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3rd Summer European University in Surgical Robotics

Montpellier, France
September 5-12, 2007

LIRMM
Laboratoire d'Informatique de Robotique et de Microélectronique de Montpellier

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Biomedical Robotics Laboratory
Università Campus Bio-Medico

10 September 2007

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Summary

- Campus Bio-Medico
- Research Group
- PhD Research
  - Neurodevelopmental Engineering
  - TACT
  - Wearable Audio - Visuo - Vestibular systems
  - Work in Progress
  - Preliminary Results
- Future Work

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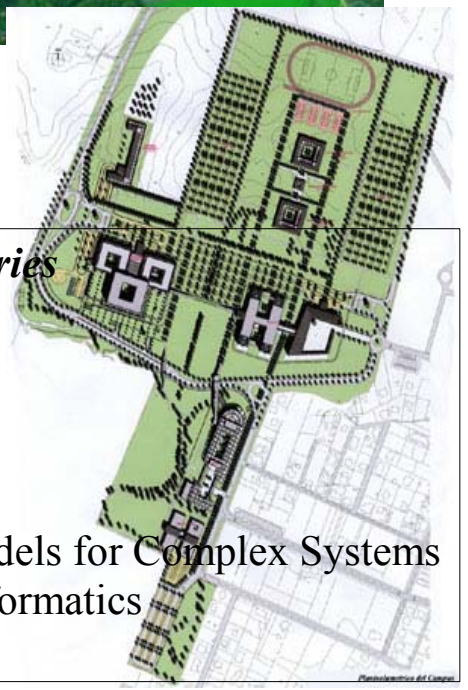
www.unicampus.it



- Founded in Rome in **1991**
- **Goal:**
  - *train qualified and ethical professionals*
  - *ensure a person-centred environment*
  - *encourage multidisciplinary and international collaborations*
  - *promote partnerships with biomedical companies*
- **Faculties:**
  - Medicine
  - Biomedical Engineering
  - Nursering
  - Alimentation and Nutrition Sciences
- **University Hospital** including
  - day-hospital
  - pre-hospitalisation
  - departments for in-patients
- **Interdisciplinary Research Center (CIR)**
- PhD in Neuroscience, Endocrinology, Experimental Oncology, Biomedical Engineering
- Total of 815 students and 65 between full, associate and assistant professors
- Collaborative partnerships with 18 Countries

- ***Biomedical Engineering Laboratories***
  - Automation and Controls
  - Biomedical Robotics
  - Biomaterials
  - EMC
  - Biomedical Instrumentation
  - Physics and Mathematical Models for Complex Systems
  - Computer Science and Bio-informatics

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Biomedical Robotics Laboratory

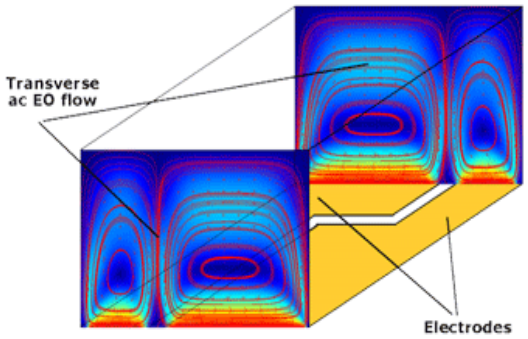
www.biorobotics.it

Research areas

- Rehabilitation Bioengineering
  - Methods and Systems for Robot-Mediated Motor Therapy
  - Functional Assessment
  - Assistive Technology

- ***Neurodevelopmental Engineering***

- Miniature Systems
  - Design techniques based on multi-domain and multi-physics
  - Microfluidic platforms for manipulation of biomolecules
  - Drug-delivery systems for oncology application
  - Miniature sensors and actuators for robots



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Neuro-developmental Engineering

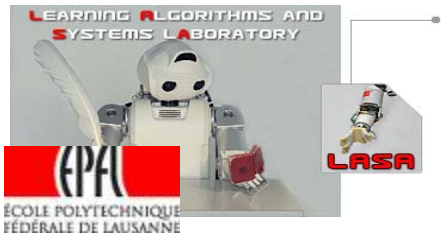
- New interdisciplinary research area at the intersection of Developmental Neuroscience and Bioengineering aiming at providing new methods and tools for:
  - Undestanding neuro-biological mechanisms of human brain development
  - Objective and quantitative analysis of human behavior during neuro-development
    - Human neurodevelopmental *milestones* from birth onwards
    - Studying neuro-developmental disorders
    - Objective assessment via telematic, mechatronic, robotic systems

