First workshop for young researchers on Human-friendly robotics

Assistive Robots dependability in domestic environment: the ASIBOT kitchen test bed

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RoboticsLab

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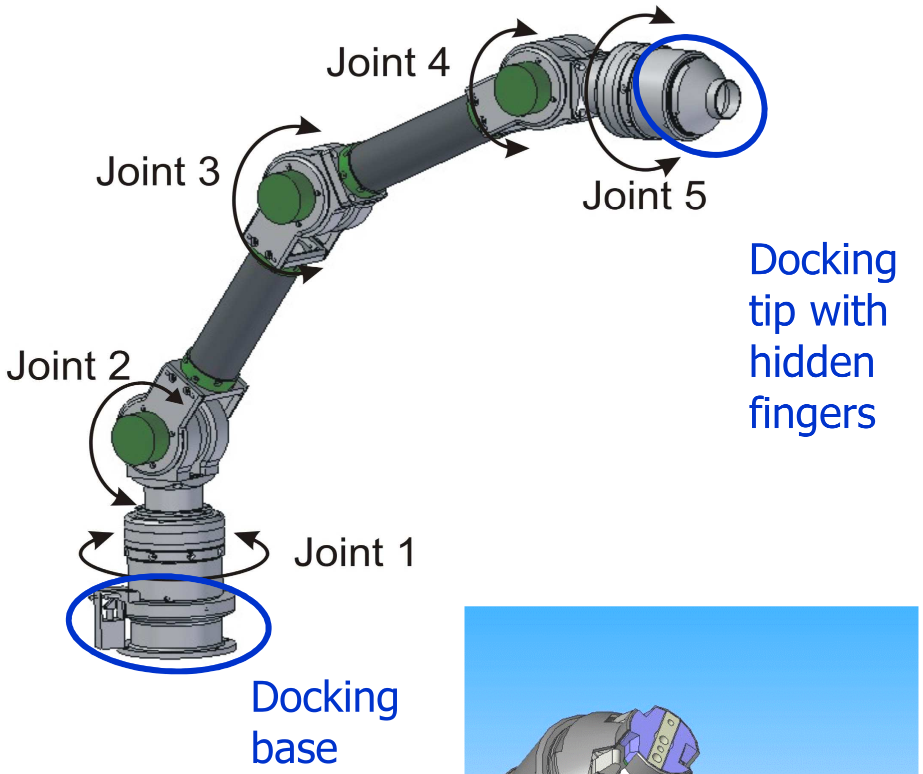
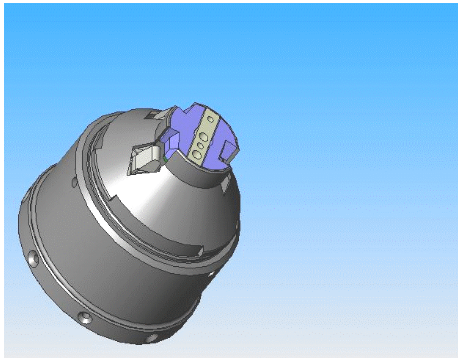
ASIBOT robot concept (I)

- Robot moving through the walls and the ceiling: **climbing robot**
- Robot wouldn’t need wall or ceiling reinforcement: **light weigh robot**
- Robot easy to transport between apartments: **portable robot**
- Robot interfacing in easy and different way with the users: **multimodal HMI**

