Cognitive Systems

T10

2020 edition

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João E. Kogler Jr.

cognitio

PSI 3560 – COGNITIVE SYSTEMS

class T10

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Department of Electronic Systems Engineering

ADAPTIVE SYSTEMS

Adaptation, cellular automata, artificial life, morphogenesis

Session T10

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Summary

  - Second session (9:20 – 11:00)
- Course Project example
  - based on artificial life

Course project

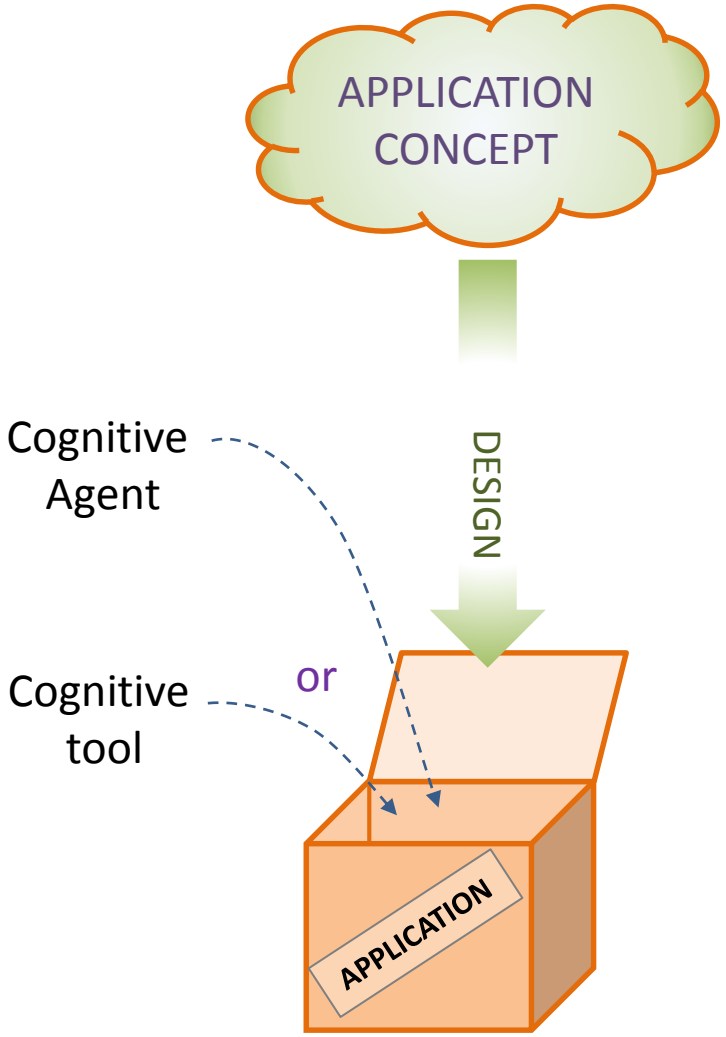
- Technical steps
  - Conceptual design
    - Uses → what for ?
    - Use → how ?
  - Pre-project
    - Functional specification → what it does ?
    - Foundational specification → how to accomplish ?
  - Project
    - Formal specification → (cognitive) architecture
    - Design specification → choice of methods
    - Project formalities → contract, deadline, costs
  - Design
  - Implementation
  - Tests
  - Application deployment

What kind of Cognitive system the application is:

- A cognitive agent
- A cognitive tool

Design of a Cognitive System – 1st step

- Conceptual analysis:
  - What the application does ?
    - » It is a cognitive system that does… ?
  - How does it do that ?
    - » Agent or tool ?



Design of a Cognitive System – 1st step

- Conceptual analysis:
  - What the application does ?

- Example:

  "An Artificial Life Approach for the animation of cognitive characters" (2001)

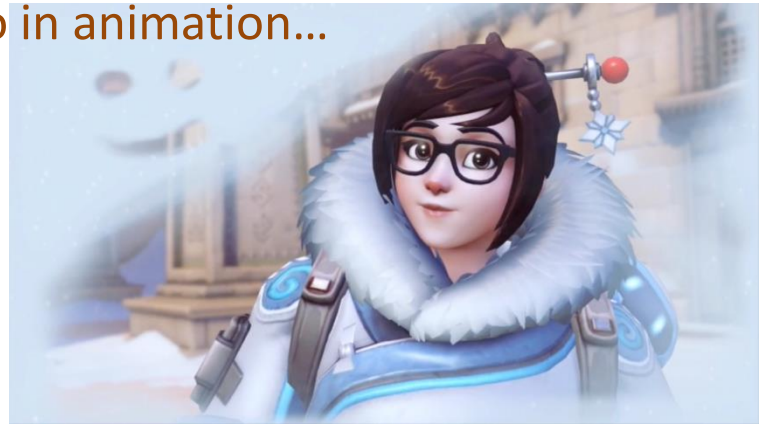
  Fabio R. de Miranda, João E. Kogler Jr. , Marcio Lobo Netto

  - Desire:
    - "Make some project that fits into robotics + computer graphics based animation"

Design of a Cognitive System – 1st step

- Conceptual analysis:
  - What the application does ?

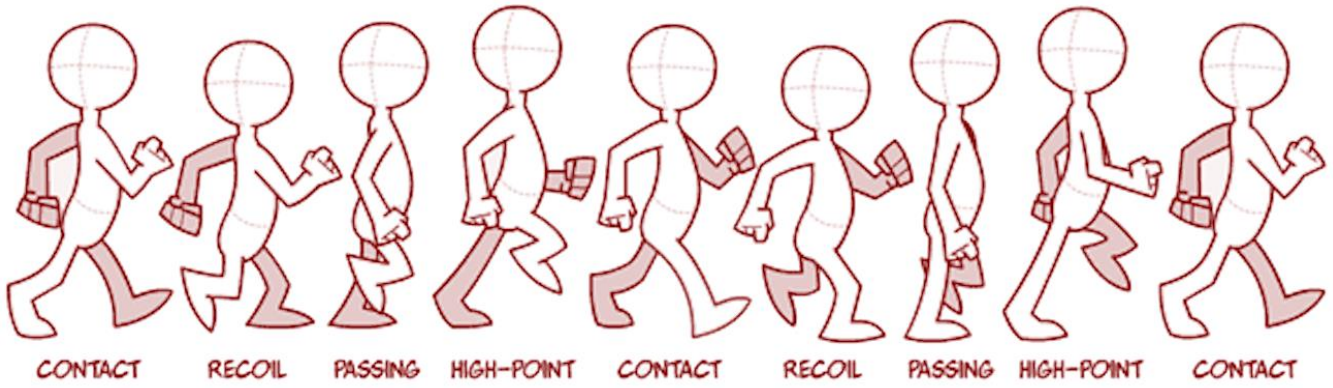
- Example:
  - Desire:
    - "Make some project that fits into robotics + computer graphics based animation"
      - Let's check what people do in animation…

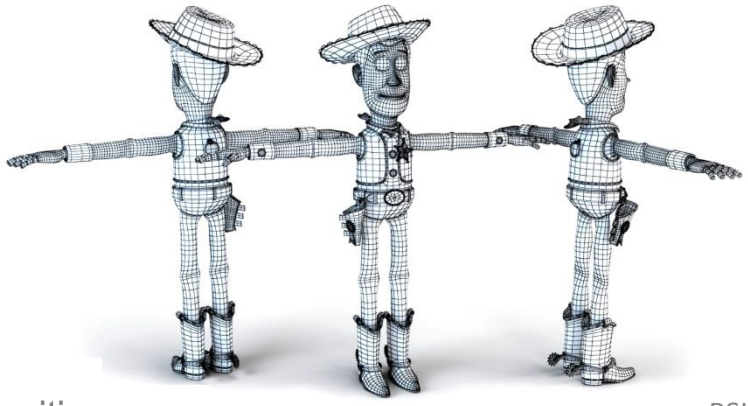


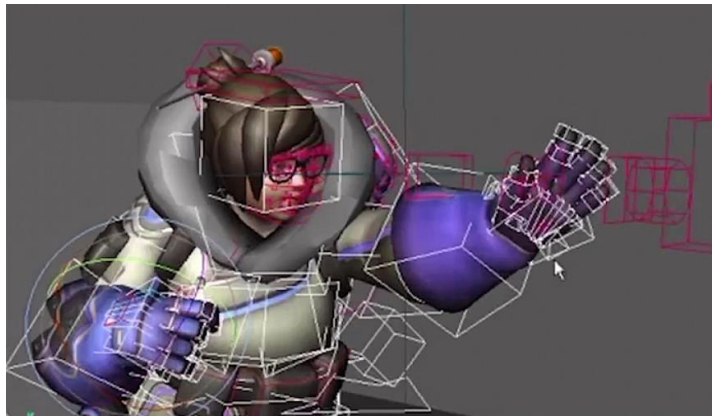
>>>>>> Play Mei animation file

Design of a Cognitive System – 1st step

- Conceptual analysis:
  - What the application does ?
- "Make some project that fits into robotics + computer graphics based animation"
  - Let's check what people do in animation…
    - They make models of the characters and animate them step by step







