WOXBOT

WOX Bot
An Open Extensible Robot for Virtual World Simulations

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Outline

- introduction

- previous work

- project overview

- foundations and concepts

- implementation

- conclusion and future work

Introduction
artificial life

WOXBOT

- simulation of large societies of single beings
  - biologists and physicists
    - study of life origin and evolution
  - mathematicians
    - theoretical aspects (is it possible?)
    - how can programs evolve by themselves?

Introduction
artificial life

WOXBOT

- simulation of complex evolved creatures (single or multiple bodies)
  - computer graphics community
    - modeling and animation
    - virtual actors
    - individual and population behaviors

Introduction
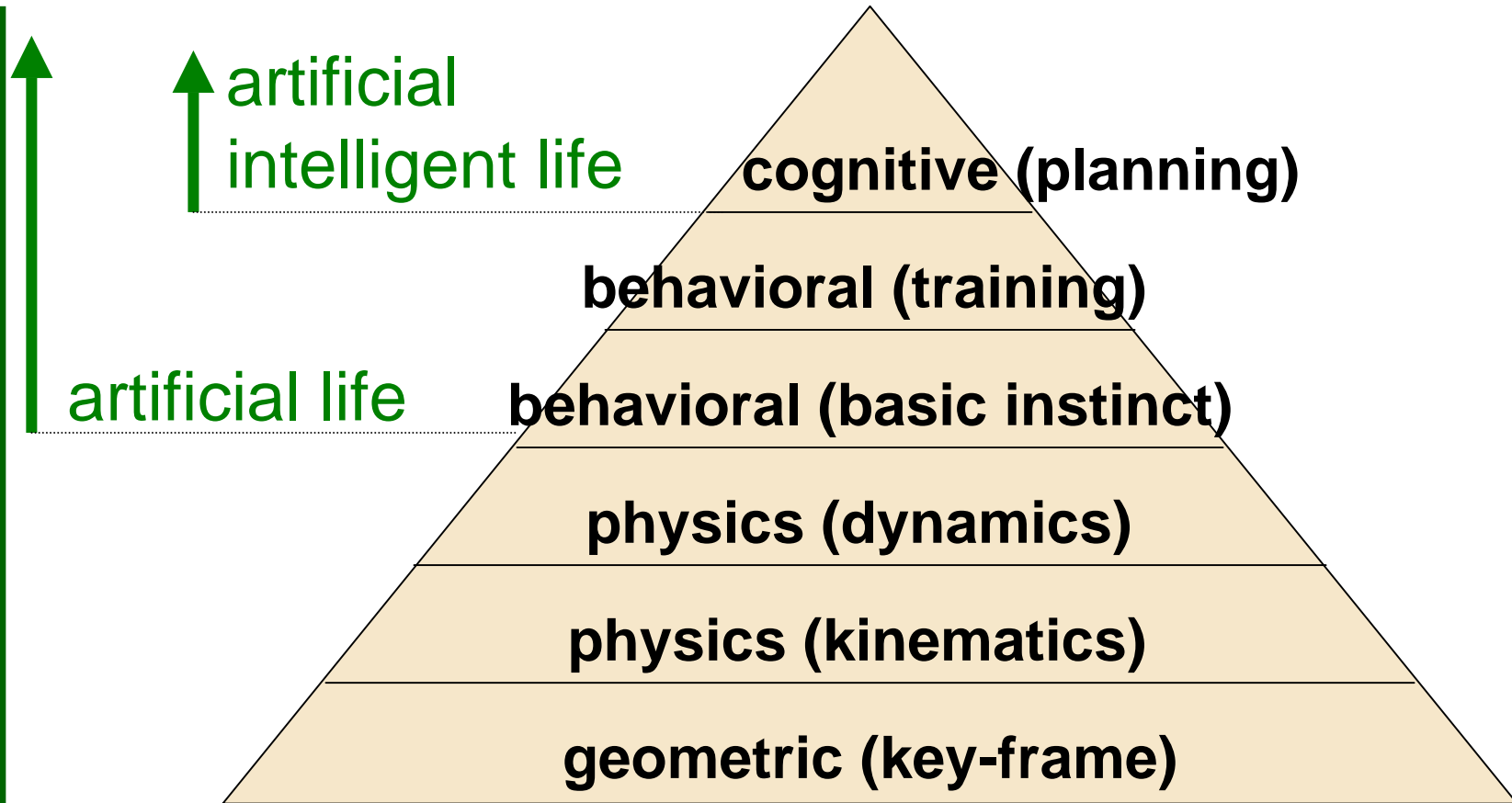## *research goal*

WOXBOT

- to study different aspects of artificial life

- character features
  - environment recognition
  - cognition / reasoning / planning / decision making
  - learning abilities
  - action control
  - use of language