ASIBOT features

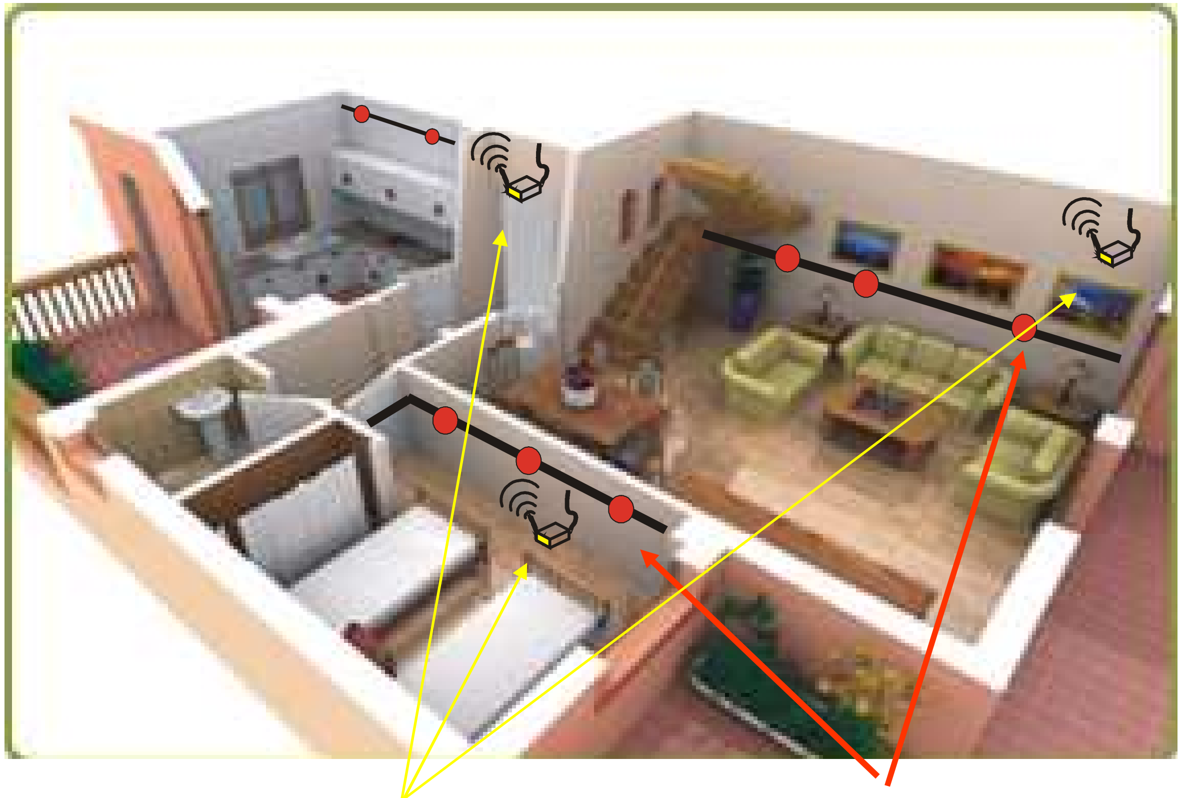
- Symmetrical robot
- Grippers in the both tips of the robot
- Docking mechanisms in the grippers to fix and get 24V power
- 5 degrees of freedom





gripper weight: 250 g.

ASIBOT robot concept (II)



