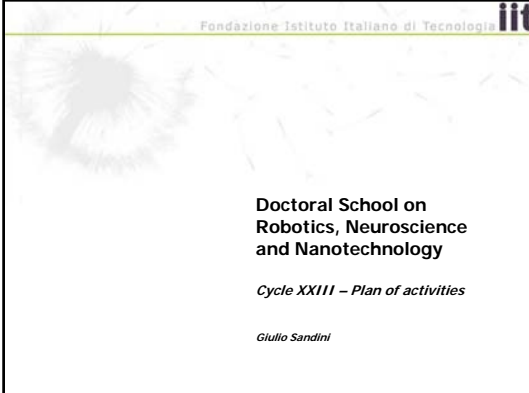


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**Doctoral School on Robotics, Neuroscience and Nanotechnology**

*Cycle XXIII – Plan of activities*

*Giulio Sandini*

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## Summary

- Introduction
- Overview of research activities
  - Fabio Benfenati
  - Darwin Caldwell
  - Jean-Guy Fontaine
  - Giulio Sandini
- Break
- More Practical Staff (Anastasia Bruzzone)

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The School is under the responsibility of the University of Genova and supported financially by the Italian Institute of Technology

**Board of Professors (Consiglio dei Docenti)**  
 Giulio Sandini, Fabio Benfenati (IIT and UNIGE)  
 Ugo Valbusa (UNIGE)  
 Fabio Beltram (Scuola Normale)  
 Roberto Cingolani (IIT and University of Lecce)  
 Paolo Dario (Scuola Superiore S. Anna - Pisa)

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## A bit of history

The school is at its 3<sup>rd</sup> year and, with the last cycle, there are now 61 students (10-23-28)

Initially all students were located in labs at the University of Genova

Now about 2/3 of the students are in Morego and this number will increase when all labs will be completed.

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## The IIT idea

Medium long-term, mission oriented, **basic research** aimed at developing enabling technologies

→

Short medium-term **precompetitive research** to enhance industrial ability to turn knowledge into products

←

- **Executive Committee**  
 V.Grilli (President), Simone Ungaro (CEO), R.Cingolani (Scientific Director)
- **Board of trustees**  
 Gabriele Galateri (chairman), Gianfelice Rocca, Paolo Scaroni, Giuseppe Vita, Konrad Osterwalder, Alessandro Ovi, Alberto Alesina, Roger Abravanel, Remo Pertica

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## IIT MULTIDISCIPLINARY RESEARCH NETWORK

Milano  
 RU Politecnico  
 RU San Raffaele  
 RU IFOM-IEO

Trieste  
 RU SISSA

Genova  
 Headquarters

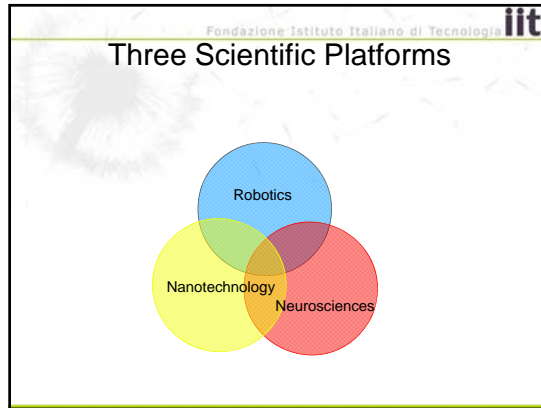
Roma  
 RU EBRI

Napoli  
 RU GRIB

Lecce  
 RU NNL

RU SNS  
 RU SSSA

• Headquarters  
 • Satellite research Units



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### @January 2008

6 Research Units led by Research Directors

Darwin Caldwell	} Robotics
Jean-Guy Fontaine	
Giulio Sandini	
Fabio Benfenati	} Neuroscience
John Assad	
Stefano Piomelli	} Drug Discovery and Development

*Each department is multidisciplinary*

13 Central Laboratories including nanobiotech facilities

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### The staff @ January 2008

- Staff January 2007: 206 employees, including about 97 PhD students, 83 researchers (post doc level), 26 administrators/managers → Forecast: >350 end 2008
- PhD Students: 55 Genova, 10 Pisa, 22 Milano
- About 400 researchers involved in the IIT-Network
- About 200 applications pending
- Gender 32/68 f/m → 27 nationalities

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### Headquarters Genova Morego

An aerial photograph of the IIT headquarters building in Genova Morego. Colored arrows point from numbered callout boxes to specific parts of the building.

