HÖGSKOLAN SKÖVDE

Modeling artificial metabolism and motivational autonomy in humanoid robots

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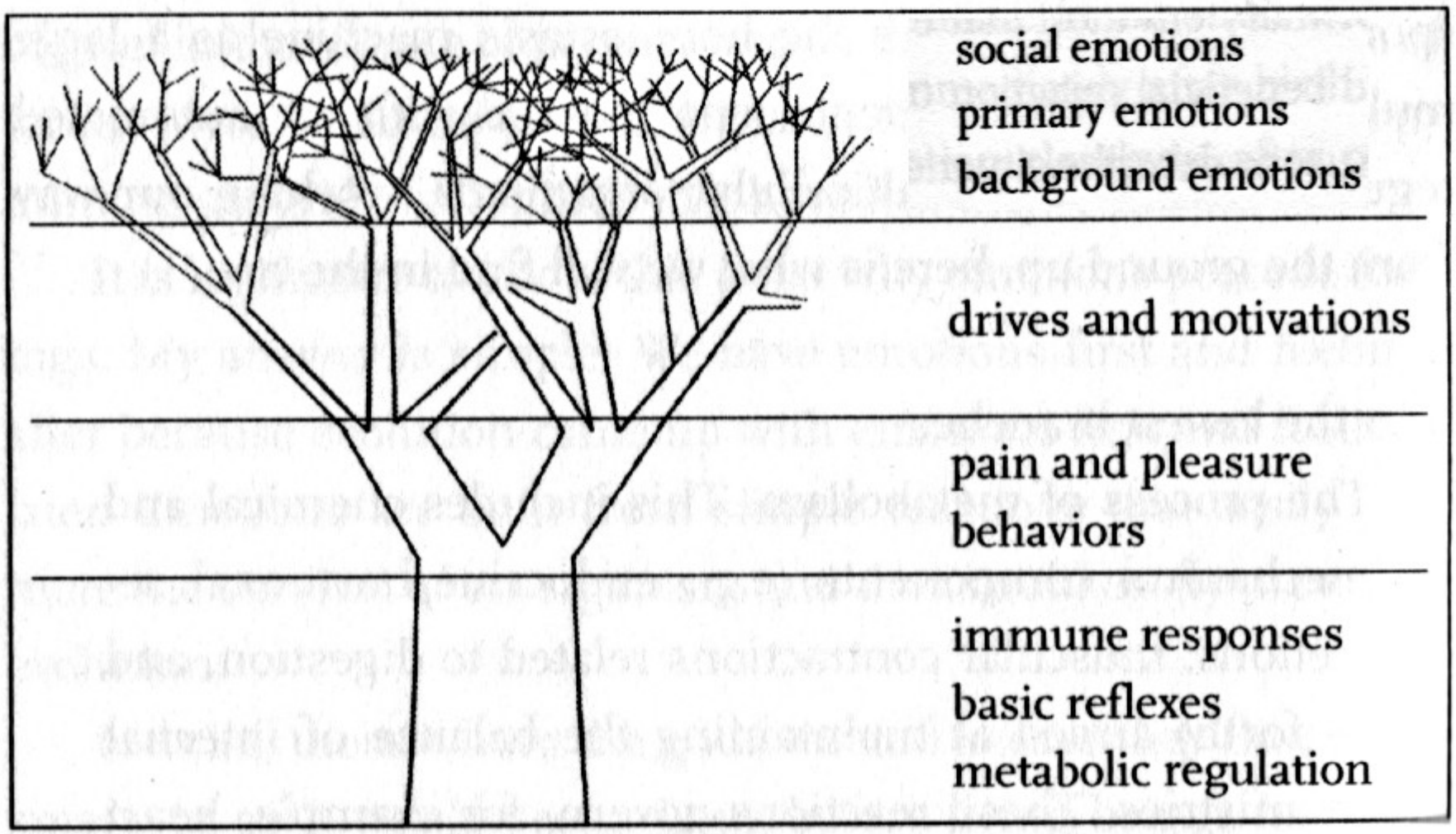
Feel and Want node