Design of a Cognitive System – 1st step

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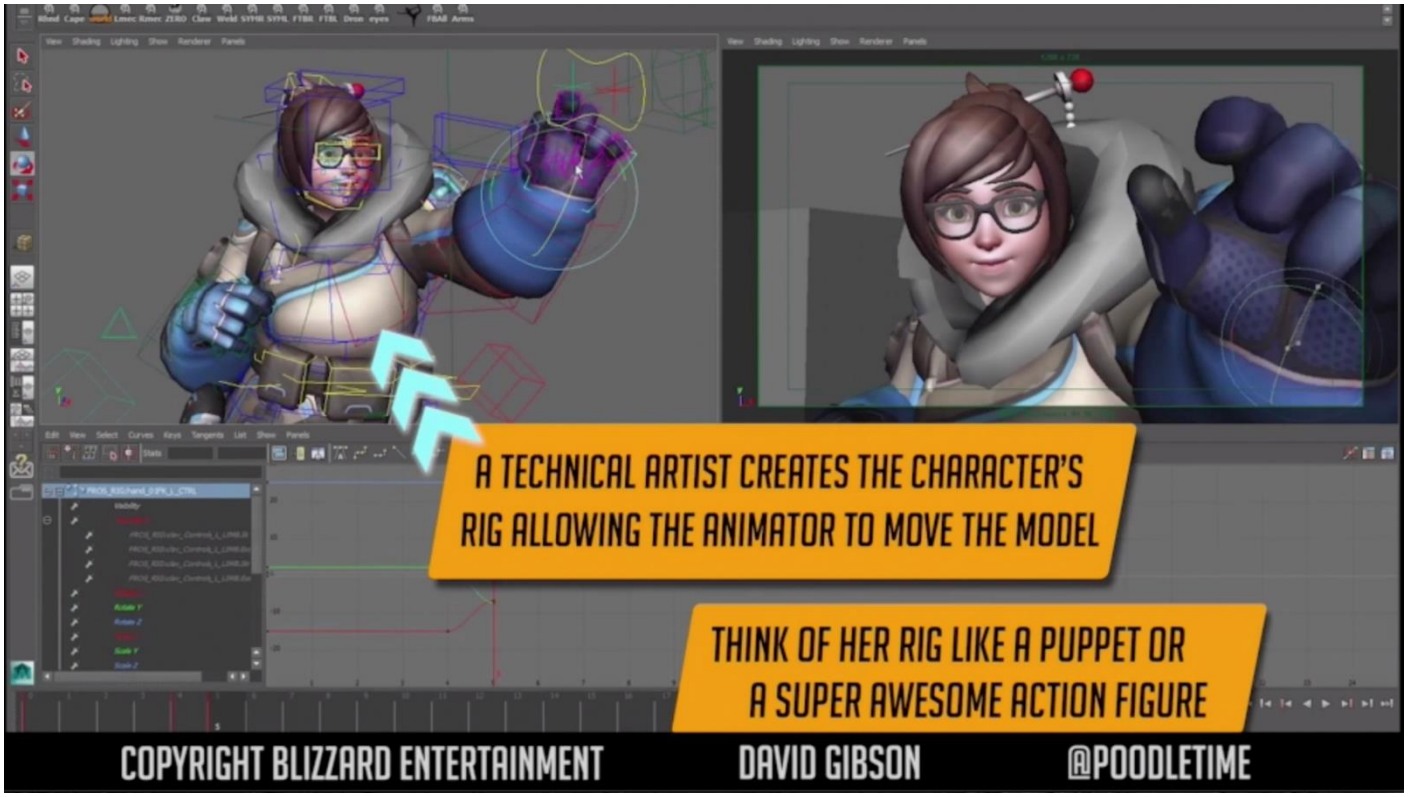
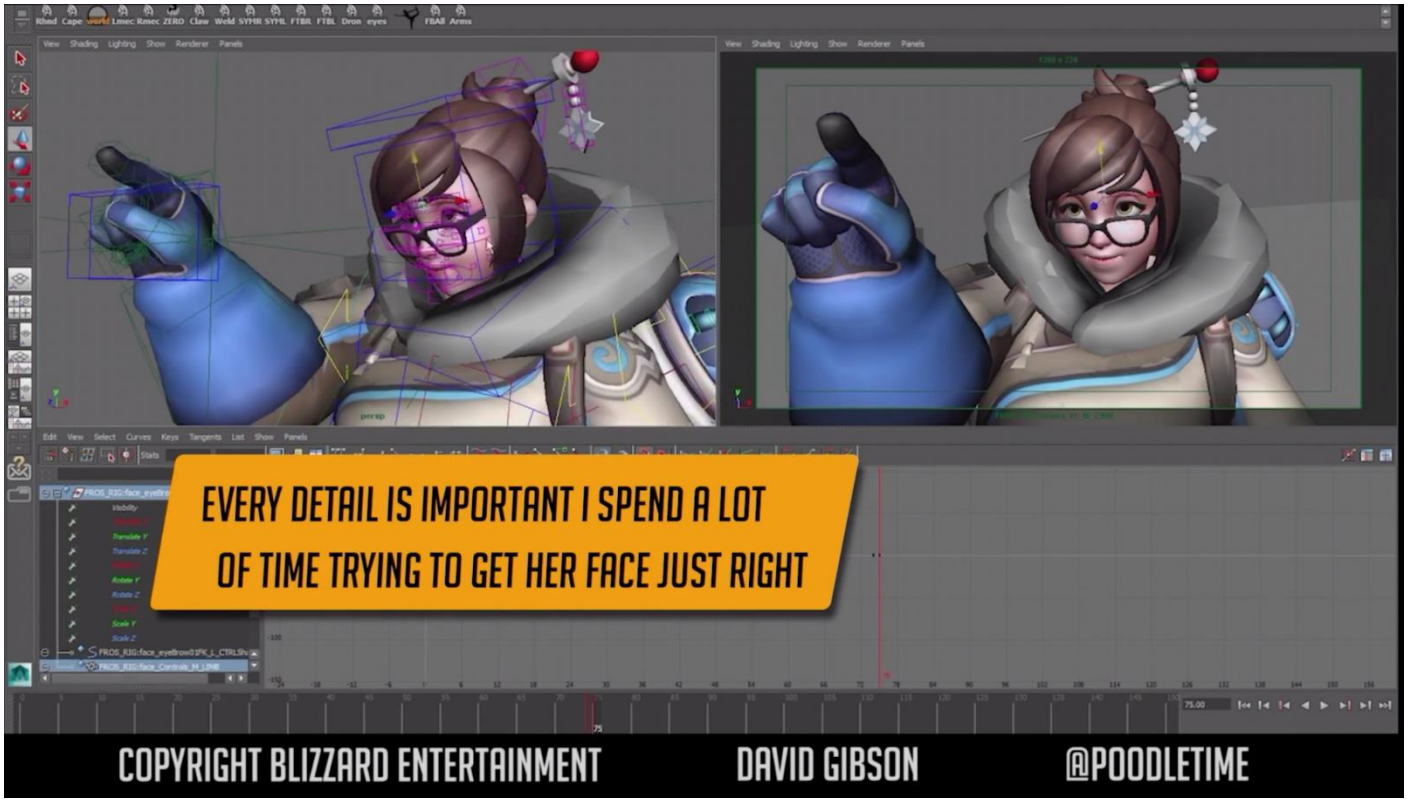
  - What the application does ?
- "Make some project that fits into robotics + computer graphics based animation"
  - Let's check what people do in animation…

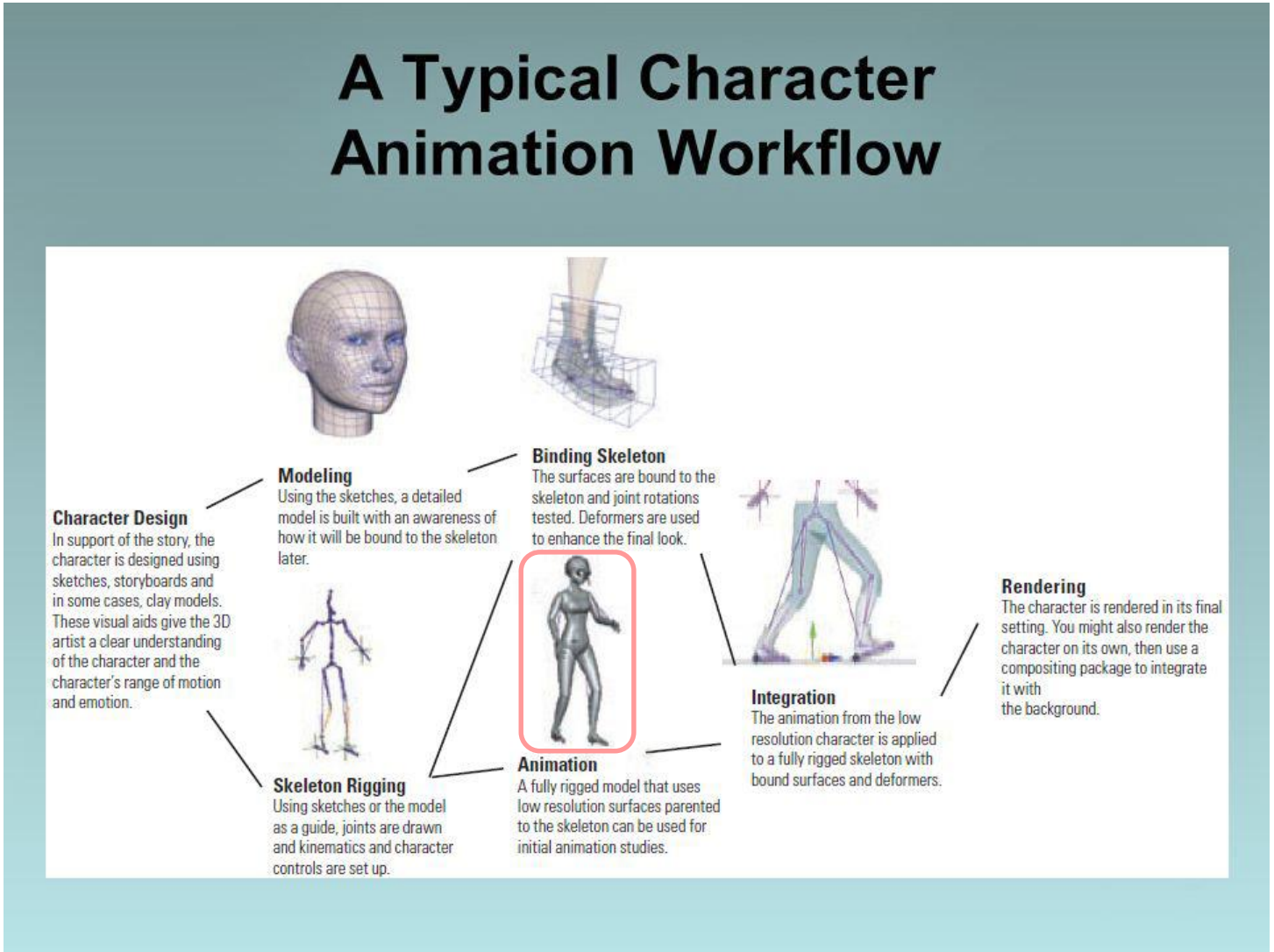


Design of a Cognitive System – 1st step

- Conceptual analysis:
  - What the application does ?
- "Make some project that fits into robotics + computer graphics based animation"
  - It's a very time-consuming activity

