

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	
■ Dates:	Nov	4	11	18	25	
	Dec	2	9	16	23	31
	Jan	6	13	20		

- **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]
- The original Computer Chess paper by C.E. Shannon [Sha50] in 1950.
- 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]*
 - ▷ *Pruning 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 [Hya84] [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 AAI**
 - 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

Collection of papers

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