

# Jonathan Frankle Curriculum Vitae

PhD Candidate in Machine Learning, Massachusetts Institute of Technology  
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## Research Interests and Vision

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**Empiricism for deep learning.** I seek to identify properties of the neural networks that we use in practice. I do so from a scientific perspective, posing hypotheses about these questions and performing large-scale experiments to empirically evaluate them. This approach makes it possible to investigate phenomena that are challenging to formalize, especially in the context of the enormous complexity of practical deep learning systems. The resulting insights are useful for advancing our understanding and for improving the practical state of the art.

**The Lottery Ticket Hypothesis and Neural Network Sparsity.** My current research focus is on understanding how large neural networks need to be to train in practice. We have long known that we can *prune* a large number (often 80-90%) of connections from neural networks after they have been trained without affecting their accuracy. I showed that they can be equally small for much or all of training. This research reveals new insights into how neural networks learn and offers opportunities for practical improvements. I believe that studying neural network pruning and the resulting *sparse* networks is a valuable strategy for improving our understanding of deep learning.

## Education

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| 2016-21 | <b>PhD, Computer Science (Machine Learning)</b><br><i>Thesis:</i> The Lottery Ticket Hypothesis: On Sparse, Trainable Neural Networks<br><i>Adviser:</i> Michael Carbin <i>Committee:</i> Leslie Kaelbling, Stefanie Jegelka, Song Han<br><i>Minor:</i> Pure Mathematics (Real Analysis, Functional Analysis) | MIT       |
| 2014-15 | <b>MSE: Computer Science (Programming Languages)</b><br><i>Thesis:</i> Example-Directed Program Synthesis: A Type-Theoretic Interpretation<br><i>Adviser:</i> David Walker                                                                                                                                    | Princeton |
| 2011-14 | <b>BSE: Computer Science</b><br><i>Highest Honors:</i> 3.92/4.00 GPA, 3.96/4.00 Departmental GPA<br><i>Award:</i> Phillip Y. Goldman '86 Senior Prize, the CS Department's Highest Recognition                                                                                                                | Princeton |

## Selected Research & Publications

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**Overview.** Published eight peer-reviewed conference papers in machine learning (1 best paper award, two competitive oral presentations) in venues such as NeurIPS, ICML, ICLR, and MLSys with additional machine learning papers in submission and additional peer-reviewed conference papers in other areas of computer science (POPL and Usenix Security). Work in my main line of research includes:

**The Lottery Ticket Hypothesis: Finding Sparse Trainable Neural Networks (Best Paper Award and Oral).** [Jonathan Frankle](#) and Michael Carbin. *International Conference on Learning Representations (ICLR)*, 2019.

**Linear Mode Connectivity and the Lottery Ticket Hypothesis.** [Jonathan Frankle](#), Gintare Karolina Dziugaite, Daniel M. Roy, Michael Carbin. *International Conference on Machine Learning (ICML)*, 2020.

**The Early Phase of Neural Network Training.** [Jonathan Frankle](#), David J. Schwab, Ari S. Morcos. *International Conference on Learning Representations (ICLR)*, 2020.

**Comparing Rewinding and Fine-Tuning in Neural Network Pruning (Oral).** Alex Renda, [Jonathan Frankle](#), Michael Carbin. In *International Conference on Learning Representations (ICLR)*, 2020.

**Pruning Neural Networks at Initialization: Why are we missing the mark?** [Jonathan Frankle](#), Gintare Karolina Dziugaite, Daniel M. Roy, Michael Carbin. In *International Conference on Learning Representations (ICLR)*, 2021.

