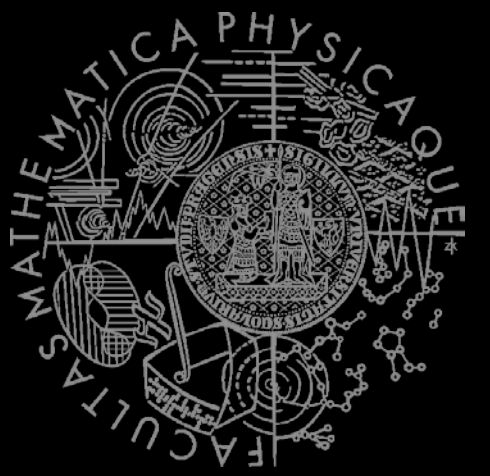
Faculty of Mathematics and Physics
Charles University in Prague
8th March 2016



Human-like Artifical Agents

IVAs, Reactive Planning, If-Then, (h)FSM

Scripting Virtual Brain

Intelligent Virtual Agents
What?

- Software agent *(by Michael Wooldridge)*
  - Embodied intelligent autonomous entity

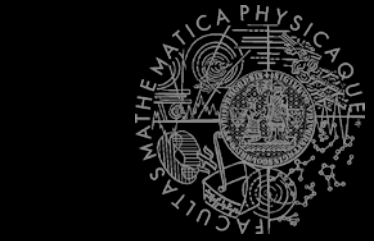
Intelligent Virtual Agents
What?

- Software agent *(by Michael Wooldridge)*
  - **Embodied** intelligent autonomous entity
    - Body that is subject to some (physical) laws within its environment

Intelligent Virtual Agents
What?

- Software agent *(by Michael Wooldridge)*
  - Embodied intelligent **autonomous** entity
    - Operating on an owner's behalf but without any interference of that ownership entity

Intelligent Virtual Agents
What?



- Software agent *(by Michael Wooldridge)*
  - Embodied **intelligent** autonomous entity
    - Reactive
    - Proactive
  - *Thermostat may be an agent too!*

Intelligent Virtual Agents
What?

- Software agent *(by Michael Wooldridge)*
  - Embodied **intelligent** autonomous entity
    - Reactive
    - Proactive
    - Social
  - *Okey… 'more' thermostats…*

Intelligent Virtual Agents
What?

- Software agent *(by Michael Wooldridge)*
  - Embodied intelligent autonomous entity
    - Reactive
    - Proactive
    - Social
- Intelligent Virtual Agent *(IVA)*
  - **Specific** software agent **type**
    - Wholly and movably embodied within Complex virtual environment / world
    - Acts under bounded rationality

Intelligent Virtual Agents

Detour

- Software agent *(by Michael Wooldridge)*
  - Embodied intelligent autonomous entity
    - Reactive
    - Proactive
    - Social
- Intelligent Virtual Agent *(IVA)*
  - Overloaded term
  - Google Images
  - Techopedia
    - … an animated, human-like graphical chat bot commonly displayed on website home pages and advertisement landing pages…

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    - **Wholly and movably embodied (… ?)**

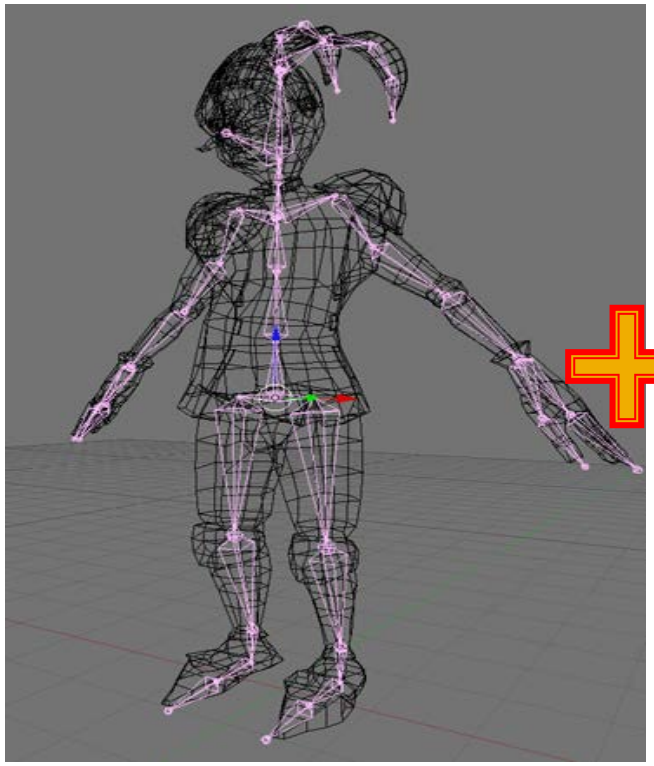
      within Complex virtual environment / world
    - Acts under bounded rationality

What is…

Wholly and movably embodied

What is…

Wholly and movably embodied



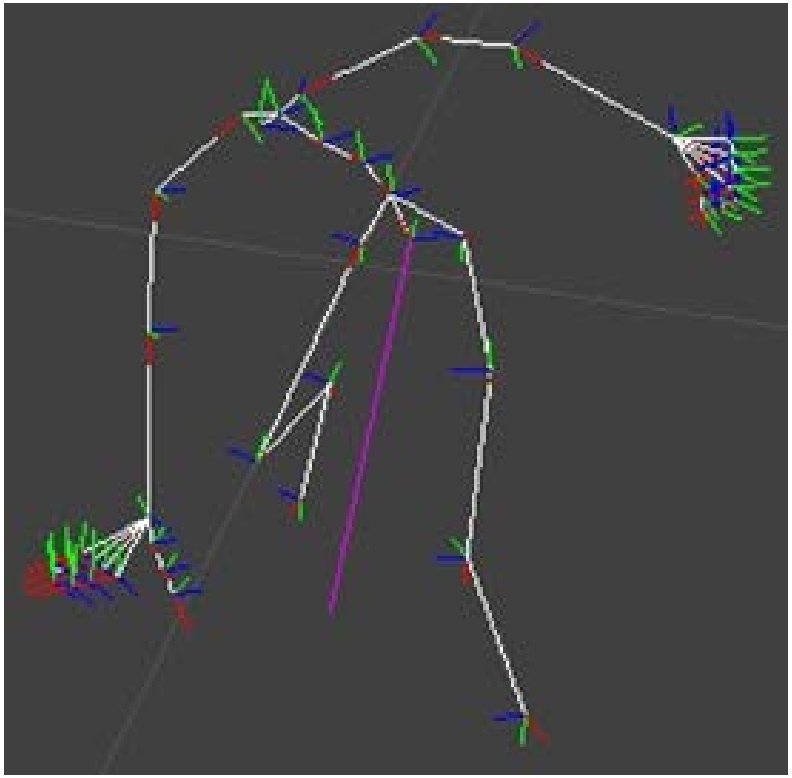
3D Model + Skeleton
(virtual invisible bones)

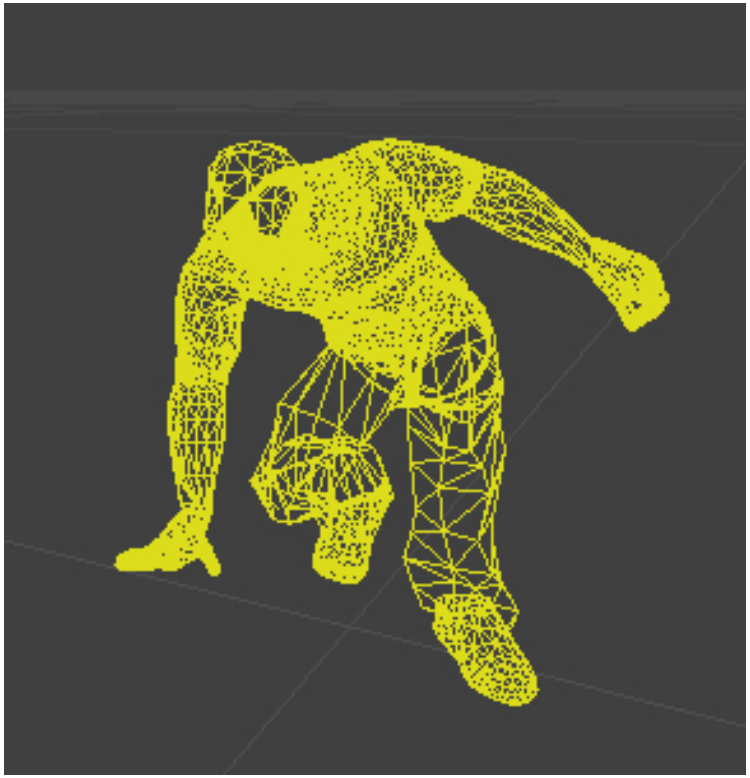
Rig
(how the model
is mapped to v-bones)

Textures
(skin, clothes, items, …)

What is…

Wholly and movably embodied





Animations in action

What if we lack a certain animation transition?

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What is…

Complex V-Environment?