WIFI Network IEEE-802.11b

DS fixed 24V 600W power bus

Minimum changes in the home environment: **docking stations (DS)**

- DS only for power supply
- DS not for communication
- Communication by Wi-fi

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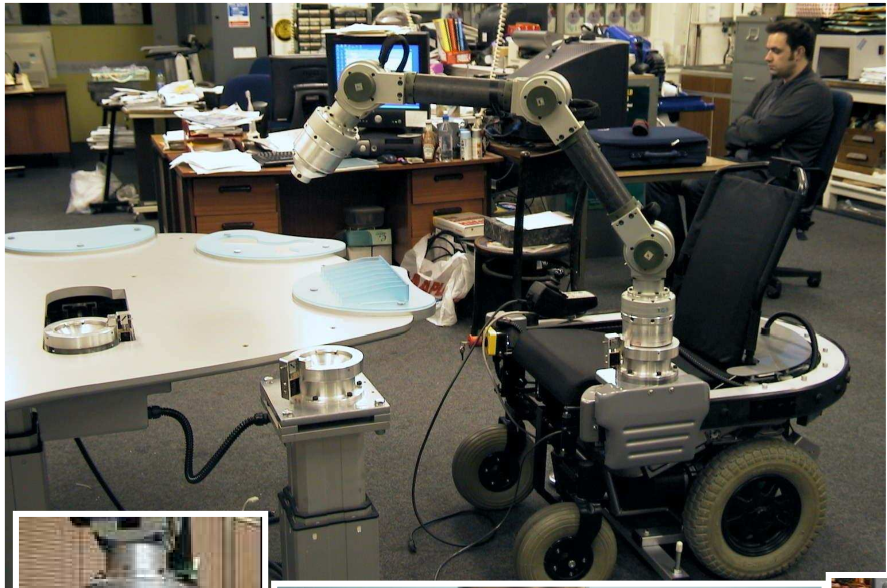
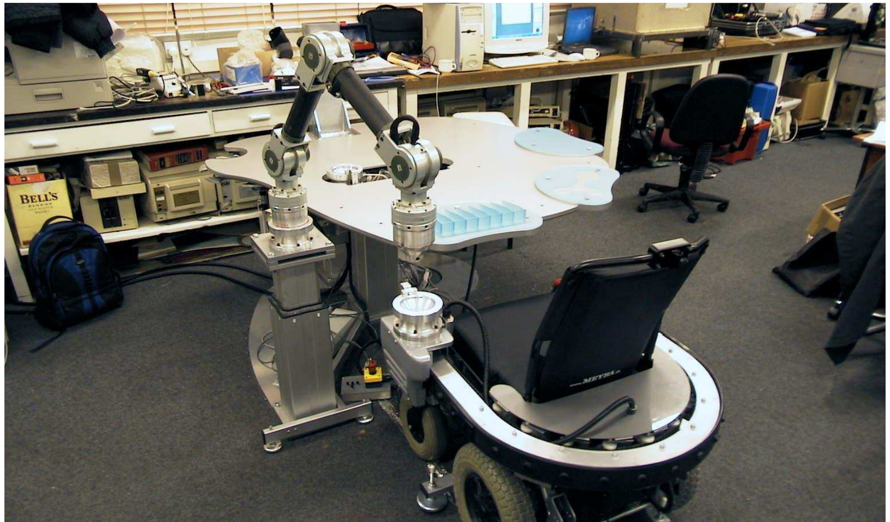
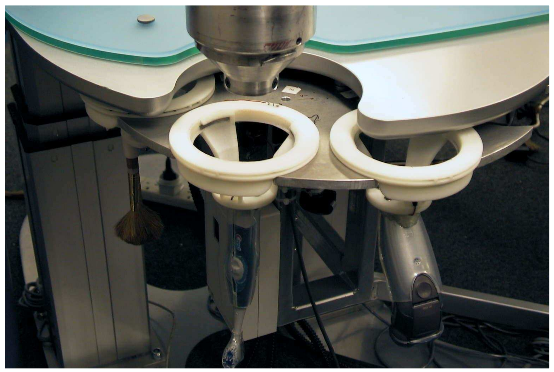
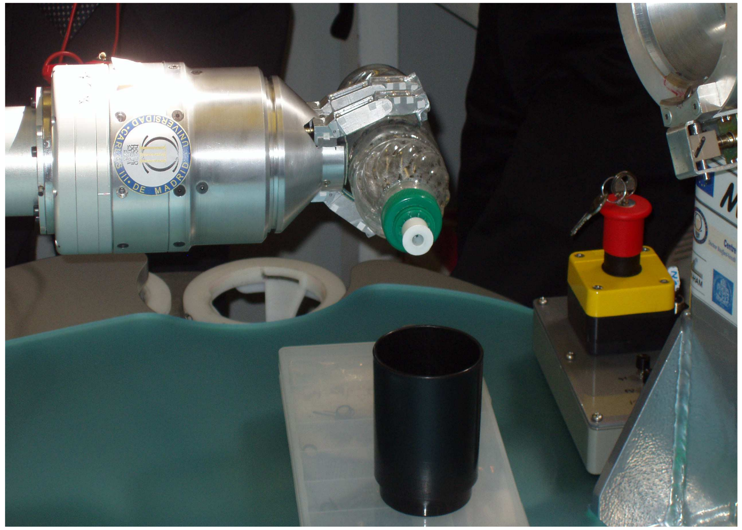
ASIBOT robot: in wheelchair