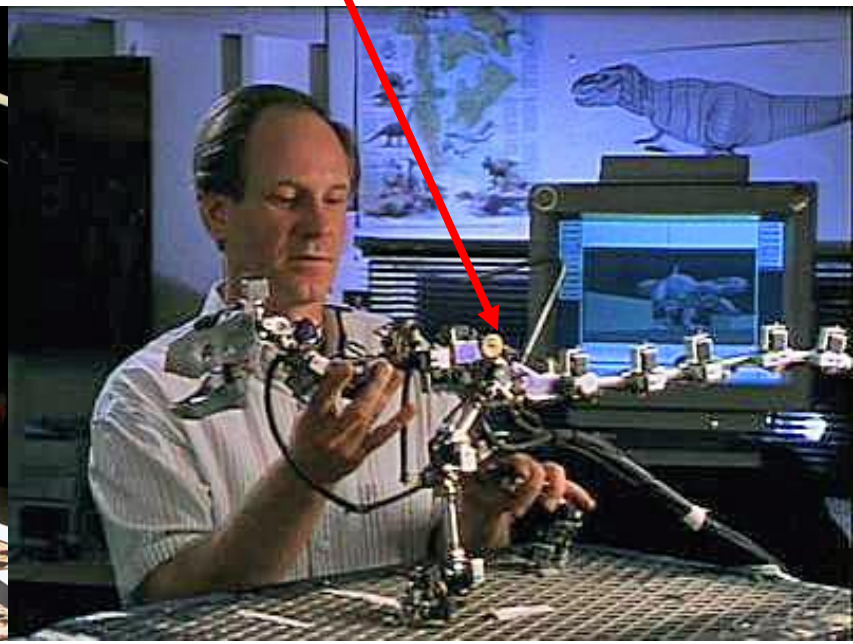


Design of a Cognitive System – 1st step



Design of a Cognitive System – 1st step

- Desire:
  - "Make some project that fits into robotics + computer graphics based animation"
    - So one could help by making the process more productive…
      - » New kind of data entry → Physical mockup



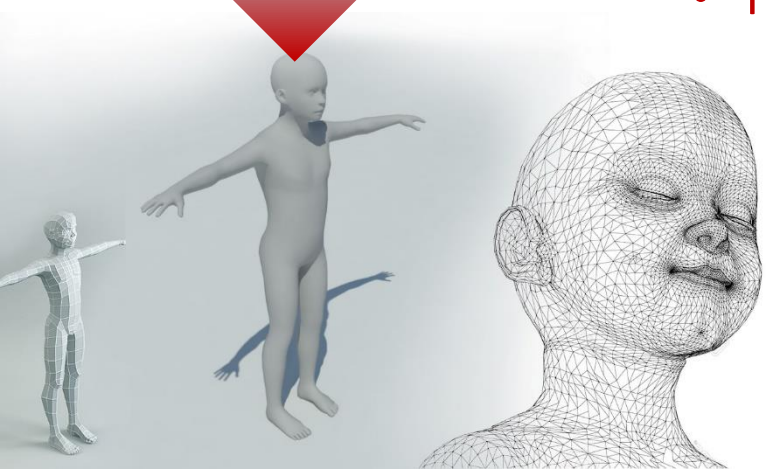
Design of a Cognitive System – 1st step

- Desire:
  - "Make some project that fits into robotics + computer graphics based animation"
    - So one could help by making the process more productive…
      - » New kind of data entry → Motion capture

Design of a Cognitive System – 1st step

- Desire:
  - "Make some project that fits into robotics + computer graphics based animation"
    - So one could help by making the process more productive…
      - » New kind of character model for animation
        - Cognitive agent
          - That learns by automatic training
          - That's able to understand the action script
        - The animator acts like a movie director
          - Just pick the right character
          - And give it the movie action script for its part

Learning capacity



- 2nd step → Formalization
  - Write down everything

Design of a Cognitive System – 3rd step

- Technical steps
  - Conceptual design
    - Uses → what for ?
    - Use → how ?
  - Pre-project
    - Functional specification → what it does ?
    - Foundational specification → how to accomplish ?
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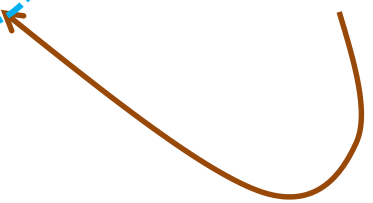
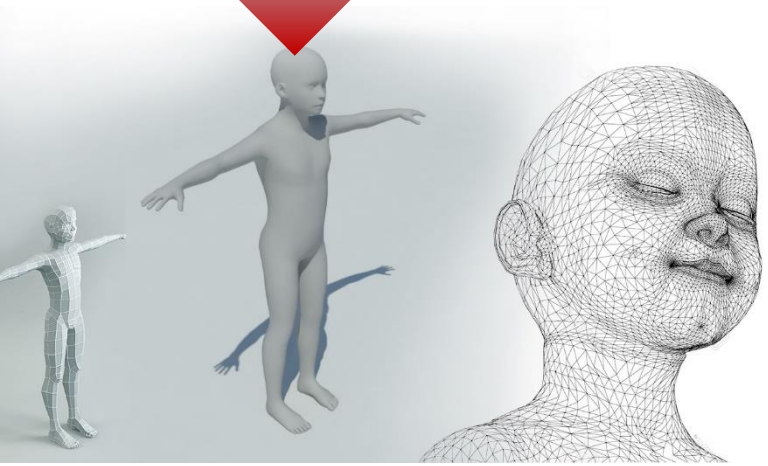


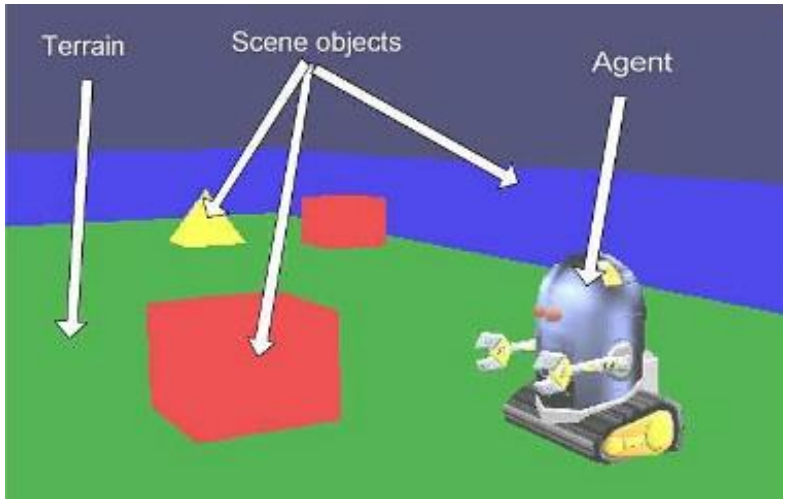
Design of a Cognitive System – 3rd step

- Pre-project
  - Functional specification → what it does ?
  - Foundational specification → how to accomplish ?

Learning capacity



» If the project is too complex, make a toy problem from it



Design of a Cognitive System – 3rd step

- Desire:
  - Cognitive agent
    - That learns by automatic training
    - That's able to understand the action script
  - The animator acts like a movie director
    - Just pick the right character
    - And give it the movie action script for its part

- Toy problem:
  - Cognitive agent
    - That learns by performing simple actions in a simple environment
    - That's able to adapt its behavioral basis to fit to the environment
    - The adaptations will be assimilated through an evolutionary processing
  - The animator has to wait..
    - This is just a proof of concept

Design of a Cognitive System – 3rd step

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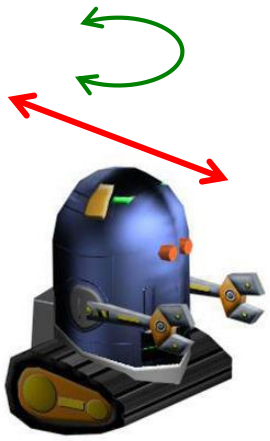
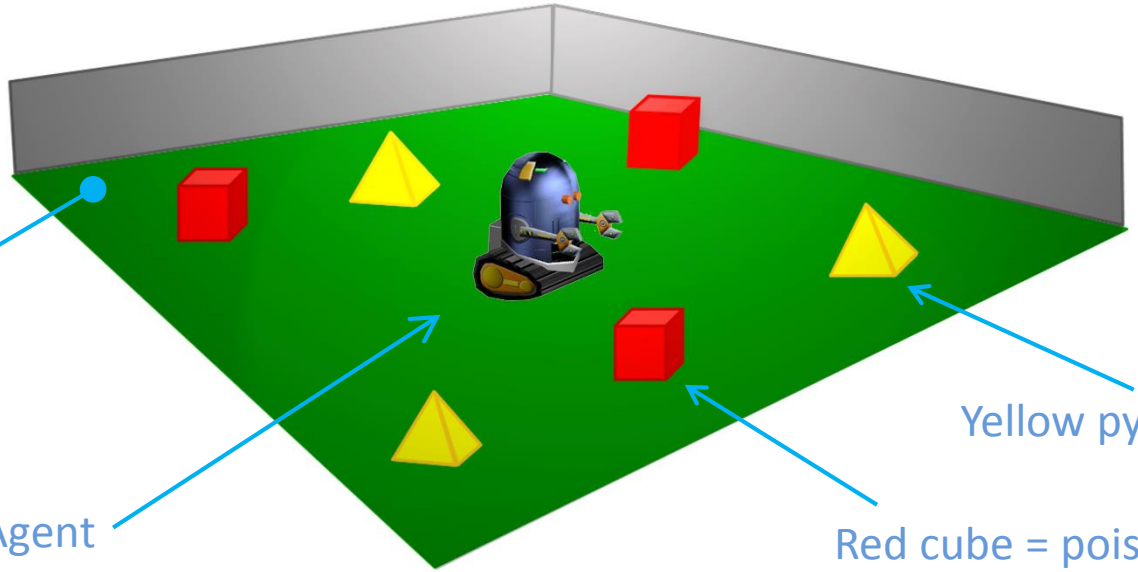