- Long term goals:
  - ***New clinical protocols and standards*** for early diagnosis, functional evaluation and therapeutic treatments for neuro-developmental disorders (ASD)
  - ***New generation of educational, interactive toys*** which can sustain, in **ecological scenarios**, the regular development of motor and cognitive abilities of the child

Thought in ACTion (TACT) project

http://tact.unicampus.it

- 3 years, EU founded, started Jan 2006
- coordinated by Campus Bio-Medico
- Partners in Italy, Swidan,Switzerland, UK
- ***NEST/Adventure programme***, 6th FP
  - New Emerging Science and Technology



- *Visionary* but scientifically *rigorous* goal
  - early diagnosis of neurodevelopmental disorders
  - highly interdisciplinary
    - developmental neuroscience, developmental psychology, child neurology, child psychiatry, robotics, mechatronics, electronic music, signal analysis, computer science & neural engineering, and bioethics.

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TACT objectives

- Development of methods and devices for:
  - ***assessing goal-directed actions*** in normally developing babies
  - ***establishing standards*** against which measuring developemental disorders
  - ***detecting early signs*** of disturbed development
  - focus on
    - ***basic sensorimotor integration***
    - patterns gaze
    - expression of emotions
    - social communication
- Novelty:
  - Movement analysis is often very complex/expensive
    - Accesible to a **limited number of children**
    - For a **limited amount of time**
  - Ecological operation conditions
    - Diagnostic tools could be directly **available to families**
  - We propose a **complementary** technology suitable to operate also in kindergardens and homes
    - **Child-centred** design
    - Long term, **continual monitoring**

TACT Instrumented Toys and Wearable Devices

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Wearable Audio-Visuo-Vestibular Systems

- Neurodevelopmental disorders (like Autism) affect ***perceptive and motory systems*** and it is proved that some features of the disorder can be observed in the first months of life, even if the diagnosis of the disorder can't be currently doneafter **3 years** from the birth
- Wearable Audio-Visuo-Vestibular Systems and Instrumented Toys for behavior analysis in infants between **0-24 months**
- **Multimodality** and **Sensor Integration**

Vilensky et al. 1981	Deambulation disorders
Hallett et al., 1993	Limited range of motion of the hip, asymmetric posture
Van der Meer et al., 1995	Motor coordination through vision control
Von Hofsten & Rosander, 1997	Tracking ability
Teitelbaum et al., 1998	Video recordings of children first steps
Mari et al., 2003	Reach-to-grasp tasks, delay in action planning and action execution

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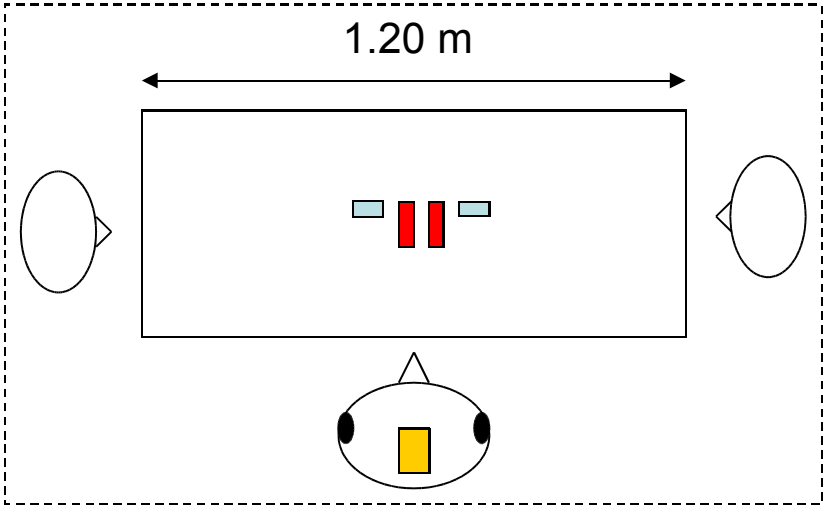
Protocol: Social Situation



Protocol Specifications

Age of the child: 8-14 months
Equipment: coloured wooden bricks
Acting personnel: two caregivers

Social Situation

The experimenters are ***talking to each other alternately***, one at the time.
All the time they are looking at each other (with an interested facial expression), not at the infant.
The experimenters are ***putting bricks in front of the infant alternately***, one at the time.

