SYMBRION

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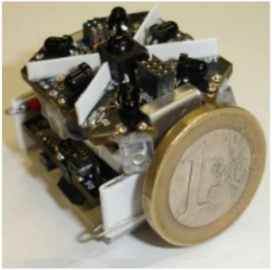
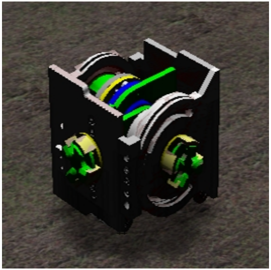
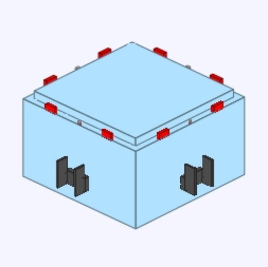
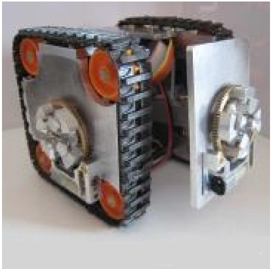
Outline

Symbiotic Evolutionary Robot Organisms

- 5 Year EU Project
- Sister project: REPLICATOR
- Swarm and reconfigurable robotics
- Sharing of power and computational resources
- Bio-inspired research:
  - Evolutionary robotics
  - Artificial multi-cellular organisms
  - Embryology, genetics, homeostasis
  - Self-organisation and emergence

(Video not included)

Robots

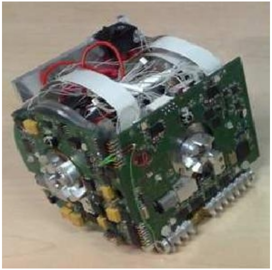
Symbricator: Delta3D Simulator

(Video not included)

(Video not included)

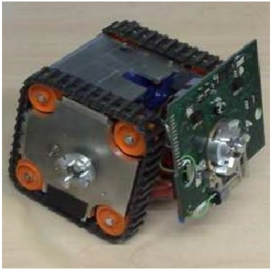
UNIKARL ‘Backbone Robot’

- University of Karlsruhe
- Task: formation of 3D organisms
- $85x85x85mm^3$, approximately 1kg
- Strong and stable structure
- Powerful actuators for lifting several docked units
- Slow, precise, omnidirectional locomotion



SSSA 'Scout Robot'

- Sant'Anna School of Advanced Studies
- Tasks:
  - Surveliance
  - Gathering of robots for assembley
  - Specialised modules in organism
- $85x85x85mm^3$, approximately 1kg
- Equipped with long-range sensors
- Weak lifting actuators
- Fast and flexible locomotion

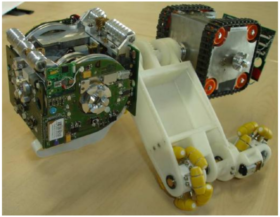


Cubic Robot Prototypes

(Video not included)

USTUTT 'Active Wheel Module'

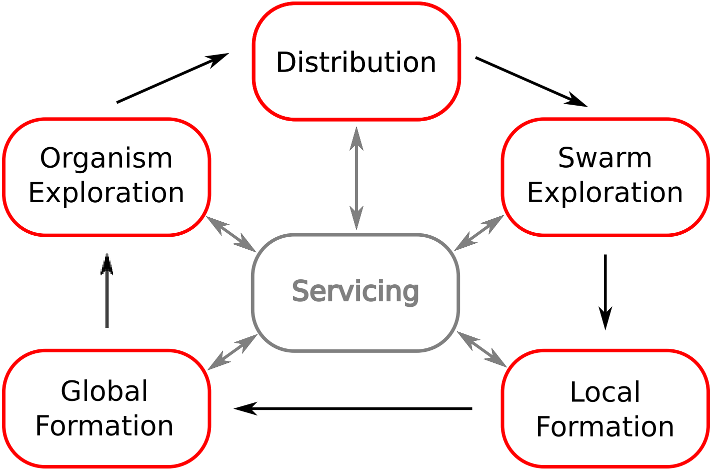
- University of Stuttgart
- An example of a 'Tool Module':
    - Compatible docking mechanism
    - Optimised for specific functions
    - Compensate for deficiencies in individual robots
- Flexible omnidirectional locomotion
- Able to carry heavy loads
- Tasks:
    - Transportation of robots
    - Act as additional energy source
    - Flip toppled robots



Active Wheel Prototype

(Video not included)

