



# COPRIN **project**

Contraintes, OPTimisation et Résolution par INtervalles  
Constraints, OPTimization and Resolving through INtervals

**COPRIN has been created in February 2002**



**12 years rule: COPRIN will close in 2014**

**Last evaluation: March 2009**

# Members of the project (03/2013)



## Staff

MERLET Jean-Pierre	(DR 1, scientific head)	
<b>DANEY David</b>	(CR INRIA)	→ 09/2013: INRIA Bordeaux
DUNE Claire	(Assistant Professor, U. Toulon)	since 09/2012
<b>NEVEU Bertrand</b>	(Ingénieur en Chef, P & C)	→ 08/2012: CERTIS Paris
PAPEGAY Yves	(Chargé de Recherche INRIA)	
POURTALLIER Odile	(Chargé de Recherche INRIA)	
<b>TROMBETTONI Gilles</b>	(Assistant Professor UNSA)	→ 08/2012: professor Montpellier

## Students

ALEXANDRE dit SANDRETTO J.	(PhD student, ANR, since 09/2010)
BAKAL K.	(joint PhD with U. Toulon, PAL, since 12/2012)
BLANCHET L.	(PhD student, EU project, since 03/2012)
GAYRAL T.	(PhD student, Thalès, since 09/2010)
RAMADOUR R.	(joint PhD with LAGADIC, PAL, since 11/2011)

**Note 1:** every PhD student spend 2 months in another lab and 2 months in a company

**Assistant:** WOODWARD Nathalie, shared with the FOCUS and LAGADIC projects

**Mannequins:** Jennifer and Charlie

# Scientific objectives and Methods



Two main complementary research axes

Robotics

Interval Analysis

uncertainty management

robot design

Robotics objectives will be presented and then illustrated in specific focuses

# Robotics objectives



- **Robotics Objective 1: robot modeling and analysis**
  - establishing the **real** performances of the robot, taking into account the **uncertainties** in the modeling and control
  - improve the modeling parameters → **calibration**
- **Robotics Objective 2: design methodology**
  - establishes the design parameters so that the robot satisfies given requirements → **appropriate design**
  - calculates **almost all design solutions**
  - allowing to choose the **best design compromises**
  - with performances that are **guaranteed** with respect to manufacturing tolerances

# Robotics objectives



- **Robotics Objective 1:** robot modeling and analysis
- **Robotics Objective 2:** design methodology
- **Robotics Objective 3:** parallel robots

+

(added at 2009 evaluation)

