# **Brandon Amos**

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 ☑ Last updated on December 18, 2023

## **Current Position**

Research Scientist, Meta AI, Fundamental AI Research (FAIR), New York City 2019 – Present

# **Education**

Ph.D. in Computer Science, Carnegie Mellon University (0.00/0.00)

Thesis: Differentiable Optimization-Based Modeling for Machine Learning

Advisor: J. Zico Kolter

B.S. in Computer Science, Virginia Tech (3.99/4.00)

2011 - 2014

# **Previous Positions**

Research Assistant, Carnegie Mellon University (with J. Zico Kolter on ML and optimization)	2016 - 2019
Research Intern, Intel Labs, Santa Clara (with Vladlen Koltun on computer vision)	2018
Research Intern, Google DeepMind, London (with Nando de Freitas and Misha Denil on RL)	2017
Research Assistant, Carnegie Mellon University (with Mahadev Satyanarayanan on mobile systems)	2014 - 2016
Research Intern, Adobe Research, San Jose (with David Tompkins on distributed systems)	2014
Research Assistant, Virginia Tech (with Layne Watson and David Easterling on optimization)	2013 - 2014
Research Assistant, Virginia Tech (with Jules White and Hamilton Turner on mobile systems)	2012 - 2014
Research Assistant, Virginia Tech (with Binoy Ravindran and Alastair Murray on compilers)	2012 - 2014
Software Intern, Snowplow (Scala development)	2013 - 2014
<b>Software Intern</b> , Qualcomm, San Diego (Python and C++ development)	2013
<b>Software Intern</b> , <i>Phoenix Integration</i> , Virginia (C++, C#, and Java development)	2012
Network Administrator Intern, Sunapsys, Virginia	2011

## **Honors & Awards**

NeurIPS Top Reviewer	2022
ICML Outstanding Reviewer	2022
ICLR Outstanding Reviewer	2019
NSF Graduate Research Fellowship 20	16 – 2019
Nine undergraduate scholarships 20	11 - 2014

Roanoke County Public Schools Engineering, Salem–Roanoke County Chamber of Commerce, Papa John's, Scottish Rite of Freemasonry, VT Intelligence Community Conter for Academic Excellence, VT Pamplin Leader, VT Benjamin F. Bock, VT Gay B. Shober, VT I. Luck Gravett

# **Publications** [Google Scholar: 7.4k+ citations and an h-index of 35]

Selected publications are highlighted.

2023.....

1. Tutorial on amortized optimization [code]

**Brandon Amos** 

Foundations and Trends in Machine Learning 2023

2. On amortizing convex conjugates for optimal transport [code]

**Brandon Amos** 

ICLR 2023

3. End-to-End Learning to Warm-Start for Real-Time Quadratic Optimization [code] Rajiv Sambharya, Georgina Hall, Brandon Amos, and Bartolomeo Stellato

L4DC 2023

- 4. Meta Optimal Transport [code] Brandon Amos, Samuel Cohen, Giulia Luise, and levgen Redko ICML 2023
- 5. Multisample Flow Matching: Straightening Flows with Minibatch Couplings Aram-Alexandre Pooladian, Heli Ben-Hamu, Carles Domingo-Enrich, Brandon Amos, Yaron Lipman, and Ricky T. Q. Chen ICML 2023
- 6. Semi-Supervised Offline Reinforcement Learning with Action-Free Trajectories Qinging Zheng, Mikael Henaff, Brandon Amos, and Aditya Grover ICML 2023
- 7. TaskMet: Task-Driven Metric Learning for Model Learning Dishank Bansal, Ricky T. Q. Chen, Mustafa Mukadam, and Brandon Amos NeurIPS 2023
- 8. Landscape Surrogate: Learning Decision Losses for Mathematical Optimization Under Partial Information Arman Zharmagambetov, Brandon Amos, Aaron Ferber, Taoan Huang, Bistra Dilkina, and Yuandong Tian NeurIPS 2023
- 9. Koopman Constrained Policy Optimization: A Koopman operator theoretic method for differentiable optimal control in robotics Matthew Retchin, Brandon Amos, Steven Brunton, and Shuran Song ICML Differentiable Almost Everything Workshop 2023
- 10. Neural Optimal Transport with Lagrangian Costs Aram-Alexandre Pooladian, Carles Domingo-Enrich, Ricky T. Q. Chen, and Brandon Amos ICML New Frontiers in Learning, Control, and Dynamical Systems Workshop 2023
- 11. Stochastic Optimal Control Matching Carles Domingo-Enrich, Jiequn Han, Brandon Amos, Joan Bruna, and Ricky T. Q. Chen arXiv 2023

