

iCub interacting with humans: software tools and best practices



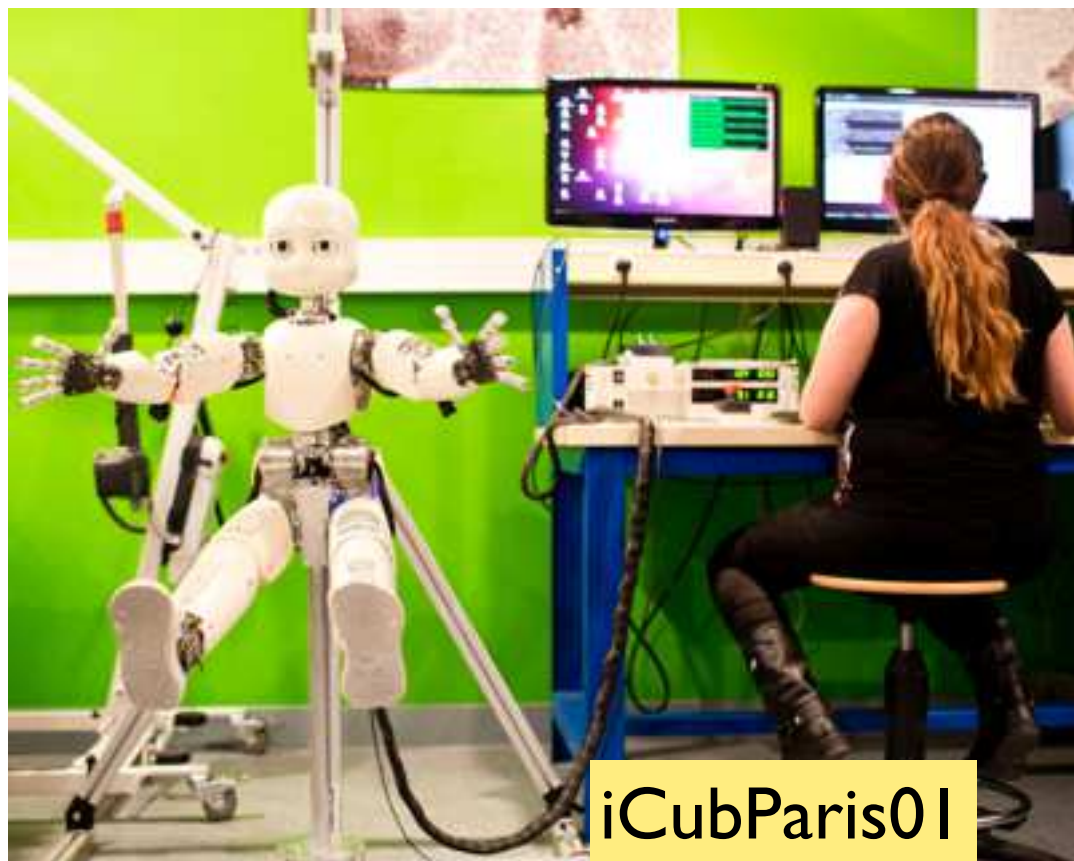
Serena Ivaldi

INRIA Nancy Grand-Est
&
IAS, TU Darmstadt

serena.ivaldi@inria.fr

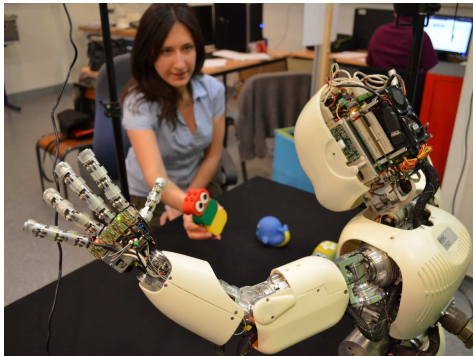
inria

“My” iCub collection



iCub interacting with humans

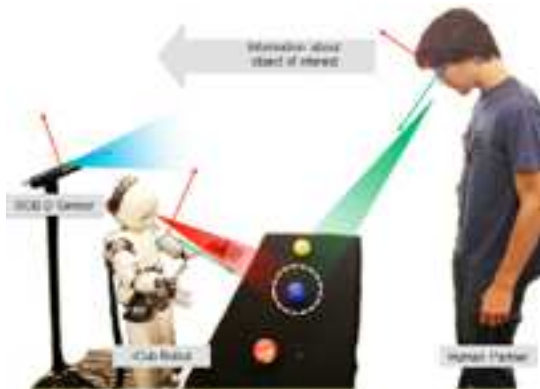
learn new objects



acquire skills



stimulus for HRI

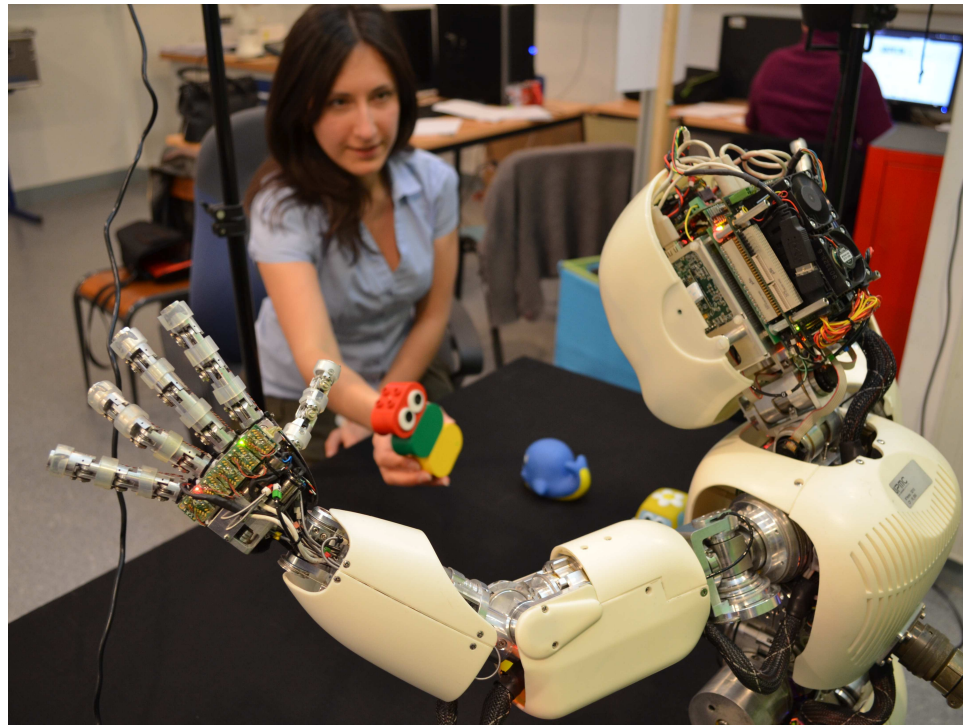


Outline

1. recognising human body during interaction
2. tracking the active human partner
3. tracking the human's gaze
4. teaching by demonstration & physical interaction
5. "variability" of naive subjects
6. operator GUI for HRI experiments

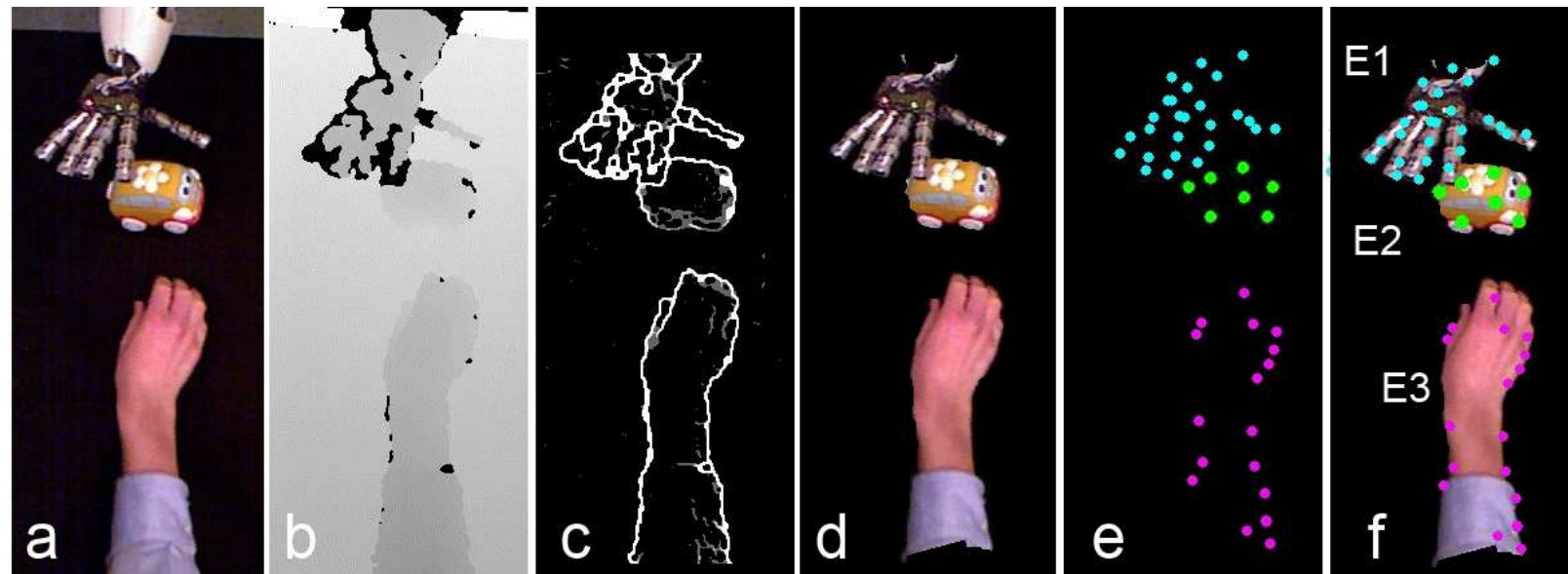
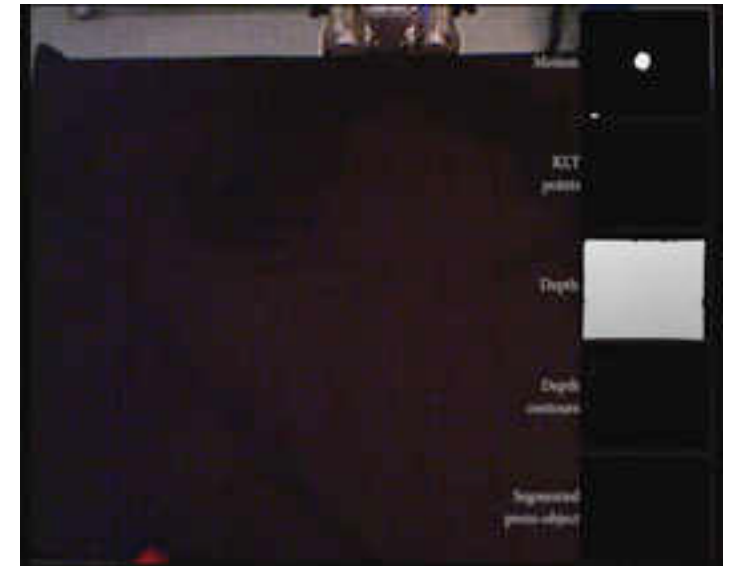
All the code for replicating the experiments is available at : macsi.isir.upmc.fr

I) Recognising humans is important!



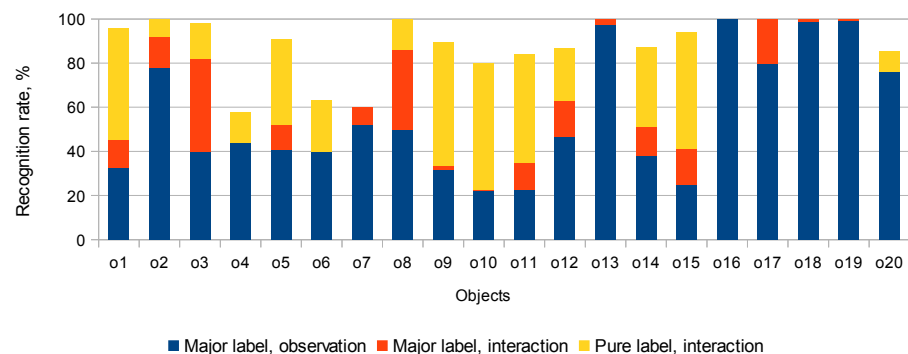
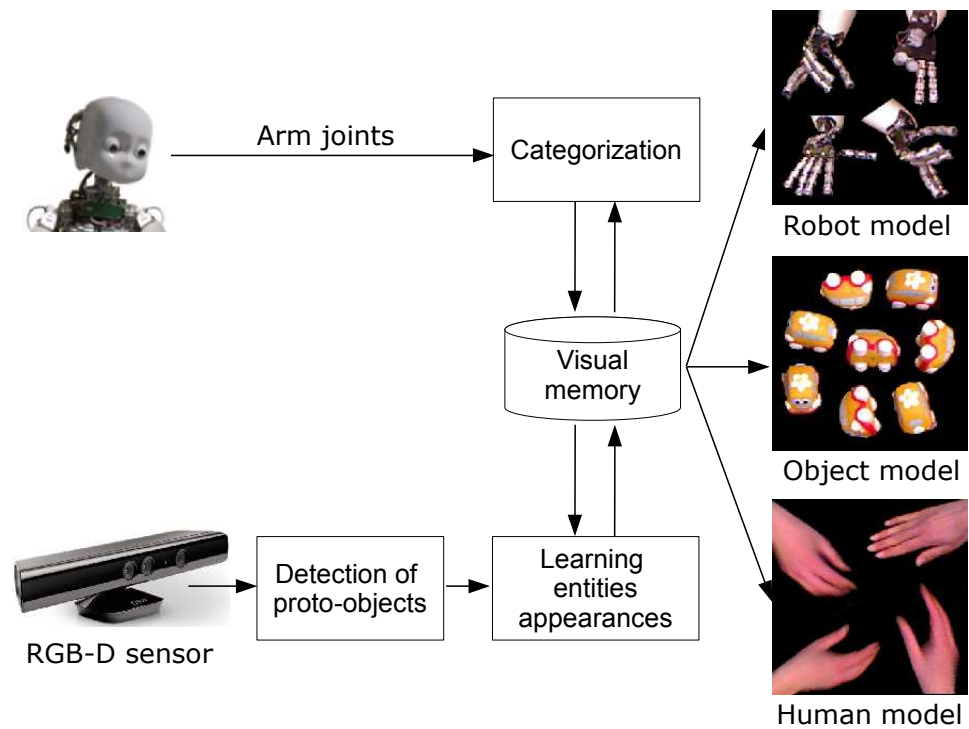
Entities:

- objects
- human arm/hand
- robot arm/hand



Ivaldi, S.; Nguyen, S.M.; Lyubova, N.; Droniou, A.; Padois, V.; Filliat, D.; Oudeyer, P.-Y.; Sigaud, O. (2014) *Object learning through active exploration*. IEEE Trans. on Autonomous Mental Development.

