Learning Through Coaching in Cooperative Side-by-Side Human-Humanoid Interaction

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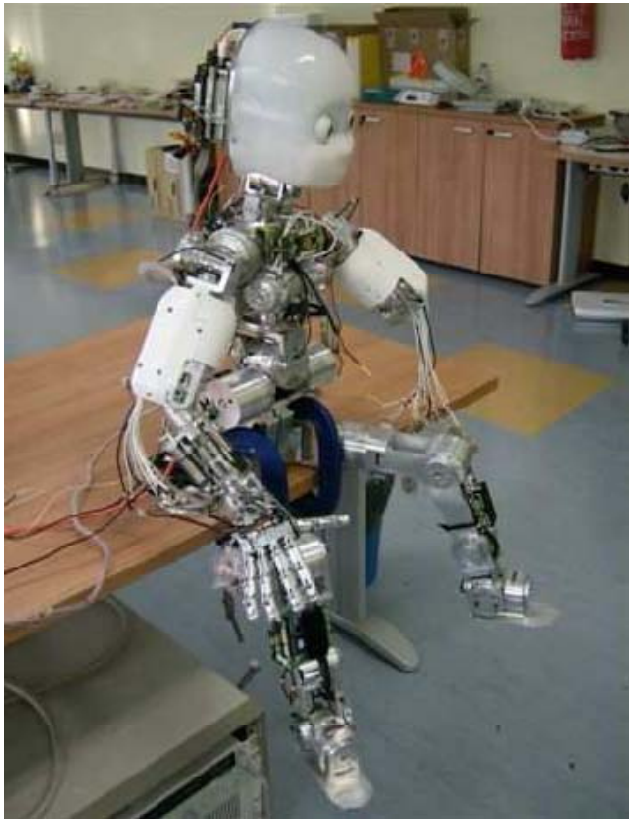
CHRIS Cooperative Human Robot Interaction Systems

2007 - 2013

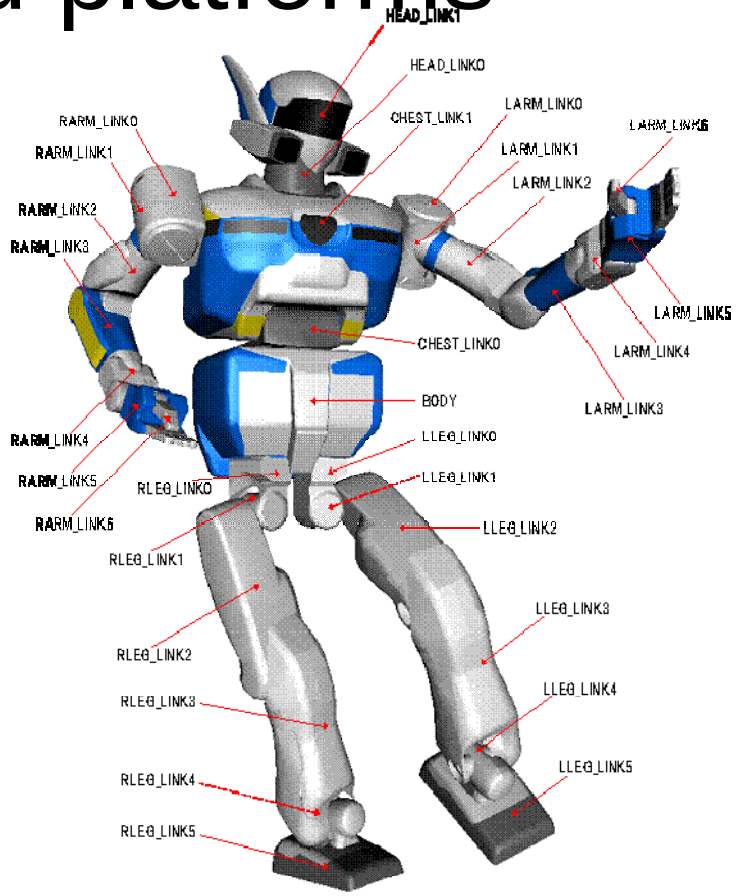
Objectives:

