Project no.:	**IST-FP6- IP-027657**
Project full title:	**Perception, Action & Cognition through Learning of Object-Action Complexes**
Project Acronym:	**PACO-PLUS**

Deliverable no.: D1.1.2

Title of the deliverable: Integration Report I

Contractual Date of Delivery to the CEC:	**31. July 2007**
Actual Date of Delivery to the CEC:	**31. July 2007**
Organisation name of lead contractor for this deliverable	University of Karlsruhe (UniKarl)
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Work package contributing to the deliverable:	WP1, WP2, WP4, WP8
Nature:	R
Version:	1.0
Total number of pages:	4
Start date of project:	1st Feb. 2006 **Duration:** 48 month

Abstract:

The technical report describes the further development of the PACO-PLUS platforms and the work on software integration. This includes the development of the humanoid head for active vision perception and the haptic sensor system for different grippers used in the project. Furthermore, the integration efforts of different components within the project is described and a summary of the communication between the groups is given.

Keyword list: Active foveated vision system, tactile hand sensors, software and hardware interfaces, meetings and communication between the groups

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0. Introduction

This document presents the further development of the hardware and software components that are being developed for the PACO-PLUS project and gives an overview about the communication that took place between the partners.

1. Hardware Development

The further development of the hardware includes the improvement of the humanoid head and the tactile sensor system for the five-finger hand at UniKarl and the jaw gripper at SDU.

- The developed humanoid head for foveated active vision has been improved in terms of robustness, user-friendliness and maintenance. The sensor system of the head consisting of two cameras per eye, one with a wide-angle lens for peripheral vision and one with a narrow-angle lens for foveal vision and six microphones has been extended by a gyroscope as a measurement unit for stabilization and control of the cameras.

- Two copies of the head have been built at UniKarl and will be delivered to JSI and KTH in September 2007. The heads are exact copies of the head used at UniKarl on the humanoid robot ARMAR-III. The fact of using the same hardware with the same controller will lead to a further minimization of the overhead in the integration of several vision components in the PACO-PLUS robot platforms.

- The first version of the artificial skin segments necessary for haptic exploration has been improved. In this context, a miniaturized, modular tactile sensor has been realized. In particular, new so called actuator pads used to cover the sensor elements have been developed. These pads serve as a force concentrator which lead to a significant increasing of the sensitivity of the sensor system. Additionally, a revised version of the hardware necessary for data acquisition has been realized and successfully tested. The new skin segments have been evaluated on the five finger hand and the jaw gripper at SDU and UniKarl.

2. Software Integration

- Implementation of sensorimotor primitives that can support learning object representations on ARMAR-III. JSI and UniKarl have implemented sensorimotor primitives for learning object representations (described in D2.1 and D2.2) on the humanoid robot ARMAR-III.

- For the integration low-level of robot vision and high-level planning, SDU and UEDIN proposed a simple object manipulation task scenario and started with first steps towards the integration. A similar scenario will be also implemented at UniKarl on the humanoid robot ARMAR in the next months.

- We have started the integration of the early-cognitive-vision system MoInS developed at SDU and BCCN on the humanoid robot ARMAR at UniKarl. For this purpose, initial work started to evaluate the MoIns by using images taken from the UniKarl head. Additionally, we have started with the parallelization of MoIns on the distributed vision cluster used at UniKarl and JSI for real-time vision applications.

- For the implementation of Q-learning on the humanoid robot ARMAR-III in the context of reaching, both a common protocol and an appropriate interface on ARMAR have been defined and implemented.

3. Communication between the groups

The members held a number of meetings and phone conferences, which will be listed in the activity report. In addition, there were numerous one-to-one discussions between the subgroup members as well as bilateral visits of project members on the sites of the partners.

The meetings related to integration efforts took place as follows:

- **April 25th- 26th** General meeting in Karlsruhe attended by all workpackage leaders for the preparation of the first PACO-PLUS review on April 26th, 2007

- **April 13th – July 20th** Visit of Damir Omrcen (JSI) in Karlsruhe

  Implementation and testing of sensorimotor processes for learning object representations on ARMAR-III

- **May 8th** meeting in Karlsruhe attended by Florentin Wörgötter (BCCN) and Alejandro Agostini (CSIC), Tamim Asfour and Pedram Azad (UniKarl)

  Discussion on how to learn a mapping from situations to actions (a policy) to fulfill a task using the help of an instructor (categorization rule system)

- **June 18th-20th** meeting in Karlsruhe attended by Florentin Wörgötter and Minija Tamosiunaite (BCCN), Tamim Asfour and Kai Welke, Pedram Azad and Rüdiger Dillmann (UniKarl)

  Discussion about implementation of Q-Learning on ARMAR-III

- **June 18th-20th** meeting in Odense attended by Alexander Bierbaum (UniKarl), Norbert Krüger, Morten Kjærgaard and Dirk Kraft (SDU)

  Experiments for the characterization of the new tactile sensors on the Stäubli arm at SDU

- **June 3rd -4th** meeting in Karlsruhe attended by Florentin Wörgötter (BCCN), Bernhard Hommel and Pascal Haazebroek (UL), Norbert Krüger (SDU), Justus Piater and Renaud Detry (ULg), Damir Omrcen (JSI), Alexander Bierbaum, Kai Welke, Tamim Asfour and Rüdiger Dillmann (UniKarl).

  Definition of a developmental scenario and discussion on closed-loop-perception-action-learning.

- **July 9rd -12th** meeting in Odense attended by Christopher Geib, Ron Petrick (UEDIN), Norbert Krüger and Dirk Kraft (SDU)

  First Testing and further specification on integration of kow level and high level modules on the SDU robotic platform.

- **July 18th-20th** meeting in Karlsruhe attended by Morten Kjærgaards (SDU) and Alexander Bierbaum (UniKarl)

  Software integration of tactile sensor modules and driver for I²C bus.