AI in Computer Games

why, where and how

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Who am I?

- Lecturer at Uppsala University, Dept. of information technology
- AI, machine learning and natural computation
- Gamer since 1980

AI in Computer Games

- Goals
- History
- Common issues and methods
- Issues in various game categories

Goals

- Games are entertainment!
- Important that things behave naturally
  - not necessarily perfect
  - "things" are not always creatures
- Follow (the game's) natural laws
 - and avoid cheating
- Characters should be aware

Game A(I?)

- Academic AI is usually concerned with making rational decisions
  - Searching for the optimal solution
- Game AI is more often about
  - Artificial Life
  - Believable behaviour
    - including stupidity!
    - realistic physics
  - Game balancing
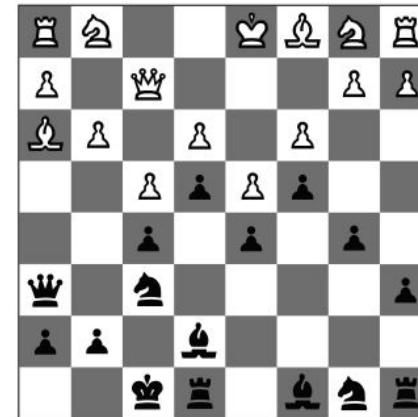   - challenging, but not unbeatable opponents

History -1980

- ■ 1960's
  - ✹ First computer games
    - ▪ SpaceWar! (PDP-1, for two human players) (1962)
    - ▪ Board games (e.g. chess) against the machine
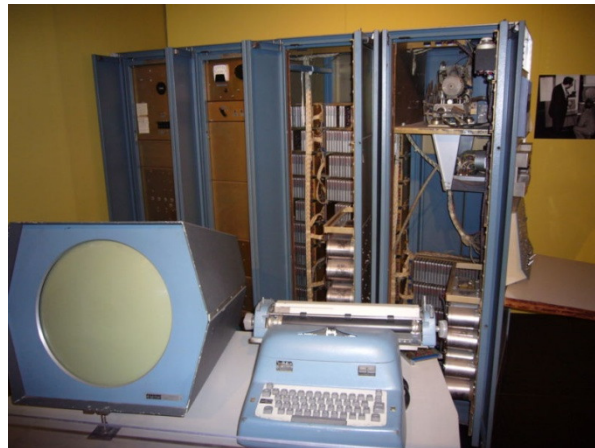
PDP-1

Chess
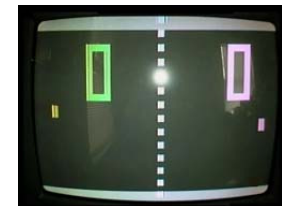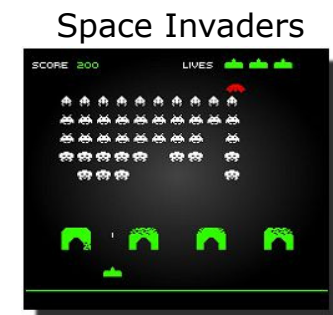
History -1980

- **1960's**
  - First computer games
    - SpaceWar! (PDP-1, for two human players) (1962)
    - Board games (e.g. chess) against the machine

Pong

- **1970's**
  - Pong (early arcade game) (1972)
  - Computer controlled opponents
  - Space Invaders (1978)
  - Predefined patterns, no awareness
  - "AI" takes 1-2% of CPU

Space Invaders

Pac Man

1980's

- Pac-Man (1980)
  - ✹ aware opponents with personality
- A computer beats a master chess player (1983)
- First fighting games
- Adventure games
  - ✹ Dungeon, Zork, ...
- First MORPG (MUD)

The way of the exploding fist (1985)

1990's

- FPS and RTS games
- Games about/with evolution and learning (Creatures, and (in 2001) Black&White)
- Deep Blue beats Kasparov (1997)
- Graphic cards take the load off the CPU
- AI takes 10-35% of CPU

Doom

Dune 2

Black & White

2000-

- Focus shift from single- to multiplayer
- Focus shift from graphics to AI
  - and physics …
- Large part of the code is AI code
  - often made from scratch for each game
- Less cheating
- Characters are more aware
  - thanks to better physics engines
- Characters collaborate better