- Humanoid robot ‘apprentice’
  - Establish base-line tasks(s)/scenario(s)
  - Set of sensory-motor primitives
  - Mechanism for composing new behavior from these primitives
  - Demonstrate generalization to a set of tasks
- Side by side interaction
  - Spoken language
  - Vision
  - Automatic learning and anticipation
- Representation Shared intentional plans

Demonstrate these capabilities on standard humandoid platforms



iCub – FP6 IST RobotCub
IIT Genoa



HRP-2 n°14 AIST-CNRS JRL
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The Robot Apprentice

- The robot works with the human to assemble the table
- And learns about the shared task
- To progressively acquire skill
- The robot should have:
  - Some Basic Skills
  - Ability to Learn from the Expert
  - Ability to use language to guide action, including learning
  - Notion of Shared Plans

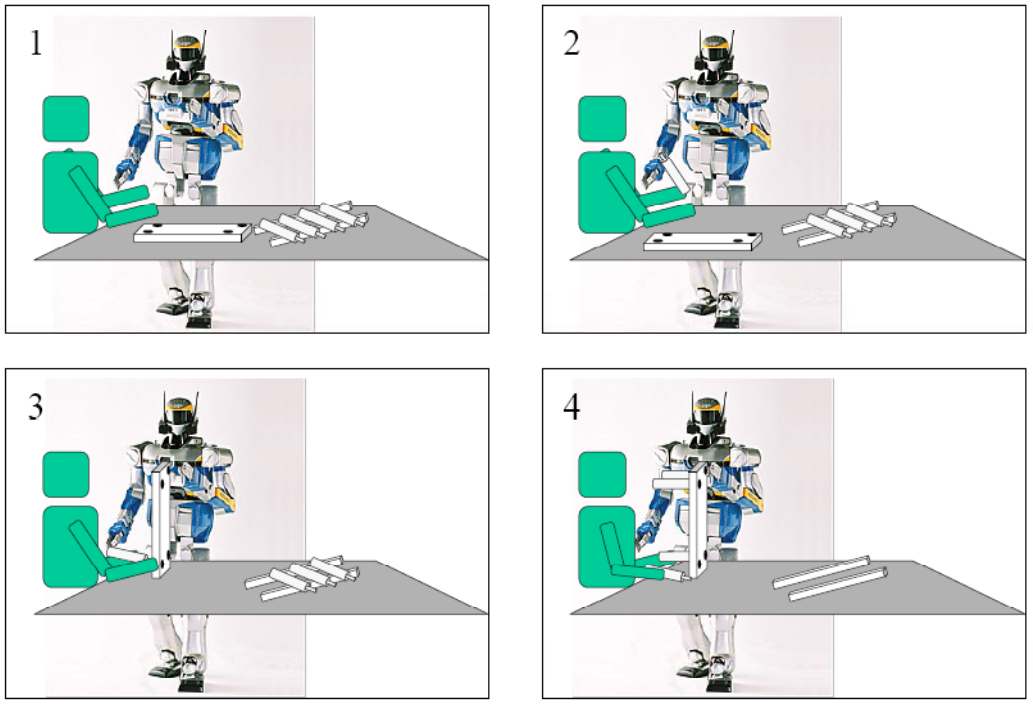

