

Michael C. Hughes

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Research Expertise

Machine Learning 2012-

- Probabilistic models, Bayesian nonparametrics, approximate inference, semi-supervised learning

Clinical Informatics 2017-

- Personalized risk and treatment prediction, phenotype discovery

Data Analysis 2012-

- Multivariate time series, images and videos, electronic health records

Education

Brown University

Ph.D., Computer Science. 2016

Brown University

M.S., Computer Science. 2012

Olin College of Engineering

B.S. Electrical & Computer Engineering 2010

Research Experience

Assistant Professor of Computer Science

Tufts University, Medford, MA 2018 - present

- Research statistical machine learning methods and applications to health informatics.
- Advise Ph.D., M.S., and B.S. students in machine learning research projects.
- Teach machine learning courses targeted at advanced undergraduates ([COMP 135 Intro to ML](#)) and graduate students ([COMP 150 Bayesian Deep Learning](#)).
- Appointed as the [Ann W. Lambertus and Peter Lambertus Assistant Professor](#) in 2019

Postdoctoral fellow: Machine learning to improve clinical decisions in healthcare

Adviser: [Prof. Finale Doshi-Velez](#) (Harvard) 2016 - 2018

- Developed semi-supervised models for characterizing and treating depression (with [Dr. Perlis](#) and [Dr. McCoy](#)).
- Applied time-series models to predict ventilator interventions in the ICU for [public dataset](#) of >36,000 patients.
- Created methods for training deep models so they are more interpretable to clinicians or other users.

Postdoc project: Estimating carbon biomass from LiDAR waveforms

Adviser: [Prof. Erik Sudderth](#) & [Prof. Jim Kellner](#) (Brown U., Ecology & Evolutionary Biology) 2016

- Predicted forest biomass from LiDAR waveforms to better understand land use and climate change.
- Modeled waveforms and biomass predictions jointly via nonparametric regression using our [BNPy toolbox](#).
- Intended for use in NASA's upcoming [Global Ecosystem Dynamics Investigation \(GEDI\)](#).

Ph.D. thesis: [Reliable and scalable variational inference for Bayesian nonparametrics](#)

Adviser: [Prof. Erik Sudderth](#)

2016

- Thesis Title: Reliable and scalable variational inference for nonparametric mixtures, topics, and sequences
- Developed optimization algorithms for Bayesian nonparametric models that scale to millions of examples.
- Optimized lower bound on marginal likelihood, thus penalizing too simple and too complex explanations.
- Escaped local optima via data-driven proposals that add useful new clusters and remove redundant ones.
- Applied to topic models of 2 million NY Times articles and sequential models of the whole human genome.
- Implemented algorithms in [open-source package: Bayesian Nonparametrics for Python \(BNPy\)](#).

Master's project: Sequential Models for Video and Motion Capture

Adviser: [Prof. Erik Sudderth](#)

2012

- Developed methods to discover common actions from many videos of humans performing household exercises.
- Improved existing inference algorithms with data-driven Metropolis-Hastings proposals.

