Sam Ganzfried
Assistant Professor, SCIS

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

Scope and applicability of game theory

- Strategic multiagent interactions occur in all fields
  - Economics and business: bidding in auctions, offers in negotiations
  - Political science/law: fair division of resources, e.g., divorce settlements
  - Biology/medicine: robust diabetes management (robustness against “adversarial” selection of parameters in MDP)
  - Computer science: theory, AI, PL, systems; national security (e.g., deploying officers to protect ports), cybersecurity (e.g., determining optimal thresholds against phishing attacks), internet phenomena (e.g., ad auctions)

Game theory background

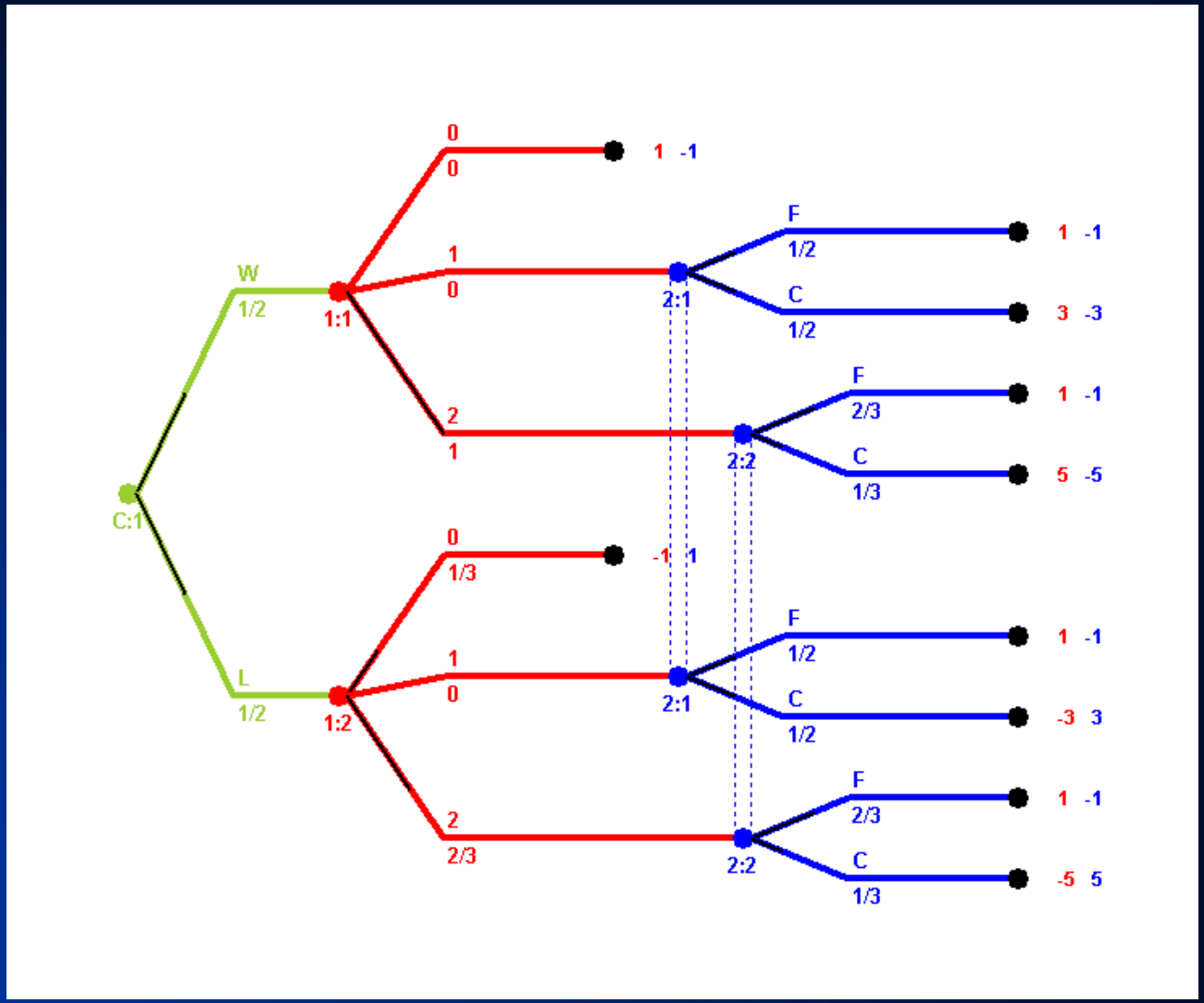
	rock	paper	scissors
Rock	0,0	-1, 1	1, -1
Paper	1,-1	0, 0	-1,1
Scissors	-1,1	1,-1	0,0