Table-Building Scenario

Spoken Language Programming: Composing primitives into behaviors

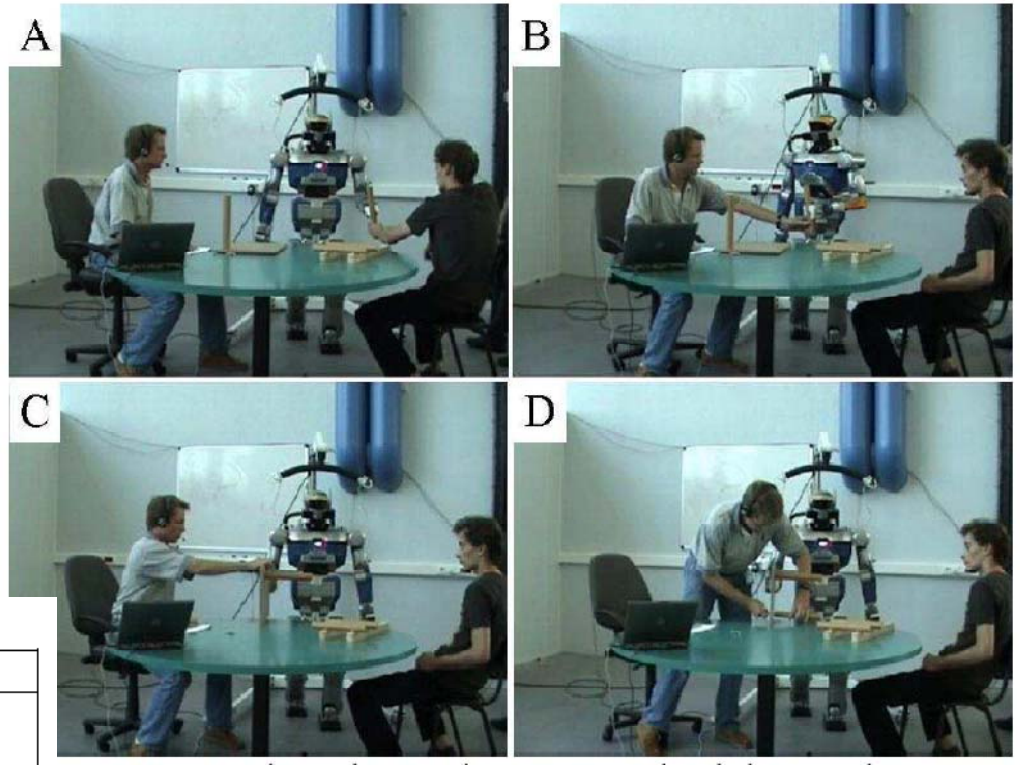

Table 1. Action Commands

Motor Command	Resulting Actions
Prepare	Move both arms to neutral position, rotate chest to center, elevate left arm, avoiding contact with the work surface (5 DOF)
OpenLeft	Open left hand (1 DOF)
CloseLeft	Close left hand (1 DOF)
Give it to me	Rotate hip to pass the object in left hand to user on the right (1 DOF)
Hold	Center hip, raise right arm preparing to hold table top (5 DOF)
Right open	Open right hand (1 DOF)
Right close	Close right hand (1 DOF)

Table 2. Learning and Control Commands

Commands	Correspondence
Learn	Begin encoding subsequent commands
OK	Store encoded command sequence in macro
Macro	Execute the stored macro
Wait	Interrupt command execution until a spoken "continue" command is issued
Continue	Terminate the "wait" pause and resume execution.

