
Wrap-up JK
Cognitive Systems
2020 edition
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cognitio

# PSI 3560 – COGNITIVE SYSTEMS

*Wrap-up JK*

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# COGNITION AND COGNITIVE SYSTEMS

Multidisciplinary views of cognition and cognitive systems

Wrap-up JK

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# Summary

- Cognition and cognitive systems
  - Computational point of view
  - Psychological point of view
  - Anthropological point of view
  - Philosophical point of view
  - Biological point of view

  - Towards a unified view

# Cognition and cognitive systems

- Points of view
  - How they can be understood in terms of…
    - Computational
      - … of transformations and abstract processes
    - Psychological
      - … of agent behavior and of psychological processes
    - Biological
      - … of anatomical structures, physiological processes and genetic expression
    - Anthropological
      - … of ergonomic, social, cultural, ecological and evolutionary aspects
    - Philosophical
      - … of epistemic, ontological, logic, ethical and aesthetical aspects

# The computational point of view

## of Cognition and cognitive systems

# Cognition and cognitive systems

- Basic concepts
  - Data
  - Information
  - Knowledge
  - Cognitive process
  - Cognition

# Cognition and cognitive systems

- Basic concepts
  - Data
    - The physical or abstract carrier of information
      - » Obs. Actually:
      - » Signal → physical carrier of data
      - » Data → abstract carrier of information
        - For simplicity, we'll put both in the same category
  - Information
  - Knowledge
  - Cognitive process
  - Cognition

# Cognition and cognitive systems

- Basic concepts
  - Data
    - The physical or abstract carrier of information
  - Information
    - Relevant data content
      - » Source side
        - Relevant to potential receptors
      - » Receptor side
        - Relevance in the sense that it is able to produce effects or changes in the receptor
  - Knowledge
  - Cognitive process
  - Cognition

# Cognition and cognitive systems

- Basic concepts
  - Data
    - The physical or abstract carrier of information
  - Information
    - Relevant data content
      - » Can be context-dependent or independent
        - Context-dependent → requires the context for interpretation
  - Knowledge
    - Context-independent information
  - Cognitive process
  - Cognition

# Cognition and cognitive systems

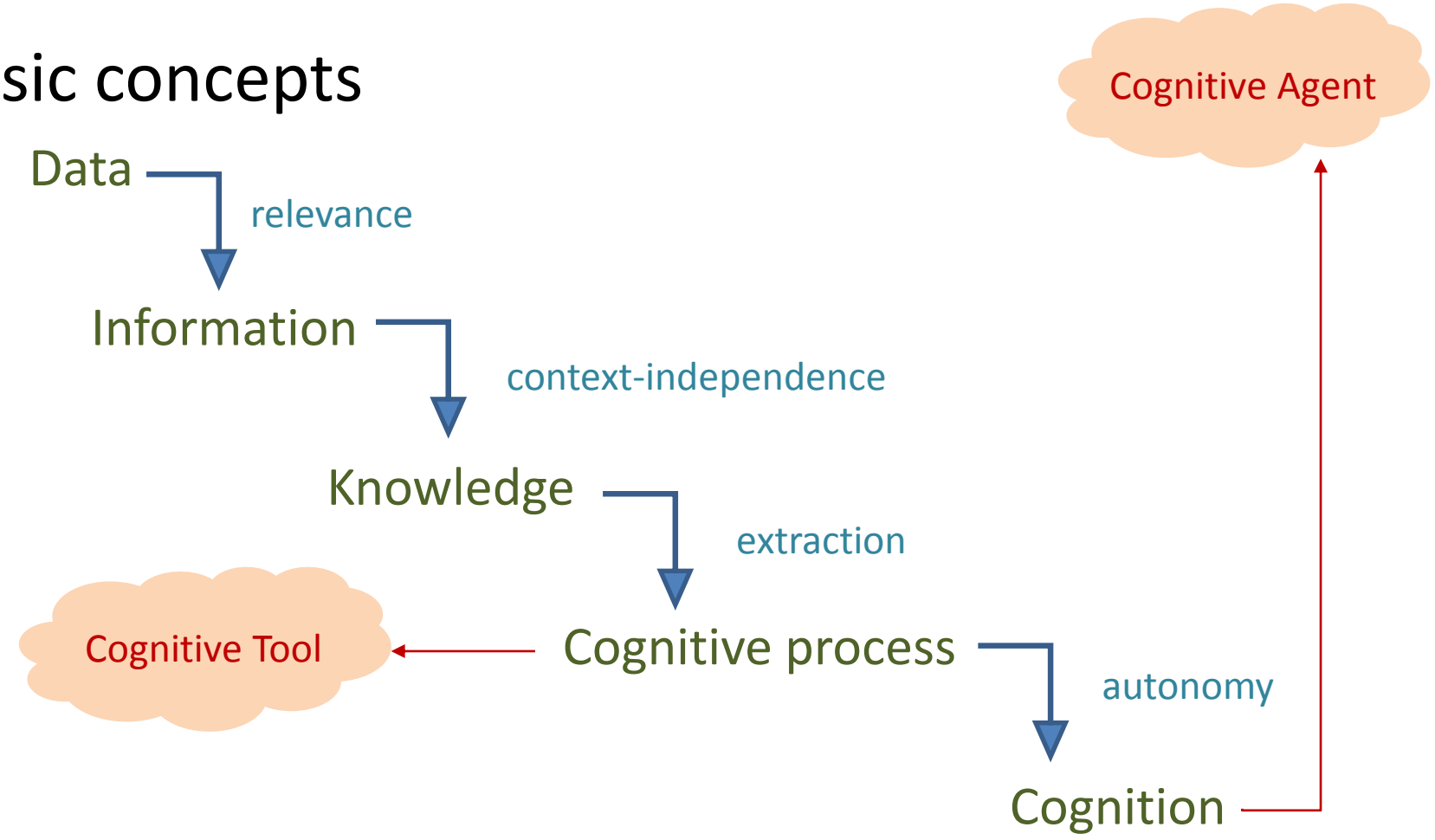
- Basic concepts
  - Data
    - The physical or abstract carrier of information
  - Information
    - Relevant data content
  - Knowledge
    - Context-independent information
  - Cognitive process
    - Process that extracts knowledge from data
  - Cognition

