# Robotic Open-Architecture Technology for cognition, Understanding, and Behaviours - FP6-IST-004370

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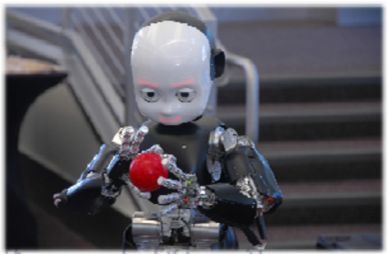
## Past

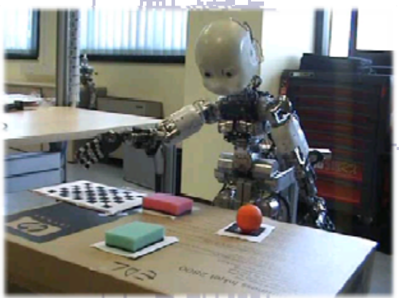
### Synopsis

RobotCub is a 5 years long project funded by the European Commission through Unit E5 "Cognitive Systems & Robotics". Our main goal is to study cognition through the implementation of a humanoid robot the size of a 3.5 years old child: the iCub. This is an open project in many different ways: we distribute the platform openly, we develop software open-source, and we are open to including new partners and form collaboration worldwide.



### Main achievements

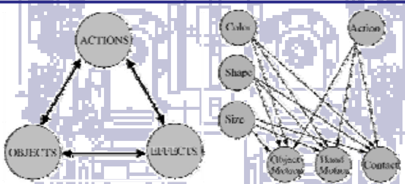
Defined and built a model of cognition starting from biological evidence
Design, build and duplicate a full-fledged humanoid robot called the iCub
Distribute our development platform Open Source
14 copies fabricated (12 distributed), 6 more in the production line
Continuation of the iCub activities beyond the end of the project



### The iCub

- 53 degrees of freedom, 41 in the upper body, 18 in the hands
- Cameras, microphones, gyroscopes, joint angle sensors, force/torque sensors
- Facial expressions
- 104 cm tall, 23 kg of weight
- Programmable low-level controllers and custom electronics
- High-performance middleware

## Present



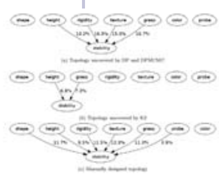

RobotCub introduced the idea of using Bayesian Networks (BN) to model the dependencies between robot actions, object characteristics and the resulting effects, therefore in practice modeling **affordances** along the way. We assumed that the robot had developed certain skills prior to be able to learn affordance: a motor repertoire (A), perhaps derived from experience, an object feature repertoire (F) also potentially acquired via object manipulation and the effects (E) resulting from manipulating the environment.
Experiments can be used to estimate the BN structure and parameters using different learning algorithms. These parameters can be updated online as the robot performs more experiments. Also, they can be updated by observation of other agents.
This model has some nice properties as for example:

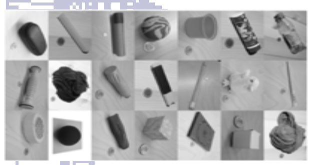
- Affordance learning through self-experience;
- Feature selection (or detection of irrelevant features);
- Affordance learning through self-observation (restricted to the update of the probability distributions);
- Usage of the model to perform prediction, recognition and planning.

The following table summarizes some of the basic operations that can be performed with the BN:

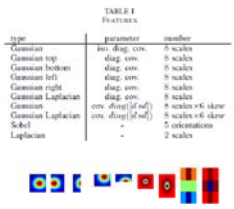
| Inputs | Outputs | Function |
|---|---|---|
| (O,A) | E | Predict effect |
| (O,E) | A | Recognize action & planning |
| (A,E) | O | Object recognition & selection |

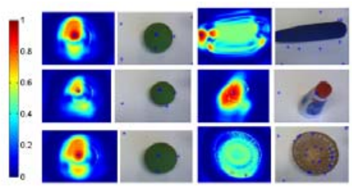
Examples of use of BN for modeling grasp stability from examples.



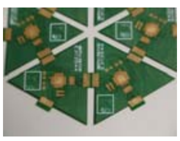


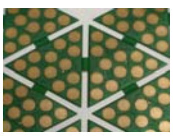
Another experiment addresses the problem of learning visual descriptors for affordance properties such as graspable. Learning is done through experimentation with the objects. Local visual descriptors of graspable objects are learned based on the return signal (success or failure) of the grasping action. Our method combines a Bayesian model of the probability of the action success based on Binomial-Beta distributions with a non-parametric kernel based approach. From a set of examples, it provides an estimate of the successful completion of an action upon the different parts of an object. It also provides information about the confidence of this estimate.



## Future





CHRIS, FP7-215805, http://www.chrisfp7.eu
ITALK, FP7-214668, http://italkproject.org
Roboskin, FP7-231500, http://www.roboskin.eu
Poeticon, FP7-215843, http://www.poeticon.eu

… and more, see http://www.robotcub.org and http://www.icub.org