- 12. Cross-Domain Imitation Learning via Optimal Transport [code] Arnaud Fickinger, Samuel Cohen, Stuart Russell, and Brandon Amos ICLR 2022
- 13. Matching Normalizing Flows and Probability Paths on Manifolds Heli Ben-Hamu\*, Samuel Cohen\*, Joey Bose, Brandon Amos, Aditya Grover, Maximilian Nickel, Ricky T. Q. Chen, and Yaron Lipman ICML 2022
- 14. Semi-Discrete Normalizing Flows through Differentiable Tessellation Ricky T. Q. Chen, Brandon Amos, and Maximilian Nickel NeurIPS 2022

15. Theseus: A Library for Differentiable Nonlinear Optimization [code] Luis Pineda, Taosha Fan, Maurizio Monge, Shobha Venkataraman, Paloma Sodhi, Ricky Chen, Joseph Ortiz, Daniel DeTone, Austin Wang, Stuart Anderson, Jing Dong, Brandon Amos, and Mustafa Mukadam NeurlPS 2022

Nocturne: a driving benchmark for multi-agent learning [code]
 Eugene Vinitsky, Nathan Lichtlé, Xiaomeng Yang, Brandon Amos, and Jakob Foerster
 NeurlPS Datasets and Benchmarks Track 2022

2021

- 17. On the model-based stochastic value gradient for continuous reinforcement learning [code] [slides] Brandon Amos, Samuel Stanton, Denis Yarats, and Andrew Gordon Wilson L4DC 2021 (Oral)
- 18. Riemannian Convex Potential Maps [code] [slides]
  Samuel Cohen\*, Brandon Amos\*, and Yaron Lipman
  ICML 2021
- CombOptNet: Fit the Right NP-Hard Problem by Learning Integer Programming Constraints [code] Anselm Paulus, Michal Rolínek, Vít Musil, Brandon Amos, and Georg Martius ICML 2021
- Scalable Online Planning via Reinforcement Learning Fine-Tuning
   Arnaud Fickinger, Hengyuan Hu, Brandon Amos, Stuart Russell, and Noam Brown NeurlPS 2021
- 21. Aligning Time Series on Incomparable Spaces [code] [slides]
  Samuel Cohen, Giulia Luise, Alexander Terenin, **Brandon Amos**, and Marc Peter Deisenroth
  AISTATS 2021
- Learning Neural Event Functions for Ordinary Differential Equations [code] Ricky T. Q. Chen, Brandon Amos, and Maximilian Nickel ICLR 2021
- Neural Spatio-Temporal Point Processes [code]
   Ricky T. Q. Chen, Brandon Amos, and Maximilian Nickel ICLR 2021
- 24. Improving Sample Efficiency in Model-Free Reinforcement Learning from Images [code]
  Denis Yarats, Amy Zhang, Ilya Kostrikov, **Brandon Amos**, Joelle Pineau, and Rob Fergus
  AAAI 2021
- 25. Neural Fixed-Point Acceleration for Convex Optimization [code]
  Shobha Venkataraman\* and Brandon Amos\*
  ICML AutoML Workshop 2021
- 26. Sliced Multi-Marginal Optimal Transport Samuel Cohen, Alexander Terenin, Yannik Pitcan, Brandon Amos, Marc Peter Deisenroth, and K S Sesh Kumar NeurIPS OTML Workshop 2021
- Input Convex Gradient Networks
   Jack Richter-Powell, Jonathan Lorraine, and Brandon Amos
   NeurlPS OTML Workshop 2021

28. Imitation Learning from Pixel Observations for Continuous Control
Samuel Cohen, **Brandon Amos**, Marc Peter Deisenroth, Mikael Henaff, Eugene Vinitsky, and
Denis Yarats

NeurIPS DeepRL Workshop 2021

MBRL-Lib: A Modular Library for Model-based Reinforcement Learning [code]
 Luis Pineda, Brandon Amos, Amy Zhang, Nathan Lambert, and Roberto Calandra arXiv 2021

