Using robotics methods for mobility and medical monitoring of frail people

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Assistance Robotics

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HEPHAISTOS is an INRIA team devoted to the assistance to frail people (elderly, handicapped, . . .)

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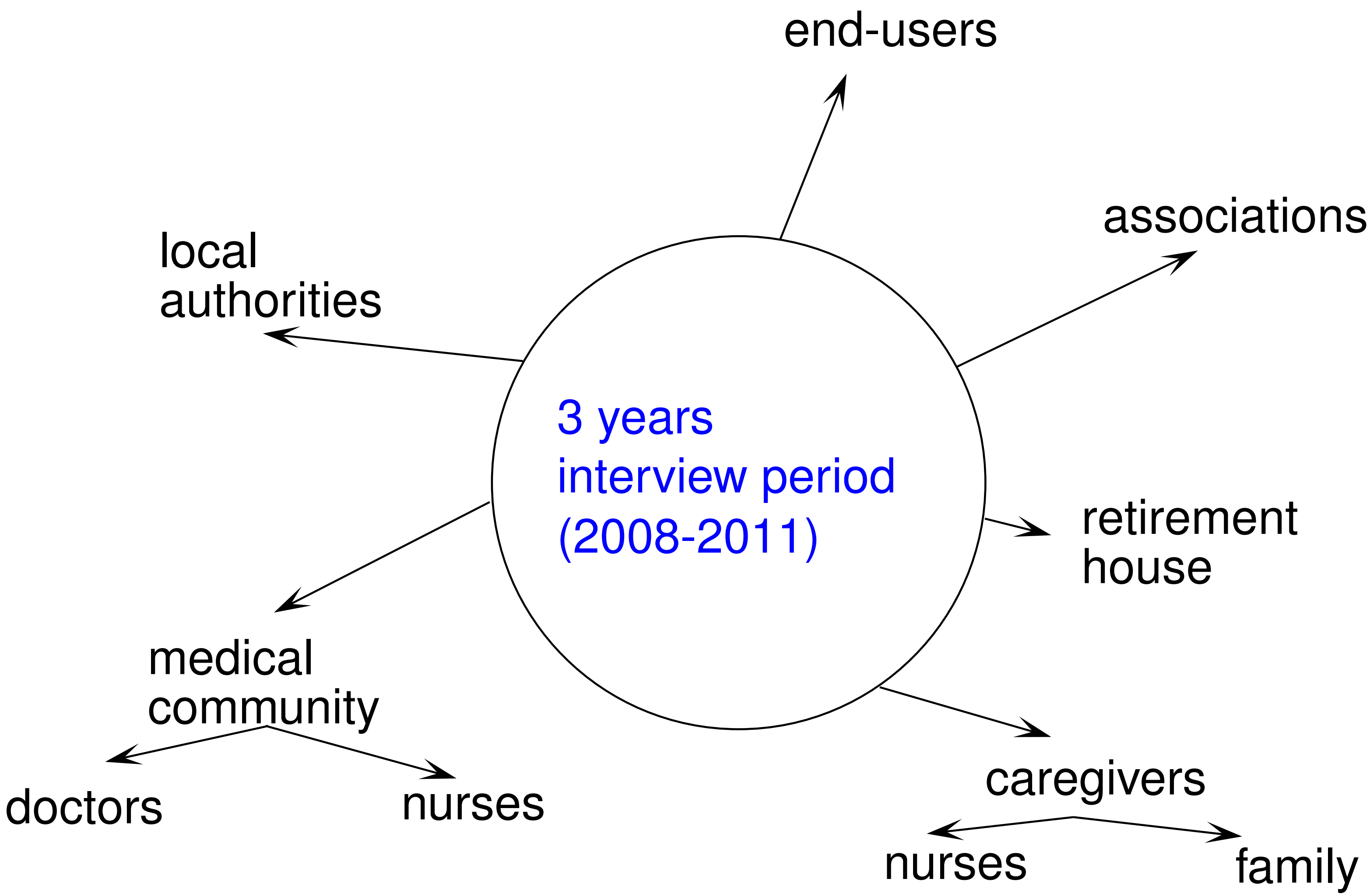
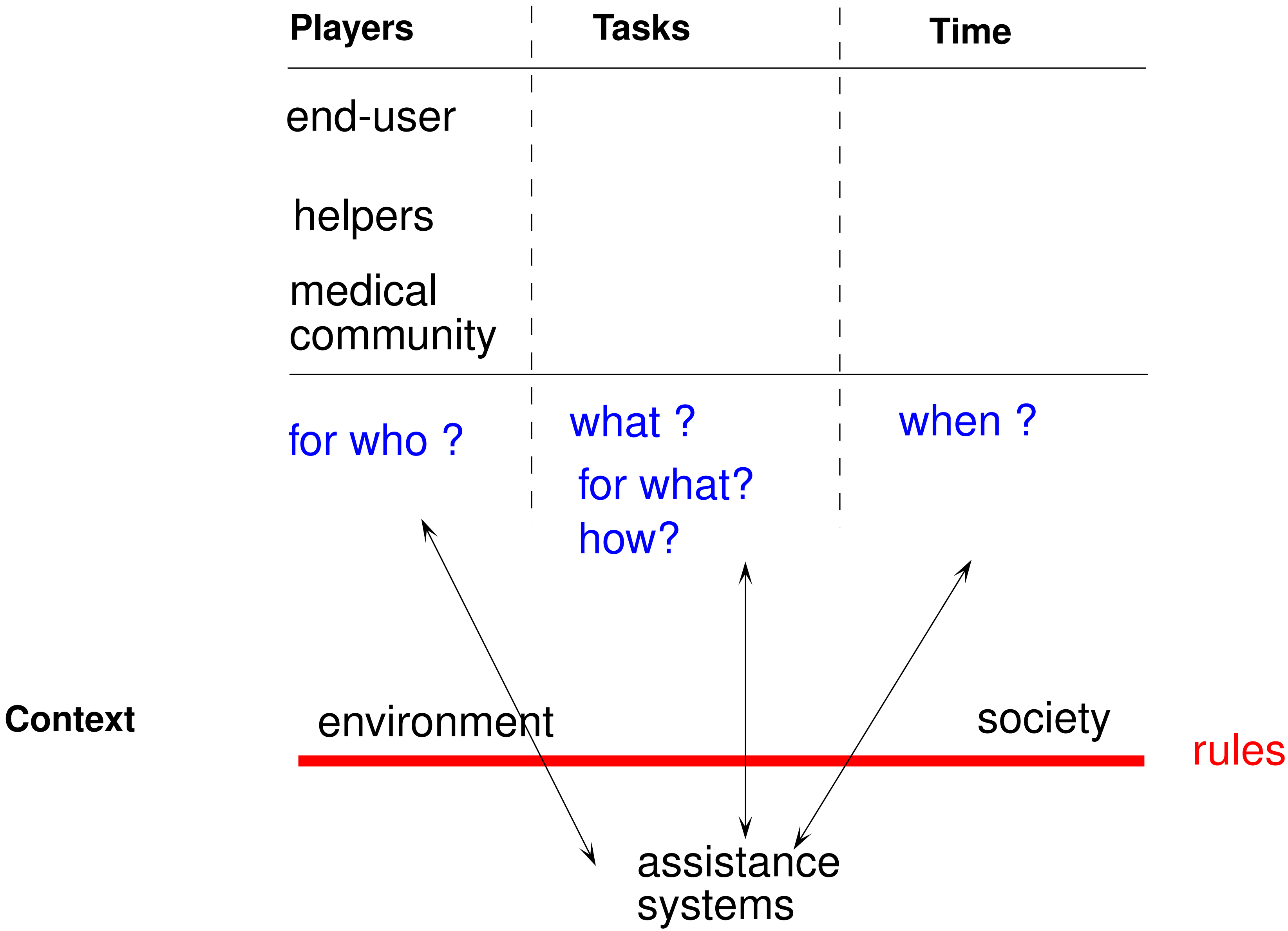
When starting to investigate this subject in 2006 we have almost no knowledge about these issues

