FUNDING OPPORTUNITIES from the FUTURE & EMERGING TECHNOLOGIES scheme

Scuola Superiore Sant'Anna

September, 20-24 2010

L.E.M. Livorno Euro Mediterranea - Livorno, Italy

Embodied Intelligence Summer School

OCTOPUS

evrion

ANGELS

EMBODY

LOCOMORPH

emorph

"The nature of the human mind is largely determined by the form of the human body."

Rodney A. Brooks, 1999

"Artificial intelligence can only be achieved by machines that have sensory and motor skills and are connected to the world through a body."

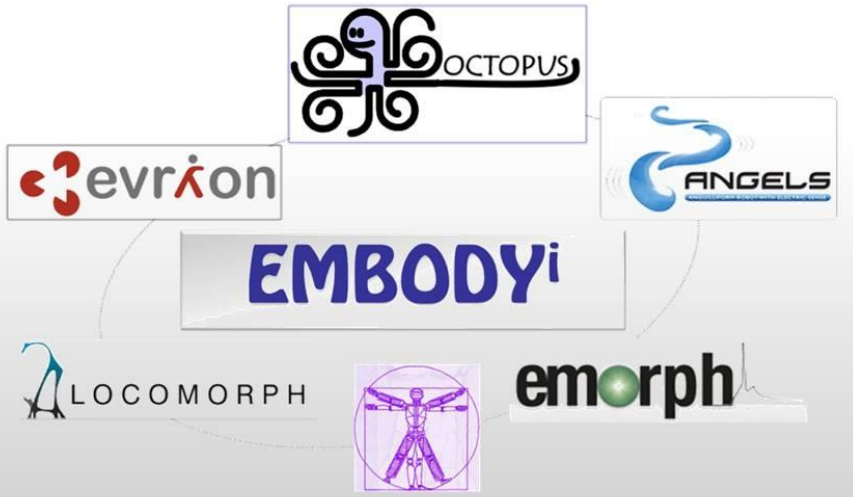
R. Pfeifer and J. C. Bongard, 2007
How the Body Shapes the Way We Think
a new view of intelligence

The Embodied Intelligence Summer School will cover the concepts of the Embodied Intelligence theory through the integration of many disciplines viewpoint, as robotics, biology, neuroscience, medicine, physiology, psychology, as well as sociology and ethics.