## Awards

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|         |                                                                                                                                                                                            |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2020    | <b>Top Reviewer (top 10%).</b> <i>Neural Information Processing Systems.</i>                                                                                                               |
| 2020    | <b>Top Reviewer (top 30%).</b> <i>International Conference on Machine Learning.</i>                                                                                                        |
| 2019    | <b>Best Paper Award for <i>The Lottery Ticket Hypothesis</i>.</b> <i>Int'l Conf. on Learning Representations.</i>                                                                          |
| 2016-17 | <b>Stata Presidential Fellowship.</b> <i>Massachusetts Institute of Technology.</i>                                                                                                        |
| 2014-15 | <b>Award for Excellence in Graduate Teaching.</b> <i>Princeton CS Department.</i><br><b>Award for Excellence in Graduate Teaching.</b> <i>Princeton Undergraduate Engineering Council.</i> |
| 2013-14 | <b>Phillip Y. Goldman Senior Prize.</b> <i>Princeton CS Department.</i><br><b>Award for Excellence in Undergraduate Teaching.</b> <i>Princeton CS Department.</i>                          |

## Teaching

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|         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|
| 2018-19 | <b>Professor of Record: Computer Programming for Lawyers</b><br>54 students. Taught 11 two-hour lectures and assigned 15 weekly problem sets.<br><b>Guest Lecture: Matrix Methods in Data Analysis (Gilbert Strang)</b><br>Neural Network Generalization and Compression                                                                                                                                                                                                                                                                                                                                                             | Georgetown Law<br>MIT                            |
| 2017-18 | <b>Teaching Assistant: Computer and Network Security (Ron Rivest)</b><br>Taught weekly recitations, advised course projects, and held office hours.<br><b>Seminar Series: Technology for Law Students</b>                                                                                                                                                                                                                                                                                                                                                                                                                            | MIT<br>New York Law School                       |
| 2016-17 | <b>Guest Lecture: Privacy Legislation: Law and Technology (Danny Weitzner)</b><br>Facial recognition and bias.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | MIT                                              |
| 2015-16 | <b>Co-Professor of Record: Computer Programming for Lawyers</b><br>Co-created the inaugural offering of the class for 17 students.<br>Co-taught 12 two-hour lectures (with Prof. Paul Ohm) and assigned 8 weekly problem sets.<br><b>Seminar Series: Technology for Law Students</b>                                                                                                                                                                                                                                                                                                                                                 | Georgetown Law<br>Georgetown Law                 |
| 2014-15 | <b>Teaching Assistant: General Computer Science (Doug Clark)</b><br>Taught two sections of 20 students, leading a classroom for four hours a week total.<br>Wrote lesson plans, held office hours, wrote exam questions, led review session for 400+ students.<br><b>Teaching Assistant: Information Security (Ed Felten)</b><br>Managed course logistics (four other TAs, two undergraduate graders, 100+ students), held office hours, wrote exam questions, led review sessions.<br><b>Departmental Award for Excellence in Graduate Teaching</b><br><b>Student Engineering Council Award for Excellence in Graduate Teaching</b> | Princeton<br>Princeton<br>Princeton<br>Princeton |
| 2013-14 | <b>Undergraduate Grader: General Computer Science</b><br><b>Undergraduate Grader: Functional Programming</b><br><b>Departmental Award for Excellence in Undergraduate Teaching</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Princeton<br>Princeton<br>Princeton              |
| 2012-13 | <b>Undergraduate Lab TA: Introductory Computer Science Curriculum</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Princeton                                        |

## Mentorship

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| 2020-21 | <b>M.Eng Student: Arlene Siswanto</b><br>Extending recent lottery ticket findings to new settings: NLP, RL, and recommender systems.<br><b>Undergraduate Researcher: Raj Movva</b><br>Parallelizing the search for sparse neural networks and winning lottery tickets.                                                                                                                            | MIT<br>MIT        |
| 2019-20 | <b>M.Eng Student: James Gilles</b><br>Studying the lottery ticket hypothesis for adversarially robust neural networks.<br><b>Undergraduate Researcher: Arlene Siswanto</b><br>Evaluating the effect of batch normalization on the lottery ticket findings.<br><b>M.Eng Student: Elizabeth Dethy</b><br>Assessing the interpretability of facial recognition and characterization neural networks. | MIT<br>MIT<br>MIT |
| 2014-15 | <b>Graduate Fellow: Forbes Residential College</b><br>Mentored undergraduate students interested in computer science, facilitated weekly discussions on technical topics of interest, and led review sessions.                                                                                                                                                                                    | Princeton         |

