PACO-PLUS: Perception, Action und Cognition through Learning of Object-Action Complexes

The PACO-PLUS project

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- University of Göttingen, Germany
- Aalborg University, Denmark
- Jozef Stefan Institute, Ljubljana, Slovenia
- Consejo Superior de Investigaciones Científicas, Barcelona, Spain
- Leiden University, Netherlands
- University of Edinburgh, Edinburgh (United Kingdom)
- ATR - Computational Neuroscience Laboratories, Kyoto, Japan

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Approach and Guiding Principles

PACO-PLUS aims at the design of a cognitive robot that is able to develop perceptual, behavioural and cognitive categories in a measurable way and communicate and share these with humans and other artificial agents. The main paradigm of the project is that *Objects and Actions are inseparably intertwined* and that categories are therefore determined (and also limited) by the action an agent can perform and by the attributes of the world it can perceive; the resulting, *so-called Object-Action Complexes (OACs)* are the entities on which cognition develops.

Entities (“things”) in the world of a robot (or human) will only become semantically useful “objects” through the action that the agent can/will perform on them. Other agents can take the role of an “object with active properties”. Each active agent is just another instance of an OAC.

Cognition is based on recurrent processes involving nested feedback loops operating on, contextualizing and reinterpreting object-action complexes. This is done through actively closing the perception-action cycle. A cup becomes a cup because you can fill it. If you turn it around it is not a cup anymore but maybe you can put another object on it. Actions define the meaning of an Object and vice-versa Objects suggest actions.

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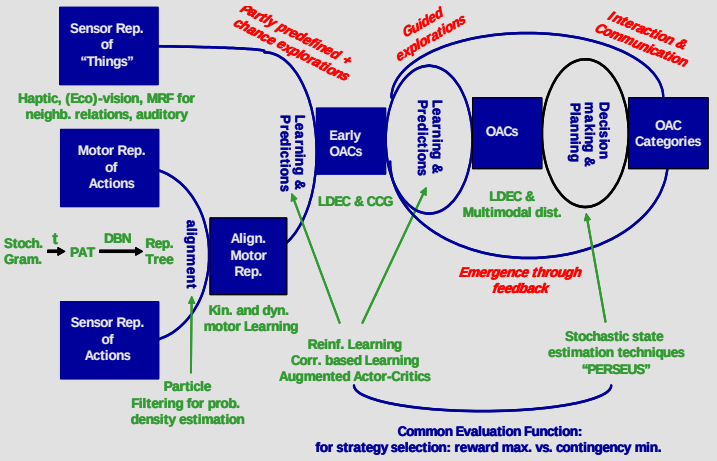
Project Objectives

- Design and develop a technical cognitive system with innate oculomotor behaviours and sensory-motor primitives to enable learning, imitating and understanding actions of humans as well as exploration of unknown objects. The system should be able to acquire cognitive capabilities through continuous interaction and exploration.
- Define invariant, multi-sensory representations of objects through actions performed on them and processes by which these representations can be derived, refined and learned.
- Define a probabilistic, hierarchical representation for actions on objects. Design and develop the process of sensory-motor matching and the learning mechanisms that can be used to acquire early OACs.
- Derive new actions by means of extrapolation within the now continuous OAC space along constraints given by motor capabilities and Gestalt statistics.
- Show that appropriate grammar fragments for representative European and non-European languages including English can be machine-learned from exposure to strings paired with plan- and action- representations induced automatically for non-linguistic object-oriented purposeful cooperative action in the world by robots
- Devise a theoretical framework for the design of a conjoint measure for learning- (and action-) success. Devise methods which allow changing strategies for learning using return maximization and/or contingency minimization as required to achieve a certain learning goal. Embed and use these methods on the robot platforms of PACO-PLUS.
- Devise a decision making and planning system operating in a continuous perception-action space, which is able to incorporate new OACs in interplay with the learning component.

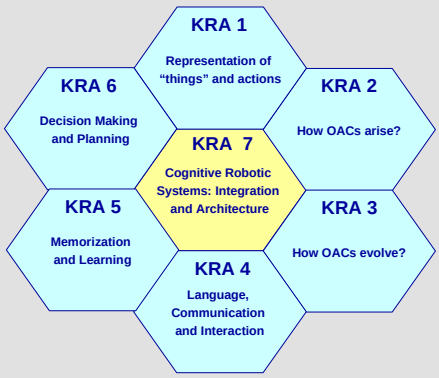
Theoretical Framework

Theory of Event Coding (TEC) Hommel et al. 2001 BBS	Computational Theory of Mind Putnam, 1961; Dennett 1984, Porr & Wörgötter 2005	Language Quine 1960, Siskind 1996, Villavicencio 2002 Steedman 2002	Theory of Learning Camerer 2003 Torras 2002, Porr & Wörgötter 2003
Shared code for perception and action exists.	Solving the Frame Problem by *embodied, situated, adaptive* agents reacting to disturbances in the environment in a *proactive, anticipatory* way.	Language learning is easy. Developing the concepts that underlie it is hard.	Convergent learning arises from minimization of contingencies together with the maximization of return.
OACs: Technical version of TEC	Richly integrated robotics platform(s) process a continuum of multiple stimuli while producing meaningful behaviour	OACs will constitute shared and grounded symbols as the basis of language	Conjoint evaluation function for success of the system

Algorithmic Framework



Key Research Activities



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