From Object Categories to Grasp Transfer Using Probabilistic Reasoning

Marianna Madry Dan Song Danica Kragic

***Abstract*— We address the problem of transferring task-specific grasp strategies from a known to novel object using information about an object category. Our system relates knowledge about: (a) several physical object properties, (b) object functionality and (c) task constrains in order to find a suitable grasp. We demonstrate that by choosing an object representation that encodes diverse objects properties and integrates information from different visual sensors our system can not only find objects that afford an assigned task, but also generate and successfully transfer task-based grasp within and across object categories.**

Perception of and interaction with objects is one of the key requirements for a robot acting in the real environment. Although excellent examples of finding and manipulating a *specific* object in a scene have been reported (Hasio et al., 2010, Welke et al. 2010) there is no system that is capable of flexibly and robustly localizing and grasping an arbitrary object that fulfills a certain functionality. Thus, executing tasks such as "**Robot, bring me something to drink from.**" or "**Robot, give me something to hammer with.**".

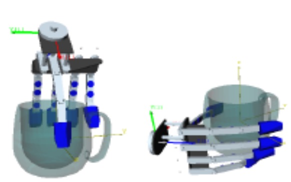
The aspect of function is related to that of affordances (Greeno, 1994) and has been addressed in works that learn relations between objects and actions (Fritz et al., 2006, Sahin et al., 2007). However, none of these consider the role of *task* in their model: task intention of the agent affects the type of action (grasp) to apply, i.e. not just any grasp can be applied on the object, see Fig. 1.

We present a system that allows not only to plan a suitable grasp for a given task, but also enables transfer of grasp knowledge between objects that share similar physical attributes and/or have the same functionality. To this end, we develop and evaluate an object representation that links information about an object, task and action.

The experimental setup is a scene containing multiple objects. Individual object candidates are first segmented (Björkman et al., 2010), categorized and then used as the input to a grasp generation and transfer module (Song et al., 2010). We integrate various 2D and 3D features describing object texture, color and shape to obtain a robust object representation. We demonstrate that encoding complementary object properties, not only significantly improves robustness of the categorization system, but assures relevant balance between discrimination and generalization in the representation. This allows to distinguish objects that both belong to the same functional category, but significantly differ in physical properties, and objects that afford different tasks, but are alike in color and shape.

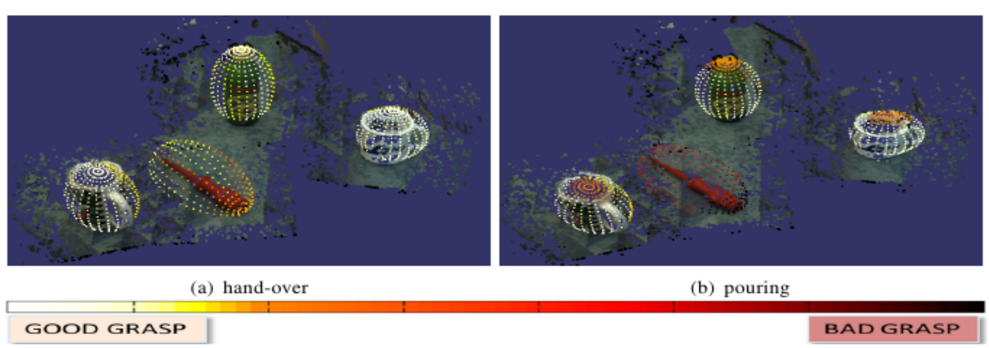
The most suitable grasp parameters are inferred by the probabilistic grasp reasoning module based on information about an object category and assigned task. Results are illustrated by marking the grasp point probability around each object. For the *pouring* task (Fig. 2b), the likelihoods of the points around the mugs and bottle are clearly higher than for the screwdriver indicating that they are the only objects affording the task. Moreover, their likelihood maps are darker on the top, since the robot hand should not block the opening of an object. Summarizing, the proposed framework enables a robot to choose the objects that afford the assigned task while plan the grasp that satisfies the constraints posed by the task, and transfer grasp knowledge between objects that belong to the same category, even under considerable differences in appearance and physical properties.

The authors are with Computer Vision and Active Perception Lab, Center for Autonomous Systems, KTH-Royal Institute of Technology, Sweden, madry,dsong,danik@csc.kth.se. This work was supported by GRASP, IST-FP7-IP-215821 and Swedish Foundation for Strategic Research. We thank *Jeannette Bohg* and *Carl Henrik Ek* for their help.



(a) *hand-over* (b) *pouring*

Fig. 1. Grasping a cup: (a) *hand-over* and (b) *pouring* task (hand should not block the opening of an object when pouring a liquid).



(a) hand-over (b) pouring

Fig. 2. Grasp hypotheses and associated probabilities for: (a) *hand-over* and (b) *pouring* task. The grasp point probability around an object is indicated by color of a point: the brighter is the point, the higher is the probability. Experimental results for a number of natural scenes and five different tasks are available on our website http://www.csc.kth.se/~madry/research/madry12icra