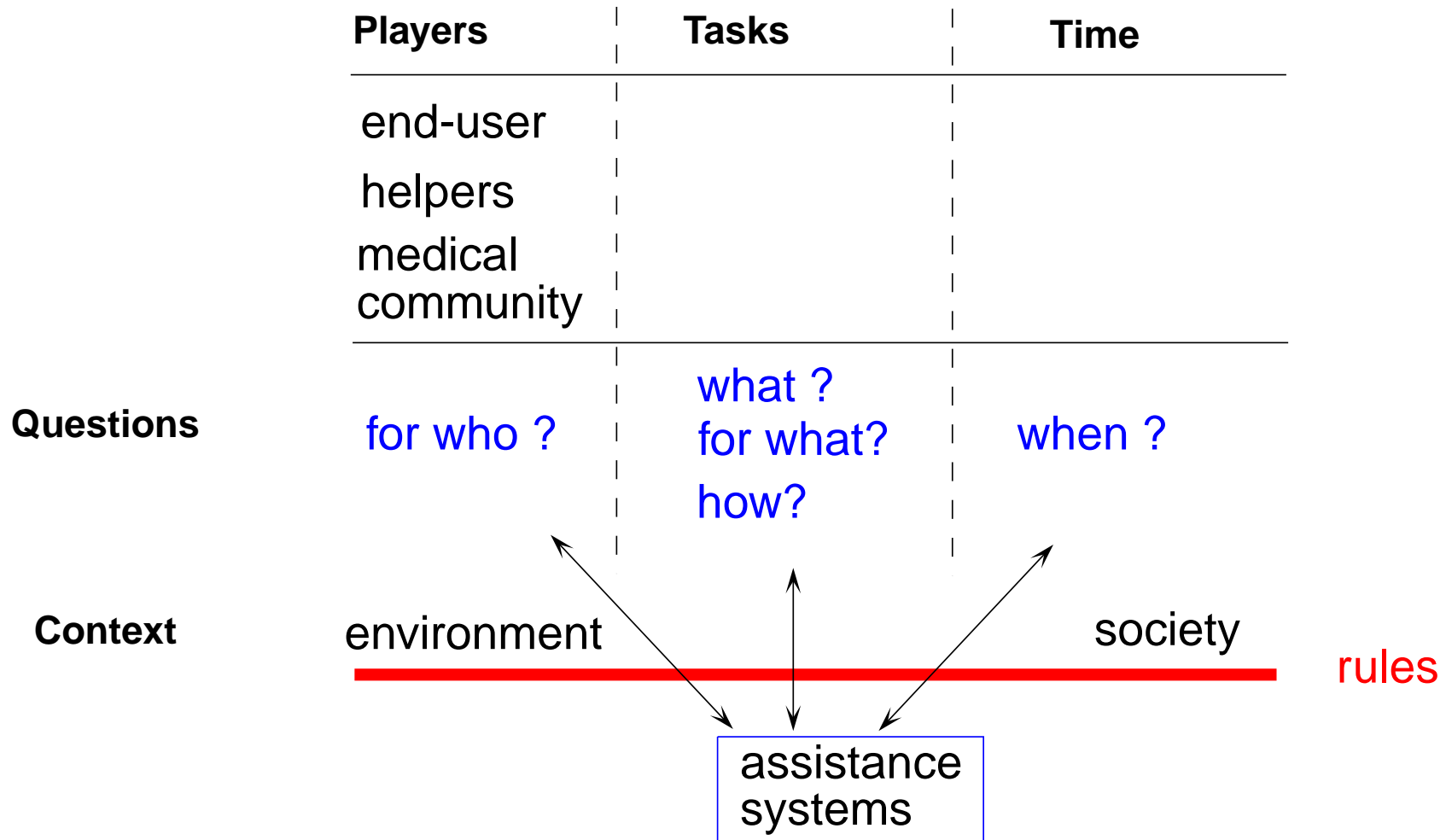
- **Robotics Objective 4:** assistance robotics

(consequence of the 2006 prospective report elaborated by the robotics teams)