Highlighted Publications

1. "[MIMIC-Extract: A Data Extraction, Preprocessing, and Representation Pipeline for MIMIC-III](#)." Shirly Wang^m, Matthew B. A. McDermott, Geeticka Chauhan, Marzyeh Ghassemi, Michael C. Hughes, and Tristan Naumann. To Appear at CHIL 2020: The ACM Conference on Health, Inference, and Learning, 2020.
2. "[POPCORN: Partially Observed Prediction-Constrained Reinforcement Learning](#)." Joseph Futoma, Michael C. Hughes, and Finale Doshi-Velez. To Appear at AISTATS 2020, 2020.
3. "[Regional Tree Regularization for Interpretability in Deep Neural Networks](#)." Mike Wu^d, Sonali Parbhoo, Michael C. Hughes, Ryan Kindle, Leo Celi, Maurizio Zazzi, Volker Roth, and Finale Doshi-Velez. AAAI 2020, 2020.
4. "[Rapid Model Comparison by Amortizing Across Models](#)." Lily H. Zhang^b, and Michael C. Hughes. Second Symposium on Advances in Approximate Bayesian Inference (AABI 2019), 2019.
5. "[Feature Robustness in Non-stationary Health Records: Caveats to Deployable Model Performance in Common Clinical Machine Learning Tasks](#)." Bret Nestor^d, Matthew B. A. McDermott, Willie Boag, Gabriela Berner, Tristan Naumann, Michael C. Hughes, Anna Goldenberg, and Marzyeh Ghassemi. Machine Learning for Healthcare, 2019.
6. "[Supervised Machine Learning Algorithms Using Patient Related Factors to Predict in-Hospital Mortality Following Acute Myeloid Leukemia Therapy](#)." Nauman Saleem Siddiqui^c, Andreas Klein, Amandeep Godara, Cindy Varga, Rachel J. Buchsbaum, and Michael C. Hughes. Proceedings of 61st Annual Meeting of the American Hematology Society, 2019.
7. "[Semi-Supervised Prediction-Constrained Topic Models](#)." Michael C. Hughes, Gabriel Hope^d, Leah Weiner^d, Thomas H. McCoy Jr, Roy H. Perlis, Erik B. Sudderth, and Finale Doshi-Velez. Artificial Intelligence and Statistics (AISTATS), 2018.
8. "[Beyond Sparsity: Tree Regularization of Deep Models for Interpretability](#)." Mike Wu^u, Michael

C. Hughes, Sonali Parbhoo, Maurizio Zazzi, Volker Roth, and Finale Doshi-Velez. Association for Advancement of Artificial Intelligence (AAAI), 2018.

9. "From Patches to Images: A Nonparametric Generative Model." Geng Ji^d, Michael C. Hughes, and Erik B. Sudderth. International Conference on Machine Learning (ICML), 2017.

Superscripts indicate mentored student's status: u = undergraduate, m = masters, d = Ph.D. student, b = post-bacc, c = medical student. Complete publication list at end of this document.

Highlighted Preprints

1. "Prediction-Constrained Training for Semi-Supervised Mixture and Topic Models." Michael C. Hughes, Leah Weiner^d, Gabriel Hope^d, Thomas H. McCoy, Roy H. Perlis, Erik B. Sudderth, and Finale Doshi-Velez. arXiv, 2017.
2. "Fast Learning of Clusters and Topics via Sparse Posteriors." Michael C. Hughes and Erik B. Sudderth. arXiv, 2016.

Honors and Awards

Top 400 Reviewer Award, [NeurIPS 2019](#) 2019

- o Recognized as one of top 400 of more than 3500 expert reviewers at the top international machine learning conference.

Top 200 Reviewer Award, [NeurIPS 2018](#) 2018

- o Recognized as one of top 200 of more than 3500 expert reviewers at the top international machine learning conference.

Best Paper Award, [SoCal NLP Symposium 2018](#) 2018

- o Awarded for [2 page summary](#) of our [AISTATS 2018 paper](#).

Nominee for AMIA Clinical Informatics Research Award 2017

- o 1 of 7 papers nominated at [AMIA's 2017 Joint Summits on Translational Science](#), out of >50 papers.

NSF Graduate Research Fellowship Award 2011

- o Three year award to fund Ph.D. studies. Covers tuition and provides research stipend.

NDSEG Graduate Research Fellowship Award 2011

- o Three year funding award. Declined to accept NSF fellowship.

Current Funding Support

ACT-NOW: Autonomous Cognitive Technologies for Novelty in Open Worlds

DARPA SAIL-ON Program

11/15/19 - 8/31/22

- o [SAIL-ON Program: Science of Artificial Intelligence and Learning for Open-world Novelty](#)
- o Team at Tufts: Matthias Scheutz (PI, CS), Liping Liu (CS), Jivko Sinapov (CS)
- o Team at Arizona State: Chitta Baral (CSE), Subbarao Kambhampati (CSE)

Amortized Inference for Large-Scale Graphical Models

NSF CISE: Robust Intelligence: Small

9/1/19 - 8/31/22

- Co-Investigators: Liping Liu (PI, Tufts CS) and Thomas Stopka (Tufts Public Health)
- Total Amount: \$399,923

Estimating Individual Treatment Effects

Tufts Collaborates Award (Internal)

7/1/19 - 6/30/20

- Title: 'Estimating Individual Treatment Effects from Randomized Clinical Trials using Machine Learning'
- Co-Investigators: David Kent (Tufts Medical Center)
- Total Amount: \$50,251

