Learning the Taxonomy and Models of Categories Present in Arbitrary Images
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PROBLEM STATEMENT
GIVEN an arbitrary set of images, with:
1) ≥ 0 occurrences of ≥ 0 categories per image
2) Articulation, partial occlusion, clutter
3) Varying illumination
4) Small changes in scale, viewpoint

DISCOVER
all categories present, and
LEARN
the models and spatial taxonomy of discovered categories.

In a new image
DETECT, RECOGNIZE, SEGMENT
all occurrences of the learned categories, and
EXPLAIN
recognition via subcategory grammar.

RECURSIVE DEFINITION OF CATEGORY
Category = Set of similar and frequently occurring 2D objects in the training set.

LOCATING SIMILAR OBJECTS
1) Images = Segmentation trees [Ahuja PAMI 96]
2) Region properties computed relative to parent regions
3) Similar objects = Similar subtrees
4) Finding similarity values between subtrees:
   GIVEN two trees t and t', FIND consistent subtree isomorphism f : (v, v') such that
   \[ S_{v,v'} = \max_{f : (v,v')} \sum_{(v,v') \in f} r_v + r_{v'} - |r_v - r_{v'}| \]
   similarity measure = region saliency - cost of region matching
   \[ r_v = \xi_v \Phi_v \]
   \[ \xi \geq 0, \xi \leq 1 \]
   region properties = relative significance to recognition

Example:
\[ f = (v, v'), (u, u') \]

DISCOVERING ALL CATEGORIES OF ALL COMPLEXITIES
1) Agglomerative binary clustering of all regions from all images
2) KS-test with sensitivity α=5% for selecting valid clusters
3) Valid cluster = Discovered category

TAXONOMY OF ALL DISCOVERED CATEGORIES:
Region containment to category containment
Region co-occurrence to category co-occurrence
Co-occurrence category = Layout of co-occurring categories

EVALUATION ON A NEW DATASET – HOOFED ANIMALS:
http://vision.ai.uiuc.edu/~sintod/datasets.html

1) Recognition is invariant to translation, in-plane rotation, articulation, partial occlusion, clutter, small variations in scale, illumination, and viewpoint.
2) Object segmentation is good even on jagged and blurred object boundaries forming complex topologies.
3) Approach robust because object boundaries often coincide with segment boundaries.

CONTRIBUTIONS:
1) Recursive definition of a category via the appearance and spatial configuration of subcategories.
2) Some subcategories may be shared by multiple categories
3) Joint, completely unsupervised learning of the models and taxonomy of arbitrarily structured categories present in a given image set.

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