Assistance Robotics



$\approx$ 200 interviews

Assistance Robotics



Assistance Robotics

These interviews has allowed us to determine:

- priorities $\rightarrow$ what, for who, when, what for
  - *mobility assistance* (for elderly, caregivers, family)
  - *medical monitoring* (especially at home)
- guidelines $\rightarrow$ how, ethical rules

  for example
  - *low intrusivity*
  - *low cost*
  - *low energy consumption*, *smart objects*

Interviews: *a real change in my life will be to be able to go alone to the toilets*

Mobility

- mobility is essential for a minimal autonomy $\rightarrow$ self-esteem
- first phase of autonomy loss: mobility problem

Mobility

Mobility operations:

- transfer operations: mechanically demanding task
- walking assistance

Mobility

Mobility monitoring is an essential tool for the medical community used for functional and cognitive assessment

- clinical tests: 10m walk, TUG, Tinetti, . . .
- suffer from: robustness, inaccurate or partial measurements, lack of objectivity, . . .

Mobility and fall

The fall problem

- in France 10 000 elderly deaths per year are a direct consequence of a fall
- car accidents: 3000 deaths/year

Objectives of mobility assistance devices

- provide the right level of assistance for the end-users and helpers
- manage the fall problem (detection/prevention)
- medical monitoring (provide synthetic assessment indicators that may be used by doctors, detect rare events that are warnings for emerging pathologies)

Objectives of mobility assistance devices

- low cost and intrusivity
- user-friendly: manageable by the subject alone $\rightarrow$ self-esteem
- flexible and adaptable
- connected
  - to the external world ? yes . . . sometime
  - to other devices ? yes, as much as possible

Transfer

Available solutions: patient lifts

- require an helper, difficult to use by them

Transfer

Available solutions

- intrusive and expensive
- only 1 or 2 action directions

Transfer

Robotic solutions: RIBA robot

- really intrusive
- cost, energy autonomy, helper required

Transfer

Robotic solutions: MONIMAD walker

- quite cumbersome and heavy
- limited transfer ability (sit-to-stand)

Transfer

Purposes of a robotized solution:

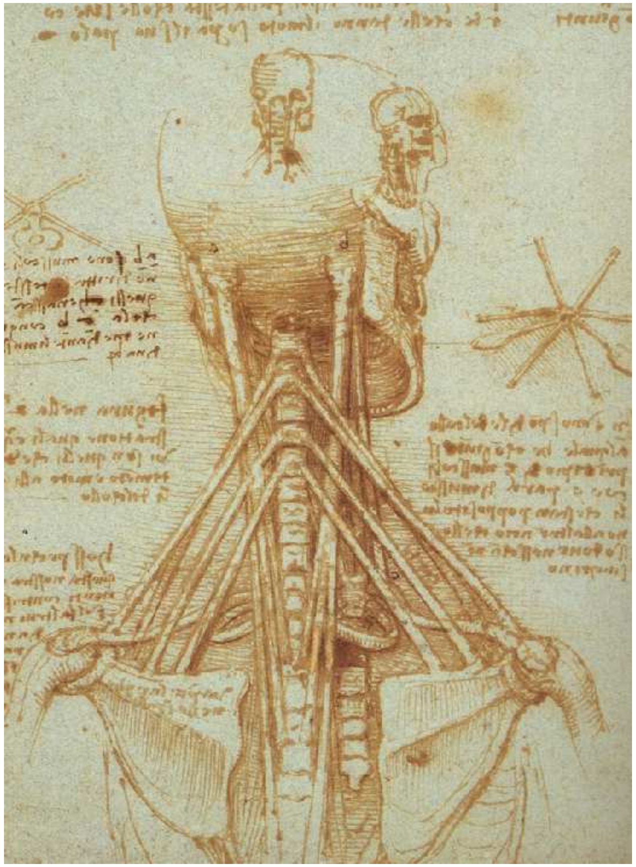
- preserving autonomy by allowing an elderly to remain mobile
- decrease the burden of the caregiver
- allow object manipulation
- avoid fall

Constraints

- should be able to fully lift an elderly: load
- allow access to any part of a room: workspace
- acceptance, cost

Transfer: another robotized solution

main constraints: load and workspace



- several links connecting the spine and the torso
- links are in parallel

Transfer: another robotized solution

How do we implement that for robots ?

Objectives

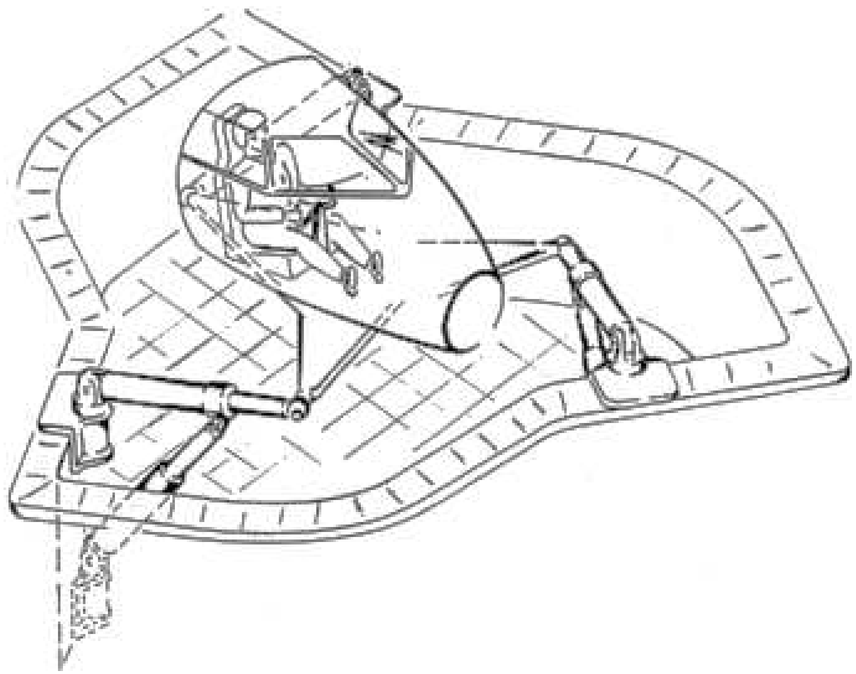
- divide the load among several links
- only traction/compression in the links

Transfer: another robotized solution

Practical implementation: 6 independent extensible legs whose extremities are connected to the base and to the platform

Gough platform 1956

Stewart platform 1965



Transfer: another robotized solution

Linear actuators have limited stroke $\Rightarrow$ parallel robots have a limited workspace

How can we increase this workspace ?