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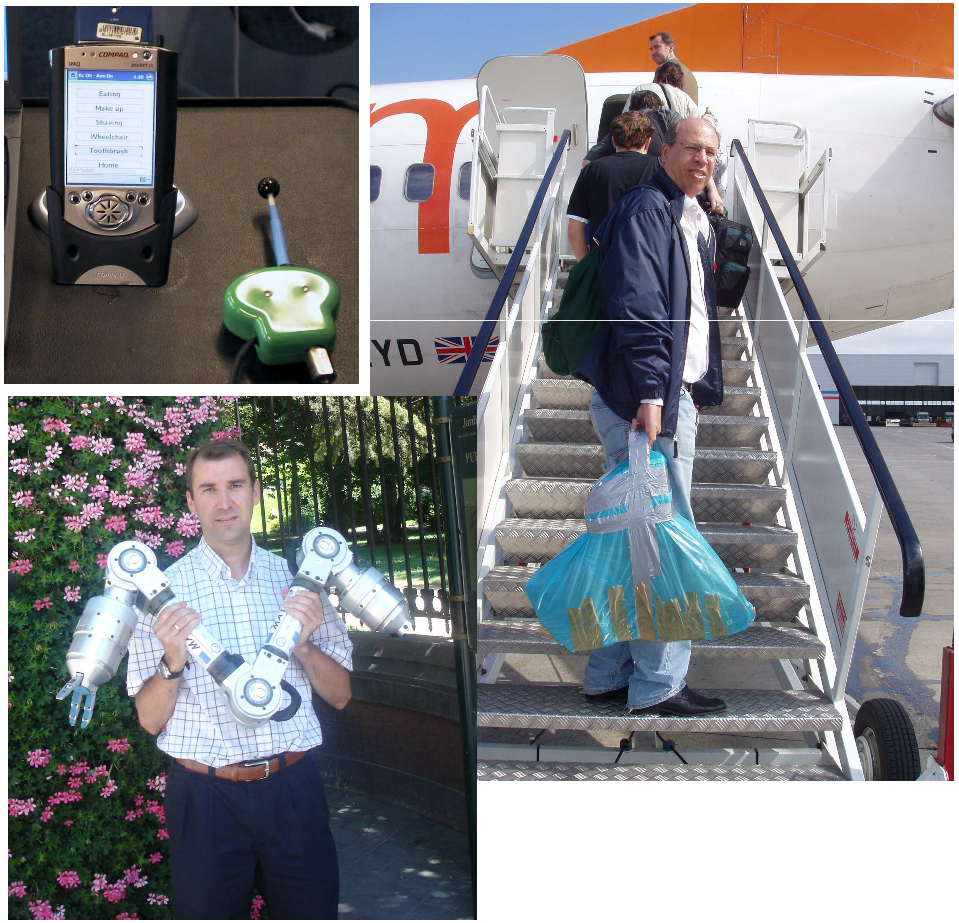
ASIBOT: robot and HMI portability



HMI’s main features:

- Runs on an PDA and send robot commands (MRL) via point-to-point WIFI link.
- Direct teleoperation
- Task learning and execution
- Mapping the environment
- Navigation between DS
- Vision sensory data (under development)
- Safety button must be push to move the robot (dead man switch)

How the users can command ASIBOT?