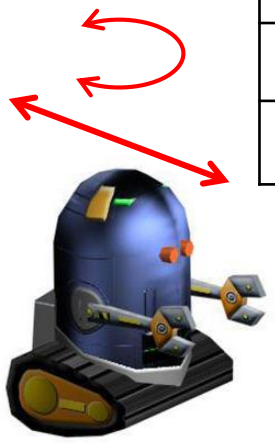


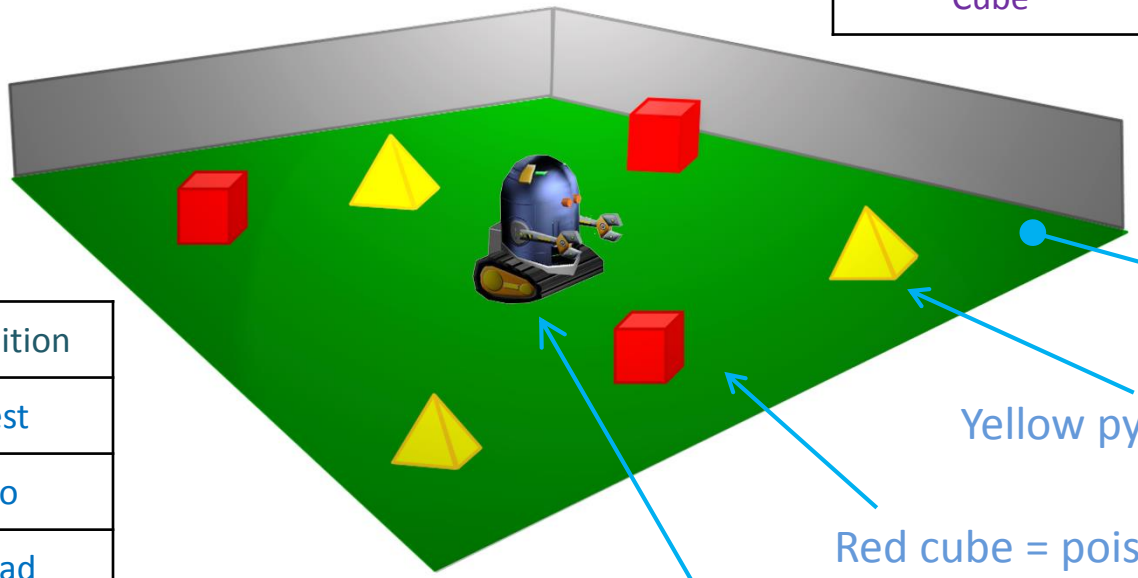
WOXBOT & ARENA ← Toy problem

Action	Code
Turn left	0
Go ahead	1
Turn right	2
Go backwards	3

World State	Code
Clean	0
Target object at left	1
Target object at center	2
Target object at right	3

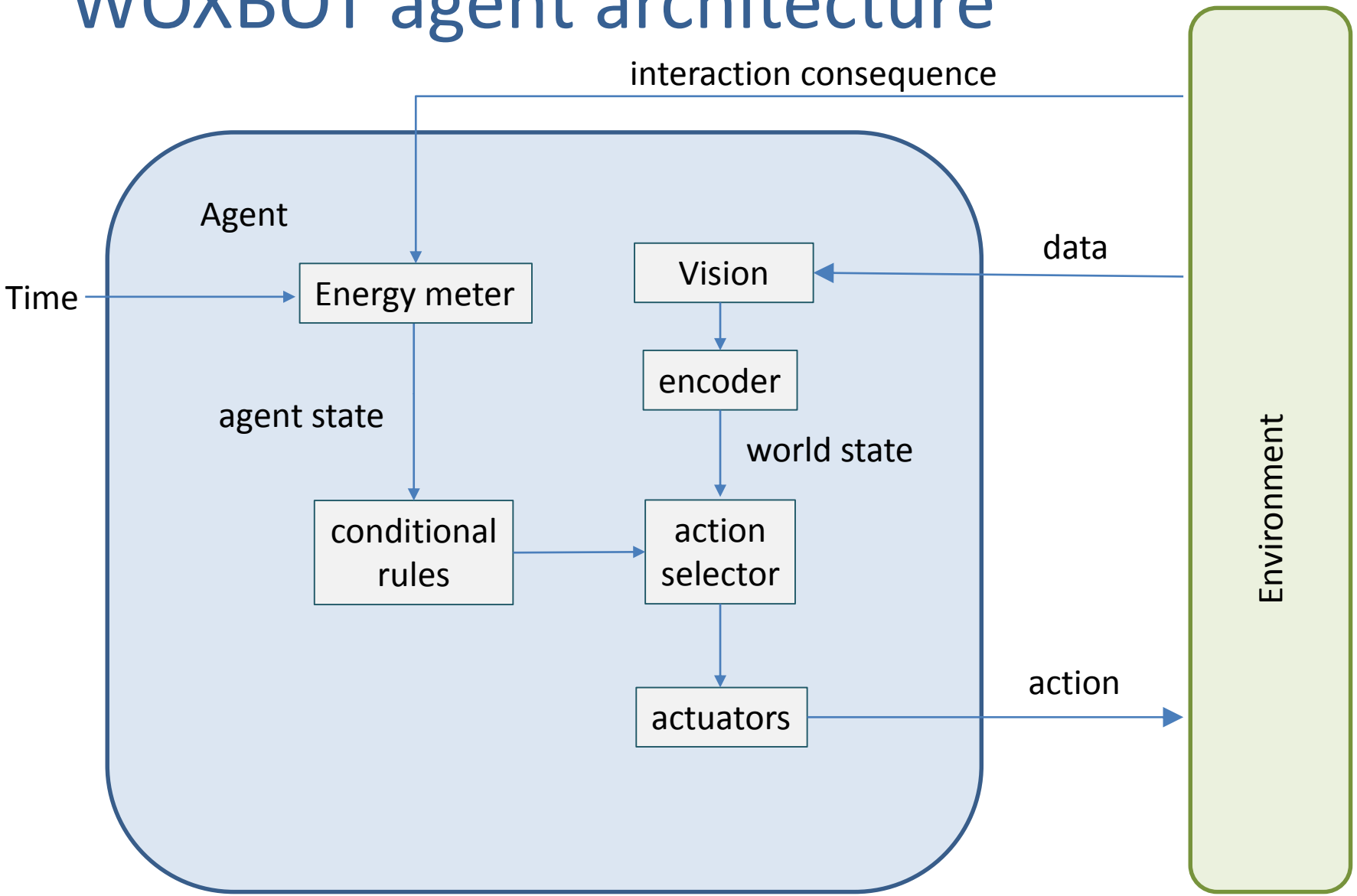
Object State	Consequence
Pyramid	Increase energy
Cube	Decrease energy





Agent State	Condition
High energy	Rest
Low energy	Go
No energy	Dead

WOXBOT agent architecture



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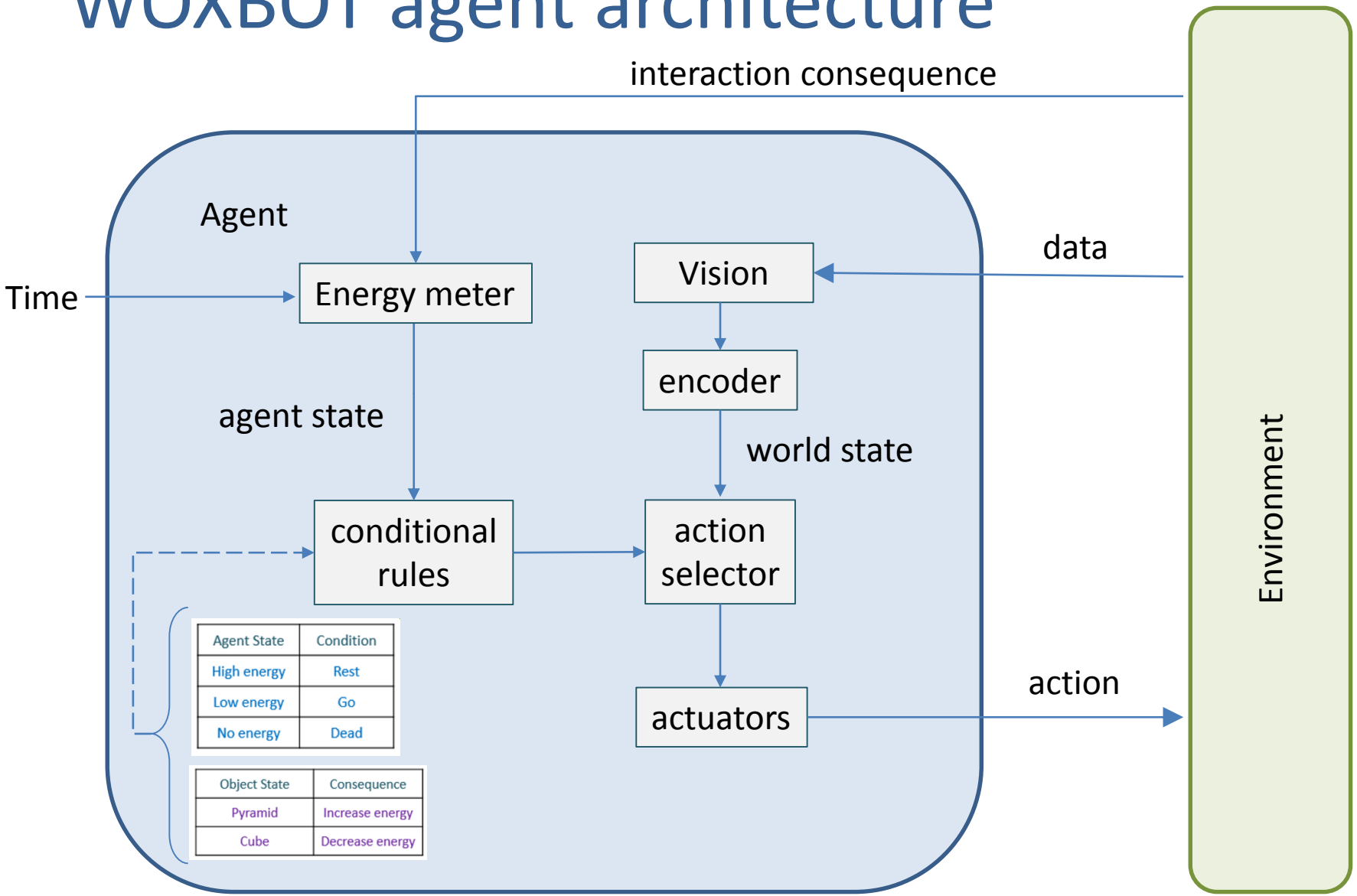