www.octopus-project.eu/summerschool

Embodied Intelligence Summer School

September 20-24, 2010
Livorno, Italy



The Lectures

EMBODY^{i} Summer School
Scientific Program

Monday 20 September

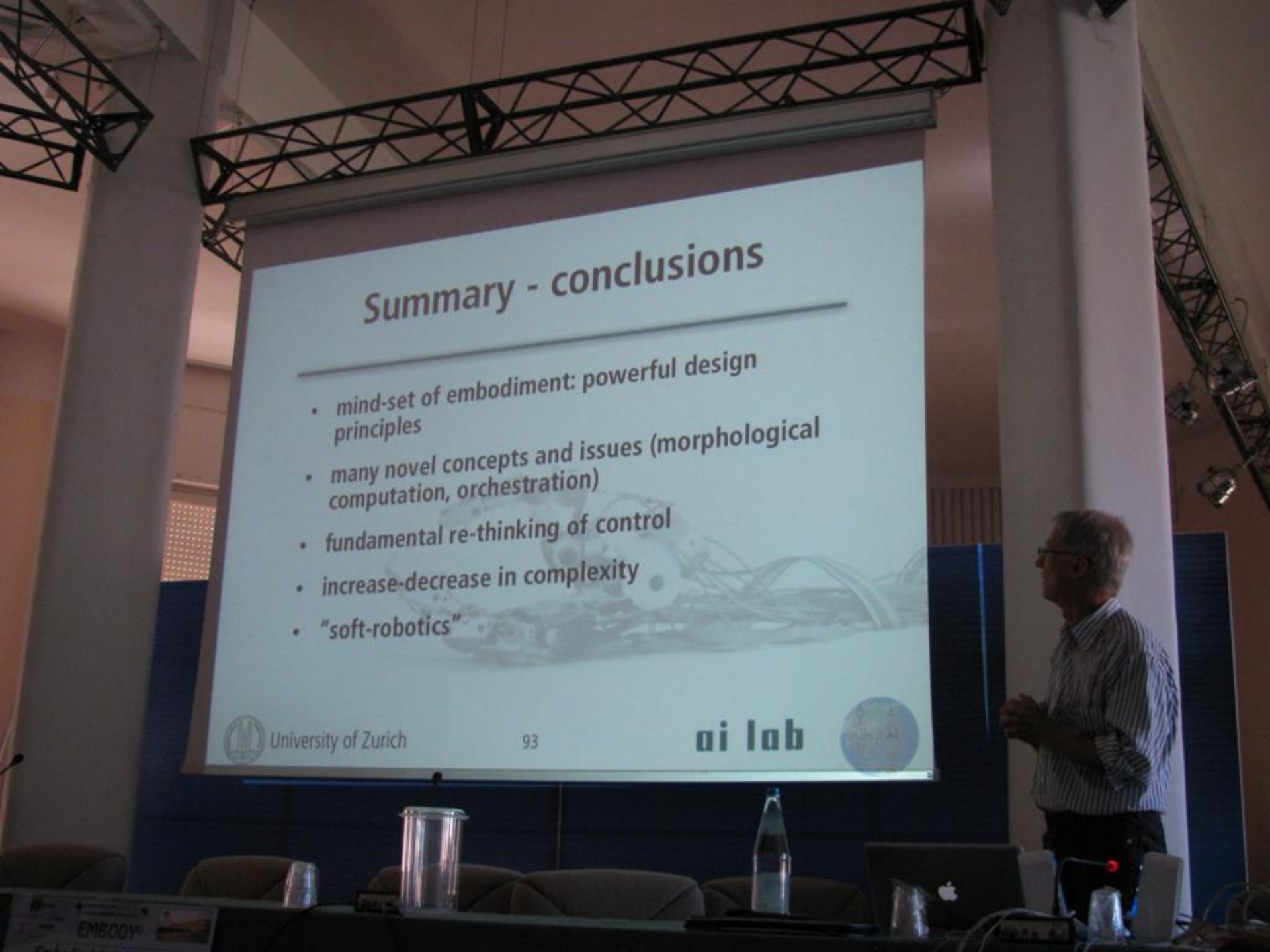
9.00-9.45 Registration and Opening
9.45-10.30 Lecture 1: Rolf Pfeifer
10.30-11.00 Coffee Break
11.00-11.30 EMBODYi Projects Students Presentation
11.30-12.30 EMBODYi Projects Group Discussion
12.30-13.00 Students Poster Session
13.00-14.30 Lunch Break
14.30-15.00 Assignment of Group Work
15.00-19.30 Technical Tour to SSSA Labs
19.30-20.30 Welcome Party


VIETATO
FUMARE


Emergence
• collective behavior: global patterns from local interactions
• behavior of individual: emergent from interaction with environment
• from time scales
University of Zurich
30
ai lab
EMBODY
Embodied Intelligence

Questions to ask

- **Task-environment, agent?** (three-constituents)
- **How to exploit interaction with environment?** (cheap design)
- **How to exploit passive dynamics?** (cheap design, ecological balance)
- **How to exploit self-stabilization? (mechanical feedback?)** (cheap design, ecological balance)
- **Weak coupling of processes through environment?** (parallel, loosely coupled processes) (insect walking)