Previous Work
comp. graph. - animation

artificial
intelligent life

cognitive (planning)

behavioral (training)

artificial life

behavioral (basic instinct)

physics (dynamics)

physics (kinematics)

geometric (key-frame)

Previous Work
computer graphics

WOXBOT

- Perlin 94-96: behavior animation (Improve)

- Terzopoulos 91-99: behavior and cognition (fishes)

- Talman 80's - 90's: human modeling (human bodies and population)

- Sims 94: evolved competing creatures (nice primitive creatures)

Project Overview
long term goal

WOXBOT

- to be able to simulate complex virtual worlds with realistic creatures, exhibiting sophisticated behaviors supported by reasoning, learning and cognition
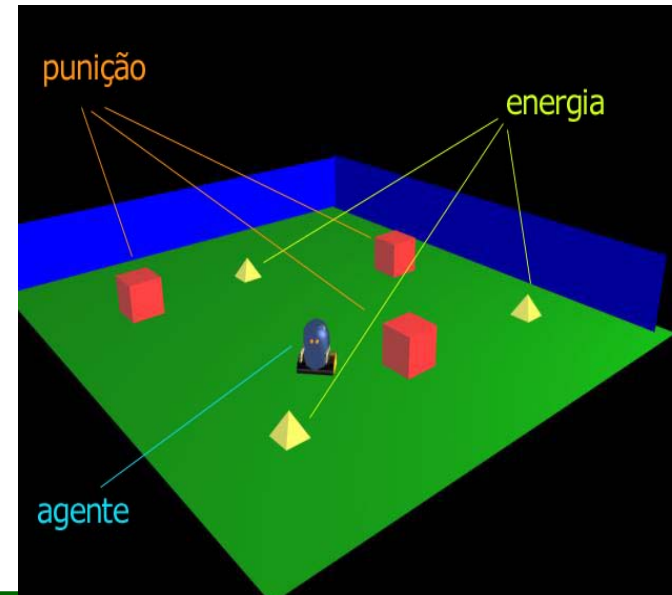
Project Overview *framework*

WOXBOT

- virtual character

  - WOXBot:
    Wide Open
    Extensible Robot

- virtual environment
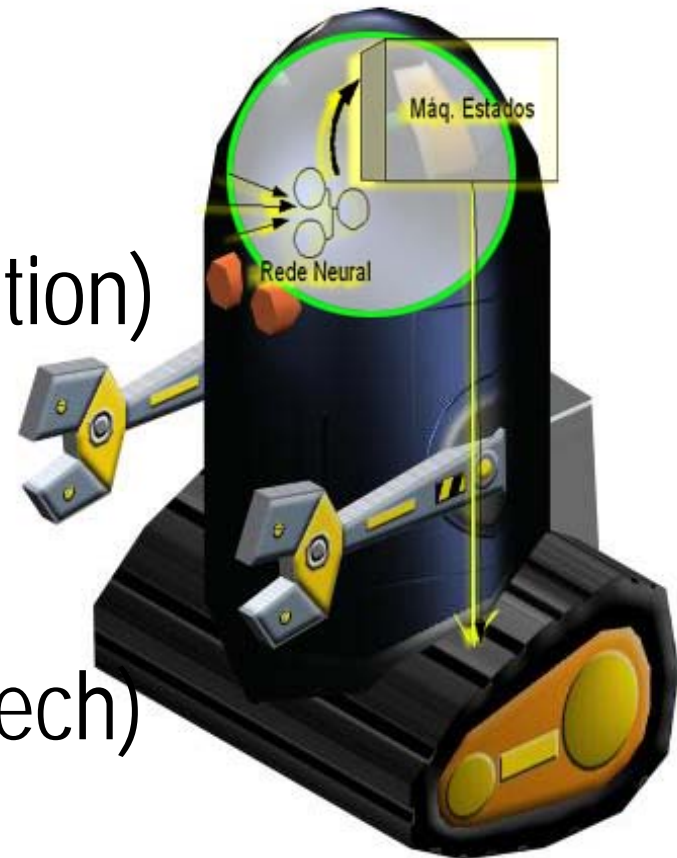
  - ARENA: the
    environment inhabited
    by WOXBots

Project Overview
framework - character

- actors are one or more robots

- perception (vision, audition)

- features recognition

- decision (behavior)

