Theory of Computer Games

電腦對局理論

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Goal

- **Course name:** Theory of Computer Games
  
  電腦對局理論

- **Prerequisite:** A.I.

- **Goal:** This course introduces techniques for computers to play various games which include Chinese chess and Go.

- **Disclaimers:**
  - NOT yet a course on game theory.
  - NOT yet a course on video games.
  - NOT yet a course on war game simulations.

- **Web page:**
  http://www.iis.sinica.edu.tw/~tshsu/tcg2010
About this class

- **Time and Place:** Every Thursday from 2:20pm to 5:20pm at Room 105 (CSIE building).
  
  Sep 16 23 30
  Oct 7 14 21 28
  Nov 4 11 18 25
  Dec 2 9 16 23 31
  Jan 6 13 20

- **Dates:**

- **Format:**
  - Lecturing: for the first 12 – 14 lectures.
  - Presentations for homework projects.
  - Occasional invited lectures.

  - Go
  - Connect6
  - ...

  - Student presentation: the last few lectures.

- **Class materials**
  - Class notes.
  - Collection of papers.
Evaluation

- **One programming homework project (15%)**
  - About single agent search.
  - Pick your own game, implement, and then present the result.

- **Written exam (25%)**

- **Presentation of a research paper (20%)**
  - Discussion before presentation.
  - 30-minute talk.
  - ≤ 30 slides in PDF format.
  - 10–15 minutes of Q & A.
  - Each student asks ≥ 1 non-trivial question.
  - Submit your revised set of slides one week later.

- **Final project (30%)**
  - A computer game program for Chinese Dark Chess.
  - The 4th NTU-TCG Cup.
  - Submitted package: Code + documents. semester.

- **Class participation (10%)**
Lecturing format

- For each topic
  - The first and most influential papers are introduced.
  - A list of recent and latest papers is provided for further readings and/or topics for presentations.
Topics

- Introduction and an AI oriented overview
- Single-player games
- Two-player perfect information games
- Other games
- Practical considerations
  - Memorizing knowledge
    - Transposition tables
    - Endgame databases
  - The graph-history interaction (GHI) problem
  - Hardware enhancements
  - Timing control
  - Opponent model
Introduction and an AI oriented overview

- Relations between computer games and Artificial Intelligence.
  - Why we study computer games?
  - Why we play or study games?

- History [SvdH02] [Sha50]
  - The Turk, a chess playing “machine” at 1780’s
  - The endgame playing machine at 1910’s
  - C. E. Shannon (1950) and A. Samuel (1960)

- Games that machines have beaten human champions [SvdH02] [Sch00]
  - Chess
  - Othello
  - Checker
  - ...
Single-player games

- Games that can be played by one person
  - combinatorial games such as 15-puzzle or Sukudo
  - other solitaire

- Classical approaches [Kor85] [KF02] [CS98]
  - Brute-force, BFS, DFS
  - Bi-directional search
  - A*
  - IDA*
  - IDA* with databases
Two-player perfect information games I

- A survey of current status [vdHUvR02]

Classical approaches
  - Alpha-beta search and its analysis [KM75]
  - Scout and Negascout [Rei83] [Fis83] [Pea80]

Enhancements to the classical approaches
  - Quiescence search [Bea90]
  - Move ordering and other techniques [Sch89] [AN77] [Hsu91]
  - Further pruning [SP96]
  - Proof-number search [AvdMvdH94]

Parallel alpha-beta based game tree search [Bro96] [FMM94] [HM02] [HSN89] [Hya97] [Man01]
Two-player perfect information games II

- Monte-Carlo game tree search
  - Basic ideas [Bru93]
  - Prunning techniques [BH04] [YYK+06]
  - Parallel Monte-Carlo game tree search [CJ08] [CWvdH08]

- Case study: Computer Chinese chess
Other games

- **Games with imperfect information and stochastic behaviors** [FBM98]
  - Backgammon
  - Bridge
- **Multi-player games** [Stu06]
  - Poker
  - Majon
Practical considerations I

- Transposition tables
  - Recording prior-search results to avoid researching
  - Design of a good hash function
    ▶ Zobrist’s hash function [Zob70]

- Open-game [Hya99] [Bur99] and endgame databases [Tho86] [Tho96] [WLH06]
  - Off-line collecting of knowledge
  - Computation done in advance

- The graph-history interaction (GHI) problem [Cam85] [BvdHU98]
  - The value of a position depends on the path leading to it.
Practical considerations II

- Hardware enhancements [DL04]
- Timing and resource usage control [Hyg84] [HGN85] [MS93]
  - Using time wisely
    - Use too little time in the opening may be fatal
    - Use too much time in opening may be fatal, too

- Opponent model [CM96]
  - How to take advantage of knowing the playing style of your opponent.
Resources I

- ICGA web site
  - http://ticc.uvt.nl/icga/
  - International Computer Games Association
  - Formally as ICCA (International Computer Chess Association)
  - Host of Computer Olympiad

- Proceedings of AAAI
  - Since 1980

- Proceedings of IJCAI
  - International Joint Conference on Artificial Intelligence
  - Since 1969, every odd numbered of year

- Proceedings of the CG conference
  - Computers and Games International Conference
  - Since 1998, every even numbered of year

- Proceedings of the ACG conference
  - Advances in Computer Games International Conference
  - Every odd numbered of year
  - 2005 at Taipei (11th)
Resources II

- **ICGA journal**
  - Quarterly publication since 1977

- **The A.I. magazine**
  - Journal for AAAI
  - Since 1980

- **Artificial Intelligence**
  - Flagship journal
  - Since 1970

- **IEEE transactions on Computational Intelligence and AI in Games**
  - A new IEEE journal
  - Quarterly publication since 2009
References


[BH04] B. Bouzy and B. Helmstetter. Monte-Carlo Go developments. In H. Jaap van den Herik, Hiroyuki Iida, and Ernst A. Heinz, editors, Advances in Computer Games, Many Games, Many Challenges, 10th


[EM09] Markus Enzenberger and Martin Müller. A lock-free multi-