# Cognition and cognitive systems

- Basic concepts
  - Data
    - The physical or abstract carrier of information
  - Information
    - Relevant data content
  - Knowledge
    - Context-independent information
  - Cognitive process
    - Process that extracts knowledge from data
  - Cognition
    - Set of cognitive processes that enables an agent to build and use knowledge, increasing the agent's autonomous behavior

# Cognition and cognitive systems

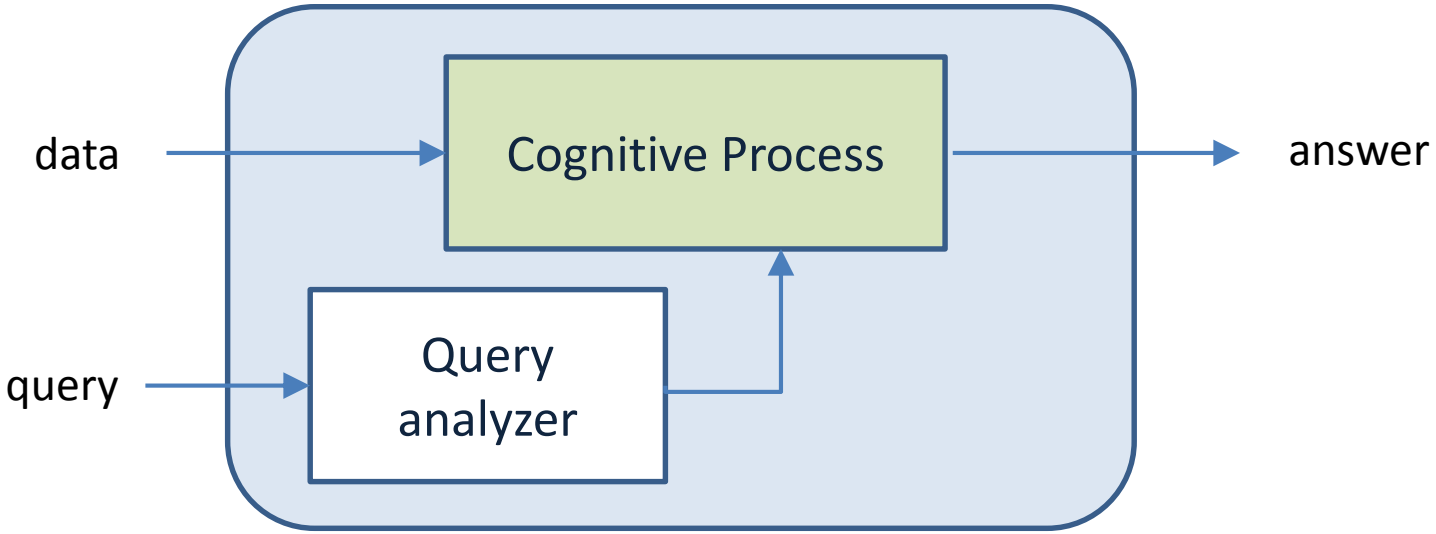
- Basic concepts



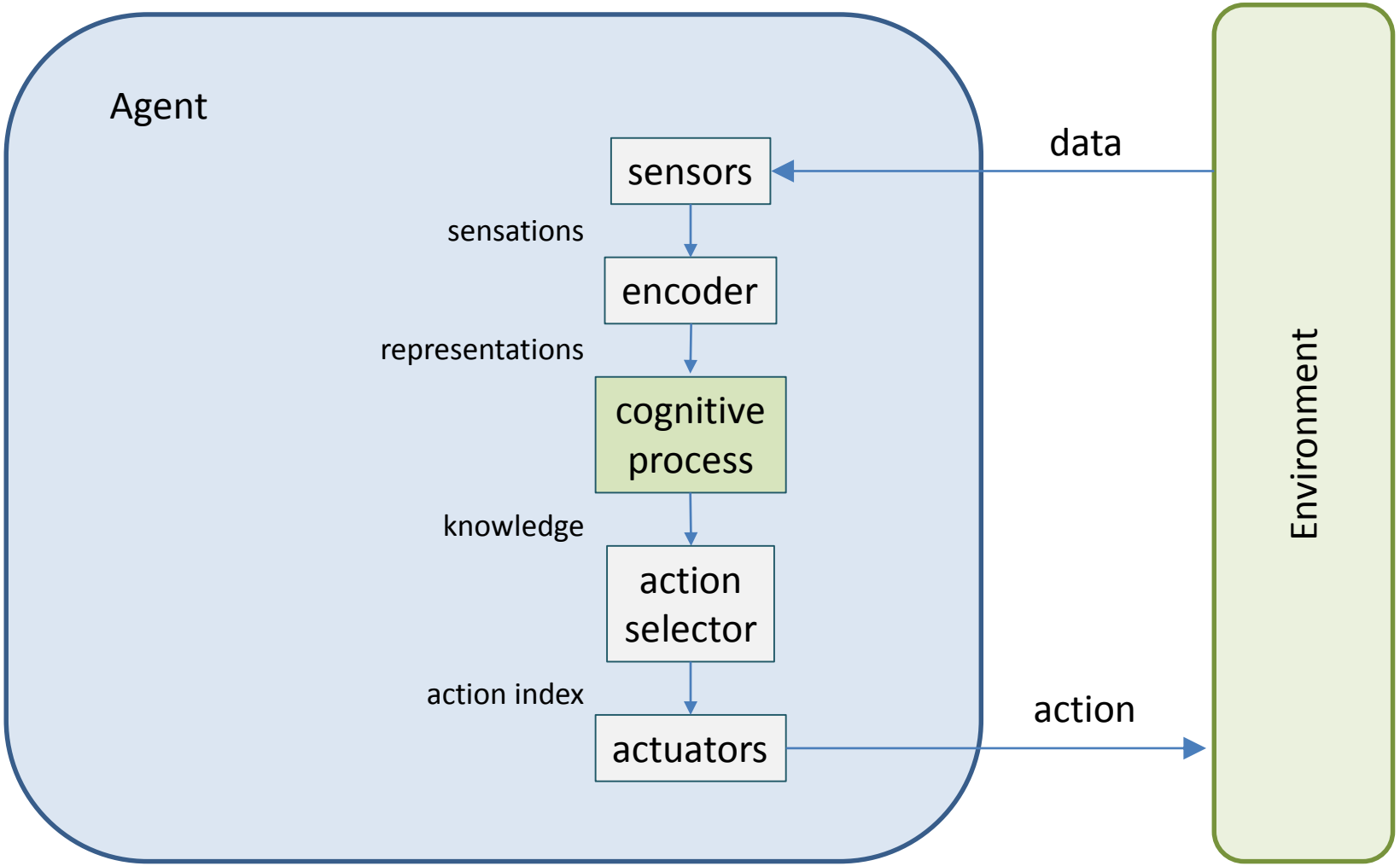
# Cognition and cognitive systems

- Cognitive process


- Cognitive tool



# The cognitive agent



# Cognitive process

- How does the cognitive process work ?
  - Logical inference on a knowledge base and data
    - Traditional artificial intelligence
  - Learning and extracting knowledge from data
    - Statistical learning