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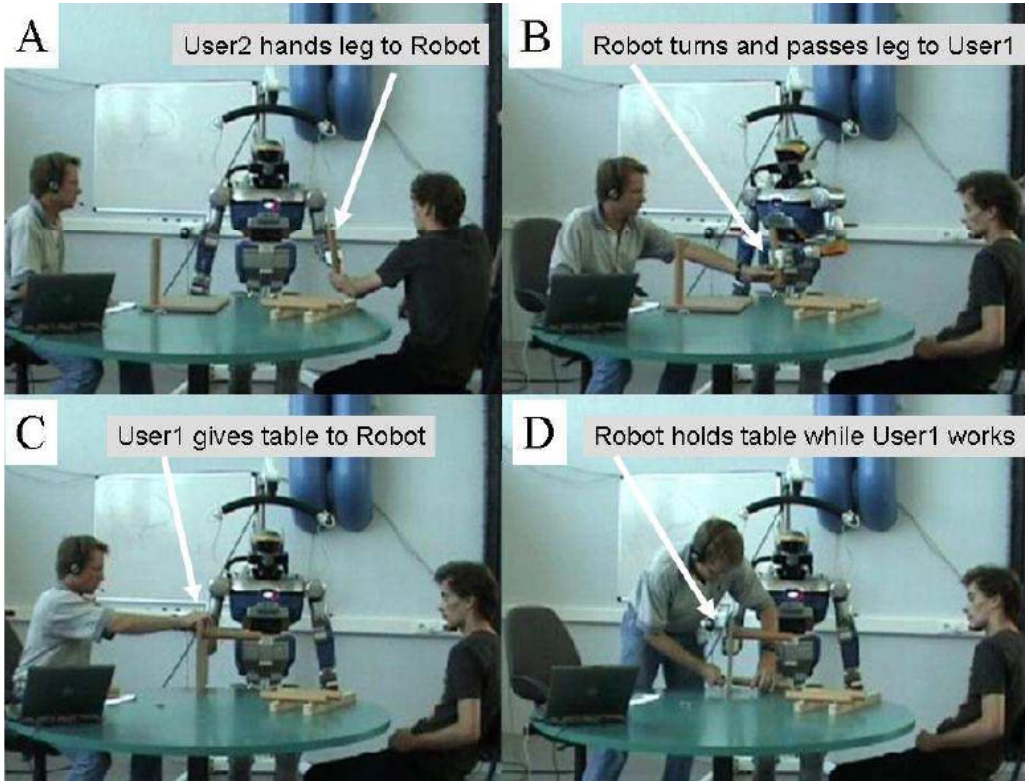
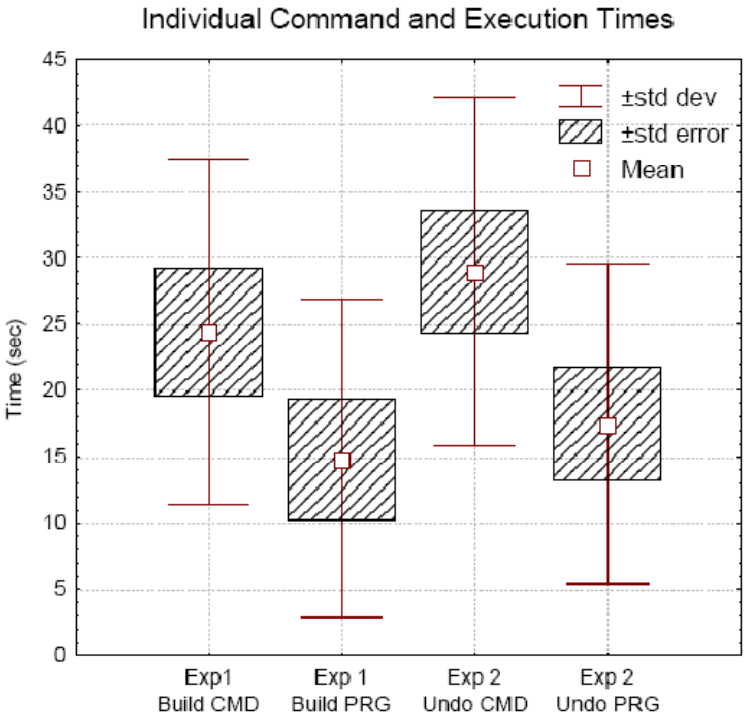
Dominey, Mallet, Yoshida (2007) IEEE Int. Conf. Robotics & Automation 2007

Table Assembly and Disassembly





Teaching a Generalized Sensorimotor Behavior

- Give me the ***green*** leg
  - Take the ***green*** leg
  - Turn right
  - Open right hand
- Training with one example
  - *Green* is passed as an argument to TAKE
  - Learned procedure generalizes over (yellow, rose, green, orange)
  - Powerful learning capability with procedures that take variables
- Embodiment of lexical categories
  - Verbs – procedures
  - Nouns – arguments
- Requires more sophisticated skills
  - Vision
  - Inverse kinematics

