

Task 5.3

Exploitation of biomechanical constraints for learning of complex movements

Cristiano Alessandro (ESR 2)

University of Zurich
BODY node

RobotDoC

Robotics for Development of Cognition

My background



- Bachelor's degree in Computer Eng.
 - University of Catania
 - Spiking neural networks



- Master's degree in Computer Eng.
 - Politecnico di Milano
 - Software engineering for robotics
- Research internship
 - 6 months, Politecnico di Milano
 - Affective interaction and machine learning



PhD and RobotDoc

- PhD candidate, University of Zurich
- Research interests
 - Biologically inspired control
 - Human movement control
- Internal supervisors
 - Prof. Rolf Pfeifer (UZH)
 - Dr. Hugo Gravato Marques (UZH)
- External supervisors
 - Prof. Giorgio Metta (IIT)
 - Dr. Francesco Nori (IIT)
 - Prof. Angelo Cangelosi (UoP)



Training experiences

- **Summer schools and workshops**
 - Multimodal and Cognitive Systems, 2010 (Switzerland)
 - Veni Vidi Vici, 2010 (Italy)
 - Machine Learning, 2011 (Singapore)
 - Impedance Control, 2011 (Germany)
 - Biomechanical Simulation of Humans and Bio-inspired Humanoids Workshop, SIMPAR 2010. Darmstad, Germany
- **Soft skills**
 - Research method in Computer Science (UZH)
 - Scientific inquiry (UZH)
 - English writing for computer science (UZH)
 - Project management for research (UZH)
- **Research exchanges**
 - Plymouth: May 30th - June 4th 2011
 - IIT: July 4th - 15th 2011



Students excuses through out the ages.

Teaching experiences

- Teaching assistance
 - Introduction to AI, Fall 2009
 - Artificial Life, Spring 2010
 - Embedded Prog, Spring 2011
 - Introduction to AI, Fall 2011



- Co-supervision bachelor thesis
 - Reflex learning in a tendon-driven robot (M. Weyland)
Journal publication in preparation

Publications

- **Journals**

Alessandro C., Martinez H., Marques H., Lungarella M., Pfeifer R. *Embodied Classification of object material properties*. Advanced robotics (submitted)

Marques G. H., Weyland M., Alessandro C., Kuppuswamy N., Pfeifer R. *Self organization of reflexive behaviour in tendon-driven machine*. (in preparation)

- **Conference proceedings**

Marques G. H., Jäntschi M., Wittmeier S., Alessandro C., Lungarella M., Knight R., Holland O. *ECCE1: the first of a series of anthropomimetic musculoskeletal upper torsos*. IEEE International Conference on Humanoid Robotics, Humanoid 2010. Nashville, USA.

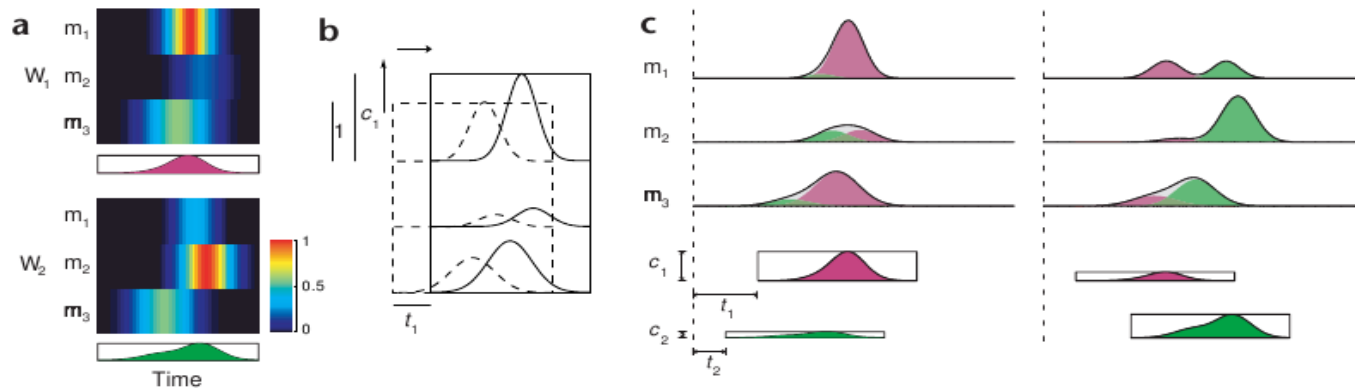
- **Posters**

Alessandro C. *Movement Control of Biologically Inspired Humanoid Robots* (talk). Marie Curie workshop, European Science Forum, ESOF 2010. Turin, Italy.