# Cognitive process

- How does the cognitive process work ?
  - Logical inference on a knowledge base and data
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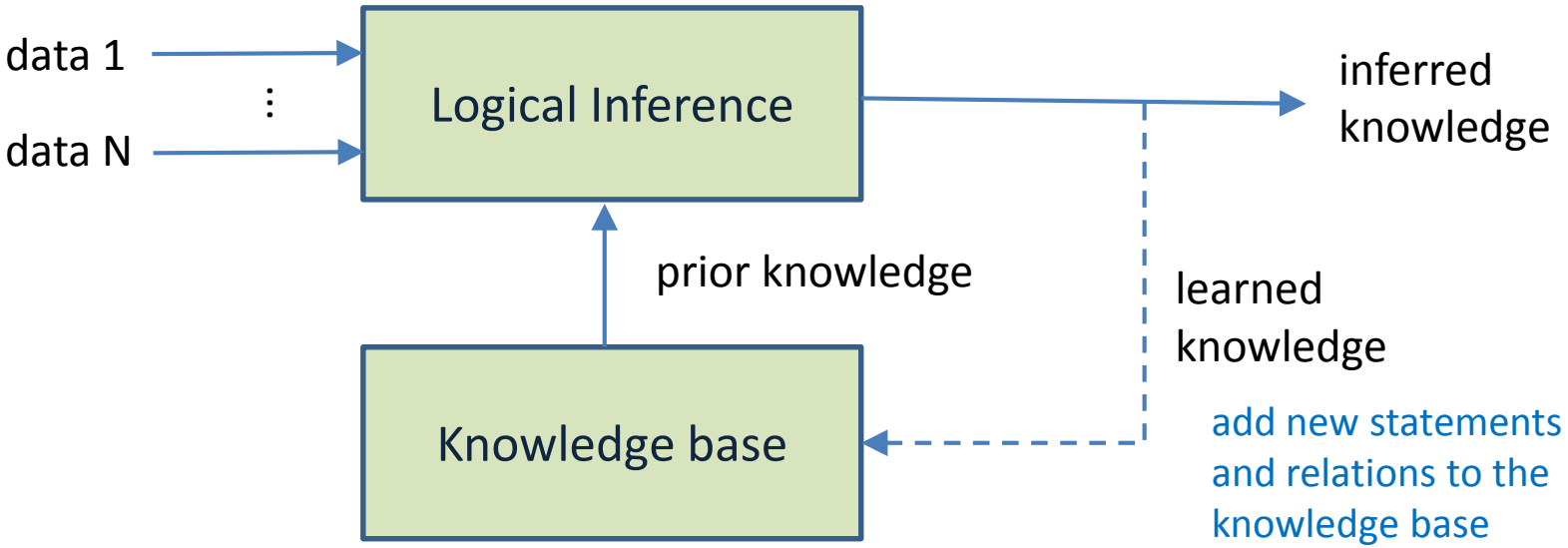

