

# Preface

Until recently, neuroscience and robotics were utterly unrelated subjects, requiring completely different background, skills and methodologies. Nowadays, the distance between the two fields is being constantly shortened by the progress in computational modeling, and the construction of increasingly skilled autonomous artificial agents inspired by the abilities and behavior of living beings. The astounding discoveries that are being recently achieved by brain scientists constitute the fundamental building blocks for computational neuroscience and biomimetic robotics. This book presents interdisciplinary research which pursues the mutual enrichment of neuroscience and robotics research.

Grasping and manipulation of every kind of object is arguably the most distinctive practical skill of human beings, and erect posture has likely evolved in order to free the upper limbs and make of the hands two unmatched tools. Despite the great efforts that are being put on it, grasping in robotics is largely an unsolved problem, due to its inherent complexity and the still limited adaptive skills of present day robots in visual and visuomotor behaviors. In our approach, the task of object grasping is dealt with by mimicking, as accurately as possible, the brain mechanisms which underlie planning and execution of grasping actions in humans and other skilled primates.

The principal contribution of the presented research is the definition and implementation of a functional model of the brain areas involved in vision-based grasping actions. The model constitutes a bridge between cognitive science and robotics research, and includes all the steps required for performing a successful grasping action from visual data. The subdivision of visual processing into the dorsal and ventral cortical streams, respectively dedicated to action-oriented and perception-oriented vision, is thoroughly taken into account. Hypotheses regarding the mechanisms that allow to achieve complex interactions with the peripersonal space, through the integration of the data provided by the streams, are put forth. Transfer functions are proposed for modeling the visuomotor transformations performed by the brain areas most critical in grasp planning and execution.

The particular attention payed to the functional role of brain areas makes the model especially suitable for implementation on a real robotic setup, and a full

vision-based robotic grasping system has been developed following its guidelines. Visual information regarding an unknown target object is acquired and transformed into a basic representation onto which two concurrent processing mechanisms are performed. The dorsal stream extracts and analyzes possible grasping features, while the ventral stream performs object classification. Dorsal and ventral visual data are merged for estimating shape, size and position of the object, and a grasping plan is devised which takes into account both visual data and proprioceptive information on the state of the arm and hand. Grasp execution is performed with the aid of tactile feedback in order to achieve a stable final hand configuration.

Grasping experiments have been performed on real objects unknown to the system, and the obtained results attest the achievement of our two concurrent goals. On the one hand, the system can safely perform grasping actions on different unmodeled objects, denoting especially reliable visual and visuomotor skills. This confirms that the new research path we propose, according to which robotic grasping can be based on the integration of the two visual processing channels of the primate brain, is significant and worth further exploration. On the other hand, the computational model and the robotic experiments help in validating theories on the mechanisms employed by the brain areas more directly involved in grasping actions. This book offers new insights and research hypotheses regarding such mechanisms, especially for what concerns the interaction between the streams. Moreover, it helps in establishing a common research framework for neuroscientists and roboticists regarding research on brain functions.

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