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 a course on game theory.
  - NOT a course on video games.
  - NOT a course on war game simulations.
- Web page: http://www.iis.sinica.edu.tw/~tshsu/tcg2008

About this class

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

Sep			18	25		
Oct	2	9	16	23	30	
Nov	6	13	20	27		
Dec	4	11	18	25		
Jan	1	8	15			

- **Format:**
  - Lecturing: for the first 11 or 12 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 ≥ 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 second NTU-TCG Cup.
  - Submitted package: Code + documents.
  - Submit check points during the last half of the 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

- **Origin [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]***

Other games

- **Games with imperfect information and stochastic behaviors [FBM98]**
  - **Backgammon**
  - **Bridge**
- **Multi-player games**
  - **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] [WLH04]**
  - 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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