THE BIOROBOTICS INSTITUTE

Scuola Superiore Sant'Anna

Robotics Class - Final Projects

MSc in Computer Science

2015

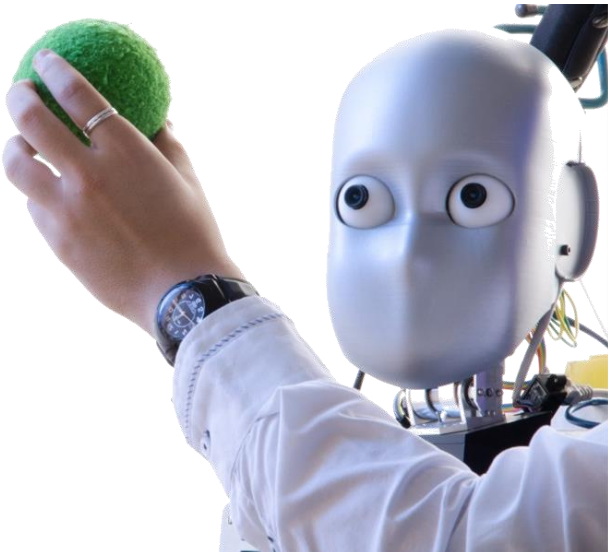
Project no. 1 → Student: Cipressi

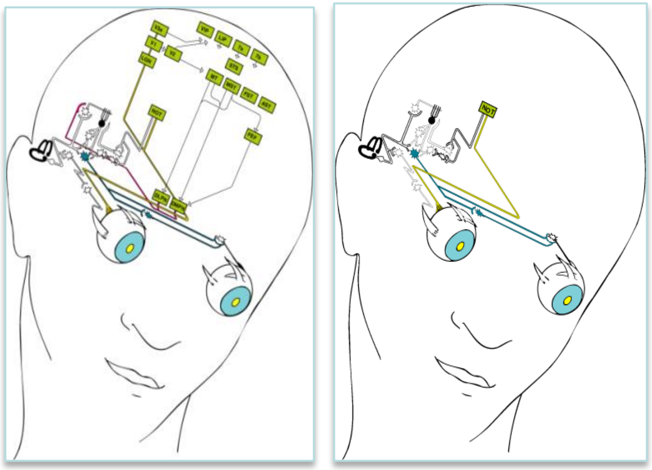
Neuroevolution for eye movements control

Evolving a neural circuit in charge of modulating the interaction among different eye movements (*Vestibulo-Ocular Reflex* and *smooth-pursuit*) during passive and active head rotation

→ Comparison with neuroscientific evidences

Tools: iCub simulator, SABIAN robot, YARP middleware, off-the-shelf neuroevolution algorithms





Expected results: A humanoid robot that is able to switch between different eye movements thanks to an evolved Neural Network.

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Project no. 2 → Student: Porciani

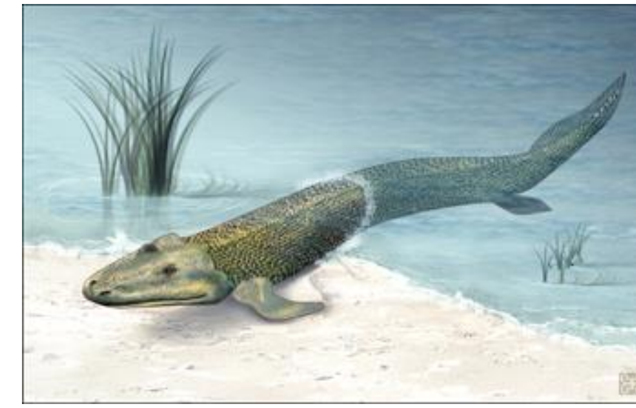
Artificial Life and Evolutionary Robotics – How the evolution of swimming have influenced the ability to learn to walk on land?

Life-forms evolved first in water, then moved to the land. As a consequence swimming came about first with respect to terrestrial walking.

Was this beneficial? What kind of morphological traits evolved for swimming may have been useful for walking? What if evolution started on land?

Tools: off-the-shelf environments for evolutionary robotics

Expected results: Experiments and comparative performance analysis among populations evolved in different environments (only land vs first water then land).



