ITALK: Integration and Transfer of Action and Language Knowledge in robots

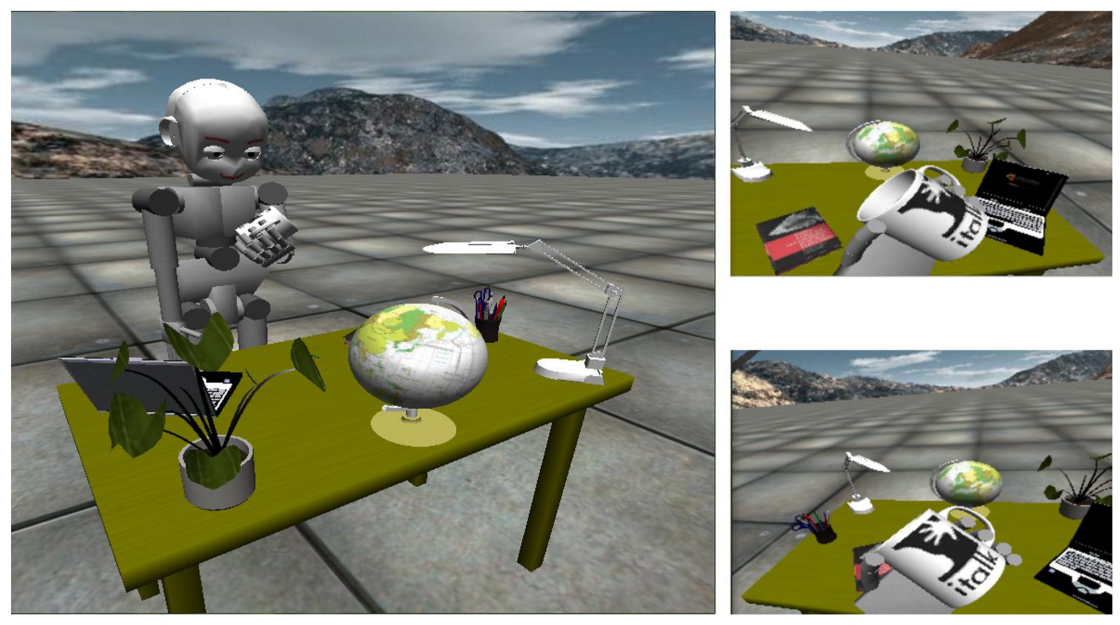
An EU Cognitive Systems, Robotics and Interaction project (214668)