- Players
- Actions (aka pure strategies)
- Strategy profile: e.g., (R,p)
- Utility function: e.g., $u_1(R,p) = -1$, $u_2(R,p) = 1$

Imperfect information

- In many important games, there is information that is private to only some agents and not available to other agents
  - In auctions, each bidder may know his own valuation and only know the distribution from which other agents' valuations are drawn
  - In poker, players may not know private cards held by other players

Extensive-form representation

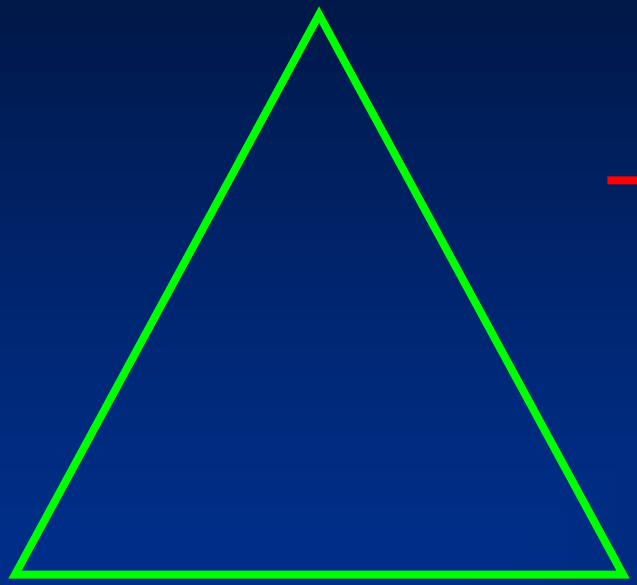


Extensive-form games

- Two-player zero-sum EFGs can be solved in polynomial time by linear programming
  - Scales to games with up to 10^8 states
- Iterative algorithms (CFR and EGT) have been developed for computing an ε-equilibrium that scale to games with 10^{17} states
  - CFR also applies to multiplayer and general sum games, though no significant guarantees in those classes
  - (MC)CFR is self-play algorithm that samples actions down tree and updates regrets and average strategies stored at every information set