# Assistance Robotics

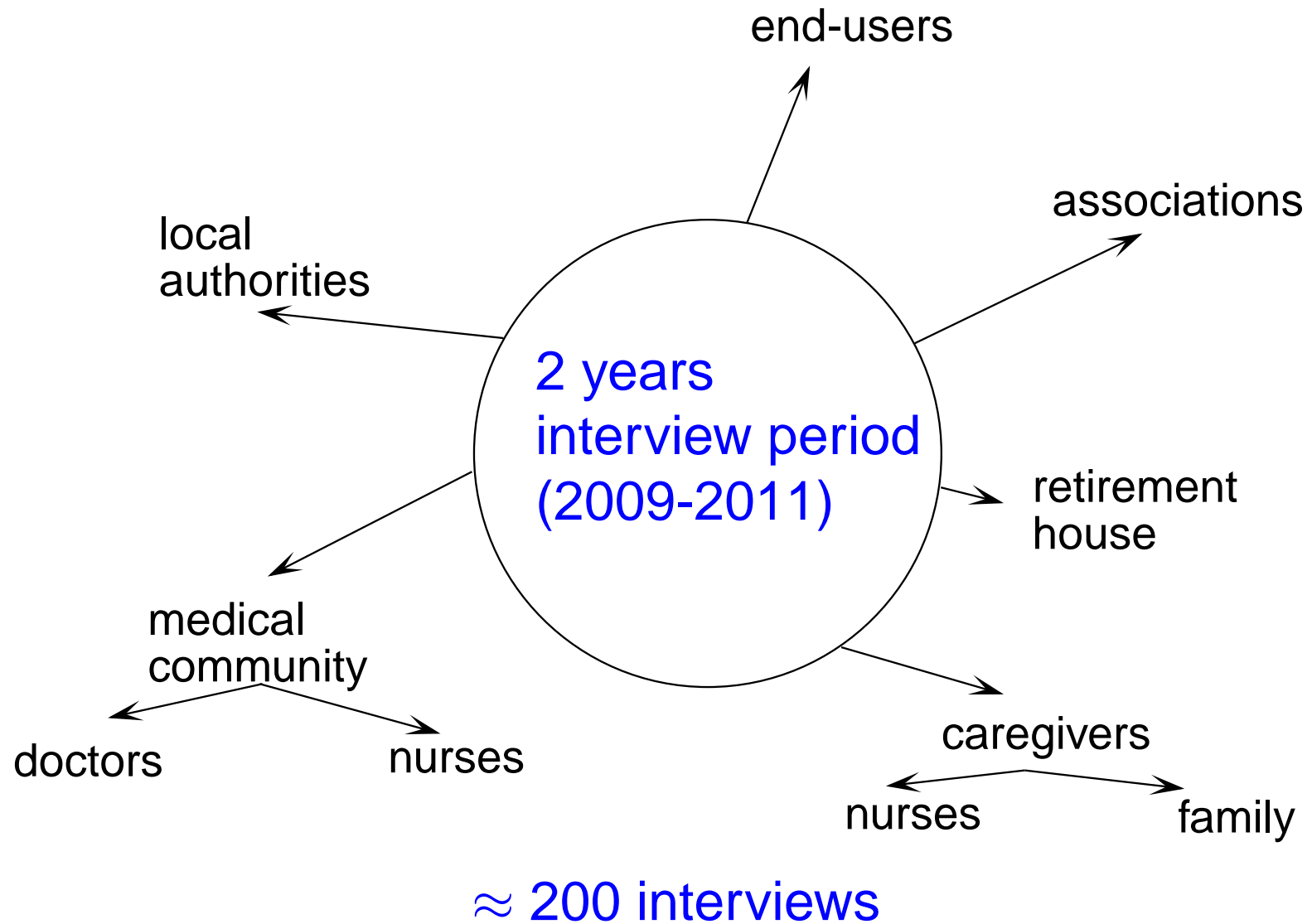


for frail people (elderly, handicapped, ...)



In 2009 we have **almost no knowledge** about these issues

# Assistance Robotics



# Assistance Robotics



These interviews has allowed us to determine:

- **priorities** → what, for who, when, what for  
for example
  - *mobility assistance* (for elderly, caregivers, family)
  - *medical monitoring* (especially at home)
- **guidelines** → how, ethical rules  
for example
  - *low intrusivity*
  - *low cost*
  - *low energy consumption, smart objects*

we cannot address all these issues ⇒ PAL

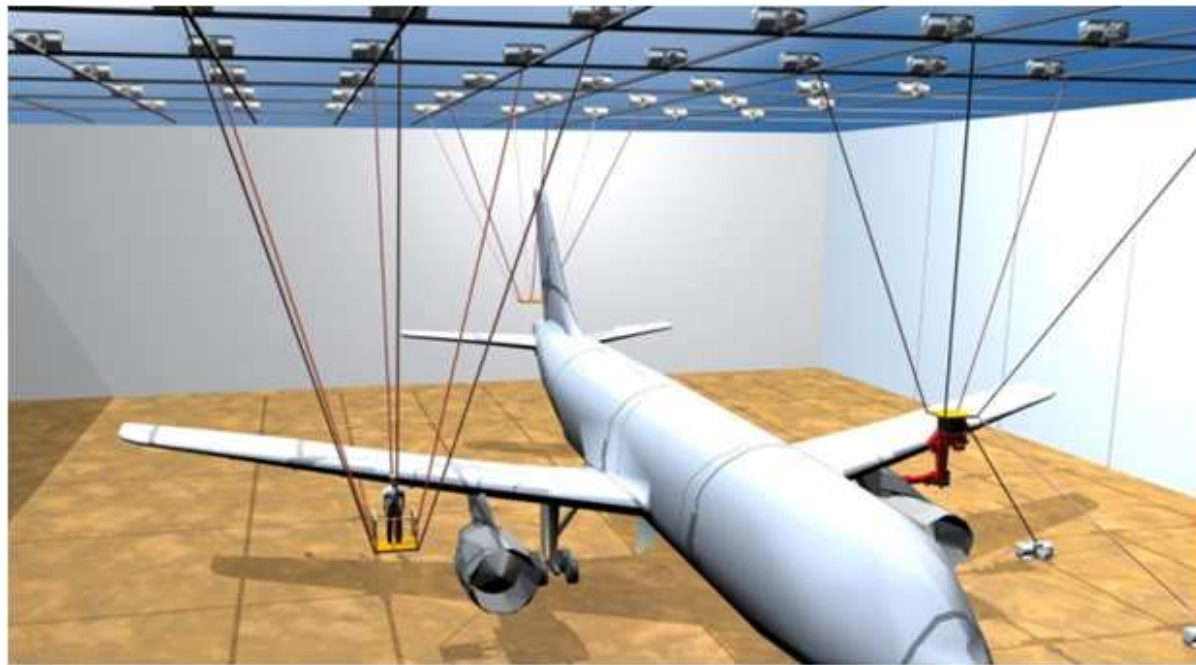


# Focus 1: wire-driven parallel robots

Same structure than classical parallel robots but

{ rigid legs substituted  
by **wires**

{ actuators allows to  
change the **wire**  
**lengths**



CableBot project

**advantages:** large workspace, mechanical simplicity



# Focus 1: wire-driven parallel robots

In the period we have developed the MARIONET family:

- MARIONET-CRANE: **rescue robot**  
6 dof robot, portable in rescuers backpacks (200 kg), lift 2 tons, deployable in 10 mn
- MARIONET-ASSIST: **transfer robot**  
allow elderly to be assisted for walking at home
- MARIONET-REHAB: **rehabilitation robot**  
illustrated here for measuring knee motion while walking
- MARIONET-VR: **robot for immersive room**
- MARIONET-SCHOOL: **low-cost robots for dissemination**

Video **red**



# Focus 2: theoretical aspects, redundancy

**Redundancy** more than  $n$  wires to control  $n$  dof

- having more wires **increases** the robot workspace
- **usual claim:** *redundancy allows for changing the tension distribution in the wires*

**our contributions**

- for **stiff wires**: this claim is **wrong**
- for **elastic wires**: claim is **right** in theory but **wrong** in practice

Many other **contributions** in **calibration, forward kinematics, singularity analysis, ...**

# Factual data

## Contracts



### 2009 evaluation:

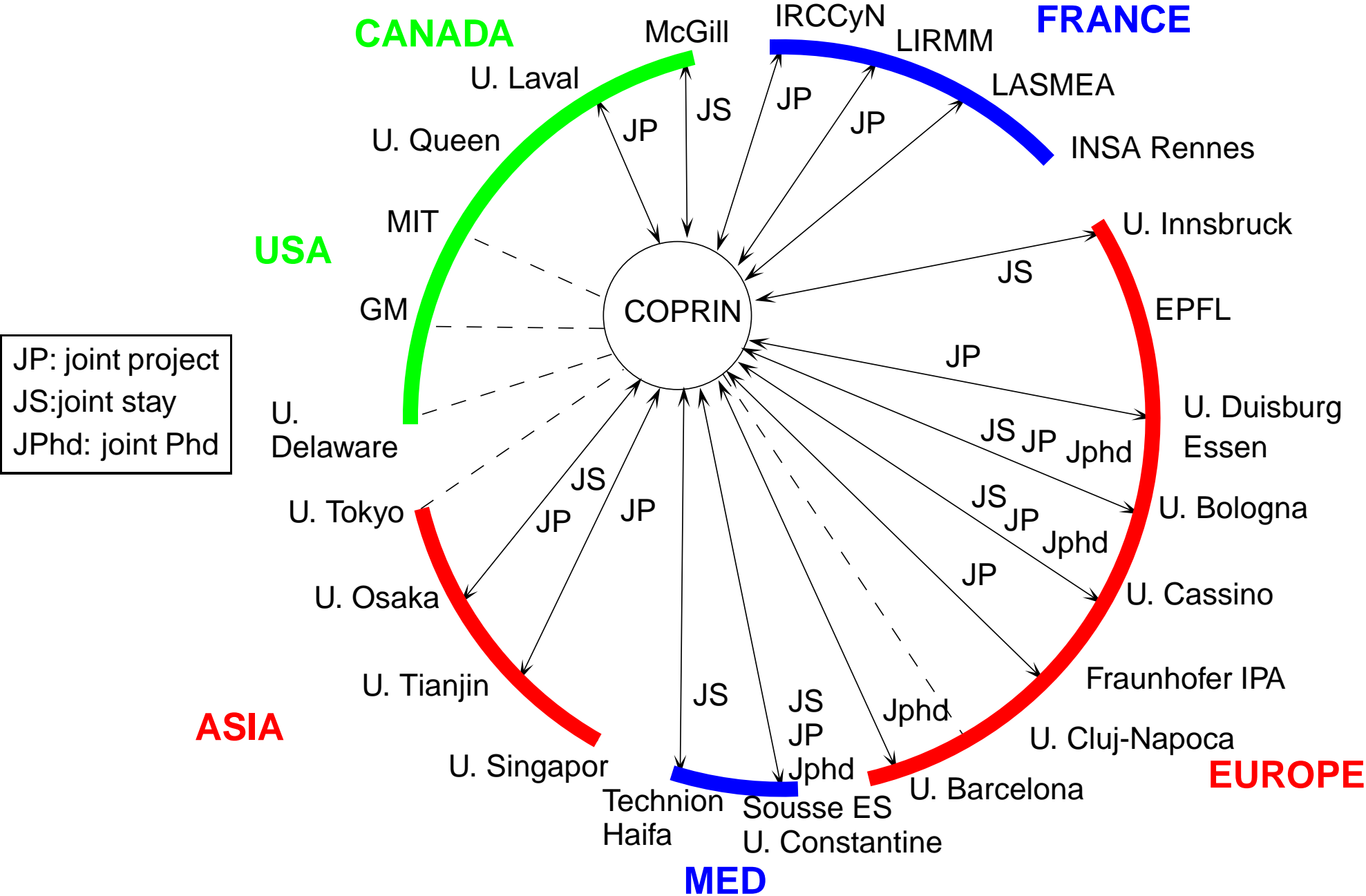
*we will need time to identify issues and to focus on assistance robotics  $\Rightarrow$  less short-term contracts (ANR, European), lower budget*