- 5: Nanobiotechnologies Facilities (Chemistry, Biology Labs, Offices)
- 4: Robotics, Brain and Cognitive Sciences Labs, Offices
- 3: Robotics, Brain and Cognitive Sciences Labs, Offices
- 2: Neuroscience and Brain Technologies Labs, Offices
- 1: Administration, Drug Discovery and Development Labs, Offices
- 0: Seminar Room, Restaurant, Administration, Offices
- 1: Nanobiotechnologies Facilities: Clean Room, Microscopy Labs, Optical Labs and Animal Facility

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### This Year Strategy and Statistics

This year IIT offered 50 PhD fellowships on specific topics proposed by Fabio Benfenati, Darwin Caldwell, Jean-Guy Fontaine and Giulio Sandini.

We received 62 submissions and selected 28 students of which 14 are from Italy

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### 4 Research Areas

- Neuroscience and Brain Technologies (Prof. Fabio Benfenati) → Themes 2.1 to 2.10
- Robotics, Brain and Cognitive Sciences (Prof. Darwin Caldwell) → Themes 3.1 to 3.4
- Robotics, Brain and Cognitive Sciences (Prof. Jean-Guy Fontaine) → Themes 4.1 to 4.4
- Robotics, Brain and Cognitive Sciences (Prof. Giulio Sandini) → Themes 5.1 to 5.16

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### What we expect from you

- Define your PhD theme with your tutor and submit it by end of March.
- Help to set up the IIT labs
- Attend PhD courses
- ...do a lot of research

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### What we can provide

- Access to labs (of course...)
- Support in defining your PhD theme
- Financial support to:
  - participate to conference and schools (max 4,000 €/Year)
  - Accommodation (max 4,000 €/Year) **BEWARE!!!**
  - research period in a foreign lab (50% increase and travel)
- A laptop
- Participate in the start-up of new labs...

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### Logistics (as of now)

- Robotics Labs are working in Morego
- By end of 2008 all labs will be ready and functioning
- At present some activities will be carried out at hosting labs at the University of Genoa

Department of  
Neurosciences and  
Brain Technologies

→

University of Genoa  
DEPARTMENT OF  
EXPERIMENTAL MEDICINE  
Viale Benedetto XV, 3  
Contact: Prof. Fabio Benfenati

Department of Robotics, Brain  
and Cognitive Sciences

→

IIT - MOREGO Labs  
Via Morego, 30  
Contacts: Caldwell, Fointaine, Sandini

Nanotechnology

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### Training Activities

To give you an overview of the activities carried out in the IIT labs, the initial three weeks will be devoted to introductory lectures in IIT's three areas of research: Robotics, Neuroscience, Nanotechnology.

During the year courses will be organized on different topics and your plan of studies will be planned with your tutor.

Seminars and lectures are part of the training activities (they are usually organized on Monday afternoon).

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### Robotics Introductory Week