Overview and Aims

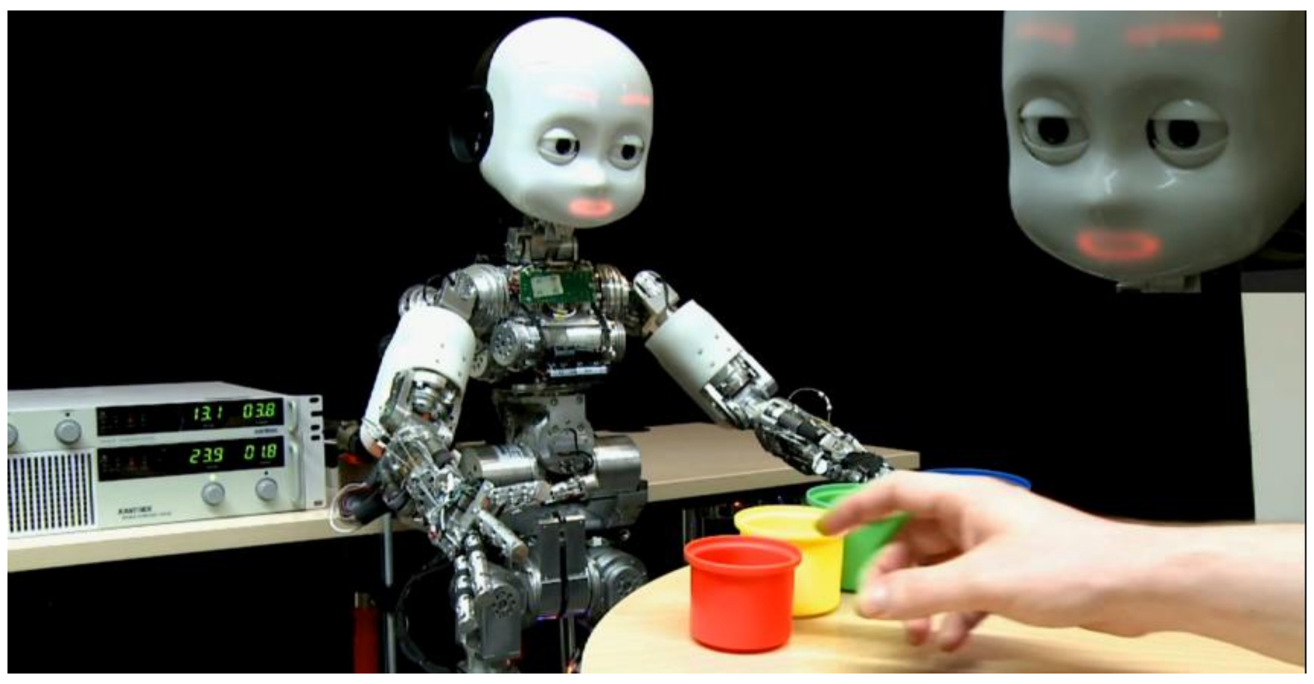
The ITALK project aims to develop artificial embodied agents able to acquire complex behavioural, cognitive, and linguistic skills through individual and social learning. This will be achieved through experiments with the iCub robot to **learn to manipulate objects** and tools autonomously, and **learn to communicate** with other robots and humans, and to adapt to changing internal, environmental, and social conditions.

The project will lead to the development of:

- new **theoretical insights, models and scientific explanations** of the integration of action, social and linguistic skills to bootstrap cognitive development
- new **interdisciplinary sets of methods** for analysing the interaction of language, action and cognition in humans and artificial cognitive agents
- new **cognitively-plausible engineering principles** and approaches for the design of robots with behavioural, cognitive, social and linguistic skills
- **robotic experiments** on object manipulation and language with the iCub robot



The Open Source iCub simulator was developed in the first year and is now used by many labs outside the ITALK consortium.



Experiment with iCub on acoustic packaging

Selected publications

- Saunders J., Nehaniv C.L. & Dautenhahn K. (2008). What is an Appropriate Theory of Imitation for a Robot Learner? *ECSIS Symposium on Learning and Adaptive Behaviors for Robotic Systems.*
- Schillingmann L., Wrede B. & Rohlfing K. (2009). Towards a computational model of acoustic packaging. *ICDL2009* (*best paper*)
- Tuci E., Massera G. & Nolfi S. (2009). Active categorical perception in an evolved anthropomorphic robotic arm. *IEEE International Conference on Evolutionary Computation*.
- Tikhanoff V., Cangelosi A., Fitzpatrick P., Metta G., Natale L. & Nori F. (2008). An open-source simulator for cognitive robotics research. *Proceedings of IEEE PerMIS'08.*

Highlight of Results in Year 1

Roadmap. The consortium has produced a RoadMap for research in developmental robotics, with respect to future challenges on the integration of action and language knowledge in robots. See milestones in table below.

iCub Simulator. A new Open Source iCub simulator software was produced. This is available at: http://eris.liralab.it/italk

Social learning experiments. We extended the ROSSUM learning architecture to a humanoid robot platform, and work has commenced on the experimental issues for various aspects of negation and grammar induction.

Cognitive linguistics grammar learning scenarios. Empirical analyses of child-directed and robot-directed speech interactions led to the definition of incremental cognitive linguistic scenarios for language learning experiments.