Summary - conclusions
• mind-set of embodiment: powerful design principles
• many novel concepts and issues (morphological computation, orchestration)
• fundamental re-thinking of control
• increase-decrease in complexity
• "soft-robotics"
University of Zurich
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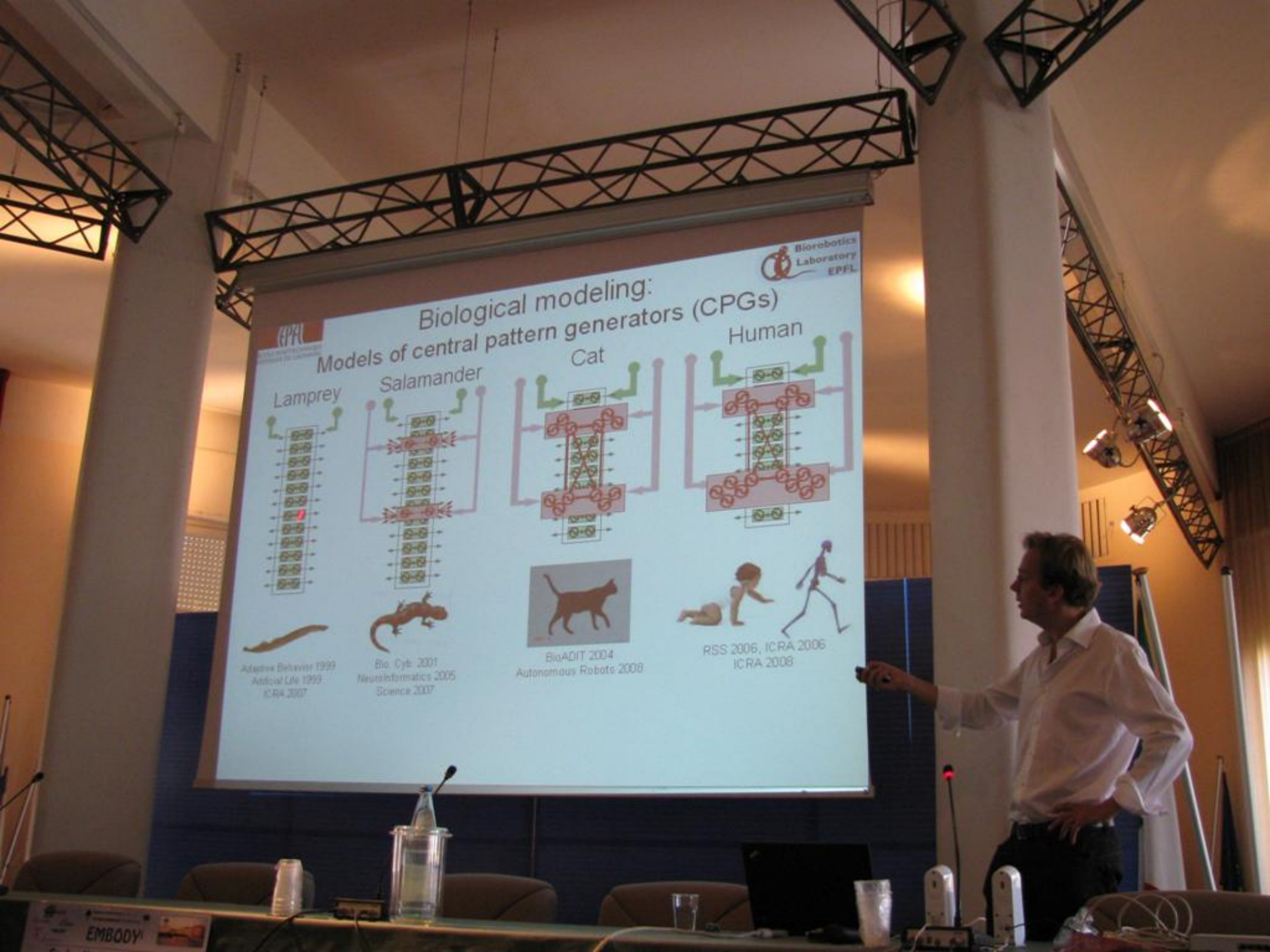
ai lab


Biorobotics Laboratory EPFL
Biological modeling:
Models of central pattern generators (CPGs)
Lamprey
Salamander
Cat
Human
Adaptive Behavior 1999
Artificial Life 1999
ICRA 2007
Bio. Cyb. 2001
Neuroinformatics 2005
Science 2007
BioADIT 2004
Autonomous Robots 2008
RSS 2006, ICRA 2006
ICRA 2008
EMBODY

Biorobotics Laboratory EPFL

Why modeling/studying salamanders?