Transfer: another robotized solution

Linear actuators have limited stroke $\Rightarrow$ parallel robots have a limited workspace

How can we increase this workspace ?

Replace the rigid actuators by cables that can be coiled and un-coiled at will

- low cost, low intrusivity
- high lifting capacity, allow for walk monitoring

VIDEO1 VIDEO2

Transfer: another robotized solution

Still many theoretical/practical issues to be solved:

- kinematics
- cable tension control
- standards, norms ?

Walking assistance

Tools used when the first mobility problems appear

Walking assistance

How can we transform these objects for:

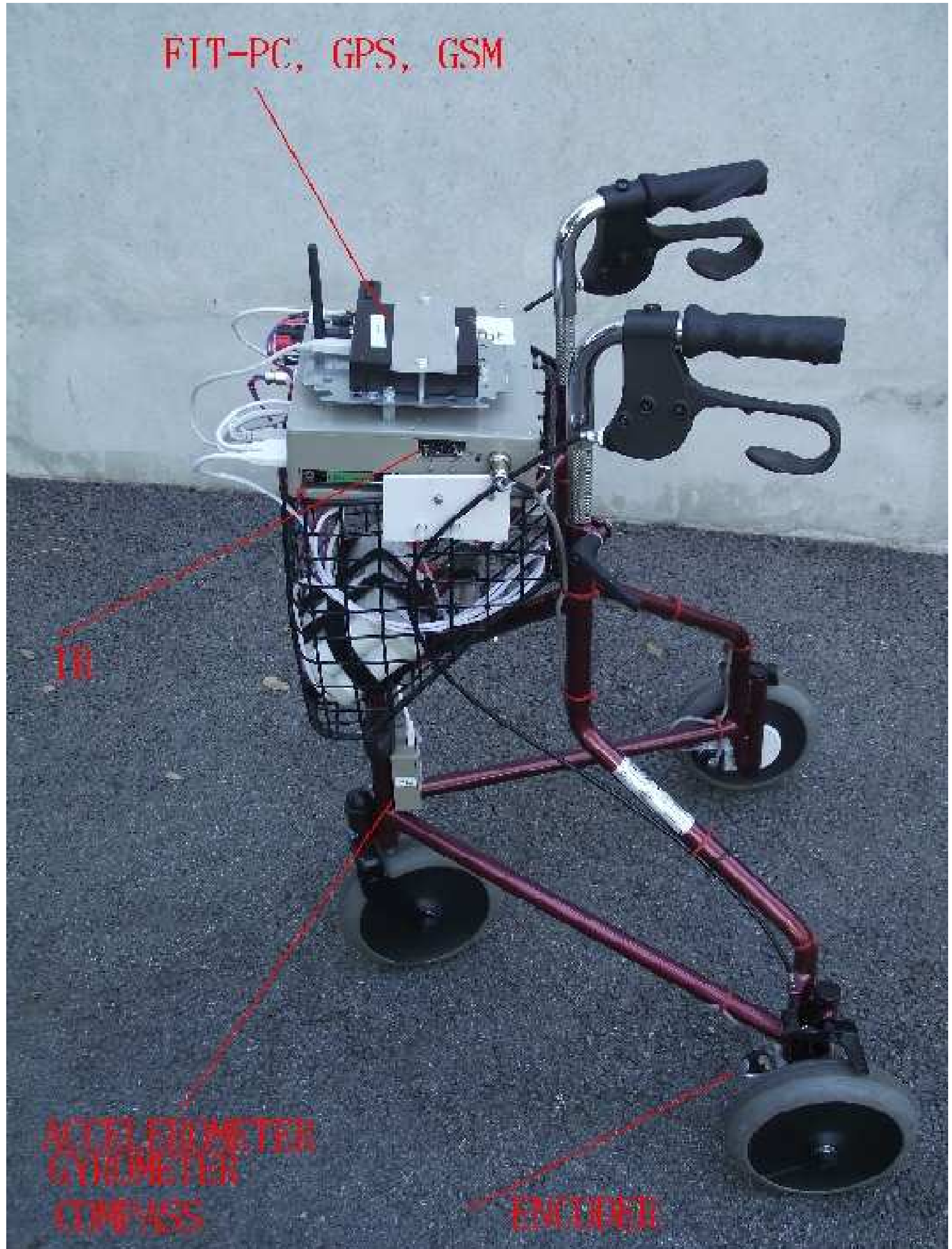
- medical monitoring
- managing fall
- assistance

Walking monitoring

ANG-light walker

- incremental encoders in the rear wheels
- accelerometer/gyrometer
- GPS,GSM
- wifi, infra-red

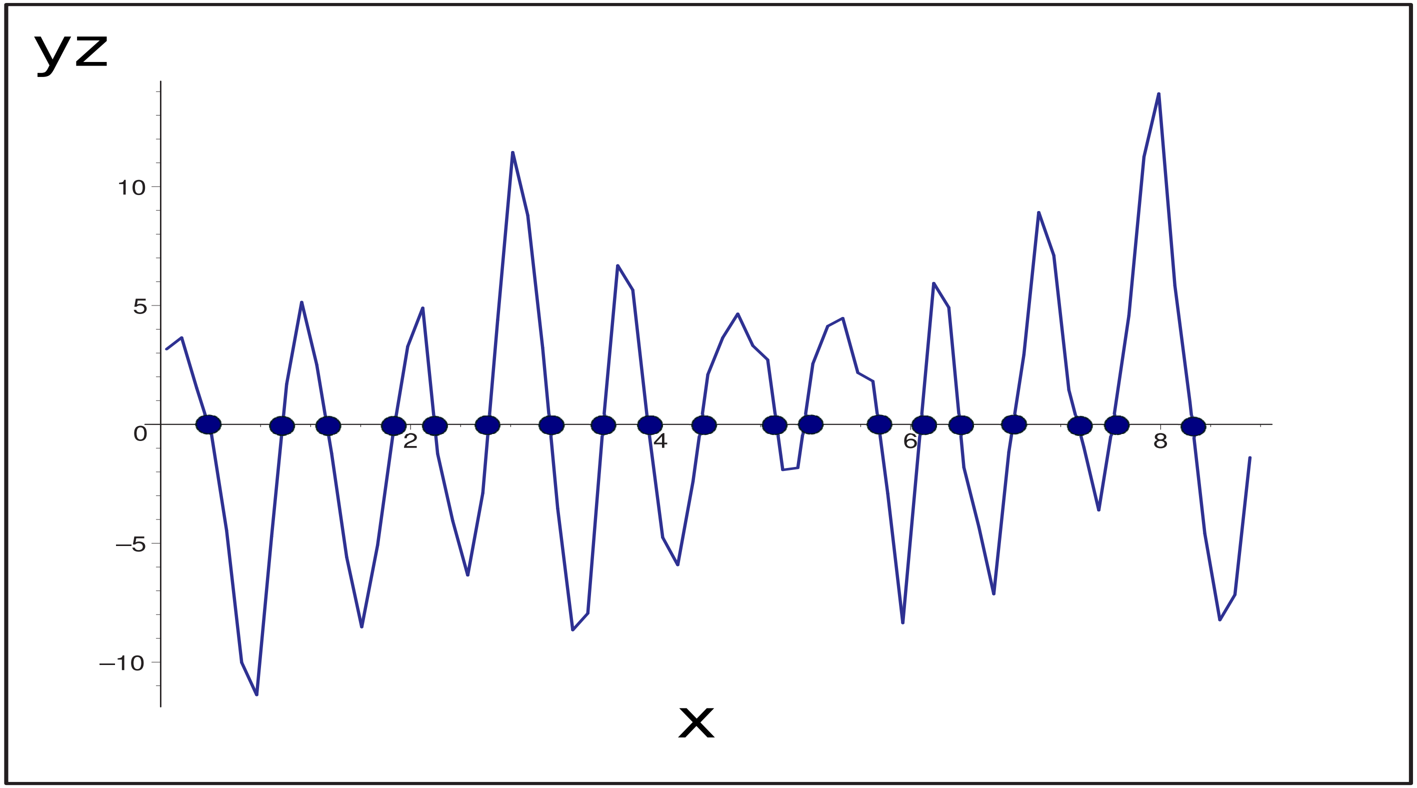
position accuracy:
$\approx$ 1cm over 10m
rectilinear trajectory