I) Recognising humans is important!

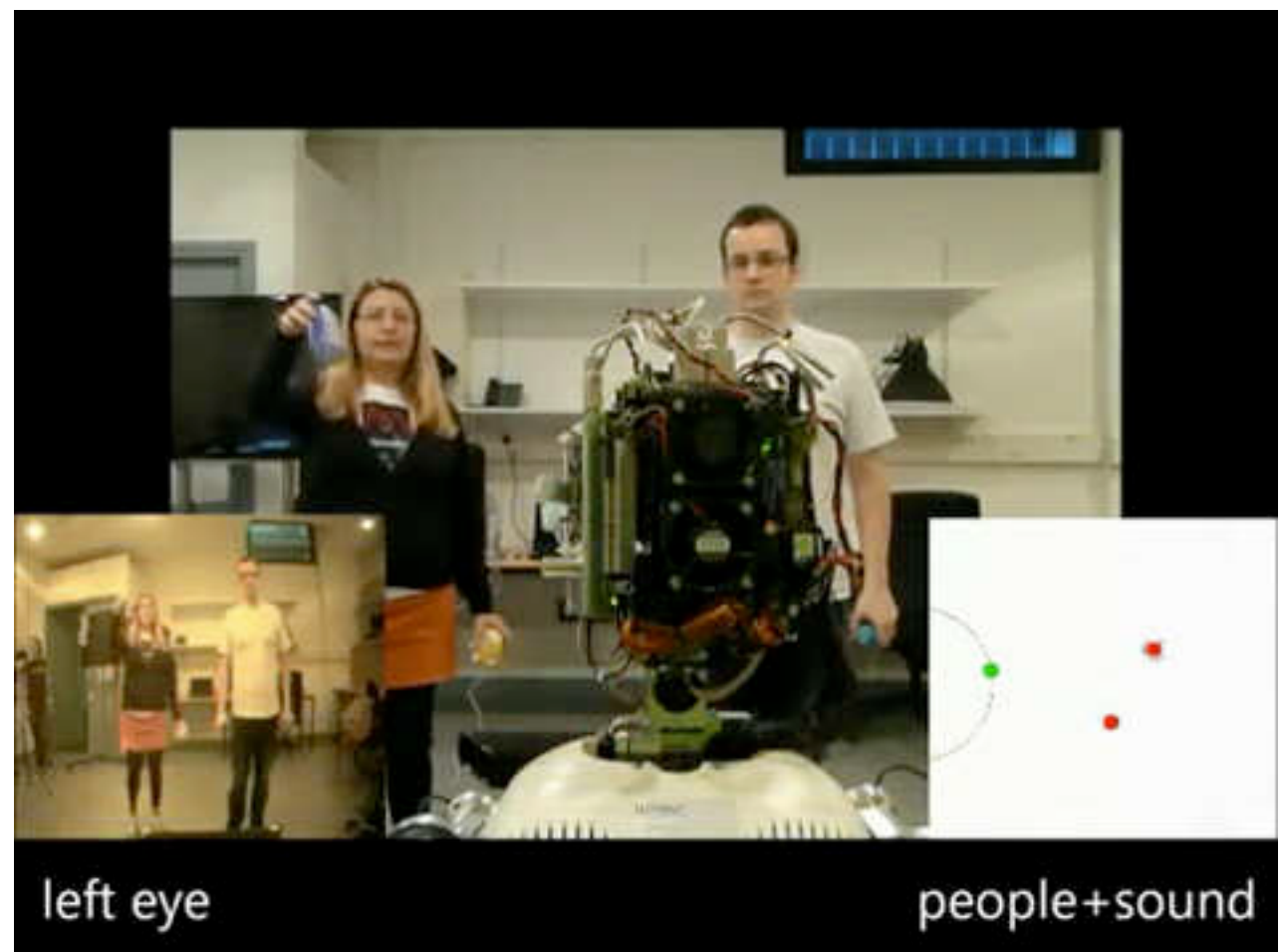
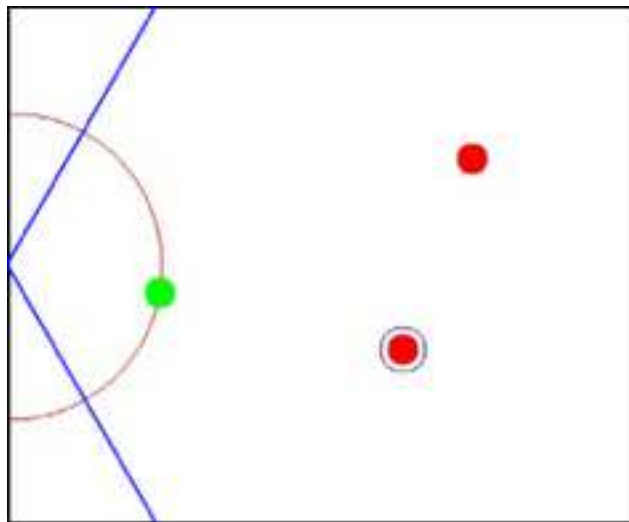
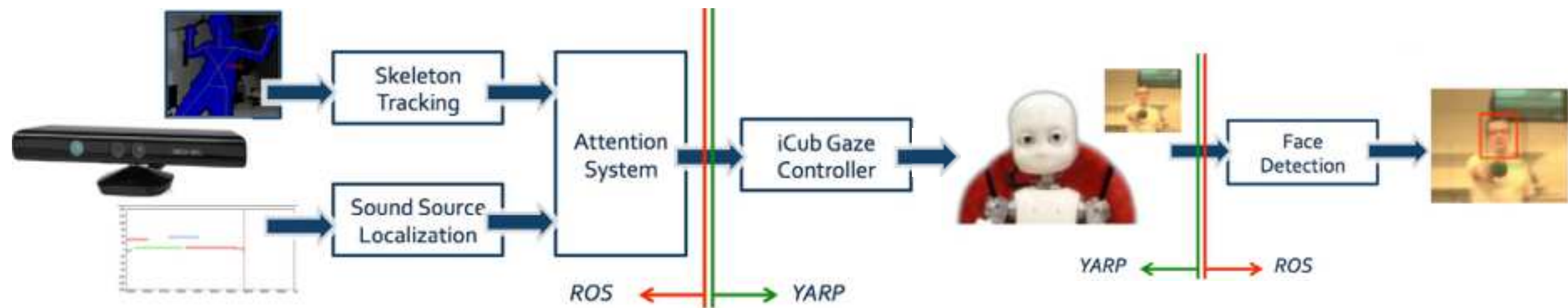


The robot learns the objects through manipulation.

The robot learns to identify its body, hence entities can be categorized as "robot hand", "human hand" and "object".

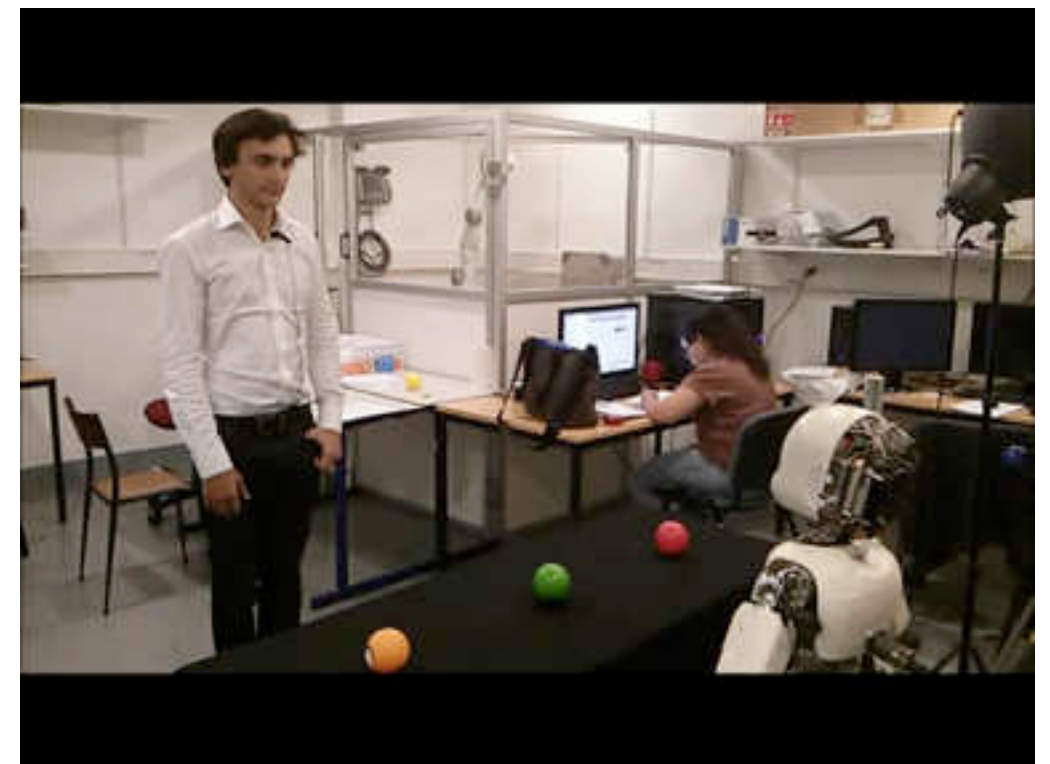
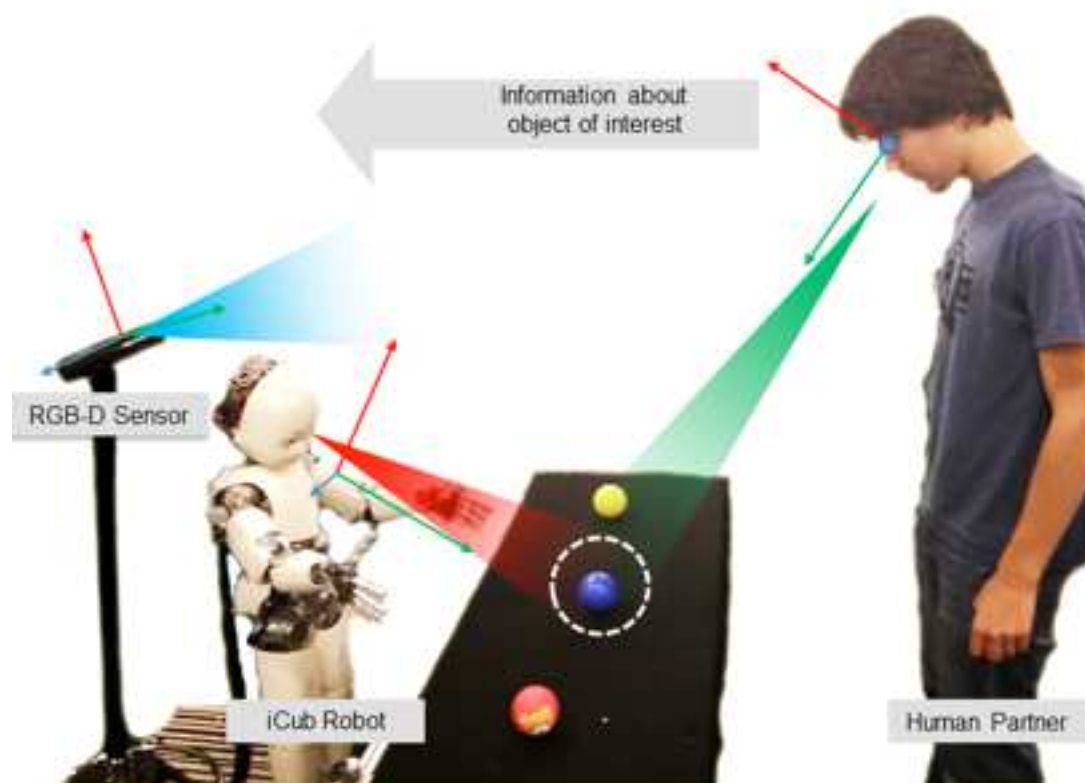
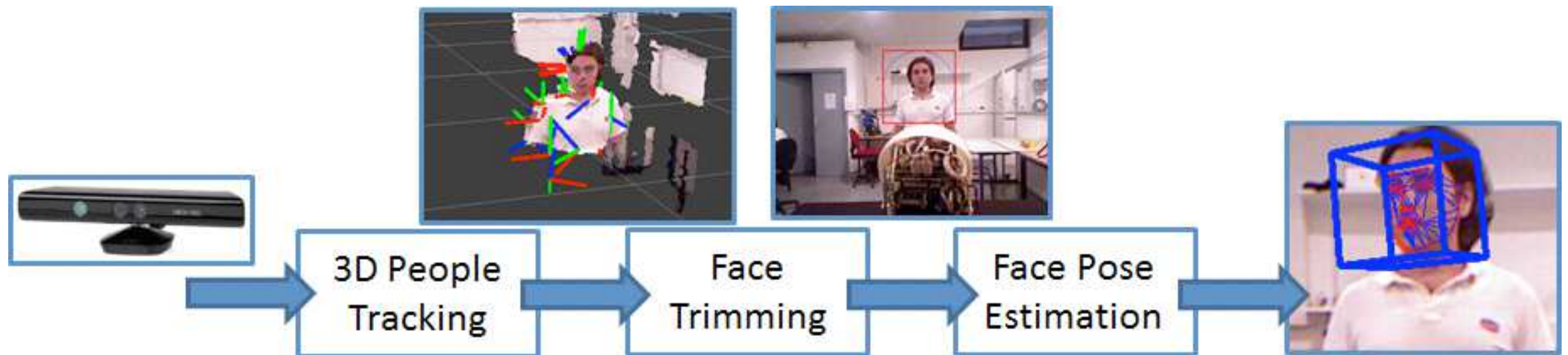
Human and robot identification improve object recognition