Env. Classification
Properties

- Fully *vs.* Partially observable
- Episodic *vs.* Sequential
- Static *vs.* Dynamic
- Single *vs.* Multi agent
- Deterministic *vs.* Stochastic
- Discrete *vs.* Continuous
- Known *vs.* Unknown
- Turn-based *vs.* Real-time
- Noiseless *vs.* Noisy

TicTacToe
Properties

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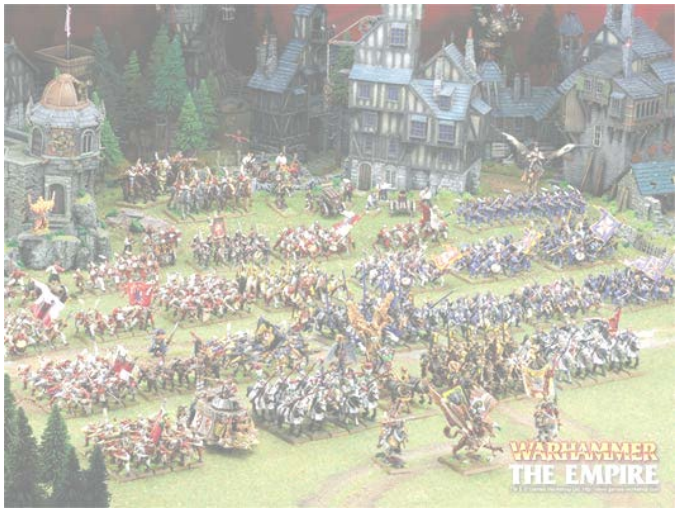

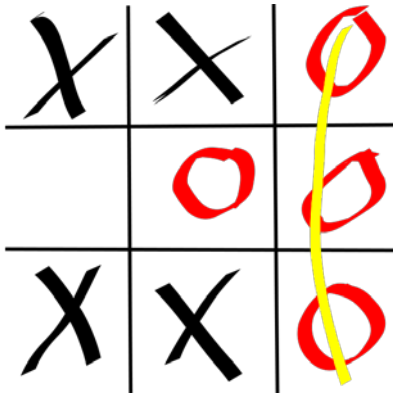

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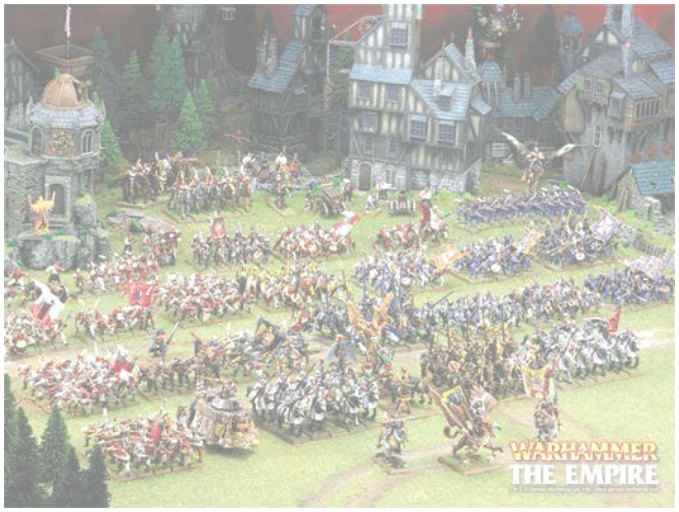

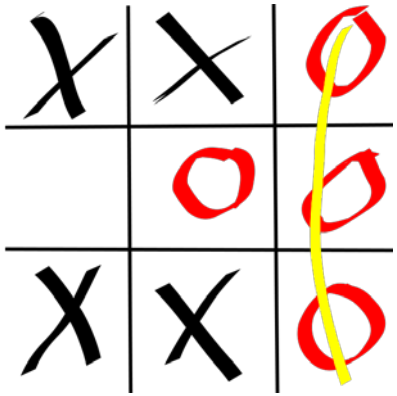

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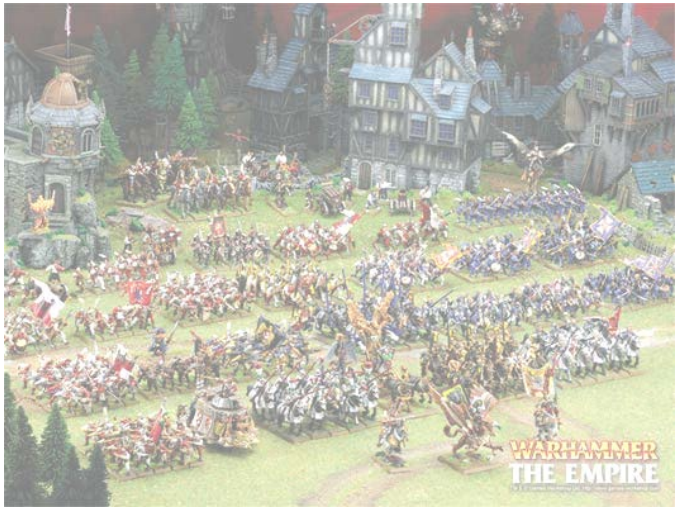

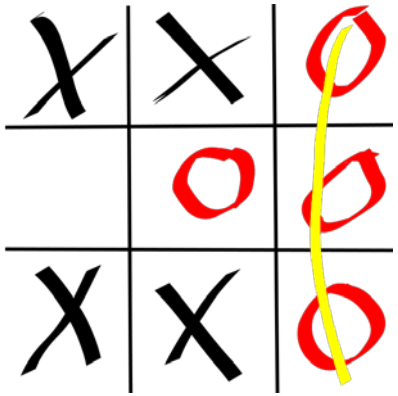

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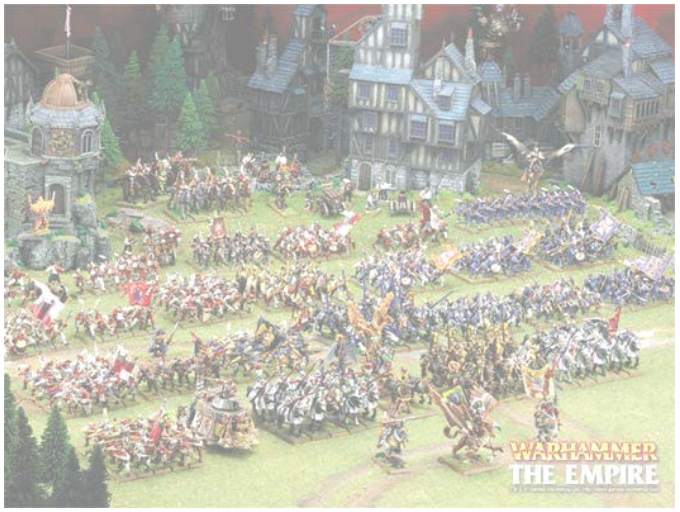

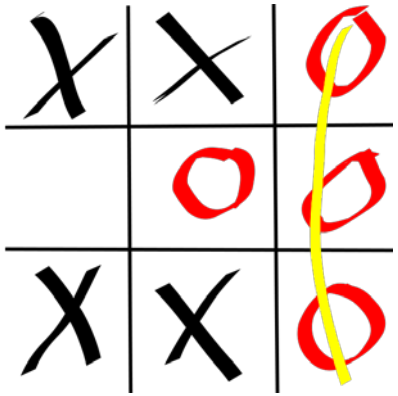

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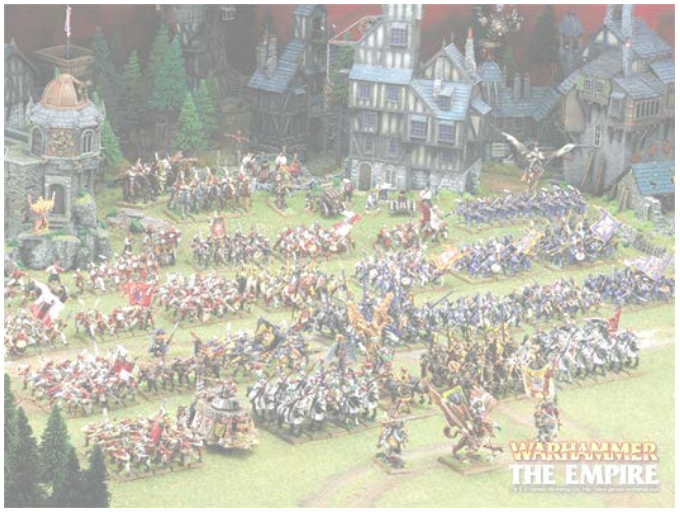