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Project no. 3 → Students: Ragusa, Delogu, Bruno

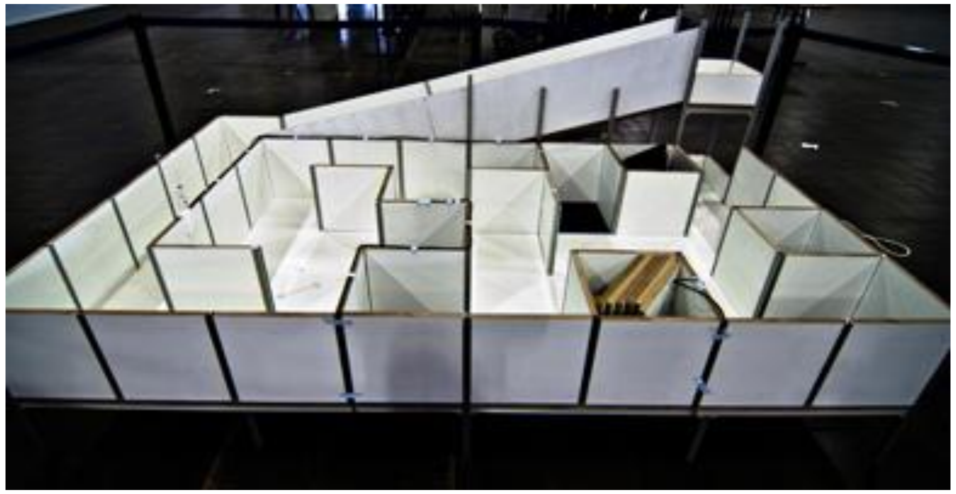
AIBO Search & Rescue

Visually guided exploration of a maze. The robot must be able to fully explore a maze and search for ‘‘victims’’ painted on the walls.

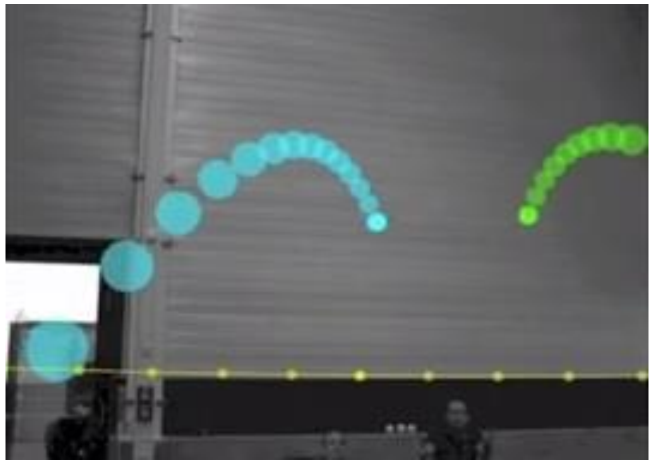
Skills: control architectures, navigation, computer vision

Tools: AIBO robot + libraries, URBI middleware

Expected results: Live demo of the AIBO robot performing in a previously unseen maze



Project no. 4 → <u>Student</u>: Benvenuti



Ball catching through prediction

The objective of this work is to catch a tossed ball with the robot hand. The trajectory must be predicted with a neural network in order for the robot to catch it.

<u>Skills</u>: computer vision, neural networks

<u>Tools</u>: iCub simulator, SABIAN robot, YARP middleware

<u>Expected results</u>: A humanoid robot performing a catching task using the prediction generated by a neural network

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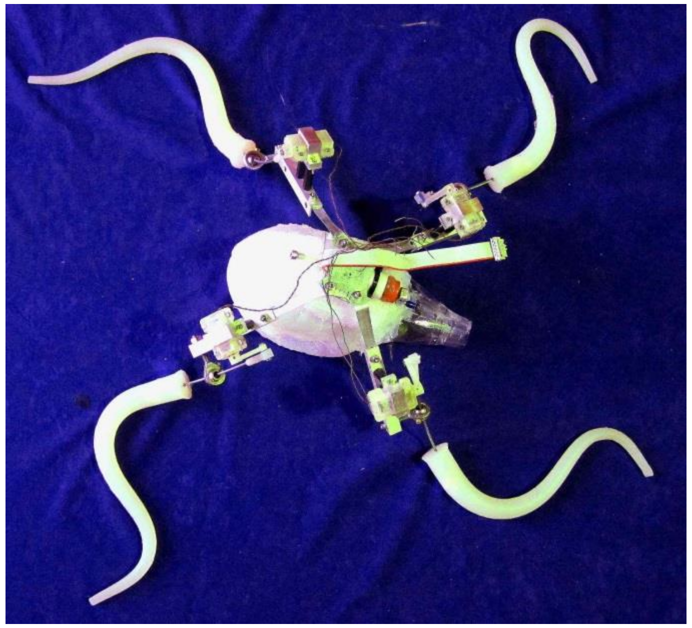
Project no. 5 → Student: Crecchi