# Cognitive process

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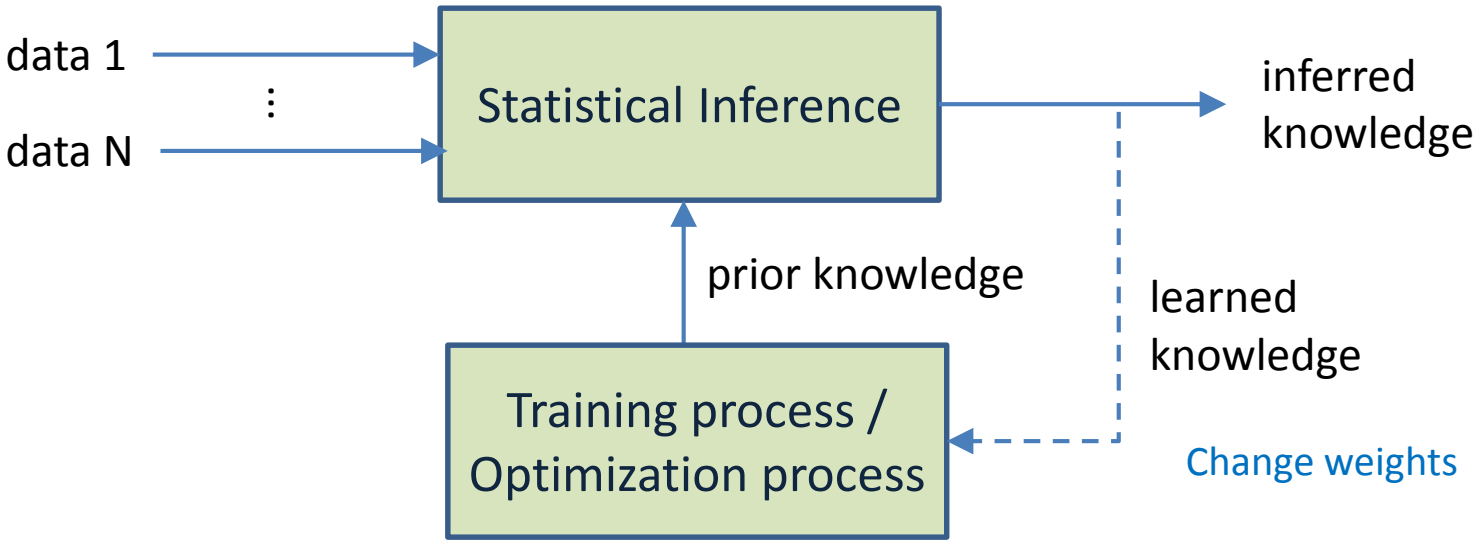
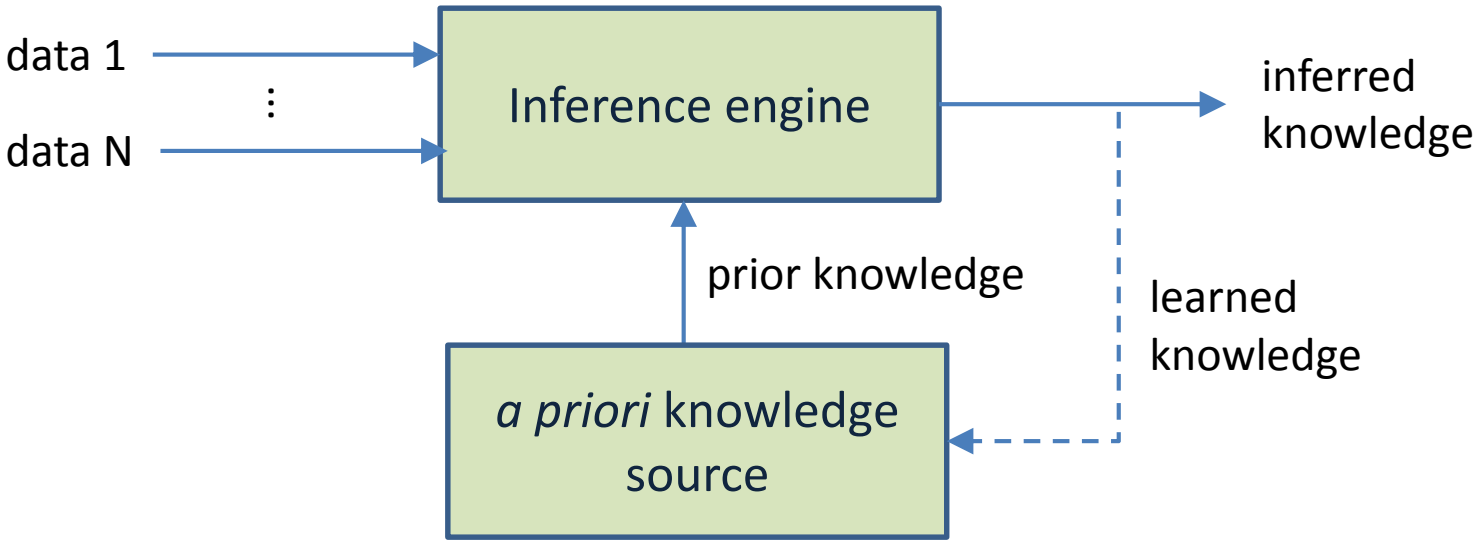
    - Statistical learning



# Cognitive process

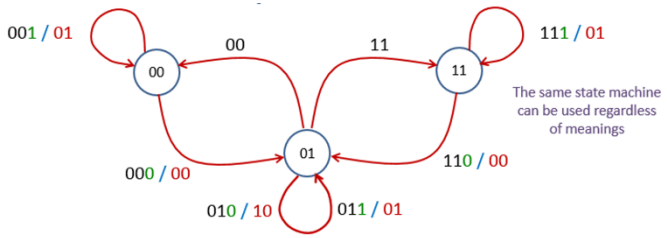
- Generalization
  - In both cases there is an inferential process operating with data and knowledge




- ... provided all variables and data are suitably represented

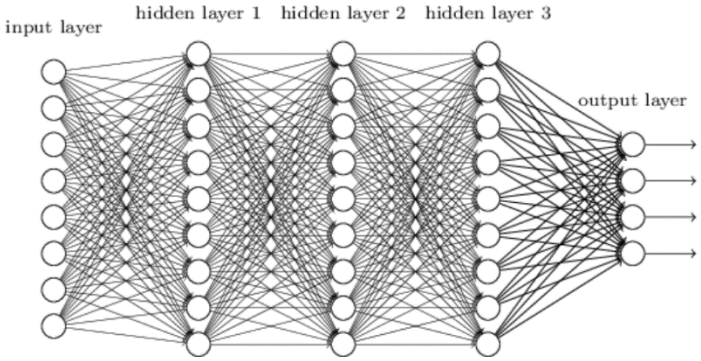
# Representations

- For logical (deductive) inference based systems
  - Symbol system




| Agent Position | World Status | Code | Action | Action Code |
|---|---|---|---|---|
| Nose | Painted | 000 | Turn | 00 |
| Nose | Unpainted | 001 | Paint | 01 |
| Fuselage | Painted | 010 | Move | 10 |
| Fuselage | Unpainted | 011 | Paint | 01 |
| Tail | Painted | 110 | Turn | 00 |
| Tail | Unpainted | 111 | Paint | 01 |

- For statistical (inductive) inference based systems
  - Activations and weights