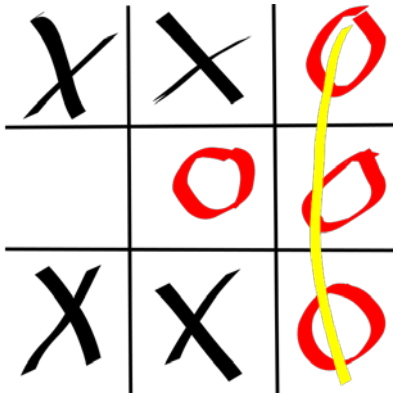

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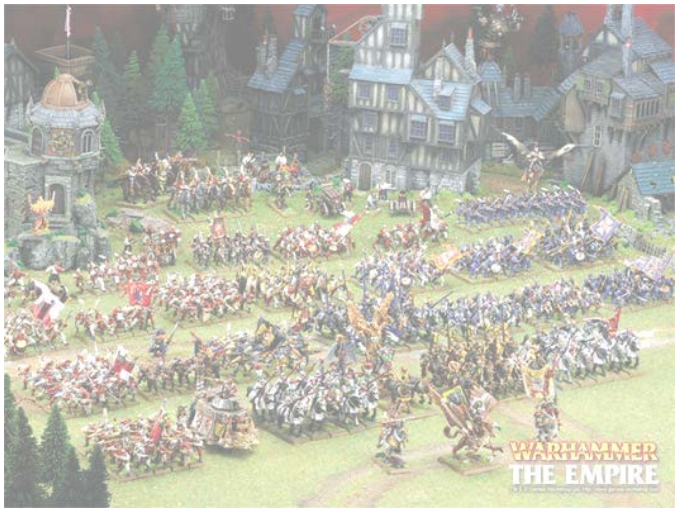

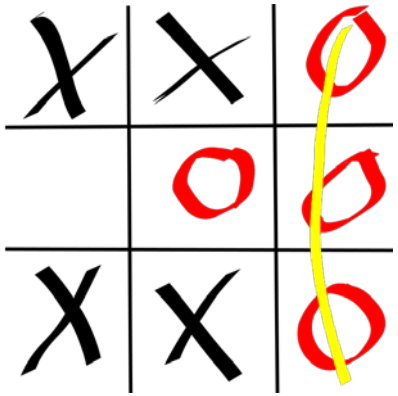

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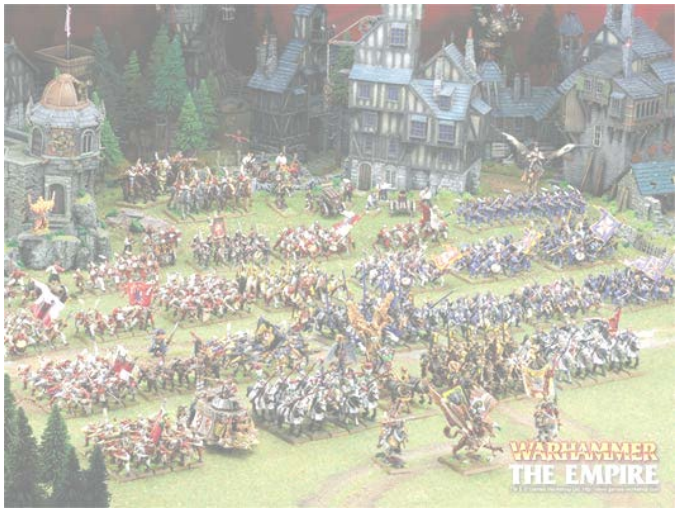

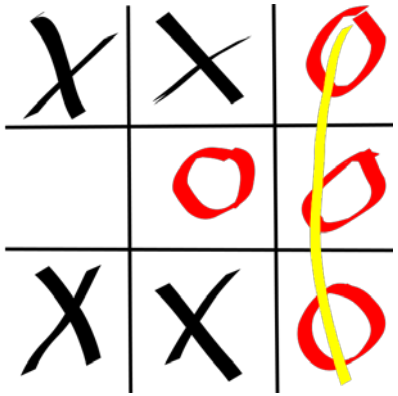

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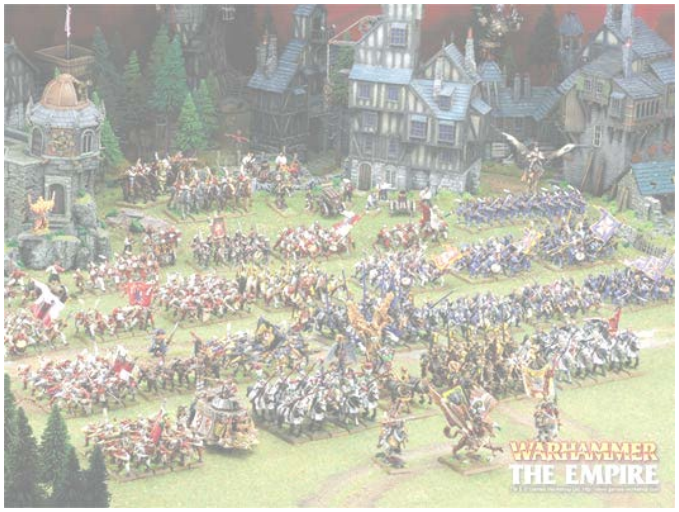

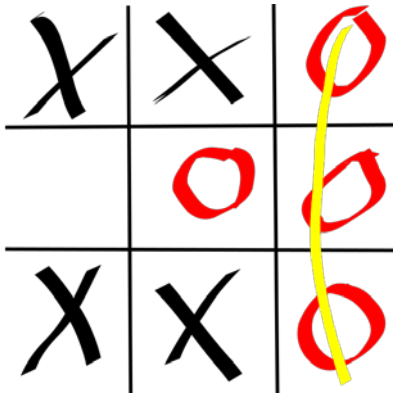

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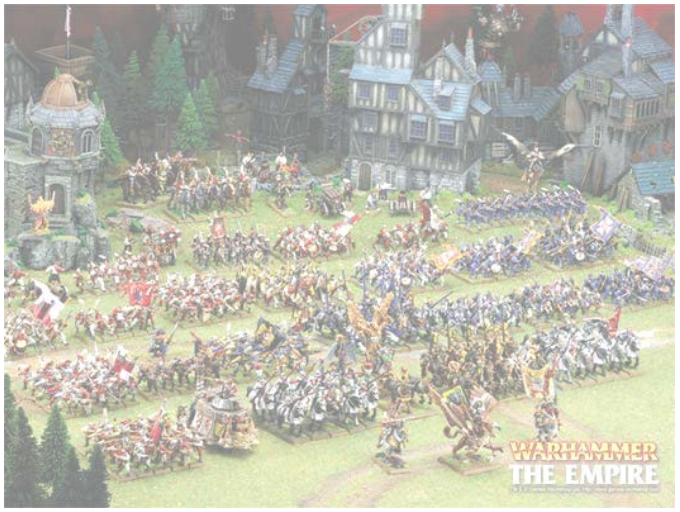

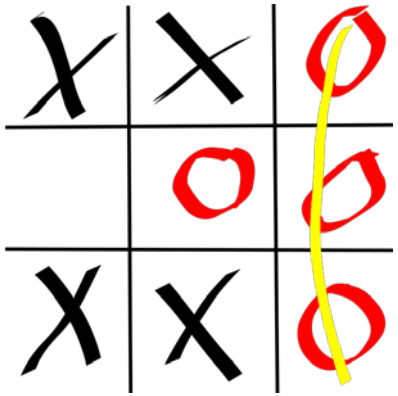

TicTacToe
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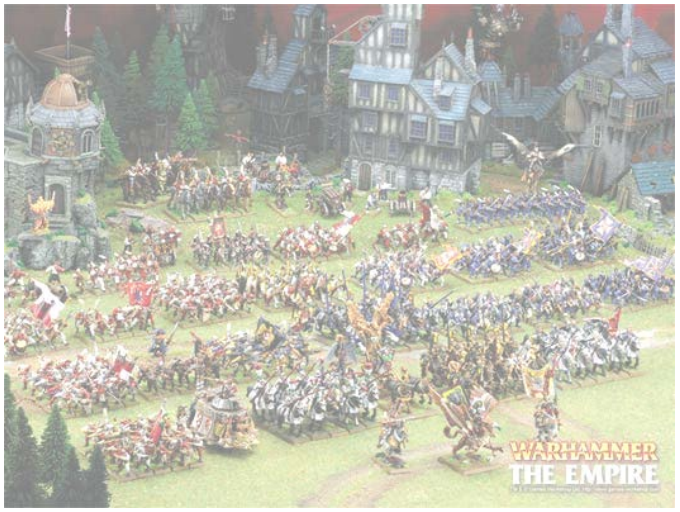

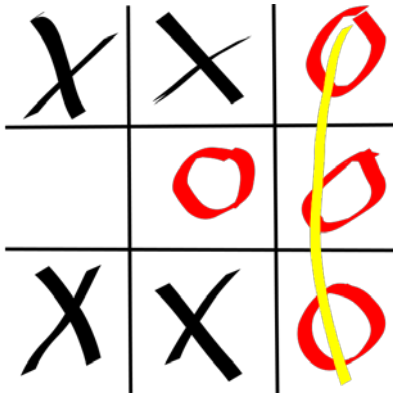

TicTacToe
What does it mean?