2) Tracking the active partner



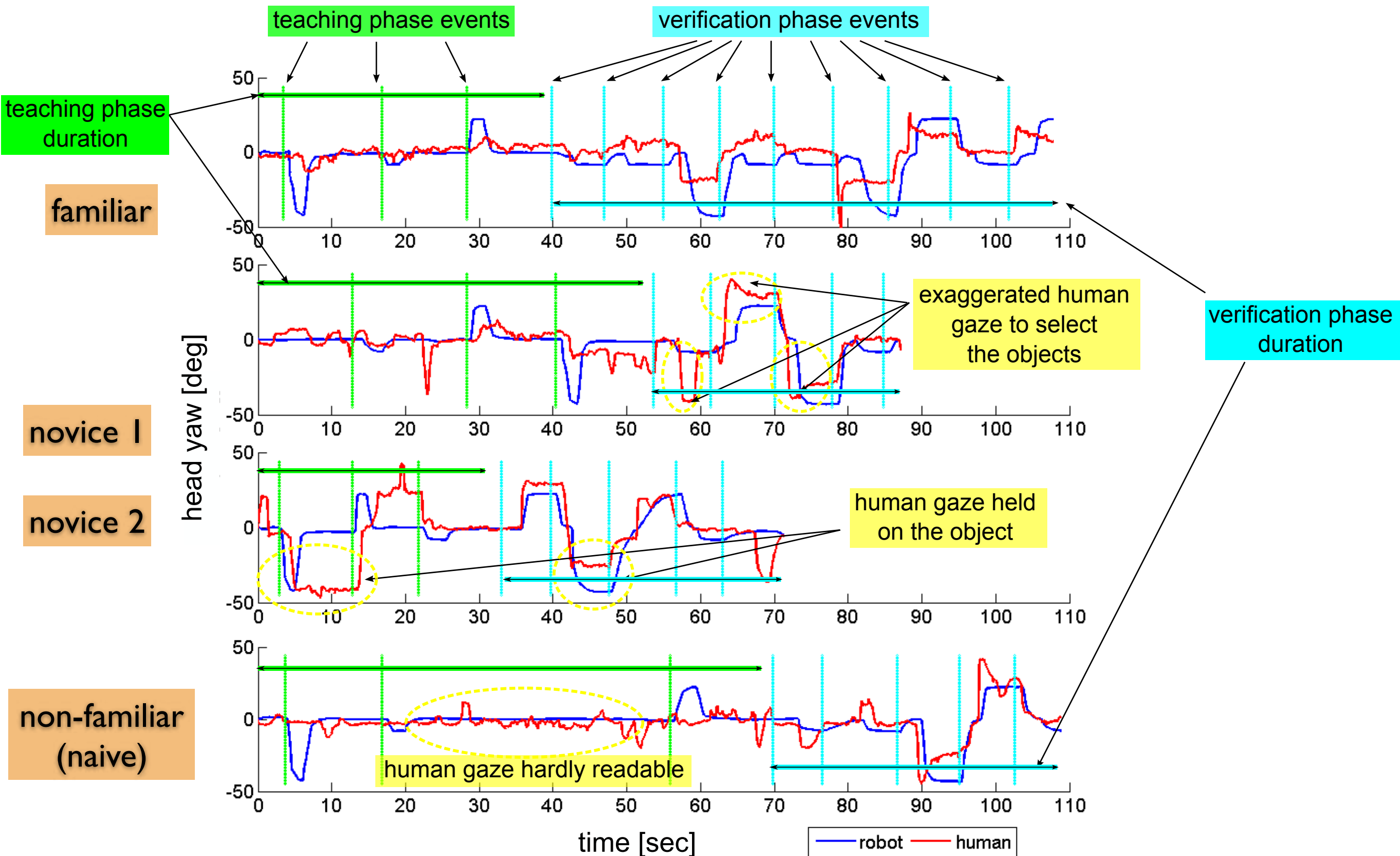
Anzalone, S. M. ; Ivaldi, S.; Sigaud, O.; Chetouani, M. (2012). *Multimodal people engagement with iCub*. Int. Conf. on Biologically Inspired Cognitive Architectures. Palermo, Italy.

3) Gaze tracking (simplified)



Ivaldi et al, *Robot initiative in a team learning tasks increases the rhythm of interaction but not the perceived engagement*, Frontiers in Neurorobotics, 2014

3) Gaze tracking (simplified)



4) Teaching by Demonstration

Physical interaction thanks to whole-body dynamics, compliance and torque control

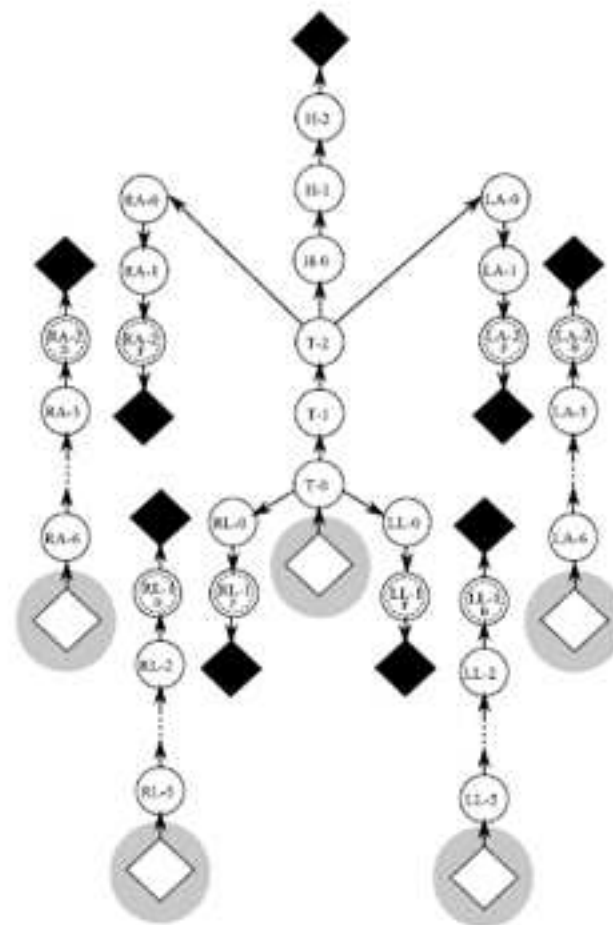
Inertial sensor



F/T sensor



contacts
by skin



Ivaldi, Fumagalli, Randazzo, Nori, Metta, Sandini. Computing robot internal/external wrenches by inertial, tactile and FT sensors: theory and implementation on the iCub.
HUMANOIDS 2011 & Autonomous Robots 2012

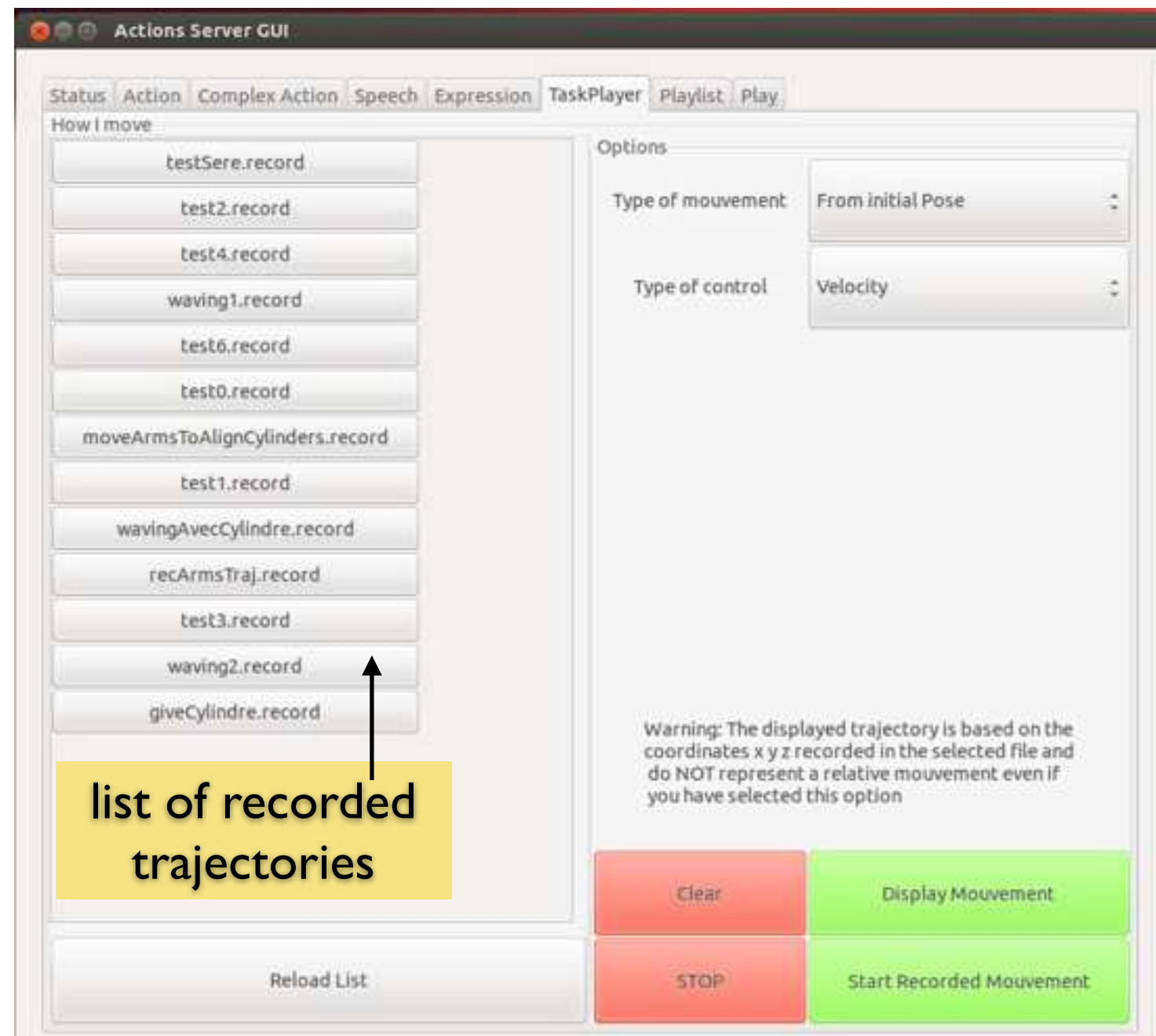
4) TbD + demoForceControl

demoForceControl

left arm	right arm	left leg	right leg	torso (EXPERIMENTA
<input checked="" type="radio"/> position <input type="radio"/> zero torque <input type="radio"/> soft spring <input type="radio"/> medium spring <input type="radio"/> hard spring	<input checked="" type="radio"/> position <input type="radio"/> zero torque <input type="radio"/> soft spring <input type="radio"/> medium spring <input type="radio"/> hard spring	<input checked="" type="radio"/> position <input type="radio"/> zero torque <input type="radio"/> soft spring <input type="radio"/> medium spring <input type="radio"/> hard spring	<input checked="" type="radio"/> position <input type="radio"/> zero torque <input type="radio"/> soft spring <input type="radio"/> medium spring <input type="radio"/> hard spring	<input checked="" type="radio"/> position <input type="radio"/> zero torque <input type="radio"/> soft spring <input type="radio"/> medium spring <input type="radio"/> hard spring
J0: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J0: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J0: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J0: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J0: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)
J1: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J1: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J1: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J1: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J1: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)
J2: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J2: stiff: 0.000 Nm/deg damp: 0.200 Nm/(deg/s)	J2: stiff: 0.000 Nm/deg damp: 0.200 Nm/(deg/s)	J2: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J2: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)
J3: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J3: stiff: 0.200 Nm/deg damp: 0.000 Nm/(deg/s)	J3: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J3: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	
J4: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J4: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J4: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J4: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	
		J5: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	J5: stiff: 0.000 Nm/deg damp: 0.000 Nm/(deg/s)	