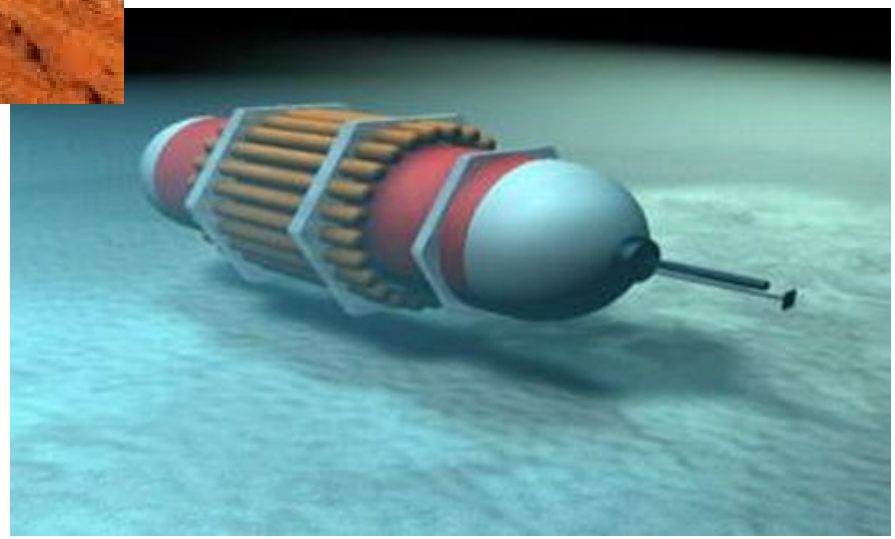
- Affective modulation of embodied higher-level cognition (ESR8)
  - Metabolic regulation integrated in high level decision making mechanism
- Emergence of affective ‘representation’ and predictive capabilities (ESR7)

The nested levels of emotions (Damasio, 2004)