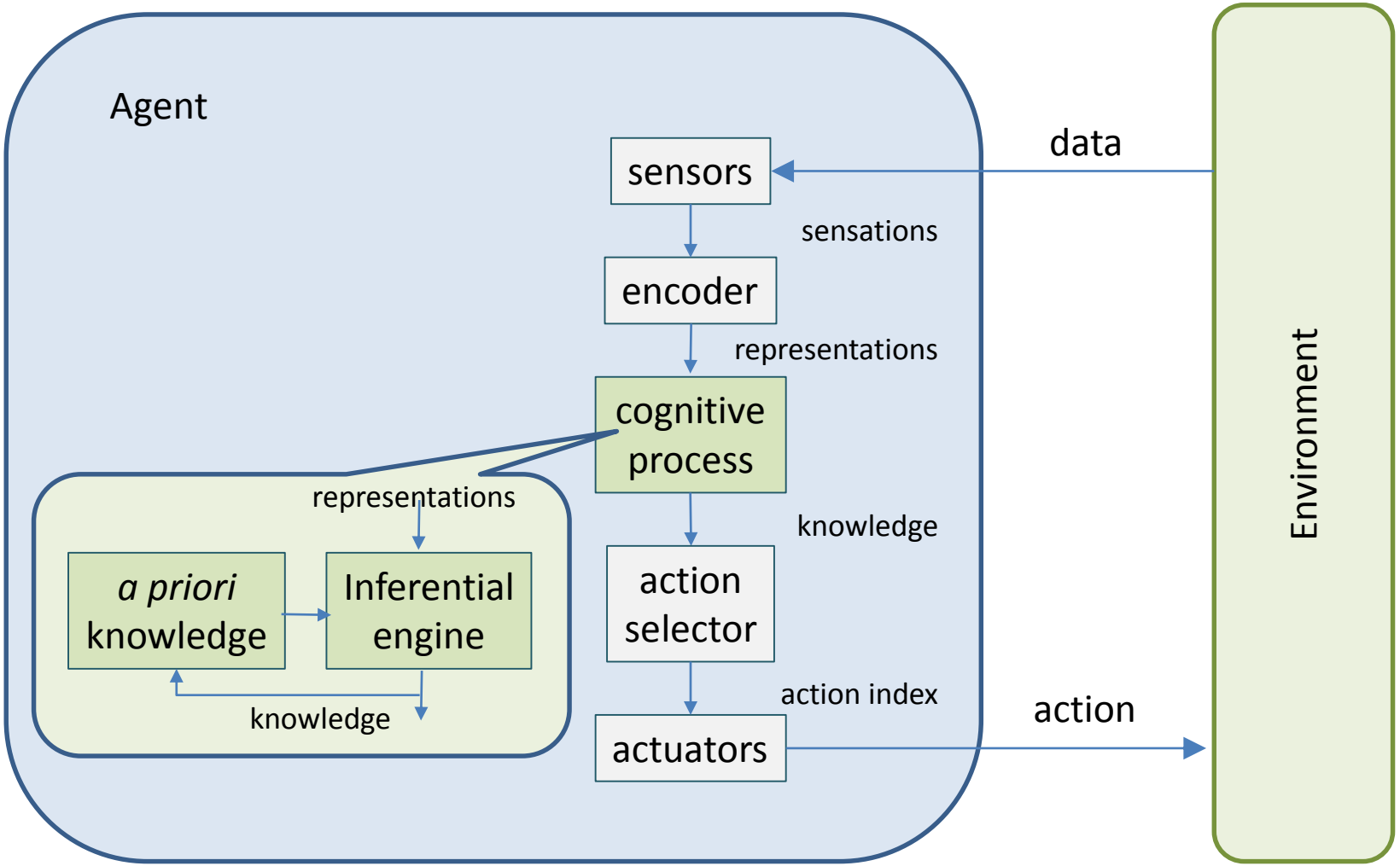
# Cognition

- "Set of cognitive processes that enables an agent to build and use knowledge, increasing the agent's autonomous behavior"
  - Implies:
    - An agent…
      - » That is cognitive, and
      - » Its cognition increases its autonomy…
      - » By building new knowledge about the environment and tasks execution

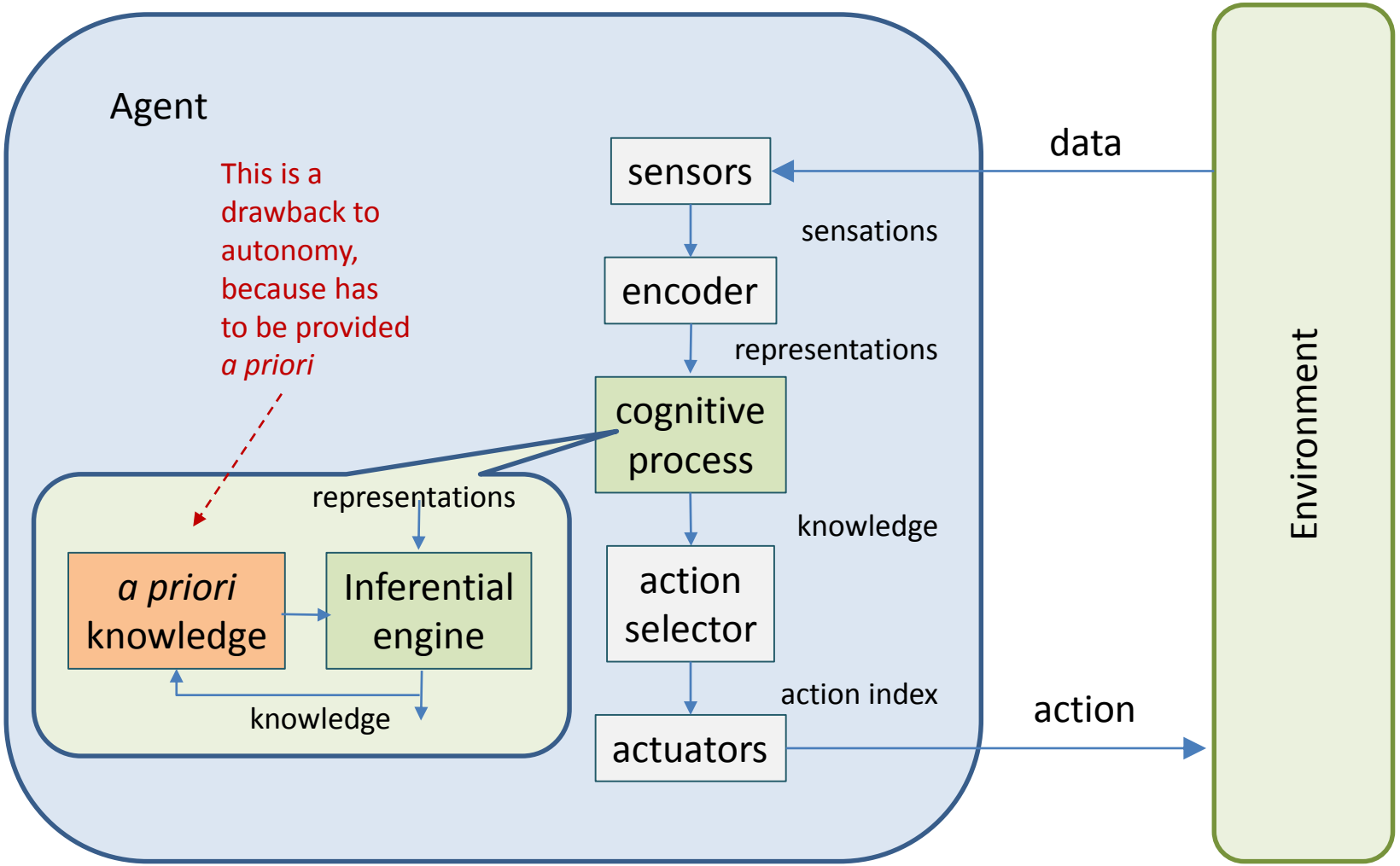
# Cognition

- Cognitive process
  - A cognitive process is a process that builds **knowledge** from the pieces of information that are not context-dependent.
- Agent
  - Entity capable of deciding and generating its own actions
- Autonomous action
  - Action based on **autonomous decisions** → the agent set its own goals
  - Goal setting
    - by the constitutive capacity of performing actions
    - by the possibilities of adaptations resulting from predictions
    - by simulating and planning scenarios of action using knowledge
      - » Obs.: Not required that the goal setting be conscious