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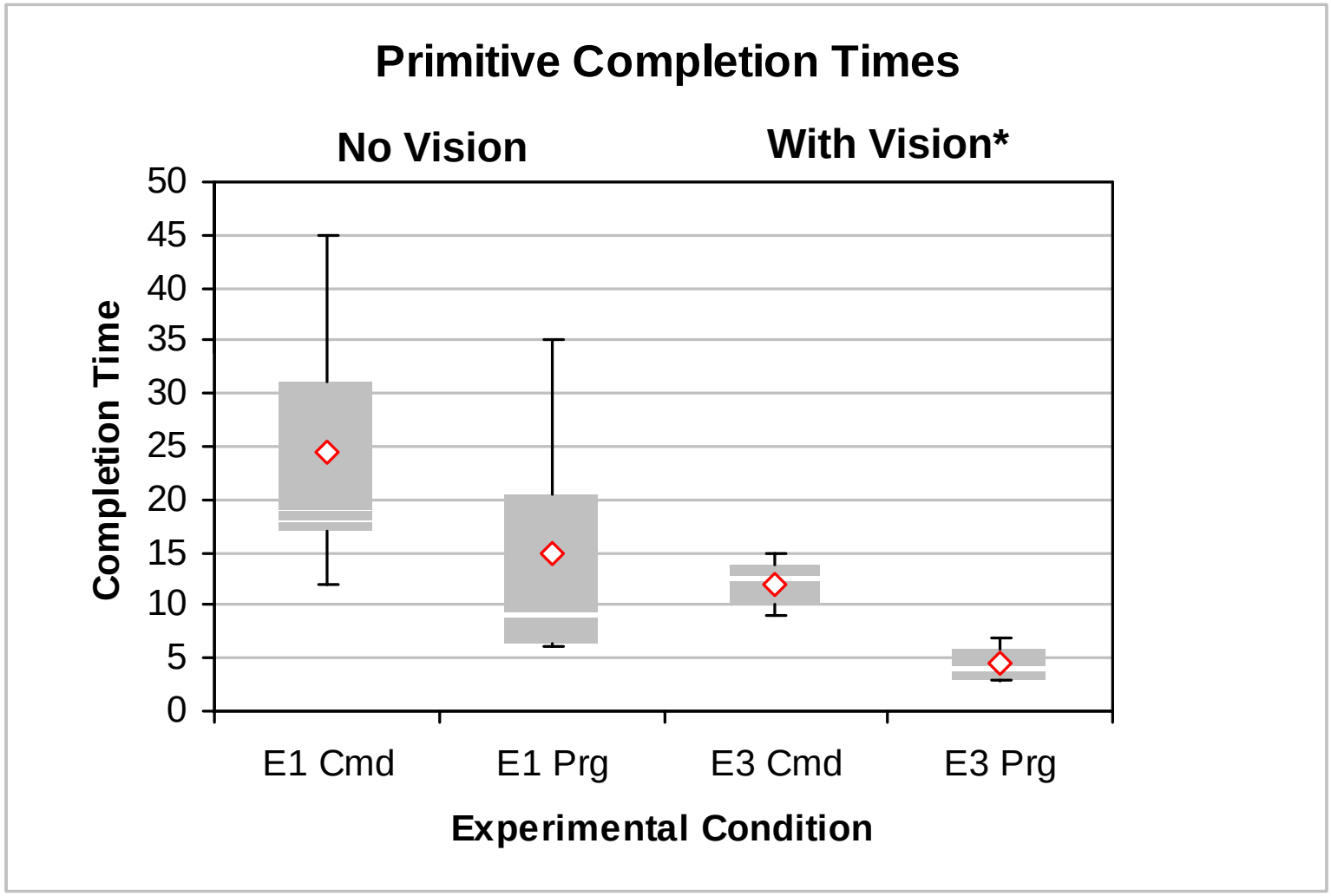
Dominey, Mallet, Yoshida (2007) IEEE Int. Conf. On Humanoid Robotics

Performance Evaluation



*and improved motion trajectories

Automatic Learning, and Anticipation

- On-line Learning of complex cooperative behavior via continuous interaction history monitoring
- Yeilds Aniticpation for
  - Speech recognition
  - Action propositions
  - Action Inititiatve taking