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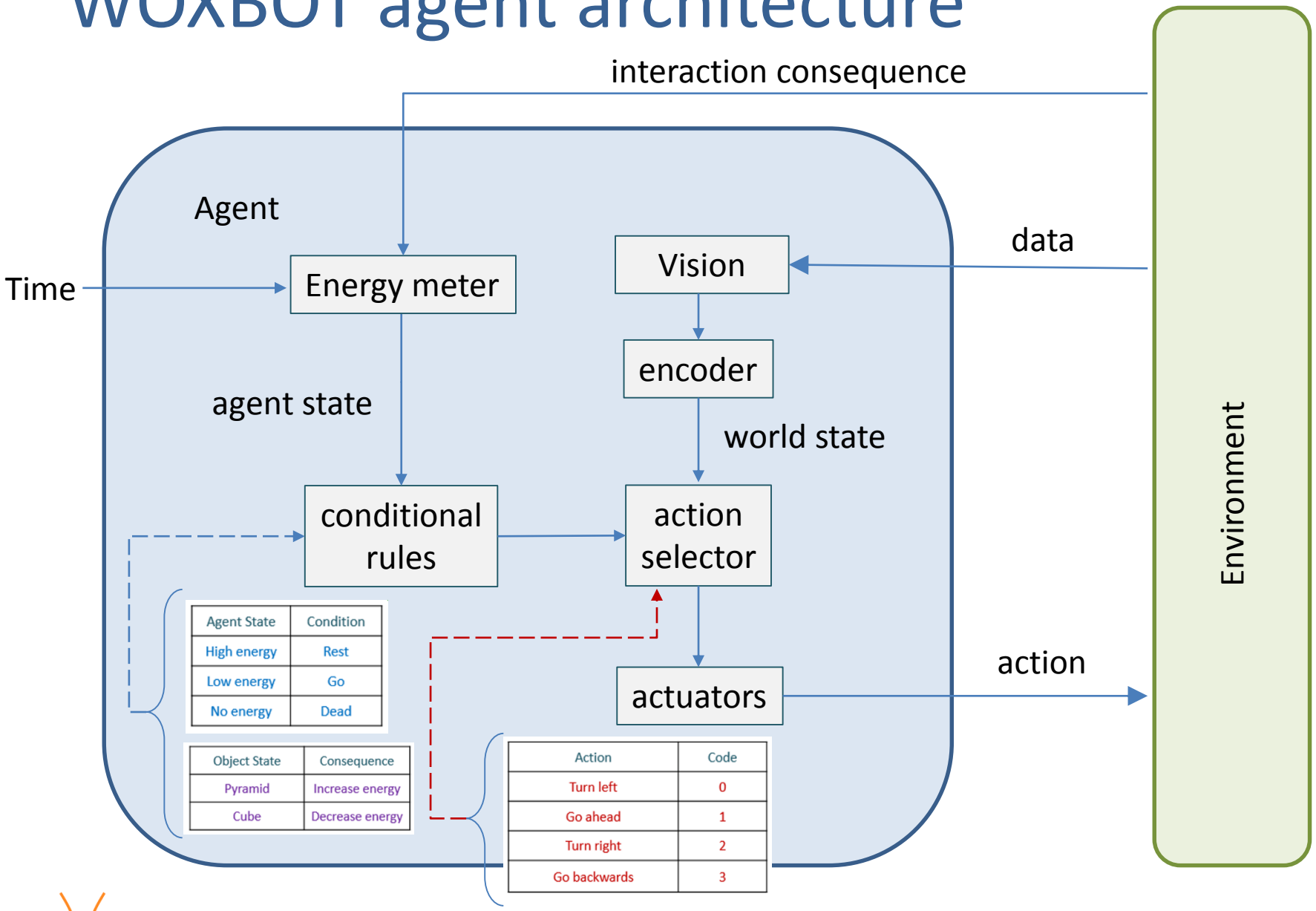

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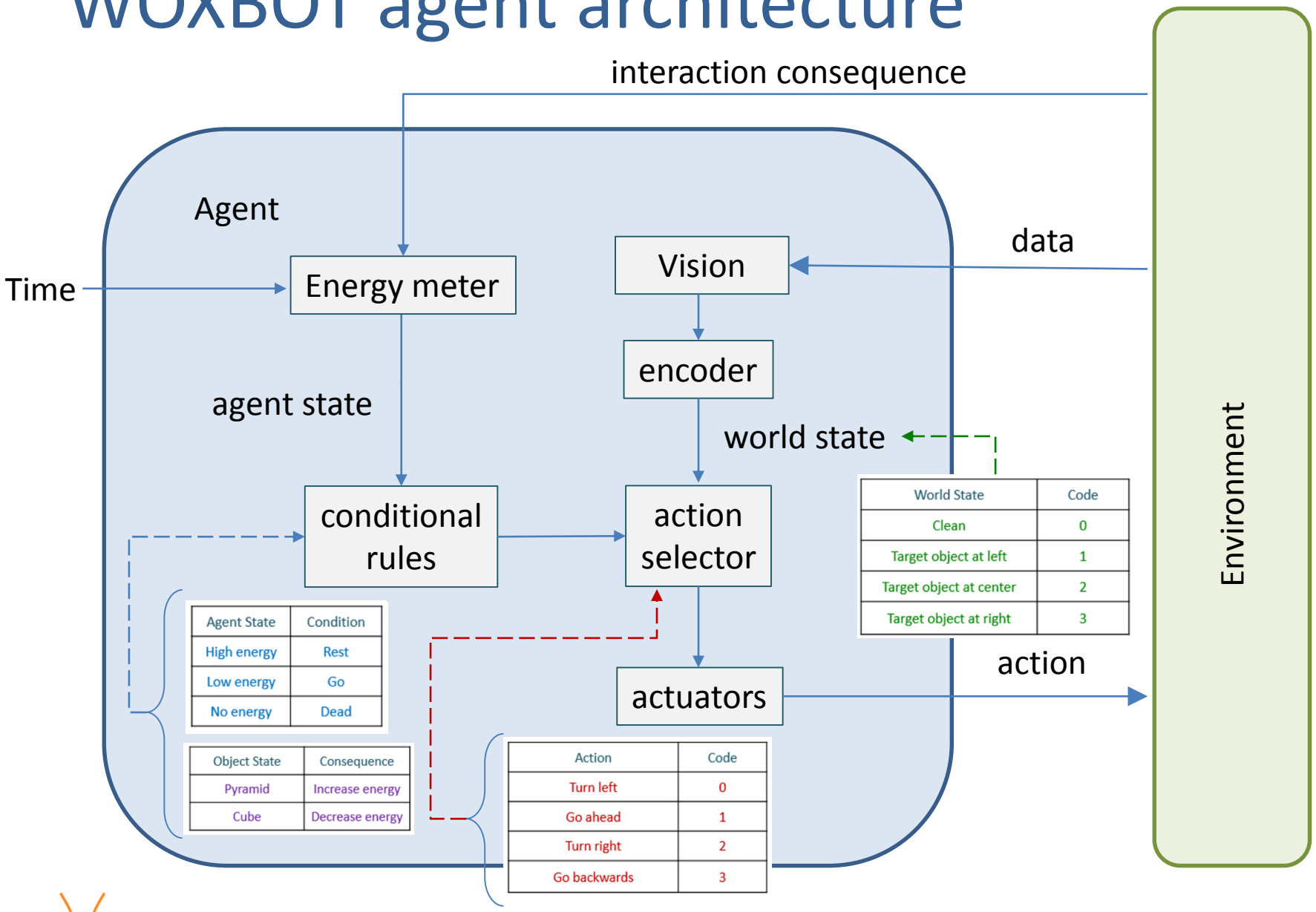