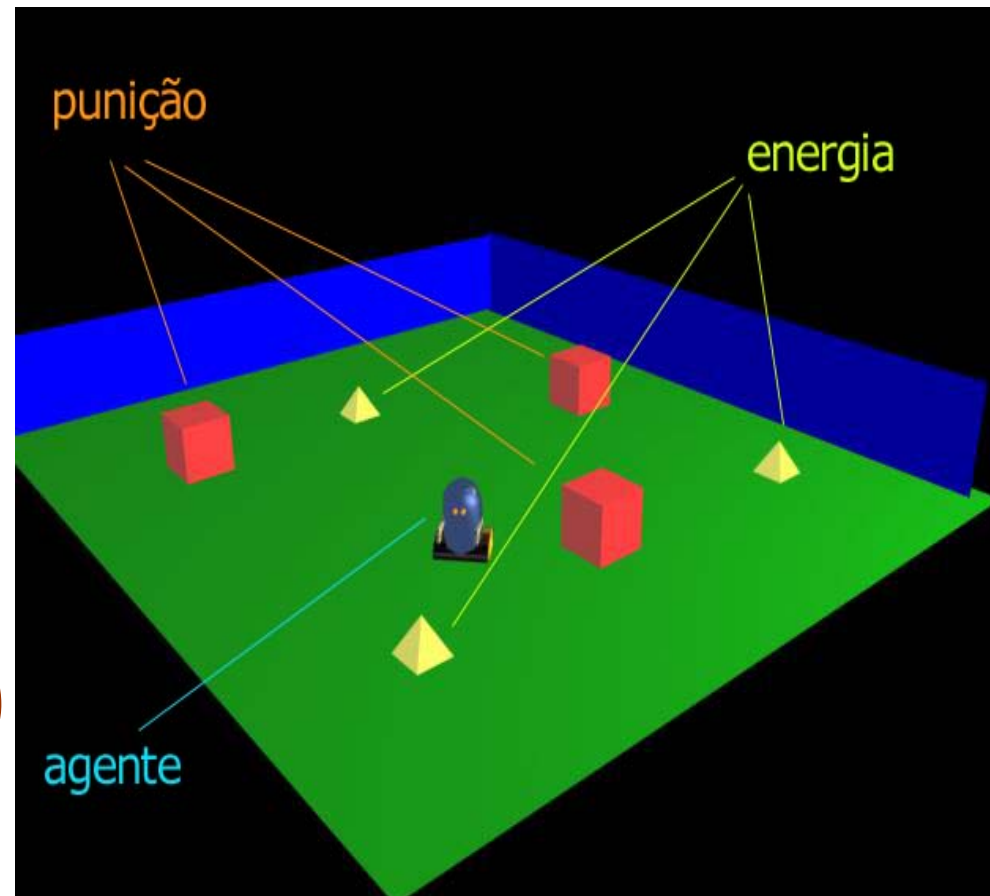- action (movement, speech)

- evolution

Project Overview
framework - scenario

WOXBOT

- scene is an area where woxbots live

- scenario for life adaptation
  - rewards
  - traps (punishment)

Concepts
artificial life

WOXBOT

- cellular automata theory

  – origin and evolution of life

- computer graphics animation

  – natural behavior

- how to achieve it?

  – usage of evolution strategies

Concepts
artificial life

WOXBOT

- local aspects

  – ability of a character to regulate its own behavior

- global aspects

  – adaptation of a certain specie (trough generations)

  – emerges from the local one

Concepts
evolution & *genetic algorith.*

- evolutionary strategies

  – rules of evolution and natural selection

- genetic algorithms

  – codification of beings features into genes

  – generation of new beings by reproduction and mutation

Concepts
intelligent agents

WOXBOT

- agents

  - to move alone (mobility)

  - to communicate (sociability)

  - to take decisions (intelligence)

- intelligent agents

  - use of knowledge

  - production / update of knowledge

Concepts
intelligent agents

- Computational entities that behave with autonomy in order to manipulate the information associated with its knowledge

  - goals

  - motivation (?)