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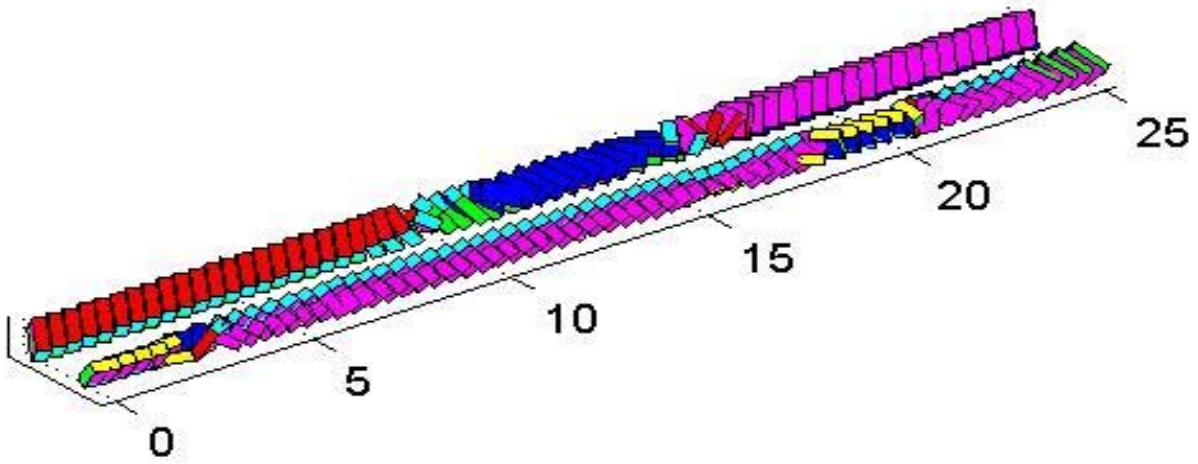
Sensorised Toy

3D magnetometers
3D gyrosopes
3D accelerometers

→ Toy orientation →

Manipulation ability
Affordance

Study on Imitation



External camera

wear-cam

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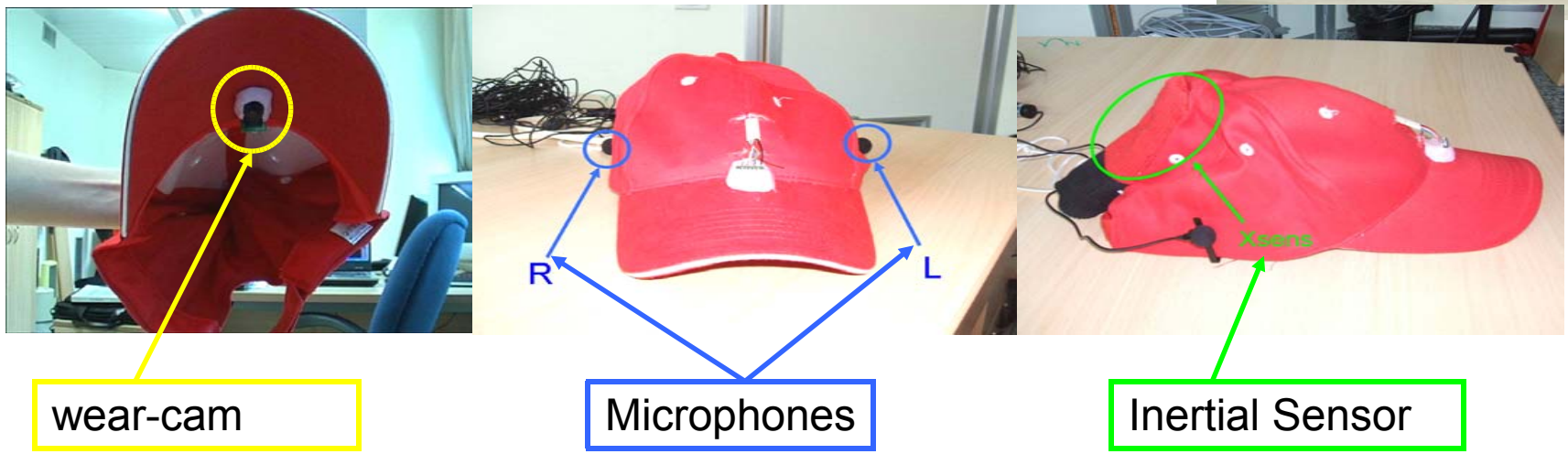
Audio-Visuo-Vestibular Cap