Kuppuswamy N., Alessandro C. *Impact of Body Parameters on Dynamic Movement Primitives for Robot Control* (abstract). The European Future Technologies Conference and Exhibition, FET 2011. Budapest, Hungary

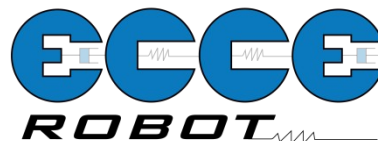
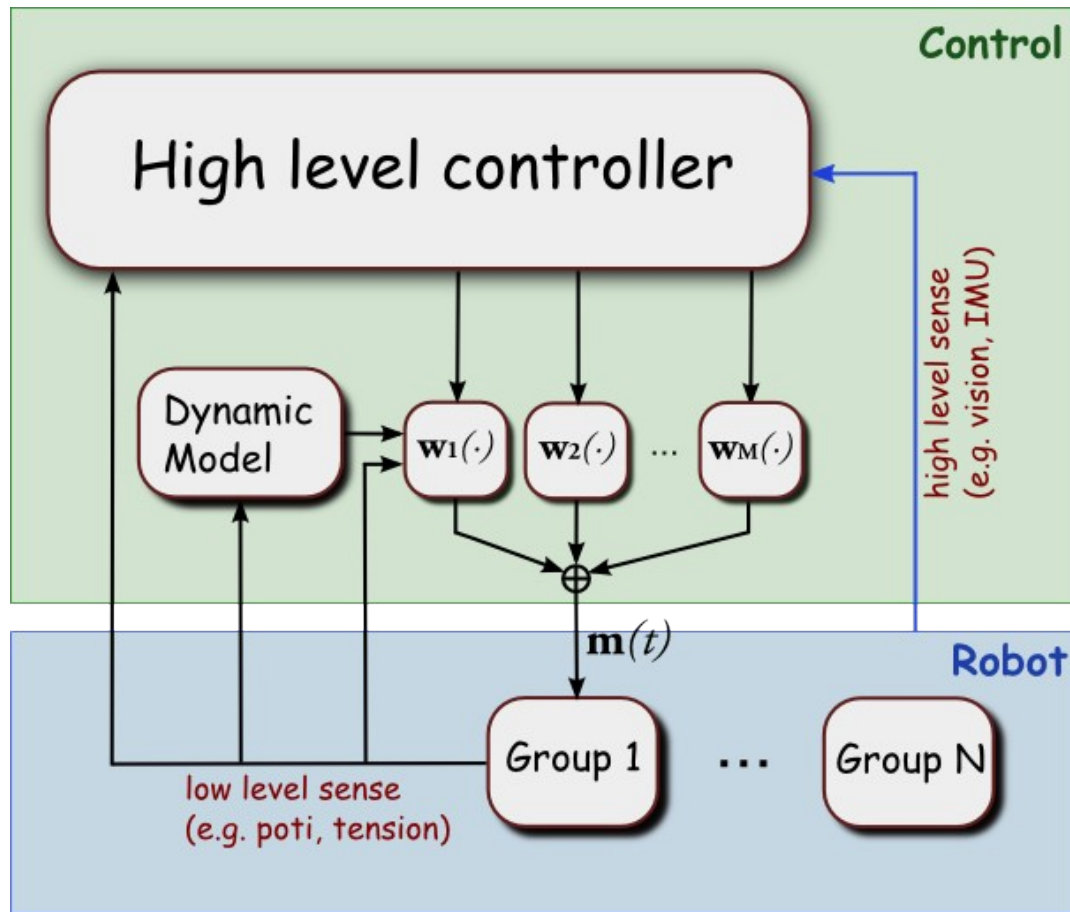
Science!