Walking monitoring

Initial assumptions: measuring the trajectory of the walker will provide information on the walking pattern

example: angular speed around the z axis will allows step number measurements

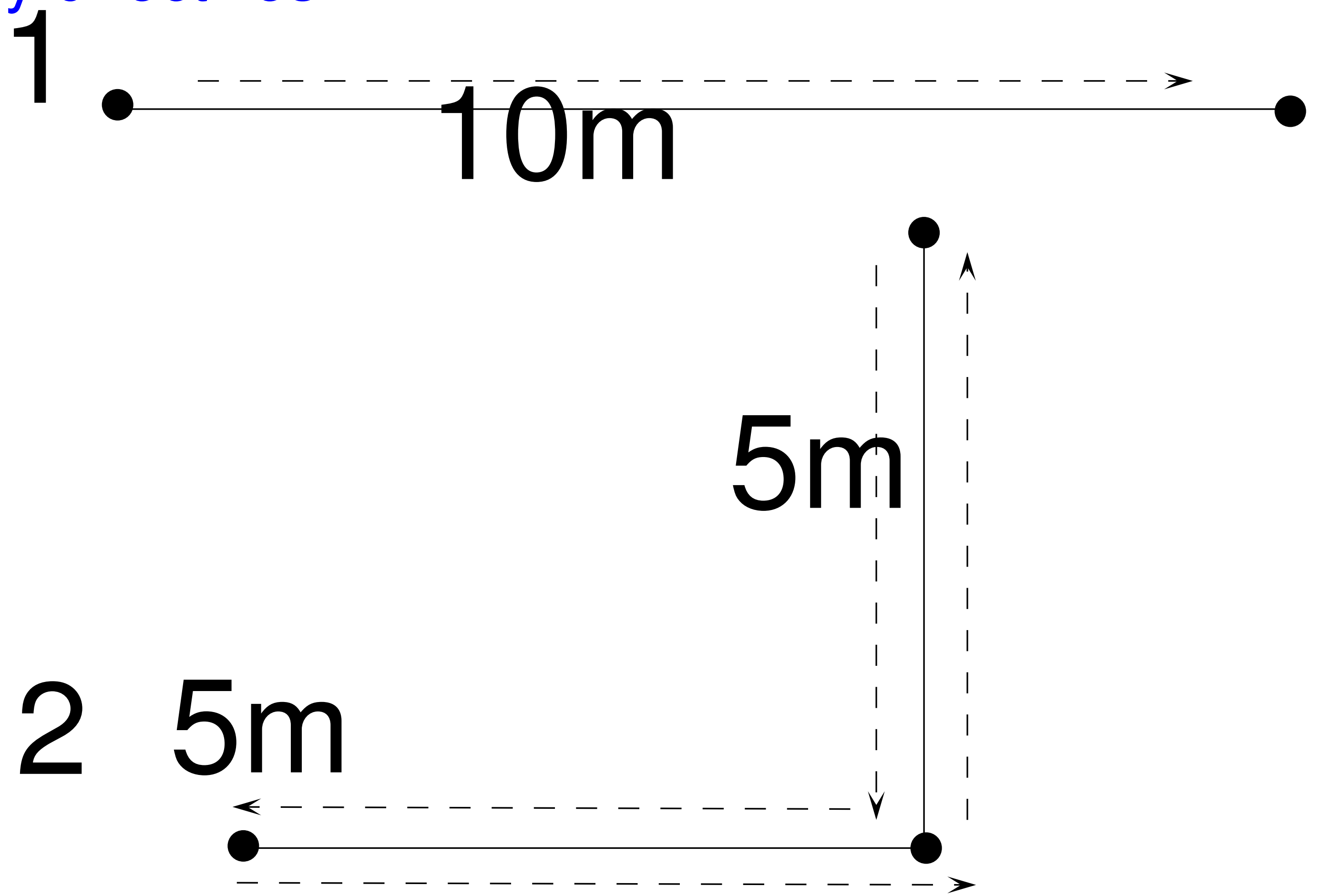


Walking monitoring: experiments

- 24 "young" subjects at INRIA
  - mean age: 32 years, min 28, max 65
- 30 elderly people at Nice hospital
  - age $\geq$ 65, no severe mobility problem