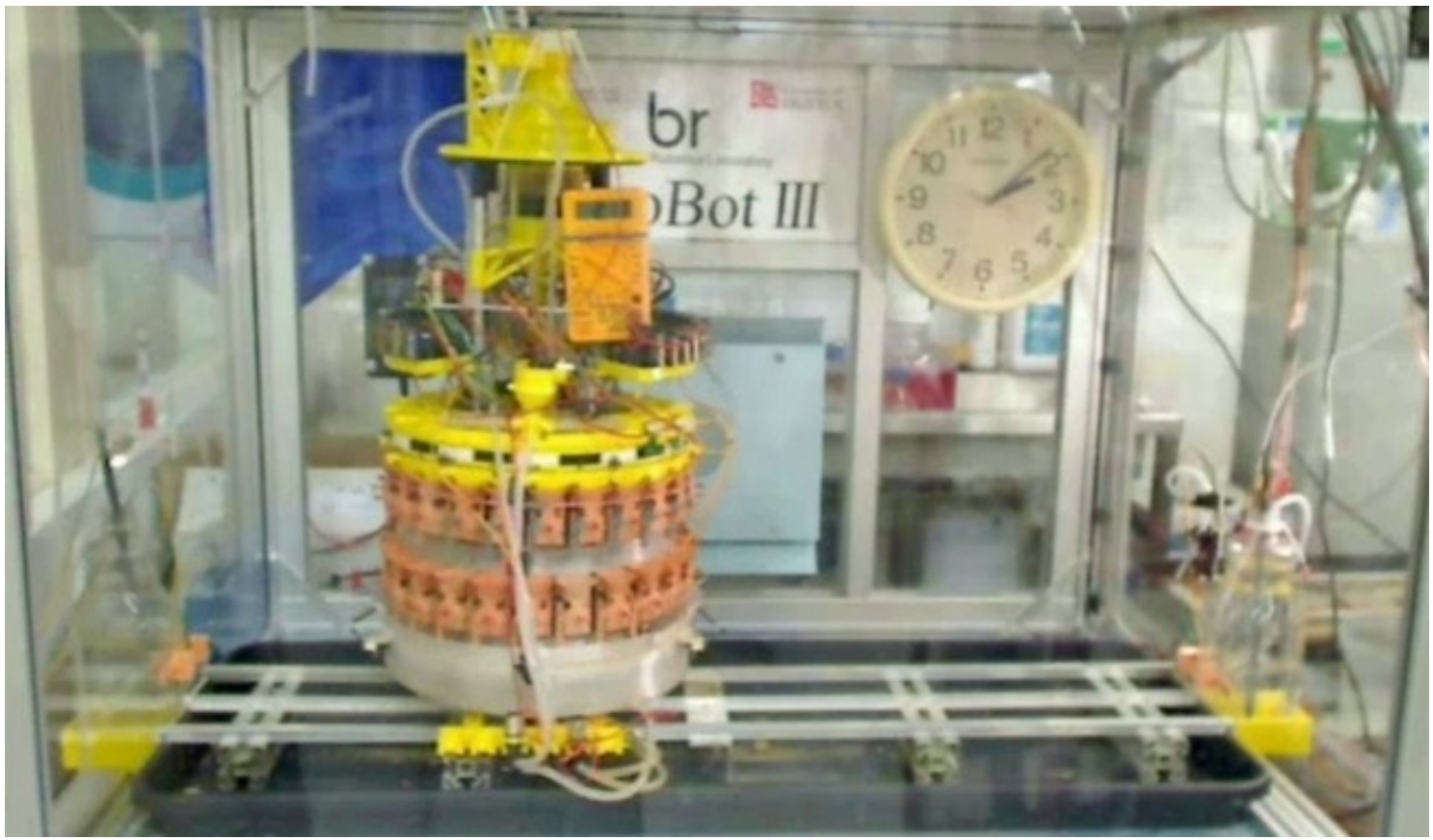
Energy autonomous robots

Solar powered
Mars rover



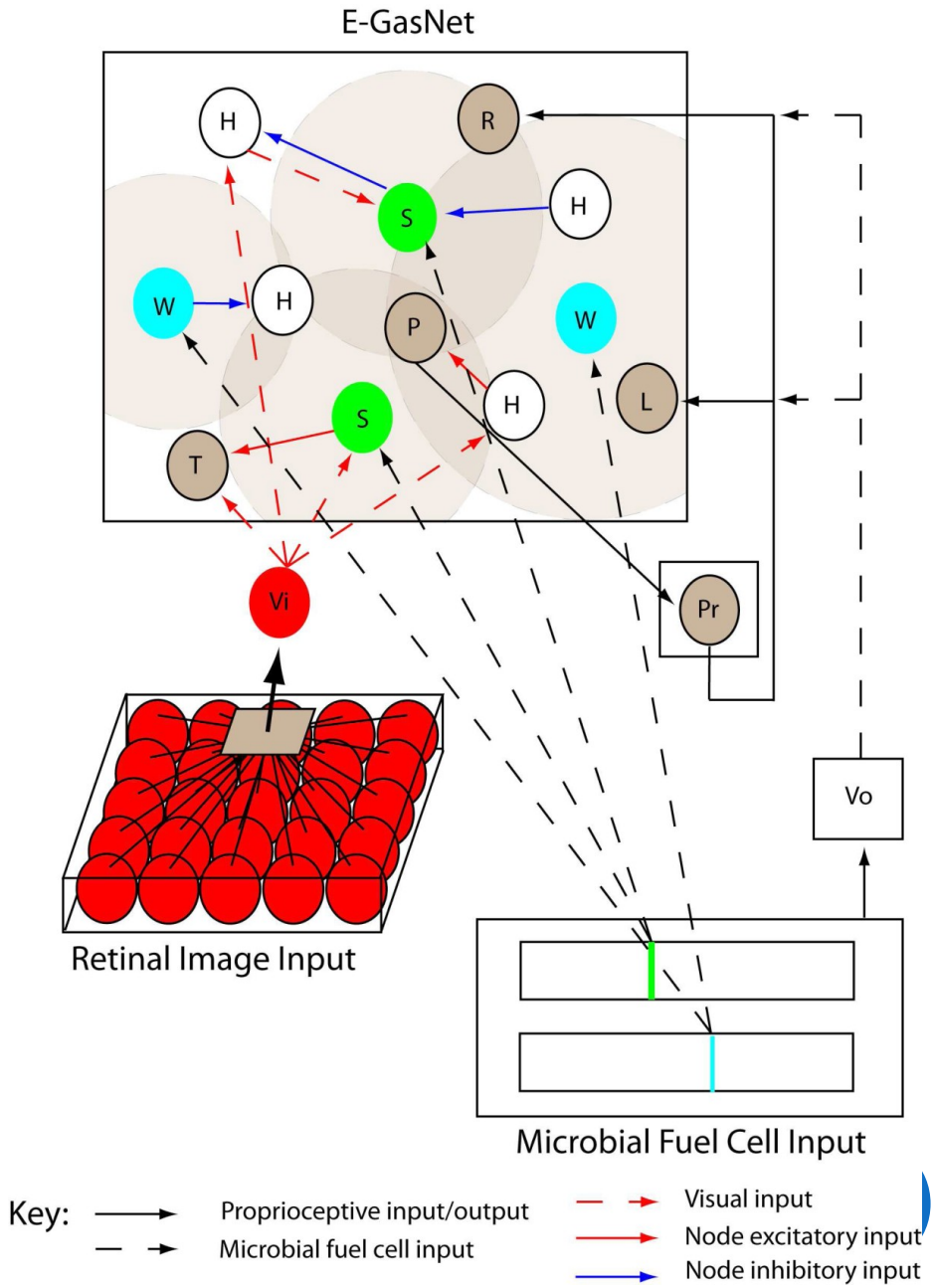
SOLO-TREC robot powered by ocean’s thermal energy