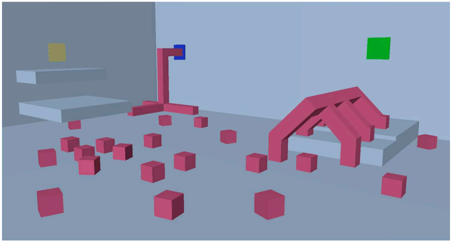
Example Scenario



Grand Challenges

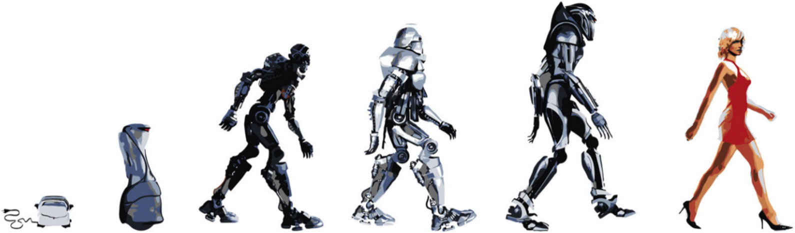
- SYMBRION and REPLICATOR share two “Grand Challenges”
- Devised in order to demonstrate the potential breakthroughs in:
  - Reliability
  - Plasticity and adaptivity
  - Scalability
  - Regulatory autonomy
  - Long-term independence

Grand Challenge 1: 100 Robots 100 Days



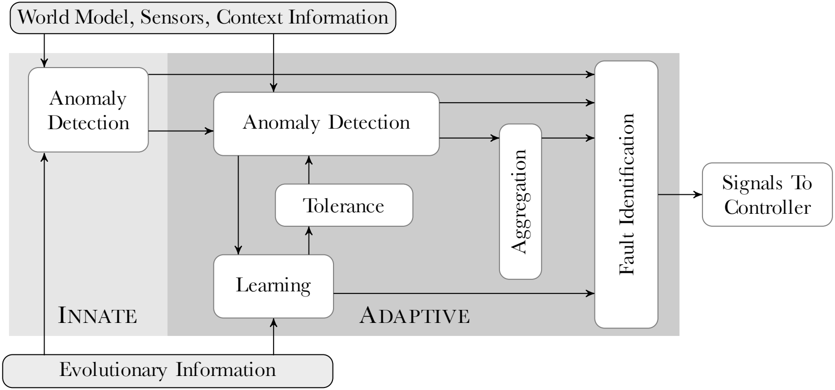
- Long-term independency in middle-rate changeable environment
- 100 Heterogeneous modules
- Environment contains power sockets and power cubes:
  - Energy is a limited resource
  - Sockets turn on and off over time
  - Sockets are inaccessible to individual robots
  - Overall availability of energy decreases over time

Grand Challenge 2: The Origin of Species

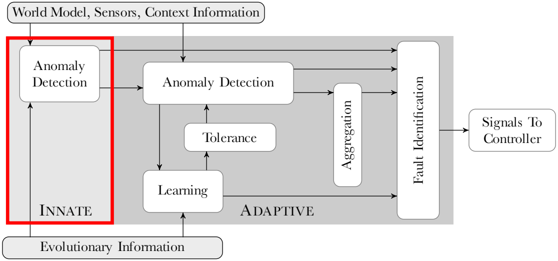


- Investigating on-line, on-board, open-ended co-evolution
- Physical environment similar to GC1
- Evolution in a high-rate changeable environment
- When and if a split between one species into several is possible

AIS Framework

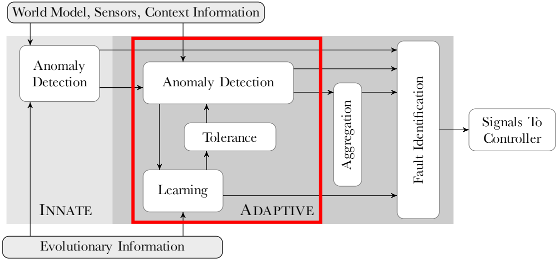


Innate Immune System



- Modified Dendritic Cell Algorithm (mDCA)
- Detection of faulty IR sensors
- Monitoring of energy homeostasis
- Monitoring of actuation module

Adaptive Immune System



- Instance based B-cell algorithm
  - Fed by information from the innate immune system
  - Detects both behavioural and component based anomalies
- Receptor density algorithm
  - Adaptable error detection in power module

My PhD

- Immune-inspired Fault Tolerance in Collective Robotic Systems
- Power management and fault tolerance in the power module
- Further integration of previous work
- Continued development of the adaptive AIS
- Predictive immunity
  - Identification of errors before they occur
  - Prevent a potentially faulty robot from joining an organism
- Evolved immunity
  - Off-line parameter optimisation
  - On-line evolution of the AIS

And finally...

- Demo 1: Wenguo Liu's (UWE) work using the Stage simulator
- Demo 2: My plans for using the Stage simulator