  - reasoning about actions and their consequence
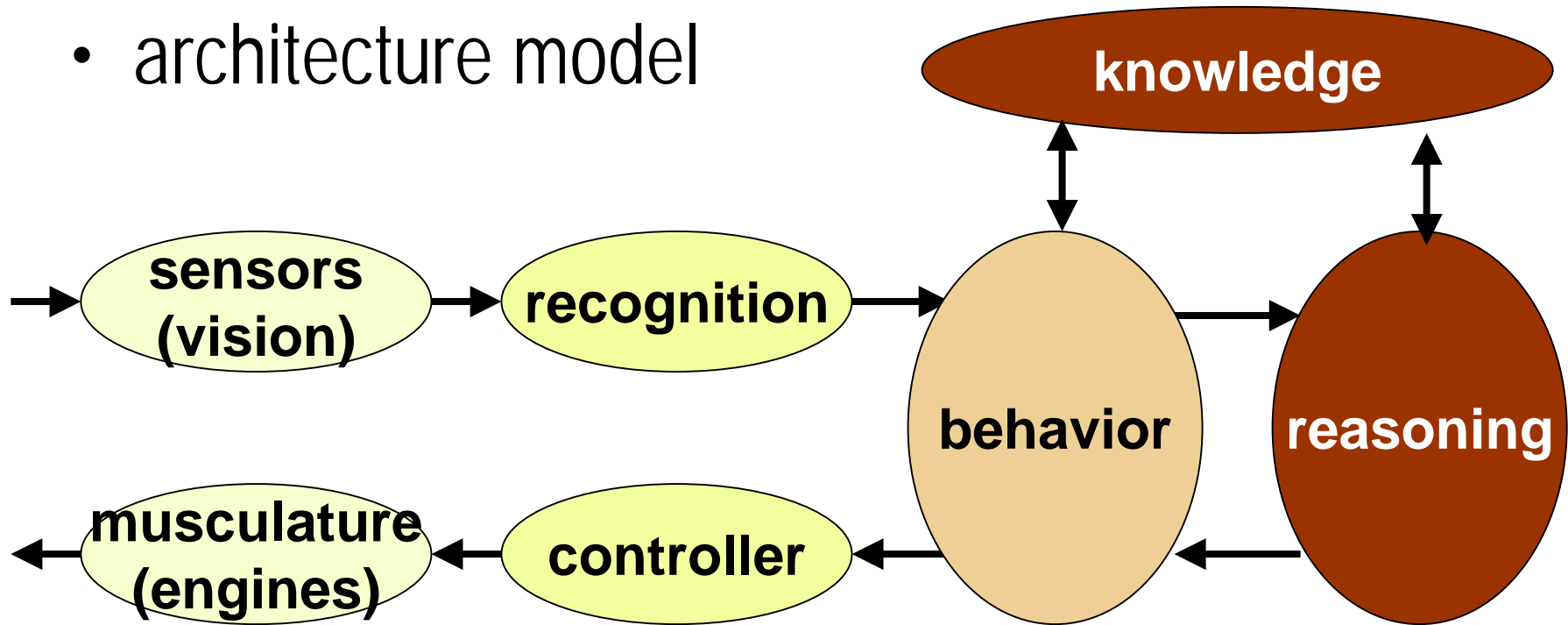
Implementation
intelligent agents

- each module can be
  - pre-specified (hard coded)
    - does not allow adaptations without programmer interference
    - able to be trained or not
  - based on evolution concepts
    - naturally adapted
    - allow improvements to be achieved spontaneously

Implementation
intelligent agents

- architecture model

knowledge

sensors (vision) → **recognition** → **behavior** → **reasoning**

musculature (engines) ← **controller** ← **behavior** ← **reasoning**

Implementation
perceptual modules

WOXBOT

- vision

  - observation of their environment through simulated vision process

    - image generation (computer graphics camera)

    - image interpretation and recognition (neural nets)

  - learning / training

    - neuronal nets

    - identification of objects and other robots

Implementation
perceptual modules

- audition (listening)

  – observation of their environment through simulated listening process

    - symbol generation (sound recognition)

    - information interpretation and recognition (neural nets)

  – learning / training

    - neuronal nets

    - identification of objects and other robots
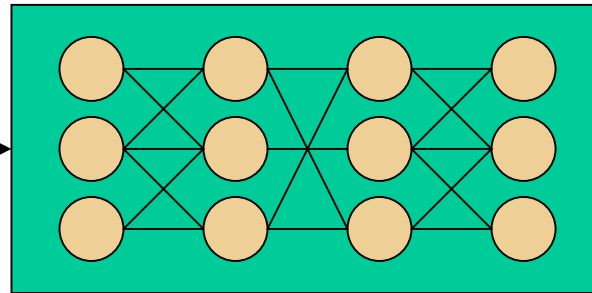
Implementation
learning in perception