#### 2020.....

30. The Differentiable Cross-Entropy Method [code] [slides]
Brandon Amos and Denis Yarats
ICML 2020

Objective Mismatch in Model-based Reinforcement Learning
 Nathan Lambert, Brandon Amos, Omry Yadan, and Roberto Calandra L4DC 2020

QNSTOP: Quasi-Newton Algorithm for Stochastic Optimization [code]
 Brandon Amos, David Easterling, Layne T. Watson, William Thacker, Brent Castle, and Michael Trosset
 ACM TOMS 2020

33. Neural Potts Model

Tom Sercu, Robert Verkuil, Joshua Meier, **Brandon Amos**, Zeming Lin, Caroline Chen, Jason Liu, Yann LeCun, and Alexander Rives MLCB 2020

34. Deep Riemannian Manifold Learning
Aaron Lou, Maximilian Nickel, and Brandon Amos
NeurlPS Geo4dl Workshop 2020

#### 2019

35. Differentiable Optimization-Based Modeling for Machine Learning [code]
Brandon Amos

Ph.D. Thesis 2019

36. Differentiable Convex Optimization Layers [code]
Akshay Agrawal\*, Brandon Amos\*, Shane Barratt\*, Stephen Boyd\*, Steven Diamond\*, and
J. Zico Kolter\*
NeurlPS 2019

37. The Limited Multi-Label Projection Layer [code] Brandon Amos, Vladlen Koltun, and J. Zico Kolter arXiv 2019

Generalized Inner Loop Meta-Learning [code]
 Edward Grefenstette, Brandon Amos, Denis Yarats, Phu Mon Htut, Artem Molchanov,
 Franziska Meier, Douwe Kiela, Kyunghyun Cho, and Soumith Chintala
 arXiv 2019

39. Learning Awareness Models

Brandon Amos, Laurent Dinh, Serkan Cabi, Thomas Rothörl, Sergio Gómez Colmenarejo, Alistair Muldal, Tom Erez, Yuval Tassa, Nando de Freitas, and Misha Denil ICLR 2018

- **40.** Differentiable MPC for End-to-end Planning and Control [code] Brandon Amos, Ivan Dario Jimenez Rodriguez, Jacob Sacks, Byron Boots, and J. Zico Kolter NeurIPS 2018
- 41. Depth-Limited Solving for Imperfect-Information Games Noam Brown, Tuomas Sandholm, and Brandon Amos NeurIPS 2018
- 42. Enabling Live Video Analytics with a Scalable and Privacy-Aware Framework Junjue Wang, Brandon Amos, Anupam Das, Padmanabhan Pillai, Norman Sadeh, and Mahadev Satyanarayanan ACM TOMM 2018

- 43. OptNet: Differentiable Optimization as a Layer in Neural Networks [code] [slides] Brandon Amos and J. Zico Kolter **ICML 2017**
- 44. Input Convex Neural Networks [code] [slides] Brandon Amos, Lei Xu, and J. Zico Kolter **ICML 2017**
- 45. Task-based End-to-end Model Learning [code] Priya L. Donti, Brandon Amos, and J. Zico Kolter NeurIPS 2017
- 46. Quasi-Newton Stochastic Optimization Algorithm for Parameter Estimation of a Stochastic Model of the Budding Yeast Cell Cycle

Minghan Chen, Brandon Amos, Layne T. Watson, John Tyson, Yang Cao, Cliff Shaffer, Michael Trosset, Cihan Oguz, and Gisella Kakoti IEEE/ACM TCBB 2017

- 47. You can teach elephants to dance: agile VM handoff for edge computing Kiryong Ha, Yoshihisa Abe, Thomas Eiszler, Zhuo Chen, Wenlu Hu, Brandon Amos, Rohit Upadhyaya, Padmanabhan Pillai, and Mahadev Satyanarayanan **SEC 2017**
- 48. An Empirical Study of Latency in an Emerging Class of Edge Computing Applications for Wearable Cognitive Assistance

Zhuo Chen, Wenlu Hu, Junjue Wang, Siyan Zhao, Brandon Amos, Guanhang Wu, Kiryong Ha, Khalid Elgazzar, Padmanabhan Pillai, Roberta Klatzky, Daniel Siewiorek, and Mahadev Satyanarayanan