January 22-25, 2008  
IIT Headquarters - Via Morego 30 - Genoa

Day	Time	Topic	Speaker
January 22 - Monday	9:30 - 0:30	Introduction	Giulio Sandini
	9:30 - 1:30	A robotic project	Giorgio Metta
	11:00 - 0:30	Coffee Break	
	11:30 - 1:30	Robot Sensing and Manipulation	Luca Natale
	13:00 - 1:30	Lunch	
	14:30 - 1:30	Motor Control	Francesco Nori
	16:00 - 0:30	Coffee Break	
January 23 - Tuesday	16:30 - 1:30	From sensorimotor learning to robot-therapy	Fabrizio Morassut
	18:00	End of Day	
January 23 - Wednesday	9:30 - 1:30	From action to perception	Thomas Pozzo
	11:00 - 0:30	Coffee Break	
	11:30 - 1:30	Functional Brain Imaging	Franco Bortone
	13:00 - 1:30	Lunch	
	14:30 - 1:30	Haptics	Darwin Caldwell
	16:00 - 0:30	Coffee Break	
	16:30 - 1:30	End Effectors and Manipulation	Darwin Caldwell
January 24 - Thursday	18:00	End of Day	
	9:30 - 1:30	Brain Machine Interface	Luciano Fadiga
	11:00 - 0:30	Coffee Break	
	11:30 - 1:30	Decoding brain signals	Stefano Panerai
	13:00 - 1:30	Lunch	
	14:30 - 1:30	Nanomaterials for Bio-interfaces and robotics	David Ricci
	16:00 - 0:30	Coffee Break	
January 25 - Friday	16:30 - 1:30	The Ins and Outs of Brain Machine Interfaces	Lee Miller
	18:00	End of Day	

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### PHD SCHOOL IN ROBOTICS, NEUROSCIENCE AND NANOTECHNOLOGIES

XXXII CYCLE - INTRODUCTORY COURSE OF NEUROSCIENCE AND BRAIN TECHNOLOGIES - JANUARY 29-FEBRUARY 1, 2008

DATE	TIME	SPEAKER	SUBJECT	
TUE, JAN 28	MORNING	9:30-10:30	F. SCHERMANI	INTRODUCTION TO CELLULAR NEUROSCIENCE
		10:30-11:30	P. PARADISI	FUNCTIONAL PROPERTIES OF NEURONS: ELECTROPHYSIOLOGY
		11:30-12:30	A. CASOLI	FUNCTIONAL PROPERTIES OF NEURONS: IMAGING
TUE, JAN 29	AFTERNOON	14:30-15:00	T. FELLER	GSA NEURON INTERACTIONS
		15:00-15:30	DISCUSSION	
		16:30-18:00	A. DATTA	NEURONAL DEVELOPMENT AND SYNAPSE FORMATION
WED, JAN 30	MORNING	9:30-10:30	A. SARKIS	NEUROTRANSMITTER RECEPTORS
		10:30-11:00	LAB VISIT	AL, RT, CA, ES
		11:00-12:30	P. MERLINI	SYNAPTIC PLASTICITY
WED, JAN 30	AFTERNOON	14:30-16:00	L. GAUFERRI	NEURONAL DEGENERATION
		16:00-16:30	LAB VISIT	AL, RT, CA, ES
		16:30-18:00	T. TRINZI	MODULATING NEURONAL ACTIVITY
THUR, JAN 31	MORNING	9:30-10:30	B. THOMAS	SYNAPTIC CORRELATES OF DRUG ADDICTION
		10:30-11:00	LAB VISIT	AL, RT, CA, ES
		11:00-12:30	D. DE PETERI	ADULT MANIPULATION GENE EXPRESSION IN NEUROSCIENCE
THUR, JAN 31	AFTERNOON	14:30-16:00	M. MORANO	GENETIC MODELS IN NEUROSCIENCE
		16:00-16:30	LAB VISIT	AL, RT, CA, ES
		16:30-18:00	B. CASCO	BEHAVIORAL ANALYSIS IN NEUROSCIENCE
FRI, FEB 1	MORNING	9:30-10:30	L. BERGOMINI	NEUROELECTRONIC NETWORKS
		10:30-11:00	DISCUSSION	
		11:00-12:30	A. BIANCHI	GETTING ON NATURE'S NERVES: WHAT'S SO GREAT ABOUT NEURAL NETWORKS?