Ecobot (Bristol Robotics Laboratory)

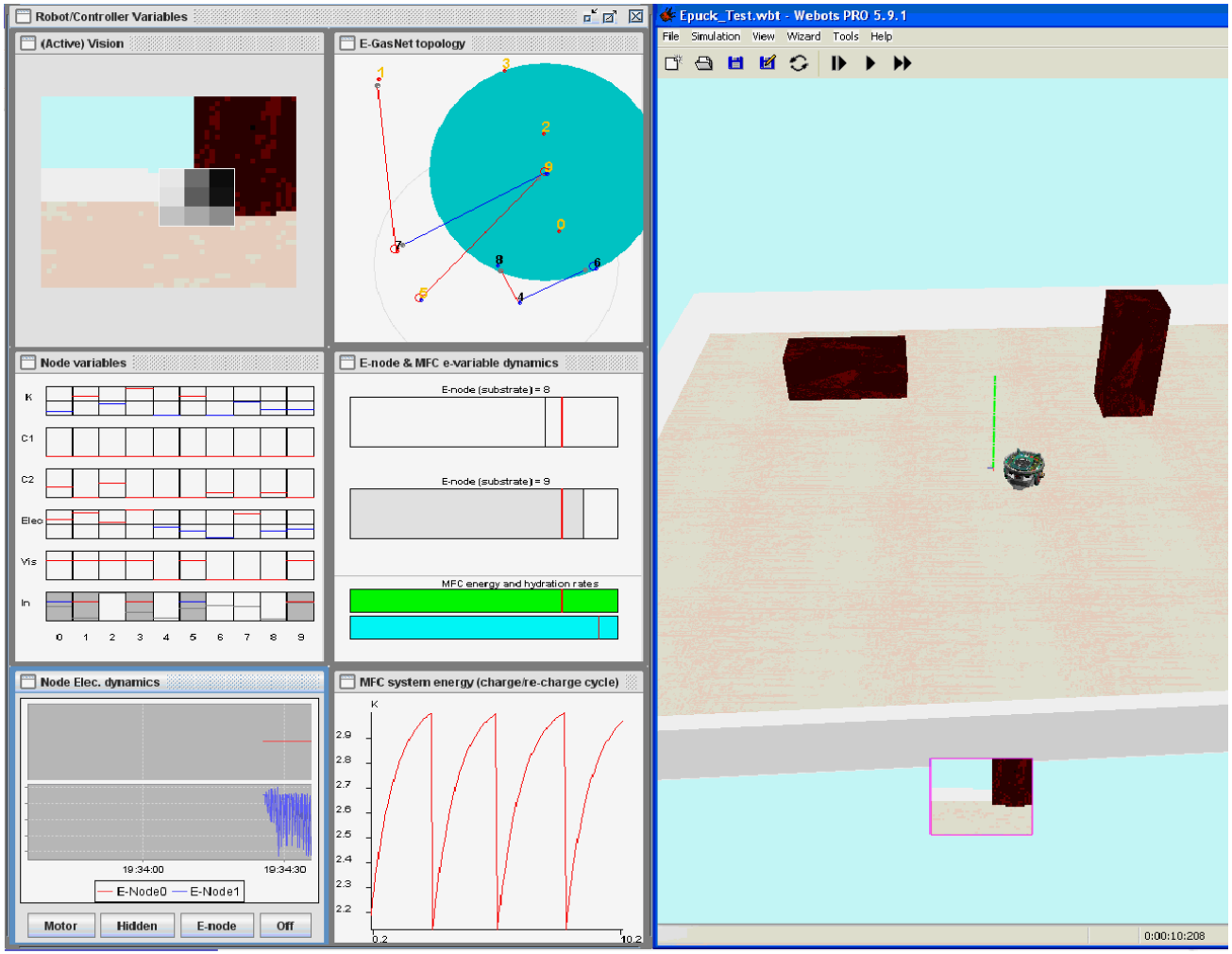


The architecture
(Lowe, R. et. al., 2010)

- The E-GasNet
  - GasNet - interfaces body (metabolic values) with sensori-motor control
  - Essential variable monitoring
- Artificial Metabolism
  - Microbial fuel cell – energy producing from two resources
- Grounded high level cognitive process
  - Active vision
- Evolutionary Algorithms