The PDA HMI allow several ways to control the robot:

Users/caregivers can create by they self tasks (programs) by guidance (point to point demonstration)

- attaching a joystick (for direct control)

Task divided in simple stages or motion programs that must be executed in order

- tactile screen using a pointer or a finger
- using a scanning system and a button
- a voice recognition system

} to select contextual button to launch the right motion

There is also possible to combine some of these control modes, in order to adapt the interface as much as possible to the concrete needs of every user

HMI: running pre-programming task

Tasks are divided in simple stages or motion program :

- A button launch each stage
- A Petri-net logic helps the user to launch in right order (In case of error, a screen message provides feedback)
- After task preparation, the user interaction is reduced to press the right button
- Several ways to activate buttons
  - screen+ tactile big buttons
  - Joystick + big buttons
  - Speech recognition & synthesis
  - Button scanning + switch

Special issues for disabled users

- *Users are not robotics technicians, non skilled* ➔ Need to be provided with easy tools for performing and/or programming tasks
- *User must decide how to use the robot aid* ➔ The key part in the control architecture of any assistive robot is the usability of the HMI
- *Many users profiles* (also in the same group: upper limb impaired like spinal cord injuries from C4 to C8 neurological levels) ➔ a flexible solution is needed
- Users are also very limited in the ways in which they can interact with the device
- Lack of standard criteria to evaluate users acceptance
- The **usability** of the aid is the most critical factor
  - If too complex ➔ hard to use ➔ useless
  - If too simple ➔ low functionality ➔ low usefulness

ASIBOT usability assessment

- Real experimentation in the HNPT (National Hospital of Paraplegic of Toledo)

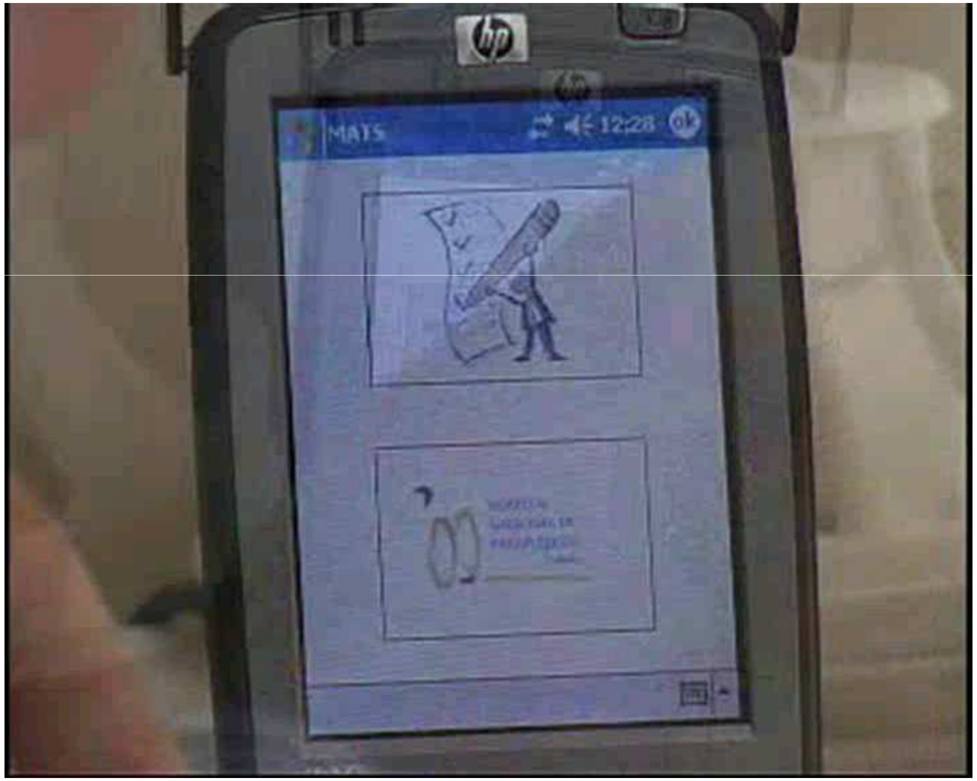
Adapted hospital bathroom provided with: DSs, automatic soap dispenser and water faucet, height adjustable sink,…
and a set of adapted tools (sponge, toohbrush, cup, make up brush and electrical shave machine)

