Teaching Robots to Grasp through a User Friendly Interface

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ABSTRACT

One characteristic of a robust grasp is its ability to comply with external perturbations applied to the grasped object while still maintaining the grasp. We achieve this goal by taking a 3-steps approach: (1) compute a variety of stable grasps adapted to different tasks, (2) learn a model that allows the hand to adapt to external perturbations and (3) corroborate tactile information from the sensors on the fingertips by feedback modalities to illustrate, in a user-friendly way, the contact strength and grasp stability. The approach is validated on the 9 degrees of freedom hand of the iCub humanoid robot.

A. Computing the initial grasp

In everyday life, people employ a large diversity of grasps enabling them to manipulate objects. We propose a method for generating such a variety of good grasps that can be used for the accomplishment of many different tasks [1]. This is challenging given the high dimensionality of the grasping space and the non-linearity of the constraints. Our approach formulates grasp synthesis as a single constrained optimization problem, generating grasps that are at the same time feasible for the hand's kinematics and optimal according to a force related quality measure. The algorithm succeeded in generating 20 different grasps for a cylinder (a basic superquadric shape). These grasps can be used subsequently as preshapes for grasping a variety of objects. Figure 1 shows an example of four of the typical grasps obtained. These grasps are then used for learning grasp adaptation to external perturbations through tactile refinement.

B. Grasp adaption framework

Our grasp adaptation approach learns a statistical model to adapt the hand posture solely based on the perceived contact between the object and the fingers [3]. Using a multi-step learning procedure, the model dataset is built starting from one of the previously computed 20 grasps, which is then physically corrected by a human teacher pressing on the robot's fingertips, exploiting compliance in the hand. The learner then replays the resulting sequence of hand postures, to generate a dataset of posture-contact pairs that are not influenced by the touch of the teacher. The learned model may be further refined by repeating the correction-replay steps, see Figure 1. Grasp adaptation can be then tested in response to changes in contact. Alternatively, the model may be reused in the development of new models, characterized by changes in contact signatures, specific to a different object, by simply providing additional rounds of model refinement.

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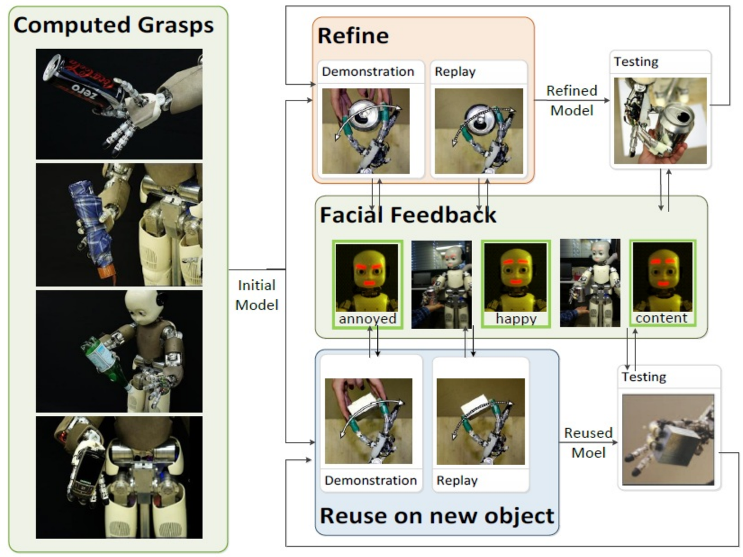

Fig. 1: Overview of the grasp models learning approach.

C. User friendly teaching interface

In our grasp adaptation framework, tactile information is crucial. For example, when the tactile response is week, that particular instance will not be included in the model. Therefore, we make this information transparent to the user, through corroborating it by facial expressions feedback. This improves the effectiveness of teaching by demonstration by reducing the teaching time, making the interaction rewarding and keeping the user engaged throughout the learning procedure. This approach was validated through a user study with 29 subjects [2].

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