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Summary

I enjoy every step of the problem-solving process, from design and theoretical analysis of new algorithms to implementation in large-scale systems. For my PhD research I developed scalable approaches for computing game-theoretic solution concepts and learning in imperfect-information games. I have applied several of these techniques to the domain of poker: 2-player no-limit Texas hold 'em agent Tartanian7 that I created won the Computer Poker Competition, and Claudico competed against top human specialists in the Brains vs. Artificial Intelligence competition. I also developed approaches for games with more than two players, robustly exploiting suboptimal opponents, and computing strategies that are human understandable.

Interests: artificial intelligence, game theory, multiagent systems, multiagent learning, large-scale optimization, large-scale data analysis and analytics, knowledge representation.

Education

- Ph.D., Computer Science, Carnegie Mellon University, 2015
  - Thesis: "Computing Strong Game-Theoretic Strategies and Exploiting Suboptimal Opponents in Large Games"
- M.S., Computer Science, Carnegie Mellon University, 2009
- A.B., Mathematics, Harvard University, 2005
  - Concentration GPA: 3.9; President of club tennis team for 3 years; Co-founder of bridge club

Awards

- Best Paper Award, "Computing Equilibria in Multiplayer DAG-Structured Stochastic Games with Persistent Imperfect Information" at *Conference on Decision and Game Theory for Security (GameSec)*.
- Paper "Reflections on the First Man vs. Machine No-Limit Texas Hold 'em Competition" selected to be feature article in SIGecom Exchange Newsletter for ACM Interest Group on Electronic Commerce.
- First place, Annual Computer Poker competition, two-player no-limit Texas hold 'em bankroll instant run-off and total bankroll divisions, at the *AAAI Conference on Artificial Intelligence (AAAI)*, 2014 (with Noam Brown and Tuomas Sandholm). Our agent beat each opponent with statistical significance.
- Paper "Safe Opponent Exploitation" from *ACM Conference on Electronic Commerce* invited to "Best of EC" special issue of journal *ACM Transactions on Economics and Computation* (with Tuomas Sandholm).
- Finalist, Best Student Paper Award, "Computing an Approximate Jam/Fold Equilibrium for 3-Player No-Limit Texas Hold'em Tournaments" at *International Conference on Autonomous Agents and Multiagent Systems* (with Tuomas Sandholm).
- United States Presidential Scholar.
- National Merit Scholar.

Employment

- Independent consultant and principal investigator on contract for DARPA grant, 2018–present
  - "Serial Interactions in Imperfect Information Games Applied to Complex Military Decision Making."
- Assistant Professor, Florida International University, Computer Science, 2016–2018, Miami, FL
  - Director, Strategic Adversarial Multiagent Artificial Intelligence Laboratory, www.sam-ai.com.
- Founder, Ganzfried Research, 2015–present
  - Conducting research and building technology in artificial intelligence and game theory with applications including poker, education, medicine, socialization, and hurricane prediction.
- Quantitative Trader, Tower Research Capital LLC, 2005–2006, New York, NY
  - Designed, implemented, and deployed high-frequency trading algorithms.
- Director's Summer Program, National Security Agency, Summer 2005
- Research Experiences for Undergraduates, Mathematics, Oregon State University, Summer 2004

Media

- "Meet the FIU professor who created program that can beat the poker pros," Miami Herald, front page of "Tropical Life" section, March 14, 2017.
- "Turing and the Poker Endgame," PokerNews online article, August 30, 2016.
- "Poker-playing AI 'bot' carries long-range impact," Pittsburgh Tribune-Review, August 26, 2016.
- Played in high-stakes poker game for the television series "Poker Night in America," November 2015.
  - Season 4 episodes 17 and 18, aired in October 2016 on CBS Sports Network.
  - Commentated for and played on the show again 11/19–20/16 and commentated on 3/11/17.

