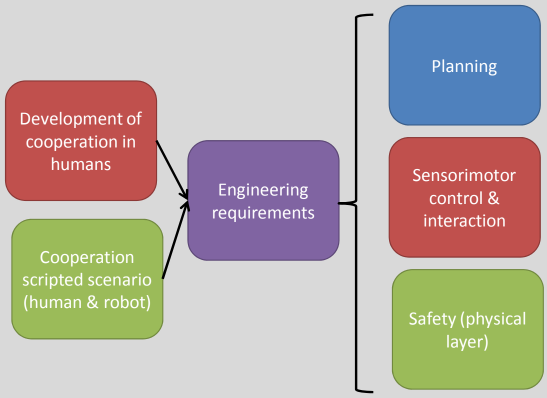
CHRIS

Cooperative Human Robot Interaction Systems

One of the long-term goals for **humanoid robotics** is to have these robots working side-by-side with humans, helping them in a variety of open ended tasks, which can change in real-time. In such contexts a crucial component of the robot is to behave safely in a human populated environment and to learn as rapidly as possible from the regularities of human behavior.

CHRIS addresses the fundamental issues which would enable safe Human Robot Interaction (HRI). It addresses the problem of a human and a robot performing cooperative tasks in a co-located space.

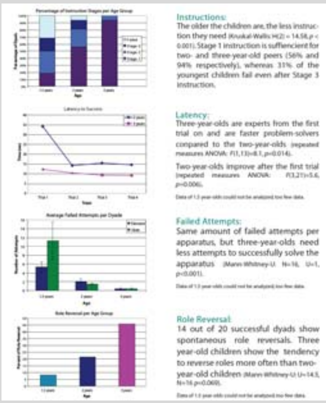
Several robots are used for demonstrating the project results including HRP2 (LAAS), Bert2 (BRL) and the iCub (IIT & INSERM).

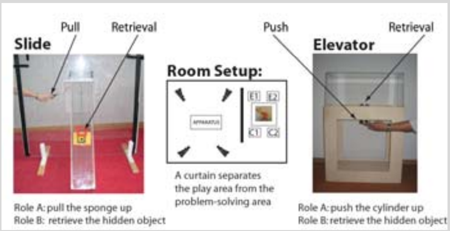


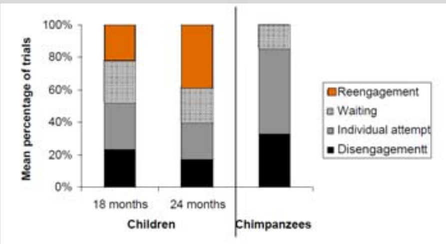
Multi-layer architecture

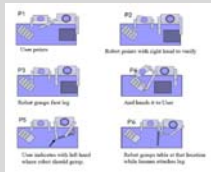
Past studies have shown that with adults, children as young as 14 months show rudimentary skills to cooperate. Slightly older children (18 - 24 months) can collaborate successfully in complementary problem-solving tasks. In these previous studies, an adult assisted and structured the cooperative activity. When children interact with same age peers instead of adults, the ability to collaborate skillfully emerges at around 24 months of age. Although children of this age can successfully solve simple problem-solving tasks which require the engagement of two partners, their behavioral coordination remains rudimentary.

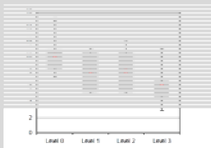
- Role reversal in tasks with complementary actions?
- Scaffolding by competent partner?
- Human-specificity?





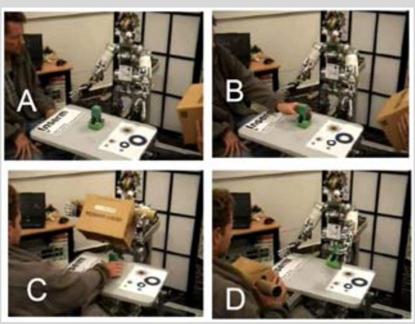


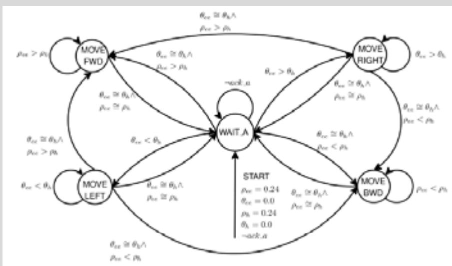




The humanoid robot maintains and uses an "interaction history" – a literal record of all past interactions that have taken place. During on-line interaction, the system continuously searches the interaction history for sequences whose onset matches the actions that are currently being invoked. Recognition of such matches allows the robot to take different levels of anticipatory activity. As predicted sequences are successively validated by the user, the level of anticipation and learning increases. Level 1 anticipation allows the system to predict what the user will say, and thus eliminate the need for verification when the prediction holds. At Level 2 allows the system to take initiative to propose the predicted next event. At Level 3, the robot is highly confident and takes initiative to perform the predicted action. We demonstrate how these progressive levels render the cooperative interaction more fluid and more rapid.

Contributions from developmental psychology have identified that the system should be able to form a "bird's eye view" of a cooperative interaction, based on observation of two agents performing the action, and should then be able to use this representation to take the role of either agent, demonstrating a capability for "role reversal". This is related to the learning of invariant action properties from the third-person perspective. Based on these ideas, we have developed the "Uncover the target". The robot should be able to observe a sequence of actions, form a shared plan, and then use that plan to take either role in the cooperative action.





We considered the problem of ensuring that a multi-agent (see architecture to the right) robot control system is both safe and effective in the presence of learning components. Safety, i.e., proving that a potentially dangerous configuration is never reached in the control system, usually competes with effectiveness, i.e., ensuring that tasks are performed at an acceptable level of quality. We attack this problem using automata-theoretic formalisms and associated verification tools, showing experimentally that our approach can yield safety without heavily compromising effectiveness.

Starting from results from developmental psychology and the scripted scenario we devised the requirements for a practical and effective human-robot interaction.

In particular, we have shown experiments directed at analyzing a set of scenarios relevant for human-robot interaction, we also started preparing an architecture to support large-scale HRI experiments with humanoid robot, and, finally, we started addressing safety at various levels in the architecture.

Examples of this work are provided.