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Simulation-Based Grasp Affordances for the PISA/IIT Softhand

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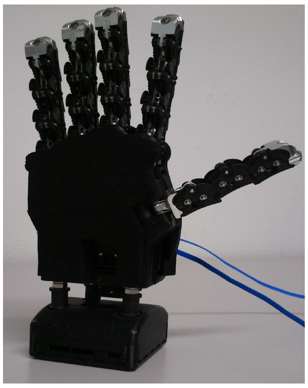
Abstract

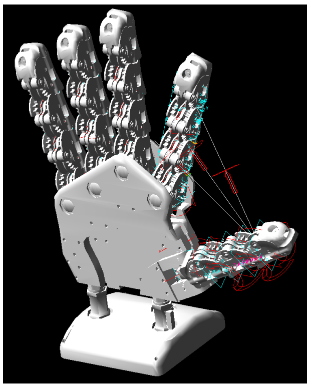
Recently, some research groups came out with a new generation of robotic hands that can be grouped under the name *Soft Hands*, as suggested in [1]. One of the main characteristic of such prototypes is to afford capabilities that are comparable to human grasping. Indeed, studying human grasping, researchers realized that a correct use and combination of compliance and underactuation can be profitably exploited for designing new robotic hands, both robust to environment interactions, and simple to control. Moreover, the adaptability of these prototypes can be profitably used to increase the range of possible executable task. For example, using soft hands, both the interaction with the object and with the environment, can be in turn used to functionally shape the hand, going beyond its nominal kinematic limits by exploiting structural softness. For this reason, in the field of grasp planning with *Soft Hands*, they refer to the object to grasp and to the environmental constraints with the collective name of *enabling constraints* [1].

Soft hands bring to a new challenge in grasp planning. Since the fact that, the low degrees of actuation is compensated exploiting the deformation of the hand through the interactions with objects and the environment, a grasp planner for Soft Hands has now to find the relative hand/object configuration able to achieve the grasp.

The adaptive hand behavior, entangled with the complex dynamical interactions between the hand phalanxes and the objects – the object are not fixed during the grasp acquisition – simply cannot be modeled using conventional physics simulators like GraspIt, Open-Rave and OpenGRASP, as the complex routing of a single tendon through all the limbs is a fundamental feature which is, to be best of our knowledge, out of the above physics engines' capabilities. For this purpose, we modeled the Pisa/IIT SoftHand [2] in ADAMS [3].

Figure 1: Comparison between (a) real and (b) simulated PISA/IIT SoftHand


(a)

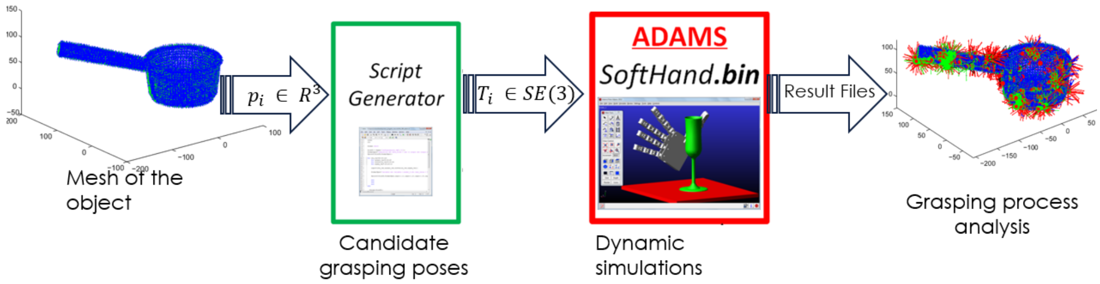

(b)

In this paper we explain the development of a MBD simulator for the PISA/IIT SoftHand, which is then used in a simulation-based approach to extract grasp affordances for different kitchenware objects using the PISA/IIT SoftHand.

On of the main characteristics of the Pisa/IIT SoftHand is the use of the so called *rolling-contact* (RC) joints, instead of the typical revolute ones. The RC joint is composed by two parts, one rolling on the other. The properly simulate its behavior, in the ADAMS model the RC joints are included using *Gear*

Joints. Furthermore, the closure movement of the Pisa/IIT SoftHand is entrusted to a tendon that goes through the whole hand. Initially, it engages the pulleys on one side of the thumb. At the fingertip it turns around another pulley, before coming back toward the palm, engaging pulleys on the other side of the thumb. The tendon path goes on similarly across the other fingers, until arriving again to the motor. In the ADAMS model, the tendon routing was included using a *GCON* constraint, imposing the proper *synergistic* relationship on the closure movement of the joints.
The reader can find more details about the *rolling contact joints*, *tendon routing*, *embedded hand compliance* and the other peculiarities of the Pisa/IIT SoftHand in [2].

Figure 2: Simulation pipeline to extract grasp affordances for the PISA/IIT SoftHand. This process is executed in batch mode using ADAMS/Solver



The used setup for running simulations in batch mode is summarized in Fig. 2. Through the mesh description of the object, we randomly select 50 points on it. Then, the hand palm is placed $5mm$ farm from the object, with the normal of the palm aligned with the normal mesh on each point, in opposite direction. The initial number of candidate poses are 400, since for each of the previous random points we select 8 configurations rotating the palm around the normal. All these starting palm postures are then tested in batch mode with the ADAMS/Solver, in order to attempt the grasp. From simulation results, we then extract all configurations that brought to a stable grasp, checking if the object is firmly kept in the hand. Later, a second set of simulations are performed with the aim of exploring deeper each successful grasp. New candidate grasp poses are selected choosing randomly 10 of the 40 closest points on the mesh, around each successful initial point. The process of placing the hand with respect to the object is then repeated and simulated, for other 8 configurations for each point. Figure 2(d) shows an example of simulations results for one of the analyzed objects (a pot), successful postures are in green, unsuccessful postures are in red. At the end of the simulation procedure, all successful grasp postures are evaluated using different quality index, as, for example, a measure of the closure of the whole hand, the internal forces in the final grasp configuration, and the number of successful grasps around each point.

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