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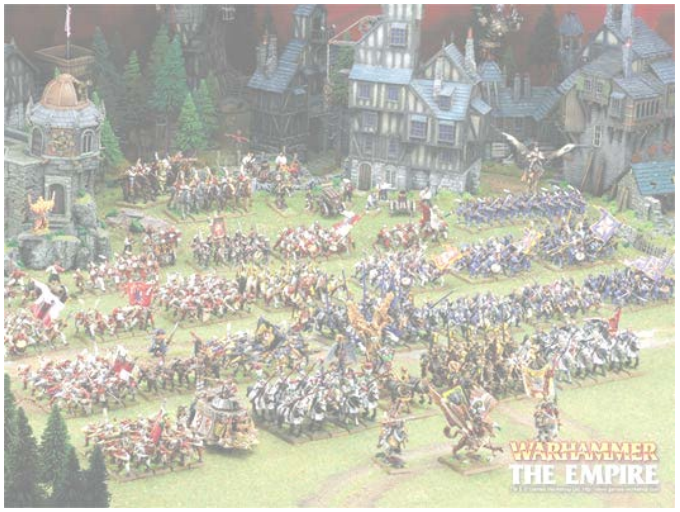
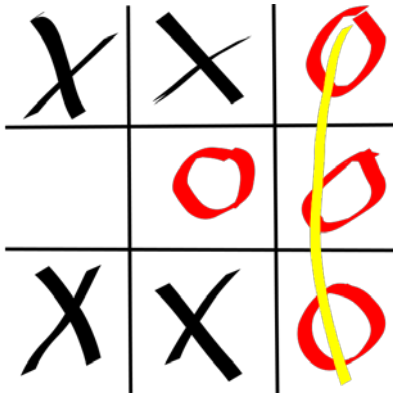
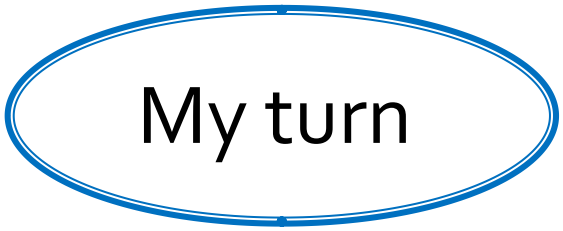
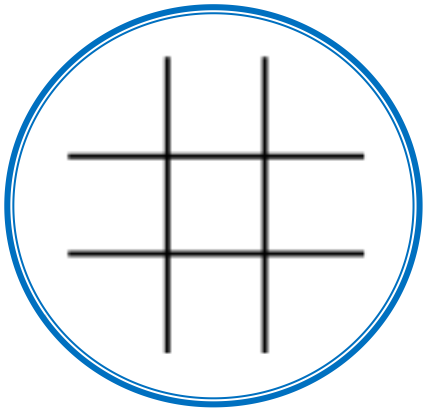