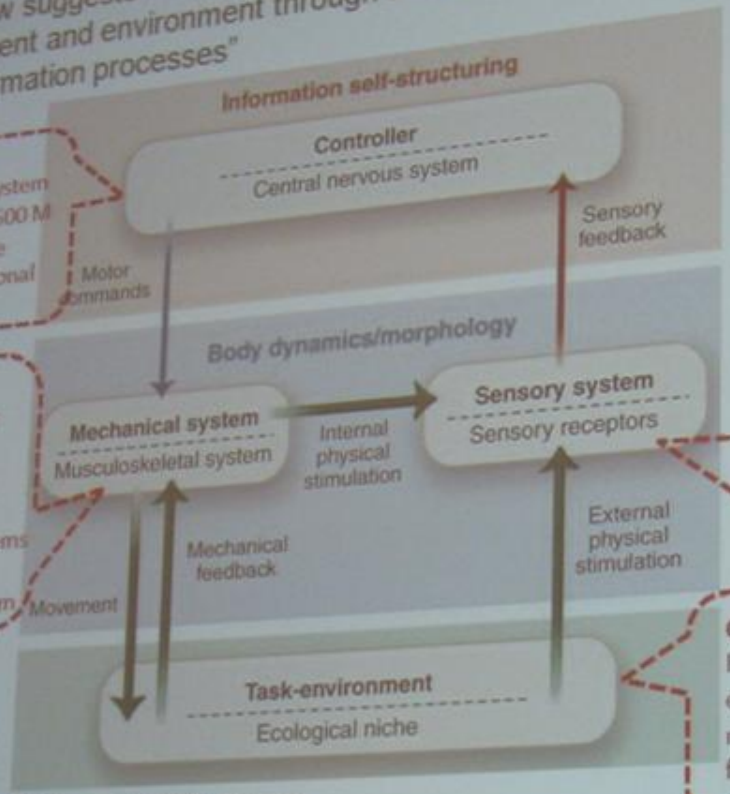
1. Relatively simple animal
2. Interesting bimodal locomotion (swimming + walking)
3. Its body plan has changed little over 150 million years (Gao & Shubin, Nature, 2002). Key animal to study the transition from aquatic to terrestrial locomotion during evolution.
4. Link between lamprey and tetrapod research

Gao & Shubin, 2002

Work done in collaboration with Jean-Marie Cabelguen, Univ. Of Bordeaux, France


The neural organization of the octopus embodiment
OCTOPUS
Summer School, Sept 20-24, 2010, Livorno
Benny Hochner
Dept Neurobiology, Inst of Life Sciences and the
Interdisciplinary Center for Neuronal Computation,
Hebrew University of Jerusalem.

"Embodied view suggests that the actual behavior emerges from the interactions dynamics of agent and environment through a continuous and dynamic interplay of physical an information processes"



Cephalopods:
The largest nervous system among invertebrate (500 M neurons) with a unique anatomical and functional organization

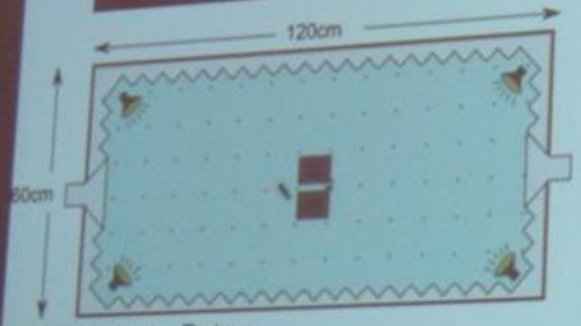
Cephalopods:
Rich repertoire of motor outputs:
2 motor system:
1) image generating neuromuscular systems
2) Motion generating neuromuscular system

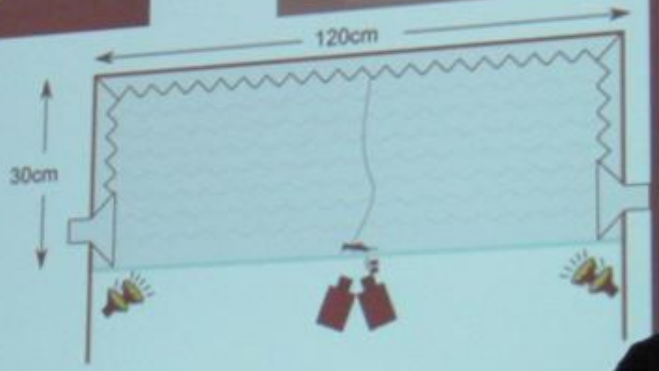
Cephalopod:
Huge amount of sensory **inputs**; (large eyes, tactile and chemical senses, olfaction, vestibular)

