EUCOGNITION Network Action. Report

Tactical Modular Conception for the Internal Simulation of Perception in Cognitive Systems. Experiments on the Aibo robot

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Introduction

Goal of the action is developing a tactical modular architecture based on Intelligent Hardware Units for the emergence of behaviors. The approach is interesting from three points of view:

1. dynamical hypothesis of cognition: a collaborative control architecture with internal simulation of perception;
2. behavior-based robotics: a novel tactical modular conception behavior;
3. cognitive systems: research on the mind-body separation problem by using internal robotics.

Start of the action was July 1st, 2006, extended for three months: two weeks in July have been employed for a short-visit to the DIBE and DIST labs at the University of Genoa for developing about and improving our approach. Rest of the time, until end September, have been used for developing the remaining pre-fixed outcomes. These concrete outcomes of the action can be enumerated as,

1. short-term visit to the University of Genoa working on the approach;

2. pilot test-bed evaluation of the tactical modular conception on the Aibo robot;

3. demonstration of the system in the form of multimedia video clips;

4. articles for general readership about the approach development, experimentation and results;

Produced material

On the website http://www.upcnet.es/∼upc15838/eucognition.html are available all the produced outcomes. They include,

Reports and Articles. Two main documents have been generated.

- Cecilio Angulo, Ricardo A. Téllez and Diego E. Pardo. *Tactical Modular Conception for the Internal Simulation of Perception in Cognitive Systems*. Working scientific report to be submitted in an international journal.

This document is the main scientific written outcome. The new paradigm based on tactical modularity is presented in this work. Using neural evolutionary robotics in the form of modules, the so-called Intelligent Hardware Units (IHUs), the new collaborative control architecture conception allows the emergence of a behavior-based system as the result of the interactions of the control system with both the external environment and the internal environment generated by the modules. As a consequence, the achieved fully separation between the autonomous agent's inner world and its external real world gives some lights about how the mind-body problem can be dissolved. Two experiments, the first one on a simple 2 IR sensors 2 motors simulated robot orbiting around an object and a second one about the generation of walking gaits on the Aibo robot illustrate the performance of the proposed paradigm and introduce discussion about concepts into the robot's inner world.

- Diego Pardo , Cecilio Angulo and Ricardo Téllez. *Cognitive Architecture for the Robot Learning of Sensorimotor Coordination*. Submitted to the 2007 IEEE International Conference on Robotics and Automation (ICRA'07) to be held in Roma, Italy, from April 10 to April 14, 2007.

Neural evolutionary algorithms used in the Intelligent Hardware Units disable any type of rigorous mathematical analysis of the dynamics generated, from the point of view of control engineering. For this reason a simplified structure working on linear dynamics has begun to be analyzed. In this document the Layered Cooperative Control (LCC) architecture is presented, a control scheme that allows to govern the dynamic behavior of an articulated mobile robot with several degrees of freedom (DOF) and redundancies. These type of robots need a high level of coordination between the motors performance to complete their motions, thus, a simplified IHU-based collaborative scheme is proposed, where the actuators involved in a specific task share information and then computing integrated control actions. The control functions are found using a stochastic reinforcement learning technique allowing the robot to automatically generate them based on experiences. Endowing the robot with this capacity intends to formulate a machine extrapolation of human cognition, understood like the interplay of brain, body and environment. Complex phenomenon as human-like intelligence can no be described by formulating primary laws, then, the design of the LCC is based on a modularization principle: complex overall behavior is the result of the interaction of individual simple components. Unlike the standard procedures, the LCC scheme is not meant to follow a trajectory generated by a planner, instead, it emerges as a consequence of the collaboration between joints movements that seek to achieve a goal. The learning of the sensorimotor coordination in a simulated humanoid is presented as a demonstration.

Evaluation on the Aibo robot. Pilot test-bed evaluation of the tactical modular conception on the Aibo robot has been widely discussed in the working scientific report through the complex task of generating a walking gait for the quadruped, a highly complex robot with several DOFs (see Figure 1). A total of 31 sensors and actuators are managed by the tactically modularized architecture. You can see video examples on the website http://www.ouroboros.org/evo_gaits.html

Multimedia video clips Demonstrations of the tactical modular conception have been performed in the form of four multimedia video clips.

