General Game Playing (GGP)
Winter term 2013/2014
### Outline

<table>
<thead>
<tr>
<th>Date</th>
<th>What will we play?</th>
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<tbody>
<tr>
<td>22.10.2013</td>
<td>Introduction</td>
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<td>29.10.2013</td>
<td>Half-Life 2</td>
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<td>05.11.2013</td>
<td>FIFA 2014</td>
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<td>12.11.2013</td>
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<td>World-of Warcraft</td>
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<tr>
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<td>Tetris</td>
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<td><strong>Mid-term competition</strong></td>
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<tr>
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<td>The Elder Scrolls 3: Morrowind</td>
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<tr>
<td>21.01.2014</td>
<td>Need For Speed: Underground</td>
</tr>
<tr>
<td>28.01.2014</td>
<td>SimCity3000</td>
</tr>
<tr>
<td>04.02.2014</td>
<td><strong>Final competition</strong></td>
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You wish!
Almost there ...
Almost there …

In 1996 4:2
In 1997 2.5:3.5
Really: General Game Playing

• General Game Players are systems
  – able to understand formal descriptions of arbitrary games
  – able to learn to play these games effectively.

• Translation:
  – They don't know the rules until the game starts.

• Unlike specialized game players (e.g. Deep Blue), they do not use algorithms designed in advance for specific games.
About me

- Sebastian Wandelt
  - B.Sc. in computer science (HWR Berlin)
  - M.Sc. in computational logic (TU Dresden)
  - Ph.D. in computer science from (TU Hamburg-Harburg)
- Background
  - Semantic Web and Knowledge representation
  - Indexing and Compression of large databases
About me

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“Then why (on earth) do you offer a course on General Game Playing?”
How about you?

• Name
• Bachelor/Master/Diploma?
• Why do you attend this course?
  – 8 SP is a bad answer 😊
Why (did I like) General game playing?

My own hidden talent/interest?

No, not really.
Why (did I like) General game playing?

Did I have an excellent teacher/instructor?

Well yes, maybe.
Why (did I like) General game playing?

• The major reason, I believe, is:
  General game playing combines a wide range of core computer science topics, e.g.:
  • Knowledge representation
  • Search
  • Planning
  • Learning
  • Problem solving
  • Decision making
  • Programming
  while making them fun to play with!
告訴我，我會忘記。
教我，我會記住。
讓我參予，我會理解。
Teaching guideline

Tell me, I will forget.

教我，我會記住。
讓我參予，我會理解。
Teaching guideline

Tell me, I will forget.

Show me and I may remember.

讓我參予，我會理解。
Teaching guideline

Tell me, I will forget.

Show me and I may remember.

Involve me and I will understand.
Let’s have a look …

• Games can be played here:
  – http://www.ggp.org/kiosk
  – http://tiltyard.ggp.org/hosting/
Single-Player Games

- Sudoku
- Mahjong
- Go
Multi-Player Games
<table>
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<tr>
<th>Date</th>
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</tr>
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<tbody>
<tr>
<td>22.10.2013</td>
<td>Introduction, Repetition propositional logic and FOL</td>
</tr>
<tr>
<td>29.10.2013</td>
<td>Datalog and Prolog</td>
</tr>
<tr>
<td>05.11.2013</td>
<td>Game Description Language</td>
</tr>
<tr>
<td>12.11.2013</td>
<td>Design of GDL games</td>
</tr>
<tr>
<td>19.11.2013</td>
<td>Search Algorithms 1</td>
</tr>
<tr>
<td>26.11.2013</td>
<td>Search Algorithms 2</td>
</tr>
<tr>
<td>03.12.2013</td>
<td>Incomplete information</td>
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<tr>
<td>10.12.2013</td>
<td>Fluent Calculus and Fluxplayer</td>
</tr>
<tr>
<td>17.12.2013</td>
<td><strong>Midterm competition</strong></td>
</tr>
<tr>
<td>14.01.2014</td>
<td>Meta-Gaming</td>
</tr>
<tr>
<td>21.01.2014</td>
<td>Game Theory</td>
</tr>
<tr>
<td>28.01.2014</td>
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Prolog (and Datalog)