- **industrial**: Airbus (100 Keuros), Thalès (50 Keuros)
- **academics**: European contract CableBot, 3 ANR

### Budget (Keuros):

Year	2010	2011	2012	2013
Budget	275.5	433.5	206	172.5

# Factual data: robotics collaboration







## Factual data: Publications 2009-2012

**2009 evaluation:** *we will need time to identify issues and to focus on assistance robotics  $\Rightarrow$  probably less publications*

we were **wrong**, for this period:

- 4 PhD Thesis, 2 HDR
- 23 journal papers
- 70 conference papers
- 1 book chapters

but the **2009 note** will be true for the next period

**Open access:** yes ! **but green only!**

# Transfer, Scientific life, Dissemination

**Transfer** 2 software licenses in the period

**Scientific life** large **involvement**, see synthesis

**Dissemination** a true and large involvement of the project

- **200 visitors/year** attend our demo (age: 6 months→87 years)
- **4 summer schools**, one organized at INRIA
- **web log** for 2012 :
  - ALIAS library (download, tutorial): 225059 hits
- MARIONET-SCHOOL **pedagogic robots** designed to be used by any scientist (math, network, computer science,...)
- toward the **police** ... each time we transport our hardware



# Focus 3: walking aids



First phase of autonomy loss: **mobility problem**

**First solution:**  
the walking aid

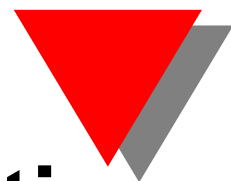


# Focus 3: walking aids



Interviews feedback:

- **mobility assistance** required by all
- **in-depth analysis of walking patterns** required by the medical community  
→ gives good indication on the state of health
- **fall problem**
  - in France **10 000 elderly deaths per year** are a direct consequence of a fall  
(car accidents: 3000 deaths/year)



# Focus 3: walking aids ANG, objectives

improve  
mobility

analyse walking by  
measuring walker trajectory



+  
fall  
detection/  
prevention  
schemes

ANG minimal instrumentation: rear wheels encoders, 3D accelerometer, GPS

# Focus 3: walking experiments



2011-2013: [walking experiments](#) to determine if the walker trajectory can provide [information on walking patterns](#)