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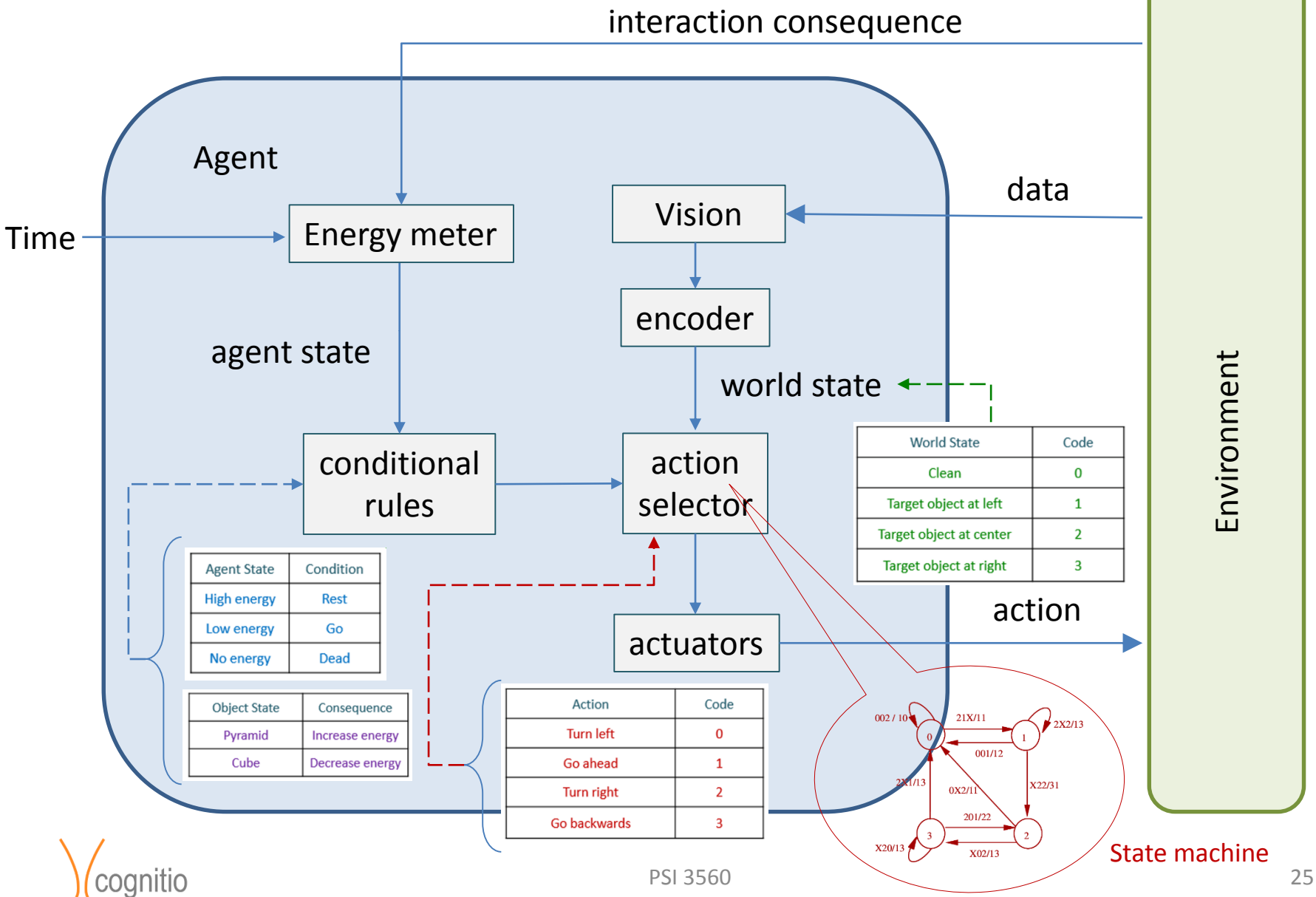

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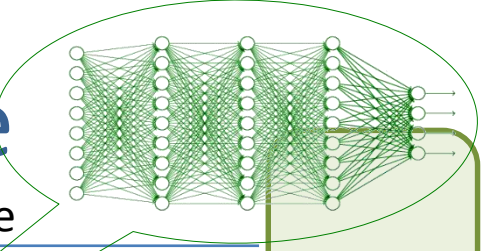

Neural network

interaction consequence

Agent

Time

Energy meter

Vision

data

encoder

agent state

world state

conditional rules

action selector

World State	Code
Clean	0
Target object at left	1
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Environment

Agent State	Condition
High energy	Rest
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action

actuators

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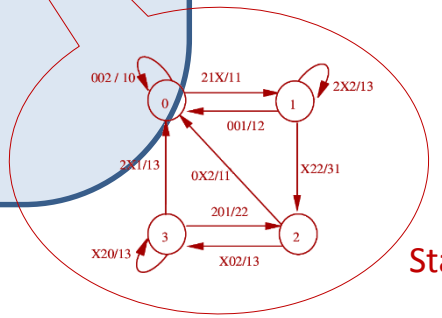

State machine

Design of a Cognitive System – 3rd step

- Technical steps
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Notice that:

- We specified the control architecture
- We still didn't considered the cognitive aspect
- So, we still haven't presented the cognitive architecture

Design of a Cognitive System – 3rd step

- Desire:
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Design of a Cognitive System – 3rd step

MODELLING THE COGNITIVE SYSTEM

– Marr's approach

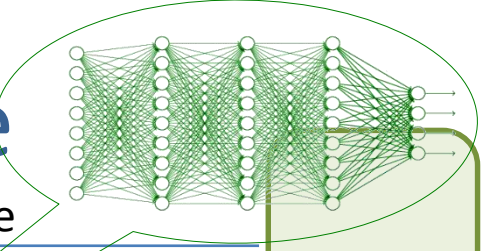
- Three levels of analysis
  - Computational model
    - » What kind of computations are required ?
    - » What is the nature of the computations ?
      - Logical, statistical , both ?
        - ARTIFICIAL INTELLIGENCE
        - MACHINE LEARNING
        - EVOLUTIONARY COMPUTATION
  - Algorithmic specification
  - Physical implementation

Design of a Cognitive System – 3rd step

MODELLING THE COGNITIVE SYSTEM

- Computational model
  - » What kind of computations are required ?
  - » What is the nature of the computations ?
    - EVOLUTIONARY COMPUTATION
  - » The evolutionary computation is here used as a means to incorporate a cognitive process
    - By incorporating knowledge
    - Building knowledge
    - Defining its use to control behavior
    - Increasing the agent's autonomy
  - » So, precisely where / when these (cognitive) processes may happen, via the evolutionary approach ?

WOXBOT agent architecture



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interaction consequence

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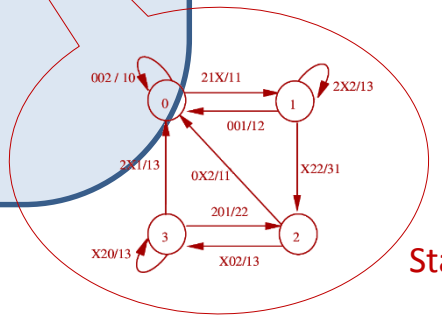
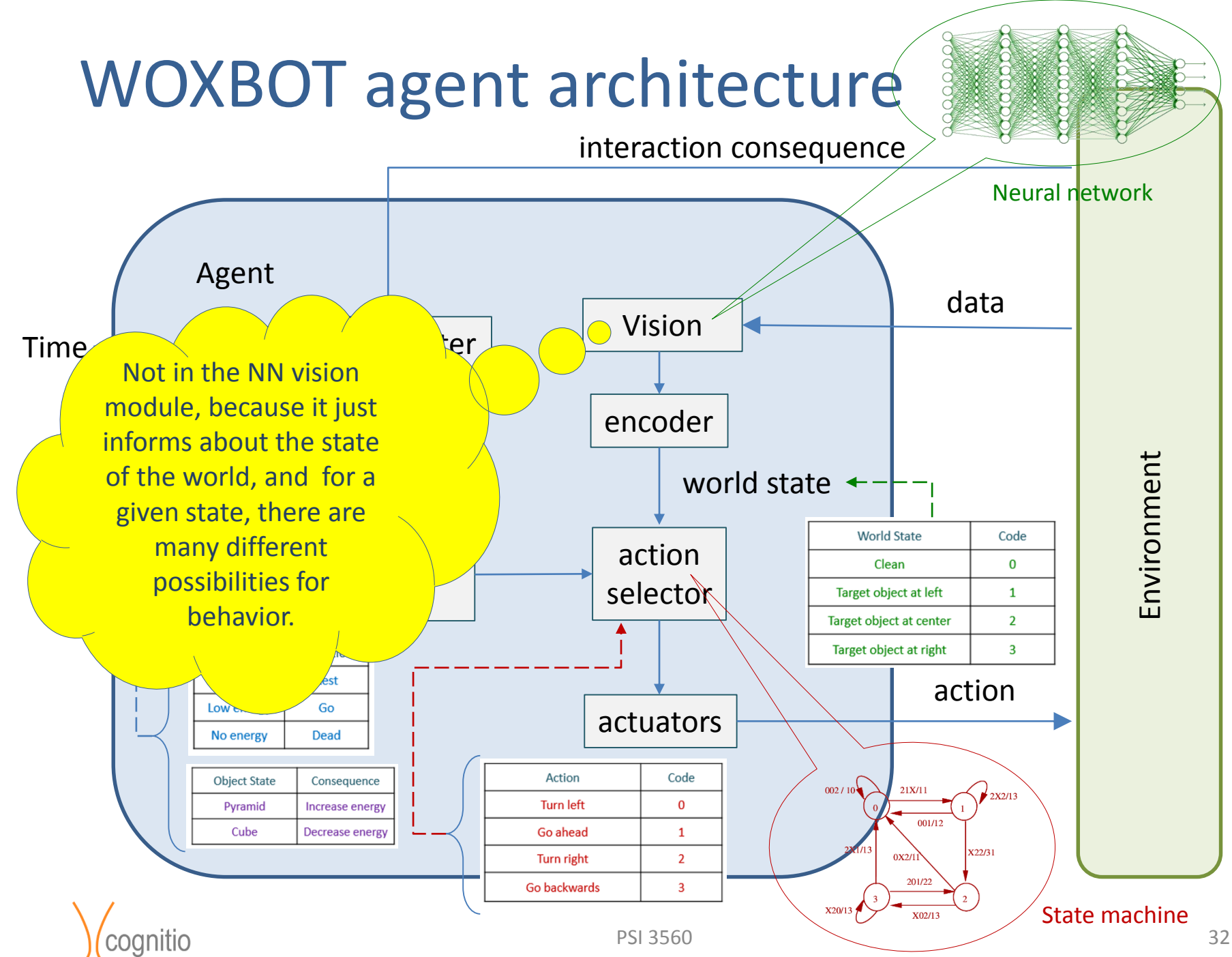
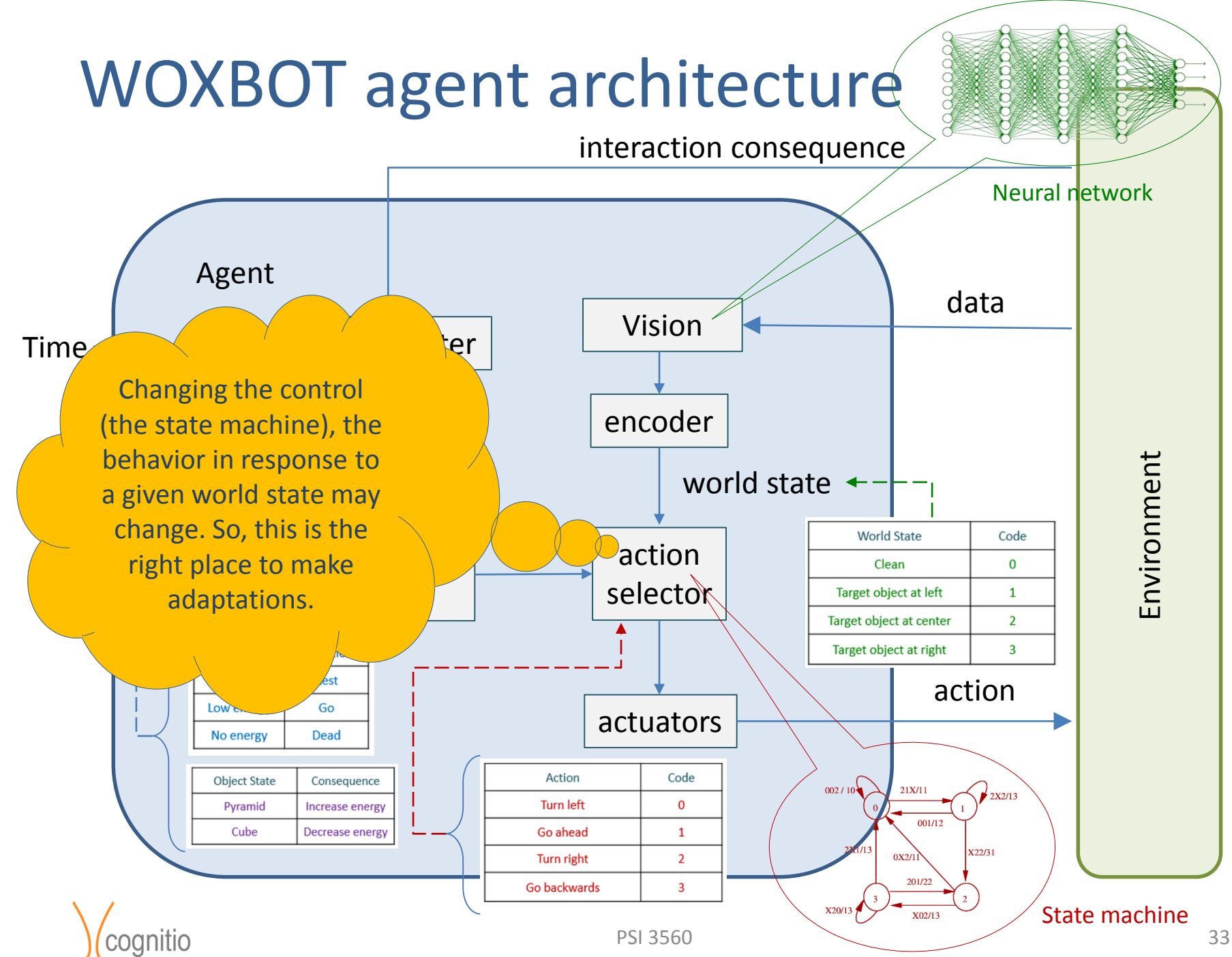