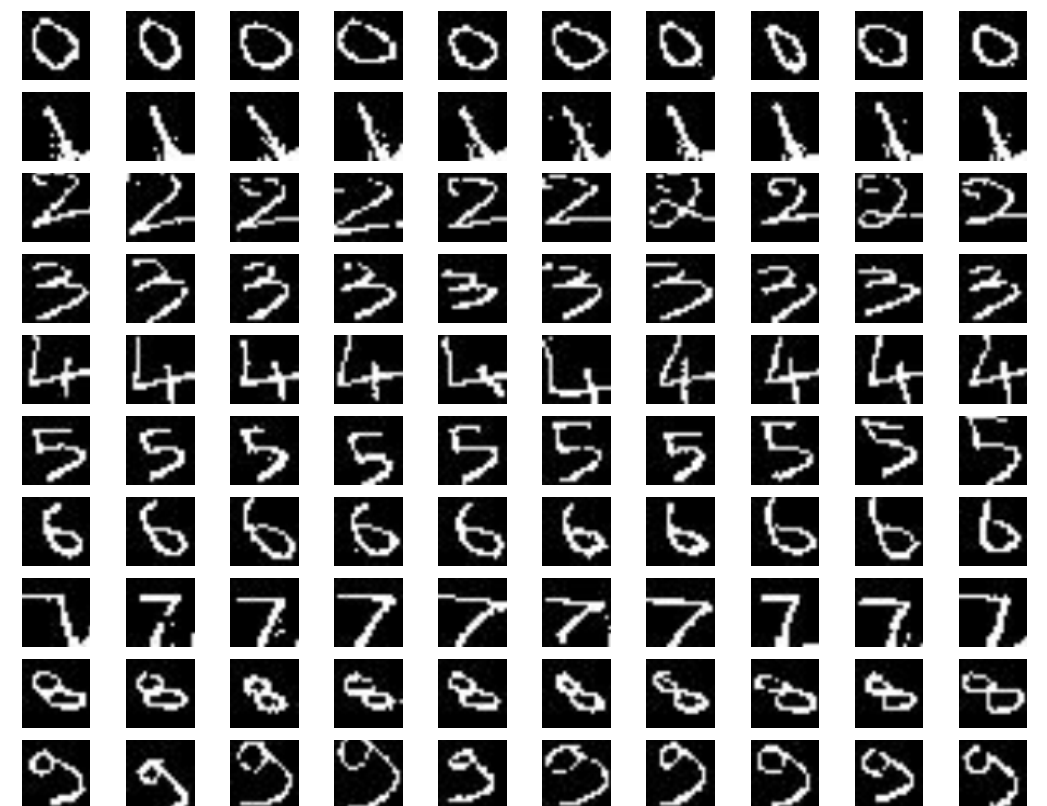
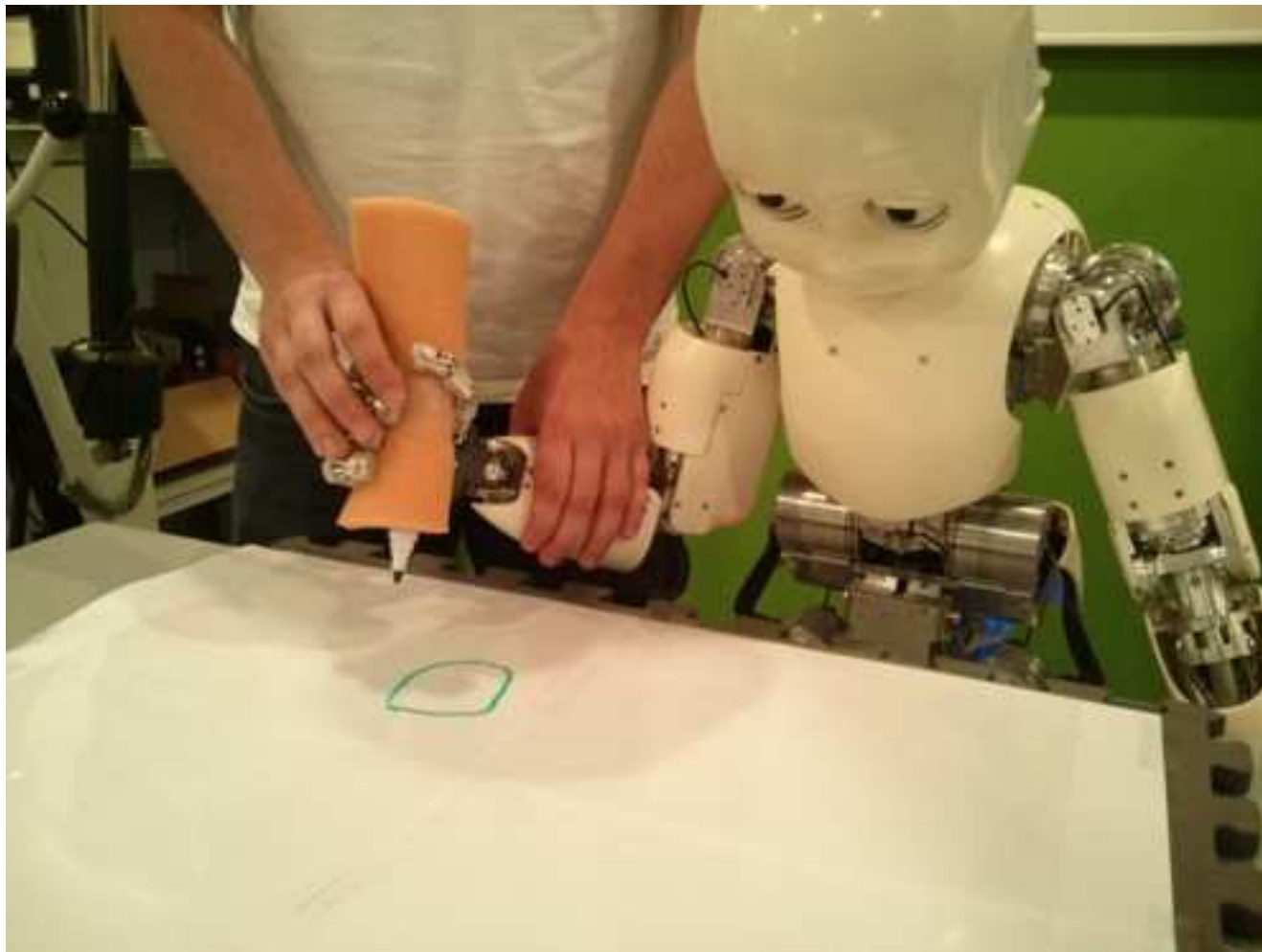
+ wholeBodyDynamics with iDyn or iDynTree

4) TbD + demoForceControl



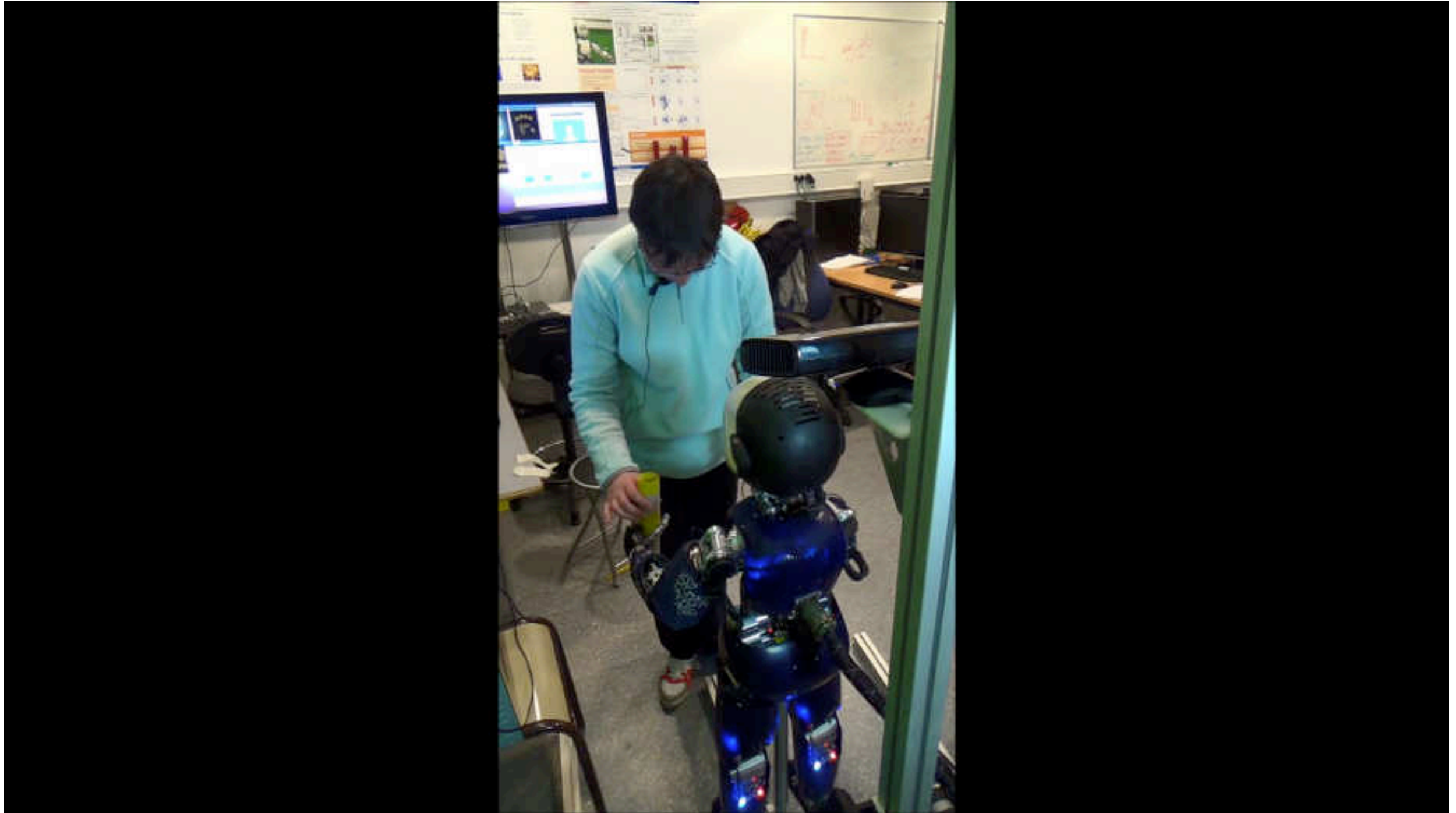
Stulp, F.; Raiola, G.; Hoarau, A.; Ivaldi, S.; Sigaud, O. (2013). *Learning Compact Parameterized Skills with a Single Regression*. HUMANOIDS.

4) TbD + demoForceControl



Droniou, A.; Ivaldi, S.; Sigaud, O. (2015) *Deep Unsupervised Network for Multimodal Perception, Representation and Classification*. Robotics and Autonomous Systems.

4) TbD by non-experts !!



experiments with 56 naive users
aged 37 ± 14 (min 19, max 65)

... seen by a non-expert (journalist) ...

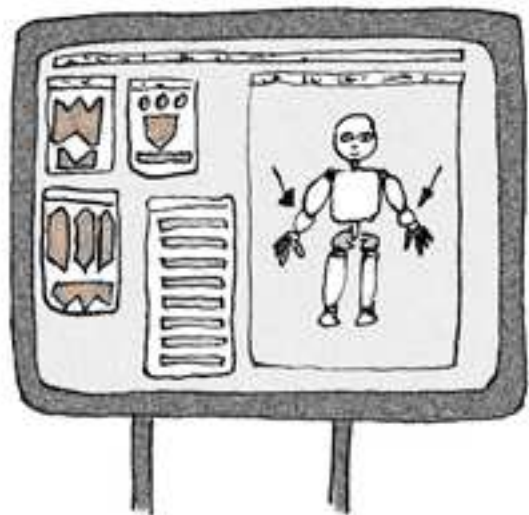


CHARLES SUIV L'EXPÉRIENCE DEPUIS L'ORDI
ET MOI, JE TIENS LE BOUTON ROUGE :
SI ÇA FOIRE, JE LE PRESSE ET J'ARRÊTE TOUT.

LA GUERRE ATOMIQUE
À L'ENVERS, QUOI... HÉ



IL A COMPRIS !
C'EST BIEN, CONTINUE.



IL A ENREGISTRÉ TES ORDRES, TES ATTITUDES,
TES POINTS DE PRESSION SUR SES BRAS...
POUR ÊTRE INTELLIGENT IL FAUT
QU'IL COMPRENNE TOUT UN CHACUN.

Le Monde

5) people meet iCub for the 1st time

**What
should I
do with
this?**



5) a “simple” teaching scenario

**Hello
iCub!**

So...



6) current solution for HRI experiments

requirements

- interaction as “natural” as possible
- safety for robot
- safety for humans

red button is
not enough!!



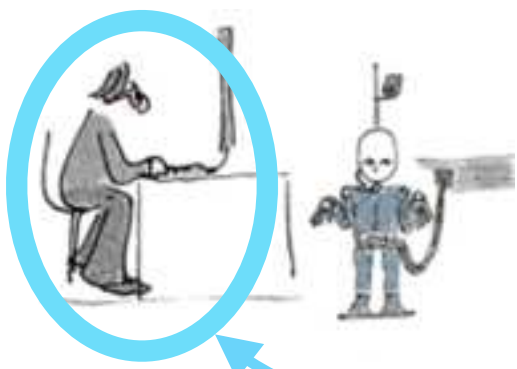
goals

- rapidly prototype experiments
- handle runtime variability of subjects



solution

WoZ << semi-autonomous + GUI (operator control) << autonomous



6) current solution for HRI experiments



CHARLES SUIT L'EXPÉRIENCE DEPUIS L'ORDI
ET MOI, JE TIENS LE BOUTON ROUGE :
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LA GUERRE ATOMIQUE
À L'ENVERS, QUOI... HÉ

operator with control GUI

experimenter with red button

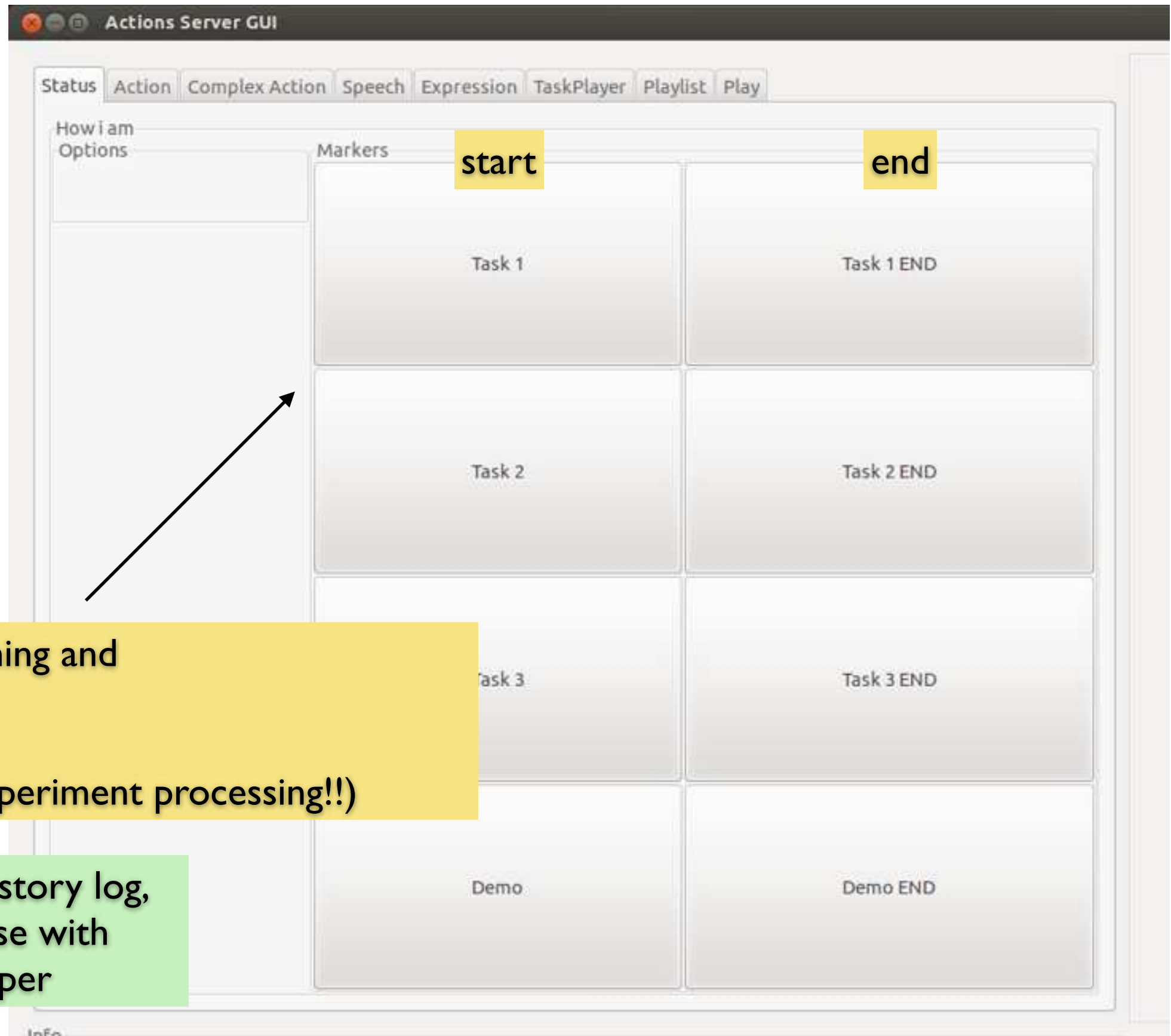
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big screen for the experimenter to monitor the robot status