Dominey, Metta, Nori, Natale (2008) IEEE Int. Conf. On Humanoid Robotics

Automatic Learning, and Anticipation

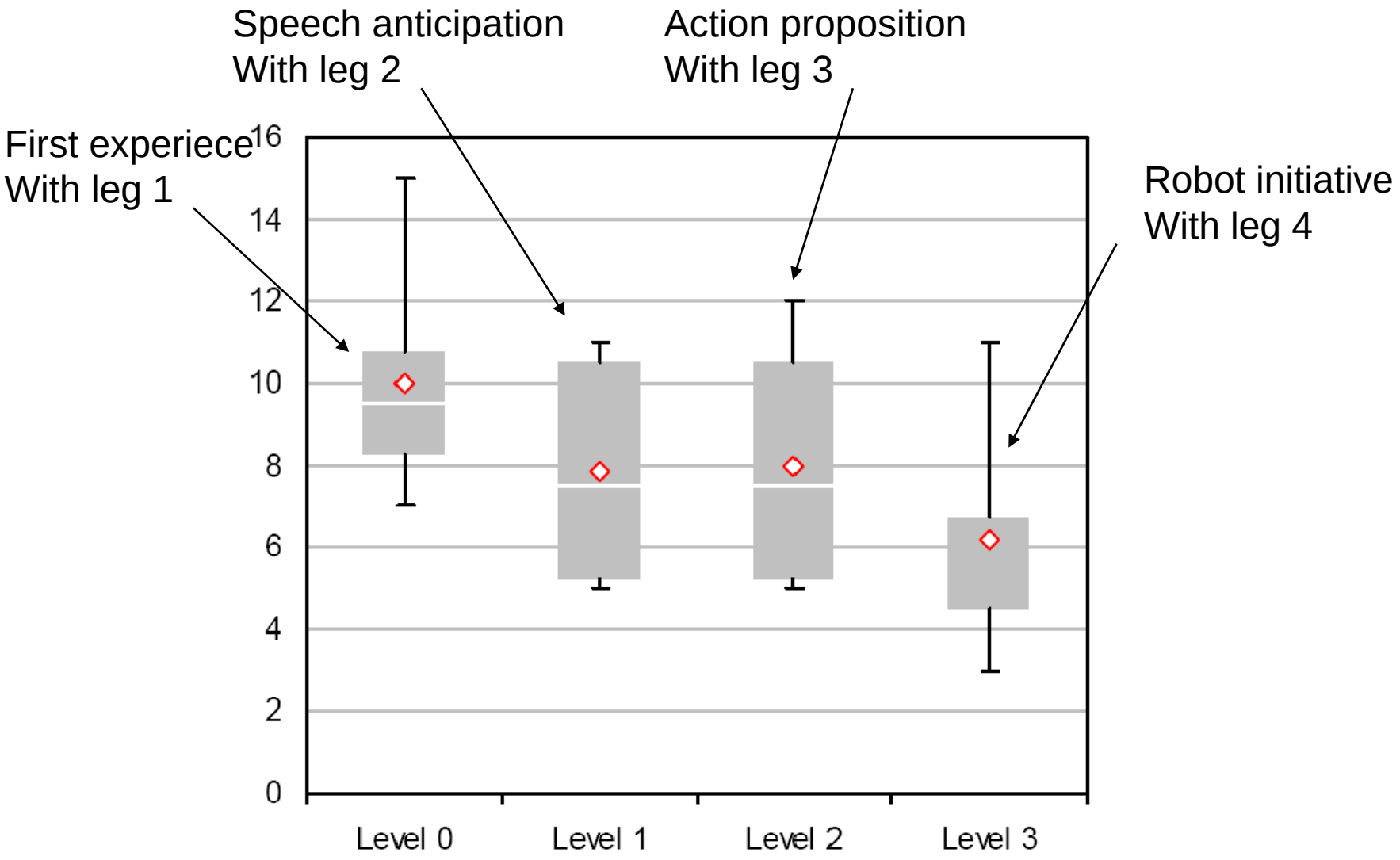
- If current subsequence is in interaction history
  - L1 – anticipate speech
  - L2 – propose next action
  - L3 – take initiative
- Else get next command
- Execute
- Update interaction history