Publications

- Sam Ganzfried. Human Strategic Decision Making in Parametrized Games. 2021. arXiv:2104.14744 [cs.GT].
- Sam Ganzfried. Computing Equilibria in Multiplayer DAG-Structured Stochastic Games with Persistent Imperfect Information. *Conference on Decision and Game Theory for Security (GameSec)*, 2021.
- Sam Ganzfried. Algorithm for Computing Approximate Nash equilibrium in Continuous Games with Application to Continuous Blotto. *Games* special issue "Economics of Conflict and Terrorism," 2021, 12(2), 47.
- Sam Ganzfried. Fast Complete Algorithm for Multiplayer Nash Equilibrium. 2020. arXiv:2002.04734 [cs.GT].
- Sam Ganzfried. Fictitious Play Outperforms Counterfactual Regret Minimization. 2020. arXiv:2001.11165 [cs.GT].
- Sam Ganzfried, Conner Laughlin, and Charles Morefield. Parallel Algorithm for Approximating Nash Equilibrium in Multiplayer Stochastic Games with Application to Naval Strategic Planning. *International Conference on Distributed Artificial Intelligence (DAI)*, 2020.
- Max Chiswick and Sam Ganzfried. Prediction of Bayesian Intervals for Tropical Storms. *Florida Artificial Intelligence Research Society Conference (FLAIRS)*, 2020.
  - Early version at *ICLR Workshop Tackling Climate Change with Machine Learning*, 2020.
- Sam Ganzfried and Max Chiswick. Most Important Fundamental Rule of Poker Strategy. *Florida Artificial Intelligence Research Society Conference (FLAIRS)*, 2020.
- Sam Ganzfried. Mistakes in Games. *International Conference on Distributed Artificial Intelligence (DAI)*, 2019.
- Sam Ganzfried, Austin Nowak, Joannier Pinales. Successful Nash Equilibrium Agent for a 3-Player Imperfect-Information Game. Invited feature paper at *Games*, 2018, 9(2), 33.
- Sheila Alemany, Jonathan Beltran, Adrian Perez, and Sam Ganzfried. Predicting Hurricane Trajectories using a Recurrent Neural Network. *AAAI Conference on Artificial Intelligence (AAAI)*, 2019.
- Sam Ganzfried and Farzana Yusuf. Optimal Weighting for Exam Composition. *Education Sciences* special issue "Artificial Intelligence and Education," 2018, 8(1), 36.
- Kailiang Hu and Sam Ganzfried. Midgame Solving: A New Weapon for Efficient Large-Scale Equilibrium Approximation. 2017. *International Conference on Tools with Artificial Intelligence*. Short paper.
- Sam Ganzfried. What is the Right Solution Concept for No-Limit Poker? *International Conference on Game Theory*, 2017.
- Sam Ganzfried. Endgame Solving: The Surprising Breakthrough that Enabled Superhuman Two-Player No-Limit Texas Hold 'em Play. *International Conference on Game Theory*, 2017.
- Sam Ganzfried and Farzana Yusuf. Computing Human-Understandable Strategies: Deducing Fundamental Rules of Poker Strategy. Invited feature paper at *Games*, 2017, 8(4), 49.
- Sam Ganzfried and Farzana Yusuf. Optimal Number of Choices in Rating Contexts. *Big Data and Cognitive Computing* special issue "Computational Models of Cognition and Learning," 2019, 3(3), 48.
  - Early version at *NIPS 2016 Workshop on Imperfect Decision Makers: Admitting Real-World Rationality*.
- Sam Ganzfried and Qingyun Sun. Bayesian Opponent Exploitation in Imperfect-Information Games. *Conference on Computational Intelligence and Games (CIG)*, 2018.
- Sam Ganzfried. Reflections on the First Man vs. Machine No-Limit Texas Hold 'em Competition. AI Magazine, Volume 48, Number 2, summer 2017.
  - Feature article in SIGecom Exchange Newsletter, Volume 14.2, 2015.
- Sam Ganzfried. Computing Strong Game-Theoretic Strategies and Exploiting Suboptimal Opponents in Large Games. PhD dissertation, 2015, available as CMU technical report CMU-CS-15-104.
- Sam Ganzfried and Tuomas Sandholm. Endgame Solving in Large Imperfect-Information Games. *International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2015.
  - Early version appeared as "Improving Performance in Imperfect-Information Games with Large State and Action Spaces by Solving Endgames" at the *Workshop on Computer Poker and Imperfect Information* at *AAAI*, 2013.
- Noam Brown*, Sam Ganzfried*, and 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.
- Sam Ganzfried and Tuomas Sandholm. Safe Opponent Exploitation. *ACM Transactions on Economics and Computation (TEAC)*, 2015. Special issue on selected papers from EC-12.
  - Early version appeared in *ACM Conference on Electronic Commerce (EC)*, 2012.
- Sam Ganzfried and Tuomas Sandholm. Potential-Aware Imperfect-Recall Abstraction with Earth Mover's Distance in Imperfect-Information Games. *AAAI Conference on Artificial Intelligence (AAAI)*, 2014. Oral and poster.
- Sam Ganzfried. Computing Strong Game-Theoretic Strategies and Exploiting Suboptimal Opponents in Large Games. Thesis proposal, 2013.
- Sam Ganzfried and Tuomas Sandholm. Action Translation in Extensive-Form Games with Large Action Spaces: Axioms, Paradoxes, and the Pseudo-Harmonic Mapping. *International Joint Conference on Artificial Intelligence (IJCAI)*, 2013.
- Sam Ganzfried and Tuomas Sandholm. Tartanian5: A Heads-Up No-Limit Texas Hold'em Poker-Playing Pro-