6) operator control GUI: status markers



markers for beginning and end of each task

(useful for post-experiment processing!!)

saved on the history log,
to synchronise with
dataDumper

6) operator control GUI: actions

list of primitives -
“simple” actions

“complex” actions

actionsServer

The screenshot shows the 'Actions Server GUI' with several tabs: Status, Action, Complex Action, Speech, Expression, TaskPlayer, Playlist, and Play. The 'Action' tab is active.

What I do:

- Reset - new action** and **Validate** buttons.
- Simple actions:** A list of radio buttons including goto, look, reach, take, point, lift, push, rotate, and **grasp** (which is selected).
- Complex actions:** A list of radio buttons including takeliftfall, takeobserve, takeputinthebox, putAonB, and takegive.
- Object A:** A text field containing 'toy'.
- Person A:** A text field containing 'Serena'.
- Object B:** A text field containing 'box'.
- Person B:** A text field containing 'friend'.
- Parameters:** A grid of numerical input fields for A and B. For A, parameters are A-x (-0.364), A-y (0.197), A-z (0.300), and A-o1 through A-o4 (all 0.000). For B, parameters are B-x (-0.322), B-y (0.186), B-z (0.300), and B-o1 through B-o4 (all 0.000).
- Used arm:** Radio buttons for right_arm (selected), left_arm, and both_arms.
- Grasp type:** A dropdown menu showing 'close_pince_1'.
- Validation:** A message stating 'Validation successful! Now click to send the command' and 'Built command: action toy right grasp close_pince_1'.
- READY TO SEND** button.

History Log:

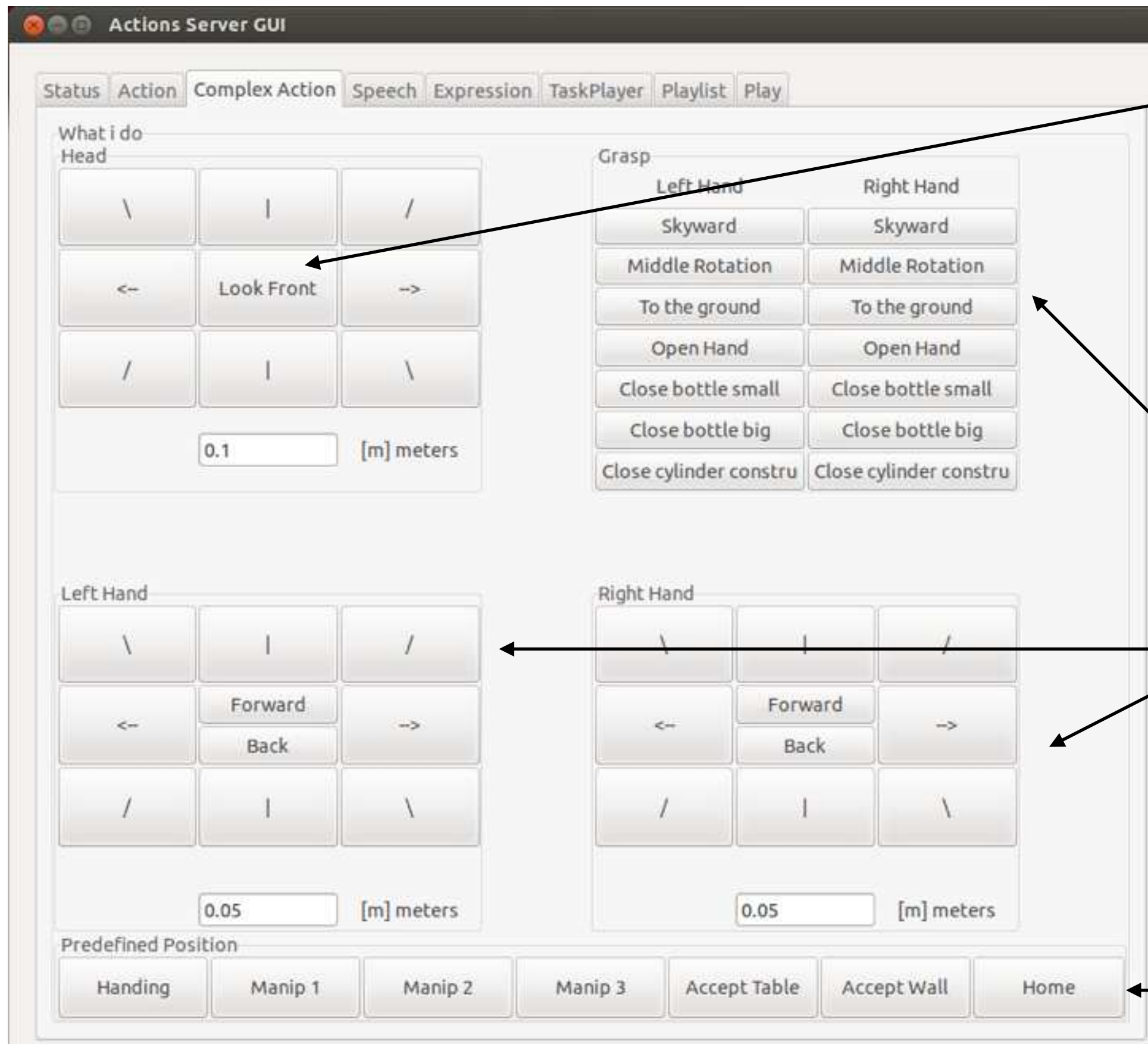
```
[21] C : Change item id = 2
[20] C : Change item id = 3
[19] -> : Add action from history to playlist: Home0
[18] ==> : Action Sent: Home: Home0
[17] Send move Home0
[16] ==> : Action Sent: Home: Home1
[15] Send move Home1
[14] -> : Add action from history to playlist: move hand
[13] -> : Add action from history to playlist: Look at left
[12] -> : Add action from history to playlist: Look at right
[11] ==> : Action Sent: moveHand: move hand
```

parameters of
the actions

predefined grasps

history

6) operator control GUI: head+hands



move head

GazeController

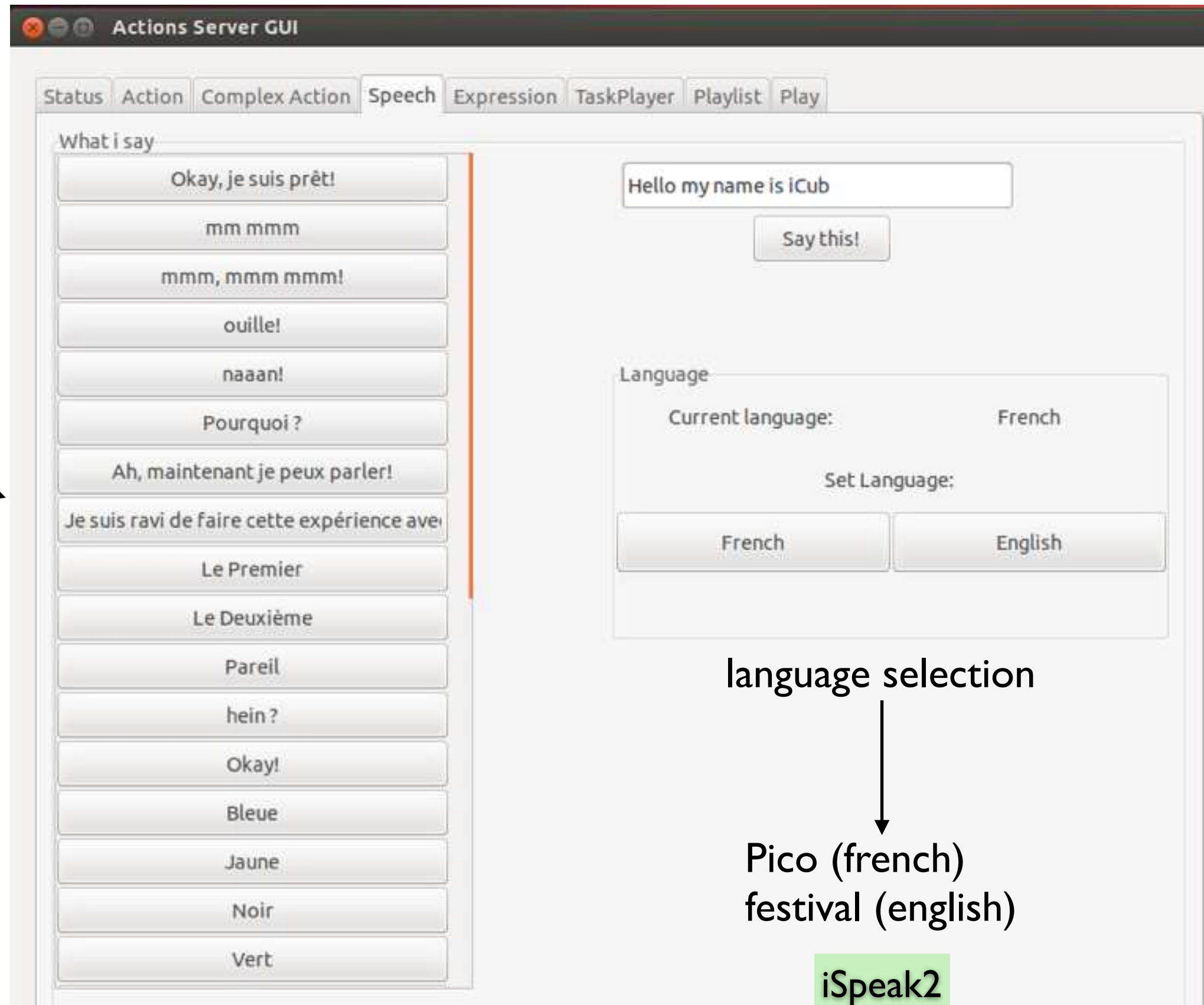
pre-defined grasps
and hand orientations

