Developmental object learning through manipulation and human demonstration

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Objectives: We present a cognitive developmental approach for a humanoid robot exploring its close environment in an interactive scenario, taking inspiration from the way infants learn about objects [1]. The proposed approach allows to detect physical entities in the visual space, to create multi-view appearance models of these entities and to categorize them into robot parts, human parts and manipulated objects without supervision and without prior knowledge about their appearances. All information about the entities appearances and behaviour is incrementally acquired while the robot and its human partner interact with objects.

Appearance models: The first step of our system is an attention module that segment the visual space into proto-objects based on coherent motion and continuous 3D shape. Each proto-object appearance is then incrementally memorized as a view encoded by pairs and triples of SURF points and colored superpixels. Each view is associated with a physical entity which may be an object, a human hand or a robot hand. The overall entity appearance is memorized as a multi-view model characterizing different perspectives of a given entity. The identification of the corresponding entity is based either on tracking across images or on appearance-based recognition with a Bayesian filter [2].

Entity categorization: All physical entities are classified into following categories: robot parts, human parts or manipulable objects. The robot self-recognition method is based on the mutual information between the sensory data and proprioception [3]. Among the remaining entities, the object category is identified from the statistics on its simultaneous motion with robot and human parts based on the condition that the object moves only when it is connected to another entity and it is static and independent on robot motors when it is single.

Interactive perception: Using the ability to recognize connected entities and to categorize them, the object model constructed during its observation can be improved during robot interactive actions. Since the entity associated with the grasped object is recognized before action, the corresponding model can be updated during manipulations with recognized views connected to the robot hand or with new views created from the features that do not belong to the robot hand. The first type of updates reduces noise in object models and the second one allows to accumulate views corresponding to unseen perspectives of the objects.

Experimental results: Our perception system is evaluated on the iCub robot interacting with a human partner and ten objects. For each real object, we estimate a major entity as the most frequently assigned to it by the robot. The experiments show that the robot manipulations notably improve the learning accuracy due to the merge of a major entity with other entities created during observation of an object demonstrated by a human. We plan to extend this model by the categorization of objects based on their appearance and affordances.

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