# The cognitive agent

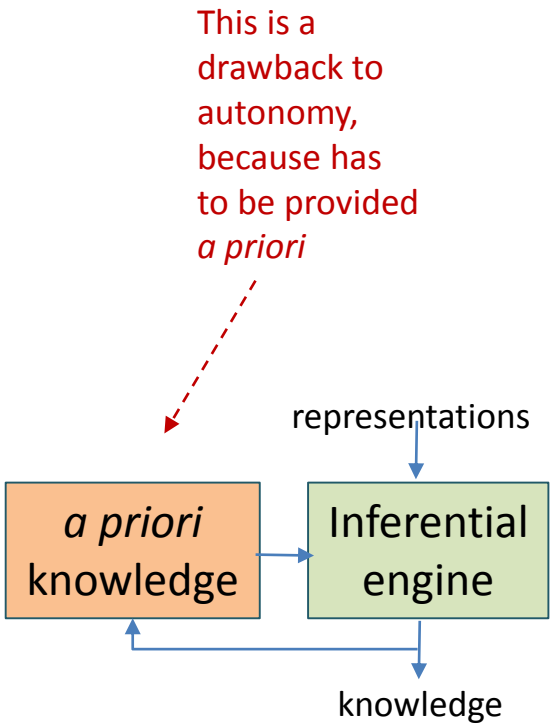


# The cognitive agent



# Cognition

- In order to make this model applicable to a biological agent, the cognitive process needs to bootstrap
  - It requires a prototypical source of *a priory* knowledge to start the process in a developing biological agent
    - This may be provided by genetic inheritance
    - Which, by its turn resulted from the evolutionary process of **autonomy**

