

Noam Brown

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noambrown.com

EDUCATION

PhD Computer Science <i>Carnegie Mellon University</i> Advisor: Tuomas Sandholm	2014–2020
MS Robotics <i>Carnegie Mellon University</i> Advisor: Tuomas Sandholm	2012–2014
BA Mathematics and Computer Science <i>Rutgers University</i> Summa Cum Laude Rutgers College Honors Program	2005–2008

WORK EXPERIENCE

Research Scientist <i>Facebook AI Research</i>	2018–Present
Research Assistant <i>Carnegie Mellon University</i>	2012–2018
Research Assistant <i>Federal Reserve Board of Governors</i>	2010–2012
Algorithmic Trading Engineer <i>MJM Trading Group</i>	2006–2010

INTERNSHIPS

Research Intern <i>Google DeepMind</i>	Summer 2017
Software Engineer Intern <i>Freshplum</i>	Summer 2012
Technology Analyst Intern <i>Merrill Lynch</i>	Summer 2008

PUBLICATIONS

Journal Papers

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

Preprints

- Jonathan Gray*, Adam Lerer*, Anton Bakhtin, Noam Brown. Human-Level Performance in No-Press Diplomacy via Equilibrium Search. *Preprint. Under Review*, 2020.
- Hengyuan Hu*, Adam Lerer*, Noam Brown, Jakob Foerster. Learned Belief Search: Efficiently Improving Policies in Partially Observable Settings. *Preprint. Under Review*, 2020.
- Eric Steinberger, Adam Lerer, Noam Brown. [DREAM: Deep Regret Minimization with Advantage Baselines and Model-Free Learning](#). *Preprint. Under Review*, 2020.
- Ryan Zarick, Bryan Pellegrino, Noam Brown, Caleb Banister. [Unlocking the Potential of Deep Counterfactual Value Networks](#). *Preprint. Under Review*, 2020.
- Chun Kai Ling, Noam Brown. Safe Search for Stackelberg Equilibria in Extensive-Form Games. *Preprint. Under Review*, 2020.

Highly Refereed Conference Papers

- Noam Brown*, Anton Bakhtin*, Adam Lerer, Qucheng Gong. [Combining Deep Reinforcement Learning and Search in Imperfect-Information Games](#). *Neural Information Processing Systems (NeurIPS)*, 2020.
- Adam Lerer, Hengyuan Hu, Jakob Foerster, Noam Brown. [Improving Policies via Search in Partially Observable Games](#). *AAAI Conference on Artificial Intelligence (AAAI)*, 2020.
- Noam Brown*, Adam Lerer*, Sam Gross, Tuomas Sandholm. [Deep Counterfactual Regret Minimization](#). *International Conference on Machine Learning (ICML)*, 2019.
- Gabriele Farina, Christian Kroer, Noam Brown, Tuomas Sandholm. [Stable-Predictive Optimistic Counterfactual Regret Minimization](#). *International Conference on Machine Learning (ICML)*, 2019.
- Noam Brown and Tuomas Sandholm. [Solving Imperfect-Information Games via Discounted Regret Minimization](#). *AAAI Conference on Artificial Intelligence (AAAI)*, 2019. **Outstanding Paper Honorable Mention**.
- Noam Brown, Tuomas Sandholm, Brandon Amos. [Depth-Limited Solving for Imperfect-Information Games](#). *Neural Information Processing Systems (NeurIPS)*, 2018.
- Noam Brown and Tuomas Sandholm. [Safe and Nested Subgame Solving for Imperfect-Information Games](#). *Neural Information Processing Systems (NIPS)*, 2017. **Best Paper Award**.

- Noam Brown and Tuomas Sandholm. [Reduced Space and Faster Convergence in Imperfect-Information Games via Pruning](#). *International Conference on Machine Learning (ICML)*, 2017.
- Noam Brown, Christian Kroer, Tuomas Sandholm. [Dynamic Thresholding and Pruning for Regret Minimization](#). *AAAI Conference on Artificial Intelligence (AAAI)*, 2017.
- Noam Brown and Tuomas Sandholm. [Strategy-Based Warm Starting for Regret Minimization in Games](#). *AAAI Conference on Artificial Intelligence (AAAI)*, 2016.
- Noam Brown and Tuomas Sandholm. [Regret-Based Pruning in Extensive-Form Games](#). *Neural Information Processing Systems (NIPS)*, 2015.
- Noam Brown and Tuomas Sandholm. [Simultaneous Abstraction and Equilibrium Finding in Games](#). *International Joint Conference on Artificial Intelligence (IJCAI)*, 2015.
- Noam Brown*, Sam Ganzfried*, Tuomas Sandholm. [Hierarchical Abstraction, Distributed Equilibrium Computation, and Post-Processing, with Application to a Champion No-Limit Texas Hold'em Agent](#). *International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2015.
- Noam Brown and Tuomas Sandholm. [Regret Transfer and Parameter Optimization](#). *AAAI Conference on Artificial Intelligence (AAAI)*, 2014.

Refereed Demonstrations

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

INVITED TALKS

- **Combining Deep Reinforcement Learning and Search**
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**
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.