Robot & Interface evaluation at HNPT

Subjects were asked about commanding the robot by each of the interfaces:

- their ease of use
- practicality
- how appropriate was, given their capacities
- the ability to handle them without any help

An also user command the robot to lauch bath DLAs



Goal: study the system performance in DLAs (video 1.04 min)

Robot User's Acceptance Results (I)

- the use of a joystick / chin controlled and the voice recognition system were the most popular
- The most of the user wants to keep the control of the robot movements also when is performing prerecorded task → semi-autonomous
- They felt that the robot could make a welcome difference to their lives (extrapolating from the bath to other home scenarios)
- The most accepted tasks
  - wheelchair transfer ≈ over 75%
  - gripping and releasing objects ≈ over 75%
  - drinking ≈ 65%
- Of the additional comments received 89% were positive

Robot User's Acceptance Results (II)

- Main reasons for a low acceptability: too large, lack of doing things, risk of isolation, reduction of communication, bad appearance, frightening, too slow, too remote from my life
- The physical size and low speed of movement of the robot had an effect on this results
- Sometimes contradictory proposals: reduce the size and at the same time increase the distance between docking stations
- This illustrates the complex nature of evaluating this type of equipment
- Further work is needed to understand exactly how changes to physical size would influence this

Safety review

Low weight arm & moderate speed: low risk of injury in case of collision

Some safety issues:

- dead man push button (optional)
- wathdog for conecction to the PDA
- emergency power-off button at wheelchair (dedicated radio link)

The system is sensitive to malintention, but must be FAIL-SAFE

We delegate to the caregiver/user a supervisor role.

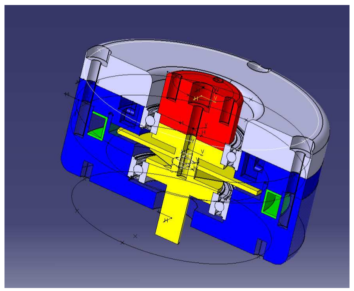
Asibot must use ubiquitous environment sensing and user reasoning.

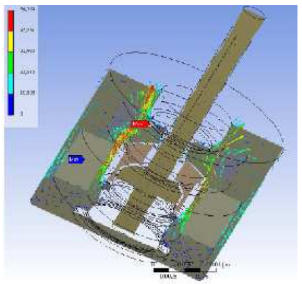
Mechanical safety oriented review

The main goal for ASIBOT2 *intrinsically safe robot*: due its light weight is possible to increase performance without decrease safety → HIC estimation need to adjust max speed

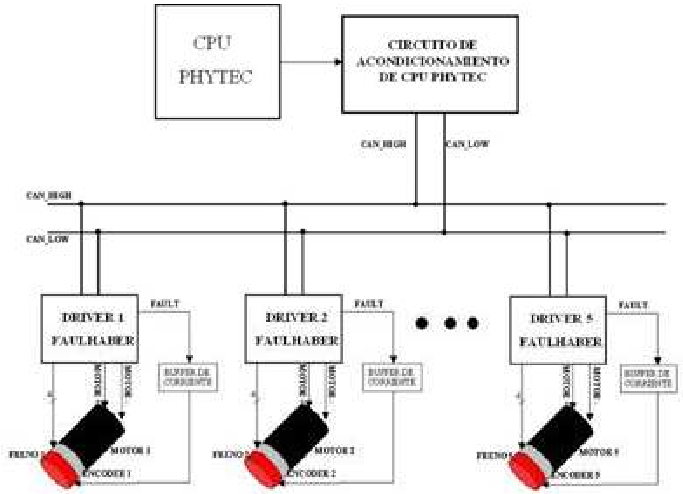
- Human arm capabilities: similar weight/load and reach and similar dexterity: 6 or 7 DOF