2000- BIG industry

- **In Sweden**
  - +39%/year on average (2006-2014)
  - 9 bilj SEK turnover in 2014
  - Most of the (213) companies make +
- **Internationally**
  - 81 bilj USD revenue in 2014
- **Tough competition (10 most sold games cover 80% of the market)**
- **Typical game project: 2 years, 70 people, 20 milj USD (+ marketing)**

Typical Game AI topics

- **Strategical/tactical decisions**
  - Against or with you
  - Search for best counter action
  - adaptivity
- **Director level AI**

- **Simulation**
  - of natural behaviour
  - for animation (e.g. bird flocks)
- **Shortest path problems**

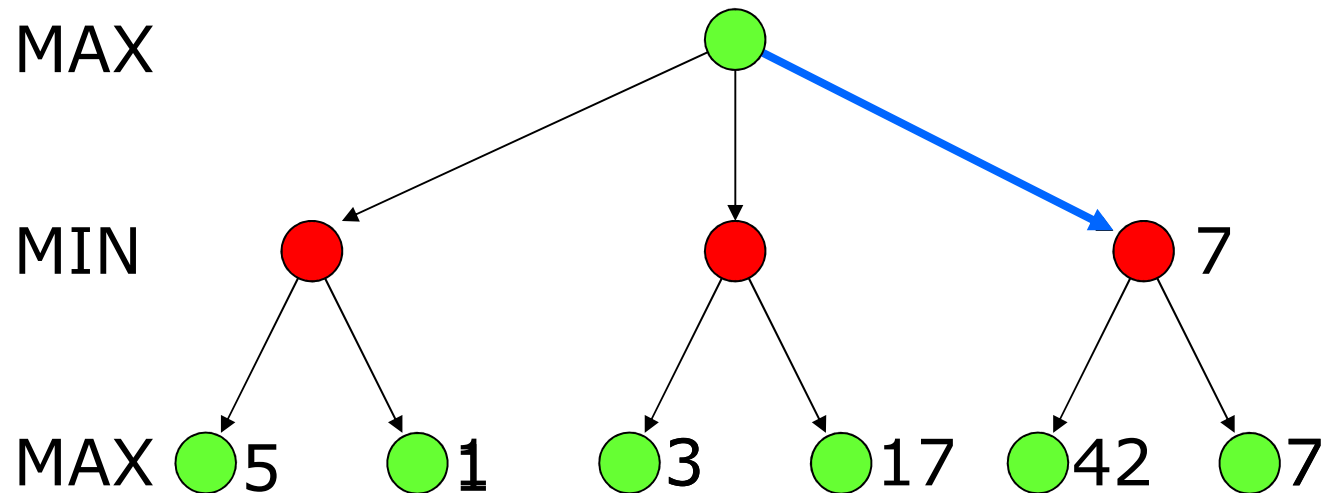# Why is Game AI hard?
(what makes it interesting to CompSci)

- Huge state space

- Huge action space

- Multiple tasks
  - on different levels of abstraction
  - of different types

- Non-deterministic
  - post-conditions difficult to set
  - makes planning difficult