MASTR-E: Machine Learning for Human Performance Prediction

U.S. Army NSRDEC, Natick, MA

6/24/19 - 6/23/20

- Co-Investigators: Eric Miller (PI, Tufts ECE) and Shuchin Aeron (Tufts ECE)
- Total Amount: \$252,348

Invited Talks

Invited Talk at U. Arizona

02/2020

- Title: [Overcoming model misspecification in structured clustering and reinforcement learning with prediction constrained training](#)
- Event: [Regular meeting of a research working group at U. Arizona](#) funded by NSF TRIPODS award
- Summarizes our recent AISTATS 2020 paper

Invited Short Talk at Duke Clinical Research Institute Think Tank meeting

01/2020

- Talk: [Preferred Quality Metrics for Clinical Prediction Models](#)
- Event: [Leveraging Artificial Intelligence and Machine Learning Methods and Approaches to Transform Clinical Trial Design, Planning, and Execution](#)
- Host Organization: [Duke Clinical Research Institute](#)
- An invitation-only event in Washington D.C. gathering 40 ML experts, clinical experts, and policy makers

Invited Talk at Meeting of Critical Care Directors in Madrid, Spain

01/2020

- Talk Title: Optimizing Machine Learning Models for Interpretable, Actionable Predictions
- Event: Reunión Sobre Nuevas Tecnologías en el Tratamiento de Datos Clínicos Electrónicos
- Translation: Meeting on New Technologies for Processing Electronic Health Records
- Hosts: RGI Informatics (Dr. Richard Goldstein, CEO) and Fuenlabrada University Hospital (Joaquín Álvarez, head of ICU).
- An invitation-only hosted event in Madrid for 30 directors of intensive care units around Madrid, Spain

Invited Mentor at 2019 PLA General Hospital - MIT Critical Data Datathon

11/2019

- [4th annual PLAGH-MIT Datathon](#)
- Event held in Beijing, China with 25 teams of local clinicians and computational scientists
- Team goal: Answer clinical question on historical public dataset ([MIMIC](#)) over 1 weekend
- Event goal: Develop local teams' skills via intense practice with expert oversight
- My role: Advise teams toward principled and clinically-useful analysis

Invited Talk at BNP 2019

06/2019

- Title: Scalable and Reliable Variational Inference for Dirichlet Process Clustering with Sparse Assignments
- Venue: [12th International Conference on Bayesian Nonparametrics](#)
- Summarizes the effective learning methods behind our [BNPy toolbox](#)

Invited Tutorial at MLHC 2018

08/2018

- [Machine Learning for Clinicians: Advances for Multi-Modal Health Data](#) at MLHC '18
- Designed to help clinicians understand enough modern machine learning to collaborate successfully with ML researchers.

Invited Panelist

12/2016

- Software panel at [Advances in Approximate Bayesian Inference workshop](#) at NIPS '16.

Professional Service

Senior Program Committee / Meta-Reviewer

- 2020 - AAAI

Program Committee / Reviewer

- 2020 - NeurIPS, AISTATS, ICLR, MLHC, AMIA CRI
- 2019 - NeurIPS ([reviewer award](#)), AISTATS, ICLR
- 2018 - NeurIPS ([reviewer award](#)), AAAI, AISTATS, ICLR, AMIA CRI
- 2017 - NeurIPS, ICML, AAAI
- 2016 - NeurIPS
- 2015 - NeurIPS, ICML
- 2014 - NeurIPS, ICML
- 2013 - NeurIPS ([reviewer award](#))

Workshop Organizer: ML4H at NeurIPS 2018

2018

- [Machine Learning for Health workshop](#) at NeurIPS '18 (NeurIPS ML4H 2018).
- Full-day workshop with invited keynotes, accepted papers/posters, and lively panel discussions.
- Provided a forum for interdisciplinary interaction between clinicians, statisticians, and computer scientists.
- Helped with website, PR, and continuity in peer-review process from previous years.