Standard paradigm for solving large imperfect-information games

Original game



Automated abstraction

Abstracted game

Custom equilibrium-finding algorithm

Nash equilibrium

Reverse mapping

Nash equilibrium

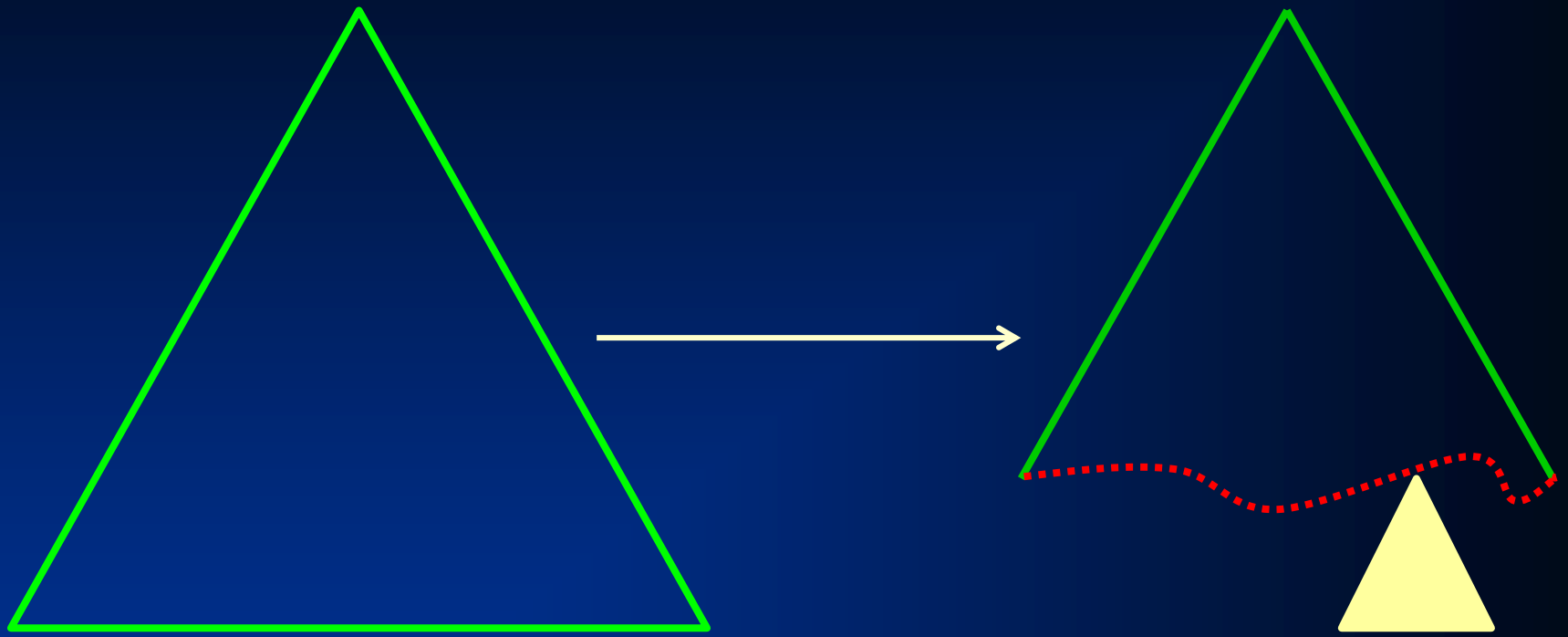
Texas hold ‘em poker

- Huge game of imperfect information
  - Most studied imp-info game in AI community since 2006 due to AAAI computer poker competition
  - Multi-billion dollar industry (not “frivolous”)
- Limit Texas hold ‘em – fixed betting size
  - ~10^{17} nodes in game tree
- No Limit Texas hold ‘em – unlimited bet size
  - ~10^{165} nodes in game tree
  - Most active domain in last several years
  - Most popular variant for humans

Brains vs. Artificial Intelligence

- April 24-May 8, 2015 at Rivers Casino in Pittsburgh, PA
- 20,000 hands of two-player no-limit Texas hold ‘em between “Claudico” and four of the strongest human players in the world
  - Dong Kim, Jason Les, Bjorn Li, Doug Polk
  - 80,000 hands in total
- Humans won by 732,713 chips, which corresponds to 9.16 big blinds per 100 hands
  - Statistically significant at 90% confidence level, but not 95% level