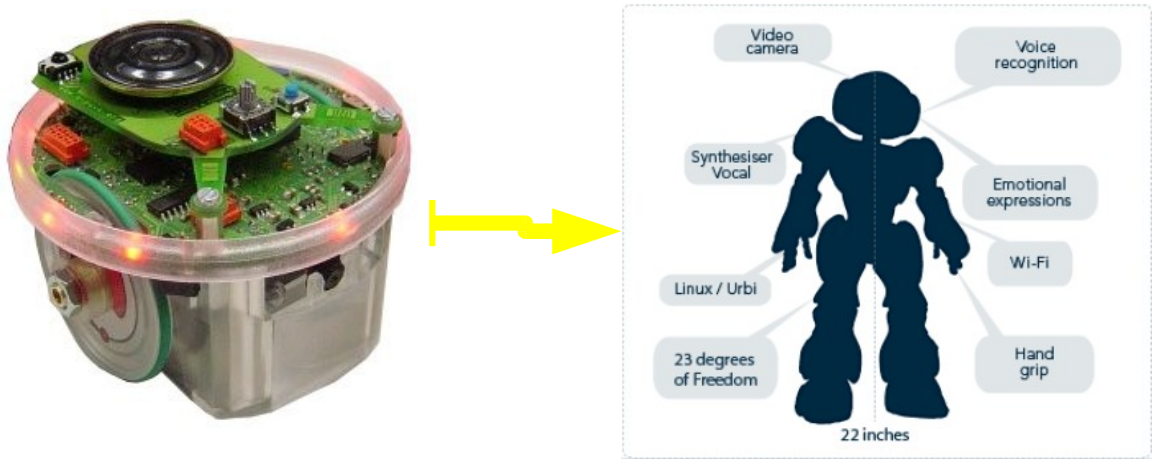
Energy autonomous wheeled robot



Motivation for a new body

- Insight to developmental psychology
  - Humanoid robot has closer structure to the human body thus could be better model
- Industrial applications
  - *Legged moves better in non-smooth terrains*
  - *Robust to disturbances*
  - *More autonomous*
  - *Service robots*

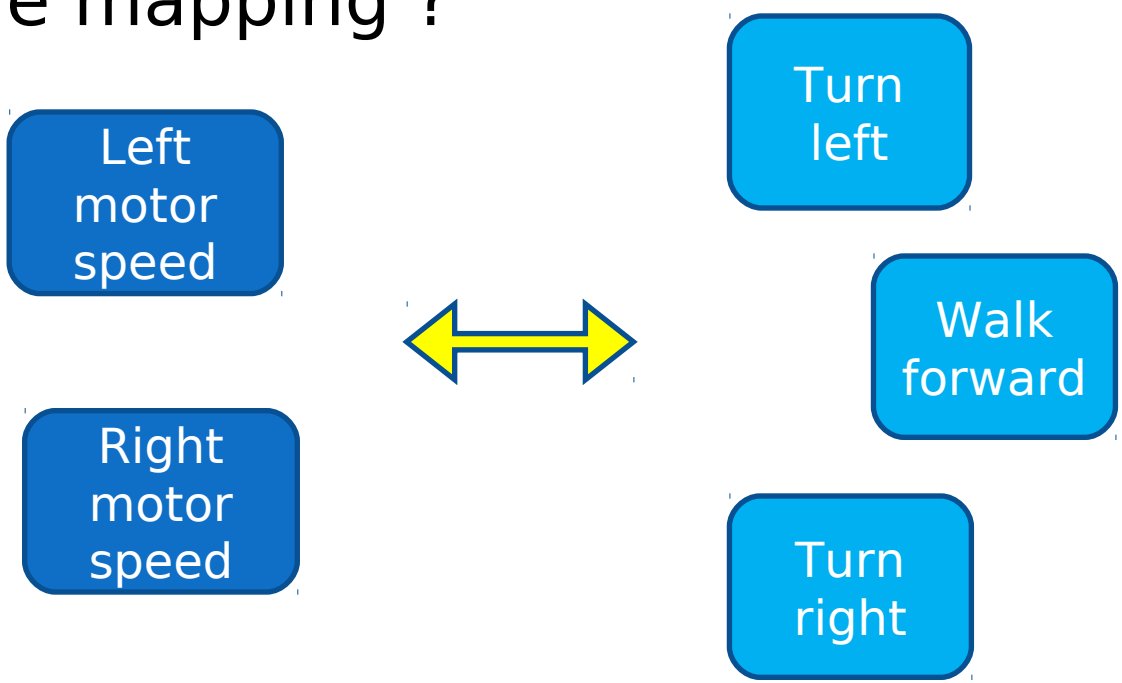
What should be changed?