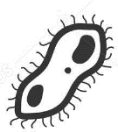


# Cognitive improvement

cognitive agents

perceptive agents

reactive agents




Kinds of behavior

intelligent

knowledge based

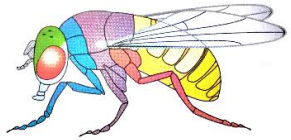
adaptive / predictive

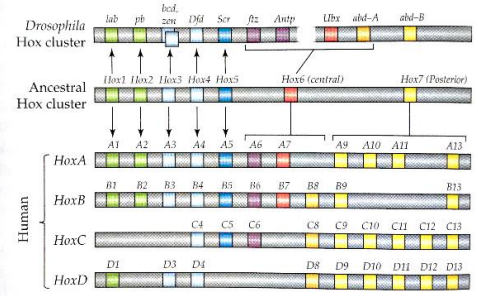
adaptive

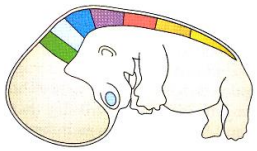
reactive

purely reactive

# Evolutionary aspects of cognition



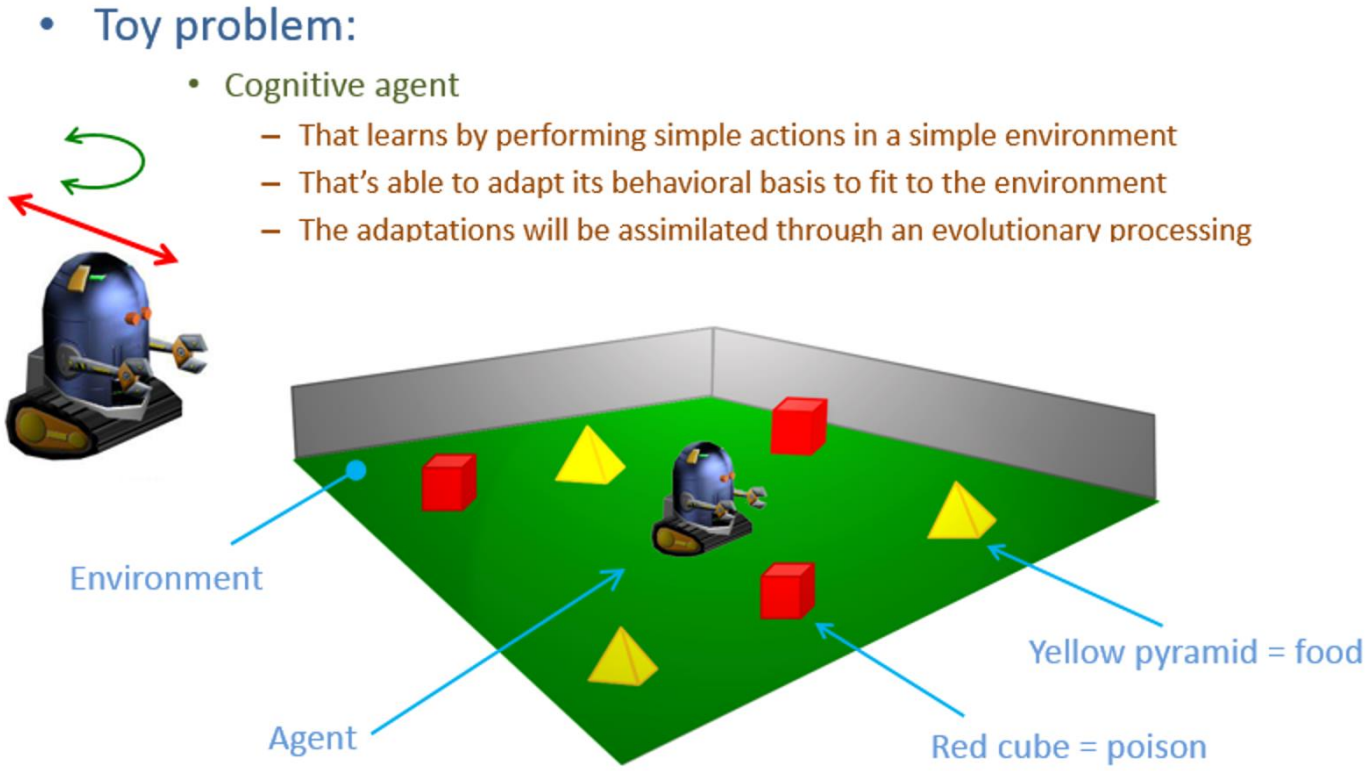


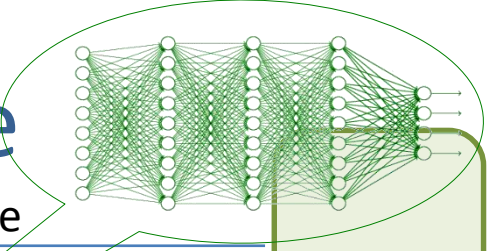
- Remembering last class…
  - Difficulties
    - No paleontological / archeological traces
  - Methods
    - Comparative anatomy / physiology across current species
      - This is somehow illustrated by the previous slide
    - Tracing evolutionary paths of species
    - Tracking features across paths
    - Cross-correlation with genetic expression
- And, if we select in the evolutionary tree only the branches that make the path to cognition, and abstract all the morphological aspects, we have an evolutionary process possibly similar to a **genetic algorithm**

# Evolutionary aspects of cognition

- Evolutionary computation
  - Remember the toy problem of the evolving agent in a small world (WOXBOT)



# WOXBOT agent architecture



Neural network

interaction consequence

Agent

Time

Energy meter

Vision

data

encoder

agent state

world state

conditional rules

action selector

Environment

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

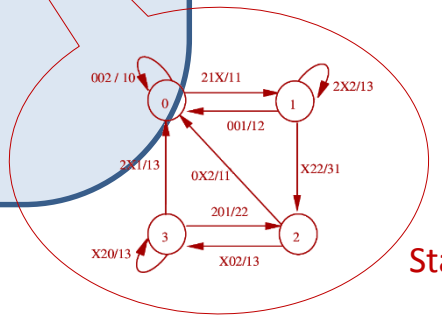
| Agent State | Condition |
|---|---|
| High energy | Rest |
| Low energy | Go |
| No energy | Dead |

action

actuators

| Object State | Consequence |
|---|---|
| Pyramid | Increase energy |
| Cube | Decrease energy |

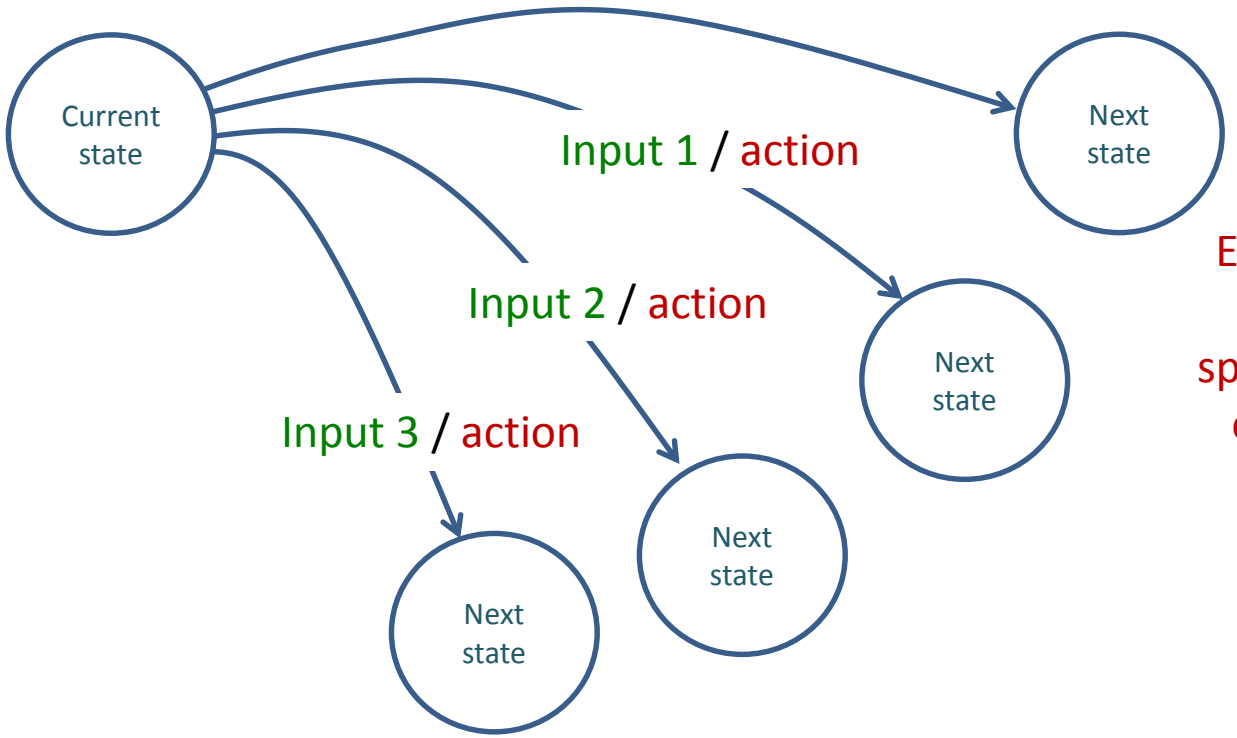
| Action | Code |
|---|---|
| Turn left | 0 |
| Go ahead | 1 |
| Turn right | 2 |
| Go backwards | 3 |




