Playful AI Education

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Introduction

• Teachers teach best when sharing from the core of their enjoyment of the material.
  – E.g. Those with enthusiasm for graphics should use graphical examples.
• Game playing is one of my favorite hobbies, so I often utilize games in my teaching.
• “Play is our brain's favorite way of learning.” - Diane Ackerman
Outline

• What makes a good game for teaching?
• What are non-game-tree search examples of game use in AI teaching?
• What are some future opportunities and challenges for playful AI education?
Good Games Have Simple Rules

• Breakthrough is better than Chess for teaching game-tree search.

• Chess:
  – Many different piece movement rules
  – En passant
  – Castling
  – 50 move rule

• Breakthrough
  – One piece movement rule

• Unless the goal is to teach complex modeling, prefer games with simpler rules (e.g. prefer Hex to Go as a connection game).
… Simple Rules and Fun Depth

- Tic-Tac-Toe has simple rules, but isn’t particularly fun once you see to its shallow depth.
- *Depth* is a term in game design that correlates with the expected range of ELO scores.
- The best games reward players that explore the subtle terrains of these microworlds. Learning → winning
Beyond Game-Tree Search

- Constraint Satisfaction Problems
- Logical Reasoning
- Planning
- Uncertain Reasoning
- Machine Learning
- Robotics
- Etc.
Playful Robotics

- **FIRST Robotics Competition (FRC)** (1992-present)
- **RoboCup** robot soccer (Pre-RoboCup-96 & RoboCup-97 - present)
- Many physical sport games become interesting testbeds for robotics.
Clue/Cluedo Case Example
The Game of Clue

• 21 cards: 6 suspects, 6 weapons, 9 rooms
• Case file has unknown, random suspect, weapon, and room (SWR)
• Remaining cards dealt to players
• Player *suggests* SWR, first player clockwise that can refute, must show card
• Each player can make 1 SWR *accusation*
• Correct $\rightarrow$ win; incorrect $\rightarrow$ lose (& refute)
More Than Child’s Play

• Children mark off each dealt/shown card
• Small notepad + instruction = trivial play
• However, consider this:
  – You know player A has 3 cards, two of which are t and u.
  – Player A refuted player B’s and C’s suggestions of (v,w,x) and (y,z,x), respectively, by showing a card.
  – Therefore, ... A’s 3rd card must be x.
Constraint Satisfaction

• Clue reasoning is constraint satisfaction.
• One formulation: Boolean variables $c_p$ denoting “Card $c$ is in place $p$.”
• Given CNF representation of Boolean constraints, reason with SAT solver refutations
• See Model AI Assignment for details (http://modelai.gettysburg.edu/2011/clue)
Basic Logic Concepts

• Concepts: sentences, operators, literals, truth assignments, (un)satisfiability, models, validity, tautologies, entailment, logical equivalence, derivation, soundness, completeness, ...

• That’s covering a lot without first-order logic.

• Simple, minimalist, high-utility approach
  – Con: No predicates, unification, FOL generalizations.
  – Pro: Time-efficient, experiential learning.
ClueReasoner cr = new ClueReasoner();
String[] myCards = {"wh", "li", "st"};
cr.hand("sc", myCards);
cr.suggest("sc", "sc", "ro", "lo", "mu", "sc");
cr.suggest("mu", "pe", "pi", "di", "pe", null);
cr.suggest("wh", "mu", "re", "ba", "pe", null);
cr.suggest("gr", "wh", "kn", "ba", "pl", null);
cr.suggest("pe", "gr", "ca", "di", "wh", null);
cr.suggest("pl", "wh", "wr", "st", "sc", "wh");
cr.suggest("sc", "pl", "ro", "co", "mu", "pl");
cr.suggest("mu", "pe", "ro", "ba", "wh", null);
cr.suggest("wh", "mu", "ca", "st", "gr", null);
cr.printNotepad();

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At-Least Constraints

- One constraint omitted from CNF SAT representation: Player $p$ has exactly $n$ cards.
- A CNF SAT clause is true iff at least one literal is true. Generalizing...
- An at-least constraint clause is true iff at least $n$ literals are true.
- Example, for each player in a 6 player game, each player holds exactly 3 cards, so...
  - at least 3 cards are in a player’s hand, and
  - at least 18 cards are not in a player’s hand.
Gettysburg College Faculty/Student Projects with At-Least Constraints

• Mixed logical and probabilistic estimation:
  – Generalizations of WalkSAT, DPLL, and Knuth’s Dancing Links algorithms
  – Empirical study of SLS sampling bias in estimation of card location probabilities

• Explanation generation (auto-generation of natural language proof of case-file contents)

• Study of human vs. computer reasoning patterns
The Dice Game of Pig

You never sausage a simple and fun game!
Pig: Simple Yet Fun and Highly Useful

• Rules:
  – The first player reaching 100 points wins.
  – On each turn, a player rolls a die as many times as desired until either the player holds and scores the sum of the rolls, or rolls a 1 and scores nothing.

• High Fun-to-SLOC (source lines of code) ratio

• Many uses for teaching probabilities in Mathematics, control structures and incremental build model in CS1, simple GUI development, and in AI...
Pig in AI Education

• Reinforcement Learning:
  – Value iteration for computation of optimal play
  – Reinforcement learning algorithm results compared to value iteration solution (e.g. On-/Off-Policy Monte Carlo, TD-learning, etc.)

• Supervised Learning:
  – Regression fit to collected human roll/hold data

• Unsupervised Learning:
  – Examination of clusters of suboptimal human plays
Games Throughout AI

• Bayesian reasoning? Estimating an opponent’s hand in Gin Rummy
• Computer vision? Autonomous driver races, robot soccer, Zachary Dodds’ Set gameplay with OpenCV
• Natural Language Processing? Computer play of interactive fiction
• There is nothing in AI we cannot make playful.
Bringing People Together

• Activities that bring people together in cultures universally:
  – Working together
  – Eating together
  – Playing games together

• So what is a game in its most general sense?
Game Definition

• From diverse definitions, I clustered related terms/concepts:
  – system/activity/form of art/play
  – players/decision-makers/forces/voluntary participants
  – goal/outcome/objective/state of affairs
  – rules/structure/limiting context/resource management
  – voluntary/accept limitations

• My consensus game definition: “a voluntary activity where players pursue goals according to an agreed-upon set of rules.”
Generalizing

• In truth, most any activity we enjoy can be gamified, e.g.
  – Protein folding (fold.it)
  – Fitbit step average rankings among friends
• In a general sense, we can bring a playfulness to most any activity.
  – Play can be cooperative rather than competitive as well.
Sharing Inspiration

• Games are not the only means of bringing joy to AI education.

• You (and your colleagues) undoubtedly bring unique enthusiasms, hobbies, experiences, skills, etc. to your own teaching of AI.

• How have you (or a colleague) brought what you enjoy most into your teaching of AI?
Future Opportunities and Challenges

• Beyond “Computers can play X better than humans” there are other opportunities:
  – Computer-aided game design
  – Computer game trainer (human play modeling, coaching/teaching)
  – Computer opponent rank-matching

• And there are challenges:
  – Computer-aided cheating
  – Game AI assignment plagiarism
Conclusion

• I greatly enjoy games and delight in finding ways games can be used to playfully teach AI and CS in general.
• However, teachers teach best when they enjoy what they share.
• Teach to your strengths and enthusiasms!
• Thank you for this award and the joy of sharing playful AI education through the years.
Questions?