- Energy cost / movement
- Locomotion pattern
- Gaze around
- Field of view / active vision
- Reaching / Grasping the resource
- Evolutionary algorithm

Move towards resources

- Left right Motor E-Gas NET nodes ↔ motors
- Different walking patterns – develop energy efficient learning
- E-Gas net node ↔ each joint
- E-Gas net node ↔ parameters to a CPG
- How to do the mapping ?



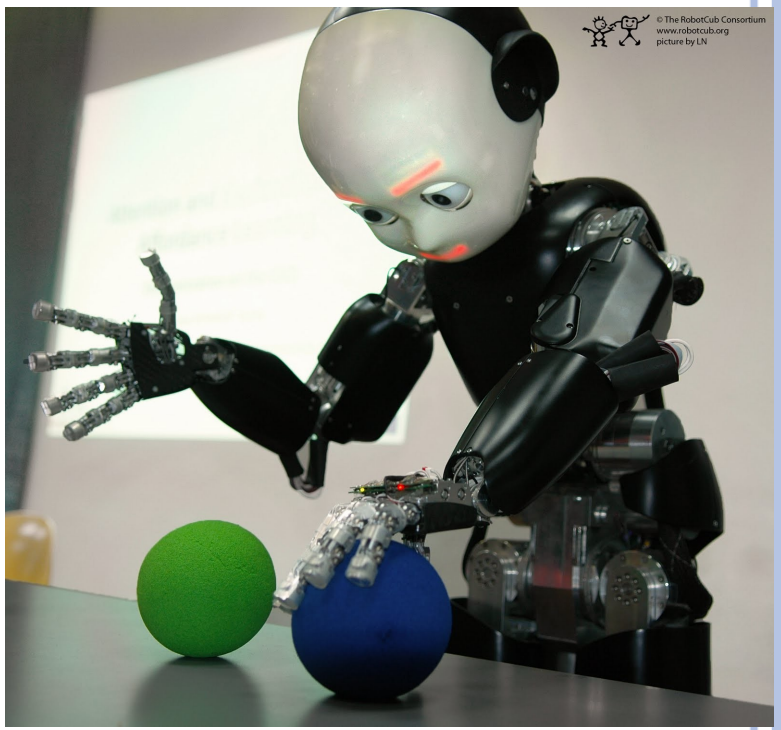
Develop energy efficient motion pattern (Kimura et. al., 2005)

Age group	No. of trials	Dimensionless cycle duration	Dimensionless stride length	Dimensionless speed	Stance phase duration in ln (%)	Braking duration in ln (%)
Infants						
1-year-0-month	104	4.413^{***}, 1.162	1.171^{***}, 0.365	0.2489^{***}, 0.1190	4.259^{***}, 0.100 (91)	3.679^{***}, 0.310
1-year-3-month	133	3.920^{***}, 0.931^{+++}	1.388^{***}, 0.345^{+++}	0.3744^{***}, 0.1276^{+++}	4.235^{***}, 0.083^{+} (122)	3.713^{***}, 0.209
1-year-6-month	163	3.563, 0.765^{+++}	1.425^{***}, 0.301^{+++}	0.4243^{**}, 0.1416^{++}	4.212^{***}, 0.081^{+++} (156)	3.813^{***}, 0.221^{+++}
1-year-9-month	65	3.918^{***}, 0.934^{++}	1.460^{***}, 0.228^{+++}	0.3987^{***}, 0.1280^{+++}	4.237^{***}, 0.078 (63)	3.856^{**}, 0.218^{++}
2-year-0-month	43	3.578, 0.880^{+++}	1.463^{***}, 0.226^{+++}	0.4362^{*}, 0.1351^{++}	4.215^{***}, 0.084^{+} (42)	3.819^{**}, 0.287^{+}
3 years	33	4.351^{***}, 0.743 (30)	1.496^{***}, 0.278^{+++} (30)	0.3624^{***}, 0.1101^{++}	4.237^{***}, 0.058 (31)	3.906, 0.189^{+}
Adults 1	27	–	–	–	–	–
Adults 2	88	3.471, 0.244^{+++}	1.643, 0.171^{+++}	0.4767, 0.0691^{+++}	4.163, 0.025^{+++}	3.926, 0.072^{+++}

- Algorithm used to assess human energy efficiency over a number of different dimensions
- Compare architecture performance to humans data