gram. *Computer Poker Symposium* at the *AAAI Conference on Artificial Intelligence (AAAI)*, 2012.
- Sam Ganzfried, Tuomas Sandholm, and Kevin Waugh. Strategy Purification and Thresholding: Effective Non-Equilibrium Approaches for Playing Large Games. *International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2012.
- Sam Ganzfried. Computing Strong Game-Theoretic Strategies in Jotto. *Conference on Advances in Computer Games (ACG)*, 2011.
- Sam Ganzfried and Tuomas Sandholm. Game Theory-Based Opponent Modeling in Large Imperfect-Information Games. *International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2011.
- Sam Ganzfried and Tuomas Sandholm. Computing Equilibria by Incorporating Qualitative Models. *International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2010.
- Sam Ganzfried and Tuomas Sandholm. Computing Equilibria in Multiplayer Stochastic Games of Imperfect Information. *International Joint Conference on Artificial Intelligence (IJCAI)*, 2009.
- Sam Ganzfried and Tuomas Sandholm. Computing an Approximate Jam/Fold Equilibrium for 3-Player No-Limit Texas Hold'em Tournaments. *International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2008.
- Sam Ganzfried. A New Algorithm for Knight's Tours. Proceedings of the *Research Experiences for Undergraduates (REU) Program in Mathematics*, 2004.

Other presentations
- "Successful Nash Equilibrium Agent for a 3-Player Imperfect-Information Game"
    - Princeton University, 5/1/18, organized by Princeton Poker Club.
    - MIT, 5/3/18, organized by MIT Poker Club.
- "Optimal Number of Choices in Rating Contexts" 4/20/2018, FIU Department of Mathematics and Statistics Annual Mini-Conference in Statistical Methods and Mentoring.
- "Artificial Intelligence: From Poker Agents to Hurricane Prediction" 9/30/2017, FIU ShellHacks hackathon.
- "Strong Game-Theoretic Strategies: Beyond Two Agents" 9/15/2017, MIT, organized by MIT Poker Club.
- Three-part guest lecture on computer poker at Tsinghua University game theory class, 5/8/17.
- "Endgame Solving: The Surprising Breakthrough that Enabled Superhuman Two-Player No-Limit Texas Hold 'em Play"
    - Princeton University, 3/13/17, organized by Princeton Poker Club.
    - Tsinghua University, 5/7/17.
    - Microsoft Research Asia Lab, 5/11/17.
- "First Man vs. Machine No-Limit Texas Hold 'em Competition" 2/1/17, Stanford University.
- "Computing Strong Game-Theoretic Strategies in Large Games" 3/24/16, Princeton University Poker Club.
- "Reflections on the First Man vs. Machine No-Limit Texas Hold 'em Competition" 3/18/16, Susquehanna International Group.

Professional service
- Guest editor: *Mathematics* journal special issue on "Game Theory and Artificial Intelligence" (2022).
- Organizer: Tutorial on Computer Poker at Conference on Economics and Computation (2016) and AAAI (2017).
- Organizer: AAAI Workshop on Computer Poker and Imperfect Information (2014, 2015).
- Program committees: AAAI (2012, 2014–2018), AAMAS (2014, 2016, 2021), IJCAI (2013, 2015, 2016), WWW (2018, 2019), NeurIPS (2021), AAAI Workshop on Computer Poker and Imperfect-Information Games (2017), AAAI Demonstrations Program (2019).
- Additional conference reviewing: AAAI (2010), AAMAS (2013), EC (2013), NIPS (2016).
- Journal reviewing: Artificial Intelligence ('10–'14,'18), Computational Intelligence ('10), Games ('14, '18, '19), Transactions on Computational Intelligence and AI in Games ('14,'15,'17), Sensors ('17,'18,'21), Algorithms ('18), Applied Sciences ('19, '20, '21), Computers ('19), Mathematics ('19,'20,'21), International Journal of Environmental Research and Public Health ('19), Symmetry ('19,'20), Education Sciences ('19), IEEE Intelligent Systems ('20), Healthcare ('20), Challenges ('20), Machine Learning ('21), Journal of Artificial Intelligence Research ('21).

Teaching
- Instructor, Game Theory, new graduate course at FIU (2017), `www.bestgametheoryclass.com`.
- Instructor, Artificial Intelligence, new undergraduate course at FIU (2017), `www.ultimateaiclass.com`.

Mentoring
- Farzana Yusuf, PhD student at FIU. Areas: artificial intelligence, machine learning.
- Sheila Alemany, Undergraduate CS student at FIU. Areas: artificial intelligence, machine learning.
    - Finalist for CRA Outstanding Undergraduate Research Award.
- Max Chiswick, MSc in electrical engineering from Technion. Areas: artificial intelligence, machine learning.
- Worked with Princeton undergraduate student Bradley Snider on his thesis in mathematics (2017).
- Worked with Stanford mathematics PhD student Qingyun Sun on opponent exploitation algorithms.
- Worked with Harbin Institute of Technology MS student Kailiang Hu on game-theoretic algorithms.