State machine

WOXBOT agent architecture



WOXBOT agent architecture



Design of a Cognitive System – 3rd step

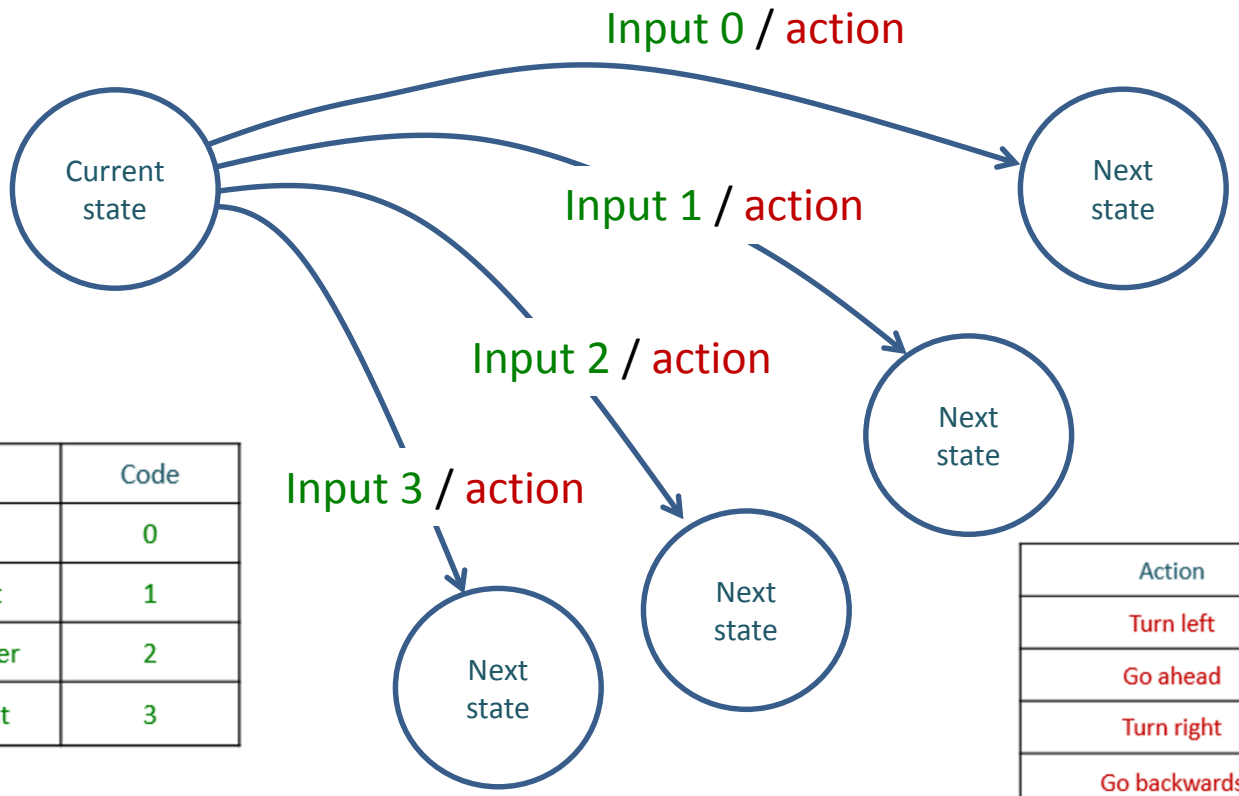
MODELLING THE COGNITIVE SYSTEM

- Computational model
  - » What kind of computations are required ?
  - » What is the nature of the computations ?
    - EVOLUTIONARY COMPUTATION
      - How to use evolutionary computation to change the behavioral control (state machine) of the agent ?
        - Must represent the state machine as an item capable of adaptation
          - In the case of evolutionary process:
            - Subjected to accidental changes (mutations)
            - Pass the changes to descendants (reproduction)

Genome → chromosomes

Design of a Cognitive System – 3rd step

- Representation of the state machine as the "agent's genome"



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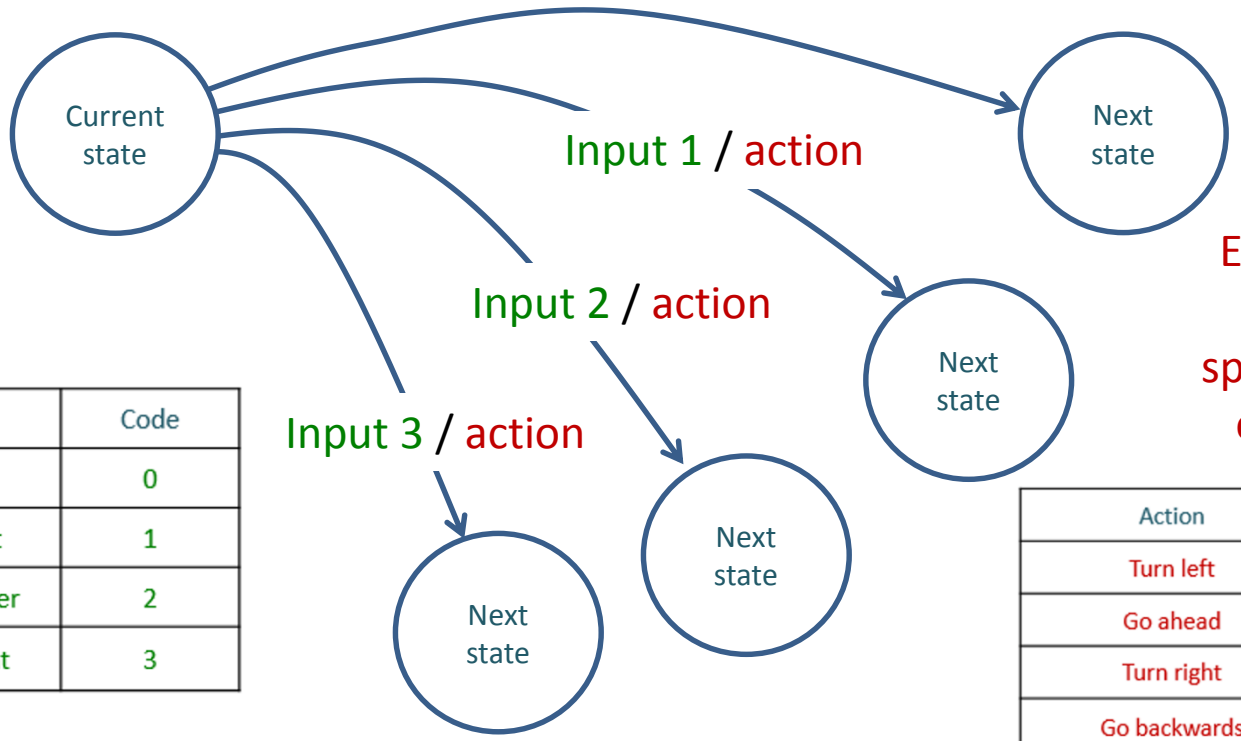
Design of a Cognitive System – 3rd step

