

# 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.

# About this class

- **Format:**
  - Lecturing: before mid-term.
  - Occasional invited lectures.
    - ▷ *Chinese chess*
    - ▷ *Go*
    - ▷ ...
  - Student presentation: after mid-term.
- **Class materials**
  - Class notes.
  - Collection of papers.

# Evaluation

- **One programming homework**
  - About single agent search.
- **Mid-term exam**
- **Presentation of a research paper**
  - 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 1 weeks later.
- **Final project**
  - A computer game program.
  - The NTU-TCG Cup Series.
  - Submitted package: Code + documents.
- **Class participation**

# 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 and 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]**
  - 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]**
  - 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]
- Enhancements to the classical approaches
  - ▷ *Quiescence search* [Bea90]
  - ▷ *Move ordering and other techniques* [Sch89]
  - ▷ *Further pruning* [SP96]
- Other approaches
  - ▷ *Monte Carlo simulations* [Bru93] [BH04] [YYK<sup>+</sup>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] [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 conferences**
  - 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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