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

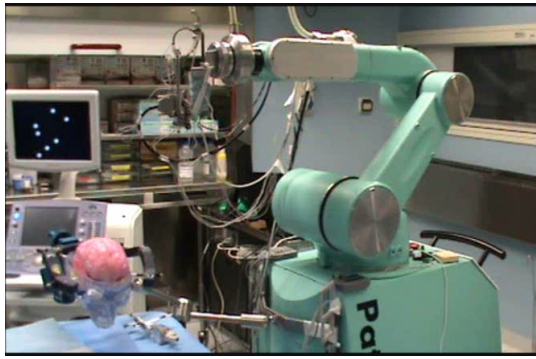
- Architecture and Urban studies
- Architecture, buildings
- Chemistry and materials
- Design
- ICT and Bioengineering
- Energy
- Physics
- Civil Engineering and environment
- Management
- Mathematics
- Mechanics
- Aerospace

DEIB: 6 sections (250 staff – tot 1000)

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

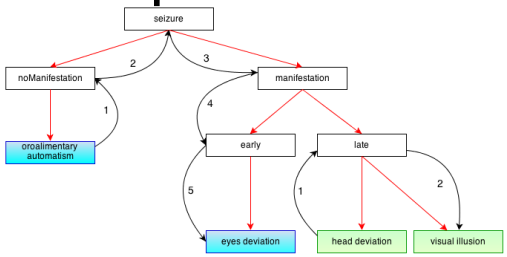
Activities relevant to CPS

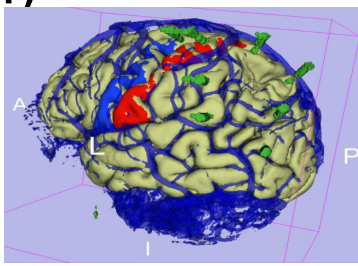
NearLab Skills: Surgical robotics - Navigation



- 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





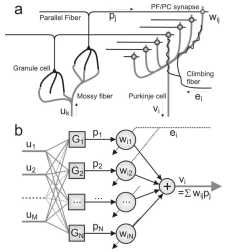
- **Sensors, WF, Models** and **fixtures** for safety in neurosurgery
  - (Active Constraints, OF cameras, guiding WF, models of physical device)
    - **Autonomous** patient motion compensation

NearLab Skills:
Assistive robotics and motor system analysis

Robotic **Hybrid human-exoskeleton ADL support**

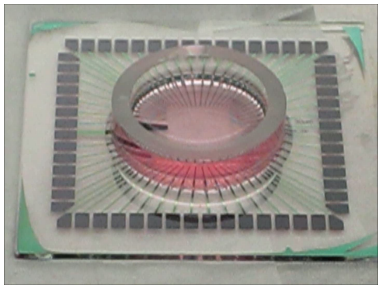
MUNDUS

Knowledge gained by Experiments of motor control on ISS



Motor control in learning robots

realnet
FP7-ICT-2009-6



Boundary with wet biology:

Technologies for bio-artificial interfaces

Vision

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 knowlegde)**

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

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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