## Service

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| 2020 | <b>Graduate and Postdoc Advisory Council.</b> <i>MIT Computer Science and Artificial Intelligence Lab.</i><br><b>Reviewer.</b> <i>International Conference on Learning Representations.</i><br><b>Reviewer.</b> <i>Neural Information Processing Systems.</i><br><b>Reviewer, Top Reviewer Award.</b> <i>International Conference on Machine Learning.</i><br><b>Panelist &amp; Presenter.</b> <i>Machine Learning Retrospectives Workshop, ICML.</i>                                                                                           |
| 2019 | <b>Backup Reviewer.</b> <i>Neural Information Processing Systems.</i><br><b>Backup Reviewer.</b> <i>International Conference on Learning Representations.</i><br><b>Backup Reviewer.</b> <i>Society for Artificial Intelligence and Statistics.</i><br><b>Panelist &amp; Presenter.</b> <i>Machine Learning Retrospectives Workshop, NeurIPS.</i><br><b>Lab Working Group on Email Lists.</b> <i>MIT Computer Science and Artificial Intelligence Lab.</i><br><b>Computer Science Department Advisory Council.</b> <i>Princeton University.</i> |
| 2018 | <b>Panelist.</b> <i>Northeastern University AI &amp; Democracy Conference.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

## Invited Talks

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### **The Lottery Ticket Hypothesis: On Sparse, Trainable Neural Networks**

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|-----------------------------------------------------------------------------------------|-----------|
| University of Wisconsin (Madison) Computer Sciences Department (Job Talk)               | Mar. 2021 |
| Boston University Computing and Data Sciences (Job Talk)                                | Mar. 2021 |
| Carnegie Mellon University Machine Learning and Computer Science Departments (Job Talk) | Mar. 2021 |
| Cornell University Computer Science Department (Job Talk)                               | Mar. 2021 |
| University of Maryland Computer Science Department (Job Talk)                           | Mar. 2021 |
| Harvard University Computer Science Department (Job Talk)                               | Feb. 2021 |
| Northeastern University Computer Science Department (Job Talk)                          | Jan. 2021 |
| Allen Institute for Artificial Intelligence (Job Talk)                                  | Oct. 2020 |
| Facebook AI (Job Talk)                                                                  | Oct. 2020 |
| Google Brain (Job Talk)                                                                 | Oct. 2020 |
| Cerebras                                                                                | Oct. 2020 |
| Microsoft Research (New York)                                                           | Oct. 2020 |
| University of Texas, Austin, Visual Informatics Group Seminar                           | Aug. 2020 |
| University of California, Berkeley, Robot Learning Lab (Pieter Abbeel Group) Seminar    | Jul. 2020 |
| Google Brain (Mountain View, California)                                                | Jun. 2020 |
| UCLA/MPI Machine Learning Seminar                                                       | May 2020  |
| Brown University Computer Science Department                                            | Apr. 2020 |
| VMWare Research                                                                         | Apr. 2020 |
| NVIDIA GTC                                                                              | Mar. 2020 |
| University of Massachusetts, Lowell, Anna Rumschisky Group Seminar                      | Mar. 2020 |
| Facebook AI (Paris)                                                                     | Feb. 2020 |
| Princeton University, Ryan Adams Group Seminar                                          | Feb. 2020 |
| Institute for Advanced Study (Princeton)                                                | Feb. 2020 |
| AAAI Sister Conference Track Invited Talk                                               | Feb. 2020 |
| Google Brain (Cambridge, Massachusetts)                                                 | Jan. 2020 |
| Element AI                                                                              | Oct. 2019 |
| ReWork Deep Learning Montreal                                                           | Oct. 2019 |
| The Vector Institute                                                                    | Oct. 2019 |
| MIT Quest for Intelligence Research Blitz                                               | Oct. 2019 |
| MIT-IBM Watson AI Lab Seminar                                                           | Oct. 2019 |
| MIT CSAIL Machine Learning Tea Seminar                                                  | Oct. 2019 |
| Uber AI Seminar                                                                         | Sep. 2019 |
| Simons Institute Foundations of Deep Learning Talk                                      | Aug. 2019 |