CartesianController

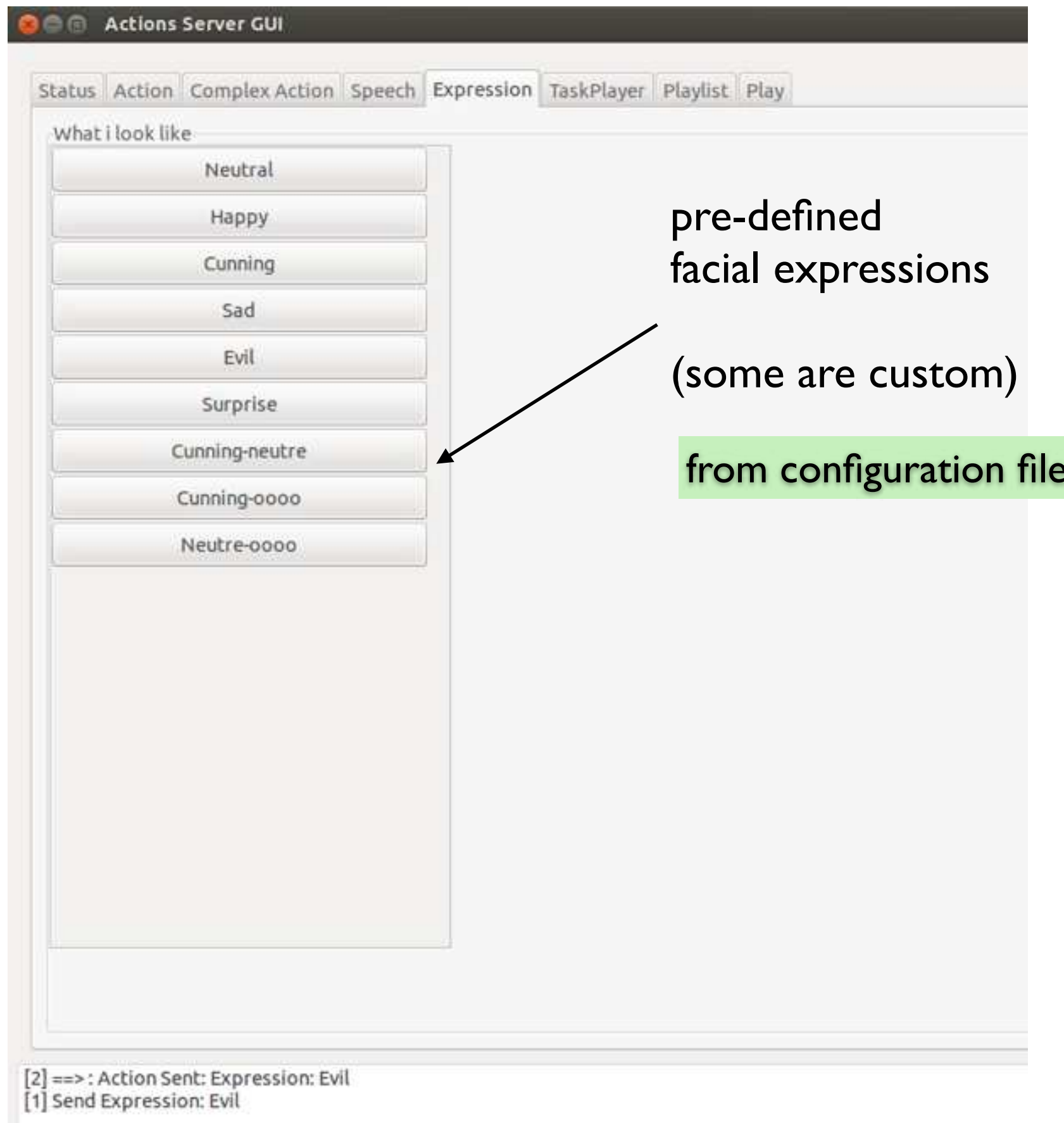
hand positions

"GOTO"
predefined
positions

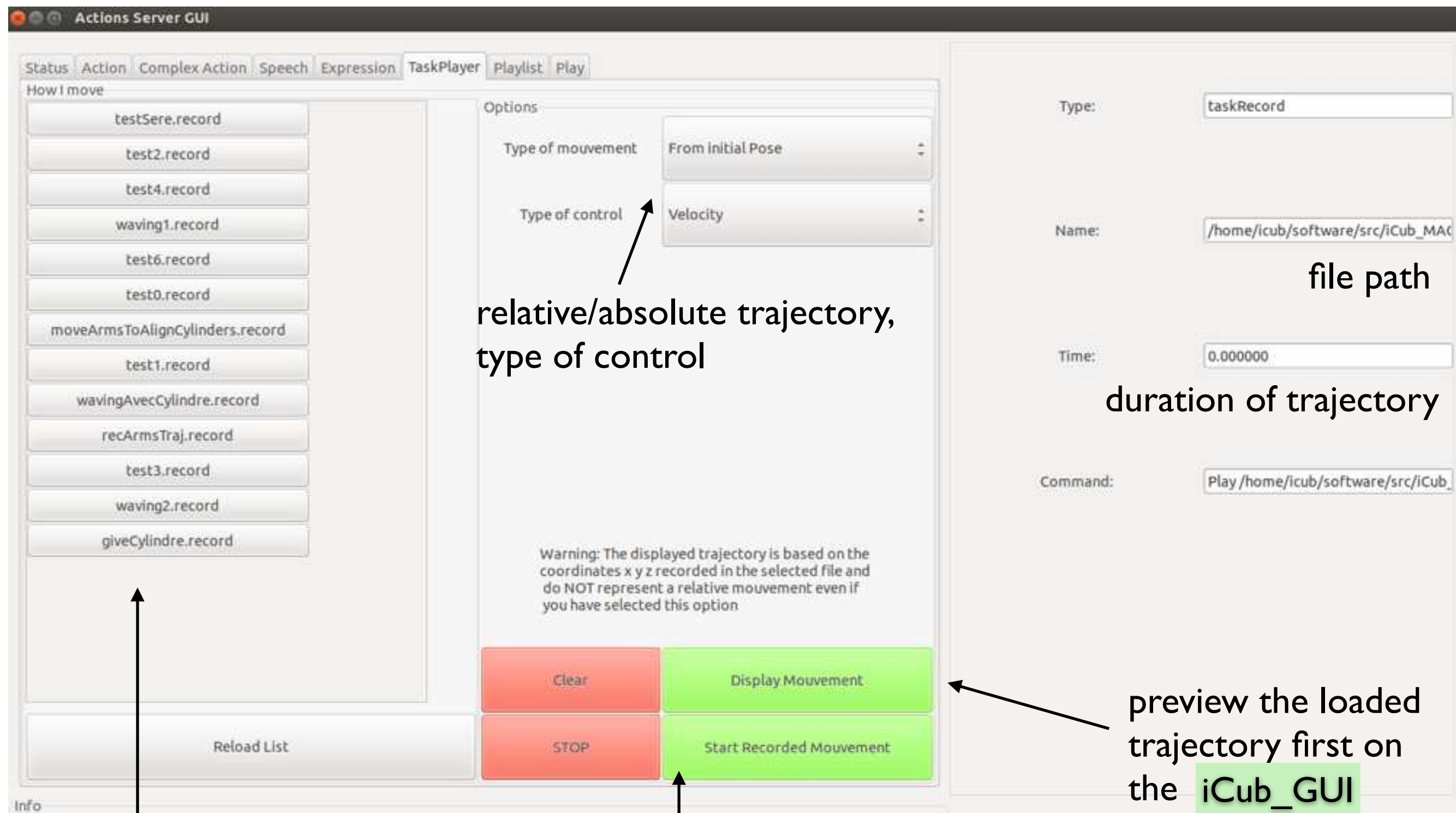
6) operator control GUI: speech



6) operator control GUI: expressions



6) operator control GUI: trajectories



relative/absolute trajectory,
type of control

file path

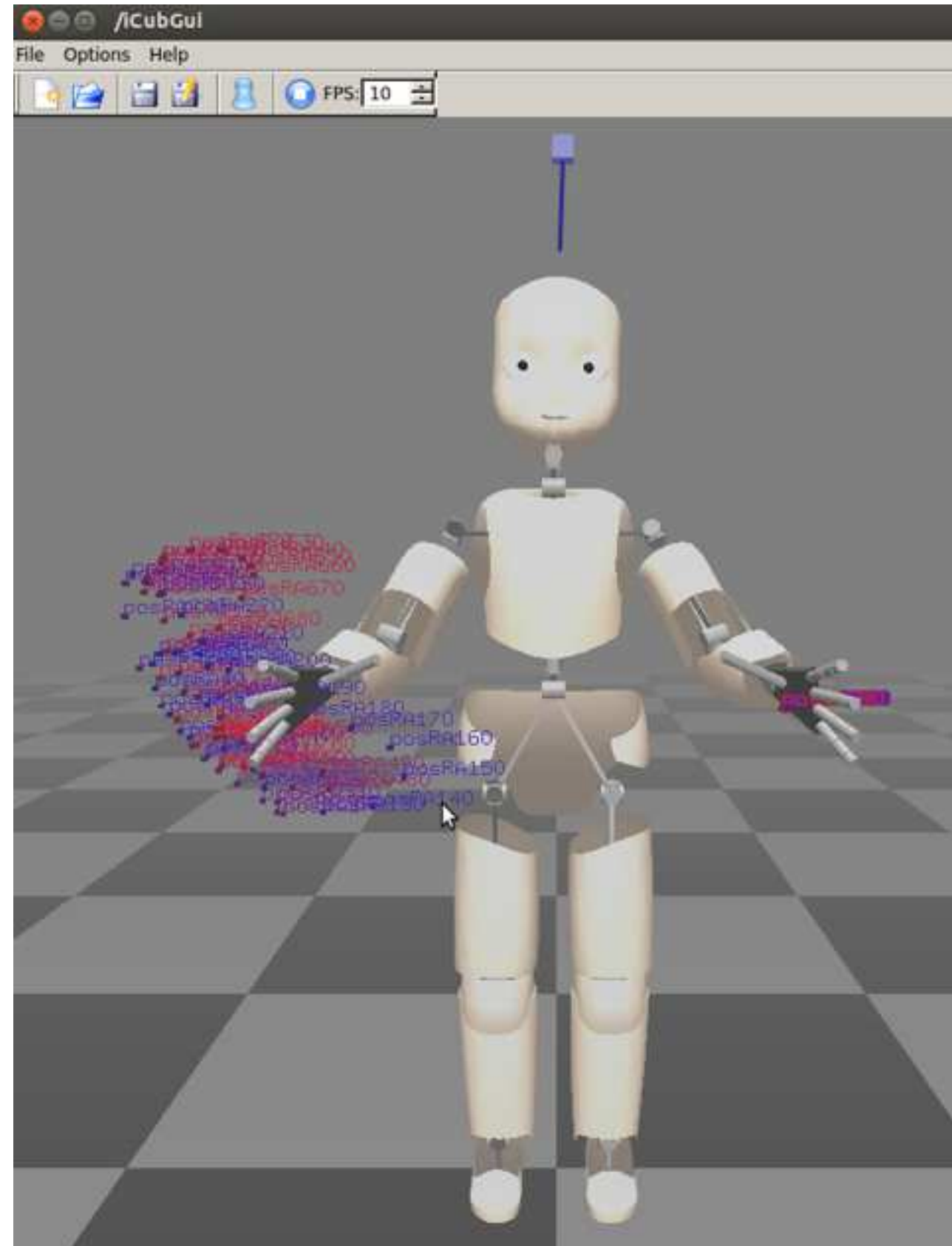
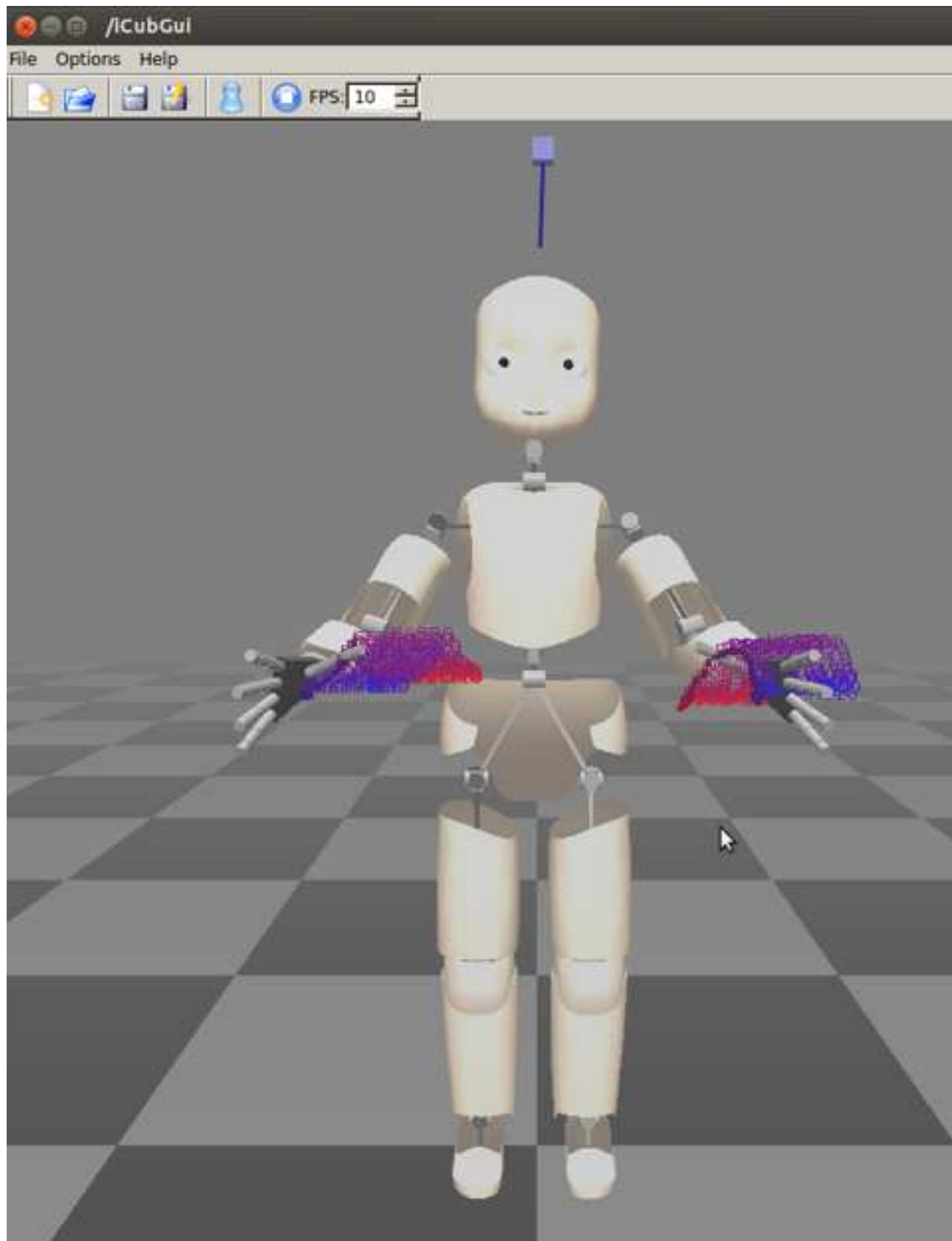
duration of trajectory