- Often real time

Some common methods

- Minimax
  - logic games, search for best counter action
- Finite State Machines (FSM)
  - Behaviour
- A*
  - For shortest path problems
- Particle methods
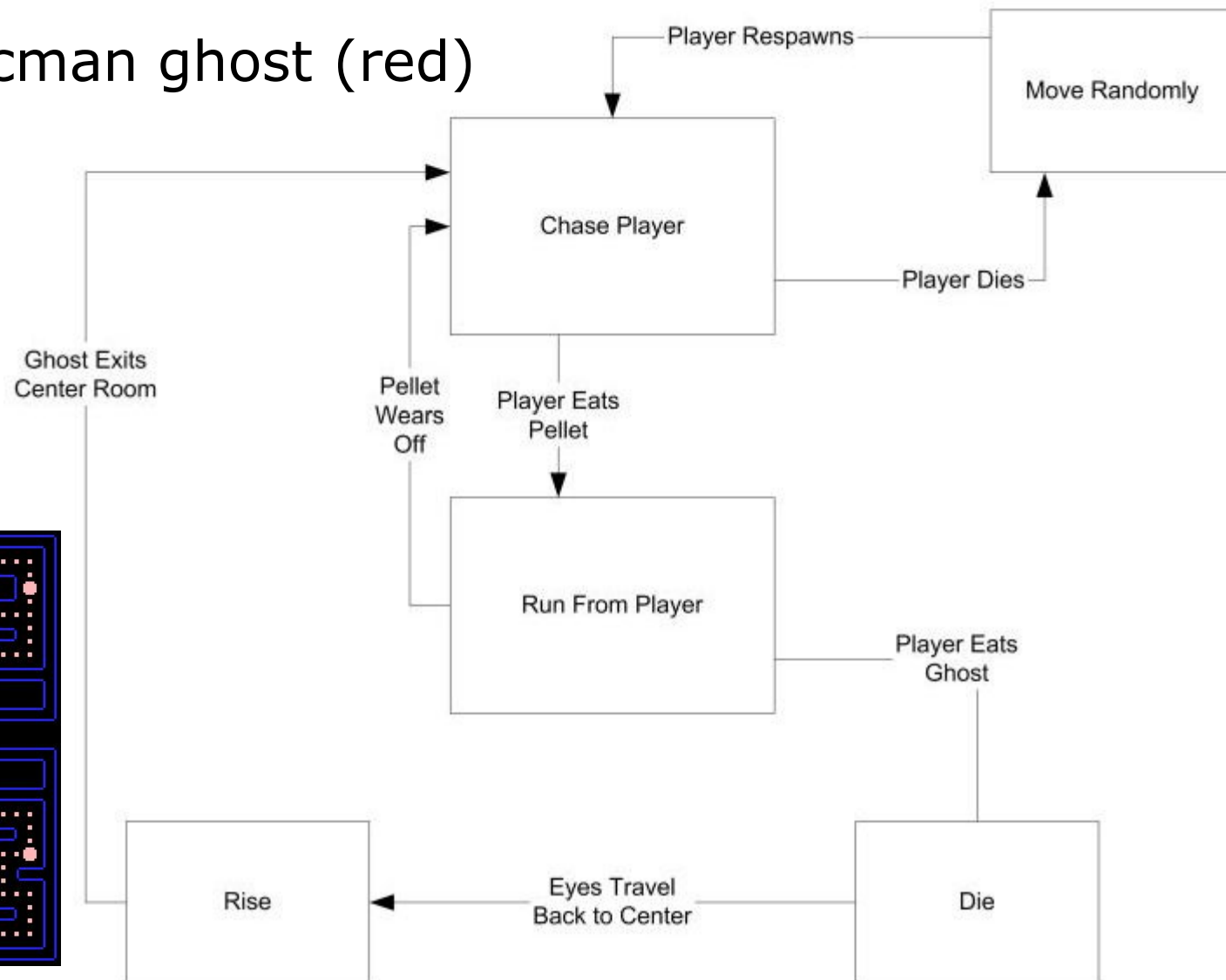 - Simulation of flocks, smoke, water, grass,...
- Smart terrain

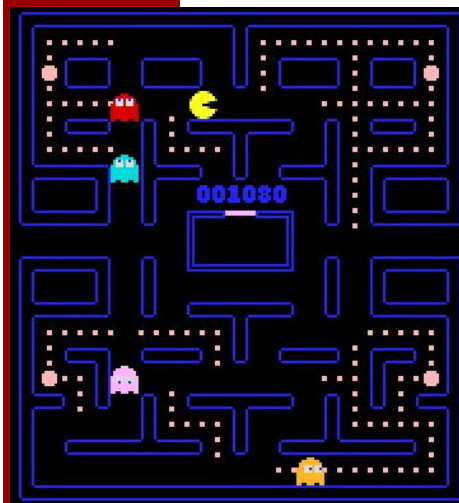# **Minimax (counter actions)**

MAX

MIN   7

MAX 5   1   3   17   42   7

Variants: "α-β-pruning" and "expectimax"