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**IIT DEPARTMENT OF NEUROSCIENCE AND BRAIN TECHNOLOGIES**

Temporarily at:  
 DEPARTMENT OF EXPERIMENTAL MEDICINE – SECTION OF PHYSIOLOGY  
 LABORATORY OF MOLECULAR AND CELLULAR NEUROSCIENCE

**LAB VISITS**

4 GROUPS: A, B, C, D

LABORATORIES:

1. MEA ELECTROPHYSIOLOGY
2. PATCH-CLAMP ELECTROPHYSIOLOGY
3. LIVE NEURON IMAGING
4. NEUROBIOLOGY AND NEUROCHEMISTRY

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**A few Deadlines**

- On March 5 and 6 we will organize the annual “PhD workshop”. Students from previous years will present the status of their ongoing project. Students from this year may present a poster on past work or on the draft of their planned activity.
- End of March: document describing the research project of your PhD.
- End of November presentation of the first year report. This is the official document that will be evaluated to admit you to the following year.

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**LOGISTICS**

Shuttle-bus service.

Refer to Anastasia

...suggestions are welcome...

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**Contacts**

Contact with University and various help  
 Anastasia Bruzzone (anastasia@liralab.it)  
 010 353 2994 (UNIGE) – 010 81871 418 (IIT)

Science, teaching, complains  
 Your tutor and  
 Giulio Sandini (giulio.sandini@iit.it)  
 010 71 781 416 (328 100 3229)

<http://www.liralab.it> → [http://www.liralab.it/IIT\\_school/CICLOXXI](http://www.liralab.it/IIT_school/CICLOXXI)  
 → [http://www.liralab.it/IIT\\_school/CICLOXXII](http://www.liralab.it/IIT_school/CICLOXXII)  
 → [http://www.liralab.it/IIT\\_school/CICLOXXIII](http://www.liralab.it/IIT_school/CICLOXXIII)  
 → [http://www.liralab.it/IIT\\_school/CICLOXXI/Talks.htm](http://www.liralab.it/IIT_school/CICLOXXI/Talks.htm)  
 (TALKS)

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**Next Lectures**

Prof. Lee Miller Department of Physiology, Northwestern University, Feinberg School of Medicine	The Ins and Outs of Brain Machine Interfaces	January 24 - 16:30 IIT – RBCS dept.
Prof. Sandro Musca Ivakic Department of Biomedical Engineering, Northwestern University	The adaptive control of motions and forces	January 28 - 15:00 IIT - RBCS dept.
Gabriella Stocca, PhD Physiologisches Institut University of Freiburg	Efficient temporal summation of dendritic Calcium signals in young hippocampal granule cells	February 4 - 15:00 DIMES – NBT dept.
.....	.....	.....

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Cognome	Nome
Alì	Hayder
Bassolino	Michela
Bentalab	Toufik
Bisio	Amra
Biso	Maurizio
Bory	Guillaume
Castagnola	Eisa
Clovis	Youssef
Doggar	Mehmet R.
Dvoretzkova	Elena
Facco	Giorgio
Ciprietti	Arian
Ishai	Jamshad
Iurili	Giuliano
Jafar	Amir
Kheifia	Bazid
Maglie	Stefano
Manago	Francesca
Naceri	Abdelqaili
Nistaro	Giuseppe
Palart Lamarche	Jean-Christophe
Panaccioni	Ligo
Rocchi	Anna
Saimas	Paola
Semprini	Marianna
Tavella	Michele
Verspagen	Hanneke

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We hope it will be a lot of fun!

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### Robotics: three main streams

Jointly Developed with Darwin Caldwell and Jean-Guy Fontaine in collaboration with the other departments and facilities

Robotics, Brain and Cognitive Sciences Department

Three Research Units

Giulio Sandini Darwin Caldwell  
Jean-Guy Fontaine

Giulio Sandini IIT- RBCS

### PhD Students (Sandini's Unit of Research)

XXI Cycle	XXI Cycle	XXI Cycle
Ravinder Dahiya	Francesco Campanella	Michela Bassolino
Boris Duran	Enrico Chiovetto	Toufik Bentaleb
Monica Gori	Angelo Maria Fiorilla	Ambra Bisio
Marco Maggiali	Matteo Fumagalli	Maurizio Biso
Vishwanathan Mohan	Serena Ivaldi	Elisa Castagnola
Randazzo Marco	Massimiliano Izzo	Mehmet R. Dagar
Jayathu	Lorenzo Jamone	Giorgio Facco
Samarawickarama	Alberto Parmiggiani	Arjan Gijsberts
	Alessandra Sciutti	Giuseppe Notaro
	Valentina Squeri	Ugo Pattacini
	Alexander Schmitz	Paola Salmas
		Marianna Semprini
		Michele Tavella