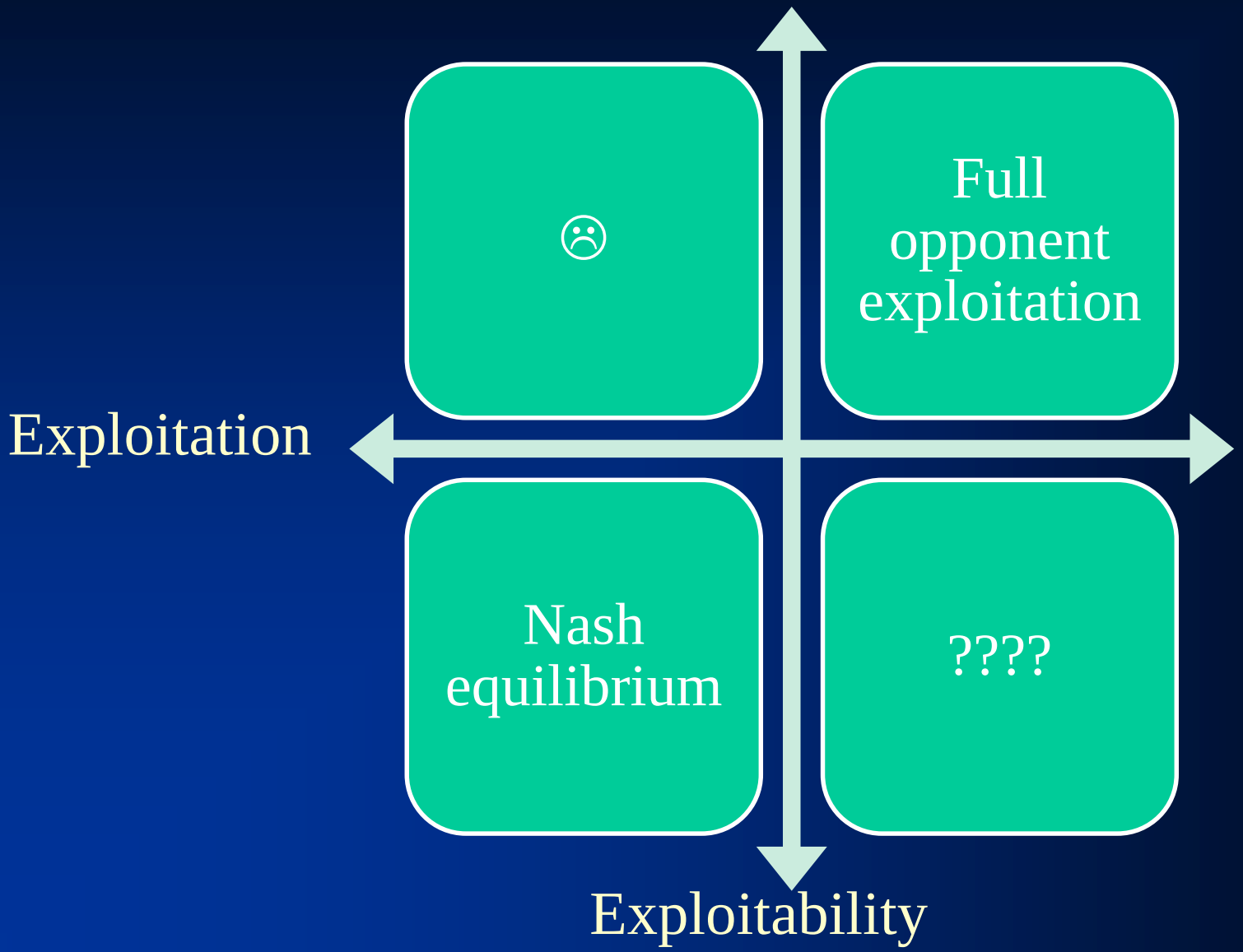
Endgame solving



Strategies for entire game computed offline

Endgame strategies computed in real time to greater degree of accuracy

Exploitation-exploitability tradeoff



Big picture questions

- Solution concepts, theory, and algorithms for games with more than two agents
- Improved algorithms and theoretical analysis of endgame solving and abstraction
- Interplay between opponent exploitation/learning and game-theoretic solution concepts
- Fundamental theory and applications to other domains
  - medicine, national security
- Fundamental problems in AI and big data analytics
  - New manuscript “Optimal Number of Choices in Rating Contexts,” applications to grading, paper reviewing, dating

- www.ganzfriedresearch.com
- Strategic Adversarial Multiagent Artificial Intelligence Lab (http://www.sam-ai.com/)
- http://forumserver.twoplustwo.com/29/news-views-gossip-sponsored-online-poker-report/wcgrider-dong-kim-jason-les-bjorn-li-play-against-new-hu-bot-1526750/
- https://www.youtube.com/watch?v=phRAyF1rq0I