Cephalopods:
Highly adaptive to their environment (locomotion maneuverable arms, flexible body, color and shape camouflage)

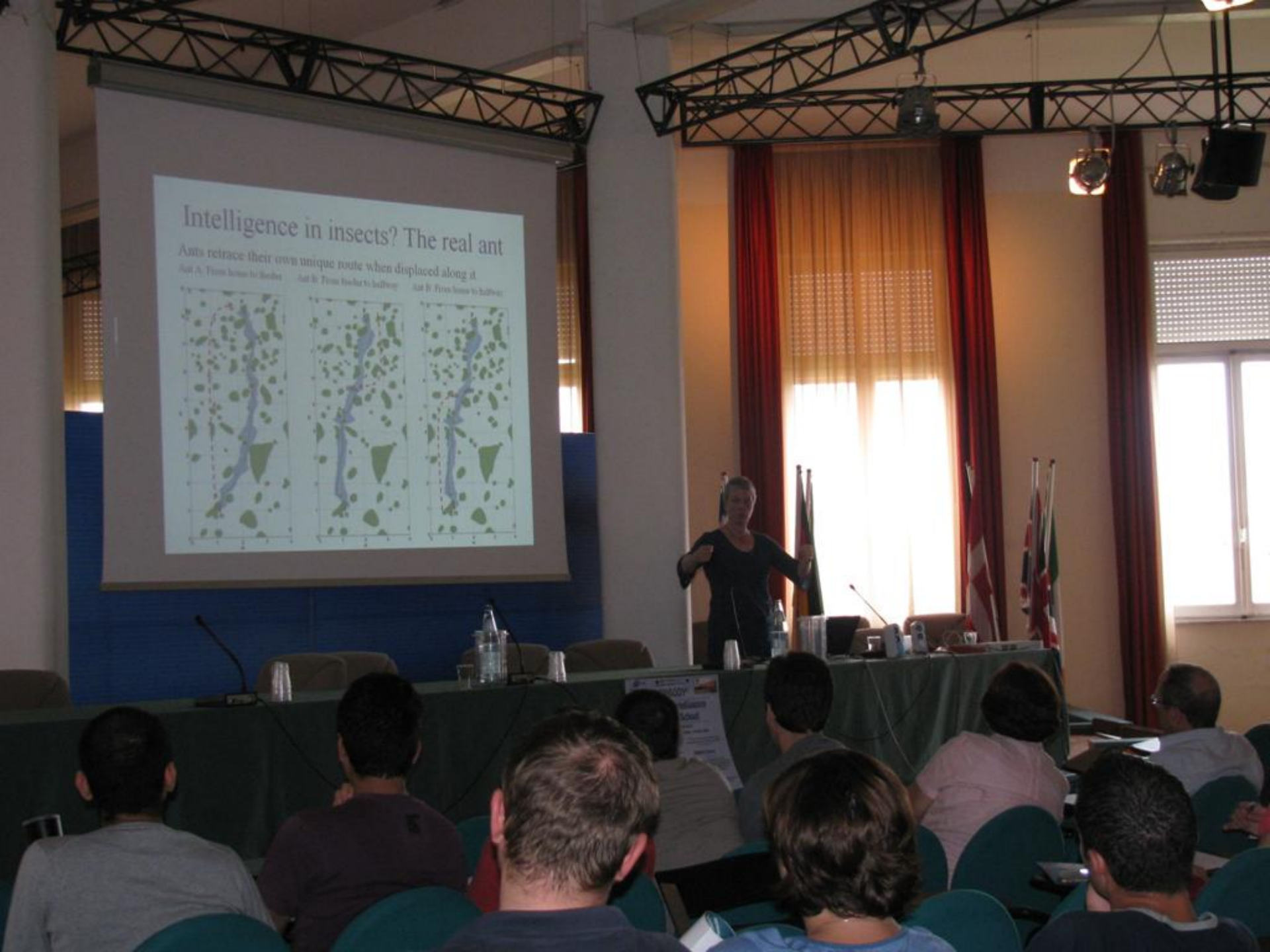
Pfeifer et al (2007). *Science*.

