Visually and haptically controlled skills for the dextrous manipulation of humanoid robots

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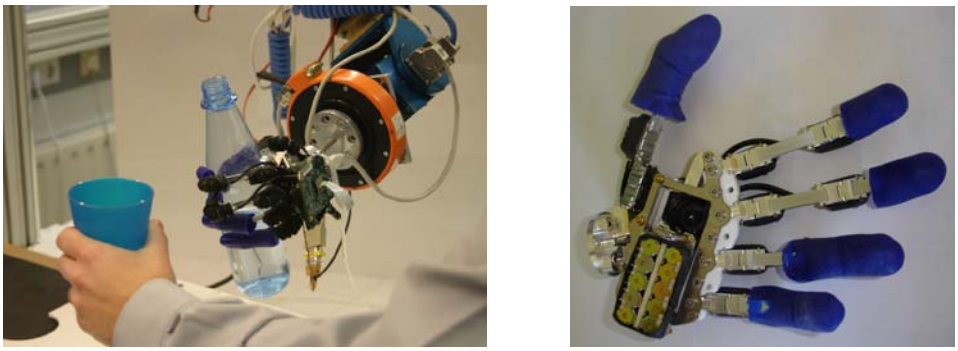

Figure 1: Dexterous Manipulation by a Smart Robot Hand

Grasping randomly placed fragile objects within a complex environment by a humanoid robot is an ambitious basic skill which requires a smart visually and haptically controlled hand.

The first phase of this dexterous manipulation task comprising both perception of the object and visual servoing of the robot hand relies on two cameras: a wide range stereo camera integrated in the robot head as well as a close range camera embedded in a five finger robotic hand (figure 1). A robust visually controlled grasping of objects is achieved, even in the case of disturbed signals or dynamic obstacles, by using a fuzzy decision making algorithm for the optimal fusion of information from both cameras. Moreover, the hand camera can obviate occlusions of the head camera e.g. caused by the robot arm.

In the second phase of the task a safe stable grasping is achieved by a smart haptic control concept using integrated tactile arrays and slip sensors. Optimally controlled contact forces avoid both slipping of the object due to low friction as well as destruction of the fragile object structure due to high contact pressure. Since the friction coefficient is estimated at the beginning of every grasping process in the case of varying or unknown friction coefficients, the haptic control parameters can be adapted automatically. In the case of disturbances (e.g. due to varying liquid mass in the glass), the gripper reacts immediately to a minimal slip of the object by an increase of contact force.

The optimal coordination of the different visual and haptic motion phases is managed by a multi-sensor based, discrete-continuous supervisory control concept in which each skill is divided into a sequence of primitive skills [Milighetti 2007b]. Both theoretical approach and experimental results of the ongoing research within the Collaborative Research Centre SFB588 “Humanoid Robots” will be presented in this paper.

References

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