The iCub Humanoid Robot Simulator

Vadim Tikhanoff(1), Paul Fitzpatrick (3), Francesco Nori (2), Lorenzo Natale(2),
Giorgio Metta (2) and Angelo Cangelosi (1)

(1) Adaptive Behaviour and Cognition Group, University of Plymouth, UK
(2) Humanoid Robotics Lab, Italian Institute of Technology, Genoa Italy
(3) LiraLab Lira-Lab University of Italy

The authors present the prototype of a new computer simulator for the humanoid robot iCub. The iCub is a new open-source humanoid robot developed as a result of the RobotCub project (robotcub.org), a collaborative European project aiming at developing a new open-source cognitive robotics platform. The iCub simulator has been developed as part of a joint effort with the European project "ITALK" (italkproject.org) on the integration and transfer of action and language knowledge in cognitive robots. This is available open-source to all researchers interested in cognitive robotics experiments with the iCub humanoid platform.

Computer simulations play an important role in robotics research. Despite the fact that the use of a simulation might not provide a full model of the complexity present in the real environment and might not assure a fully reliable transferability of the controller from the simulation environment to the real one, robotic simulations are of great interest for cognitive scientists. A robotic platform simulator can be used as a tool for testing algorithms in order to quickly check for any major problems prior to use of the physical robot. A simulator for the iCub robot magnifies the value a research group can extract from the physical robot, by making it more practical to share a single robot between several researchers. The fact that the simulator is free and open makes it a simple way for people interested in the robot to begin learning about its capabilities and design, with an easy "upgrade" path to the actual robot due to the protocol-level compatibility of the simulator and the physical robot. And for those without the means to purchase or build a humanoid robot, such small laboratories or hobbyists, the simulator at least opens a door to participation in this area of research.

The iCub simulator has been designed to reproduce, as accurately as possible, the physics and the dynamics of the robot and its environment. The simulated iCub robot is composed of multiple rigid bodies connected via joint structures. It has been constructed collecting data directly from the robot design specifications in order to achieve an exact replication (e.g. height, mass, Degrees of Freedom) of the first iCub prototype developed at the Italian Institute of Technology in Genoa. The total height is around 105cm, weighs approximately 20.3kg and has a total of 53 degrees of freedom (DoF). These include 12 controlled DoFs for the legs, 3 controlled DoFs for the torso, 32 for the arms and six for the head. The environment parameters on gravity, objects mass, friction and joints are based on known environment conditions.

The iCub simulator uses ODE [13] (Open Dynamic Engine) for simulating rigid bodies and the collision detection algorithms to compute the physical interaction with objects. The same physics library was used for many projects including the Gazebo project and the Webots

commercial package. ODE is a widely used physics engine in the open source community, whether for research, authoring tools, gaming etc. Although ODE is a good and reliable physics engine, computing all the physical interaction of a complex system can take a good deal of processing power. Since ODE uses a simple rendering engine based on OpenGL, it has limitations for the rendering of complex environments comprising many objects and bodies. This can significantly affect the simulation speed of complex robotic simulation experiments. It was therefore decided to use OpenGL directly combined with SDL [15], an open source cross platform multimedia library. This makes it possible to render the scene with much more ease and to carry out computationally-efficient simulation experiments.

As for its software architecture the simulator uses YARP [?????] (Yet Another Robot Platform). YARP is an open-source software tool for applications that are real-time, computation-intensive, and involve interfacing with diverse and changing hardware. The simulator and the actual robot have the same interface either when viewed via the device API or across network and are interchangeable from a user perspective. A great deal of effort has been made to replicate the controller of the iCub in order to have the same type of trajectory in a position over torque control. The simulator, like the real robot, can be controlled directly via sockets and a simple text-mode protocol; use of the YARP library is not a requirement. This can provide a starting point for integrating the simulator with existing controllers in esoteric languages or complicated environments. For the vision we use cameras located at the eyes of the robot which in turn can be sent to any workstation using YARP in order to do develop vision analysis algorithms.

The system has full interaction with the world/environment. The objects within this world can be dynamically created, modified and queried by simple instruction resembling those that YARP uses in order to control the robot.

The current version of the iCub simulator has been used for testing and research by partners in the RobotCub and ITALK project. In addition to being used for experiments on the development of controllers for the iCub robot, some groups have used the simulator to create a mental model [?????] used by the robot to represent the current state of the environment.

Future plans on the simulator development will mostly involve the design of functionalities to model and interact with the physical environment. For example, this will allow the users to modify the objects in the world where the iCub resides, in order to allow different types of experiments. Finally, further work will focus on the systematic testing and replication of simulation studies with the physical robot.