Walking monitoring: experiments

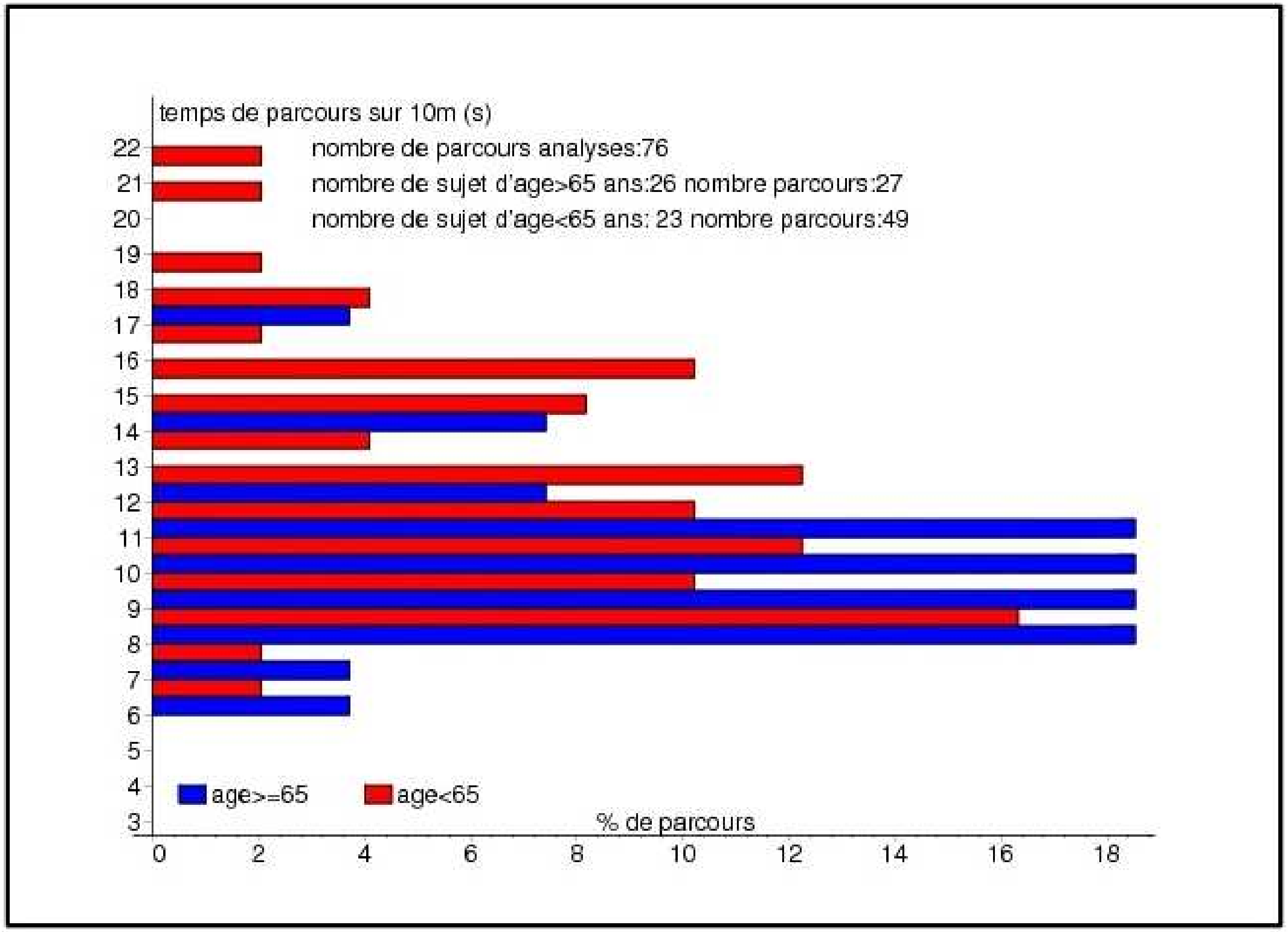
Trajectory directives



VIDEO1

Walking monitoring: experiments

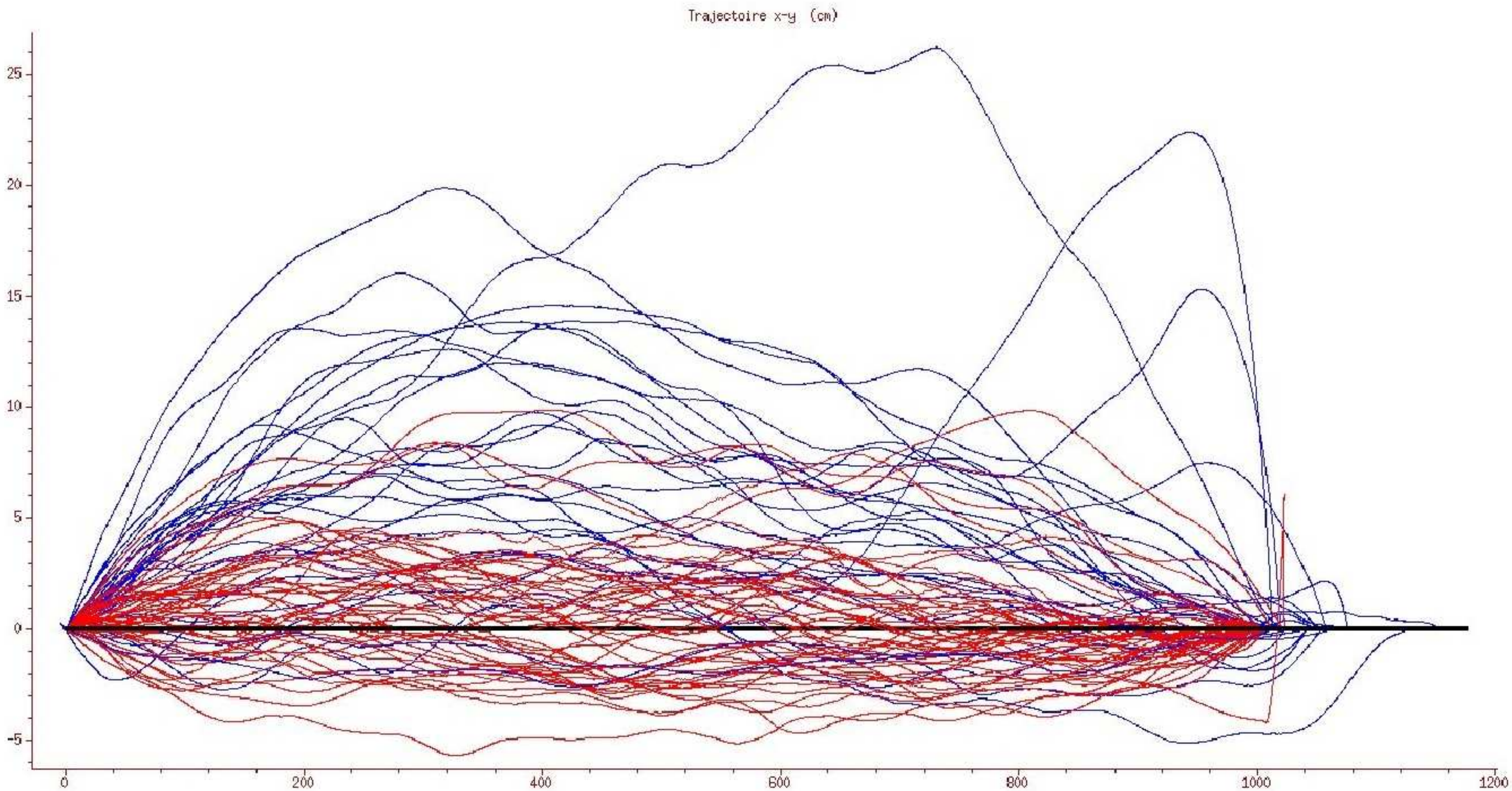
10m walking test



elderly people are faster than young people!