WOXBOT

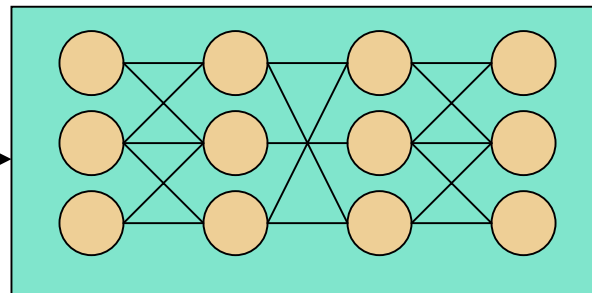– information recognition from achieved data

vision image   **identification system**   **coded information**

0: no object
1: obj. @ left
2: obj. @ right
3: obj. @ center

0: no sound
1: high freq. near
2: high freq. far
3: low freq. near

audio   **identification system**   **coded information**

Implementation
action and behavior

WOXBOT

- behavior defined in a state evolved machine

  – trough evolution there is a natural improvement in the state machine

- actions are related to state transitions

- sensor inputs control state transitions

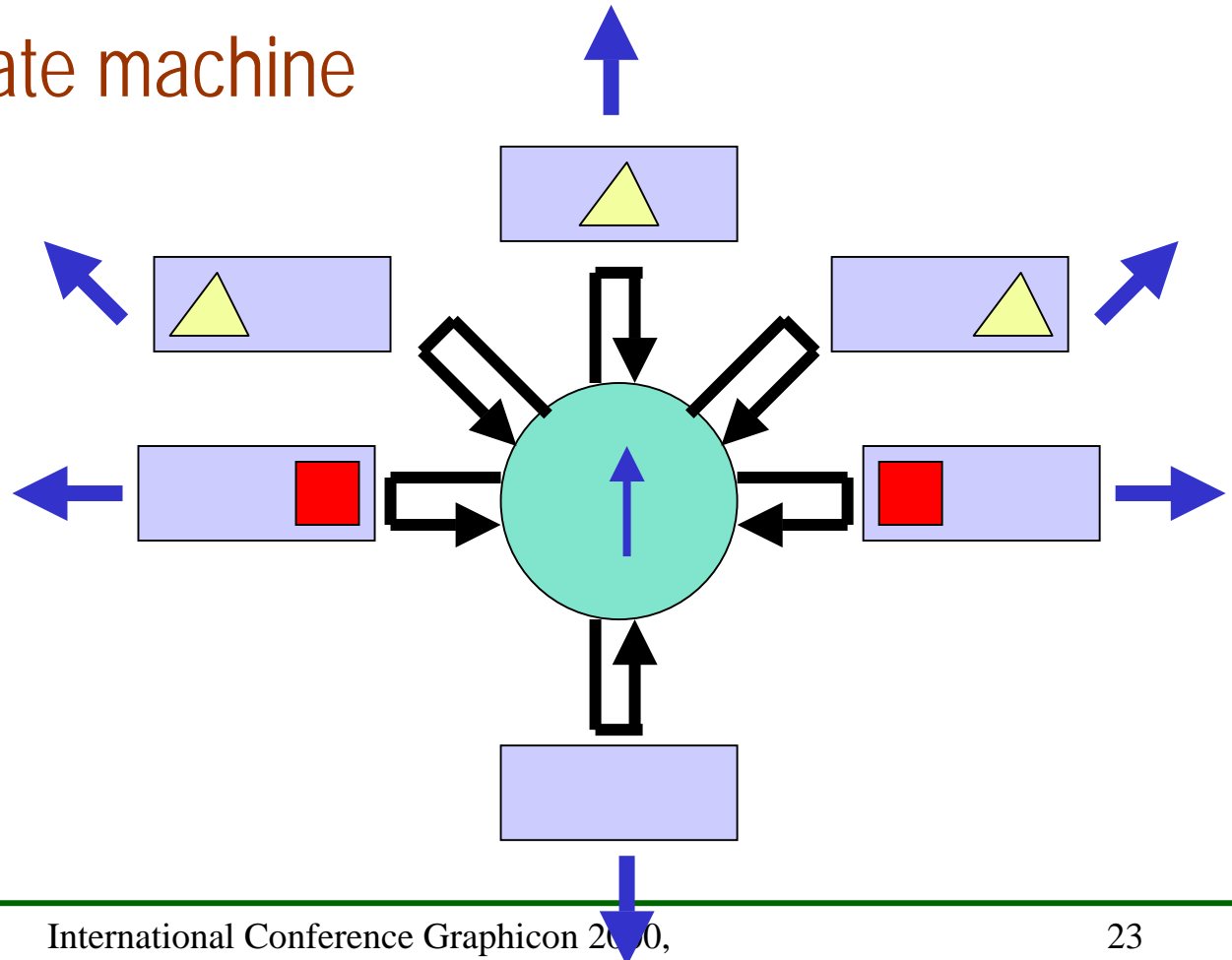- states represent a memory about the current situation