SEC 2017

49. A Scalable and Privacy-Aware IoT Service for Live Video Analytics [code] Junjue Wang, Brandon Amos, Anupam Das, Padmanabhan Pillai, Norman Sadeh, and Mahadev Satyanarayanan ACM MMSys 2017 (Best Paper)

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- OpenFace: A general-purpose face recognition library with mobile applications [code]
   Brandon Amos, Bartosz Ludwiczuk, and Mahadev Satyanarayanan
   CMU 2016
- 51. Collapsed Variational Inference for Sum-Product Networks
  Han Zhao, Tameem Adel, Geoff Gordon, and Brandon Amos
  ICML 2016
- 52. Quantifying the impact of edge computing on mobile applications
  Wenlu Hu, Ying Gao, Kiryong Ha, Junjue Wang, **Brandon Amos**, Zhuo Chen, Padmanabhan Pillai,
  and Mahadev Satyanarayanan
  ACM SIGOPS 2016
- Privacy mediators: helping IoT cross the chasm
   Nigel Davies, Nina Taft, Mahadev Satyanarayanan, Sarah Clinch, and Brandon Amos HotMobile 2016

#### 2015 and earlier.....

- 54. Edge Analytics in the Internet of Things Mahadev Satyanarayanan, Pieter Simoens, Yu Xiao, Padmanabhan Pillai, Zhuo Chen, Kiryong Ha, Wenlu Hu, and Brandon Amos IEEE Pervasive Computing 2015
- 55. Bad Parts: Are Our Manufacturing Systems at Risk of Silent Cyberattacks?

  Hamilton Turner, Jules White, Jaime A. Camelio, Christopher Williams, Brandon Amos, and Robert Parker

  IEEE Security & Privacy 2015
- 56. Early Implementation Experience with Wearable Cognitive Assistance Applications Zhuo Chen, Lu Jiang, Wenlu Hu, Kiryong Ha, Brandon Amos, Padmanabhan Pillai, Alex Hauptmann, and Mahadev Satyanarayanan WearSys 2015
- 57. The Case for Offload Shaping

Wenlu Hu, **Brandon Amos**, Zhuo Chen, Kiryong Ha, Wolfgang Richter, Padmanabhan Pillai, Benjamin Gilbert, Jan Harkes, and Mahadev Satyanarayanan HotMobile 2015

58. Are Cloudlets Necessary?

Ying Gao, Wenlu Hu, Kiryong Ha, **Brandon Amos**, Padmanabhan Pillai, and Mahadev Satyanarayanan CMU 2015

59. Adaptive VM handoff across cloudlets

Kiryong Ha, Yoshihisa Abe, Zhuo Chen, Wenlu Hu, **Brandon Amos**, Padmanabhan Pillai, and Mahadev Satyanarayanan CMU 2015

60. Global Parameter Estimation for a Eukaryotic Cell Cycle Model in Systems Biology
Tricity Andrew, **Brandon Amos**, David Easterling, Cihan Oguz, William Baumann, John Tyson, and
Layne T. Watson
SummerSim 2014

61. Applying machine learning classifiers to dynamic Android malware detection at scale [code] Brandon Amos, Hamilton Turner, and Jules White IWCMC 2013

# **Open Source Repositories**

28.3k+ GitHub stars across all repositories.

