

 POLITECNICO DI MILANO



Politecnico di Milano

Giancarlo Ferrigno



Six schools:

- ✎ **Architecture and Society**
- ✎ **Civil Architecture**
- ✎ **Design**
- ✎ **Civil, Environmental and Territory Engineering**
- ✎ **Industry and Information Engineering**
- ✎ **Building Engineering and architecture**

Twenty four PhD programs



Twelve Departments

- ✎ **Architecture and Urban studies**
- ✎ **Architecture, buildings**
- ✎ **Chemistry and materials**
- ✎ **Design**
- ✎ **ICT and Bioengineering**
- ✎ **Energy**
- ✎ **Physics**
- ✎ **Civil Engineering and environment**
- ✎ **Management**
- ✎ **Mathematics**
- ✎ **Mechanics**
- ✎ **Aerospace**

DEIB: 6 sections (250 staff – tot 1000)

- Automation and control
- **Computer Science**
- Tele-Communications
- Electronics
- Electrical Power
- **Bioengineering**

Activities relevant to CPS

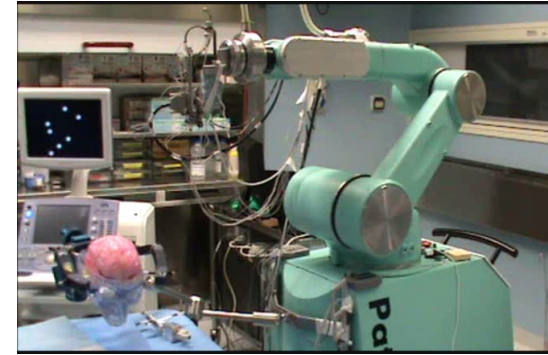


NearLab Skills: Surgical robotics - Navigation

ROB  **CAS** 

Active 

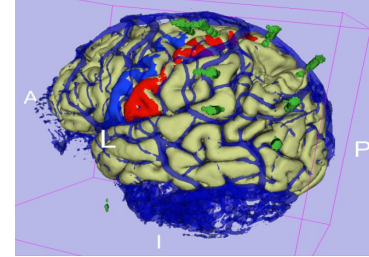
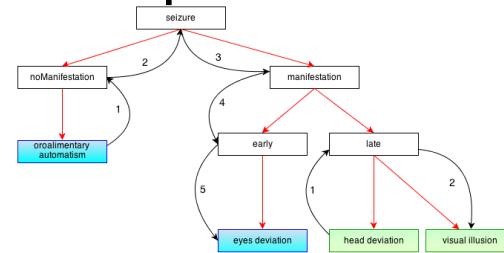
Emerge



- 👁️ **Robotic devices** for neurosurgery
 - Frameless stereotactic systems
 - Cooperative, autonomous, tele-operation

- 👁️ **Planning** - (multiple policies for optimal solution)

- 👁️ **AI** - Autonomous diagnosis
 - Epileptogenic zone estimate
 - NN (ART-SOM), Ontology



- 👁️ **Sensors, WF, Models** and **fixtures** for safety in neurosurgery

- (Active Constraints, OF cameras, guiding WF, models of physical device)



- 👁️ **Autonomous** patient motion compensation



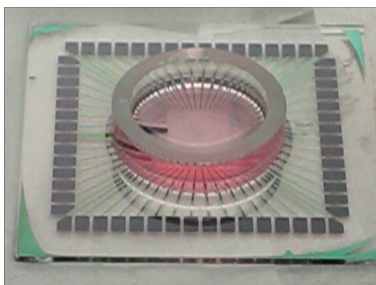
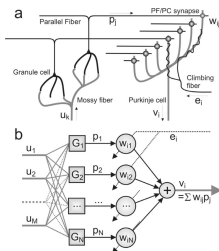
NearLab Skills:

Assistive robotics and motor system analysis

Robotic Hybrid human-exoskeleton ADL support



Knowledge gained by Experiments of motor control on ISS



Motor control in learning robots



Boundary with wet biology:
Technologies for bio-artificial interfaces



New methods for cooperation with machines in service robots

- cooperative haptic interface, master-slave mapping, learning of probabilistic workflows (**input understanding, formal representation of procedural knowledge**)

Integration of robots in hybrid Operating rooms (**advanced sensors & actuators, intelligent room**)

New methods for patient-rehabilitation device interface

- Simultaneous assessment and therapy (**sensing, reasoning, actuation**)

User centered development of CPS



Contributions to CPS programming

Luciano Baresi, Gianpaolo Cugola, Matteo Rossi
Dipartimento di Elettronica Informazione e Bioingegneria
Politecnico di Milano
{luciano.baresi,gianpaolo.cugola,matteo.rossi}@polimi.it



Skills: Tools and Techniques for Distributed Systems

Middleware for Adaptive Systems

- Content-Based Routing
 - Messages are routed to recipients based on their content (e.g., "there is a traffic jam on Main Street"), rather than an explicit recipients' address
 - Publish/subscribe is the typical incarnation
 - Reduces coupling among components, easing dynamic reconfigurations
- Complex Event Processing middleware (T-Rex)
 - Takes streams of primitive events (e.g., "my vehicle is stopped on Main Street") and produces new, complex events based on user-defined rules
 - Example of rule: "if there are more than 20 vehicles stopped on street X, generate event 'traffic jam on Street X'"

Frameworks for programming the Internet of Things

- The Erlang-based ELIoT language. Adapts Erlang to IoT scenarios



Skills: Formal Verification & Validation of Embedded Systems

Tools and Techniques for the automated verification of specification based on Metric Temporal Logics

Automated Verification of properties of UML designs of embedded systems

- built on a temporal logic-based semantics of behavioral UML diagrams (state, sequence, interaction overview)
 - provides a precise timing semantics of UML diagrams
- allows users to check properties of UML designs

Simulation of hybrid systems

- Physical environment described as a continuous system
 - Modelica model
- Software described as a discrete system
 - Metric Temporal logic model
- Co-simulation of Software with the environment with which it interacts



Some relevant projects

Green Move (funded by regione Lombardia, 2011-2013)

- goal: to build the next-generation vehicle-sharing system based on electric vehicles
 - uses middleware technology (T-Rex in particular) to distribute information among vehicles and coordination center
 - developed mechanisms to automatically reconfigure at run-time Android-based On Board Unit (the Green e-box)

MADES (EU FP7, 2010-2012)

- goal: develop model-driven development techniques for avionics systems
- Results: Formal Verification and Simulation techniques

SMScom (ERC, 2009-2013)

- goal: develop techniques and tools to develop and run highly adaptive applications
- Results:
 - middleware technology for adaptive systems,
 - Formal Verification techniques



Vision: distributed systems

Verification of distributed systems

- Analysis of ELIoT programs

Application to various domains

- Content-Based Routing and Complex Event Processing as the backbone to distribute information across complex systems
 - vehicle management
 - medical systems
 - wireless sensor networks
- Complex Event Processing as a tool for big data (streaming)



Vision: Formal Verification and Validation

Modular and incremental formal verification techniques to scale up verification

Domain-specific verification techniques

- improve efficiency through domain-specific optimizations
- domain-specific feedback to verification users

Verification and validation of workflows described, e.g., through UML diagrams

- e.g. from the medical domain