Noam Brown

Curriculum Vitae

Education

2014–2020 **PhD in Computer Science**, *Carnegie Mellon University*.
Advisor: Tuomas Sandholm
School of Computer Science Distinguished Dissertation Award

2012-2014 **MS in Robotics**, *Carnegie Mellon University*.
Advisor: Tuomas Sandholm

2012-2014 **BA in Mathematics and Computer Science**, *Rutgers University*.
Summa Cum Laude
Rutgers College Honors Program

Work Experience

2018–Present **Research Scientist**, *Facebook AI Research*, New York.

2012–2018 **Research Assistant**, *Carnegie Mellon University*, Pittsburgh.

Summer 2017 **Research Intern**, *DeepMind*, London.

2010–2012 **Research Assistant**, *Federal Reserve Board of Governors*, Washington, DC.

2006–2010 **Algorithmic Trading Engineer**, *MJM Trading Group*, New York.

Publications

Journal Papers

- Superhuman AI for Multiplayer Poker. Noam Brown and Tuomas Sandholm. *Science*, 2019. **Cover Article**.
- Superhuman AI for Heads-Up No-Limit Poker: Libratus Beats Top Professionals. Noam Brown and Tuomas Sandholm. *Science*, 2017.

Preprints

- Mastering the Game of No-Press Diplomacy via Human-Regularized Reinforcement Learning and Planning. Anton Bakhtin*, David J Wu*, Adam Lerer*, Jonathan Gray*, Athul Paul Jacob*, Gabriele Farina*, Alexander H Miller, Noam Brown. *Preprint. Under Review*, 2022.
- Human-AI Coordination via Human-Regularized Search and Learning. Hengyuan Hu, David J Wu, Adam Lerer, Jakob Foerster, Noam Brown. *Preprint. Under Review*, 2022.
- A Unified Approach to Reinforcement Learning, Quantal Response Equilibria, and Two-Player

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Zero-Sum Games. Samuel Sokota*, Ryan D'Orazio*, J Zico Kolter, Nicolas Loizou, Marc Lanctot, Ioannis Mitliagkas, Noam Brown, Christian Kroer. *Preprint. Under Review*, 2022.