- 24 "young" subjects at INRIA
- 30 elderly subjects at Nice hospital

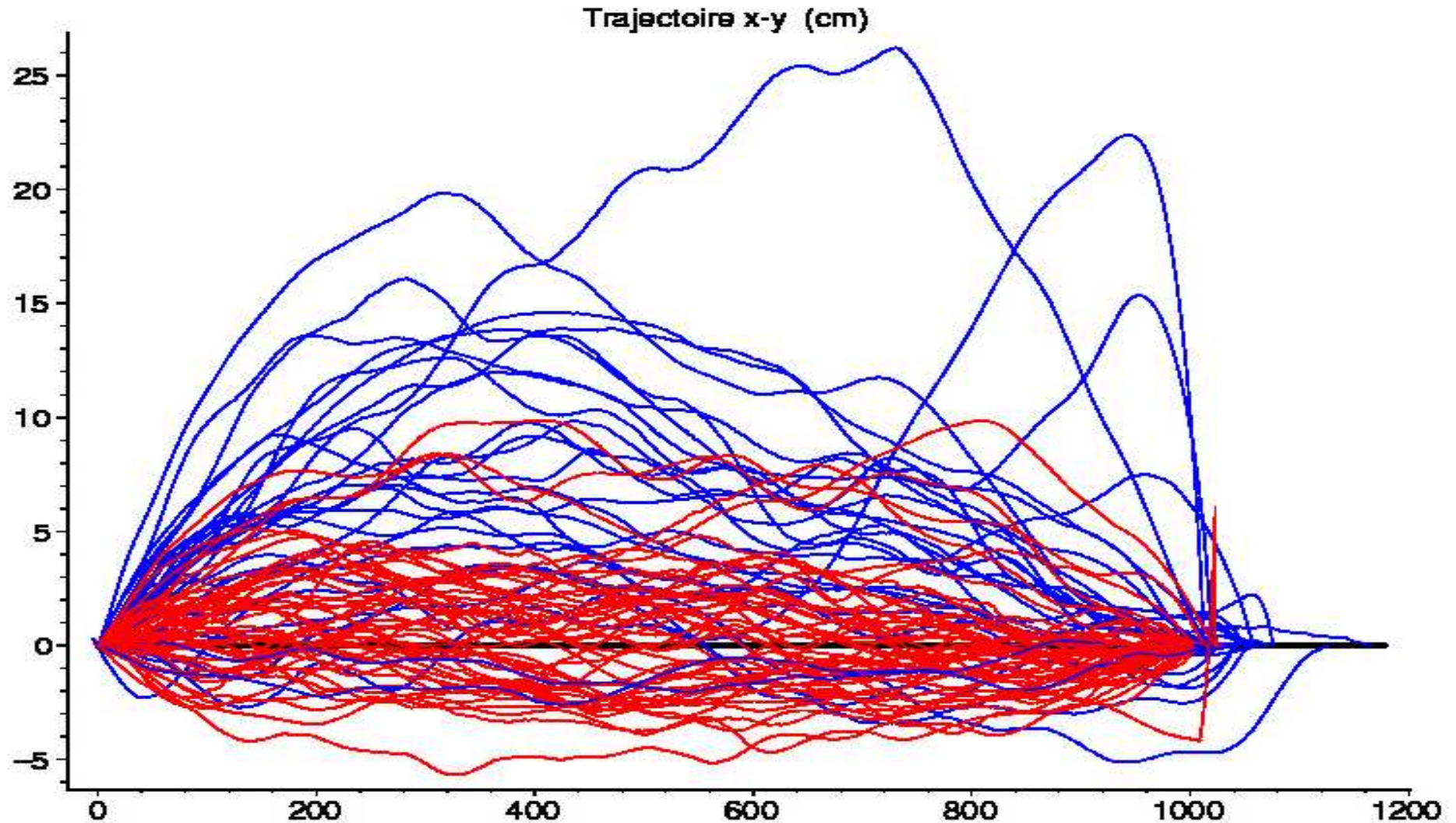
were asked to perform pre-defined trajectories with the walker

video [green](#)

# Focus 3: walking experiments



Experiments have shown **very interesting results**





remember the fall sequence in the video ?

# The future



Strong background/collaborations in **assistance robotics** → team is ready to propose a new 12 years project on this topic:

code name: **HEPHAÏSTOS**

*Hephaestus was the God of Fire and the Forge, the smith and craftsman of the gods. To compensate for his lameness, the god Hephaestus built two golden robots to help him move around ...*



ok ?

# HEPHAISTOS: focus



- *low intrusivity* and **low cost**
- **adaptability** and *mobility*
- *safety* and *smart devices*
- *human physiology* and *rehabilitation*
- *intention detection* and *interfaces*
- **energy**
- **networking** and **programming**
- *ethical issues*



# Conclusion



the remaining slides have been updated during the presentation

# Conclusion



the remaining slides have been updated during the presentation

## Proof:

**Time:** 16:19

**News GN:** Roma : Totti souffle ses vingt bougies et parle de Lippi, Mourinho ...

# Conclusion



- presentation duration: 25 minutes, 33 seconds
- travelled distance during the talk: 62 (meters)
- number of steps: 81
- energy consumption: 112 (Joules)  
(does not count the consumption due to the stress)

Special thanks to COPRIN "Special operations group" which has designed, transported and installed the hardware for this talk

Questions ?