- **Multimodal System**
  - *Auditory system* binaural microphones
  - *Vision system* wear-cam
  - *Kinematic system* inertial sensor



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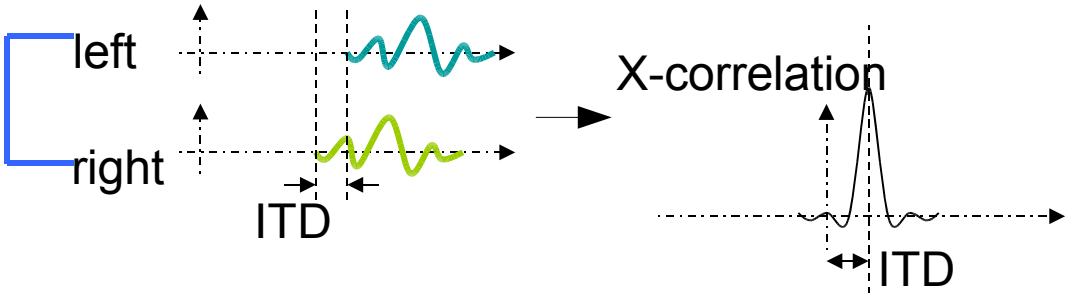
Sound-Vestibular module

Sound localization in the horizontal plane

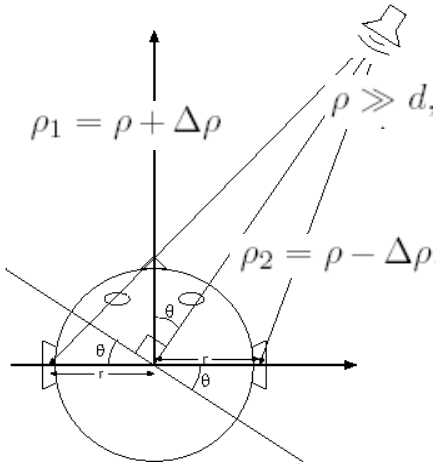


Free-field: simple scenario

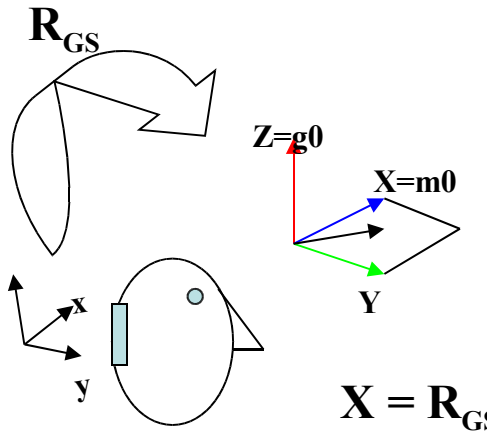
$$\Delta T = \frac{\rho_1 - \rho_2}{c} = \frac{2r\sin\theta}{c},$$

Effect of the shadowing of the head

$$\Delta T = \frac{r(\sin\theta + \theta)}{c}.$$



Head azimuth in the horizontal plane



$\mathbf{X = R_{GS}\, x}$

Nicoleta Roman, DeLiang Wang, Guy J. Brown, Speech segregation based on sound localization, J. Acoust. Soc. Am., Vol. 114, No.4, pp. 2236-2252, Pt. 1, October 2003

