Mechanism science and assistance to elderly

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COPRIN: a team of 15 people, 6 staff, 9 phd, postdoc located at Sophia-Antipolis

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2005: strategic decision to focus on assistance robotics

2011: INRIA launches the Large Scale Initiative Personally Assisted Living (PAL)
We need guidelines to work in this field

• why ?: the specific problem(s) we target
We need guidelines to work in this field

• **why ?**: the specific problem(s) we target

• **who ?**: decide that an assistance device is needed, use it or help to use it
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• **why ?**: the specific problem(s) we target

• **who ?**: decide that an assistance device is needed, use it or help to use it

• **when ?**: all the time ? on demand ?
We need **guidelines** to work in this field

- **why ?**: the specific problem(s) we target
- **who ?**: decide that an assistance device is needed, use it or help to use it ?
- **when ?**: all the time ? on demand ?
- **how ?**: the mean. universal ? specific ?
Objectives and priorities
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2006-2009: discussion for establishing our objectives and priorities
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- personal of retirement houses: nurses, staff
- doctors
- elderly and handicapped people associations
- local authorities
- individuals

Over 200 individuals have been interviewed
Objectives and priorities

Some of the established needs:
Objectives and priorities

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- **End-users**: low intrusivity
Objectives and priorities

Some of the established needs:

• **End-users**: low intrusivity

• **End-users/Doctors**: adaptability
  • to the end-user needs, evolving in time
  • to the environment of the end-user
  • to the uncertainty of the real world
Objectives and priorities

Some of the established needs:

- **End-users**: low intrusivity
- **End-users/Doctors**: adaptability
  - robot must adapt to the user, not the opposite!
Objectives and priorities

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- **End-users/Doctors**: adaptability
- **End-users, Practitioners**: low-cost, easy installation and maintenance
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- **Practitioners**: low-energy consumption
- **Doctors**: monitoring for prevention
- **Roboticists**: connectivity
- **Roboticists**: not a single "universal" device
Objectives and priorities

Needs with highest priority:
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• transfer: especially in the toilets!
Objectives and priorities

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- **transfer**: especially in the toilets!
- **fall prevention/detection**
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• **easier and more human communication systems**
Objectives and priorities

Needs with highest priority:

- **transfer**: especially in the toilets!
- **fall prevention/detection**
- **mobility aid**: but no **navigation aid**
- **large variety of interfaces**
- **easier and more human communication systems**
- **monitoring**: give information to doctor for prevention, objective assessment and diagnostic
The role of mechanics
The role of mechanics

MMT will play an important role in assistance devices
The role of mechanics

transfer and fall prevention
The role of mechanics

transfer and fall prevention

• involve large forces
The role of mechanics

transfer and fall prevention

• involve large forces
• safety issues
The role of mechanics

transfer and fall prevention

- involve large forces
- safety issues
- a difficult task for non-intrusive humanoid robots
The role of mechanics

Designing low cost devices
The role of mechanics

**Guidelines** for designing low cost, easy to install and maintain devices
The role of mechanics

Guidelines for designing low cost, easy to install and maintain devices

• use only on-the-shelf hardware
The role of mechanics

Guidelines for designing low cost, easy to install and maintain devices

• use only on-the-shelf hardware
• propose innovative mechanical design
The role of mechanics

**Guidelines** for designing low cost, easy to install and maintain devices

- use only on-the-shelf hardware
- propose *innovative* mechanical design
- propose a dimensioning methodology that:
The role of mechanics

Guidelines for designing low cost, easy to install and maintain devices

• use only on-the-shelf hardware
• propose innovative mechanical design
• propose a dimensioning methodology that:
  • allows to adapt the hardware to the end-user and its surrounding
The role of mechanics

**Guidelines** for designing low cost, easy to install and maintain devices

- use only on-the-shelf hardware
- propose **innovative** mechanical design
- propose a dimensioning methodology that:
  - allows to adapt the hardware to the end-user and its surrounding
  - guarantees the performances of the system
The role of mechanics

Guidelines for designing low cost, easy to install and maintain devices

• use only on-the-shelf hardware
• propose innovative mechanical design
• propose a dimensioning methodology that:
  • allows to adapt the hardware to the end-user and its surrounding
  • guarantees the performances of the system
  • facilitate the installation by providing several design solutions
Transfer aid: **MARIONET-ASSIST**
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- wire-driven parallel robot
- 3 to 6 dof
- lift 150kg anywhere
- stowed in the ceiling when not in use
- a manipulation robot
- rehabilitation robot
- **Cost:** \( \approx 1000 \) euros
Design problem:

• crane must be able to lift the elderly wherever is his location in the room
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Design parameters

- maximal forces of the winch (within a catalog of standard hardware)
- location of the winches in the ceiling
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Design parameters

- maximal forces of the winch (within a catalog of standard hardware)
- location of the winches in the ceiling

Design methodology

- allow to determine a safe 3D region for the location of each winch

VIDEO
Walking aids
Walking aids

- **who ?**: elderly having still some motricity
Walking aids

- **who ?**: elderly having still some motricity
- **when ?**: any walking period
Walking aids

- **who ?**: elderly having still some motricity
- **when ?**: any walking period
- **why ?**: 
Walking aids

- who ?: elderly having still some motricity
- when ?: any walking period
- why ?: 
  - fall detection
Walking aids

• who ?: elderly having still some motricity
• when ?: any walking period
• why ?:
  • fall detection
  • provide gait information for the doctors
Walking aids

- **who ?**: elderly having still some motricity
- **when ?**: any walking period
- **why ?**:
  - **fall detection**
  - provide *gait information* for the doctors
- **how ?**: accepted mechanical design
Walking aids

ANG-light:

- gait monitoring through trajectory reconstruction
- fall detection: accelerometer
- wifi, phone, gps
- **Cost**: 400 euros
Walking aids

- MMT is used to determine the walker trajectory based on the wheels rotation and accelerometer measurements
- currently being tested with real patients at Nice hospital
Walking aids

Typical record
Walking aids

ANG

- 150W motors
- electric clutches
- > 50 sensors
- solar panel
- active fall prevention
- control: tv remote, radio, IR,
- automatic homing
- fallen object recovery
- GPS, wifi, bluetooth
- **Cost**: 2000 euros

VIDEO
Rehabilitation: MARIONET-REHAB
Rehabilitation: MARIONET-REHAB

At home rehabilitation, with the following modes: passive (monitoring), semi-active (decreasing fatigue), active (sophisticated rehabilitation protocol)
Conclusion
Conclusion

The components of an assistance device:

- computers
- sensors and actuators
- communication
- mechanism
Conclusion

computers: new embedded computers allow to

- manage and control easily sensors and actuators
- are low-cost and wearable
Conclusion

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  • manage and control easily sensors and actuators
  • are low-cost and wearable

sensors: low cost sensors are already available
communication chips are almost common
Conclusion

Hence MMT will play a central role in assistance devices
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- innovative design:
  - that are intrinsically safe
  - whose control is simple (design for control)
Conclusion

Hence MMT will play a central role in assistance devices

- innovative design
- modular/adaptable design
  - low-cost
  - easy to install and maintain
Conclusion

Hence MMT will play a central role in assistance devices

- innovative design
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**design methodology:**
- that takes uncertainties into account to guarantee performances
- that provides several set of solutions to be able to manage unexpected installation constraints
Conclusion

Hence MMT will play a central role in assistance devices

- innovative design
- modular/adaptable design
- design methodology

Let’s go to work!