Reaching / Grasping the resource

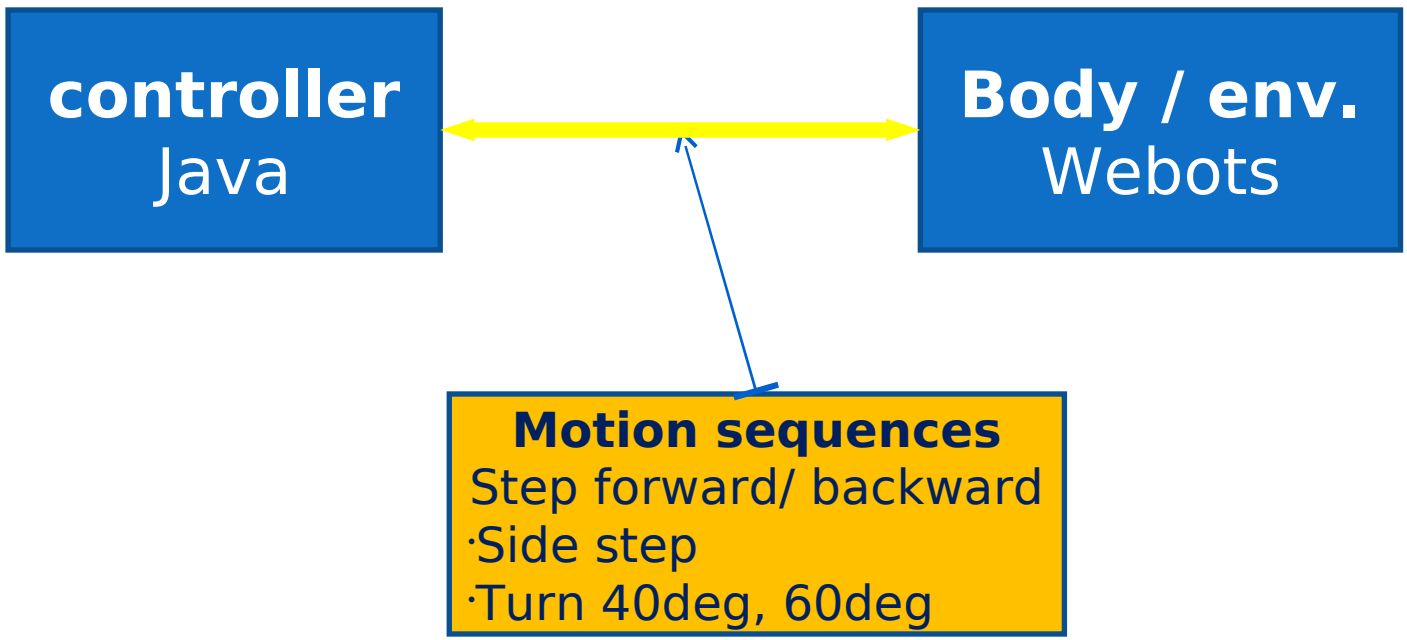
- Solve the grasping problem → action primitive
- Self-maintaining a quantity of sufficient energy to finish the movement (grasping, consuming)
  - Learning how much energy is needed for behavior
- Action selection – chose appropriate action with the current amount of energy