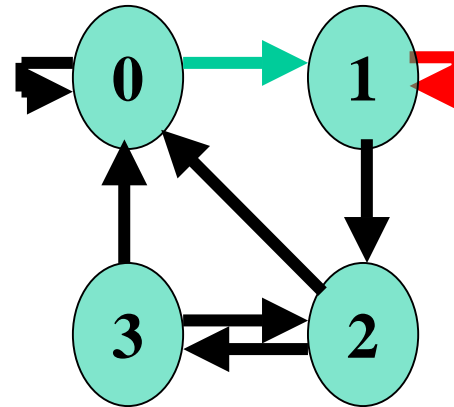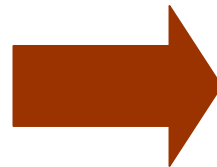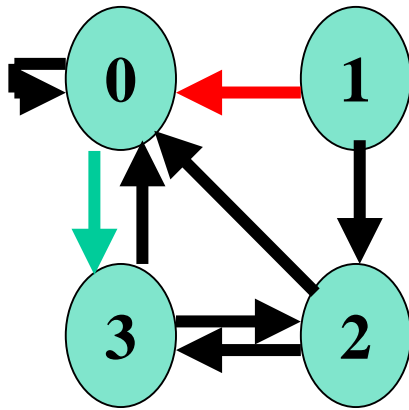# Implementation
action and behavior

– single state machine

Implementation
action and behavior

– behavior state machine (without special meaning)

states

0 stay
1 going ahead
2 turning right
3 turning left

S	I	S	A	I	S	A
0	0	0	X	1	3	Z
1	0	2	Y	1	0	Z

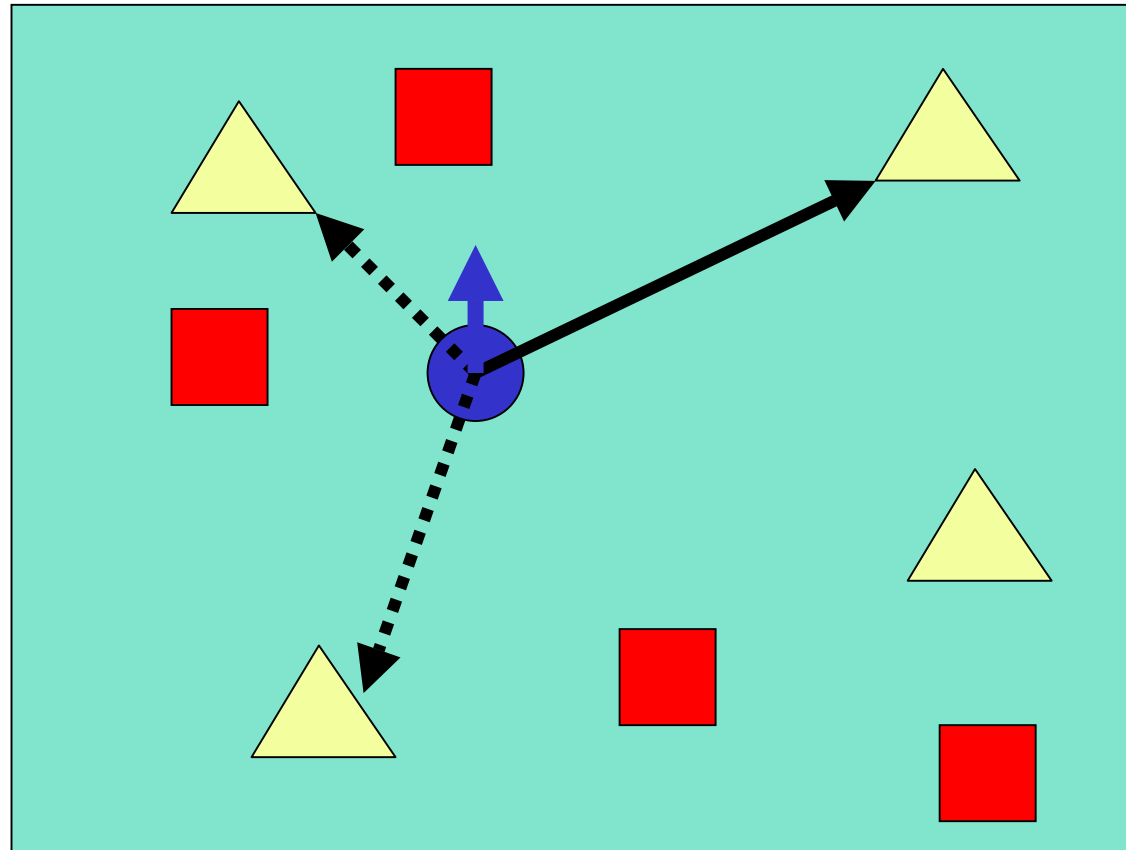| S	I	S	A	I	S	A
0	0	0	X	1	1	Z
1	0	2	Y	1	1	Z