Finite State Machines

Pacman ghost (red)

Player Respawns

Move Randomly

Chase Player

Player Dies

Ghost Exits
Center Room

Pellet
Wears
Off

Player Eats
Pellet

Run From Player

Player Eats
Ghost

Rise

Eyes Travel
Back to Center

Die

001080

UPPSALA
UNIVERSITET

A*

Distance from S +
estimated distance to G

3+8=11	2+7=9	3+6=9	4+5=9			
2+7=9	1+6=7	2+5=7	3+4=7			
1+6=7	S	1+4=5	2+3=5			
2+5=7					G	
3+6=9	4+5=9	5+4=9	6+3=9	7+2=9	8+1=9	
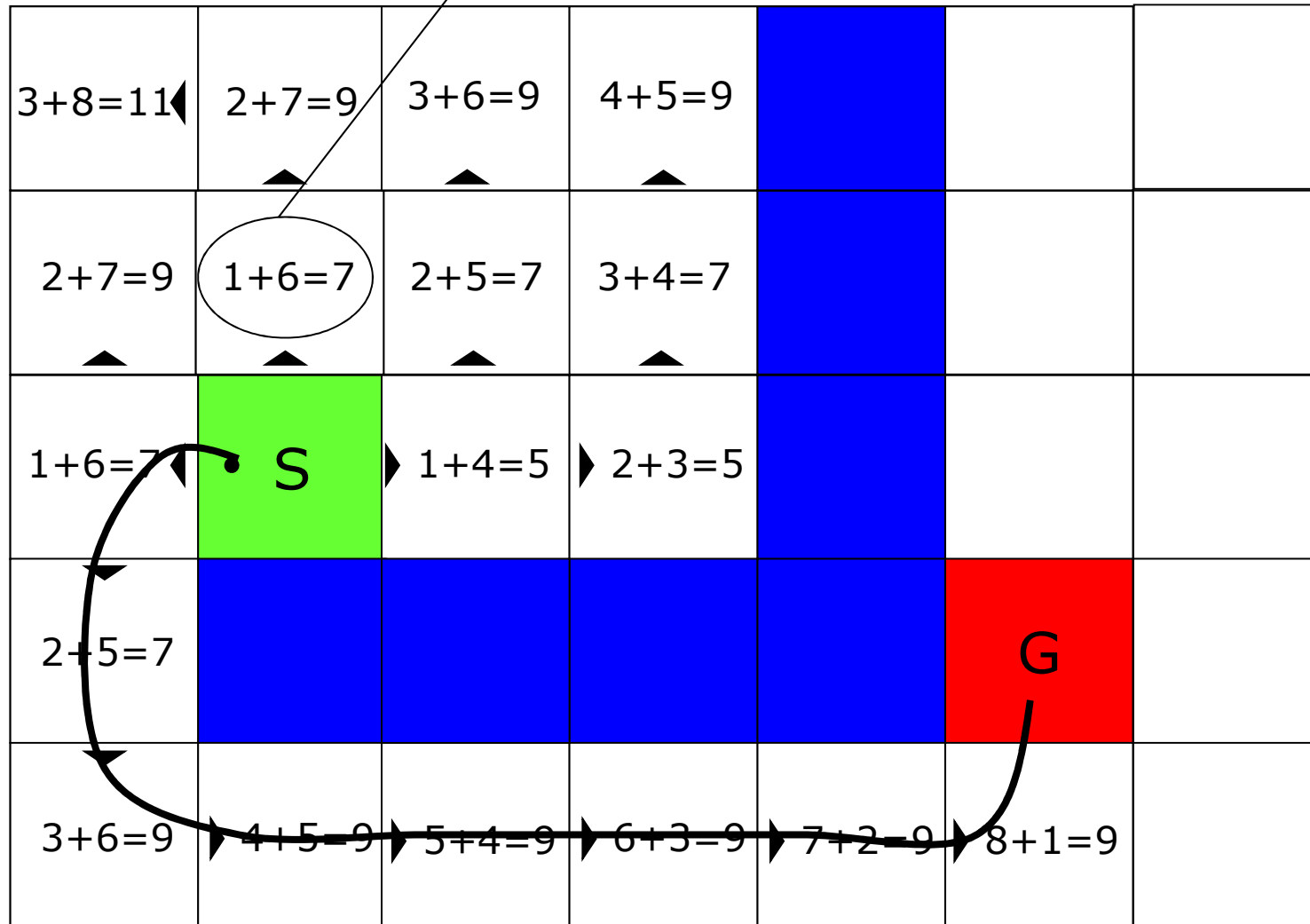
Reinforcement Learning
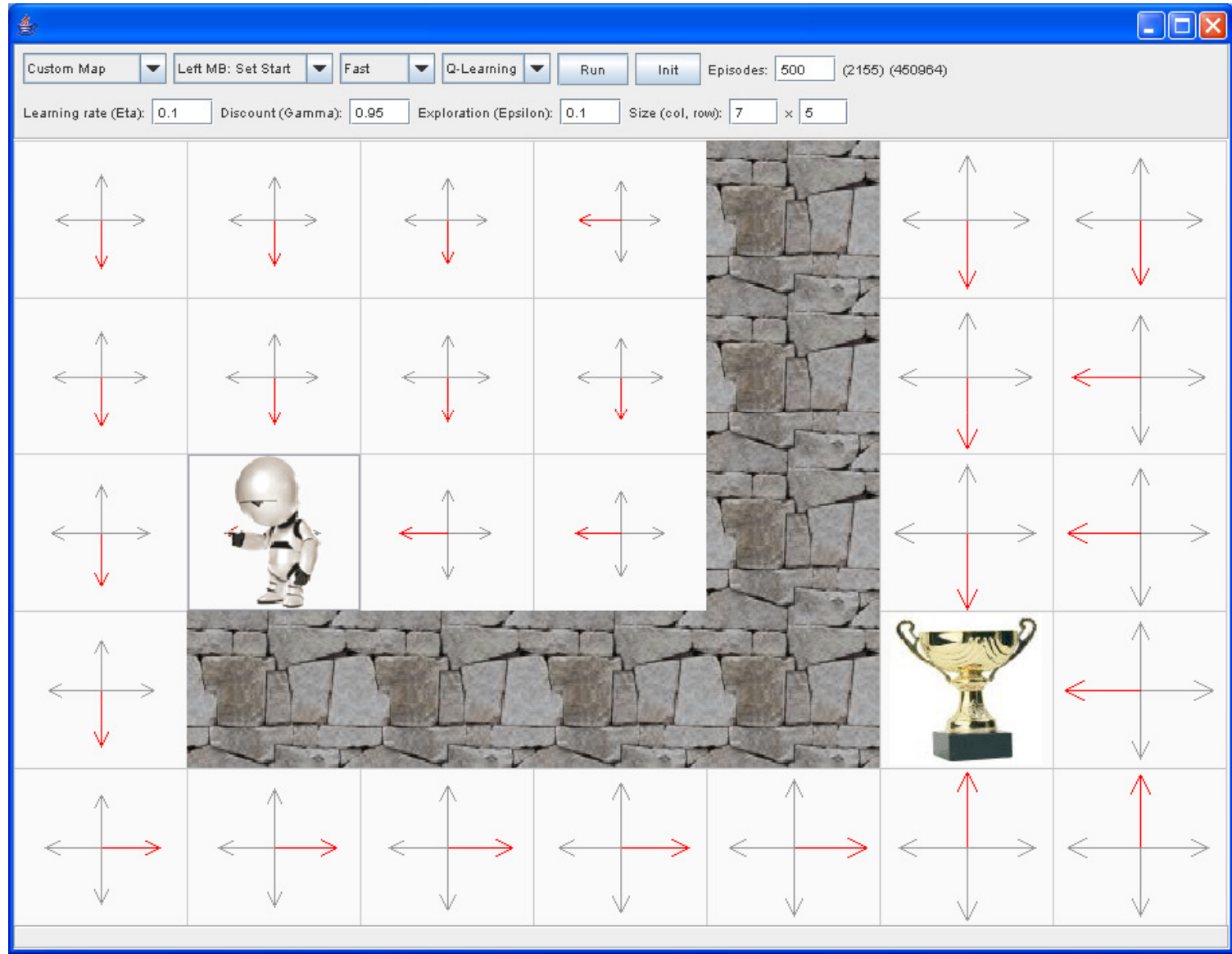
Best ≠ shortest

