# Probabilistic Models of Appearance


We developped probabilistic models to encode the appearance of objects, and inference methods to perform **detection (localization) and pose estimation** of those object **in 2D images** of cluttered scenes. We started with 3D, CAD-style models (Teney et al. 2011), but then solely focused on **appearance-based models** (Teney et al. 2012). Those are trained using 2D example images alone, the goal being here to leverage, to a maximum, the information conveyed by 2D images, without resorting to stereo or other 3D sensing techniques. Our models are identically applicable to either specific object instances, or to object categories/classes (Teney et al. 2013). The appearance is modeled as a **distributions of low-level, fine-grained image features**. The strength of the approach is its straightforward formulation, applicable to virtually any type of image feature. Appearance is represented by probability distributions of such features, for example points along image edges, or intensity gradients extracted densely over the image.
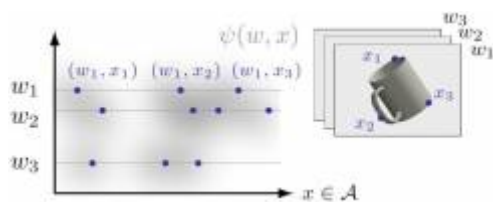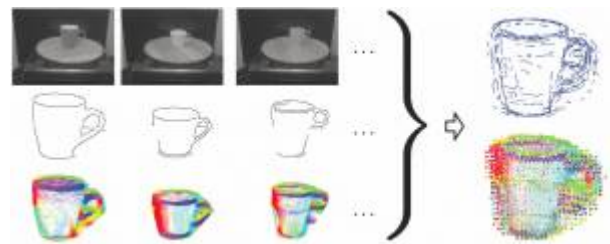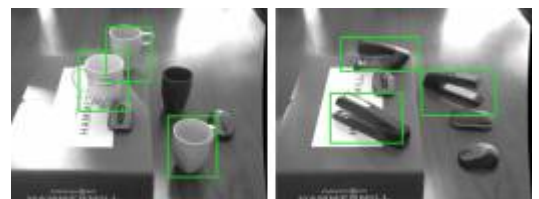
Such models of appearance have been applied to the tasks of object detection/localization, object recognition, and pose classification (by matching the test view with one of several trained viewpoints of the object). A notable advantage of the proposed model is its **ability to use dense gradients directly** (extracted over entire images), versus relying on hand-crafted image descriptors. Using gradients extracted at a coarse scale over the images allows one to use shading and homogeneous regions to recognize objects, when edges alone would be ambiguous.
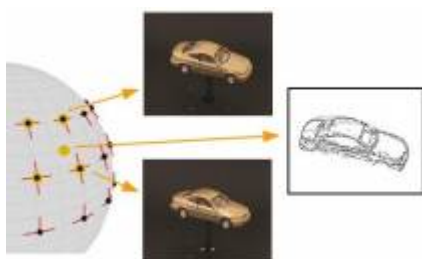
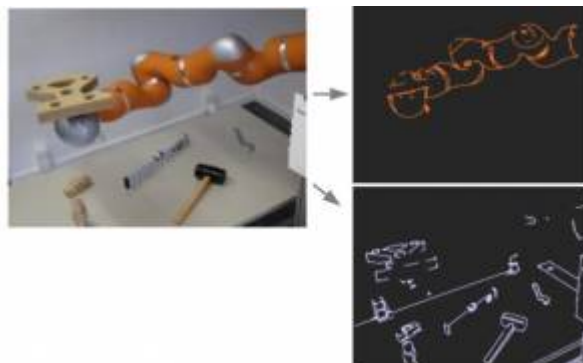
We also proposed extensions of this generative model to perform continuous pose estimation, by explicitly interpolating appearance between trained viewpoints. This makes it one of the rare methods capable of doing **appearance-based continuous pose estimation at category level**, this capability being usually reserved to methods based on 3D CAD models of objects, and limited to specific object instances.

We found an interesting application of those models and methods in the **recognition, pose estimation and segmentation of a robotic arm in 2D images** (Teney et al. 2013b). This task is very challenging due to the smooth and untextured appearance of the robot arm considered (a Kuka LWR). Moreover, the arm is made of articulated links which are absolutely identical in shape and appearance. Candidate detections of those links in the image are provided by the recognition method, and the known physical (kinematic) constraints between the articulated links are enforced by probabilistic inference. In the spirit of traditional articulated models, those constraints are modeled in a Markov random field, and an algorithm such as belief propagation can then identify a globally consistent result for the pose of all links.

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