1.	facebookresearch/amortized-optimization-tutorial — $\star$ 219 — Tutorial on amortized optimization	2023
2.	facebookresearch/w2ot — ★38 — Wasserstein-2 optimal transport in JAX	2023
3.	facebookresearch/theseus — ★1.5k — Differentiable non-linear optimization library	2022
4.	facebookresearch/meta-ot — ★86 — Meta Optimal Transport	2022
5.	bamos/presentations — ★119 — Source for my major presentations	2022
6.	facebookresearch/rcpm — ★65 — Riemannian Convex Potential Maps	2021
7.	facebookresearch/svg — ★53 — Model-based stochastic value gradient	2021
8.	facebookresearch/mbrl-lib — ★871 — Model-based reinforcement learning library	2021
9.	facebookresearch/dcem — ★119 — The Differentiable Cross-Entropy Method	2020
10.	facebookresearch/higher — ★1.6k — PyTorch higher-order gradient and optimization library	2019
11.	bamos/thesis — ★306 — Ph.D. Thesis LaTeX source code	2019
12.	cvxgrp/cvxpylayers — ★1.6k — Differentiable Convex Optimization Layers	2019
13.	locuslab/Iml — ★56 — The Limited Multi-Label Projection Layer	2019
14.	locuslab/mpc.pytorch — ★753 — Differentiable PyTorch Model Predictive Control library	2018
15.	locuslab/differentiable-mpc — ★169 — Differentiable MPC experiments	2018
16.	locuslab/icnn — ★263 — Input Convex Neural Network experiments	2017
17.	locuslab/optnet — ★466 — OptNet experiments	2017
	locuslab/qpth — ★626 — Differentiable PyTorch QP solver	2017
19.	bamos/densenet.pytorch — ★806 — PyTorch DenseNet implementation	2017
20.	bamos/block — ★290 — Intelligent block matrix constructions	2017
21.	bamos/setGPU — ★105 — Automatically use the least-loaded GPU	2017
22.	bamos/dcgan-completion.tensorflow — ★1.3k — Image completion with GANs	2016
23.	cmusatyalab/openface — ★14.9k — Face recognition with deep neural networks	2015
	vtopt/qnstop — ★10 — Fortran Quasi-newton stochastic optimization library	2014
	bamos/snowglobe — $\star$ 27 — Haskell-driven, self-hosted web analytics with minimal configuration	2014
	bamos/zsh-history-analysis — ★209 — Analyze and plot your zsh history	2014
	bamos/beamer-snippets — ★110 — Beamer and TikZ snippets	2014
	bamos/latex-templates — ★363 — LaTeX templates	2013
	cparse/cparse — $\star$ 323 — C++ expression parser using Dijkstra's shunting-yard algorithm	2013
	bamos/cv — ★392 — Source for this CV: Creates LaTeX/Markdown from YAML/BibTeX	2013
	bamos/python-scripts — ★197 — Short and fun Python scripts	2013
	bamos/reading-list — ★189 — YAML reading list and notes system	2013
33.	bamos/dotfiles — ★234 — ♥ Linux, xmonad, emacs, vim, zsh, tmux	2012

# **Invited Talks**

Slides for my major presentations are open-sourced with a CC-BY license at bamos/presentations.

1	Amortized optimization for optimal transport, NeurIPS	2023
	On optimal control and machine learning, ICML Learning, Control, and Dynamical Systems Workshop	2023
	Tutorial on amortized optimization, Brown University	2023
4.	Learning with differentiable and amortized optimization, NYU AI Seminar	2023
5.	Learning with differentiable and amortized optimization, Vanderbilt ML Seminar	2023
6	Learning with differentiable and amortized ontimization. Microsoft Research	2022

7. Amortized optimization for computing optimal transport maps, Flatiron Workshop	2022
8. Learning with differentiable and amortized optimization, Cornell AI Seminar	2022
9. Learning with differentiable and amortized optimization, Cornell Tech Seminar	2022
10. Learning with differentiable and amortized optimization, Argonne National Laboratory	2022
11. Theseus: A library for differentiable nonlinear optimization, NYU	2022
12. Theseus: A library for differentiable nonlinear optimization, University of Zurich	2022
13. Differentiable optimization-based modeling for machine learning, Colorado Mines AMS Colloquiur	n 2022
14. Differentiable optimization, IJCAI Tutorial	2022
15. Differentiable optimization for control and RL, ICML Workshop on Decision Awareness in RL	2022
16. Differentiable optimization-based modeling for machine learning, CPAIOR Master Class	2022
17. Tutorial on amortized optimization, ICCOPT	2022
18. Differentiable optimization for control and RL, Gridmatic	2022
19. Learning for control with differentiable optimization and ODEs, Columbia University	2021
20. Differentiable optimization-based modeling for machine learning, IBM Research	2021
21. Differentiable optimization for control, Max Planck Institute (Tübingen)	2020
22. Differentiable optimization-based modeling for machine learning, Mila Seminar	2020
23. Deep Declarative Networks, ECCV Tutorial	2020
24. On differentiable optimization for control and vision, CVPR Deep Declarative Networks Worksho	p 2020
25. Differentiable optimization-based modeling for machine learning, Caltech CS 159 (Guest Lecture)	2020
26. Unrolled optimization for learning deep energy models, SIAM MDS Minisymposium	2020
27. Differentiable optimization-based modeling for machine learning, NYU CILVR Seminar	2019
28. Differentiable optimization-based modeling for machine learning, INFORMS	2019
29. Differentiable optimization-based modeling for machine learning, Facebook Al Research	2019
30. Differentiable optimization-based modeling for machine learning, ISMP	2018
31. Differentiable optimization-based modeling for machine learning, Google Brain	2018
32. Differentiable optimization-based modeling for machine learning, Bosch Center for Al	2018
33. Differentiable optimization-based modeling for machine learning, Waymo Research	2018
34. Differentiable optimization-based modeling for machine learning, Tesla Al	2018
35. Differentiable optimization-based modeling for machine learning, NVIDIA Robotics	2018
36. Differentiable optimization-based modeling for machine learning, Salesforce Research	2018
37. Differentiable optimization-based modeling for machine learning, OpenAl	2018
38. Differentiable optimization-based modeling for machine learning, NNAISENSE	2018
39. Differentiable optimization and control, UC Berkeley	2018
Interns and Students	
Anselm Paulus (visiting FAIR from Max Planck Institute, Tübingen) 2023 –	present
Aram-Alexandre Pooladian (visiting FAIR from NYU) 2022 –	present