AWARDS

- *Pluribus* chosen as one of nine runners-up for Science Magazine's Breakthrough of the Year for 2019
- 2019 MIT Tech Review 35 Innovators Under 35
- 2019 Marvin Minsky Medal for Outstanding Achievements in AI
- AAAI 2019 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)
- NIPS 2017 Best Paper Award (one of three out of 3,240 submissions and 678 accepted papers)
- 2017 Allen Newell Award for Research Excellence
- *Libratus* (together with University of Alberta's *DeepStack*) selected as one of 12 candidates for Science Magazine's Scientific Breakthrough of the Year for 2017
- *Libratus* listed in *La Recherche* as one of the top ten scientific achievements of 2017
- *Libratus* won HPCWire's "Best Use of AI" Award for 2017 and 2018
- Co-created *Libratus*, the first AI to defeat top humans in no-limit poker
- 1st place in the Annual Computer Poker Competition No-Limit Texas Hold'em Instant Runoff Event, 2016 (there was no 2015 competition)

- 1st place in the Annual Computer Poker Competition No-Limit Texas Hold'em Total Bankroll Event, 2016 (there was no 2015 competition)
- 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
- Rutgers Computer Science Department Highest Honors
- Rutgers College Scholarship Recipient

TEACHING

Carnegie Mellon University

Teaching Assistant	Artificial Intelligence	Fall 2017
Teaching Assistant	Artificial Intelligence	Fall 2014

Rutgers University

Instructor	Young Scholars Program: Game Theory	Summer 2018
Recitation Instructor	Calculus I	Spring 2009
Recitation Instructor	Calculus I	Fall 2008
Recitation Instructor	Pre-Calculus	Spring 2008
Recitation Instructor	Pre-Calculus	Fall 2007
Peer Mentor	Calculus II	Spring 2007
Peer Mentor	Calculus II	Fall 2006
Teaching Assistant	Young Scholars Program	Summer 2006

OUTREACH

Young Scholars Programs

Summers 2009 – Present

Rutgers University

- Presented lessons on game theory to gifted high school students.

Creative Technologies Nights

2015 – 2018

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.

FedEd

2010 – 2012

Federal Reserve Board of Governors

- Taught financial literacy and monetary policy through guest lectures to D.C.-area public and private high school students.

Douglass Project: Women in STEM

2008 – 2009

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.

ACADEMIC SERVICE

(Co-)Chair

- Workshop on AI for Imperfect-Information Games at AAAI 2018

Journal Reviewing

- IEEE Intelligent Systems 2020
- Journal of Artificial Intelligence Research (JAIR) 2017
- Cognitive Science 2015, 2018
- Artificial Intelligence Journal (AIJ) 2014, 2019

Conference Reviewing

- Senior Program Committee
AAAI Conference on Artificial Intelligence (AAAI) 2020
- Program Committee
Neural Information Processing Systems (NeurIPS) 2017, 2018, 2019, 2020
International Conference on Machine Learning (ICML) 2020
AAAI Conference on Artificial Intelligence (AAAI) 2018, 2021
International Conference on Autonomous Agents and Multiagent Systems (AAMAS) 2016
International Joint Conference on Artificial Intelligence (IJCAI) 2015, 2016

Workshop Reviewing

- Workshop on Reinforcement Learning in Games at AAAI 2019, 2020
- Deep Reinforcement Learning Workshop at NeurIPS 2018, 2019, 2020
- Workshop on Computer Poker and Imperfect-Information Games at AAAI 2017

Departmental Service

- Computer Science Department Immigration Course 2014, 2015, 2016, 2017, 2018
- Computer Science Department Open House 2015, 2016, 2017, 2018
- Computer Science Department Speakers Club 2017, 2018

SELECTED MEDIA COVERAGE

- Our 2019 results from “Improving Policies via Search in Cooperative Partially Observable Games” was covered in Engadget, Fortune, Business Insider, Observer, and many others.
- The 2019 Pluribus multiplayer poker AI results were covered in the Wall Street Journal (front page of the print edition), New York Times, Bloomberg News, The Washington Post, MIT Technology Review, IEEE Spectrum, Engadget, Quartz, NPR Radio, The Verge, New Scientist, FiveThirtyEight, Business Insider, CNN Business, The Guardian, Financial Times, BBC News, and many other articles.
- The man-machine poker competition in Haikou, China in April 2017 between our poker AI *Lengpudashi* and six Chinese poker pros received over 50 million views and was covered extensively by the Chinese media, as well as Bloomberg News, MIT Technology Review (2 articles), Engadget, and many others.
- The “Brains vs AI: Upping the Ante” 2017 man-machine poker competition and our poker AI *Libratus* were covered in HBO VICE News (including a TV segment), La Vanguardia (leading Spanish TV), ABC (leading Spanish TV), Discovery Channel Canada (TV), Bloomberg Businessweek, The Washington Post (3 articles), The Wall Street Journal (3 articles), Wired (4 articles), MIT Technology Review (3 articles), Time, IEEE Spectrum (3 articles), Engadget (2 articles), Quartz, PBS Newshour, The Verge (2 articles), New Scientist, Mashable, Quanta Magazine, Science News, FiveThirtyEight, Business Insider (5 articles), Fox News, CNN Money, Slate, The Guardian (2 articles), Financial Times, The Economist, Reuters (New York Times), BBC News, BBC Radio 4, Der Spiegel, Westdeutscher Rundfunk, a YouTube commercial by HPE (31 million views), a Facebook video by CNN’s Great Big Story (1 million views), other YouTube videos (1 million views), and many other articles.
- The “Brains vs AI” 2015 man-machine poker competition and our poker AI *Claudico* were covered by the BBC, PBS, NBC, CBS, Der Spiegel, New York Times, LA Times, IEEE Spectrum (3 articles), Wired, ABC News, Christian Science Monitor, Daily Mail, Fox News, New Scientist (2 articles), Science Times, Motherboard, Poker News, and many others.
- “Carnegie Mellon ‘Baby Tartanian8’ Pokerbot Sweeps Annual Competition.” UCSD News Center, 8/31/2016.
- “Heads-Up Bots Will Be Stronger Than Humans; No-Limit Hold’em May Never Be Solved”. PokerNews.com, 3/16/2016.
- “Championship Poker Bot: ‘A Nuclear Weapon For Poker’”. Card Player Magazine, 9/24/2014.