- generating a walking gait for the Aibo robot: it illustrates the ability of the proposed architecture for generating complex behaviors on complex robots;
- finding and orbiting around an object with a simple simulated 2 wheeled

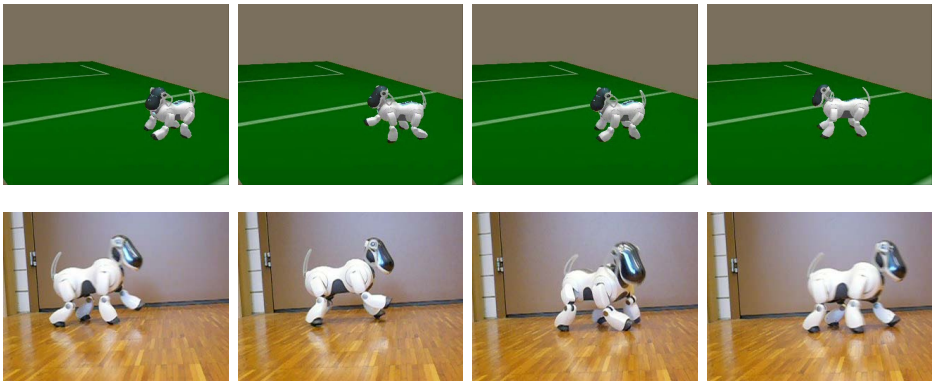

Figure 1: Sequence of pictures showing obtained walking behavior of Aibo in both simulated robot and real robot.

robot endowed with 2 IR sensors: it helps illustrating the internal models generated between IHU-sensors and IHU-motors (see Figure 2);

- the garbage collector problem: a popular problem developed for simulated Kephera robots in order to compare our proposed architecture with other state-of-the-art ones;

- simplified IHU-based tactical modular architecture (Layered Cooperative Control, LCC) accomplishing an average-complexity goal, not reachable with the standard controller, on a simulated humanoid robot.

Short-term visit to the University of Genoa. A mobility grant obtained from the Technical University of Catalonia to visit the SmartLab-DIBE in the University of Genoa for 4 months (March to June) gave me the opportunity to know the work developed at DIST and LIRA Lab around cognition. Fortunately, my application for continuing my research line on cognitive robotics was approved for the EUCOGNITION network and I had the opportunity to visit them for two weeks (July 12th-27th, 2006).

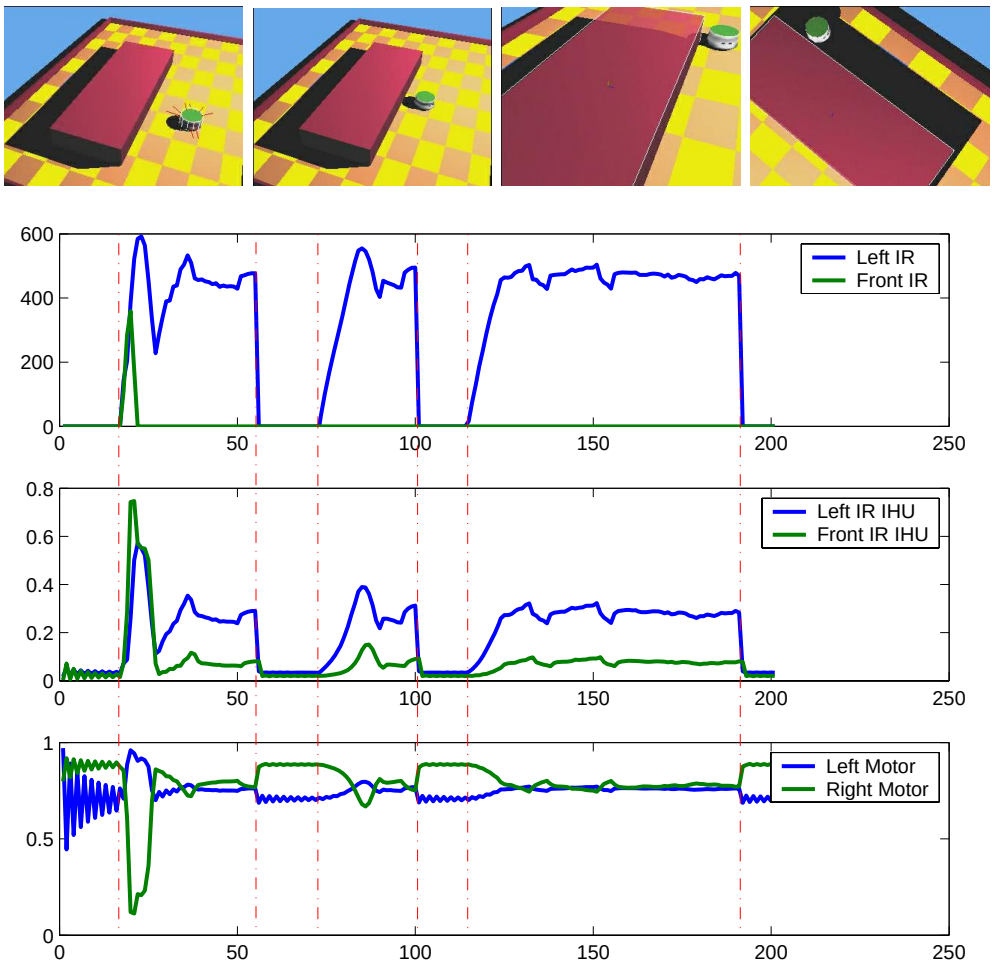

Figure 2: Upper: Sequence of pictures showing the orbiting behavior. Down: Signals from sensors, IHU sensors translation and IHU motor actuation.