Open Affordance Feature and Entity Definition Framework - AfNet

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Given the need for task based visual environment processing for domestic robots as well as object category representation in terms of robust features that are insensitive to instance specific variations in color, texture and geometry, Recognition of objects/object categories by Component Affordances (RBCA) has attained a critical role. While the use of ontologies for representation of semantic knowledge about objects based on local features (such as SIFT) or geometry (such as CAD), suffers from scalability issues, affordance features provide a convenient mechanism to circumvent the issue. AfNet – The Affordance Network (www.theaffordances.net) provides a concise set of affordance features for object/ object class description. AfNet is designed as an open framework, enabling community based addition of new affordance features as well as object/ object descriptions (termed as entity descriptions) based on these affordance features. AfNet represents the first initiative towards standardizing affordance features and rendering a community interface to semantic representation of objects using affordances.

In this paper, we describe the structure of the Web Learning Interface provided by AfNet, which can be used to teach the system new affordance features as well as define objects or classes using existing affordance features. AfNet represents each entity or conceptual equivalence class in terms of various structural (SA), material (MA), grasp (GA) affordances and topological relationships between the various components which constitute the object in question. AfNet currently provides 68 affordance types – 25 structural, 10 material and 33 grasp affordances, supporting over 250 equivalence classes. Community users can teach the system new affordance types by defining an affordance label, its level 0-4 categorization in the affordance hierarchy (see Fig 1b), along with textual definitions, geometric mapping information and examples of objects or classes that possess the affordance. In addition, users can also define assertions – i.e. users can define objects or equivalence classes in terms of a maximum of 5 labeled or generic parts, each providing single or multiple affordances (from all three categories of affordances), along with the scale of each part and its cardinality. The scales of the object parts can be defined in abstract measures with respect to the human arm: sizes comparable to finger, hand, bi-hand, arm/knee, torso, standing posture, sitting posture, non-conformal. Scales of the parts can also be specified in terms of ranges. In addition, abstract topological relationships (axial and spatial connectivity) between the object parts can also defined with respect to Part Connectivity Calculus (PCC). Given the three axes of local orientation for each part, there are 6 possible axial connectivity relationships. The spatial connectivity is defined on a 18-connectivity 3D grid, each of which is uniquely represented by a label according to PCC. In addition, the AfNet interface allows the optional storage of generic data, sample color and range/point cloud data corresponding to each object/class entity. In addition, similar to the Open Mind Indoor Common Sense (OMICS), the AfNet web interface allows for community based voting on affordance feature based entity definitions (or assertions). The voting interface presents options to the community user to provide his response with regard to the fidelity of the available representation for a list of entities which is updated in real-time (Fig 1a). The votes garnered through this process are stored in the records for each entity and is available for further processing. The online entity interface also provides a mechanism to search the database using entity labels (such as cup, table etc.). AfNet stores the assertion records in tables composited into a SQLite3 database, which can be downloaded for offline usage (on domestic robots). Alternatively, SparQL and RDF bindings are also provided, thereby enabling support for complex queries. Since AfNet defines symbol binding mechanisms for each affordance, users can mix and match visual affordance detection algorithms (pre-defined or user-defined) to enable perceptual linking of objects of interest in the given scenario with the knowledge inference schema.

As samples, AfNet, defines a pen as belonging to Equivalence Class labeled Pen, composed of 1 part(s): 1. A Generic part with Engraveability SA, Writing Tripod GA, a scale comparable to the Finger of a human, cardinality of 1. The definition for a Knife is: belongs to Equivalence Class labeled Knife, composed of 2 part(s): 1. A Blade part with Incisionability SA, Lateral GA, Durability MA, a scale comparable to the Finger of a human, cardinality of 1, 2. A Handle part with Grab-supportability SA, Ventral GA, a scale comparable to the Finger of a human, cardinality of 1, with the multiple components of the object linked by an axis connectivity of 1,1- 2,2- 3,3, and a spatial connectivity of Horizontal Left.

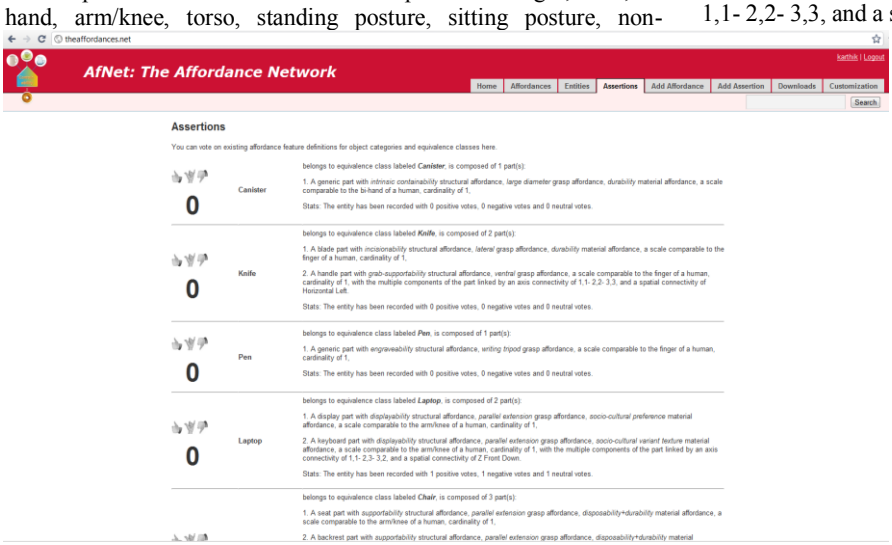

Figure 1. Left (a) Entity voting interface in AfNet. Right (b) Partial Affordance Hierarchy

The research leading to these results has received funding from the European Community's Seventh Framework Program under grant agreement no IST-FP7-IP-215821 (GRASP).Karthik Mahesh Varadarajan and Markus Vincze are with the Vienna University of Technology, Automation and Control Institute, Gusshausstrasse 30 / E376, A-1040 Vienna, Austria (email: {kv,mv} @acin.tuwien.ac.at).