- Representation of the state machine as the "agent's genome"

The inputs are indexed, thus already specified

The next state after each input must be specified



Each action must be specified for each input

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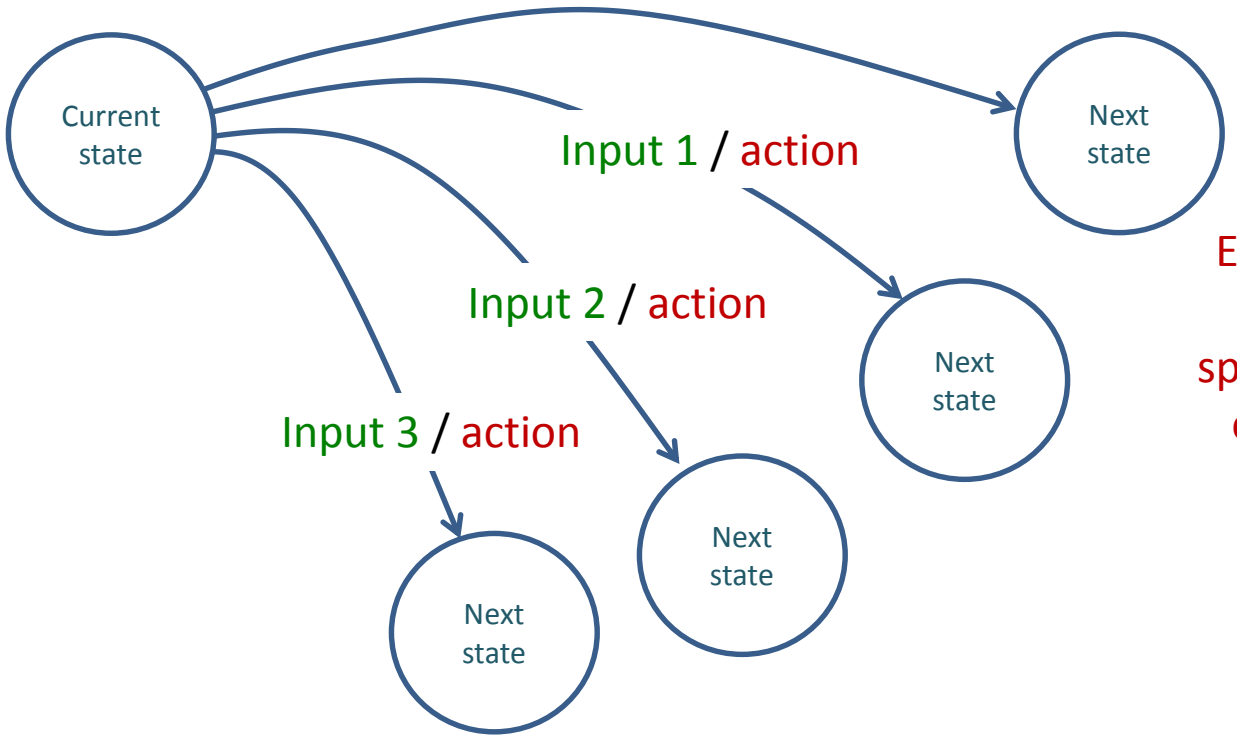


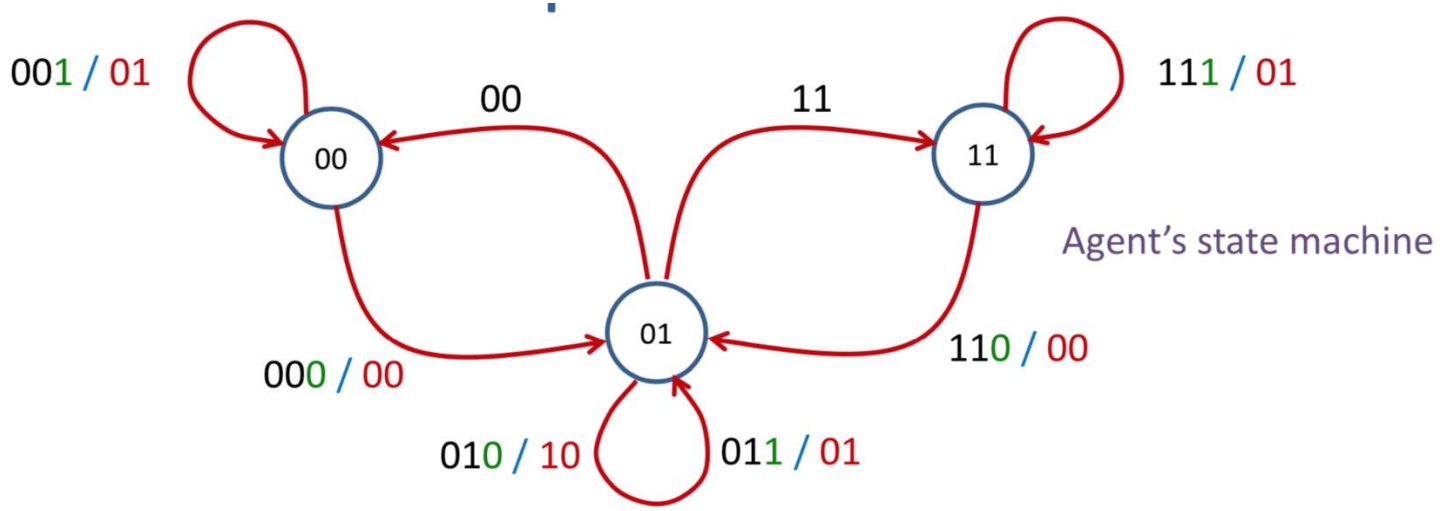
Each action must be specified for each input

– Representation of the state machine as the "agent's genome"
  - For each current state there is a chromosome:

Input 0 / Next state / action	Input 1 / Next state / action	Input 2 / Next state / action	Input 3 / Next state / action

Exercise:

- Construct the genome for the following machine:



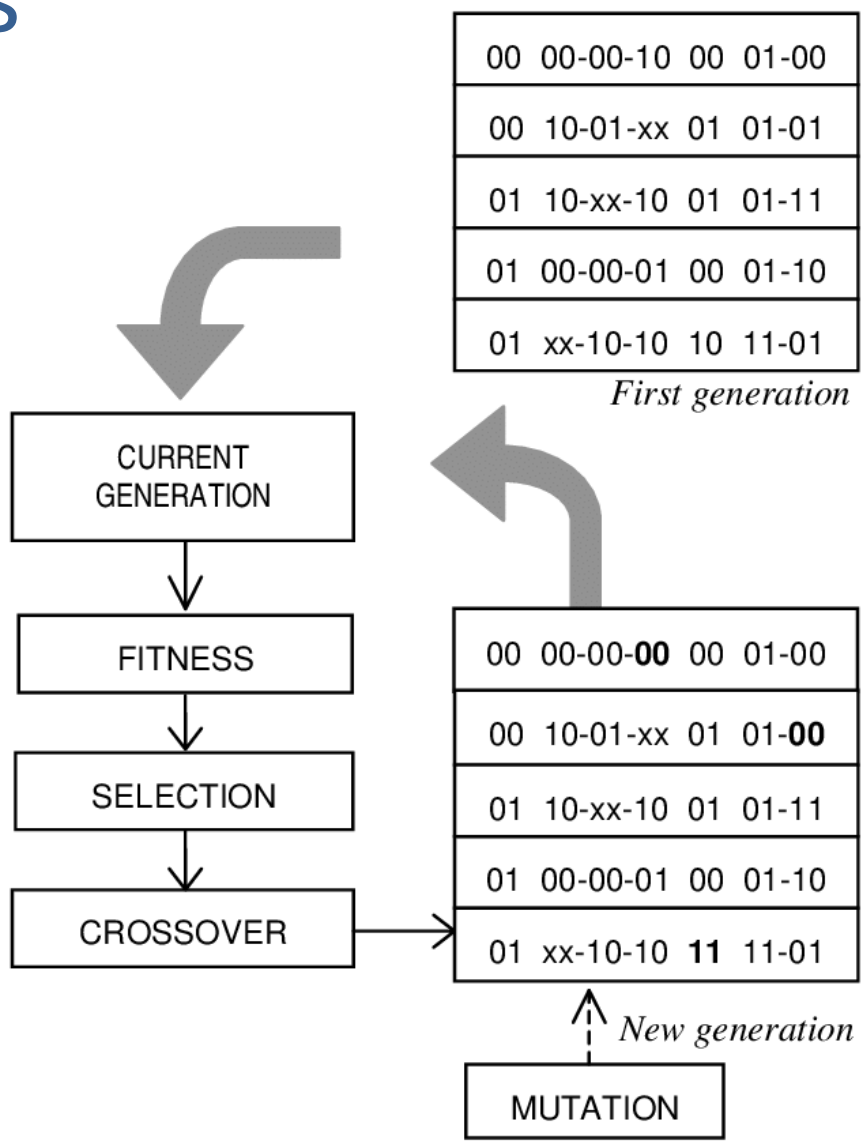
Agent Position	World Status	Code	Action	Action Code
Left boundary	Clean	000	Turn	00
Left boundary	Dirty	001	Suck	01
Any place	Clean	010	Move	10
Any place	Dirty	011	Suck	01
Right boundary	Clean	110	Turn	00
Right boundary	Dirty	111	Suck	01

For each state:

Input 0 / Next state / action	Input 1 / Next state / action	Input 2 / Next state / action	Input 3 / Next state / action

Evolutionary process

- For each generation of agents:
  - Select fitted ones
    - For each agent (genome):
      - Pair chromosomes with the mating agent's
      - Make crossover
      - Do mutation



>>>>>> Play Woxbot file

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NEXT CLASS !!

This is all for today.

See you next week !