State machine

The inputs are indexed, thus already specified

The next state after each input must be specified



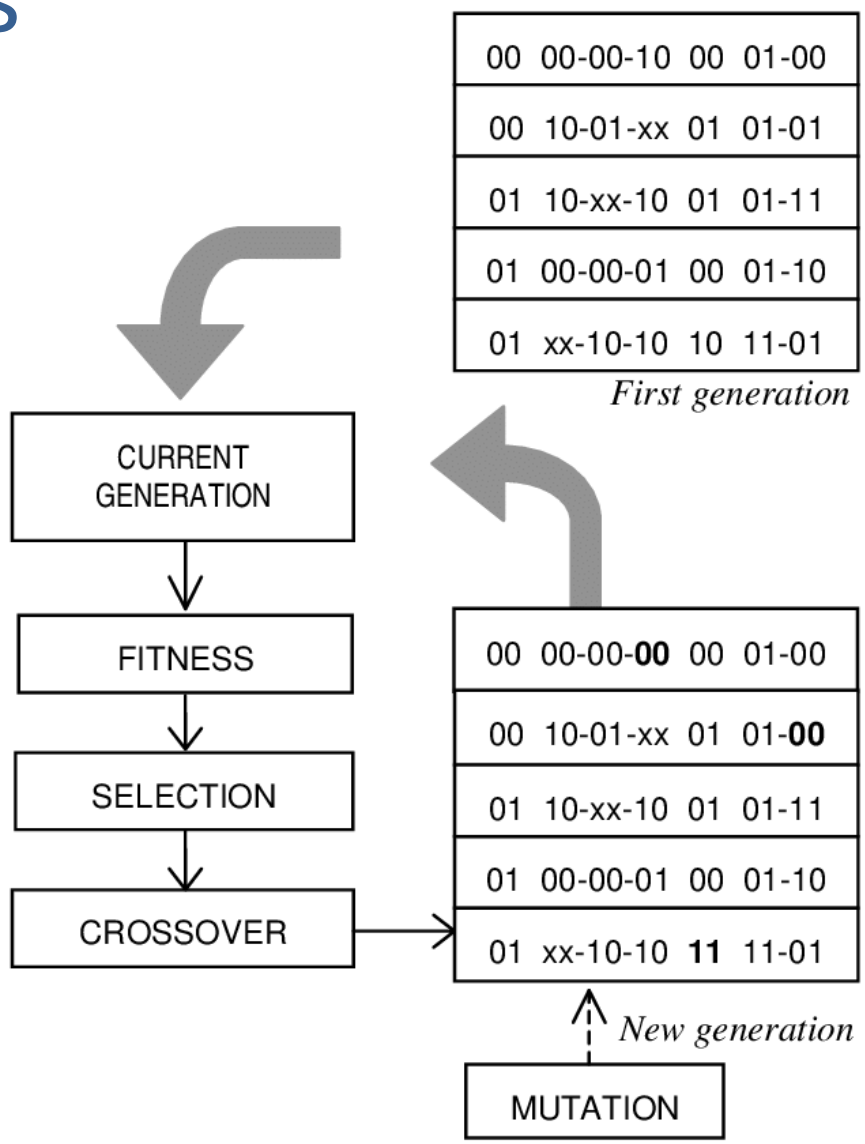

Each action must be specified for each input

– 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 |
|---|---|---|---|

# 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



# Cognitive Systems

- Organizational aspects
  - Cognitive architectures
    - How to map the cognitive processes onto a functional modular structure ?
      - Cognitivist solutions
        - » Symbol manipulation
        - » Functional specialized modules
      - Emergentist solutions
        - » Connectionist model
      - Hybrid architectures

# The psychological point of view

## of Cognition and cognitive systems

# Cognition and cognitive systems

- Psychological point of view
  - How cognition and cognitive systems can be understood in terms of agent behavior and of psychological processes
    - Organization of behavior
      - Reactive responses
        - » Action units
      - Perception
        - » Action-perception cycle
      - Cognition
        - » Action plans and simulation
    - Developmental aspects

# Psychological point of view

- Developmental theories
  - Cognitive features are **innate and just expand**
    Nativist models → Cognitive competence theory
  - Cognitive features **emerge from experience**
    Associationist models → Semantic networks
  - Cognitive features are **constructed through stages**
    Constructivist models → Epistemological genetics theory
  - Cognitive features **are acquired via social interactions**
    Sociocognitive models → Dialogical socioconstructivism

# The anthropological point of view

## of Cognition and cognitive systems

# Cognition and cognitive systems

- Anthropological point of view
  - How cognition and cognitive systems can be understood in terms of ergonomic, social, cultural, ecological and evolutionary aspects
    - Ergonomic factor
      - How body shape tailored cognition
      - Embodied cognition
    - Social cognition
      - Models of social interaction
      - Communication and cognition
    - Cultural aspects
      - How social culture influences cognitive development
      - How cognitive factors shape the society culture
    - Ecological view of cognition
      - Embedded cognition
    - Evolutionary aspects
      - Evolution of cognition

# Social cognition

- Social cognition

  Studies…

  – The cognitive processes underlying relations with other individuals…

    » … of the same or of different species

    - Related elements of these cognitive processes:
      - Schemas (*schemata*)
      - Attributions
      - Saliency
      - Priming

  …and…

  – How social relations affects cognition

    - Social cognitive theory

# The philosophical point of view

## of Cognition and cognitive systems

# Cognition and cognitive systems

- Philosophical point of view
  - How cognition and cognitive systems can be understood in terms of epistemic, ontological, logic, ethical and aesthetical aspects
    - Philosophy of mind
      - Mind-body problem
        - » Dualism
          - There are two kinds of entities, the **mental** and the **physical**
            - Substance → soul / body
            - Process → epiphenomena
        - » Monism
          - Just one kind, the physical
            - Materialism or physicalism
            - Reductionism

# Philosophical point of view

- Reductionism
  - Nagelian reduction
  - Bridge laws
- Identity theory
  - Type identity
  - Token identity
- Functionalism
  - Fodor & Putnam
  - Marr's computational theory
  - Representations
- Internalism versus externalism
  - Internalism → computationalism (A.I. , cognitivism)
  - Externalism
    - Embodied, embedded, extended, enacted

# The biological point of view

## of Cognition and cognitive systems

# Cognition and cognitive systems

- Biological point of view
  - How cognition and cognitive systems can be understood in terms of anatomical structures, physiological processes and genetic expression
    - Structure and function
    - Levels of organization
      - Molecular level → information carriers, neurotransmitters, modulators
      - Cellular level → neurons, synapses, glia, action potential, local potentials
      - Circuit level → neuron associations, neuron assemblies, action potential trains
      - Structures level → cortical organization, sub-cortical structures, functional areas
      - Networks level → connectome, rhythms
    - Scales of investigation
      - Static → anatomical structures (microscopy, dissection, anatomical imaging)
      - Dynamic → electrophysiology, video microscopy, functional imaging, EEG

# This is all for today.

See you next week (final exam) !