Conference Papers

- Modeling Strong and Human-Like Gameplay with KL-Regularized Search. Athul Paul Jacob*, David J Wu*, Gabriele Farina*, Adam Lerer, Hengyuan Hu, Anton Bakhtin, Jacob Andreas, Noam Brown. *International Conference on Machine Learning (ICML)*, 2022.
- A Fine-Tuning Approach to Belief State Modeling. Sam Sokota, Hengyuan Hu, David J Wu, Zico Kolter, Jakob Foerster, Noam Brown. *International Conference on Learning Representations (ICLR)*, 2022.
- Equilibrium Finding in Matrix Games Via Greedy Regret Minimization. Hugh Zhang, Adam Lerer, Noam Brown. *AAAI Conference on Artificial Intelligence (AAAI)*, 2022.
- Scalable Online Planning via Reinforcement Learning Fine-Tuning. Arnaud Fickinger*, Hengyuan Hu*, Brandon Amos, Stuart Russell, Noam Brown. *Neural Information Processing Systems (NeurIPS)*, 2021.
- No-Press Diplomacy from Scratch. Anton Bakhtin, David J Wu, Adam Lerer, Noam Brown. *Neural Information Processing Systems (NeurIPS)*, 2021.
- Human-Level Performance in No-Press Diplomacy via Equilibrium Search. Jonathan Gray*, Adam Lerer*, Anton Bakhtin, Noam Brown. *International Conference on Learning Representations (ICLR)*, 2021.
- Off-Belief Learning. Hengyuan Hu, Adam Lerer, Brandon Cui, Luis Pineda, Noam Brown, Jakob Foerster. *International Conference on Machine Learning (ICML)*, 2021.
- Safe Search for Stackelberg Equilibria in Extensive-Form Games. Chun Kai Ling, Noam Brown. *AAAI Conference on Artificial Intelligence (AAAI)*, 2021.
- Combining Deep Reinforcement Learning and Search for Imperfect-Information Games. Noam Brown*, Anton Bakhtin*, Adam Lerer, Qucheng Gong. *Neural Information Processing Systems (NeurIPS)*, 2020.
- Improving Policies via Search in Partially Observable Games. Adam Lerer, Hengyuan Hu, Jakob Foerster, Noam Brown. *AAAI Conference on Artificial Intelligence (AAAI)*, 2020.
- Deep Counterfactual Regret Minimization. Noam Brown*, Adam Lerer*, Sam Gross, Tuomas Sandholm. *International Conference on Machine Learning (ICML)*, 2019.
- Stable-Predictive Optimistic Counterfactual Regret Minimization. Gabriele Farina, Christian Kroer, Noam Brown, Tuomas Sandholm. *International Conference on Machine Learning (ICML)*, 2019.
- Solving Imperfect-Information Games via Discounted Regret Minimization. Noam Brown and Tuomas Sandholm. *AAAI Conference on Artificial Intelligence (AAAI)*, 2019. **Outstanding Paper Honorable Mention**.
- Depth-Limited Solving for Imperfect-Information Games. Noam Brown, Tuomas Sandholm, Brandon Amos. *Neural Information Processing Systems (NeurIPS)*, 2018.
- Safe and Nested Subgame Solving for Imperfect-Information Games. Noam Brown and Tuomas Sandholm. *Neural Information Processing Systems (NeurIPS)*, 2017. **Best Paper Award**.
- Reduced Space and Faster Convergence in Imperfect-Information Games via Pruning. Noam Brown and Tuomas Sandholm. *International Conference on Machine Learning (ICML)*, 2017.
- Dynamic Thresholding and Pruning for Regret Minimization. Noam Brown, Christian Kroer, Tuomas Sandholm. *AAAI Conference on Artificial Intelligence (AAAI)*, 2017.
- Strategy-Based Warm Starting for Regret Minimization in Games. Noam Brown and Tuomas Sandholm. *AAAI Conference on Artificial Intelligence (AAAI)*, 2016.
- Regret-Based Pruning in Extensive-Form Games. Noam Brown and Tuomas Sandholm. *Neural*

Information Processing Systems (NeurIPS), 2015.

- Simultaneous Abstraction and Equilibrium Finding in Games. Noam Brown and Tuomas Sandholm. *International Joint Conference on Artificial Intelligence (IJCAI)*, 2015.
- Hierarchical Abstraction, Distributed Equilibrium Computation, and Post-Processing, with Application to a Champion No-Limit Texas Hold'em Agent. Noam Brown*, Sam Ganzfried*, Tuomas Sandholm. *International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2015.
- Regret Transfer and Parameter Optimization. Noam Brown and Tuomas Sandholm. *AAAI Conference on Artificial Intelligence (AAAI)*, 2014.

Workshop Papers

- Learned Belief Search: Efficiently Improving Policies in Partially Observable Settings. Hengyuan Hu*, Adam Lerer*, Noam Brown, Jakob Foerster. *AAAI Workshop on Reinforcement Learning in Games*, 2021.
- DREAM: Deep Regret Minimization with Advantage Baselines and Model-Free Learning. Eric Steinberger, Adam Lerer, Noam Brown. *NeurIPS Deep RL Workshop*, 2021.
- Unlocking the Potential of Deep Counterfactual Value Networks. Ryan Zarick, Bryan Pellegrino, Noam Brown, Caleb Banister. *NeurIPS Deep RL Workshop*, 2021.

Refereed Demonstrations

- Libratus: Beating Top Humans in No-Limit Poker. Noam Brown and Tuomas Sandholm. *Demonstrations Program at Neural Information Processing Systems (NeurIPS)*, 2017.
- Libratus: The Superhuman AI for No-Limit Poker. Noam Brown and Tuomas Sandholm. *Demonstrations Program at International Joint Conference on Artificial Intelligence (IJCAI)*, 2017.
- Baby Tartanian8: Winning Agent from the 2016 Annual Computer Poker Competition. Noam Brown and Tuomas Sandholm. *Demonstrations Program at International Joint Conference on Artificial Intelligence (IJCAI)*, 2016.
- Claudico: The World's Strongest No-Limit Texas Hold'em Poker AI. Noam Brown and Tuomas Sandholm. *Demonstrations Program at Neural Information Processing Systems (NeurIPS)*, 2015.
- Tartanian7: A Champion Two-Player No-Limit Texas Hold'em Poker-Player Program. Noam Brown, Sam Ganzfried, Tuomas Sandholm. *Demonstrations Program at AAAI Conference on Artificial Intelligence (AAAI)*, 2015.