Civilization III

Smart terrain

- Store knowledge in objects instead of in the characters

  drink me! ➔ not thirsty, warm

  - Easier to know what is relevant
  - Easier to add new objects later

- Attributed to Will Wright (Sims)

Machine Learning?

- Game characters are short lived
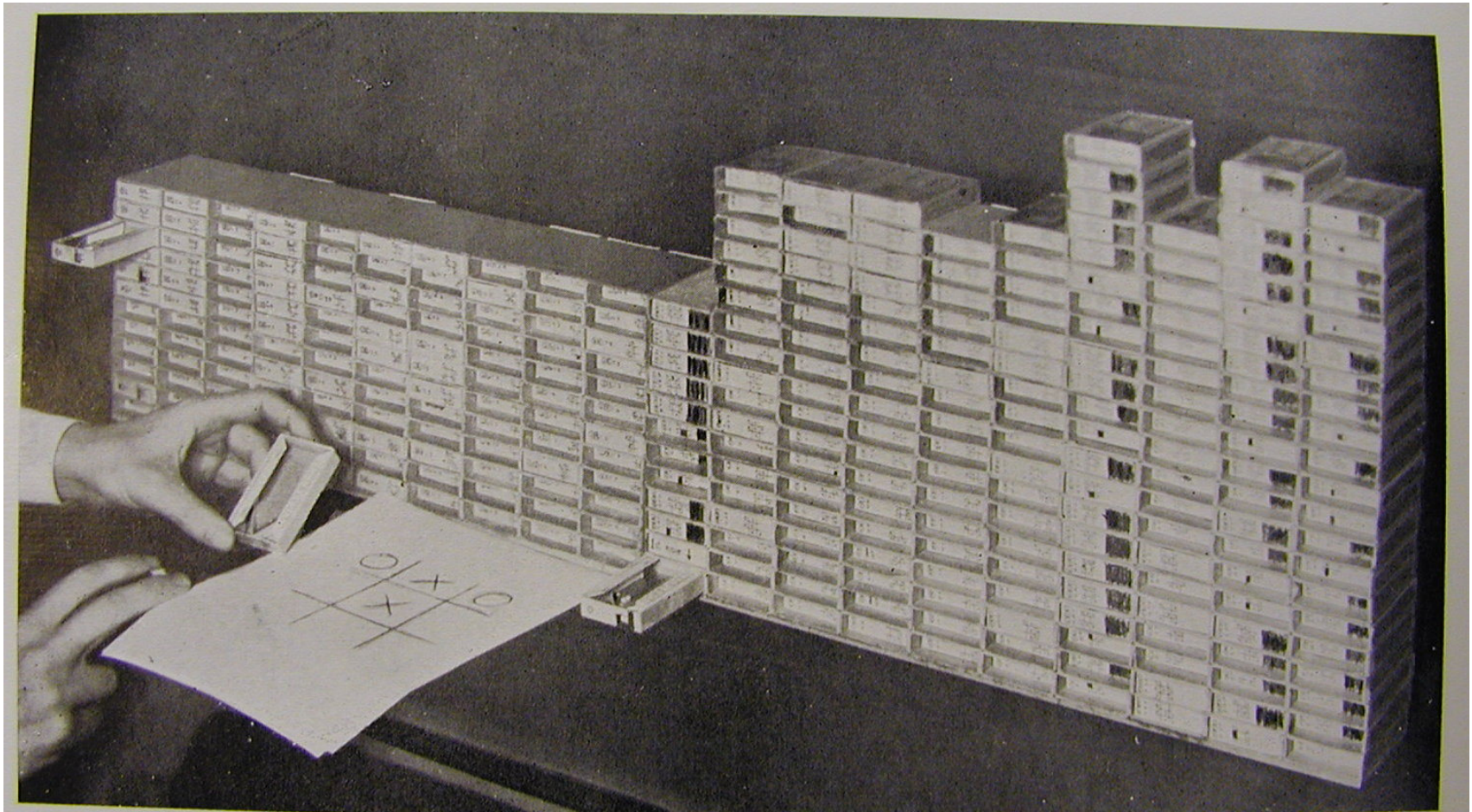- Learning requires many attempts

Keep it simple!