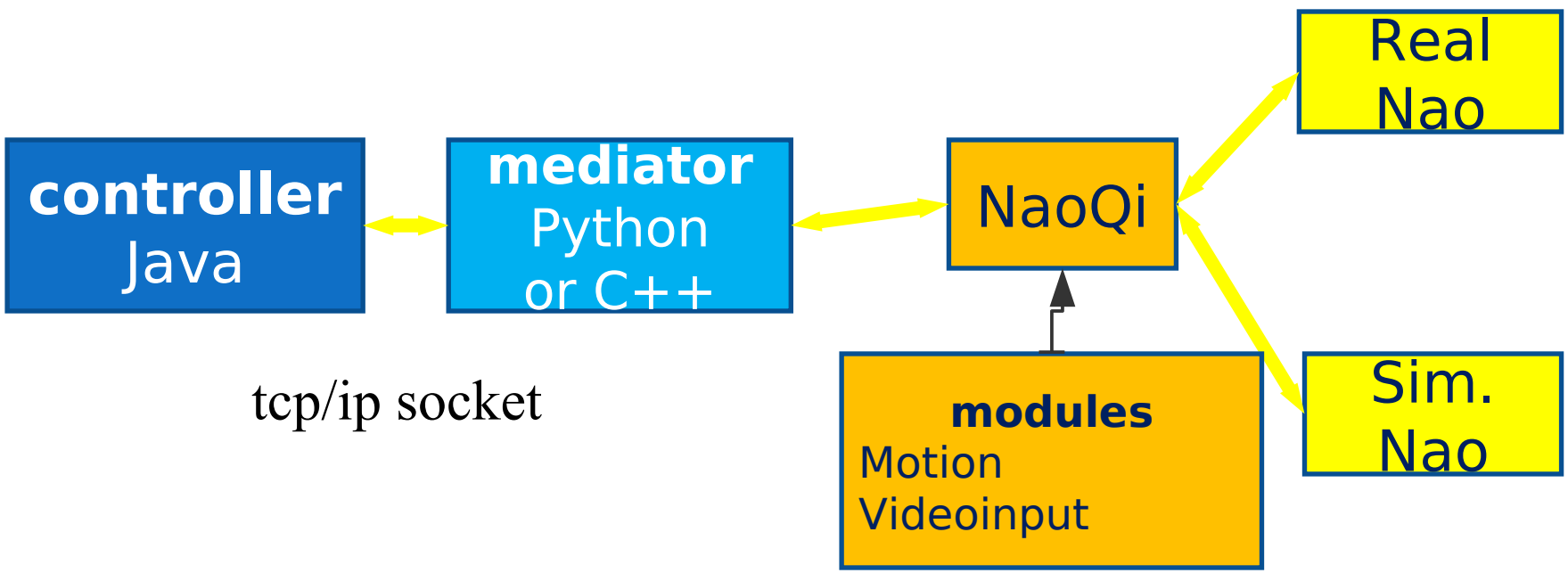
Study the difference

- Compare performance
  - Number of generations to achieve fitness
  - Type of controller evolved
  - Times to reach to resources, patterns of behavior
- Parameters to modify
  - Field of vision
  - Energy constraints
  - Crawling vs walking

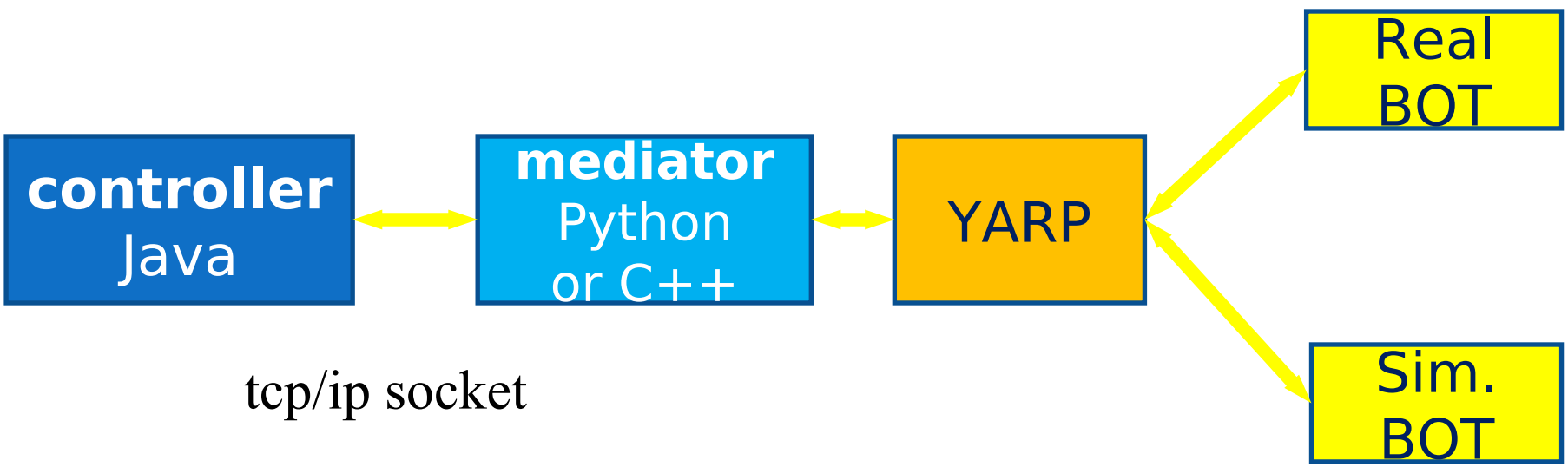
Implementation



More generic architecture



Portability to another robots - iCub



Summary

- State of the art
  - affective cognitive architectures and
  - autonomous agents
- Play with the robots
  - NAO, epuck, iCub
- Modify / reimplement
  - Architecture for artificial metabolism and motivational autonomy

Future work

- More robots
  - Icub, Asimo, Anybot
- Learning abilities
- More complex environment
  - Dynamic resources
  - Obstacles
  - Different objects
- Climb up the tree
  - More complex emotions

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Thanks for the attention!