Directional walking in cricket phonotaxis





Georgious Petrou


Intelligence in insects? The real ant
Ants retrace their own unique route when displaced along a


EMBODY! - Embodied Intelligence Summer School
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Livorno, Italy
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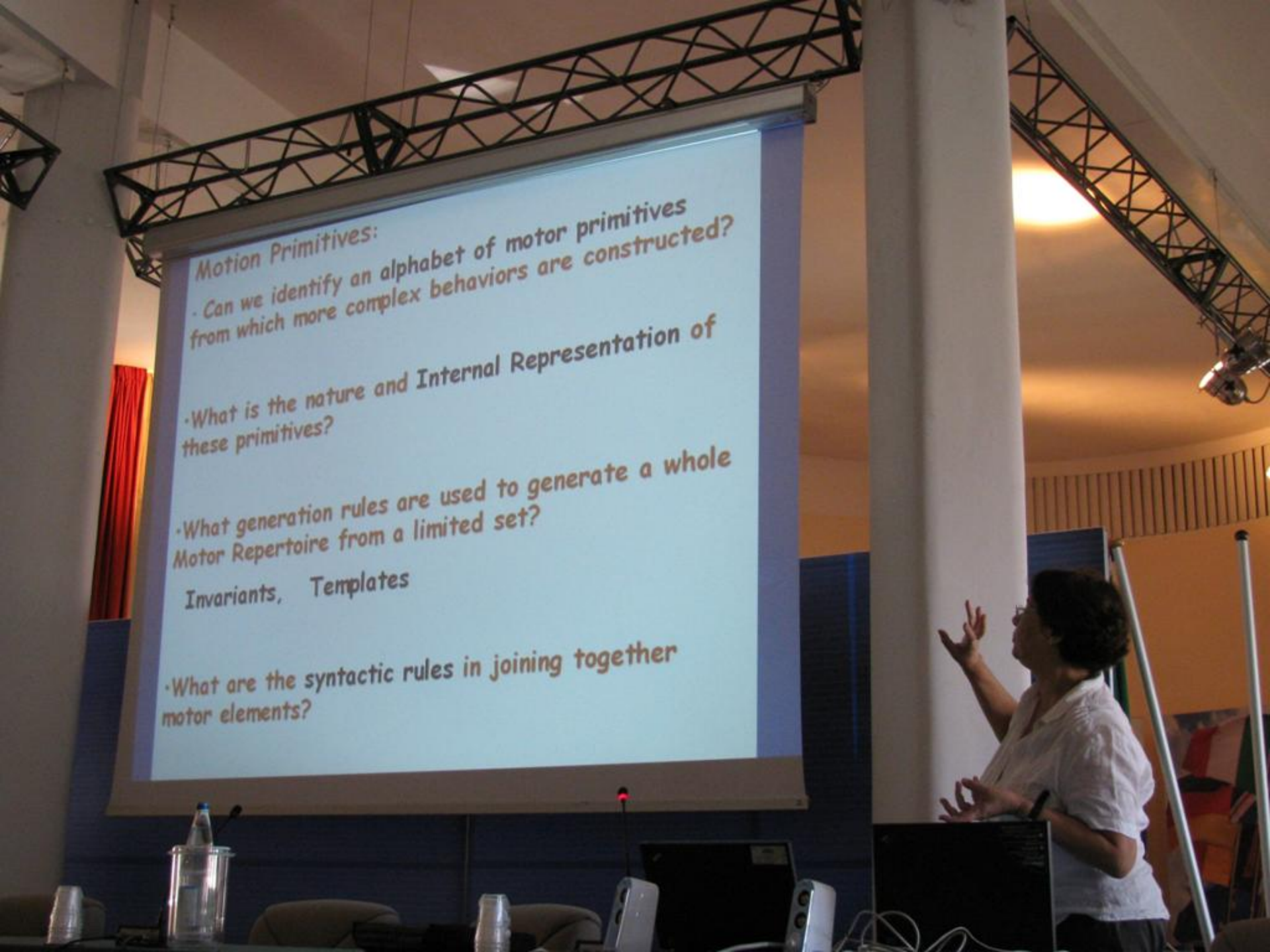
ARTS Lab
New Paradigms in Robotics:
Biomimetics for new Science,
Bioinspiration for new Technology
Paolo Dario
Scuola Superiore Sant'Anna, Pisa
and
Center for Micro-BioRobotics
Italian Institute of Technology, Italy
September 23, 2010 – Livorno, Italy


Fundamental questions
motion planning and control in
biological systems
• What is the hierarchical organization of the motor control system?
• What basic control strategies underlie complex behavior?
• Whether and how movements / actions are constructed from a basic vocabulary of motor primitives?