Acoustic packaging. Acoustic packaging has been observed as a means of communication towards infants when adults demonstrate actions. A computational model of detecting Acoustic Packaging has been implemented on iCub. We applied the concept of contingency to our studies on human-robot-interaction and found that in comparison to an interaction with a child or adult, people show little eye gaze towards a virtual robot, suggesting that contingency of the interaction is impaired.

Cognitive biases. Initial experiments on category learning and naming in human-robot interactions have demonstrates the presence of a spatial/location bias, previously observed in developmental psychology.

Action learning	Learning of simple actions (primitives). Capacity to categorise and name objects, events and states	Acquisition of hierarchical and compositional actions	Learning the association between syntactic constructions and composite actions via social learning	Social based acquisition of action generalization rules Ability to correlate action and language generalization	Ability to generalize over goals Ability to correlate recursive/composite actions with recursive linguistic expressions	Ability to learn rich action repertoires based on social/linguistic descriptions
Language learning	Naming of individual objects . Acquisition of early, holophrastic, natural language utterances in embodied learning tasks	Naming of individual events and states. Embodied learning of item-specific early syntactic constructions from verbal human-robot interactions	Bootstrapping of compositional linguistic structures and contextually embedded syntactic constructions from embodied verbal interactions.	Development of general-purpose grammatical constructions and syntactic competence	Scalable lexicon, grammar and discourse learning from embodied linguistic interaction with humans	Interactional acquisition of symbolic communication systems sharing relevant properties with natural language
Social learning	Harnessing of elementary non-verbal social cues (gaze, turn-taking, mirroring etc.) to enhance social learning for language and skill acquisition. Modelling intermodal learning (acoustic packaging)	Development of a tutor spotter for social learning scenarios Joint intentional framing and referential intent. Acquisition of negation usage of various types (e.g. refusal, absence, prohibition, propositional denial)	Development of architectures for pragmatic skills and use of prosody for grammatical learning. Harnessing of Model/Rival learning, motivational systems and predictive social interactions.	Exploiting interactions of prosody, internal motivation, inter-subjectivity and pragmatics in language acquisition and dialogue. Developing architectures based on intermodal learning and sensitivity to a tutor	Temporally extended understanding of social motivations intentions of other minds, and (auto)biographic and narrative (re)constructions. Development of first systems capable of sequential organisation of interaction	Development of systems that are capable of social learning and pragmatic organisation of interaction in various scenarios
Cognitive integration	Integration of basic action and naming representations and emergence of shared representation roles for both actions and names	Simulation of Action-Language Compatibility effects. Co-evolution of action and language skills for simple grounded lexicons.	Computational neuroscience models of action and language integration	Use of general purpose grammatical constructions for the creation of new complex motor and perceptual concepts	Scalable lexicons of abstract concepts based on the developmental acquisition of a grounding kernel	Acquisition of open repertoires of compositional actions and lexicons sharing natural language properties
	(End Year 2 italk)	***(End Year 4 italk)***	***(post-italk: 6-8 years' goal)***	***(10 years' goal)***	***(15 years' goal)***	***(20+ years' goal)***
TIME						

Milestones in the ITALK Roadmap on language and action integration research

ITALK researchers:
A Cangelosi - T Belpaeme - A Morse
D Marocco - M Peniak - C Larcombe
G Metta - G Sandini - L Fadiga
F Nori - L Natale - V Tikhanoff
A Gijsberts - A Sciutti
G Sagerer - B Wrede - K Rohlfing
L Schillingmann - K Pitsch - K. Lohan
S Nolfi - E Tuci - G Massera
C Nehaniv - K Dautenhahn - C Lyon
J Saunders - F. Foester - Y Sato
K Fischer - A Zeschel - J Tani

iit istituto italiano di tecnologia · Universität Bielefeld · University of Hertfordshire · University of Southern Denmark · Brain Science Institute RIKEN · University of Plymouth

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