- Control of Anthropomorphic Robots
 - Highly redundant
 - Muscle groups
- Muscle synergies
 - Coordinate activations of groups of muscles with specific time-varying profile



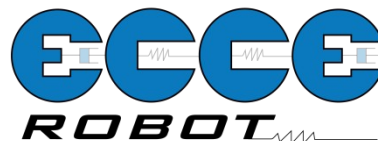
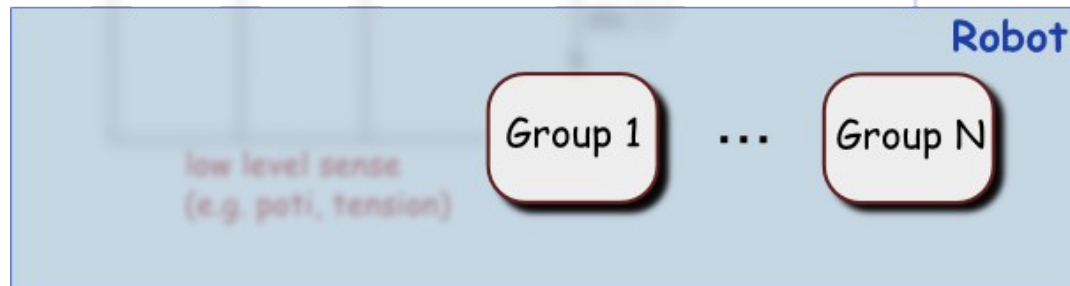
d'Avella A, Saltiel P, Bizzi E. *Combinations of muscle synergies in the construction of a natural motor behavior*. Nature neuroscience. 2003;6(3):300-8.

Control architecture



Robot and muscle grouping

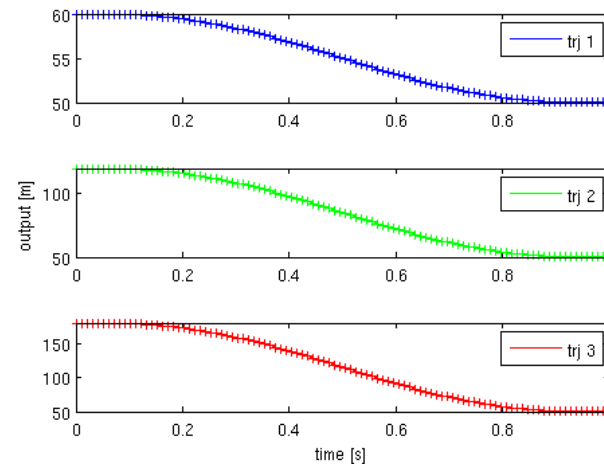
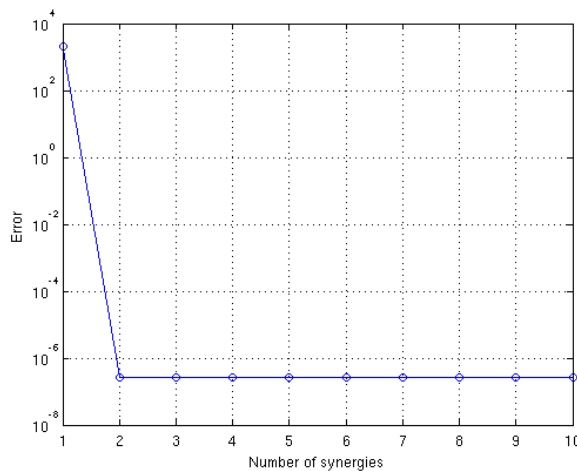
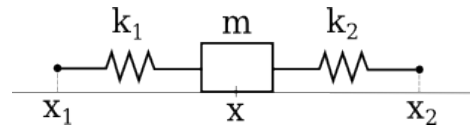
- Design of the pendulum Robot
 - Compliant, Redundant, Muscle groups
- Technique to identify muscle groups
 - Correlation between sensory signals and motor commands





Synergy identification

- Muscle synergies are defined as parametrized functions of time (Open loop control)
- Input as linear combination of synergies
- Optimization of the parameters to best approximate a set of trajectories (training set)



Future work

- Evaluation of synergy identification on the pendulum robot
- State dependent (closed-loop) and “optimal” synergies (optimal control)
- Investigate muscle grouping and its impact on the performance
- Generalization to newer control tasks
- Evolution of the synergies wrt changes in the body and in the task (development)
- Case study: ECCERobot



Conclusion

- The RobotDoc is supporting my career development by helping me to get in touch with the field and develop both technical and non-technical skills.
 - Control, optimization, neuroscience, developmental rob.
 - RobotDoc Coaching
- Really nice and easygoing group of people, while being focused on producing valuable results.

Pleasure in the job puts perfection in the work

Aristotele (384-322 BC)



University of
Zurich^{UZH}

Department of Informatics

ai lab



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Thanks!!!