Intelligent humanoids

(i.e. my CV explained, from 2005 to 2015)

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The future of humanoid robots is to become efficient helpers for humans, both in the execution of everyday tasks and in the accomplishment of tedious and dangerous works. Driven by this vision, researchers have been challenged to design more and more complex robots, that show an increasing number of degrees of freedom and sensors; these robots should be able to cope with the unstructured environment in which humans daily live and act. In particular, it would be desirable that robot behaviors become autonomous (not requiring the supervision of a human expert) and flexible (applicable to different situations and contexts).

To achieve this, robots have to learn from the interaction with the environment, as humans do. In the past 10 years I have been studied this general topic, and applied my research to different humanoid robots, that I made... a bit more intelligent than they were before :)

[2013--today (2015)]

I am currently Associate Researcher at VisLab (ISR/IST, Lisbon, Portugal), holding a Marie Sklodowska-Curie Grant (IEF) for the realization of the Project LIMOMAN [PIEF-GA-2013-628315] since May 2014. The project focuses on three main aspects of human motor control that can be combined to improve the ability of current robots in dexterous manipulation: internal models, developmental learning and multisensory integration.
I investigated the use of different probabilistic techniques for the incremental learning of both kinematic and dynamic internal models for the humanoid robot iCub. Such models have been used for motion control, prediction and planning. In [7] the IMLE (Infinite Mixture of Linear Experts) algorithm was used to incrementally learn the robot dynamic model. This internal model is continuously updated to cope with changes that are caused by the manipulation of objects of different weights (i.e. different contexts); the detection of the different dynamic context is automatic and based on the statistics of the online gathered sensory data (i.e. probabilistic learning). The internal model is encoded with a compact representation that can be efficiently used for real-time robot control. In [5] the use of Gaussian Radial Basis Functions (RBFs) was explored to obtain a compact representation of dynamic robot movements. Such representation can then be adapted to different context (e.g. different length, velocity, position of the movement) by using quadratic programming techniques. In [1,2,6,10] Particle Filtering techniques were employed to continuously update a kinematic internal model of the robot eye-hand coordination during reach-to-grasp movements. Visual and proprioceptive data collected online during the robot operations were combined. In [9] the use of Bayesian Networks was investigated to model the sensorimotor capabilities of the

robot relying on the concept of object affordances; the robot learns the model by exploring the environment through object manipulation actions. Data compression techniques have been also explored to optimize the structure of the Bayesian Network and achieve better accuracy and generalization in the prediction. The predictions based on the learned internal model are used for tool use and probabilistic planning, as shown in [3].

I am also involved (since 2013) in the EU Project Poeticon++, whose goal is to integrate natural language and visual action/object recognition tools with motor skills and learning abilities, in the iCub humanoid robot. My main task will be the implementation of learning strategies that allow the co-development of motor and perceptual skills, both through autonomous exploration and through interaction with human partners [3,5,9,11,13].

[2010--2012]

For two years I was Associate Researcher at Takanishi Laboratory, Humanoid Robotics Institute of Waseda University, Tokyo, Japan. The research goal was to implement learning-based whole-body reaching on a full humanoid robot (KOBIAN-R), following bio-inspired principles and supporting autonomous and flexible behaviors. I studied how the robot could build autonomously a motor representation of its workspace from the goal-directed interaction with the environment [21,22,24], and how such knowledge could be used to plan and execute complex behaviors, such as bimanual reaching and whole-body optimal reaching [12]. I also investigated how to reach with different tools [15,16] and how to integrate locomotion [14]. Moreover, I studied how the robot could use whole-body behaviors to interact with people [17,18,19], and how to improve human-like design of humanoid robots [20]. Part of my studies were in the framework of the EU Project Robosom.

[2006--2010]

I conducted my PhD research at the Italian Institute of Technology (Genoa, Italy), and obtained the title in 2010 with a thesis on autonomous sensorimotor learning in humanoid robots. The research included study on the basis of learning in biological and artificial systems, robot advanced programming and coordinated control of multiple DOFs, robot maintenance and updating (software, firmware, mechanics, electronics, computers network). I applied my research on the humanoid robot James, that learned autonomously how to move its human-like neck [26,28] and how to reach for visually detected objects [23]. I also studied how to obtain and use force/torque sensing on the robot [25,27], and explored the use of motor primitives for motion control [29]. Part of my studies were in the framework of the EU Projects Contact and RobotCub.

[2005--2006]

I obtained my Master Degree in Computer Engineering (with specialization in Robotics and Automation) in 2006, with a thesis on design and realization of tactile sensors for an anthropomorphic robotic hand, working at the LIRA-Lab laboratory (University of Genoa, Italy). The research included study on materials (elastomers), electronics (data collection board, cable routing, signal processing), software and firmware programming and robot control. The preliminary version of the sensors is described in [30]; they are integrated on a robot hand and used for object classification. Then, I recently realized an improved version of the sensors, that are accurately characterized [4] and used in reach-to-grasp robot movements [8].

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