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:** Computer Programming, and Data Structure and Algorithms.
- **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/tcg/2013
About this course

- **Time and Place:** Every Thursday from 2:20pm to 5:20pm at Room 110 (NTU CSIE building).
  - Sep 12 19 26
  - Oct 3 10 17 24 31
  - Nov 7 14 21 28
  - Dec 5 12 19 26
  - Jan 2 16

- **Dates:**
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- **Format:**
  - Lectures.
  - Presentations for homework projects.
  - Invited lectures.
    - Chinese chess
    - Go
    - ... 
  - Student presentation: the last few lectures if time allows.

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

- Thanks to the students of this course for providing constructive feedbacks on the slides.

- Special thanks the following persons.
  - Yuh-Jie Chen (class of 2008)
  - Jennya Chang (class of 2011)
  - Jessica Lin (class of 2011)
  - 许祐程 (TA of the class of 2012)
Evaluation (1/3)

- **Homework (30%)**
  - One homework project about single-agent search (15%)
    - *About single agent search.*
    - *Pick your own game, implement, and then present the result.*
  - One homework project about Monte-Carlo simulation (15%)
    - *About 2 player games.*
    - *Your program against TA’s program.*

- **Written exam: midterm exam (30%)**
Final project (40%)

- A computer game program for Chinese Dark Chess.
  - A sample code with GUI will be provided.
  - The usage of this sample code is restricted for anything related to this course only.
- The 7th NTU-TCG Cup.
- Submitted package: Code + documents.

Class participation (bonus)
Evaluation (3/3)

- Presentation/Report of a research paper on game tree search.
  - If we have more than 16 students, then
    - Bonus for selected students who are obviously falling behind.
  - If we have less than 17 students, then
    - This is required for each student.
    - This will be 10% of your score in which case the two programming homework each take 10%.
  - If time allows, give an in-class presentation.
    - 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.
  - If time does not allow, a written report.
    - Pick a paper related to the course.
    - Write a report with at least 1000 words in PDF format.
    - Summary of results in the paper.
    - Comments about this paper, its strength, weakness and potential improvements.
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: an A.I. oriented overview
- Single-player games
- Two-player perfect information games
- Practical considerations
  - Memorizing knowledge
    - Transposition tables
    - Endgame databases
  - The graph-history interaction (GHI) problem
  - Opponent model
  - Timing control
  - Hardware enhancements
Introduction and an A.I. oriented overview

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

- History \[\text{SvdH02}] \[\text{Sha50}\]
  - 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 \[\text{SvdH02}] \[\text{Sch00}\]
  - 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 and its variations including DFID
  - Bi-directional search
  - A*
  - IDA*
  - IDA* with databases
Two-player perfect information games (1/2)

- A survey of current status [vdHUvR02]
- Classical approaches
  - Alpha-beta search and its analysis [KM75]
  - Scout and Negascout [Pea80] [Rei83] [Fis83]
  - MTD(\(f\)): Best-first fixed-depth search [PSPdB96] if time allowed [Pea80]
- Enhancements to the classical approaches
  - Quiescence search [Bea90]
  - Move ordering and other techniques [Sch89] [AN77] [Hsu91]
  - Further pruning techniques [SP96]
  - Proof-number search [AvdMvdH94] if time allowed
- Parallel alpha-beta based game tree search [Bro96] [FMM94] [HM02] [HSN89] [Hya97] [Man01]
Two-player perfect information games (2/2)

- Monte-Carlo game tree search
  - Original ideas [Bru93]
  - Best first game tree growing
  - UCT
  - Pruning techniques
    - Online knowledge [BH04] [YYK06]
    - Offline knowledge [ST09] [HCL10a]
  - Parallel Monte-Carlo game tree search [CJ08] [CWvdH08]

- Case study:
  - Computer Chinese chess [YCYH04]
  - Computer Chinese dark chess [CSH10]
Other games – if time allowed

- **Games with imperfect information and stochastic behaviors** [FBM98]
  - Backgammon
  - Bridge
- **Multi-player games** [Stu06]
  - Poker
  - Majon
Practical considerations (1/2)

- **Transposition tables**
  - Recording prior-search results to avoid researching
  - Design of a good hash function
    - Zobrist’s hash function [Zob70]
- **Open-game [Hy99] [Bu99] and endgame databases [Tho86] [Tho96] [WLH06]**
  - Off-line collecting of knowledge
  - Computation done in advance
- **The graph-history interaction (GHI) problem [Ca85] [BvdHU98] [WHH05]**
  - The value of a position depends on the path leading to it.
    - *Position value is dynamic and static.*
Practical considerations (2/2)

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

- **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.
    - Knowledge from real tournament environments [vV09].
    - For Monte-Carlo type of search [HCL10b].

- **Hardware enhancements** [DL04]
Resources (1/4)

- **ICGA web site**
  - http://ticc.uvt.nl/icga/
  - Formally as ICCA (International Computer Chess Association)
    - *Between 1977 and 2001.*
  - International Computer Games Association
    - *Since 2002.*
  - **Host of Computer Olympiad**
    - *International competition of games played by computers*
    - *Hold every year since 2000*
    - 1989 at London, United Kingdom (1st)
    - 2004 at Ramat-Gan, Israel (9th)
    - 2005 at Taipei, Taiwan (10th)
    - 2011 at Tilburg, the Netherlands (16th)
    - 2013 at Yokohama, Japan (17th)

- **TCGA web site**
  - Taiwan Computer Games Association
  - *Since 2011.*
  - http://tcga.ndhu.edu.tw
  - Annual conference and tournaments
Resources (2/4)

- **Proceedings of IJCAI**
  - International Joint Conference on Artificial Intelligence
  - Covers all areas of A.I.
  - Computer games occupy only a small session now
  - Since 1969, odd numbered of years

- **Proceedings of AAAI**
  - Association for the Advancement of A.I.
  - Covers all areas of A.I.
  - Computer games occupy only a small session now
  - Since 1980
Resources (3/4)

- **Proceedings of the ACG conference**
  - Advances in Computer Games International Conference
  - Every (if possible) odd numbered of year
    - 1999 at Paderborn Germany (9th)
    - 2003 at Graz, Austria (10th)
    - 2005 at Taipei, Taiwan (11th)
    - 2009 at Pamplona, Spain (12th)
    - 2011 at Tilburg, the Netherlands (13th)

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

- **Proceedings of IEEE CIG**
  - Computational Intelligence and Games International Conference
  - Since 2005, every year.
  - Video game, ...
Resources (4/4)

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

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

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

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


[Che00] K. Chen. Some practical techniques for global search in Go. *Inter-