### **Pruning Neural Networks at Initialization: Why are we missing the mark?**

|                                      |           |
|--------------------------------------|-----------|
| The Machine Learning Collective      | Sep. 2020 |
| Google Brain, Sparsity Reading Group | Sep. 2020 |

### **Linear Mode Connectivity and the Lottery Ticket Hypothesis**

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|----------------------------------------------|-----------|
| International Conference on Machine Learning | Jul. 2020 |
| Google Brain, Sparsity Reading Group         | Mar. 2019 |

### **The Lottery Ticket Hypothesis: Finding Sparse, Trainable Neural Networks**

|                                                                        |           |
|------------------------------------------------------------------------|-----------|
| International Conference on Learning Representations Oral Presentation | May 2019  |
| MIT, Regina Barzilay Group Meeting                                     | May 2019  |
| MIT, Song Han Group Meeting                                            | May 2019  |
| MIT, Graphics Group Seminar                                            | Apr. 2019 |
| MIT, Aleksander Madry Group Seminar                                    | Feb. 2019 |
| MIT, ALFA (Una-May O'Reilly) Group Seminar                             | Jan. 2019 |
| Princeton University, AI Bias Reading Group                            | Mar. 2018 |

### **AI for Policymakers**

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|----------------------------------------------------------------|-----------|
| Georgetown Law, Computer Programming for Lawyers Final Lecture | Apr. 2020 |
| OECD Global Parliamentary Network                              | Feb. 2020 |
| ReWork Deep Learning Montreal                                  | Oct. 2019 |
| Georgetown Law, Computer Programming for Lawyers Final Lecture | Apr. 2019 |
| Boston University, Cyber Alliance Seminar                      | Oct. 2018 |
| Princeton University, Limits of AI Workshop                    | Sep. 2018 |
| New York Law School, Technology for Lawyers Series             | Apr. 2018 |
| Georgetown Law, Computer Programming for Lawyers Final Lecture | Apr. 2017 |

## Invited Talks Ctd.

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### **Policy for AI-Makers & The Perpetual Lineup**

Facebook AI Research, AI and Society Reading Group May 2020  
Brown University, Computer Science Department Apr. 2020

### **Training BatchNorm and Only BatchNorm**

NeurIPS Science Meets Engineering of Deep Learning Workshop, Oral Presentation Dec. 2019

### **Practical Accountability of Secret Processes**

Usenix Security Conference, Oral Presentation Aug. 2018

### **Example-Directed Synthesis: A Type-Theoretic Interpretation**

Principles of Programming Languages Conference, Oral Presentation Jan. 2016

## Press & Interviews

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### **The Lottery Ticket Hypothesis (General)**

MIT News: *Shrinking Deep Learning's Carbon Footprint (Interview)* Aug. 2020

Machine Learning Street Talk Podcast (Interview) May 2020

NVIDIA AI Podcast (Interview) Mar. 2020

Allen Institute AI Highlights Podcast (Interview) Jan. 2020

MIT News: *What a Little More Computing Power Can Do (Interview)* Sep. 2019

### **The Lottery Ticket Hypothesis: Finding Sparse, Trainable Neural Networks**

MIT Tech. Review: *A New Way to Build Tiny Neural Nets Could Create Powerful AI on Your Phone* May 2019

MIT News: *Smarter Training of Neural Networks* May 2019

Engadget: *MIT Finds Smaller Neural Networks that are Easier to Train* May 2019

VentureBeat: *MIT CSAIL Details Tech. for Shrinking Neural Nets without Compromising Accuracy* May 2019

### **Practical Accountability of Secret Processes**

MIT News: *Holding Law Enforcement Accountable for Electronic Surveillance* Aug. 2018

BBC Radio *Click (Interview)* Aug. 2018

FastCompany: *MIT's Tool for Tracking Police Surveillance* Aug. 2018

### **Face Recognition (General)**

The New York Times: *How China is Using AI to Profile a Minority (Interview)* Apr. 2019