„Reasoning as search“
AI for Two-Player Games

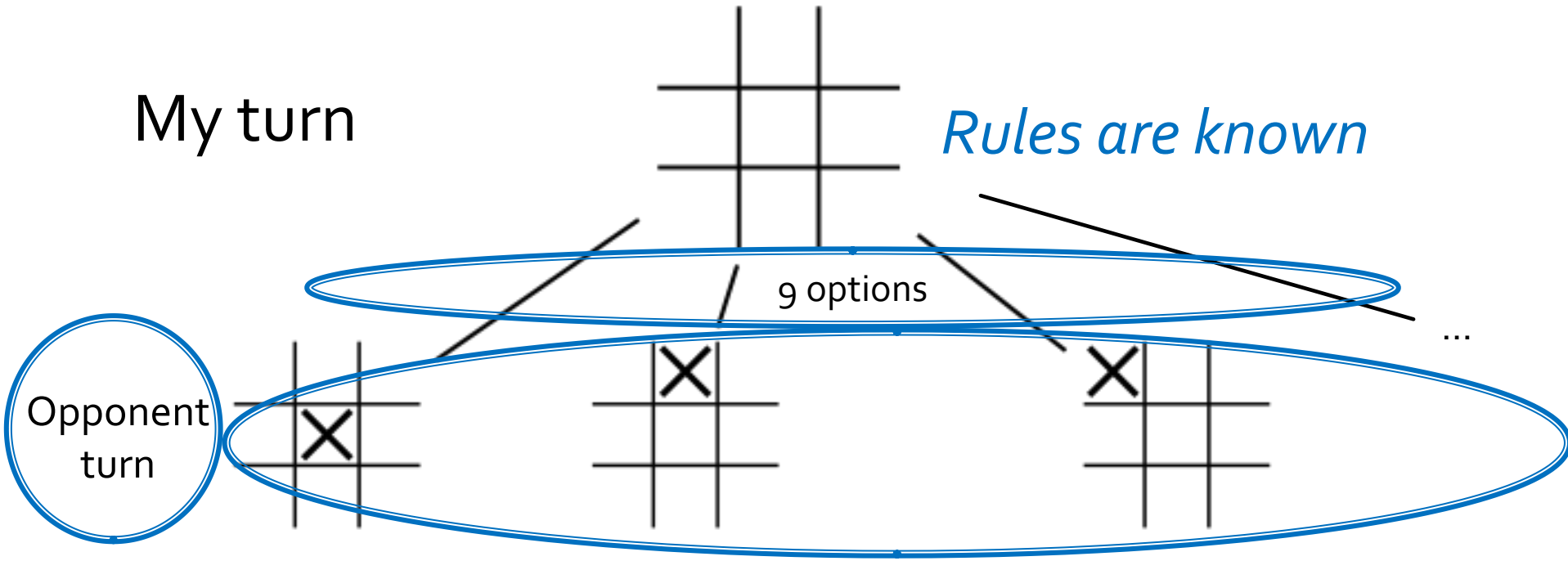


Static environment



Fully observable

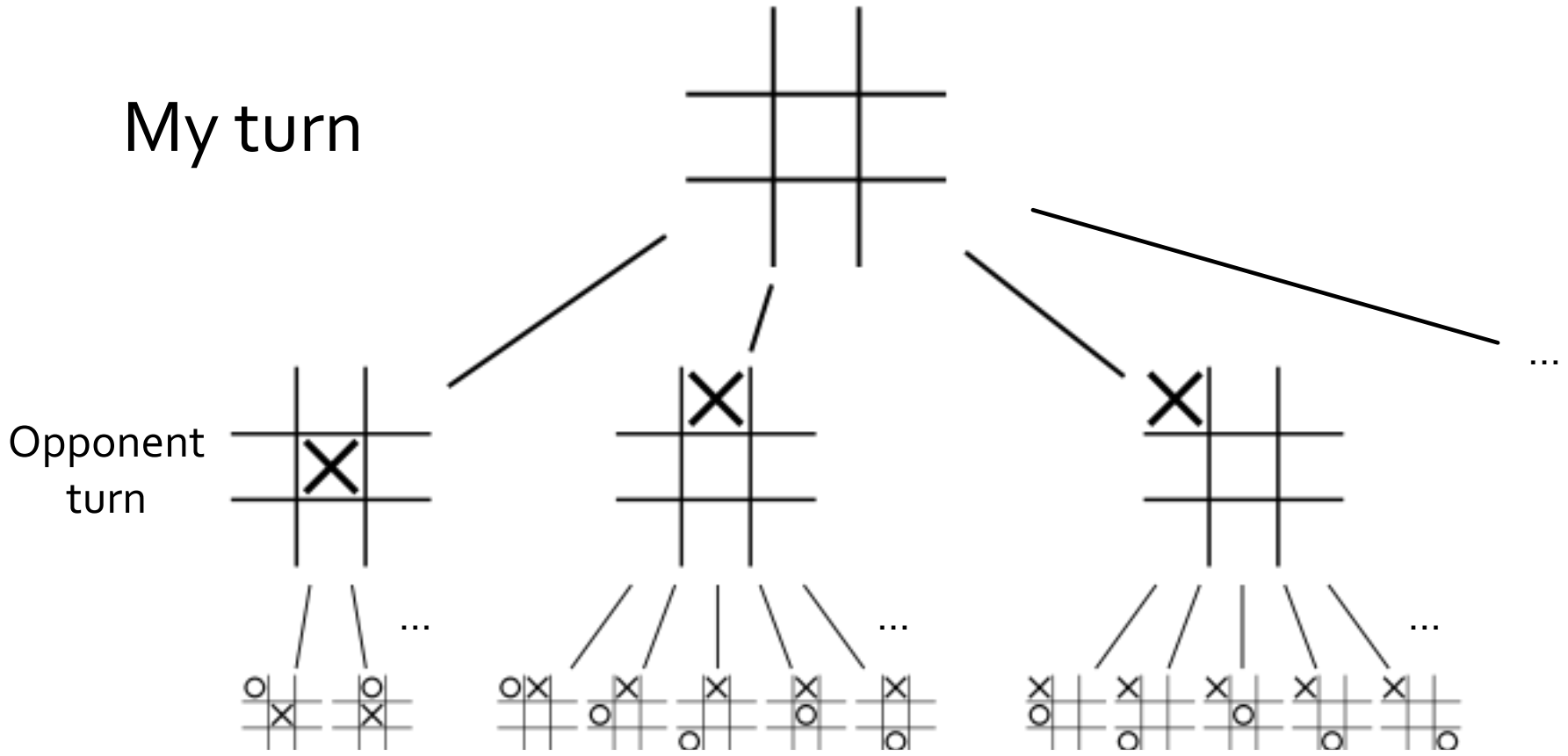
„Reasoning as search“
Game Space



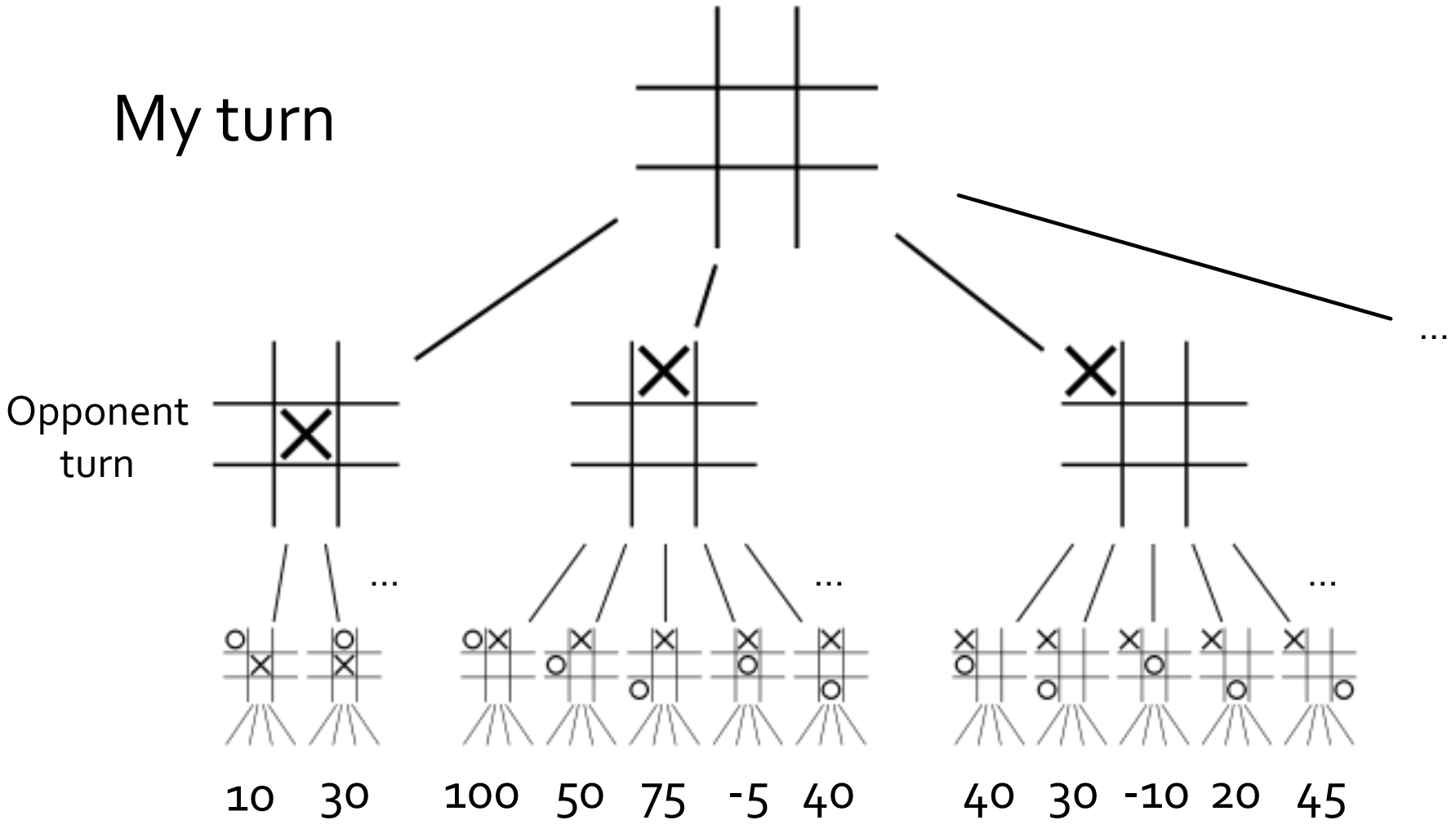
Turn-based

Environment is discrete
Actions are deterministic
Limited number of available actions

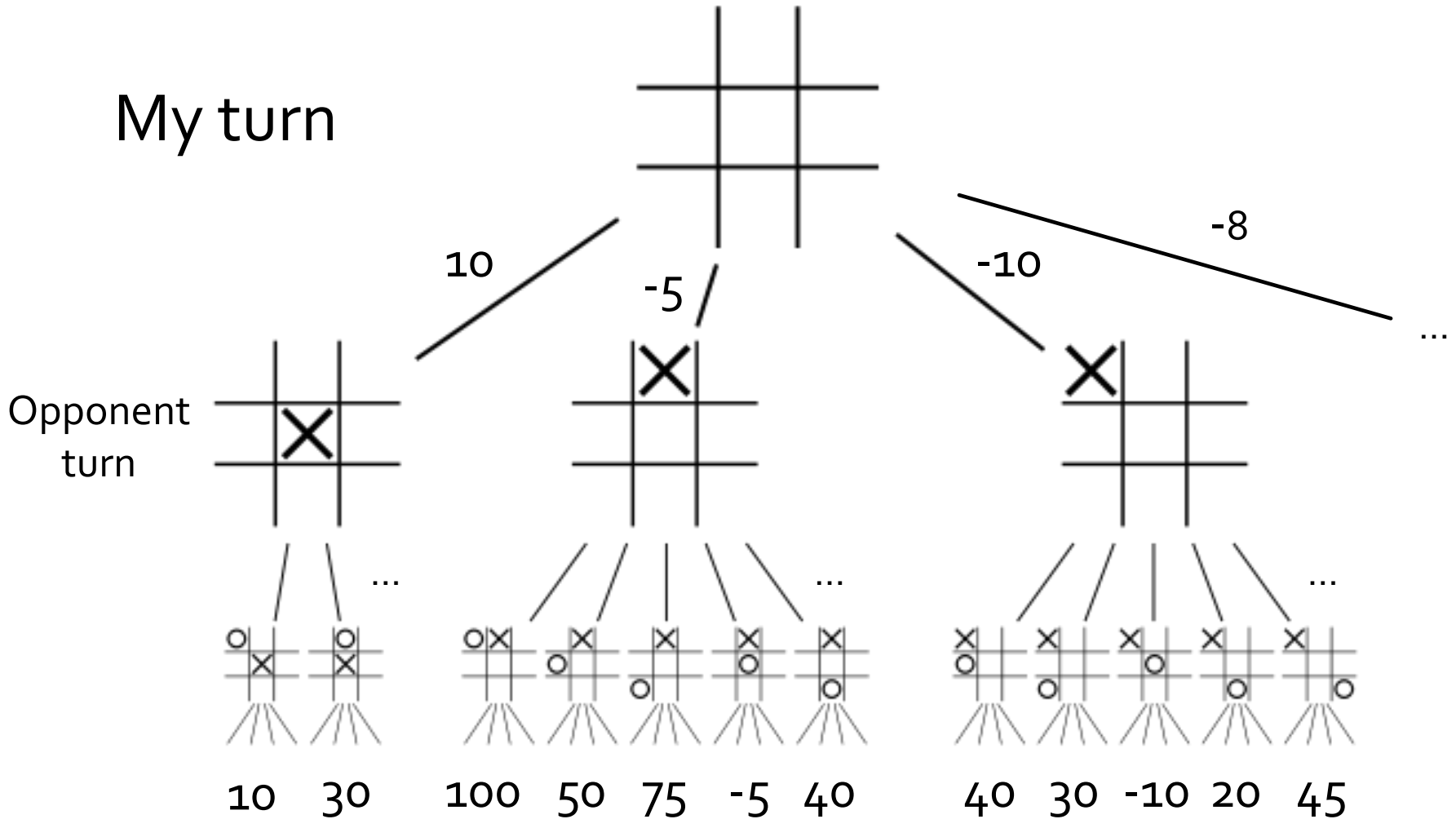
„Reasoning as search“
What if the space is too big?



