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Towards a Framework for Tactile Perception in Social Robotics

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The first step for building reliable humanoid systems is to provide them with perceptual mechanisms that have human attributes, such as the skill development, social interaction, environmental embodiment and sensorial integration. Despite tactile perception being one of the most important elements for human interaction with the world, its implementation within artificial systems has been tardy, principally because it requires a complete integration with the motor systems and an environmental coupling to extract comprehensible information [1]. Thus, this work aims to generate a platform based on haptic information, allowing humanoids to perceive and represent surrounding objects using concepts fully grounded in the sensorial data.

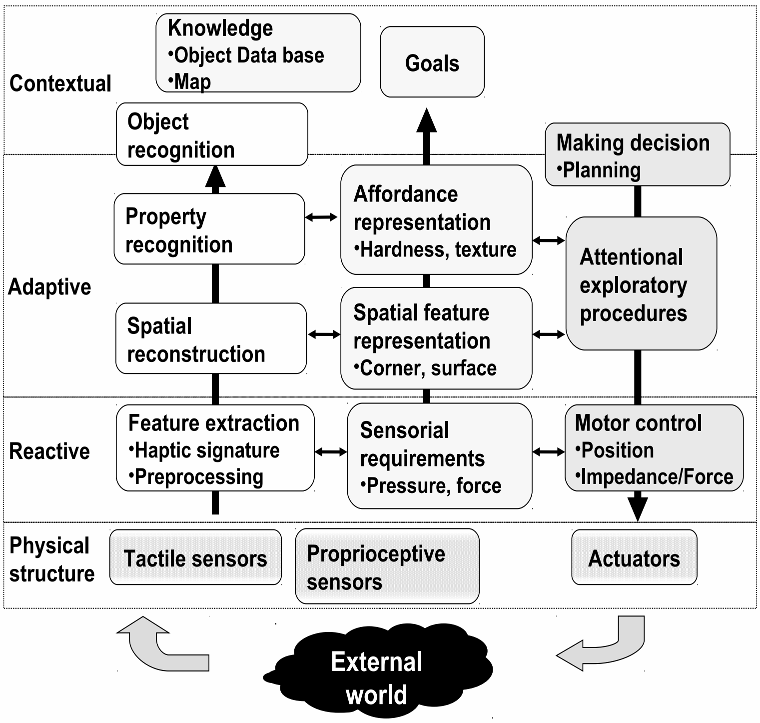

Fig. 1. Functional blocks of the tactile framework

The proposed architecture, inspired in the Distributed Architecture Control [2], has a modular design defined by three levels of processing that represent

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degrees of cognition (see Fig. 1). Such an architecture is not only targeted to build up the perceptual basis for social robotics, but also to explore neuropsychological models for understanding the development of human haptic skills.

The lowest layer is composed of proprioceptive sensors, tactile sensors and actuators. The respective biological elements in the human being are muscles and the mechanoreceptors located in tendons and skin. A higher level of the framework provides enactive mechanisms to extract significant haptic information and control the hand. Engineering advances related to the function of the cerebellum could provide a substantial contribution to haptic manipulation, for example by representing forward and inverse models of the interaction of the manipulator with its environment for optimal control [3].

The second level provides a type of processing that is more representational, such as the physical characteristics of the objects being identified. The implementation of this layer requires that the haptic signatures are grouped in spatiotemporal patterns, generating a hierarchical representation of the object [4]. For instance, probabilistic approaches have been efficiently used to reconstruct the spatial configuration while performing object manipulation [5]. On the other hand, qualitative information is linked to the action that objects afford. Thus, we propose that the appropriate actions should be learnt as new grounded tactile concepts are formed. Such exploratory procedures, driven by attention, provide a mechanism for active perception, as implemented in Bayesian approaches to cortical modelling [6]. Making decisions, recognizing objects and long-term memory are the executive functions for the haptic perception that comprises the highest level of the framework.

We conclude that this framework, designed with an engineering methodology, can in principle be mapped onto a cortical implementation. Furthermore, we propose that the framework be implemented using development cycle that allows the gradual improvement of haptic capabilities in androids, until potentially reaching or exceeding those of humans.

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