The New York Times: *An Airline Scans Your Face: Few Rules Govern Your Data (Interview)* Aug. 2018

The New York Times: *Newspaper Shooting Shows Widening Use of Facial Recognition (Interview)* Jun. 2018

CBC Radio: *The Current: US Schools Turn to Face Rec. to Help Stop Gun Attacks (Interview)* May 2018

Undark: *Artificial Intelligence and the Resurgence of Physiognomy (Interview)* Nov. 2017

Mashable: *Why the iPhone X's Facial Recognition Could be a Privacy Disaster (Interview)* Aug. 2017

FiveThirtyEight: *Technology is Biased Too. How do we fix it? (Interview)* Jul. 2017

Undark: *Facial Recognition Technology is Both Biased and Understudied (Interview)* May 2017

NPR Article: *Facebook's Facial Rec. Software is Different from the FBI's* May 2016

### **The Perpetual Lineup: Unregulated Police Face Recognition in America**

Last Week Tonight with John Oliver: *Facial Recognition* Jun. 2020

New Scientist: *Concerns as Face Recognition Tech Used to "Identify" Criminals (Interview)* Dec. 2016

The Register: *Meanwhile In America: Half of Adult's Faces are in Police Databases (Interview)* Oct. 2016

NPR Radio: *Researchers Find Flaws in Police Facial Recognition Technology (Interview)* Jun. 2016

The Washington Post: *Police Facial ID Tech Raises Civil Rights Concerns* Oct. 2016

The New York Times: *Study Urges Tougher Oversight for Police Use of Facial Recognition* Oct. 2016

CBS Evening News: *Law Enforcement Increasing Use of Facial Recognition Technology* Oct. 2016

NPR Radio: *Police Facial Recognition Databases Log About Half of Americans* Oct. 2016

### **How Russia's New Facial Recognition App Could End Online Anonymity (The Atlantic, May 2016)**

### **Facial Recognition Software Might Have a Racial Bias Problem (The Atlantic, April 2016)**

The Guardian: *Does Facial Recognition Show Racial Bias? (Interview)* Apr. 2016

Vice Motherboard: *The Inherent Bias of Facial Recognition (Interview)* Mar. 2016

## Peer Reviewed Publications

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- 1 **Pruning Neural Networks at Initialization: Why are we missing the mark?** [Jonathan Frankle](#), Gintare Karolina Dziugaite, Daniel M. Roy, Michael Carbin. *International Conference on Learning Representations*, 2021.
- 2 **Training BatchNorm and Only BatchNorm: On the Expressive Power of Random Features in CNNs.** [Jonathan Frankle](#), David J. Schwab, Ari S. Morcos. *International Conference on Learning Representations*, 2021.
- 3 **The Lottery Ticket Hypothesis for Pre-Trained BERT Networks.** Tianlong Chen, [Jonathan Frankle](#), Shiyu Chang, Sijia Liu, Yang Zhang, Zhangyang Wang, Michael Carbin. *Neural Information Processing Systems* (Poster), 2020.
- 4 **Linear Mode Connectivity and the Lottery Ticket Hypothesis. (Previous versions called “The Lottery Ticket Hypothesis at Scale” and “Stabilizing the Lottery Ticket Hypothesis.”)** [Jonathan Frankle](#), Gintare Karolina Dziugaite, Daniel M. Roy, Michael Carbin. *International Conference on Machine Learning* (Oral), 2020.
- 5 **What is the State of Neural Network Pruning?** Davis Blalock, Jose Javier Gonzalez Ortiz, [Jonathan Frankle](#), John Guttag. *Conference on Machine Learning and Systems* (Oral), 2020.
- 6 **The Early Phase of Neural Network Training.** [Jonathan Frankle](#), David J. Schwab, Ari S. Morcos. *International Conference on Learning Representations* (Poster), 2020.
- 7 **Comparing Rewinding and Fine-Tuning in Neural Network Pruning.** Alex Renda, [Jonathan Frankle](#), Michael Carbin. *International Conference on Learning Representations* (Oral), 2020.
- 8 **The Lottery Ticket Hypothesis, Finding Sparse, Trainable Neural Networks (Best Paper).** [Jonathan Frankle](#) and Michael Carbin. *International Conference on Learning Representations* (Oral), 2019.
- 9 **Practical Accountability of Secret Processes.** [Jonathan Frankle](#), Sunoo Park, Daniel Weitzner, Shafi Goldwasser. *Usenix Security* (Oral), 2018.
- 10 **Desirable Inefficiency.** Paul Ohm and [Jonathan Frankle](#). *Florida Law Review*, 2017.
- 11 **Example-Directed Synthesis: A Type-Theoretic Interpretation.** [Jonathan Frankle](#), Peter-Michael Osera, Steve Zdancewic, David Walker. *Principles of Programming Languages* (Oral), 2016.