Giulio Sandini IIT- RBCS

### Which technologies are missing in today's humanoid robots?

- Technologies supporting learning, recognition and classification of objects and events (e.g. associative memories, stochastic computing, etc).
- Technologies for safe interaction (e.g. artificial muscles with stiffness control, back-drivability...)
- Technologies for massive connections (connectors of the order of thousands of wire per square mm - e.g. optic nerve about 80,000 axons/mm<sup>2</sup>)
- Soft flexible sensors and tissues (tendon-like, skin-like, bone-like...)
- Better "batteries" / portable energy production

Giulio Sandini IIT- RBCS

### Which abilities are most lacking in today's humanoids?

- "Prospective/associative" abilities (understanding of the situation)
- Continuous on-line learning from experience
- Social Intelligence (understanding the others)
- Perceptual abilities (e.g. vision, touch etc.)

How this abilities are "implemented" in humans is still largely unknown

Giulio Sandini IIT- RBCS

# Humanoid Robotics

Humanoid robotics research today has to be seen as a *human centered discipline* advancing science and developing new technologies along three main streams...

Giulio Sandini IIT - RBCS

# Human Centered Technologies

1. Build state-of-the-art humanoids
2. Study humans
3. Exploit human-machine interaction

"we do not want to "copy" humans, we also want to "understand"

Giulio Sandini IIT - RBCS

# Build Humanoids

Giorgio Metta  
Design and development of humanoids components and platforms

**Mind**

- Learning and adaptation
- Head hand coordination, Manipulation , grasping
- Bimanual coordination
- Discovering affordance (use of objects and tools...)
- Interaction and imitation
- ...

**Body**

- Embedded sensors (vision, touch, audition, inertial,
- Pseudo-elastic actuators
- Tendons, wires, bones
- Associative memories
- ...

**Hard-body Humanoids**

- Ravinder Dahiya
- Boris Duran
- Marco Maggiali
- Vishwanathan Mohan
- Marco Randazzo
- Jayathu
- Samarawickrama
- Matteo Fumagalli
- Serena Ivaldi
- Massimiliano Izzo
- Lorenzo Jamone
- Alberto Parmiggiani
- Alexander Schmitz
- Toufik Bentabol
- Maurizio Biso
- Mehmet R. Dogar
- Arjan Gijsberts
- Ugo Pattacini
- Michele Tavella

Giulio Sandini IIT - RBCS

# ICub

Legs designed by Darwin Caldwell and Nick Tsaganakis, now at IIT

Giulio Sandini IIT - RBCS

# ICub Fingertips and Fingernails

Sensorized fingertip with multiple (12) receptive fields

Fingernail for roughness, slip, and contact estimation

Study by Alexander Schmitz, Marco Maggiali, Marco Randazzo with Giorgio Metta and Lorenzo Natale.

Giulio Sandini IIT - RBCS

# Study Humans

Thierry Pozzo

Study how humans learn, perceive and act

- Plasticity of neural circuits (learning/adaptation)
- Perception, representation and cross-modal interaction
- Motor control and learning (locomotion, grasping, ga)
- Sensory-motor memory and motor learning
- Visual attention, recognition, generalization
- ...

