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/tcg2009**

About this class

- **Time and Place: Every Thursday from 2:20pm to 5:20pm**

- **Dates:**

Sep			**17**	**24**	
Oct	**1**	**8**	**15**	**22**	**29**
Nov	**5**	**12**	**19**	**26**	
Dec	**3**	**10**	**17**	**24**	
Jan	**7**	**14**	**21**		

- **Format:**
  - **Lecturing: for the first 11 − 13 lectures.**
  - **Presentations for homework projects.**
  - **Occasional invited lectures.**
    - ▷ *Chinese chess*
    - ▷ *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.
  - $\leq$ 30 slides in PDF format.
  - 10–15 minutes of Q & A.
  - Each student asks $\geq$ 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 third 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 a brief 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**
  - **Parallelization**
  - **Other hardware enhancements**
  - **Timing control**
  - **Opponent model**

Introduction and a brief overview

- **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

- **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]*
  - ▷ *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]*

- **Other approaches**
  - ▷ *Monte Carlo simulations [Bru93] [BH04] [YYK$^+$06] [CWvdH08] [SWvdH$^+$08]*

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]**
  - **Offline 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

- **Parallelization [HSN89]**
- **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://www.cs.unimaas.nl/icga/**
  - **International Computer Games Association**
  - **Formally as ICCA (International Computer Chess Association)**
- **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 Conference**
  - **Since 1998, every even numbered of year**
- **Proceedings of the ACG conference**
  - **Advances in Computer Games 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

Collection of papers

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