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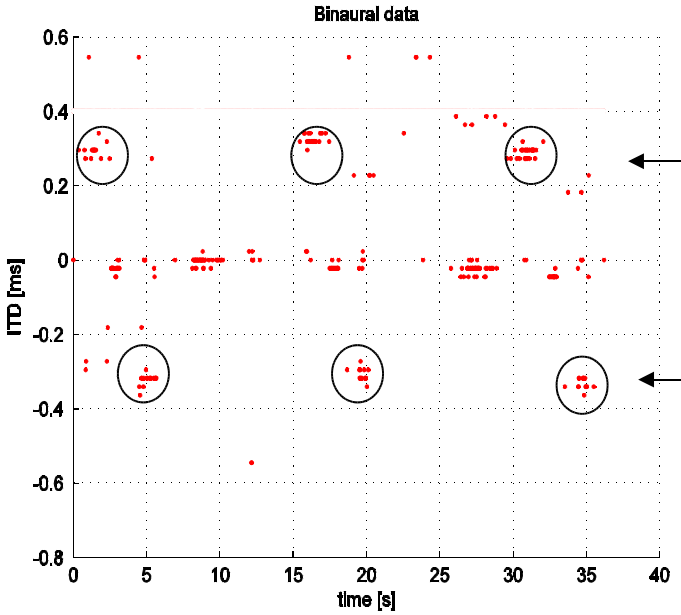
Sensory Integration

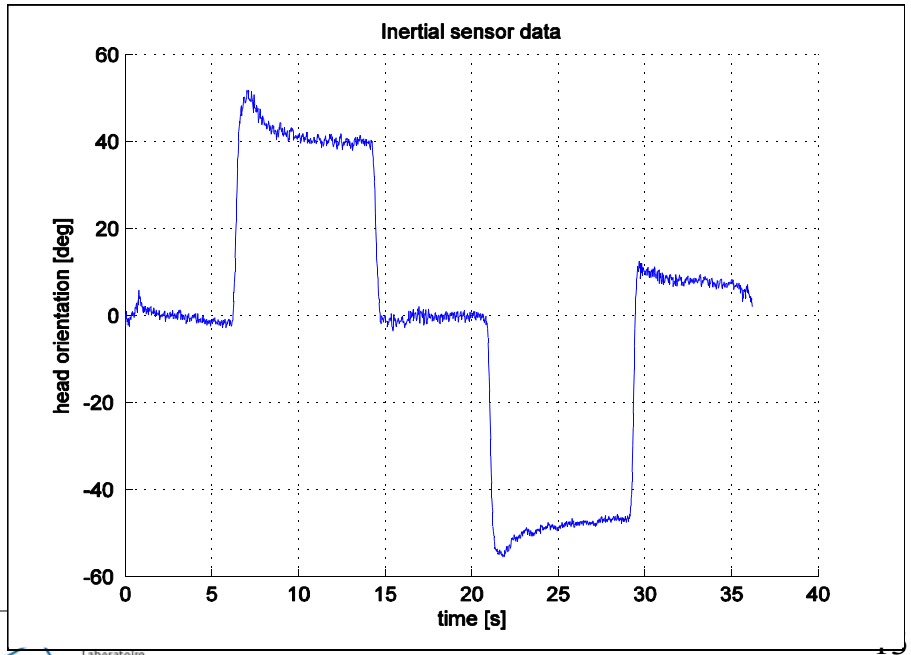


Left source contribution

Right source contribution

ITD is estimated as the lag corresponding to the position of the maximum in the cross-correlation function.

Head azimuth is obtain with the projections of the geomagnetic vector **M** on the ***xy-plane***



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Preliminary results

- Combining binaural azimuth and head azimuth it is possible to
  - identify
    - where the baby is looking
    - if he is looking to the speaking cargiver
    - if he is looking to the object
    - if he can understand the game rules
    - if he is able to understand language
  - investigate
    - the way the baby interacts with the caregiver in social situations

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Conclusion&Future Work

Sensory integration and ***multimodal approach*** can enhance quality and quantity of useful information about child interaction with the world

- Future work
  - Better solutions for computing binaural processing and sound localization
  - In-situ Test: testing the AVVC in kindergarden
  - Automatic Recognition of child behaviour
  - Classification of relevant/pathological actions

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Questions?

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…Thanks for your attention!