Table 1. iCub Specific Action Commands

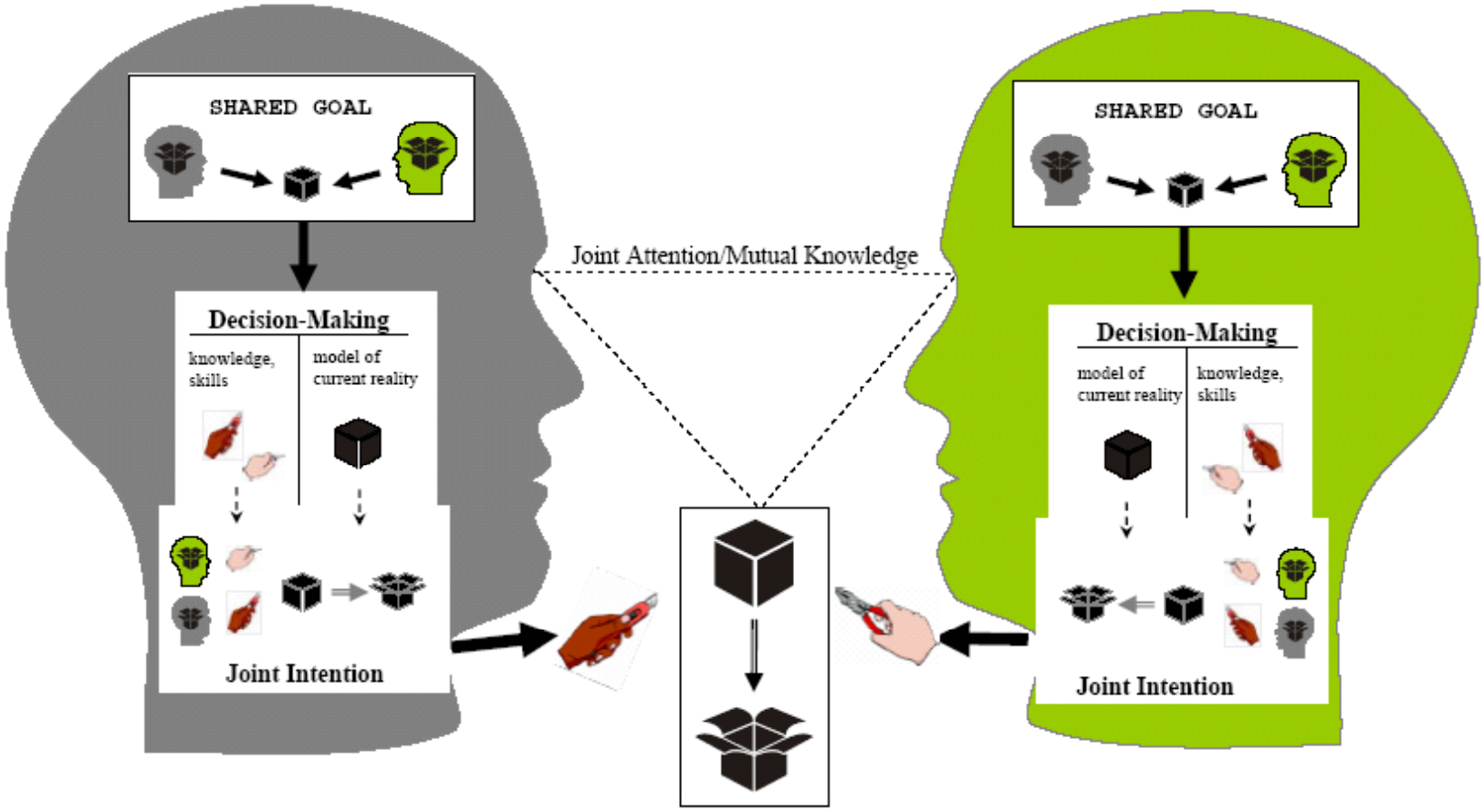
Motor Command	Resulting Actions
Reach	Position left hand next to closest table leg
Grasp	Close left hand
Lift	Raise left hand
Pass	Turn trunk and left shoulder towards user
Open	Open left hand
Hold	Bimanually coordinated holding
Release	Place both hands in upward safe position
Wait	Suspend until OK signal