Awards

2020 AAAI ACM-SIGAI Dissertation Award

2020 IFAAMAS Victor Lesser Dissertation Award

2020 Carnegie Mellon School of Computer Science Distinguished Dissertation Award

2019 *Pluribus* chosen as one of nine runners-up for Science Magazine's Breakthrough of the Year

2019 MIT Tech Review 35 Innovators Under 35

2019 Marvin Minsky Medal for Outstanding Achievements in AI

2019 AAAI Outstanding Paper Honorable Mention (one of four papers receiving special recognition out of 7,095 submissions and 1,150 accepted papers)

2018 Open Philanthropy AI Fellowship (one of seven recipients)

2018 Tencent AI Lab Fellowship (one of five recipients)

2018 *Libratus* won HPCWire's "Best Use of AI" Award (again)

2017 NeurIPS Best Paper Award (one of three out of 3,240 submissions and 678 accepted papers)

2017 Allen Newell Award for Research Excellence

2017 *Libratus* (together with *DeepStack*) selected as one of 12 candidates for Science Magazine's Scientific Breakthrough of the Year

2017 *Libratus* listed in La Recherche as one of the top ten scientific achievements of 2017

2017 *Libratus* won HPCWire's "Best Use of AI" Award

2016 1st place in the Annual Computer Poker Competition No-Limit Texas Hold'em Instant Runoff Event (there was no 2015 competition)

2016 1st place in the Annual Computer Poker Competition No-Limit Texas Hold'em Total Bankroll Event (there was no 2015 competition)

2014 1st place in the Annual Computer Poker Competition No-Limit Texas Hold'em Instant Runoff Event

2014 1st place in the Annual Computer Poker Competition No-Limit Texas Hold'em Total Bankroll Event

2014 NSF Graduate Research Fellowship Honorable Mention

2009 Rutgers Computer Science Department Highest Honors

2005-2009 Rutgers College Scholarship Recipient

Invited Talks

- **Learning to Cooperate and Compete in Diplomacy**
  Flatiron Institute. June 2022.
  Tel Aviv University. March 2022.
  Bar Ilan University. March 2022.
  Hebrew University. March 2022.
  Technion. March 2022.
  Stanford University. December 2021.
  Unversity of California, Berkeley. December 2021.
  Harvard University. September 2021.
  MIT. September 2021.
- **ReBeL: Combining Deep Reinforcement Learning and Search for Imperfect-Information Games**
  University of Oxford. November 2022.
  XTX. November 2022.
  UT Austin. October 2022.
  University of California, Berkeley, Simons Institute Workshop on Adversarial Approaches in Machine Learning. February 2022.
  London Machine Learning Meetup. May 2021.
  Unversity of California, Berkeley. April 2021.
  Unversity of California, San Diego. January 2021.
  University of Michigan. August 2020.
- **Superhuman AI for Multiplayer Poker**

Conference on Economics and Computation, Highlights Beyond EC. July 2020.
Johns Hopkins University Applied Physics Laboratory. June 2020.
University of California, Berkeley. May 2020.