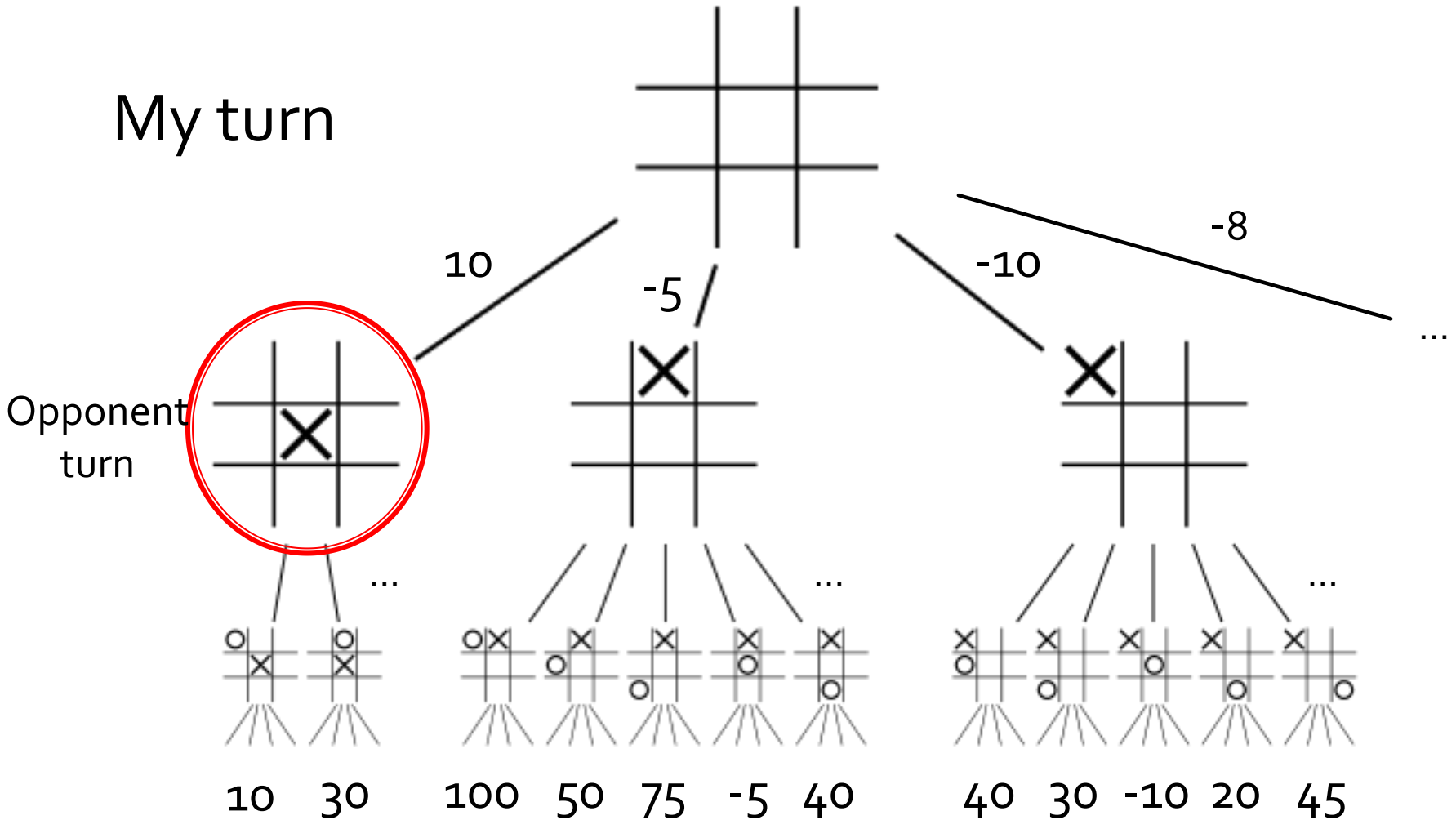
„Reasoning as search“
Apply heuristic scoring



„Reasoning as search“
Propagate values

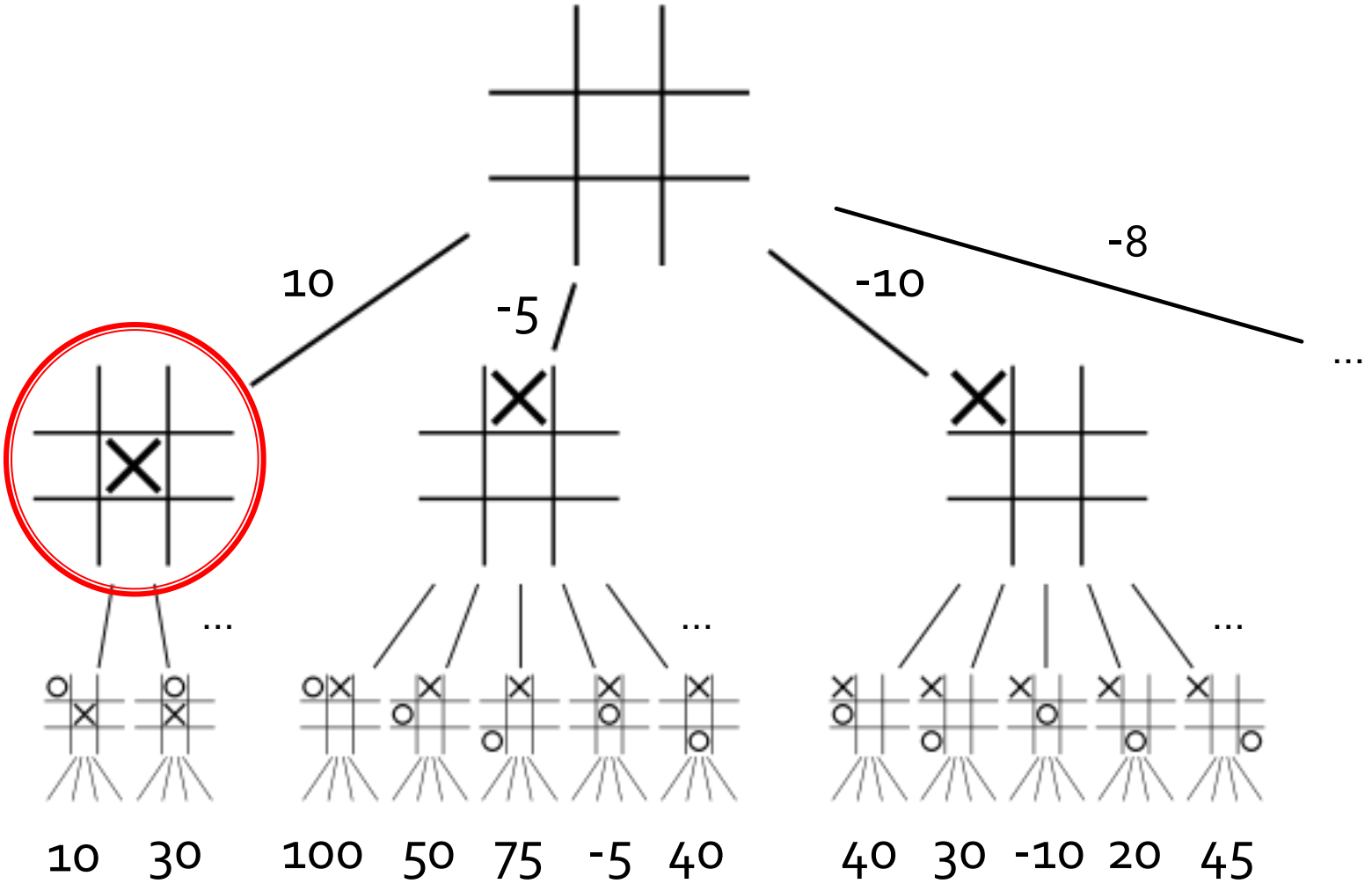


„Reasoning as search“
Choose the best



„Reasoning as search"

=> MIN-MAX / Alfa-Beta Algorithms



3D V-Environments
What can be said?

- Fully *vs.* Partially observable
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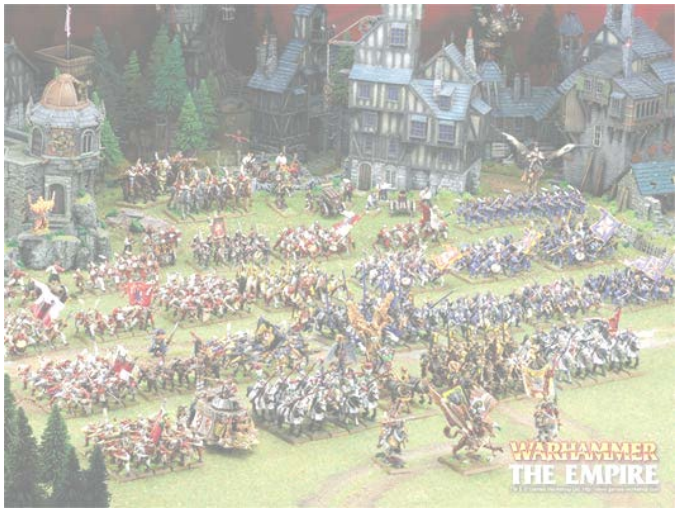

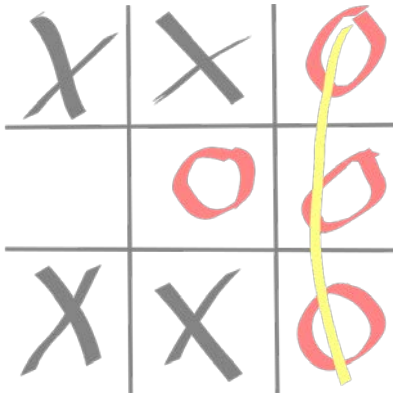

3D V-Environments

The (almost) worst case imaginable!