Workshop Organizer: BNP at NeurIPS 2018

2018

- [All of Bayesian Nonparametrics workshop](#) at NeurIPS '18 (NeurIPS BNP 2018).
- Full-day workshop with invited keynotes, accepted papers/posters, and lively panel discussions.
- Helped with peer-review process for accepted posters, <https://sites.google.com/view/nipsbnp2018/schedule>.

Workshop Organizer: ML4H at NeurIPS 2017

2017

- [Machine Learning for Health workshop](#) at NIPS '17 (NIPS ML4H 2017)
- Full-day workshop with invited keynotes and panels involving clinicians, statisticians, and computer scientists.
- Organized peer-review process for 118 submitted papers.

Workshop Organizer: *BNP at NeurIPS 2016*

2016

- o [Practical Bayesian Nonparametrics workshop](#) at NIPS '16.
- o Full-day workshop with invited speakers, contributed talks, two panel discussions, and lively poster session.
- o Led decisions on >25 submitted papers based on peer review.

Teaching and Mentorship

Tufts CS Dept.

Course: [COMP 150 Bayesian Deep Learning](#)

Fall 2019

- o Taught advanced topics seminar to 23 students
- o Course format: weekly homeworks for first month, then 2-month open-ended team project

Tufts CS Dept.

Course: [COMP 135 Introduction to Machine Learning](#)

Spring 2019

- o Taught core principles of machine learning to about 50 students
- o Course format: 3 open-ended projects, weekly homeworks, and 2 exams

Tufts CS Dept.

Course: [COMP 150 Bayesian Deep Learning](#)

Fall 2018

- o Taught advanced topics seminar to about 18 students
- o Course format: weekly homeworks for first month, then 2-month open-ended team project
- o One project resulted in publication at IEEE conference (ICDL-EpiRob 2019)

Tufts University

Research Mentor

2018-

- o Mentored undergraduate projects:
- o – Manh Duc Nguyen. 2019 CS honors thesis: Particle-based algorithms for Bayesian Neural Networks - Hamiltonian Monte Carlo and Stein Variational Gradient Descent

Harvard University SEAS

Research Mentor

2016-2017

- o Mentored undergraduate senior thesis projects on Bayesian nonparametric inference.
- o Frederick Widjaja. 2017 honors thesis: Streaming Variational Inference for the Indian Buffet Process.
- o Madhu Vijay. 2017 honors thesis: Characterizing Posterior Uncertainty for the Indian Buffet Process.

Brown University

Research Mentor

2014-2016

- o Mentored students on projects related to Bayesian nonparametric clustering and the BNPy Python package.
- o William Stephenson. 2015 undergraduate honors thesis: [Variational Inference for Hierarchical Dirichlet Process based Nonparametric Models](#).
- o Sonia Phene. 2015 undergraduate honors thesis: [Multiprocessor Parallelization of Variational Inference for Bayesian Nonparametric Topic Models](#).
- o Mengrui Ni. 2015 masters project: [Variational Inference for Beta-Bernoulli Dirichlet Process Mixture Models](#).
- o Mert Terzihan. 2015 masters project.

Lead Graduate TA for [CS 142: Intro to Machine Learning](#)

Fall 2013

- Led weekly 1 hour recitation session to review key concepts for 50+ students.
- Designed homework assignments and exam questions.

Outreach Experience

TEALS and Boston Latin Academy

Roxbury, MA

Volunteer AP Computer Science Instructor

2014-2016

- Taught 1-2 classes / week for 2 years via [TEALS "CS in every high school"](#) initiative sponsored by Microsoft.
- Developed hands-on lessons to excite students from diverse backgrounds about computational thinking.
- Mentored full-time teacher Ingrid Roche as she transitioned from media arts to AP computer science (Java).

Harvard Humanitarian Initiative

Cambridge, MA

Signal Program Fellow

2014

- Developed prototype detector for common housing structures in sub-Saharan Africa from satellite images.
- Intended for humanitarian oversight of conflict areas where burning structures is common attack pattern.
- Featured in TEDx talk: <https://youtu.be/u719rBw0nwU>

Olin College Engineering Discovery

Needham, MA

Co-Founder and Curriculum Director

2007-2010

- Managed 15 undergrads in developing hands-on lessons for 4th-8th graders.
- Hosted workshops for 30 children to design, build, and launch bottle rockets.
- Pioneered green energy workshop which earned over \$750 in outside funding.