Motion Primitives:
· Can we identify an alphabet of motor primitives from which more complex behaviors are constructed?
·What is the nature and Internal Representation of these primitives?
·What generation rules are used to generate a whole Motor Repertoire from a limited set?
Invariants, Templates
·What are the syntactic rules in joining together motor elements?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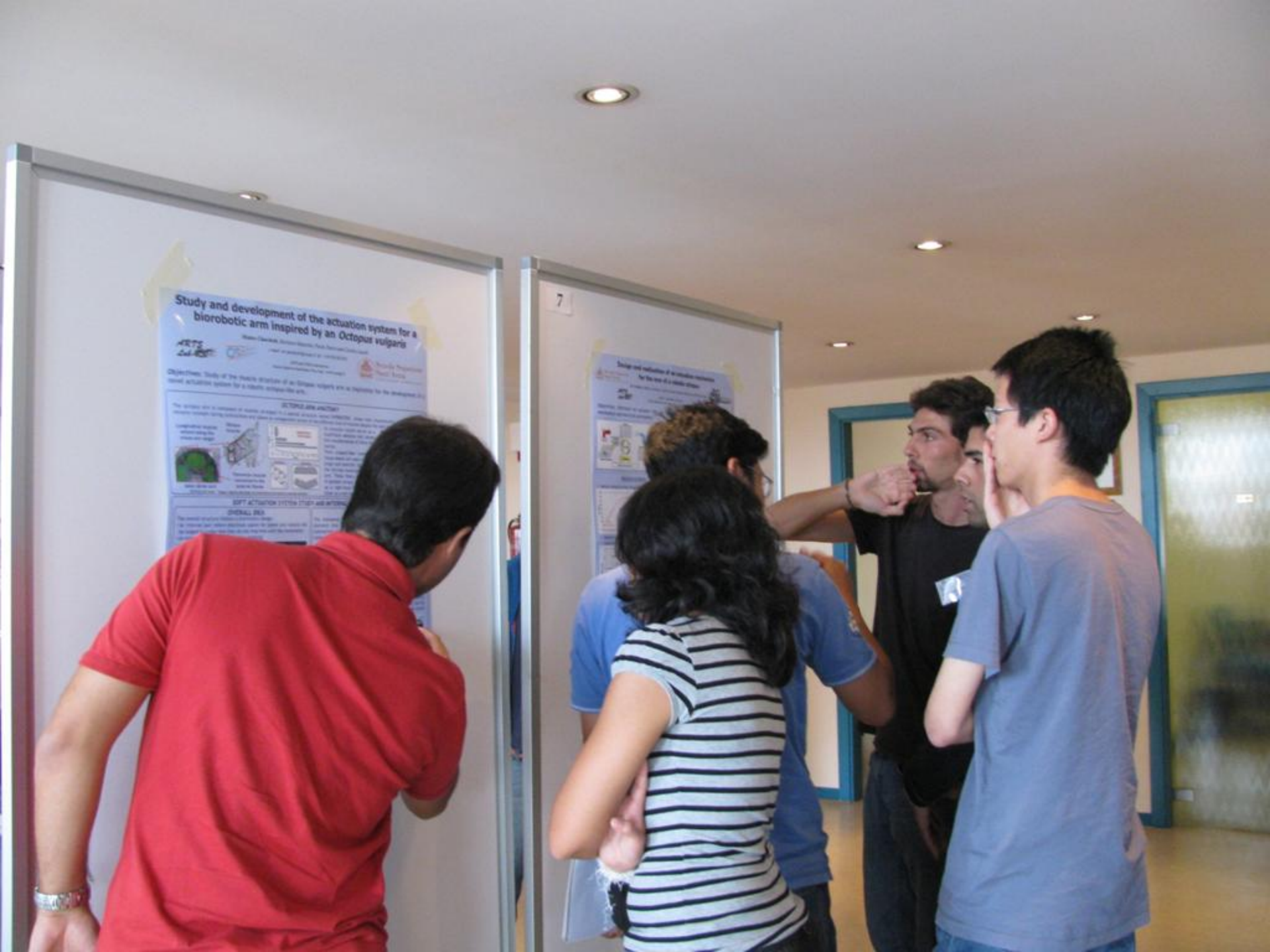
Poster Session