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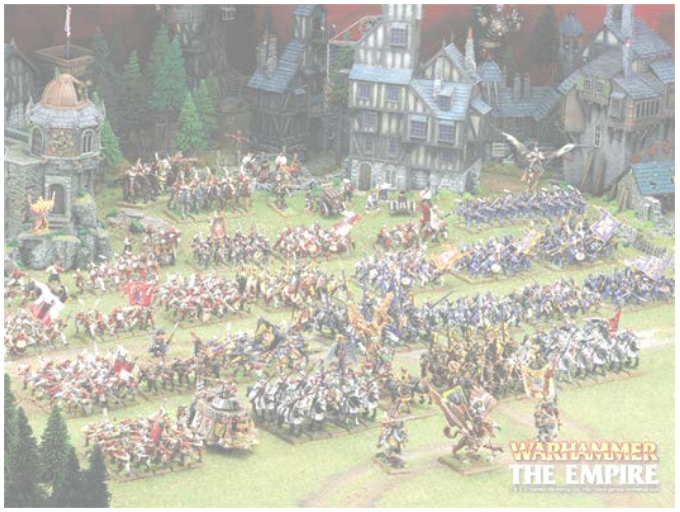

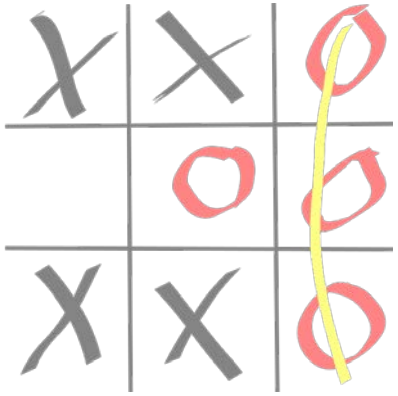

3D V-Environments

=> Hard to "search or plan"

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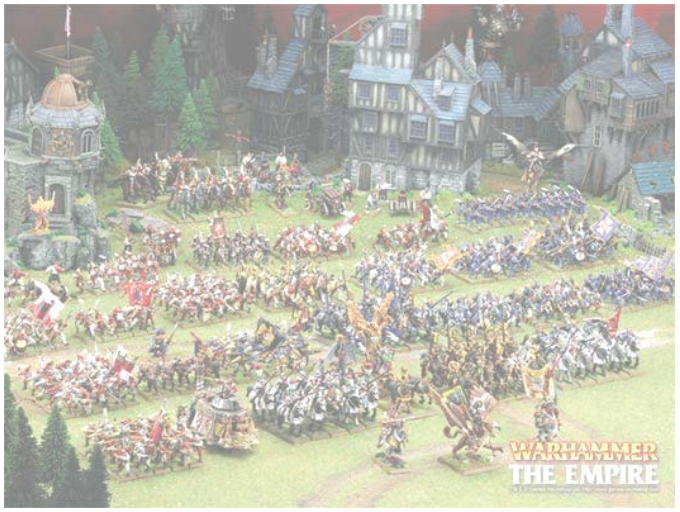

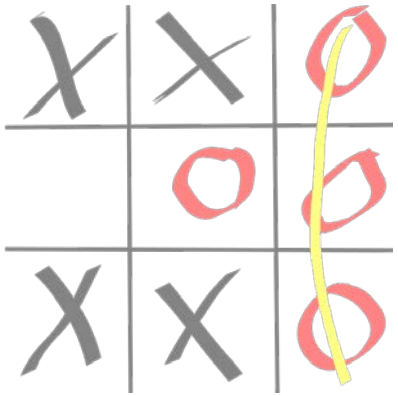

3D V-Environments

=> (Semi) Reactive Action-Selection

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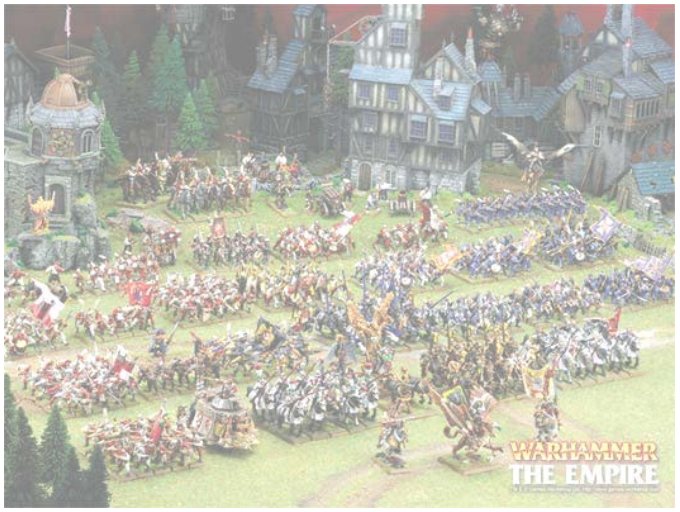
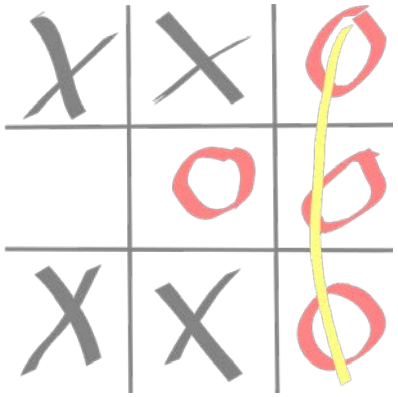
- Turn-based *vs.* Real-time
- Noiseless *vs.* Noisy





IVAs and Virtual Environments

How it works?

Environment state (E)

Action execution

Perception (P)

Action (A)

Memory / State (S)

1. Observed state E is exported to the agent **p: E -> P**
2. Agent performs action-selection **f: PxS -> AxS**
3. Actions are simulated in the environment: **s: A^n x E -> E**

One cycle for 2 agents: $\mathbf{E_{i+1} = s([f_1(p_1 (E_i), S_1), f_2 (p_2 (E_i), S_2)], E_i)}$

IVAs and Virtual Environments

Troublesome properties

Environment state (E)

Action execution

Perception (P)

Action (A)

Memory / State (S)

1. Observed state E is exported to the agent **p: E -> P**
2. Agent performs action-selection **f: PxS -> AxS**
3. Actions are simulated in the environment: **s: A^n x E -> E**

One cycle for 2 agents: $\mathbf{E_{i+1} = s([f_1(p_1 (E_i), S_1), f_2 (p_2 (E_i), S_2)], E_i)}$

IVAs and Virtual Environments

Troublesome properties

Environment state (E)

Continuous (infinite)

Memory / State (S)

Perception (P)

Action (A)

Action execution

1. Observed state E is exported to the agent **p: E -> P**
2. Agent performs action-selection **f: PxS -> AxS**
3. Actions are simulated in the environment: **s: A^n x E -> E**

One cycle for 2 agents: $\mathbf{E_{i+1} = s([f_1(p_1(E_i), S_1), f_2(p_2(E_i), S_2)], E_i)}$

IVAs and Virtual Environments

Troublesome properties

Environment state (E)

Action execution

Partially observable

Perception (P)

Action (A)

Memory / State (S)

1. Observed state E is exported to the agent **p: E -> P**
2. Agent performs action-selection **f: PxS -> AxS**
3. Actions are simulated in the environment: **s: A^n x E -> E**

One cycle for 2 agents: $\mathbf{E_{i+1} = s([\ f_1(p_1\,(E_i), S_1), f_2\,(p_2\,(E_i), S_2)\ ], E_i\ )}$

IVAs and Virtual Environments

Troublesome properties

Environment state (E)

Action execution

Perception (P)

Action (A)

Memory / State (S)

1. Observed state E is exported to the agent **p: E -> P**
2. Agent performs action-selection **f: PxS -> AxS**
3. Actions are simulated in the environment: **s: A^n x E -> E**

One cycle for 2 agents: $\mathbf{E_{i+1} = s([f_1(p_1 (E_i), S_1), f_2 (p_2 (E_i), S_2)], E_i)}$

Not fully deterministic

IVAs and Virtual Environments

Troublesome properties

Environment state (E)

Memory / State (S)

Perception (P)

Action (A)

Action execution

1. Observed state E is exported to the agent **p: E -> P**
2. Agent performs action-selection **f: PxS -> AxS**
3. Actions are simulated in the environment: **s: A^n x E -> E**

One cycle for 2 agents: $E_{i+1} = s([f_1(p_1(E_i), S_1), f_2(p_2(E_i), S_2)], E_i)$

Sequential, Dynamic, Real-time

IVAs and Virtual Environments

Troublesome properties

Environment state (E)

Action execution

Perception (P)

Action (A)

Memory / State (S)

1. Observed state E is exported to the agent **p: E -> P**
2. Agent performs action-selection **f: PxS -> AxS**
3. Actions are simulated in the environment: **s: A^n x E -> E**

One cycle for 2 agents: $\mathbf{E_{i+1} = s([\ f_1(p_1(E_i), S_1), f_2(p_2(E_i), S_2)\ ], E_i)}$

Multi-agent Interactive

IVAs and Virtual Environments

Troublesome properties

Environment state (E)

Action execution

Perception (P)

Action (A)

Memory / State (S)

1. Observed state E is exported to the agent **p: E -> P**
2. Agent performs action-selection **f: PxS -> AxS**
3. Actions are simulated in the environment: **s: A^n x E -> E**

One cycle for 2 agents: $\mathbf{E_{i+1} = s([f_1(p_1 (E_i), S_1), f_2 (p_2 (E_i), S_2)], E_i)}$