- **Tutorial on AI for Imperfect-Information Games**
  AAAI Reinforcement Learning in Games Workshop. February 2022.
  International Conference on Distributed AI (DAI). October 2019.
- **AI for Imperfect-Information Game Settings**
  Tsinghua University. October 2019.
  MIT Lincoln Labs. September 2019.
  University of Michigan, Ann Arbor. April 2019.
  Cornell Tech. April 2019.
  University of Texas at Austin. April 2019.
  New York University. March 2019.
  Cornell University. March 2019.
  MIT. March 2019.
  Stanford University. February 2019.
  University of Maryland, College Park. February 2019.
  UMass, Amherst. February 2019.
  Duke University. February 2019.
- **Deep Counterfactual Regret Minimization**.
  Deep Reinforcement Learning Workshop at NeurIPS Oral Presentation. December 2018.
- **AI for Large Imperfect-Information Games: Beating Top Humans in No-Limit Poker**.
  Microsoft Research. October 2018.
  Google Brain. July 2018.
  OpenAI. July 2018.
  Facebook AI Research. June 2018.
- **From Poker AI to Negotiation AI: Dealing with Hidden Information**.
  TTI/Vanguard: Intelligence, Natural and Artificial. June 2018.
- ***Libratus*: Beating Top Pros in No-Limit Poker**.
  6th Toulouse Economics and Biology Workshop. May 2018.
  Jane Street Capital. January 2018.
  Facebook AI Research. May 2017.
  Rutgers University. October 2017.
  Princeton University. October 2017.
  Cubist Systems. October 2017.
  Harvard University. September 2017.
  MIT. September 2017.
  Hertz Fellowship Retreat. September 2017.
  DeepMind. May 2017.
  University of Michigan. April 2017.
  Carnegie Mellon University. April 2017.
  OpenAI. February 2017.
  AAAI Workshop on Computer Poker and Imperfect-Information Games. February 2017.
- **Safe and Nested Subgame Solving for Imperfect-Information Games**.
  NIPS Oral Presentation. December 2017.
- **Super-Human AI for Strategic Reasoning: Beating Top Pros in Heads-Up No-Limit Texas**

Hold'em.
TNG Big Tech Day. **Keynote**. June 2017.

- **Reduced Space and Faster Convergence in Imperfect-Information Games via Pruning**.
  ICML Oral Presentation. August 2017.
  Carnegie Mellon University. September 2016.
- **Strategy-Based Warm Starting for Regret Minimization in Games**.
  AAAI Workshop on Computer Poker and Imperfect-Information Games, 2016.
- **Simultaneous Abstraction and Equilibrium Finding in Games**.
  AAAI Workshop on Computer Poker and Imperfect-Information Games, 2016.
  INFORMS Annual Conference, 2015. Optimization cluster.
  IJCAI Oral Presentation, 2015.
- **Regret Transfer and Parameter Optimization**.
  AAAI Workshop on Computer Poker and Imperfect Information, 2014.
  AAAI Oral Presentation, 2014.

Teaching

Fall 2017	**Teaching Assistant**, *Artificial Intelligence*, Carnegie Mellon University.
Fall 2014	**Teaching Assistant**, *Artificial Intelligence*, Carnegie Mellon University.
Spring 2009	**Recitation Instructor**, *Calculus I*, Rutgers University.
Fall 2008	**Recitation Instructor**, *Calculus I*, Rutgers University.
Spring 2008	**Recitation Instructor**, *Pre-Calculus*, Rutgers University.
Fall 2007	**Recitation Instructor**, *Pre-Calculus*, Rutgers University.
Spring 2007	**Peer Mentor**, *Calculus II*, Rutgers University.
Fall 2006	**Peer Mentor**, *Calculus II*, Rutgers University.
Summer 2006	**Teaching Assistant**, *Rutgers Young Scholars Program*, Rutgers University.

Outreach

Summers 2018-2022	**Instructor**, *Rutgers Young Scholars Program*, Rutgers University. Taught a week-long intensive course on game theory to gifted high school students
Summers 2009-2017	**Guest Lecturer**, *Rutgers Young Scholars Program*, Rutgers University. Presented lessons on game theory to gifted high school students
2015-2018	**Presenter**, *Creative Technologies Nights*, Carnegie Mellon University. Introduce middle school girls to various technology-related topics in weekly presentations as part of a program to encourage young women to pursue higher education and careers in STEM fields.
2010-2012	**Organizer and Presenter**, *FedEd*, Federal Reserve Board of Governors. Taught financial literacy and monetary policy through guest lectures to D.C.-area public and private high school students.
2008-2009	**Presenter**, *Douglas Project: Women in STEM*, Rutgers University. Presented lessons on game theory to gifted high school girls as part of a program to encourage young women to pursue higher education and careers in STEM fields.