Support research on artificial systems  
Support tele-operation/tele-presence

**Human Behavior Lab**

- Artificial Systems (humanoids)
- Teleoperation (interaction)

- Monica Gori
- Francesco Campanella
- Enrico Chiovetto
- Angelo Maria Fiorilla
- Alessandra Sciutti
- Valentina Squeri
- Michela Bassolino
- Amra Bisio
- Paola Salmas

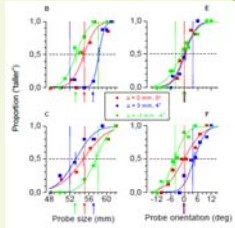
Giulio Sandini IIT - RBCS



## Study the development of visuo-tactile integration in children



- Visual and haptic integration is not optimal before 8 years of age.
- Before 8 years vision dominates in orientation discrimination and haptic dominates in size discrimination



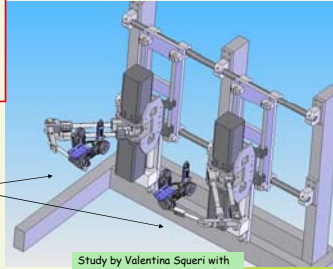
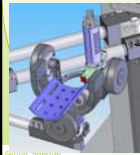
Study by Monica Gori with Prof. David Burr

Luca Sandini

IIT - RBCS

## Bimanual Multijoint Coordination in Complex Reaching and Manipulation Tasks

Bimanual workstation for haptic research and robotic rehabilitation



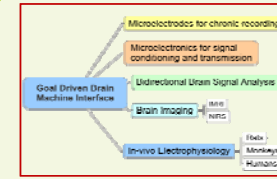
Study by Valentina Squeri with Lorenzo Masia, Maura Casadio

Luca Sandini

IIT - RBCS

## Goal-Driven Brain Machine Interface

Luciano Fadiga



Luciano Fadiga  
Franco Bertona  
Stefano Panzeri  
Davide Ricci  
Alessandro Vato  
Gytis Baranaukas  
Elisa Molinari  
Fernando Montani  
Alberto Ansaldo  
Andrea Viale

Elisa Castagnola  
Giorgio Facco  
Giuseppe Notaro  
Mariana Sempirini

Collaborations with:

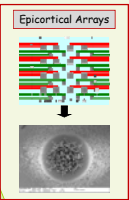
- Alessandro Spinelli at POLIMI (microelectronics)
- Carlo Porro at Univ. Modena (fMRI)
- Miran Skrap at Univ. Udine (Neurosurgery)
- Sandro Mussa Ivaldi - Northwestern University (Chronic Implants)
- Rinaldo Cubeddu at POLIMI (NIRS recording)

Luca Sandini

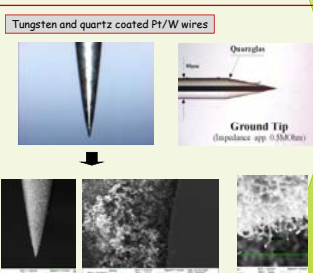
IIT - RBCS

## CNT coated electrodes for in-vivo neural recordings

On-going Activities



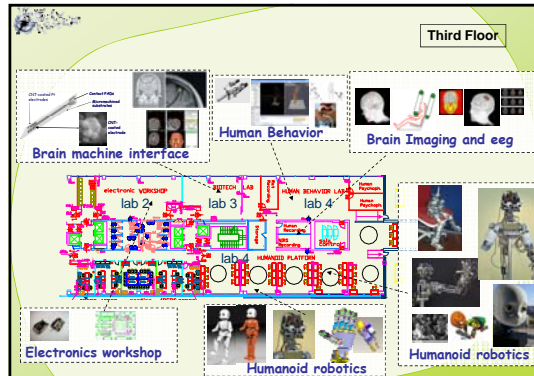
Davide Ricci and Alberto Ansaldo



GOAL: enhanced interface impedance properties and biocompatibility

Luca Sandini

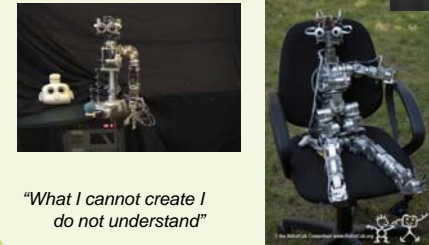
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Luca Sandini

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Grazie!



"What I cannot create I do not understand"

Richard Feynman

Luca Sandini

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