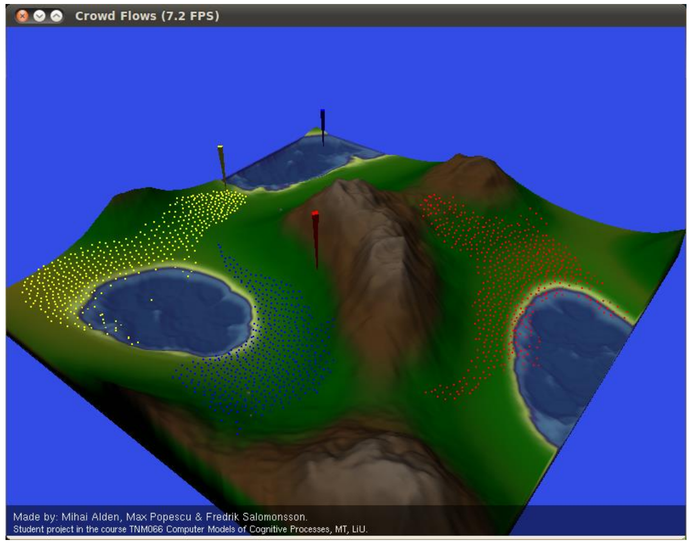
Neuroevolution, morphing and locomotion

Animals exhibit morphological adaptation during their lifetime (morphosis/morphing). We are currently working towards autonomous robots that are able to exploit the same mechanism online, understanding when and how they should adapt their body to better locomote over different terrains.

Tools: simulation environment, neuroevolution algorithms



Expected results: Emphasis can be on developing a robust model (including morphing) of our PoseiDRONE robot, as well as of complex terrains in which the model will evolve, or on neuro-evolving a morphing controller in simulation for an adapted off-the-shelf robotic model.



Contact persons: F.Corucci (f.corucci@sssup.it), M.Calisti (m.calisti@sssup.it)

For simulation projects:

1. http://www.cyberbotics.com/
2. http://www.coppeliarobotics.com/
3. http://www.framsticks.com/
4. http://gazebosim.org/
5. http://www.uvm.edu/~ludobots/
6. http://www.voxcad.com/
7. http://ero.matfyz.cz/
8. http://www.robogen.org/

Backup projects

Project no. B1

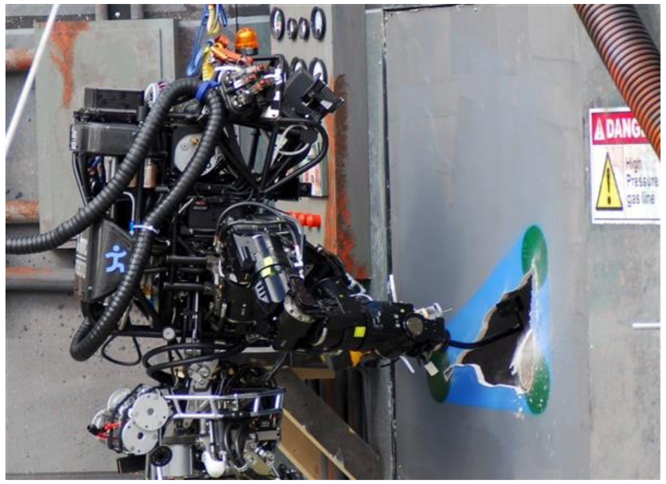
NAO Robotic Challenge

Mini Darpa Robotic Challenge (walking, tool manipulation, valve turning). The robot can be teleoperated.

Skills: control architectures, manipulation, computer vision

Tools: NAO robot + libraries, Choreographe

Expected results: Live demo of the NAO robot performing the described tasks



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Project no. B2

3D visual reconstruction of soft objects

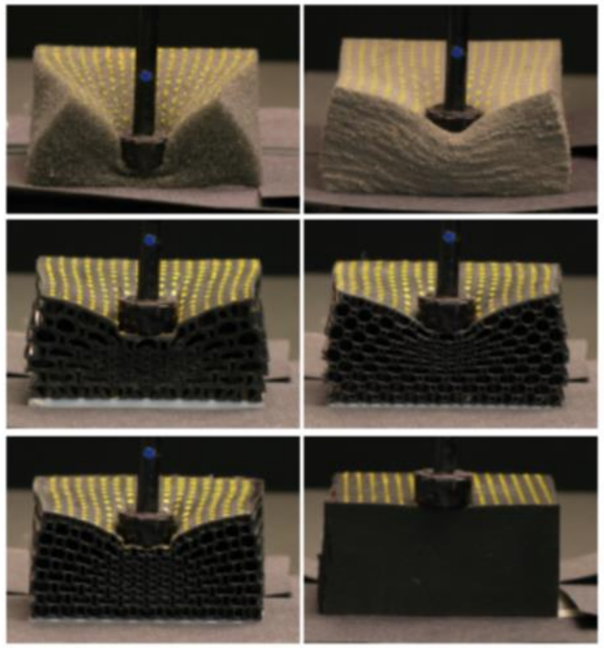
3D printing is rising as a novel and disruptive fabrication methodology. Multi-material printers are able to build, in one run, objects made of non-linear heterogeneous material. The aim of this project is to characterize simple multi-material objects to produce an advanced 3d model with dimensional and material information to feed a multi-material 3d printing machine.