preview the loaded
trajectory first on
the iCub_GUI

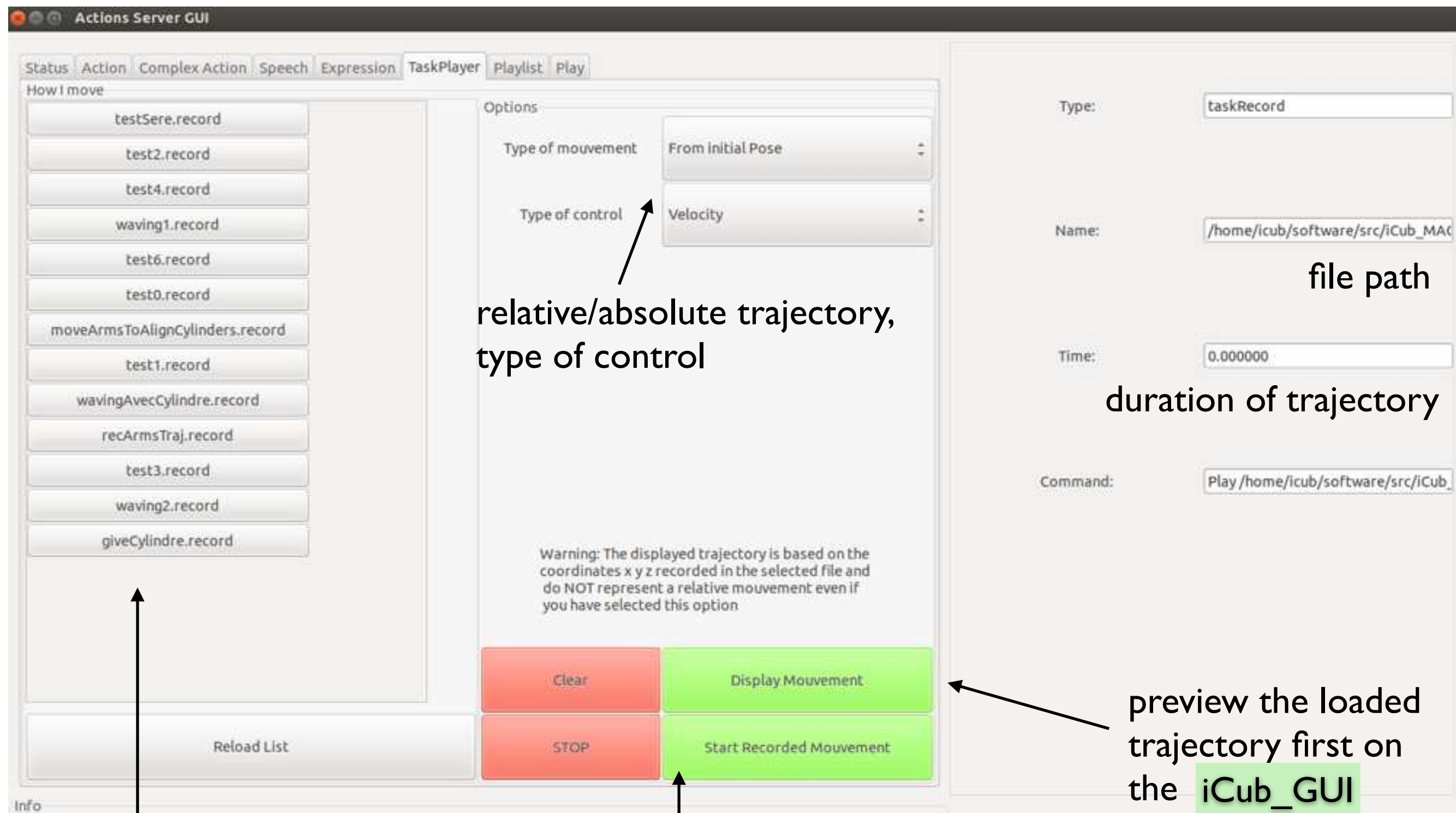
list of recorded
trajectories/movements

start/stop trajectory

... preview trajectories in iCub_GUI...



6) operator control GUI: trajectories



list of recorded
trajectories/movements

start/stop trajectory

preview the loaded
trajectory first on
the iCub_GUI

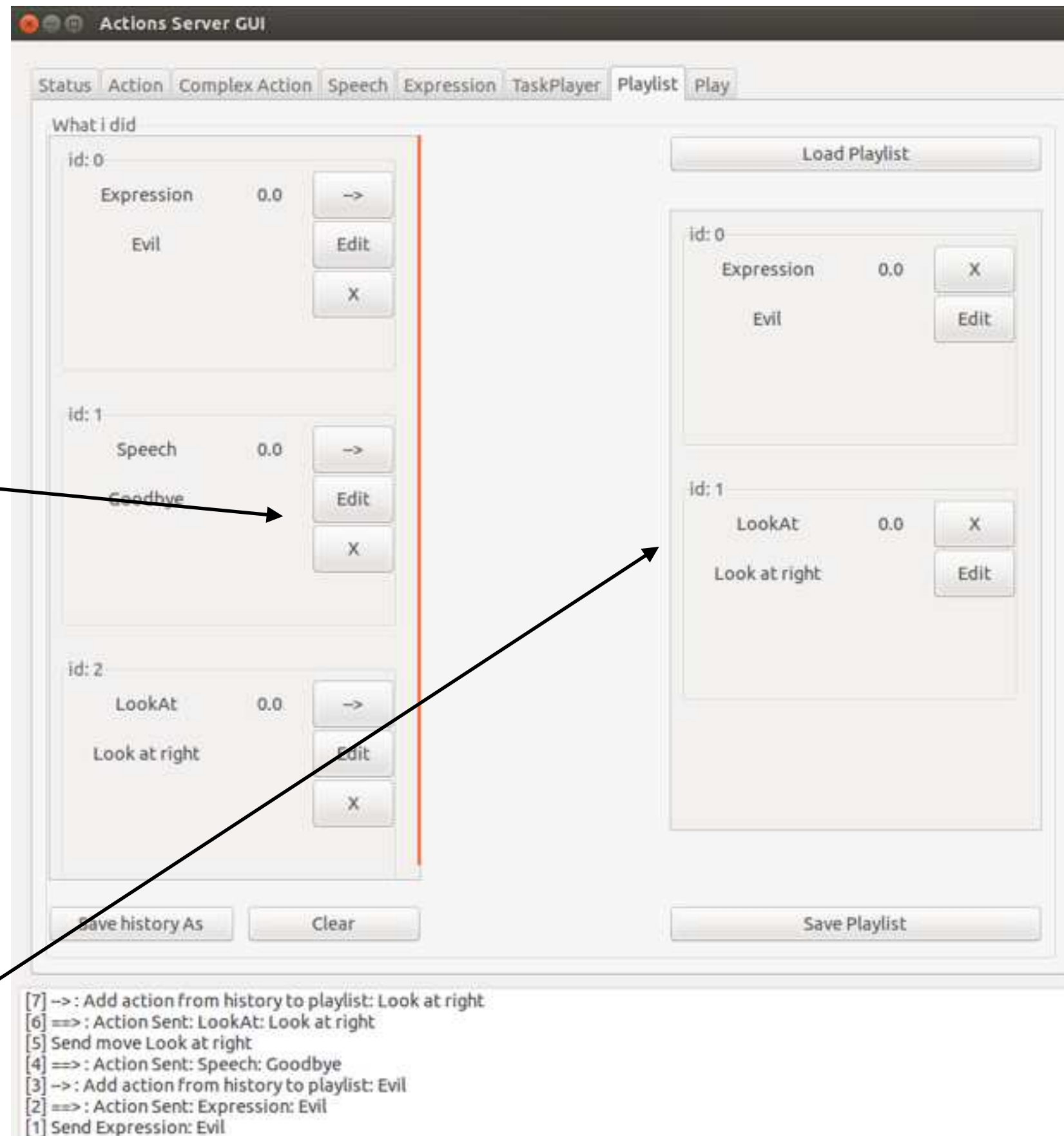
file path

duration of trajectory

6) operator control GUI: playlist

the list of commands
executed so far:
they can be modified,
added or removed from
a playlist

the playlist currently
created



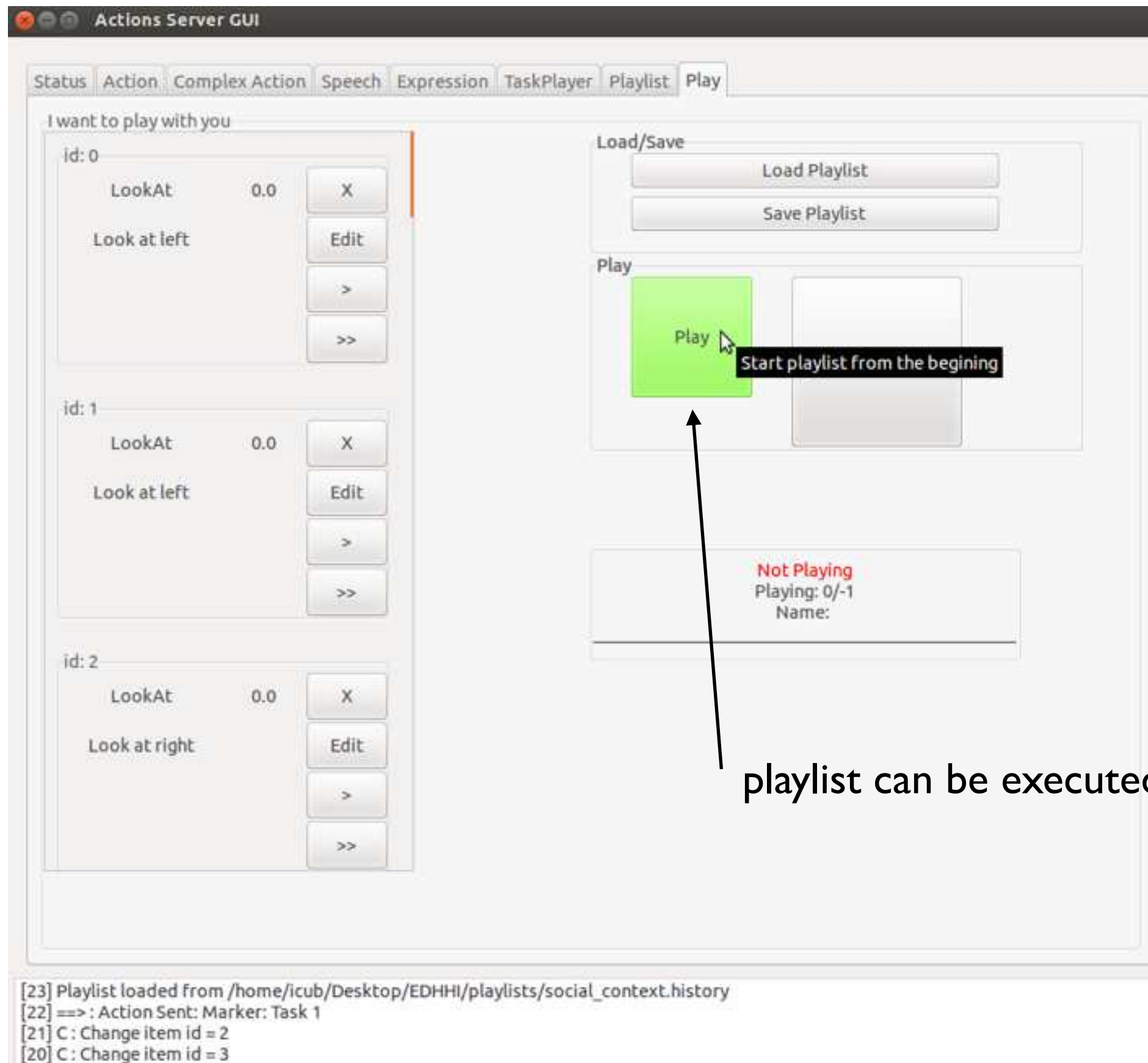
6) operator control GUI: playlist

The screenshot displays the 'Actions Server GUI' with the 'Playlist' tab selected. The interface is divided into several sections:

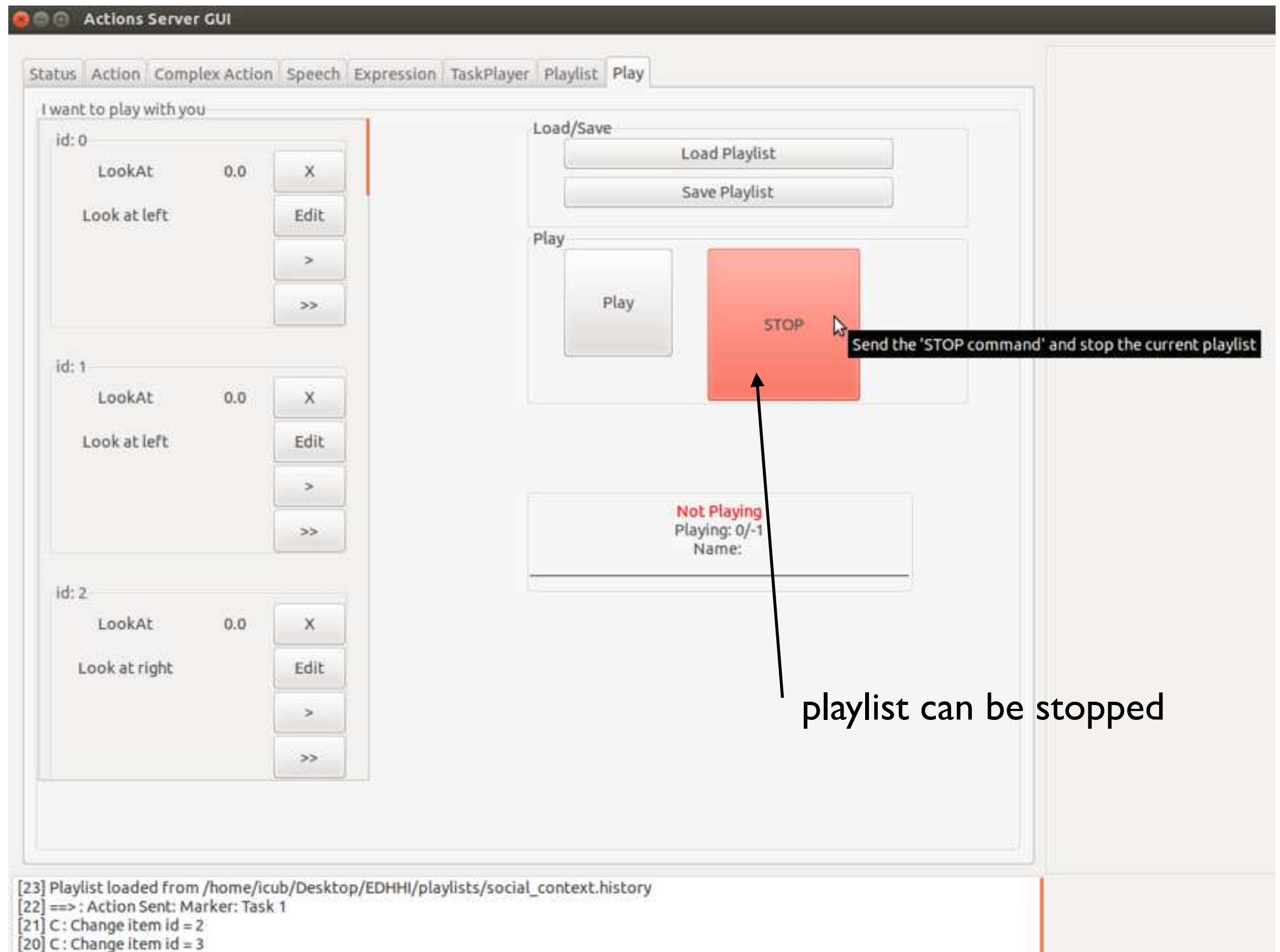
- What I did (History):** Located on the left, it shows a list of actions performed, including 'Look at right', 'Look at left', and 'moveHand', each with an 'id' and a '0.0' value. Buttons for 'Edit' and 'X' are present for each entry.
- Load Playlist:** A central area with a list of actions (id: 1, 2, 3, 4, 5) and their details. An orange box highlights the 'Edit' button for the selected action (id: 2).
- Right Panel:** Contains fields for 'Type' (moveHand), 'Name' (move hand), 'Time' (0.000000), and 'Command' (action object right grasp open_hand). Buttons for 'Close' and 'Modify' are at the bottom.
- Log:** A bottom section showing a list of system messages, including 'Add action from history to playlist' and 'Action Sent'.