- Probabilistic methods (a la MENACE)
  - ✳ Director level AI
- Evolutionary methods
  - ✳ genetic algorithms and PSO
- Neural networks
  - ✳ in game development, but not often in game

MENACE

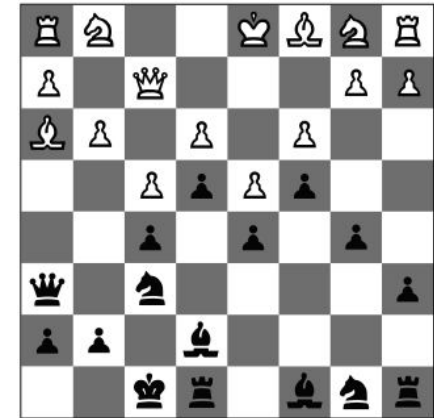Plate 1. The original matchbox version of MENACE

AI in various game types

- Board games
- Role playing games
- Strategy games
- Platform and sports games
- Racing games

Chess

Board games

- Discrete time / turn based
- Often deterministic
- AI is in the opponent
- AI goal is non-typical (for games)
  - ✳ usually strives for optimality
- Tree search
- Library
- Reinforcement learning

Role Playing and Adventure

The Elder Scrolls IV: Oblivion

- AI in enemies, bosses, party members and other NPCs, …
- Scripting, FSMs, Messaging
- Role Playing ≠ Combat
  - ✸ combat oriented games are simpler to make
- Conversations (grammar machines)
- Quest generators
- Towns

Town behaviour

Balmora, in The Elder Scrolls III: Morrowind

Town behaviour

- Need-based system
  - Needs (e.g. hunger, business, ...)
  - Actions (e.g. eating, trading, ...)
  - "Need pathfinding"
- Problems
  - Finding people
  - Unwanted interaction between NPCs

Strategy games

Civilization III

- AI heavy (on both sides)
- Shortest path problems
- Strategical decisions
- Tactical decisions
- Town building and resource management
  * planning
- Indigenous life
- Reconnaissance (fog-of-war)
- Diplomacy
- Know thy enemy (observe and adapt)

Strategy games

Civilization III

Action games (FPS, TPS)

Half Life 2

- **Enemies**

- **Cooperative agents**

- **Weapons**

- **Attention**

  - requires perception

    - requires a good physics engine

- **Pathfinding**

- **Spatial reasoning**

- **Anticipation**

Action games (FPS, TPS)

Thief 3: Deadly Shadows

Platforms and sports

- **Platform games**
  - In 3D, since 1996 (Mario 64)
  - Camera problems
- **Sports games**
  - Camera problems (harder)
  - Cooperation
  - Game balance can be difficult
  - Learning

Platforms and sports

Prince of Persia

Prince of Persia: The Two Thrones

Racing games

Forza Motorsport (2005)

Racing games

- Track AI
  * Neural networks (CMR2)
- Traffic (including pedestrians)
- Physics
- Tuning NPCs and vehicle parameters
  * Genetic algorithms
  * Particle swarm optimization

Conclusion

- Making realistic games requires more than good graphics
- Computer controlled characters must *behave*
  - Naturally
  - Reasonably intelligent, without cheating
- Graphics has dedicated hardware
  - More processing power avilable to AI
- In the future
  - Dedicated AI cards?
  - Combined AI/Physics/Graphics cards?
  - Dedicated cores?
  - From simulated to real worlds (robotics)

Robocup (Aibo league)

Recommended reading

http://aigamedev.com