Walking monitoring: experiments

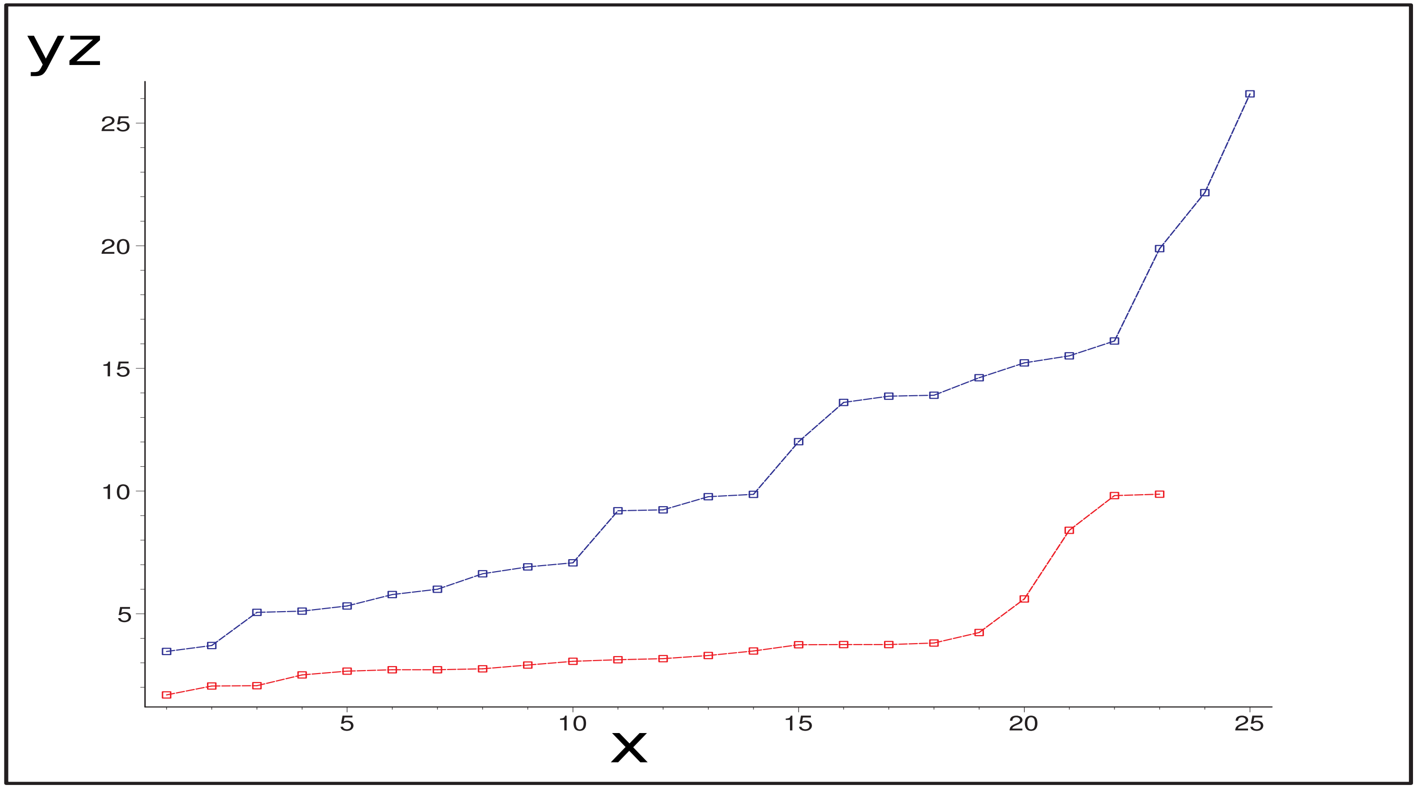
10m walking trajectory



elderly people exhibit larger trajectory deviation

Walking monitoring: experiments

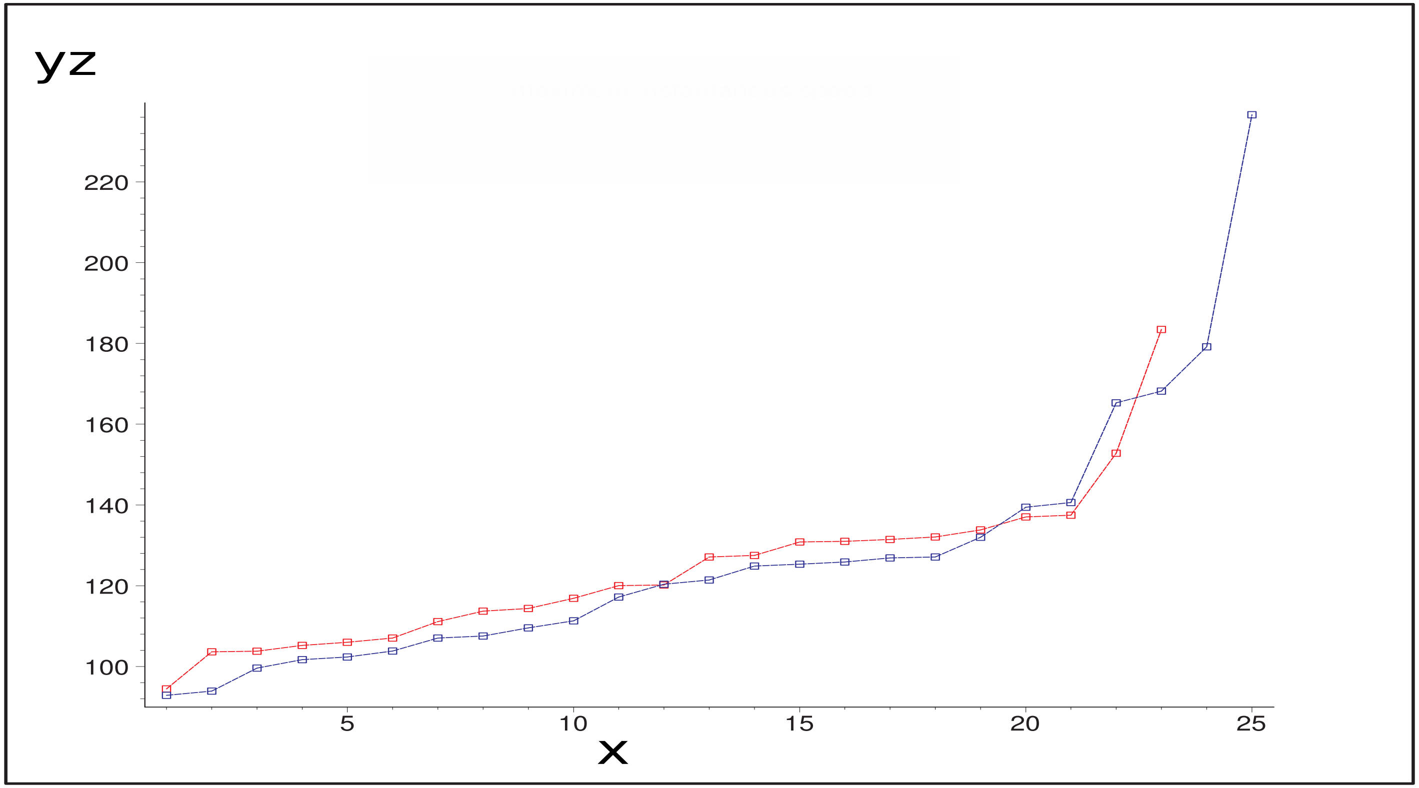
maximal lateral deviation



new walking indicator

Walking monitoring: experiments

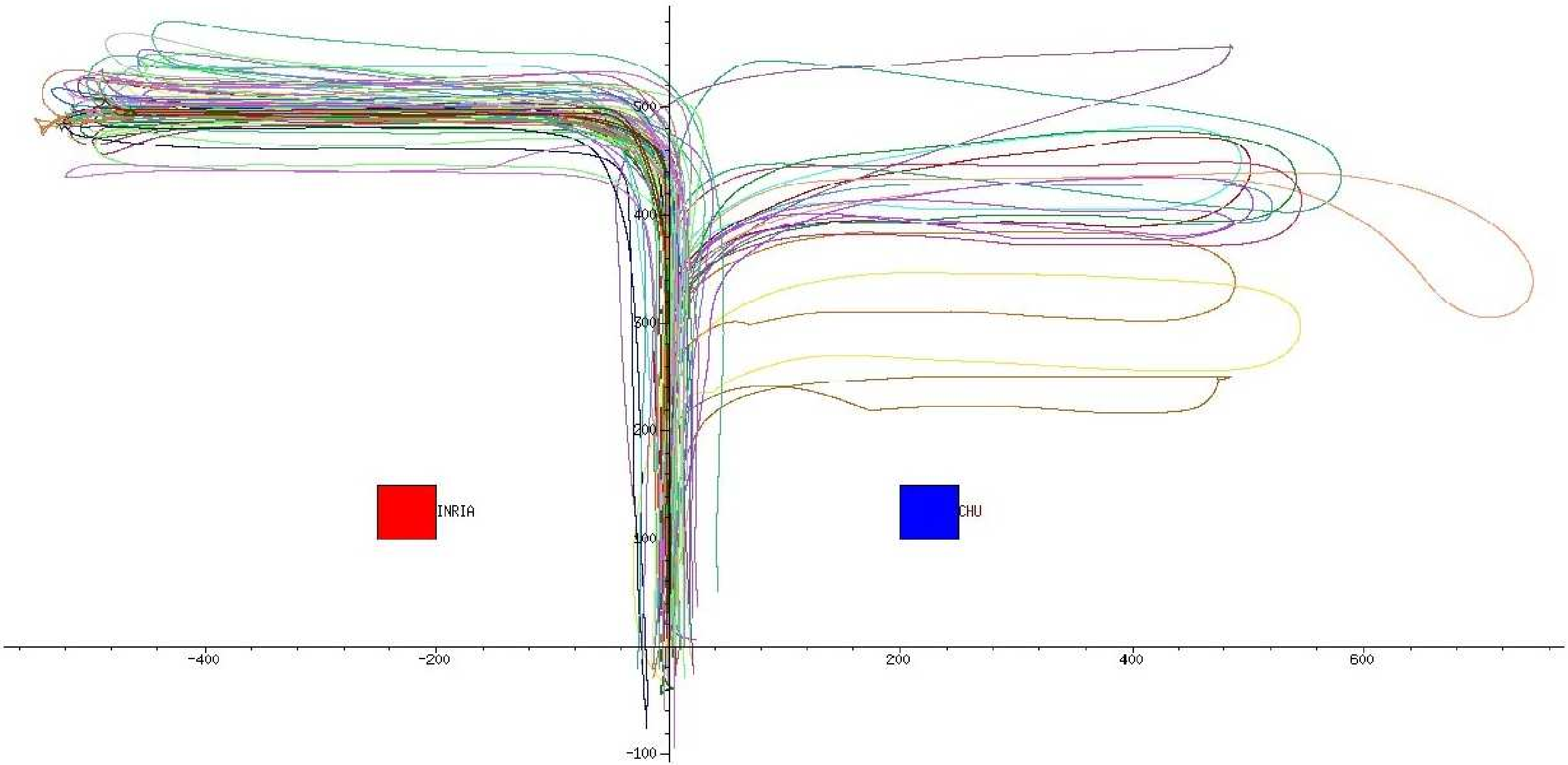
Maximal instantaneous velocity



no significant difference young/elderly

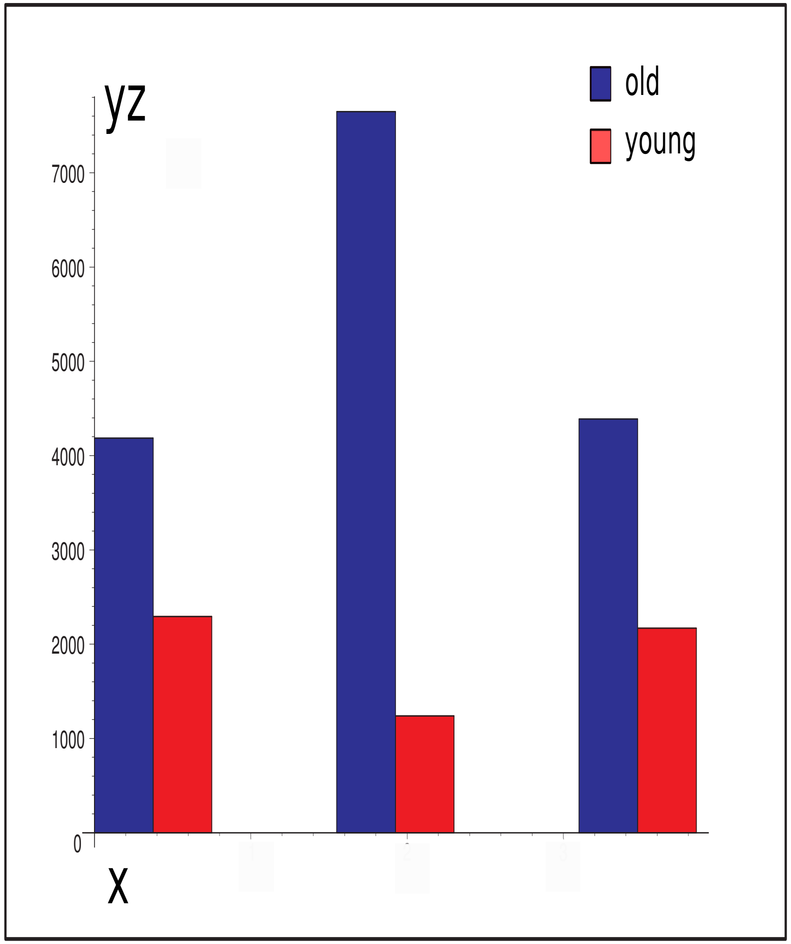
Walking monitoring: experiments

trajectory for the L-shaped directive



Walking monitoring: experiments

Area for performing the maneuvers



new walking indicator

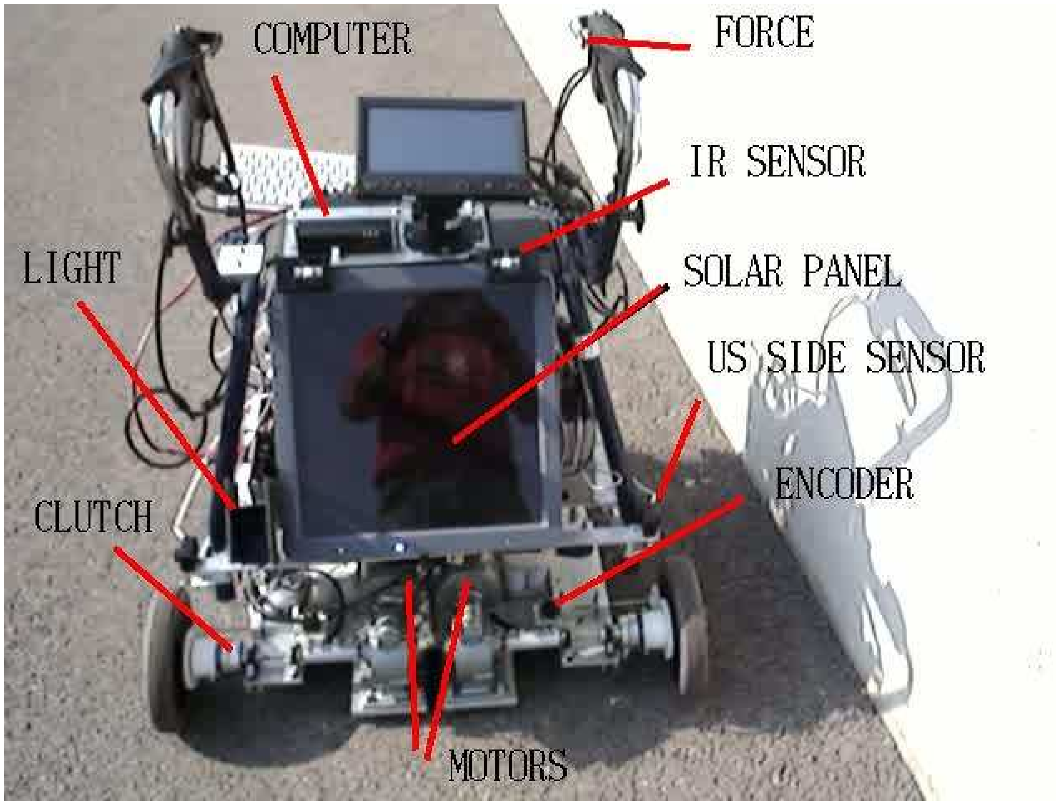
Other rollators

ANG-med

brake control