Industry Experience

Google

Mountain View, CA

Software Engineering Intern

Summer 2013

- Improved walking/biking/running classifier using smartphone accelerometer data.
- Led collection of dataset from dozens of individuals for classifier evaluation via custom Android app.

All Conference Publications (in reverse chronological order)

1. "[MIMIC-Extract: A Data Extraction, Preprocessing, and Representation Pipeline for MIMIC-III](#)." Shirley Wang^m, Matthew B. A. McDermott, Geeticka Chauhan, Marzyeh Ghassemi, Michael C. Hughes, and Tristan Naumann. To Appear at CHIL 2020: The ACM Conference on Health, Inference, and Learning, 2020.
2. "[POPCORN: Partially Observed Prediction-Constrained Reinforcement Learning](#)." Joseph Futoma, Michael C. Hughes, and Finale Doshi-Velez. To Appear at AISTATS 2020, 2020.
3. "[Regional Tree Regularization for Interpretability in Deep Neural Networks](#)." Mike Wu^d, Sonali Parbhoo, Michael C. Hughes, Ryan Kindle, Leo Celi, Maurizio Zazzi, Volker Roth, and Finale Doshi-Velez. AAAI 2020, 2020.
4. "[Feature Robustness in Non-stationary Health Records: Caveats to Deployable Model Performance in Common Clinical Machine Learning Tasks](#)." Bret Nestor^d, Matthew B. A. McDermott, Willie Boag, Gabriela Berner, Tristan Naumann, Michael C. Hughes, Anna Goldenberg, and Marzyeh Ghassemi. Machine Learning for Healthcare, 2019.

5. [“Supervised Machine Learning Algorithms Using Patient Related Factors to Predict in-Hospital Mortality Following Acute Myeloid Leukemia Therapy.”](#) Nauman Saleem Siddiqui^c, Andreas Klein, Amandeep Godara, Cindy Varga, Rachel J. Buchsbaum, and Michael C. Hughes. Proceedings of 61st Annual Meeting of the American Hematology Society, 2019.
6. [“Sensorimotor Cross-Behavior Knowledge Transfer for Grounded Category Recognition.”](#) Gyan Tatiya^d, Ramtin Hosseini^d, Michael C. Hughes, and Jivko Sinapov. Joint IEEE International Conference on Development and Learning and Epigenetic Robotics (ICDL-EpiRob), 2019.
7. [“Semi-Supervised Prediction-Constrained Topic Models.”](#) Michael C. Hughes, Gabriel Hope^d, Leah Weiner^d, Thomas H. McCoy Jr, Roy H. Perlis, Erik B. Sudderth, and Finale Doshi-Velez. Artificial Intelligence and Statistics (AISTATS), 2018.
8. [“Beyond Sparsity: Tree Regularization of Deep Models for Interpretability.”](#) Mike Wu^u, Michael C. Hughes, Sonali Parbhoo, Maurizio Zazzi, Volker Roth, and Finale Doshi-Velez. Association for Advancement of Artificial Intelligence (AAAI), 2018.
9. [“From Patches to Images: A Nonparametric Generative Model.”](#) Geng Ji^d, Michael C. Hughes, and Erik B. Sudderth. International Conference on Machine Learning (ICML), 2017.
10. [“Right for the Right Reasons: Training Differentiable Models by Constraining their Explanations.”](#) Andrew Slavin Ross^m, Michael C. Hughes, and Finale Doshi-Velez. International Joint Conference on Artificial Intelligence (IJCAI), 2017.
11. [“Predicting Intervention Onset in the ICU with Switching State Space Models.”](#) Marzyeh Ghassemi, Mike Wu^u, Michael C. Hughes, Peter Szolovits, and Finale Doshi-Velez. AMIA Summit on Clinical Research Informatics, 2017.
12. [“Scalable Adaptation of State Complexity for Nonparametric Hidden Markov Models.”](#) Michael C. Hughes, William Stephenson^u, and Erik B. Sudderth. Neural Information Processing Systems (NIPS), 2015.
13. [“Reliable and Scalable Variational Inference for the Hierarchical Dirichlet Process.”](#) Michael C. Hughes, Dae Il Kim, and Erik B. Sudderth. Artificial Intelligence & Statistics (AISTATS), 2015.
14. [“Memoized Online Variational Inference for Dirichlet Process Mixture Models.”](#) Michael C. Hughes and Erik B. Sudderth. Neural Information Processing Systems (NIPS), 2013.
15. [“Effective Split-Merge Monte Carlo Methods for Nonparametric Models of Sequential Data.”](#) Michael C. Hughes, Emily Fox, and Erik B. Sudderth. Neural Information Processing Systems (NIPS), 2012.
16. [“The Nonparametric Metadata Dependent Relational Model.”](#) Dae Il Kim, Michael C. Hughes, and Erik B. Sudderth. International Conference on Machine Learning (ICML), 2012.