Anselm Paulus (visiting FAIR from Max Planck Institute, Tübingen)	2023 – present
Aram-Alexandre Pooladian (visiting FAIR from NYU)	2022 – present
Carles Domingo-Enrich (visiting FAIR from NYU)	2022 – present
Sanae Lotfi (visiting FAIR from NYU)	2022 - 2023
Dishank Bansal (Al resident at FAIR)	2022 - 2023
Arnaud Fickinger (visiting FAIR from Berkeley)	2021 - 2022
Aaron Lou (visiting FAIR from Cornell and Stanford)	2020 - 2022
Eugene Vinitsky (visiting FAIR from Berkeley, now incoming professor at NYU)	2021 - 2022
Samuel Cohen (visiting FAIR from UCL, now CEO at FairGen)	2021 - 2022
Ricky Chen (visiting FAIR from Toronto, now scientist at FAIR)	2020
Paul Liang (visiting FAIR from CMU)	2020
Phillip Wang (at CMU, now CEO at Gather)	2018

## **Professional Activities**

AAAI Senior Program Committee	2024
NeurIPS Area Chair	2023
NeurIPS Datasets and Benchmarks Area Chair	2023
AAAI Senior Program Committee	2023
NeurIPS Learning Meets Combinatorial Optimization Workshop Organizer	2020
CVPR Deep Declarative Networks Workshop Organizer	2020
ECCV Deep Declarative Networks Tutorial Organizer	2020
CMU CSD MS Admissions	2014 - 2015

# Reviewing.....

AAAI Conference on Artificial Intelligence

American Controls Conference (ACC)

IEEE Conference on Computer Vision and Pattern Recognition (CVPR)

IEEE Conference on Decision and Control (CDC)

IEEE Control Systems Letters (L-CSS)

IEEE International Conference on Computer Vision (ICCV)

IEEE International Conference on Intelligent Robots and Systems (IROS)

IEEE International Conference on Robotics and Automation (ICRA)

International Conference on the Constraint Programming, AI, and Operations Research (CPAIOR)

International Conference on Learning Representations (ICLR)

International Conference on Machine Learning (ICML)

International Conference on Machine Learning (ICML) SODS Workshop

Journal of Machine Learning Research (JMLR)

Learning for Dynamics and Control (L4DC)

Mathematical Programming Computation (MPC)

Neural Information Processing Systems (NeurIPS)

Neural Information Processing Systems (NeurIPS) Datasets and Benchmarks Track

Neural Information Processing Systems (NeurIPS) OPT Workshop

Neural Information Processing Systems (NeurIPS) DiffCVGP Workshop

Neural Information Processing Systems (NeurIPS) Deep RL Workshop

**Optimization Letters** 

Transactions on Machine Learning Research (TMLR)

# **Teaching**

Graduate AI (CMU 15-780), TA	S2017
Distributed Systems (CMU 15-440/640), TA	S2016
Software Design and Data Structures (VT CS2114), TA	S2013

### **Skills**

Programming C, C++, Fortran, Haskell, Java, Lua, Make, Mathematica, Python, R, Scala

Frameworks JAX, NumPy, Pandas, PyTorch, SciPy, TensorFlow, Torch7 Toolbox Linux, emacs, vim, evil, org, mu4e, xmonad, git, tmux, zsh