Tools needed from the course:

- DLT transformation
- Image analysis

Additional skill that will be learnt:

- Material property
- Soft-object fabrication by silicone casting
- Testing setup building



Expected results: A software able to visually reconstruct simple objects and infer their material properties

References:

Design and Fabrication of Materials with Desired Deformation Behavior, B. Bickel, M. Bächer, M. A. Otaduy, H. R. Lee, H. Pfister, M. Gross, W. Matusik, Proceedings of ACM SIGGRAPH (Los Angeles, USA, July 25-29, 2010), ACM Transactions on Graphics, vol. 29, no. 4.

Capture and Modeling of Non-Linear Heterogeneous Soft Tissue, B. Bickel, M. Bächer, M. A. Otaduy, W. Matusik, H. Pfister, M. Gross, Proceedings of ACM SIGGRAPH (New Orleans, USA, August 3-7, 2009), ACM Transactions on Graphics, vol. 28, no. 3.

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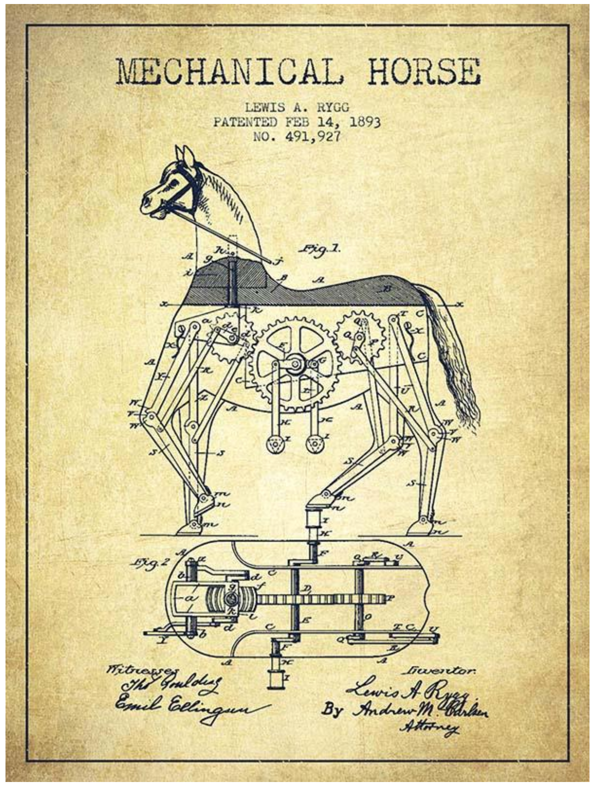
Project no. B3

Mechanical character design via optimization of traditional mechanisms



Fluent and natural movements can be obtained by complex mechanisms. Designing the correct mechanisms is often a challenging taks based on the designer experience: with optimization methods based on target path of the mechanism, design can be simplified and customized on the user needs.

Tools needed from the course:

- Kinematic analysis
- Optimization methods (gradient and GA)

Additional skills that will be learnt:

- Mechanism analysis and design
- Mechanical character building

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References: Computational Design of Mechanical Characters, ACM SIGGRAPH,
Stelian Coros et al,2013

http://www.disneyresearch.com/project/mechanical-characters/

Project no. B4 – Evolution of *penalty kick* agents

Can you evolve an agent for kicking/saving penalties kicks?

Kicker:

- E.g. an underactuated leg, you may actuate just one DoF (e.g. ankle)
- Parameters: actuation signal of activated joint(s) (e.g. torque), morphological properties of the leg (e.g. stiffness of the compliant joints), orientation of the leg with respect to the ball (yaw angle)

Keeper:

- Morphology: a simple rigid object continuously sweeping before the goal, or a more complex one (e.g. an arm)
- Control: May be hard-coded, evolved itself, co-evolved with the kicker, or even approached with different tools, e.g. NN prediction

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