Must act in timely fashion (bounded rationality, ms)

IVAs and Virtual Environments

Action-selection problem

Environment state (E)

Action execution

Perception (P)

Action (A)

Memory / State (S)

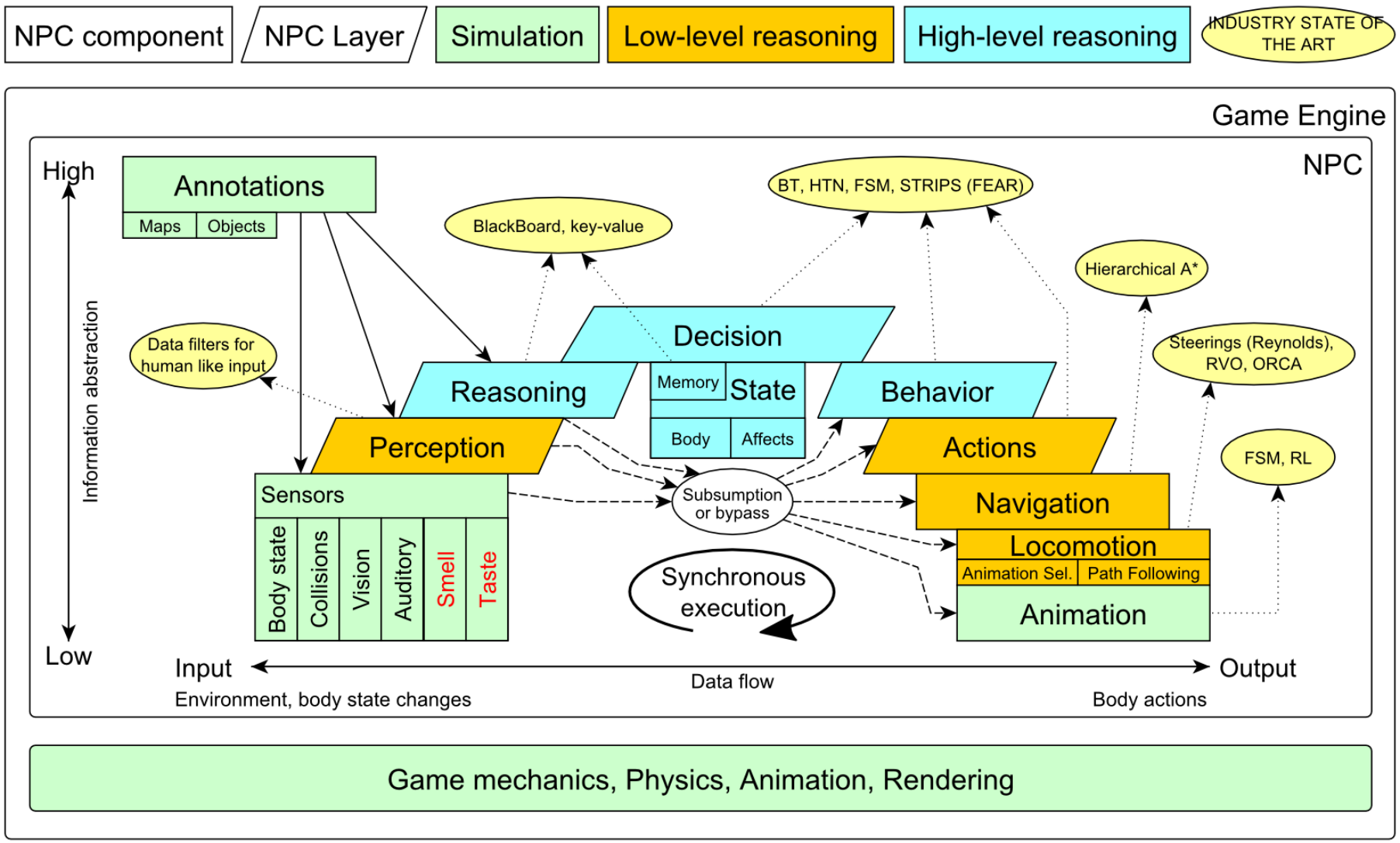
1. Observed state E is exported to the agent **p: E -> P**
2. Agent performs action-selection **f: PxS -> AxS**
3. Actions are simulated in the environment: **s: A^n x E -> E**

One cycle for 2 agents: $\mathbf{E_{i+1} = s([f_1(p_1 (E_i), S_1), f_2 (p_2 (E_i), S_2)], E_i)}$

What to do next?

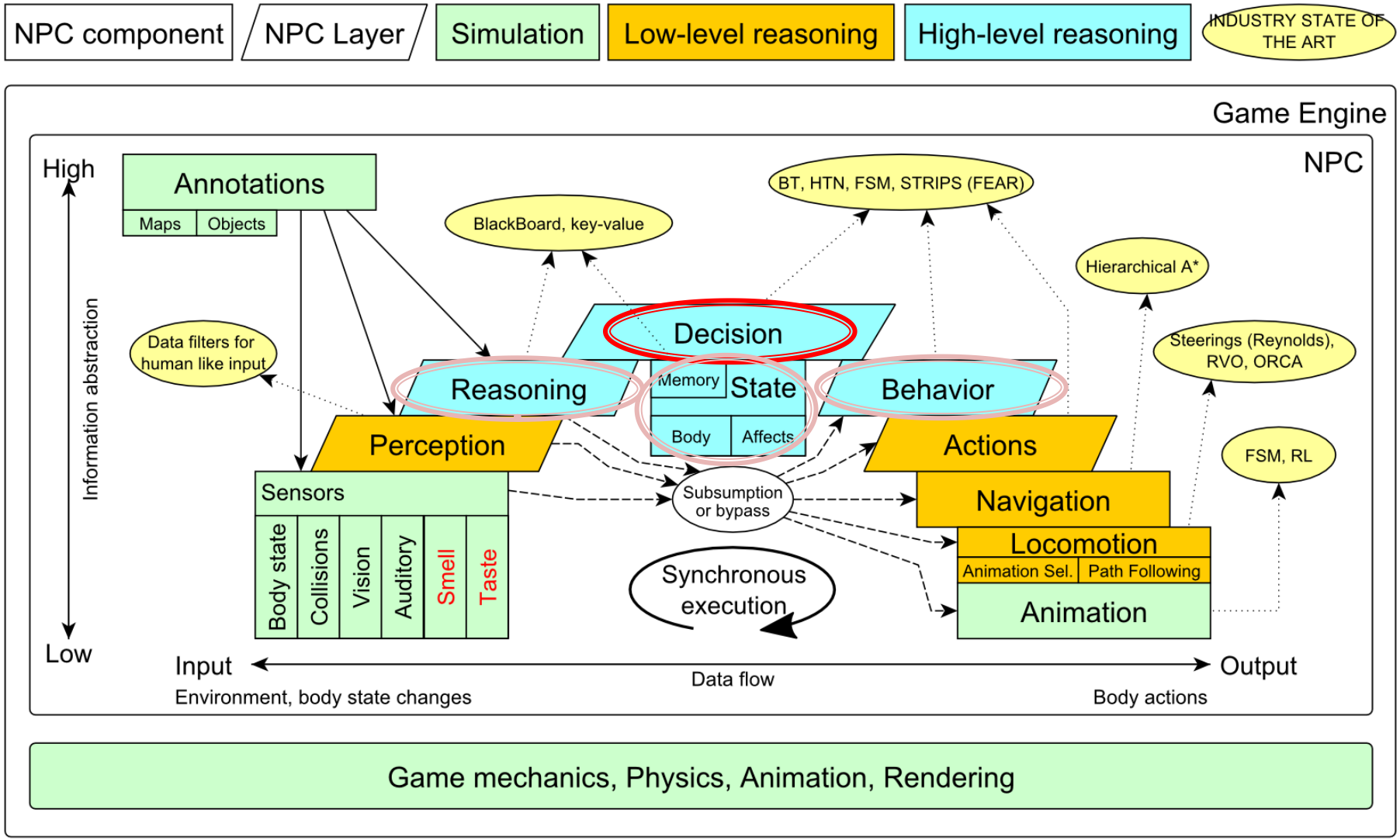
IVA in Video Games

Architecture



IVA in Video Games

"Action-selection"



Reactive Planning

An approach to action-selection problem

- Oxymoron *(from classical AI point of view)*
- Instead of calculating a plan in advance, the planner finds just the next action in every instant
- No unified definition
- „**Reactive planning** … chooses only the immediate **next action**, and bases this choice on **the current context**. In most architectures utilizing this technique, reactive planning is facilitated by the presence of **reactive plans**. Reactive plans are stored structures which, given the current context, determine the next act.“

  [Bryson & Stein, 2000]
- The choice must be made in a "**timely fashion**"

Reactive Planning

An approach to action-selection problem

- Performs: **f: PxS -> AxS**
  - P – set of percepts
  - S – mental states
  - A – set of possible actions

- Techniques
  - production rules
    - flat, hierarchical, heterarchical
  - finite state machines
  - fuzzy modifications, probabilistic modifications
  - free-flow hierarchies (?)
  - neural networks (?)
  - …