• Prolog: An expressive, declarative logic programming language, based on First-order logic
• Models a knowledge base using facts and rules
• Datalog is a special sublanguage of Prolog

• We will discuss:
  – Modeling of a domain of interest
  – Reasoning procedures, i.e. how to derive new knowledge from given facts and rules

• This part of the module is quite formal, but a prerequisite for working with the Game Description Language.
Game Description Language

• Describes the state of a game as a series of facts and the game mechanics as logical rules
• It is a variant of Datalog
• Example for the definition of Tic Tac Toe

• We will implement our own games in GDL
Search algorithms I

- Games can be represented as trees/graphs
- A state of a game is a node
- The successor states of a game state are the direct successors in the graph
Search algorithms I

- Combinatorial explosion
  - If each player has $k$ option in each state, then in order to look $n$ steps ahead, we need to consider $1 + k + k^2 + k^3 + \ldots + k^n$ states
- We need efficient search algorithms/heuristics!
Search algorithms I

• We will discuss
  – Simple graph search algorithms
  – *-Algorithm, A*-Algorithm
  – Dictionary Data structures
  – Abstraction transformations
  – Pattern Databases
Search algorithms II

- Search algorithms often have to be executed under constraints (limited space/time)
- We will discuss
  - Linear-space search, Branch-and-Bound, Iterative deepening A*, Recursive best-first search
  - Enforced Hill-climbing, Beam search, dynamic programming
  - Symbolic search, binary decision diagrams
Incomplete information

- Dealing with incomplete information can be costly, as multiple options must be considered.
- In the face of incomplete information, there may be no way of knowing that one has succeeded.
- In GGP, it is customary to ensure that the players have enough information to determine legality of moves, termination, and goals.
- We will look at:
  - State-space search with multiple players
  - Minimax with cutoff
  - Planning under uncertainty
Fluent Calculus and Fluxplayer

- Fluxplayer is a GGP system developed at TU Dresden
- Winner of the AAAI general game playing competition 2006
  - Each year is challenge for GGP programs and *everybody* can participate
  - Price: 10.000$
- We will discuss its theoretical foundation Fluent calculus and its Prolog-implementation FLUX
Metagaming and Game Theory

• Metagaming is match-independent processing
  – Not considering opponent or particular states
  – Usually done offline

• We will look at techniques for meta-analysis of games
  – Machine learning
  – Framework transformation
  – Game decomposition
  – Compilation

• We will also have a look at Game Theory:
  – Normal forms of games
  – Dominance
  – Mixed Strategies
Competitions

• Two competitions
  – Midterm competition (17.12.2013)
  – Final competition (04.02.2014)

• You take part in the competition as a team
  – A team consists of three students
  – All teams need to be fixed until next week (29.12.2013)!
  – Every team should completely participate until the end of this module
Literature Overview

• General Game Playing by Michael Genesereth
  – Available online
• Heuristic Search: Theory and Applications by Edelkamp/Schrödl
• Resources at http://www.general-game-playing.de/teaching/teaching.html
Organization of the course

• Lecture: Tuesdays 09-11
  – PDFs will be usually available Monday evening

• Exercise session: Tuesdays 11-13
  – I will be there for your questions during the exercise session.
  – But you are expected to use the time of the exercise session for working on your game player!

• Examination
  – Oral (or written, depending on the number of students)

• Any doubts/comments/suggestions?
Serious hint

- If you intend to skip a lecture, fine.
- If you intend to deliver half-ready code (written few hours before the deadline) for the final competition, this is a no go!
- Prerequisite for taking part in the examination is a general game player that, during the final competition,
  - 1) always makes a legal move for each game and
  - 2) can finish simple single player games (Blocks etc.) with a perfect score
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This module is not rocket science,
but neither it will be a walk in the park!
Acknowledgements

Parts of these slides are based on the teaching resources website of [www.general-game-playing.de](http://www.general-game-playing.de), with materials from (in alphabetical order)

- Martin Günther
- Michael Genesereth
- Michael Thielscher
- Peter Kissmann
- Stefan Edelkamp