent Application 16/548,560, filed April 30, 2020.

Soheil Kolouri, Mohammad Rostami, and Kyungnam Kim. "Systems and methods for few-shot transfer learning." U.S. Patent Application 16/532,321, filed April 30, 2020.

Charles E. Martin, Nicholas A. Ketz, Praveen K. Pilly, **Soheil Kolouri**, Michael D. Howard, and Nigel D. Stepp. Artificial Neural Network and Method of Training an Artificial Neural Network with Epigenetic Neurogenesis. U.S. Patent Application 16/561,735, filed April 23, 2020

Alexander J. Gabourie, Mohammad Rostami, **Soheil Kolouri**, and Kyungnam Kim. "System and method for unsupervised domain adaptation via sliced-wasserstein distance." U.S. Patent Application 16/719,668, filed April 23, 2020.

Charles E. Martin, Nigel D. Stepp, **Soheil Kolouri**, and Heiko Hoffmann. "Method and system for detecting change of context in video streams." U.S. Patent Application 16/415,942, filed December 5, 2019.

Soheil Kolouri, Cedrick G. Ngalande, Kyungnam Kim, and Michael J. Daily. "Systems and methods for autonomous driving using neural network-based driver learning on tokenized sensor inputs." U.S. Patent Application 15/964,401, filed October 31, 2019.

Soheil Kolouri, and Heiko Hoffmann. "System and method for estimating uncertainty of the decisions made by a supervised machine learner." U.S. Patent Application 16/262,894,

filed September 26, 2019.

Zachary Murez, **Soheil Kolouri**, and Kyungnam Kim. "Domain adaption learning system." U.S. Patent Application 16/262,878, filed August 8, 2019.

Soheil Kolouri, Mohammad Rostami, Kyungnam Kim, and Yuri Owechko. "Attribute aware zero shot machine vision system via joint sparse representations." U.S. Patent Application 16/033,638, filed January 24, 2019.

Soheil Kolouri, Amir M. Rahimi, and Rajan Bhattacharyya. "Prediction of multi-agent adversarial movements through signature-formations using radon-cumulative distribution transform and canonical correlation analysis." U.S. Patent Application No. 15/971,982.

Amir M. Rahimi, **Soheil Kolouri**, and Rajan Bhattacharyya. "System for predicting movements of an object of interest with an autoencoder." U.S. Patent Application No. 15/949,013.

Charles E. Martin, **Soheil Kolouri**, and Heiko Hoffmann. "Method for understanding machine-learning decisions based on camera data." U.S. Patent Application No. 15/946,480.

Soheil Kolouri, Charles E. Martin, and Heiko Hoffmann. "Machine-vision method to classify input data based on object components." U.S. Patent Application No. 15/936,403.

Memberships

2020-Present Senior Member, Institute of Electrical and Electronics Engineers (IEEE)

Mentorship

2019-2020 Joseph F. Comer, Post-Master's Intern, HRL Laboratories, LLC. Currently, a full-time employee at HRL Laboratories, LLC.

2018-2019 Phillip E. Pope, Post-Master's Intern, HRL Laboratories, LLC. Currently, a Ph.D. student at the Computer Science Department at University of Maryland.

2015-2016 Shinjini Kundu, Ph.D. Student, CMU. Currently, a resident physician in radiology and computer scientist at The Johns Hopkins Hospital.

2015-2016 Ligong Han, Master's Student, CMU. Currently, a Ph.D. student at the Computer Science Department at Rutgers University.

Services

Area Chair IEEE International Workshop on Machine Learning for Signal Processing (MLPS 2019)

Active Reviewer IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)
IEEE Transactions on Image Processing (TIP)
Pattern Recognition - The Journal of the Pattern Recognition Society
IEEE Signal Processing Letters (SPL)
IEEE Conference on Computer Vision and Pattern Recognition (CVPR)
Conference on Neural Information Processing Systems (NeurIPS)
International Conference on Representation Learning (ICLR)
IEEE International Conference on Computer Vision (ICCV)
IEEE International Conference on Robotics and Automation (ICRA)
European Conference on Computer Vision (ECCV)
AAAI conference on artificial intelligence

References

Prof. Gustavo K. Rohde, (Ph.D. Advisor)
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University of Virginia, Charlottesville, VA
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Phone: (434) 924-2786

Prof. Dejan Slepčev
Department of Mathematical Sciences
Carnegie Mellon University, Pittsburgh, PA
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Prof. Akram Aldroubi
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Vanderbilt University, Nashville, TN
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Prof. James L. McClelland
Lucie Stern Professor in the Social Sciences
Director, Center for Mind, Brain and Computation
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