Dominey, Metta, Nori, Natale (2008) IEEE Int. Conf. On Humanoid Robotics

Progressive effects of Learning

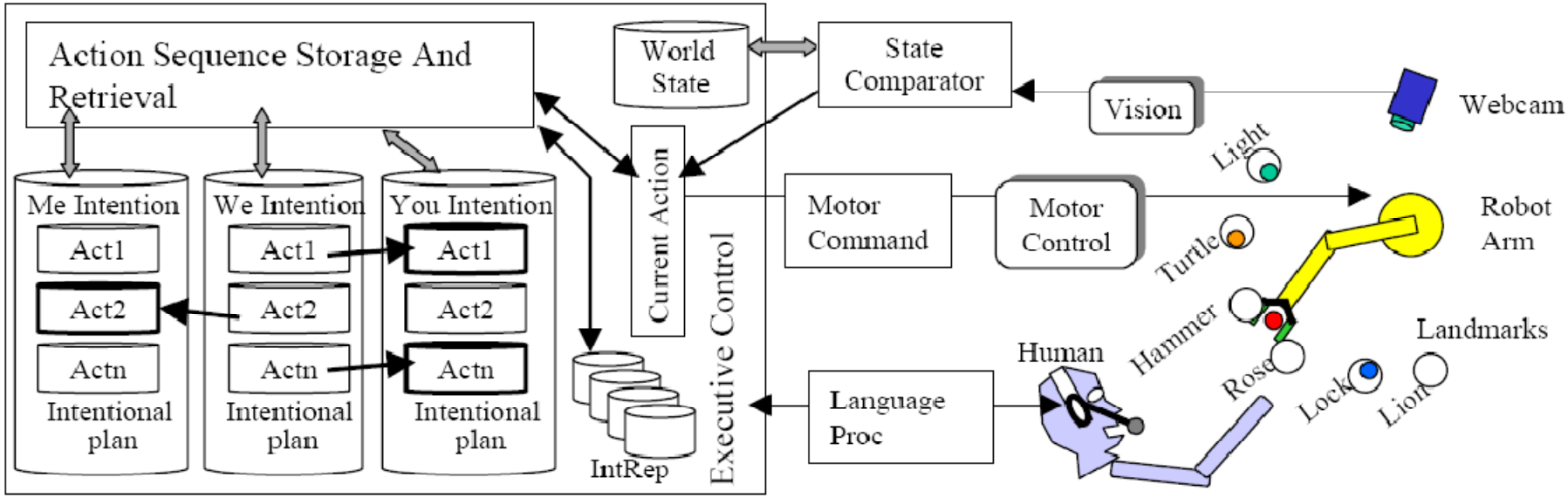


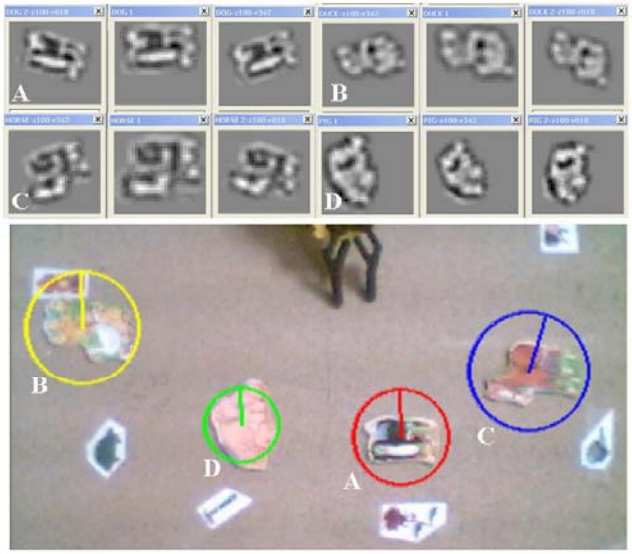
Shared Intentions & Situated Simulations



Tomasello et al. Behavioral and Brain Sciences, 2005

Implementing Shared Plans





Putting it all together:

- Primitives (perceptual and motor)
  - ‘Innate’ set
  - Ability to create new primitives
- Composition
  - On-line sequence detection
  - Explicit ‘spoken language programming’
  - Observation
  - Anticipation
  - Naming of new sequences – increasing the behavior repertoire

Acknowledgements

- Funding
  - euCognition (ICT FP6)
  - CHRIS (ICT FP7)
  - French ANR Amorces
- Collaborators
  - Anthony Mallet
  - Eiichi Yoshida
  - Giorgio Metta
  - Giulio Sandini
  - Francesco Nori
  - Lorenzo Natale
- Students
  - Jean-David Boucher
  - Stephane Lallee
  - Zhenli Lu
- Research Organizations
  - CNRS
  - INSERM

Situated Simulation Architecture