## In Submission

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- 12 **On the Predictability of Pruning Across Scales.** Jonathan Rosenfeld, [Jonathan Frankle](#), Michael Carbin, Nir Shavit. In submission to *ICLR*.
- 13 **Are All Negatives Created Equal in Contrastive Instance Discrimination?** Tiffany Cai, [Jonathan Frankle](#), David J. Schwab, Ari S. Morcos. In submission to *ICLR*.
- 14 **Computer Programming for Lawyers (Textbook).** [Jonathan Frankle](#) and Paul Ohm. In the publication process with *No Starch Press*.

## Peer Reviewed Workshop Papers

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- 15 **Revisiting “Qualitatively Characterizing Neural Network Optimization Problems.”** [Jonathan Frankle](#). *Workshop on Deep Learning Information Geometry (NeurIPS)*, 2020.
- 16 **Trade-offs of Local SGD at Scale: An Empirical Study.** Jose Javier Gonzalez Ortiz, [Jonathan Frankle](#), Ari S. Morcos, Michael Rabbat, Nicolas Ballas. *Optimization for Machine Learning Workshop* (NeurIPS), 2020. In submission to *MLSys*.
- 17 **Dissecting Pruned Neural Networks.** [Jonathan Frankle](#) and David Bau. *Workshop on Debugging Machine Learning (ICLR)*, 2019.

## Reports and Op-Eds

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- 18 **The Perpetual Lineup: Unregulated Police Face Recognition in America.** Clare Garvie, Alvaro Bedoya, [Jonathan Frankle](#). *Investigative report*, 2016.
- 19 **How Russia’s New Facial Recognition App Could End Online Anonymity.** [Jonathan Frankle](#). *The Atlantic*, 2016.
- 20 **Facial Recognition Software Might Have a Racial Bias Problem.** Clare Garvie and [Jonathan Frankle](#). *The Atlantic*, 2016.
- 21 **Type-Directed Synthesis of Products.** [Jonathan Frankle](#). *Master’s Thesis*, 2015.
- 22 **Programming Recursive Software-Defined Networks.** [Jonathan Frankle](#). *Undergraduate research*, 2014.
- 23 **Why King George III Can Encrypt.** [Jonathan Frankle](#), Sam Gichohi, Sebastian Gold, Mihai Roman, Wenley Tong (alphabetical ordering). *Undergraduate research*, 2014.