ANG-II

fully motorized



Other mobility application

Navigation in a city requires the knowledge of lowered kerbs location, sideways slope, ...

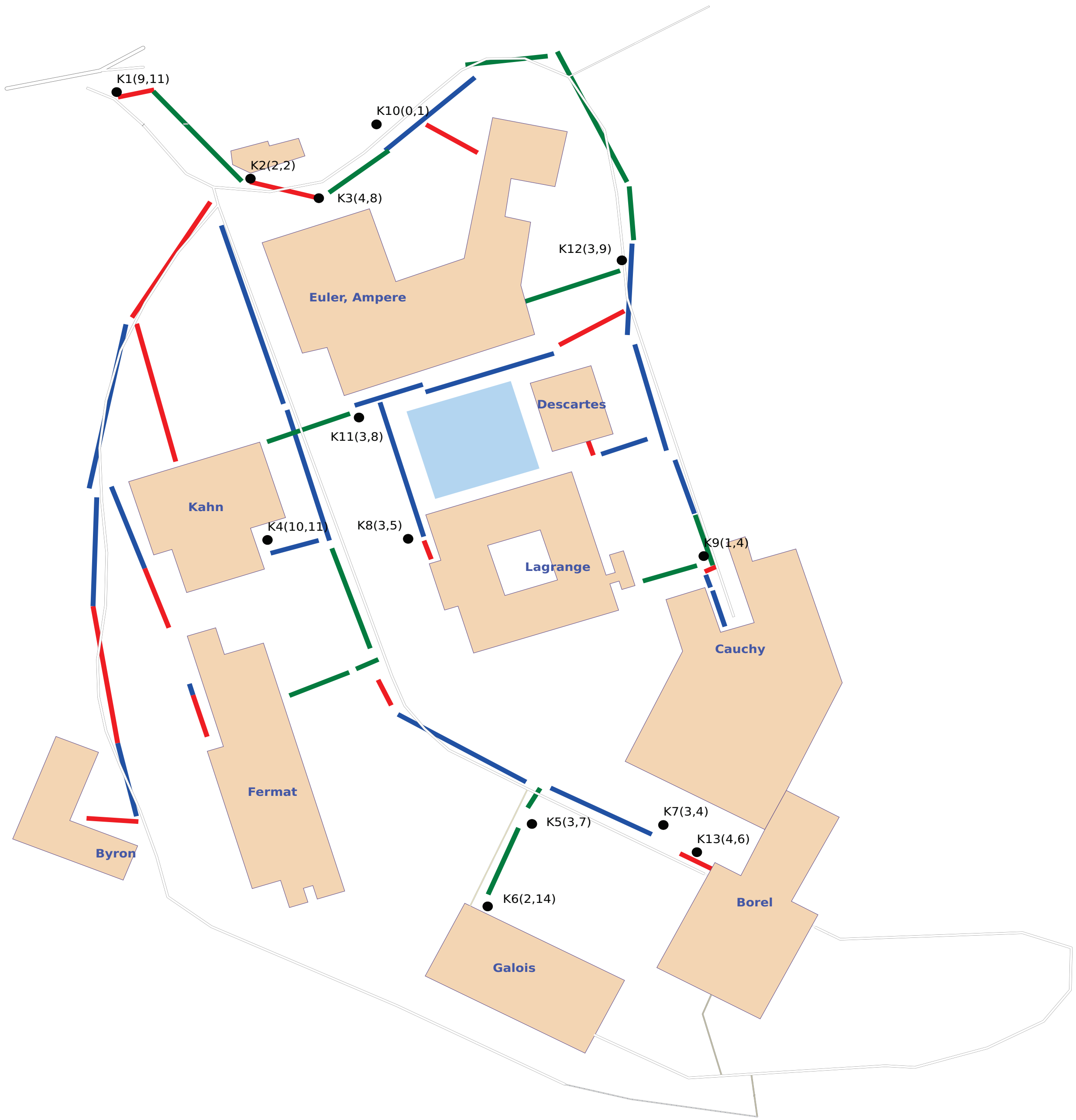
On board instrumentation of the ANG walkers allows for

- automatic detection of the location of the lowered kerbs
- sideways slope measurement

$\rightarrow$ collaborative map

- a given rollator may provide this information for a few streets
- a fleet of rollators may provide this information for a city

Other mobility application



Cane

An alternate to the walker

- monitor walking pattern
- possibly navigation help
- self-raising
- detect fall
- lightning at night
- but don't modify the look of the cane!

Conclusion

Mobility

- is a major issue for autonomy and self-esteem
- may provide functional and cognitive assessment of the subject

Mobility assistance and monitoring should respect some rules

- multi-functional and low cost
- minimal intrusivity
- collaborative and redundant

Conclusion

Issues

- our robots are **NOT** "intelligent" so that *social* robots is a dream that *may* occur when we will all be very, very old (unless a drastic change in computing technology occurs)
- ethics and privacy respect of medical monitoring
  - who should have access to the data ?
- responsibility in case of failure. . . that will definitely occur!
  - families and subject should be aware that robots will never be 100% bugproof