Project acronym: ITALK

Project full title: Integration and Transfer of Action and Language Knowledge in Robots

Grant agreement no: 214668

List of Beneficiaries

Beneficiary			Country	Date of entry	Date of exit
No.	Name	Short name			
1 (coordinator)	UNIVERSITY OF PLYMOUTH	PLYM	United Kingdom	Month 1	Month 48
2	FONDAZIONE ISTITUTO ITALIANO DI TECNOLOGIA	IIT	Italy	Month 1	Month 48
3	UNIVERSITAET BIELEFELD	BIEL	Germany	Month 1	Month 48
4	CONSIGLIO NAZIONALE DELLE RICERCHE	CNR	Italy	Month 1	Month 48
5	THE UNIVERSITY OF HERTFORDSHIRE HIGHER EDUCATION CORPORATION	UH	United Kingdom	Month 1	Month 48
6	SYDDANSK UNIVERSITET	USD	Denmark	Month 1	Month 48
7	THE INSTITUTE OF PHYSICAL AND CHEMICAL RESEARCH	RIKEN	Japan	Month 1	Month 48

ITALK
Integration and Transfer of Action and Language Knowledge in Robots

Project Summary

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 the development of cognitive robots, such as the iCub humanoid platform, that learn to handle and manipulate objects and tools autonomously, to cooperate and communicate with other robots and humans, and to adapt their abilities to changing internal, environmental, and social conditions.

The main theoretical hypothesis behind the project is that the parallel development of action, conceptualisation and social interaction permits the enhancement of language capabilities, which on their part enrich cognitive development. This is possible through the integration and transfer of knowledge and cognitive processes involved in sensorimotor learning and the construction of action categories, imitation and other forms of social learning, the acquisition of grounded conceptual representations and the development of the grammatical structure of language. Such a developmental approach towards the integration of action, conceptualisation, social interaction and language has fundamental technological implications for designing communication in robots and overcoming current limitations of natural language interfaces and human-robot communication systems.

This new project will be based on a highly interdisciplinary approach. The core of the project revolves around the use of developmental and self-organising robotics and on theoretical and empirical research based on cognitive linguistic analyses, neuroscientific studies of action and language learning, hybrid human-robot interaction experiments, and developmental studies on language development. The novelty and uniqueness of this project lies in its multi-methodological investigation of the integration and bootstrapping of cognitive system due to the parallel co-development of action, social and linguistic capabilities.

New research will lead to the development of: (i) new theoretical insights, models and scientific explanations of the integration of action, social and linguistic skills and in particular on the hypothesis that action, social and linguistic knowledge co-develop and further bootstrap cognitive development, (ii) new interdisciplinary sets of methods for analysing the interaction of language, action and cognition in humans and artificial cognitive agents, (iii) new cognitively-plausible engineering principles and approaches for the design of robots with behavioural, cognitive, social and linguistic skills.

This will be possible through the participation of leading international scientists with expertise in cognitive and developmental robotics, language modelling, neuroscience of action and language, and cognitive and developmental linguistics. The consortium includes researchers from EU countries, as well as participants from Japan and other international collaborators and advisors.

Vision

The project aims to develop artificial embodied agents able to acquire complex behavioural, cognitive, and linguistic/communicative skills through individual and social learning. We aim at designing cognitive robotic agents able to handle and manipulate objects and tools autonomously, to cooperate and communicate with other robots and humans, and to adapt their abilities to changing internal, environmental, and social conditions. The design of object manipulation and communication capabilities will be inspired by an interdisciplinary empirical and theoretical investigation of linguistic and cognitive development in children and adults, as well as of robotic experiments with the iCub humanoid robot. The main theoretical hypothesis behind such an interdisciplinary enterprise is that *the parallel development of action and social interaction permits the bootstrapping of language capabilities, which on their part enhance cognitive development*. This is possible through the integration and transfer of knowledge and cognitive processes involved in sensorimotor learning and the construction of action categories, imitation and other forms of social learning, the acquisition of grounded conceptual representations and the development of the grammatical structure of language. Such a developmental approach towards the integration of action, conceptualisation, social interaction and language has fundamental technological implications for designing communication in robots and overcoming current limitations of natural language interfaces and human-robot communication systems.

To achieve this aim we will make the following methodological choices for the design of and experimentation with our cognitive robots: (i) Agents acquire their skills in interaction with the physical environment, given the importance of embodiment, sensory-motor coordination, and action oriented representation; (ii) Agents acquire their skills in interaction with the social environment. (iii) Behavioural, cognitive and linguistic skills co-develop and co-shape each other. To overcome current limitations of established engineering approaches to robotics, and in particular the lack of adaptation and generalisation in open-ended and dynamic environments, the leading-edge approaches of developmental/epigenetic robotics, self-organising robotics, human-robot interaction, and neuroscientific analysis of human-robot communication will be employed and further developed. The robotic approaches will be integrated with the development of recent cognitive/constructivist and developmental linguistic theories. The research will result in cognitively plausible and innovative engineering principles, techniques and approaches for the design of cooperative and linguistic capabilities in cognitive robots.

Tasks for action and language experiments at Plymouth

Experiments on compositional and hierarchical actions

This task will be based on a series of robotic experiments including manipulation actions such as touch/move/modify objects. In addition, more advanced experiments will look at action patterns based on combination and sequences of movements. Tasks will be inspired by object manipulation and tool making/use observed abilities in primates and humanoids, and their relationship with the development of linguistic capabilities (e.g. Tanaka & Tanaka 1982; Greenfield 1991). Experiments will regard tasks such as:

a. Inserting objects into corresponding holes in a box;
b. Serializing nested cups;
c. Inserting variously shaped objects into corresponding holes;
d. Stacking up wooden blocks;
e. Learning to use a tool (e.g. “stick”) to push an object:
f. Constructing a composite tool (e.g. combine a stick with a cuboid object – as with the handle and head of a “hammer”);
g. Using tool on a third object (e.g. to crack open a spherical object – “nut”).

A first instance of the experiments could be to let the robot acquire manipulation capabilities by calibrating its joints and hand-eye coordination, recognizing colour, form/shapes and moving objects. Follow up experiments will involve a human user, or another robot, that provides linguistic instructions for object manipulation/assembly task (cf. Task 4.3)

We will also investigate, using aspects of extended ideomotor theory (as in Hommel & Prinz, 2001) applied to robots, how to develop more complex compositional and hierarchical actions via scaffolded learning.

Ideomotor theory is based on the idea that actions can be instigated based on their imagined effects and emphasises that perception and motor execution share the same coding structure (a common currency). This commonality allows for measures of similarity to take place between what is perceived and what has been learned based on previous motor executions. Experiments where these motor experiences are built

hierarchically by tutored scaffolding will be carried out via actions moulded on the robot body by a teacher and via observational learning.
This task will be carried out by the PLYM team, in collaboration with the IIT, CNR and UH groups.

Transition from single-word lexicons to compositional languages

Developmental robotic experiments will address the transition from single-word non compositional lexicons to languages where robots are able to use simple grammatical constructions such as “Robots grasps apple” and “Robot puts stick on cube”). Experiments will follow Steels’s (2005) grammaticalization stages III (on simple compositionality) and subsequently stage IV (on situation-specific grammar constructions for multiple object and predicate meanings). Robots will be exposed to adult-like linguistic descriptions whilst they are leaning to perform hierarchical object manipulation tasks as in task 1.4 (e.g. use tool, object staking).