## Technical Work Experience

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- 2019 Student Researcher (Part-Time During the School Year)** **Facebook AI Research**
- Studied the early phase of training, batch normalization, and self-supervised learning for vision.
  - Released the OpenLTH open-source implementation of Lottery Ticket experiments in PyTorch.
  - In submission: *Training BatchNorm and Only BatchNorm and Are All Negative Created Equal?*
- Research Summer Intern** **Facebook AI Research**
- Explored the behavior of neural networks during the early phase of training.
  - Publication: *The Early Phase of Neural Network Training*
- 2018 Student Researcher (Part-Time During the School Year)** **Google Brain**
- Explored applications of sparsity for improved transfer learning for pre-trained BERT models.
- Research Summer Intern** **Google Brain**
- Developed a pipeline for using graph neural network to predict variable misuses in Python code written by Google engineers with the goal of improving developer productivity.
- 2017 Research Summer Intern** **Google Research**
- Created a library for fully homomorphic, post-quantum encryption using ring learning with errors lattice-based cryptography (3000 lines of C++). Available at [www.github.com/google/shell-encryption](https://www.github.com/google/shell-encryption)
  - Applied these techniques to implement a *private information retrieval* system (1500 lines of C++).
  - The team continues to build on the project, and it launched as an official Google service in April 2019.
- 2014 Software Engineering Summer Intern** **Google**
- Added signatures to authenticate update messages in ubiquitous encryption key management servers.
  - Implemented the enhancement in two different codebases in 1500 lines each of Java and C++.
  - Eliminated unnecessary cryptographic operations from key management requests for better efficiency.
- 2013 Software Engineering Summer Intern** **Microsoft**
- Worked on an internal startup developing an app-creator for non-programmers (*Project Siena*) using the PowerPoint canvas with the Excel formula language. Worked on a four-person compiler team.
  - Designed and implemented a parse-level macro system and user-interface for the formula language (2000 lines of C#). Wrote compiler optimizations to eliminate redundant computation from formulas.

## Policy Work Experience

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- 2020 Invited Expert** **OECD Network of Experts on AI**
- A continuation of the earlier OECD AI expert group examining ways to measure AI development in member countries and ways to implement the OECD AI principles.
- 2019 Adjunct Professor of Law (Spring Term)** **Georgetown Law**
- Instructor of Record for *Computer Programming for Lawyers* (54 students).
- Invited Expert** **OECD Expert Group on AI**
- Developed principles on the creation and use of trustworthy AI over the course of four meetings in Paris, Boston, and Dubai in partnership with experts and diplomats from around the world.
  - The G20 adopted these principles as the basis for their AI policy.
- 2016 Adjunct Professor of Law (Spring Term)** **Georgetown Law**
- Co-creator and co-instructor of the inaugural offering of *Computer Programming for Lawyers*, which has now become a regular offering at the law school and has been adapted at six other law schools.
  - The course has been featured in the New York Times and the Washington Post.
- Staff Technologist, Center on Privacy and Technology** **Georgetown Law**
- Applied my technical background to efforts to address law and policy challenges.
  - Explored new approaches to privacy using concepts from computer science (i.e., proof of work).
  - Investigated racial bias in increasingly widespread law enforcement use of facial recognition.

## Open-Source Code

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- 2020 OpenLTH: A Framework for Lottery Tickets and Beyond** **Facebook AI Research**
- My current working codebase for research on the lottery ticket hypothesis.
  - Written in 1500 lines of Python (and 1500 lines of unit tests) using the PyTorch framework.
  - [https://www.github.com/facebookresearch/open\\_lth](https://www.github.com/facebookresearch/open_lth)
- 2018 An Implementation of the Lottery Ticket Hypothesis** **Google Brain**
- An implementation of the lottery ticket hypothesis in Python using the TensorFlow framework.
  - <https://www.github.com/google-research/lottery-ticket-hypothesis>
- 2017 SHELL: Simple Homomorphic Encryption Library with Lattices** **Google Research**
- An implementation of a lattice-based, quantum resistant, homomorphic encryption scheme.
  - Serves as the basis for Google's efforts for computing on encrypted data.
  - Written in 1500 lines of modern C++ (and 1500 lines of unit tests).
  - <https://github.com/google/shell-encryption>

## References

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### **Michael Carbin**

Assistant Professor  
Department of Electrical Engineering and Computer Science  
Massachusetts Institute of Technology

### **Daniel Roy**

Associate Professor  
Department of Statistics and Vector Institute  
University of Toronto

### **Leslie Kaelbling**

Professor  
Department of Electrical Engineering and Computer Science  
Massachusetts Institute of Technology

### **Ryan P. Adams**

Professor  
Department of Computer Science  
Princeton University

### **Paul K. Ohm**

Professor  
Georgetown University Law Center