Marine robotic platforms for water monitoring
Hydrofoil propulsion
Jellyfish Design Concept


Study and development of the actuation system for a biorobotic arm inspired by an Octopus vulgaris
7

Social Activity in Florence


BEETLE


BEETLE

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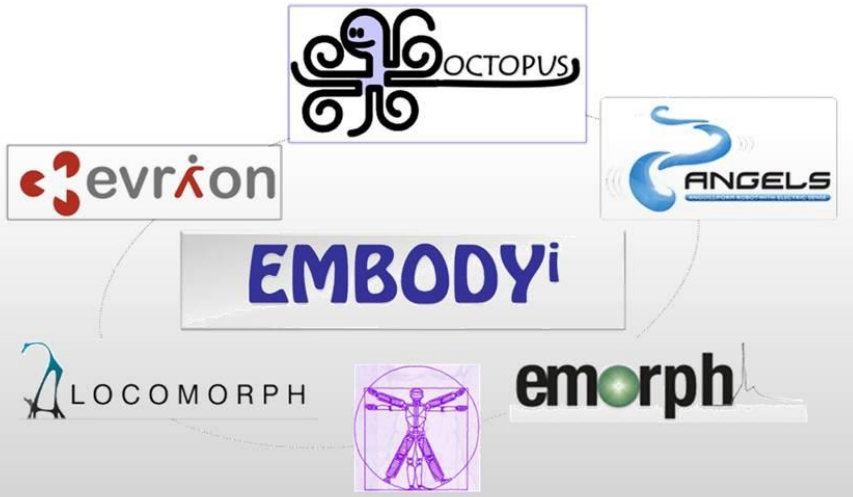

Farewell Party at Fortezza Vecchia

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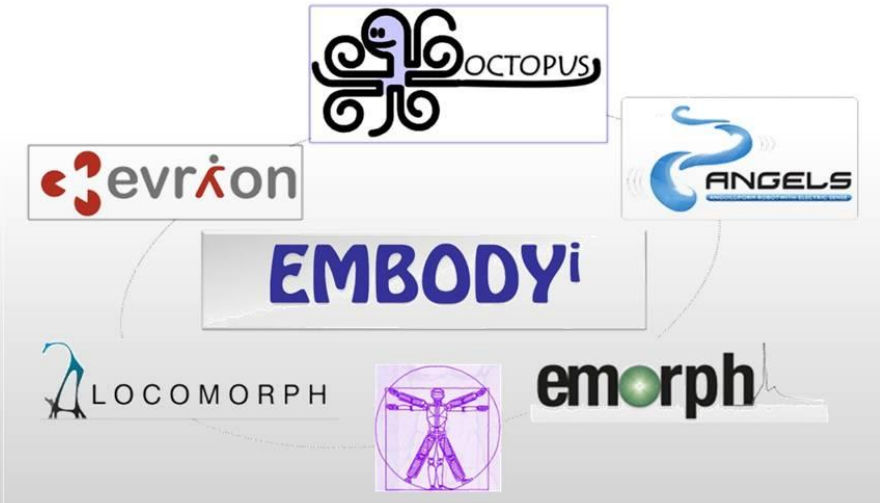

Group Work: Projects Presentations


EMBODY^i Summer School
Group Work
Propose your idea for a robot that implements the concept of Embodied Intelligence and present its design, with schemes, drawings, description of components and materials, and an estimation of budget and timing


List of Components

Initial Idea

Hypothesis: the evolution of flapping flight in terrestrial vertebrates

jumping


MDC.MO.GOV
Gliding
Efficient
Locomotion
Via
Intelligent
Shaping


MAXIMAL


List of Components


MAXIMAL


MAXIMA


MAXIMAL