each command of the playlist can be modified

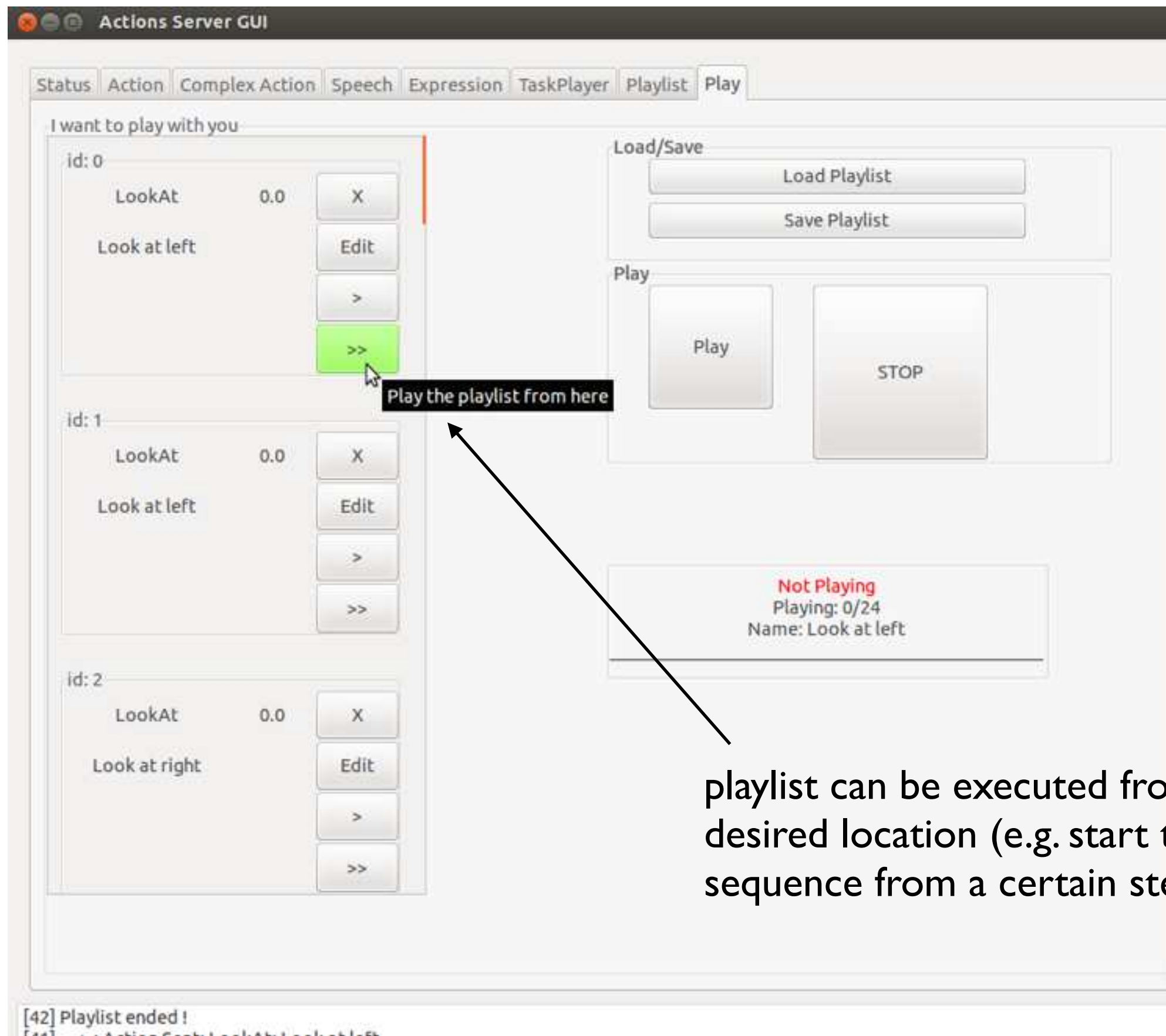
6) operator control GUI: playlist



6) operator control GUI: playlist

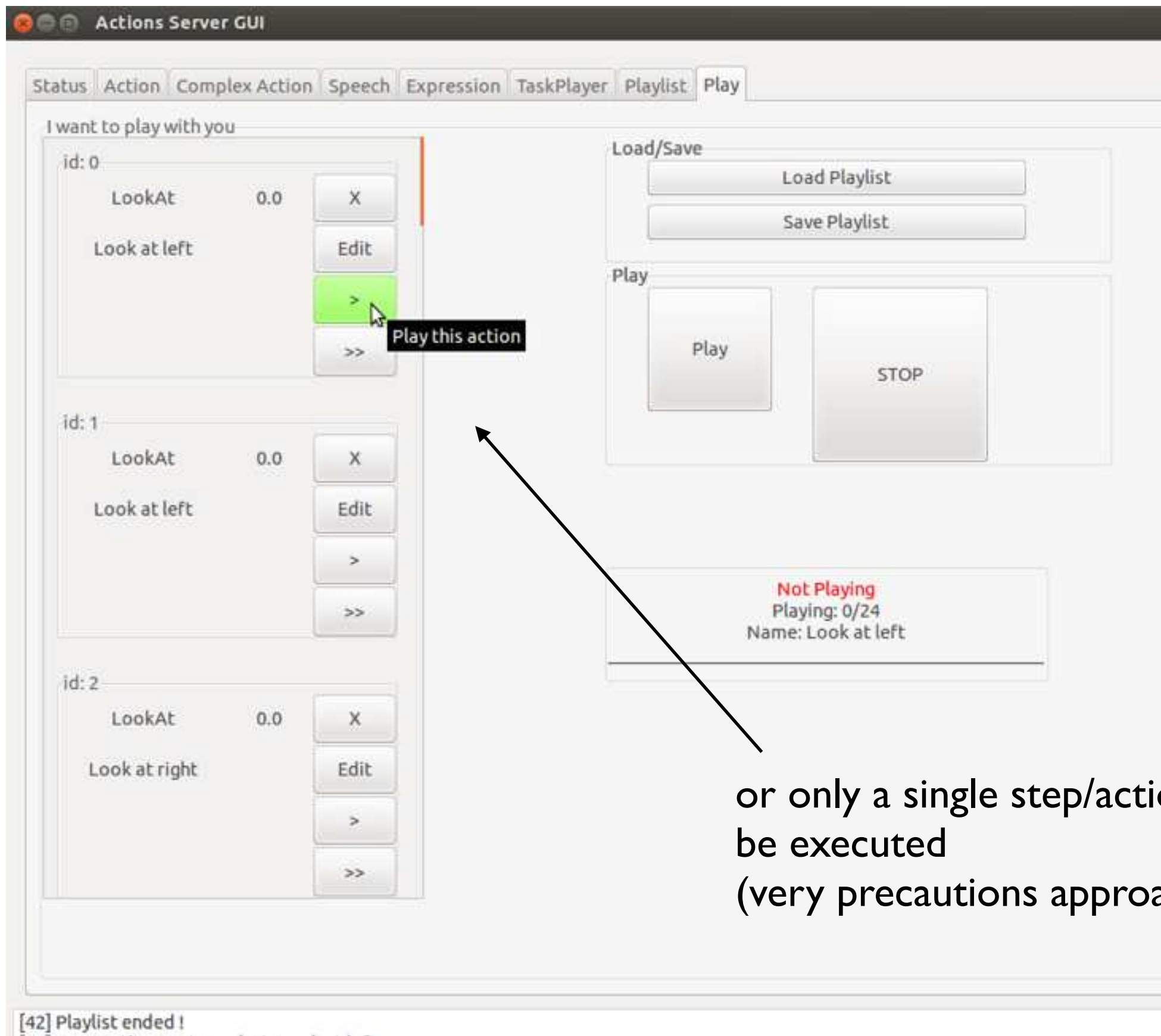


6) operator control GUI: playlist



playlist can be executed from a desired location (e.g. start the sequence from a certain step)

6) operator control GUI: playlist



or only a single step/action can
be executed
(very precautions approach!)

Take home message & future work

- The iCub must be **aware of the human** even if it is only supervising its tasks
 - A simple **joint attention** system based on human gaze tracking already makes the iCub “alive”
 - **Ordinary people are unpredictable**: a human in the loop is better than a fully autonomous robot for studying HRI
 - When ordinary people physically interact with the robot in a non-scripted scenario, it is advisable to have **an experimenter with the red button and an operator behind the operation control GUI**
-
- Upload on **github** (code is currently available at macsi.isir.upmc.fr)
 - Improve the GUI in terms of features, aesthetics and ergonomics
 - Make a **2nd GUI that can be easily used by non-experts** and ordinary people to program the robot by demonstration and simple interaction

Acknowledgements



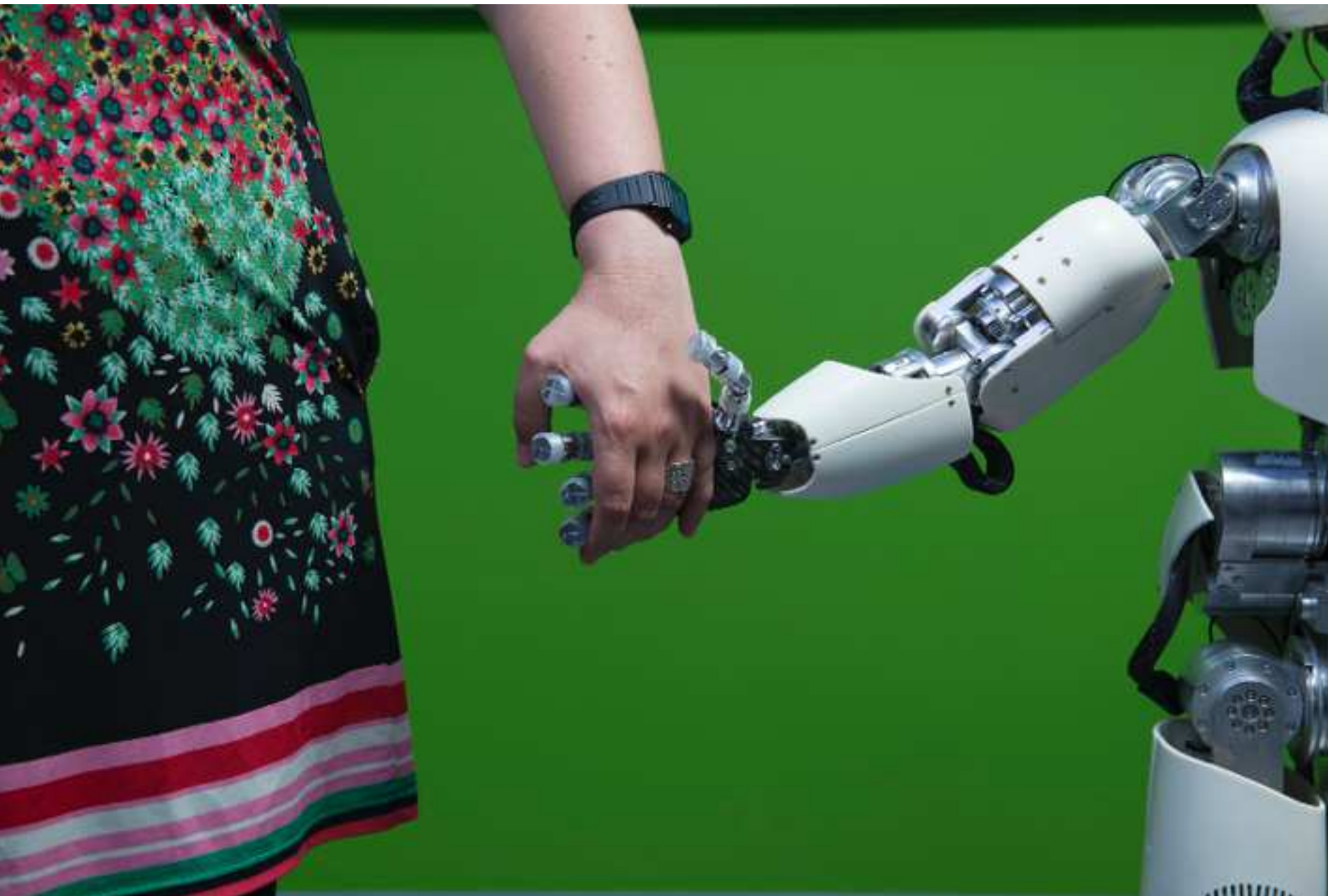
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<http://chronos.isir.upmc.fr/~ivaldi/edhhi>
ANR LABEX SMART



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