Implementation
action and behavior

WOXBOT

path planning

tradeoff
gain <=> lost

look for pyramids
avoiding cubes or
their proximity
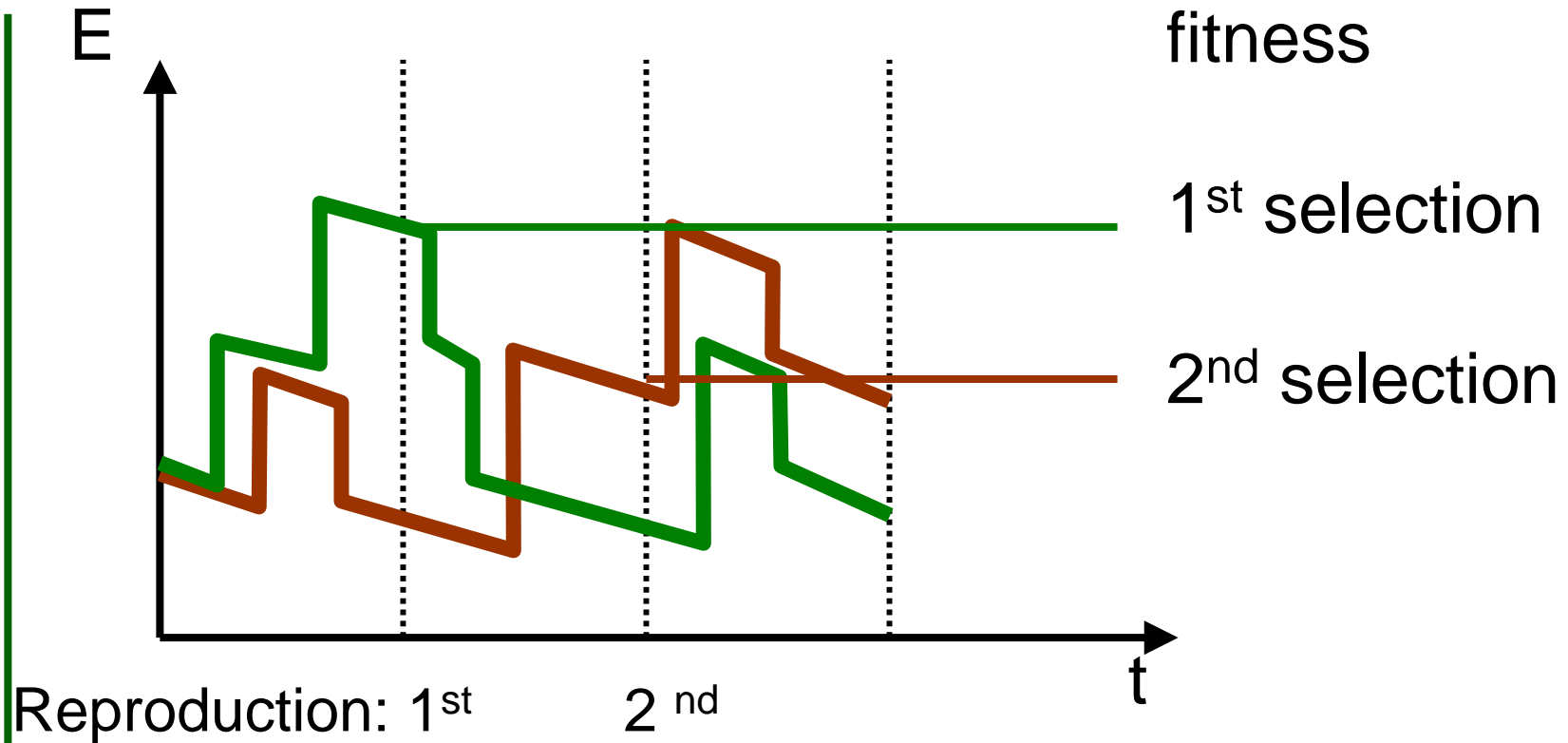
Implementation
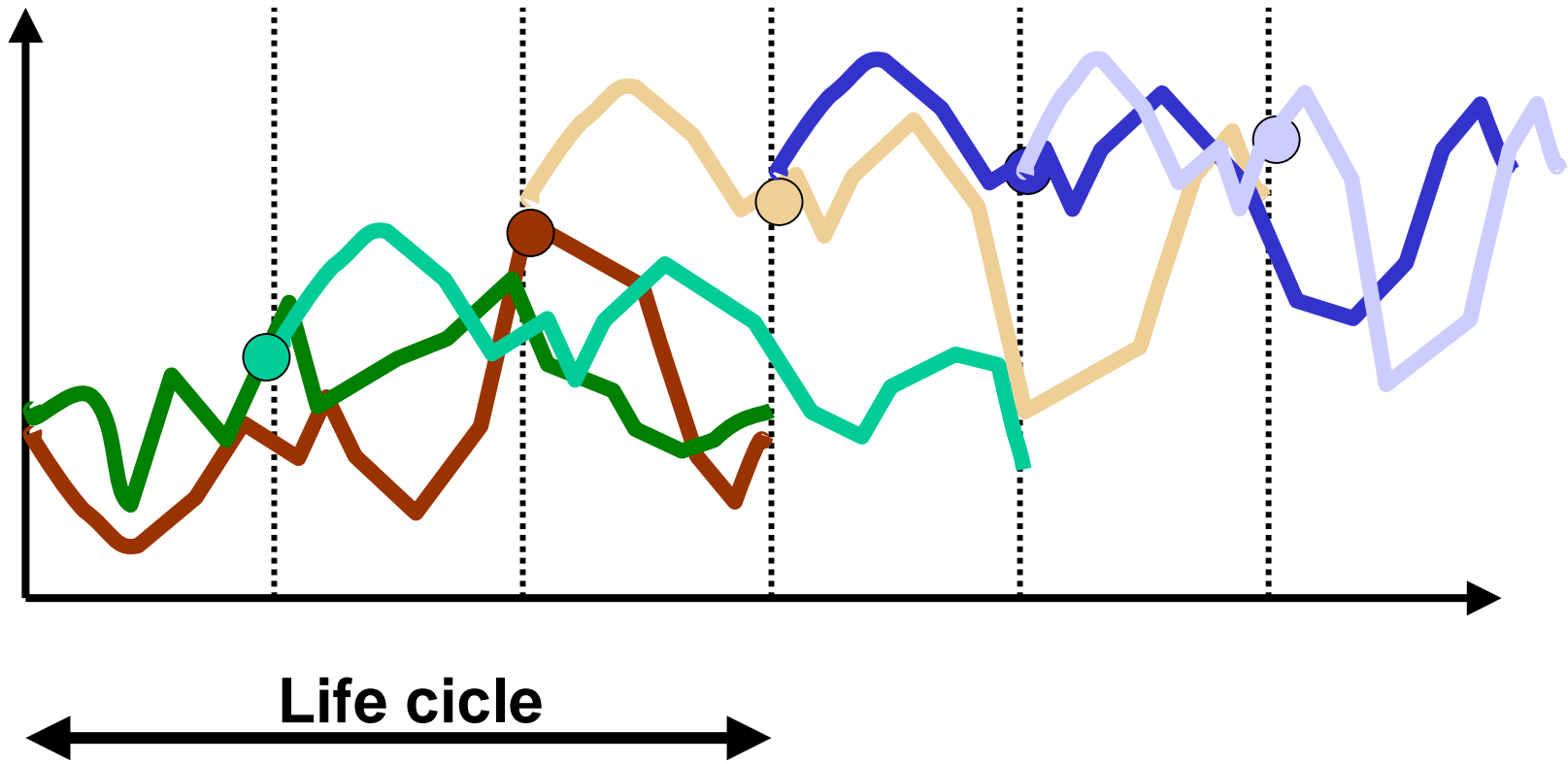## *evolution strategies*

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E

fitness

1st selection

2nd selection

t

Reproduction: 1st   2 nd

Implementation
evolution strategies

WOXBOT

Life cicle

Implementation
evolution strategies

WOXBOT

- life cycle
  - the same for all characters (less interesting)
  - dependent on their energy reserves (more interes.)

- new generation
  - reproduction from best fitted (higher energy)
  - mutation

Conclusion

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- we presented a new artificial life framework

  – multi-modal perception sensors, with training (learning) capabilities

  – adaptable behavior mechanisms, based on evolutionary concepts

  – until now we have worked with non communicating characters (no language usage)

Conclusion
future work

WOXBOT

- test and improve communication mechanisms
  - speech and its recognition
  - language development
  - requires improvements in audition simulation
- improvements in state machine evolution
  - allowing an increase in the number of states

Conclusion
future work

WOXBOT

- incorporate planning

  - knowledge base

  - how to evolve to natural cognition based on evolution ???

  - how to add emotion, and its consequences ???

  - how to incorporate the possibility to choose reproduction partners ???