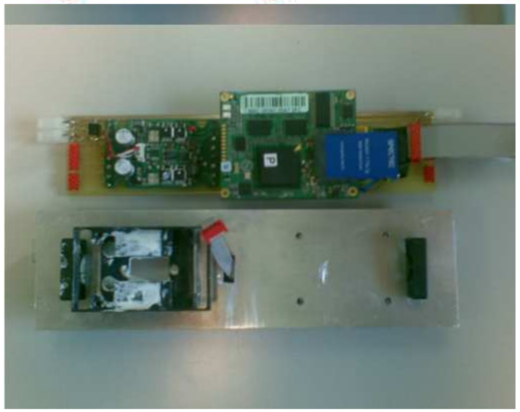
- Actuators design review: increasing speed but decoupling motor inertia: controlled compliance strategies due MRJ magnetorheological variable stiffness (joint under development…)





Mechanical On board HW review





Asibot2 HW added to the old ASIBOT mechanical structure to test new features:

On board processing capabilities limited by the CPU **Intel® PXA270 Processor 32-bit RISC Microcontroller at 520 MHz, running RT OS.**

Internal CAN-BUS and new axis controllers

Absolute encoders connected to CAN –Bus allow to skip initialization sequence

New control schemas under development

New On board HW an fusion sensory data must allow future advanced "user on the loop" control schemas

Arm & ambient sensors selection

- Sensorized environment:
  - Vision: tracking, collision avoidance, target recognition
- On board sensors:
  - Force/torque at the tips
  - Torque measurements in each joint

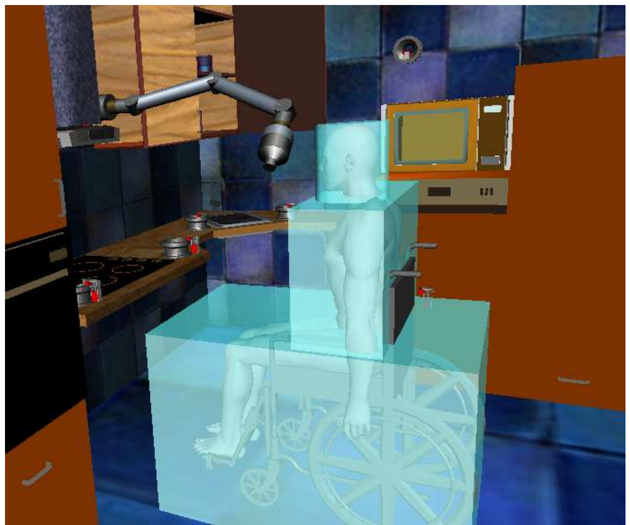
  } *CAN LINKED!!*
  - Wifi IP miniature cameras in each tip: vision data raw to PDA/AMI controller: off-board vision computing
- Reliable RT communications between AMI and PDA (or robot directly)
  - allows increase manipulation features: force & visual control schemas
  - Previously recorded set of daily present objects models database
  - Path planning & collision avoidance, programming by demonstration

A real framework: kitchen & bathroom scenarios

- Mid term objective: develop a real home scenario to perform test and validate/refuse new ASIBOT features

Simulations for ASIBOT2 development

Arm transfer from wheelchair to kitchen (video 1.21 min)



Conclusions

- Introduced the concept of dynamic elements -robots- collaborating with the environment and the user to create an intelligent ambient.
- Depending on the level of disability of the user several types of HMI has been presented. A personalization of control modes is necessary: a set of aid tools to perform each task is under develop
- Human factors are important for the commanding and for security issues.
- The actual tests have demonstrated the feasibility of the system. Good acceptance of the end-users if the cost keep low.
- The adaptation of the environment to let the system works is simple. Just install the connectors (DS) in the right place
- Robust and simple operation: sensorized arm increase functionalities.