All Journal Publications (in reverse chronological order)

1. [“Predicting Treatment Discontinuation after Antidepressant Initiation.”](#) Melanie F. Pradier, Thomas H. McCoy, Michael C. Hughes, Roy H. Perlis, and Finale Doshi-Velez. Translational Psychiatry, 2020.
2. [“Refinery: An Open Source Topic Modeling Web Platform.”](#) Daeil Kim, Benjamin F. Swanson, Michael C. Hughes, and Erik B. Sudderth. JMLR Machine Learning Open Source Software (MLOSS), 2017.
3. [“Joint Modeling of Multiple Time Series via the Beta Process with Application to Motion Capture Segmentation.”](#) Emily Fox, Michael C. Hughes, Erik B. Sudderth, and Michael I. Jordan. Annals of Applied Statistics, Vol. 8(3), 2014.

All Workshop Papers (in reverse chronological order)

1. "[Rapid Model Comparison by Amortizing Across Models.](#)" Lily H. Zhang^b, and Michael C. Hughes. Second Symposium on Advances in Approximate Bayesian Inference (AABI 2019), 2019.
2. "Classification of Enzyme Promiscuity Using Positive, Unlabeled, and Hard Negative Examples." Gian Marco Visani, Michael C. Hughes and Soha Hassoun. Machine Learning in Computational Biology Workshop (MLCB), 2019.
3. "[Prediction-Constrained POMDPs.](#)" Joseph Futoma, Michael C. Hughes, and Finale Doshi-Velez. Reinforcement Learning under Partial Observability (RLPO) workshop at NeurIPS 2018, 2018.
4. "[Rethinking clinical prediction: Why machine learning must consider year of care and feature aggregation.](#)" Bret Nestor^d, Matthew B. A. McDermott, Geeticka Chauhan, Tristan Naumann, Michael C. Hughes, Anna Goldenberg, Marzyeh Ghassemi. Machine Learning for Healthcare (ML4H) workshop at NeurIPS 2018, 2018.
5. "[Prediction-Constrained Topic Models for Antidepressant Prediction.](#)" Michael C. Hughes, Gabriel Hope^d, Leah Weiner^d, Thomas H. McCoy, Roy H. Perlis, Erik B. Sudderth, and Finale Doshi-Velez. NIPS Workshop on Machine Learning for Health (NIPS ML4H), 2017.
6. "[Associations between aboveground forest biomass and waveform LiDAR metrics: implications for modeling footprint-level biomass using Global Ecosystem Dynamics Investigation data.](#)" J. Kellner, J. B. Blair, L. Duncanson, L., S. Hancock, M. A. Hofton, M. C. Hughes, S. Marselis, S., J. Armston, E. B. Sudderth, H. Tang, L. Weiner^d, and R. Dubayah. American Geophysical Union, Fall General Assembly, 2016.
7. "[Supervised topic models for clinical interpretability.](#)" Michael C. Hughes, Huseyin Melih Elibol, Thomas McCoy, Roy Perlis, and Finale Doshi-Velez. NIPS Workshop on Machine Learning for Health (NIPS ML4H), 2016.
8. "[BNPy: Reliable and scalable variational inference for Bayesian nonparametric models.](#)" Michael C. Hughes and Erik B. Sudderth. 3rd NIPS Workshop on Probabilistic Programming, 2014.
9. "[Nonparametric Discovery of Activity Patterns from Video Collections.](#)" Michael C. Hughes and Erik B. Sudderth. CVPR Workshop on Perceptual Organization in Computer Vision (POCV), 2012.