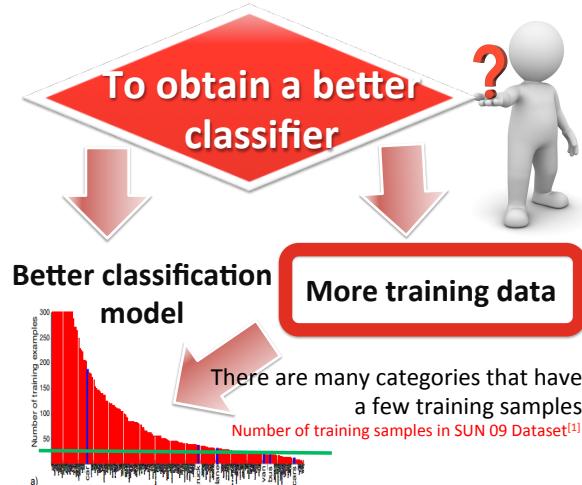


Adding Unlabeled Samples to Categories by Learned Attributes

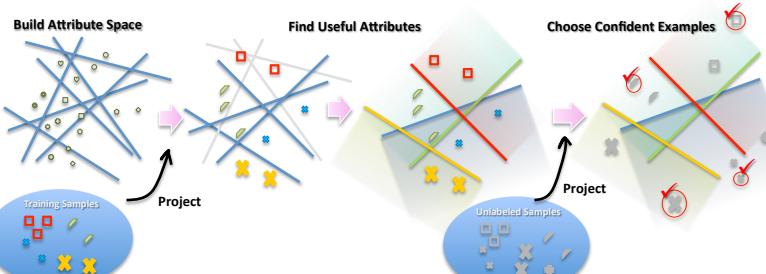
Jonghyun Choi Mohammad Rastegari Ali Farhadi  Larry S. Davis <http://umiacs.umd.edu/~jhchoi/addingbyattr>



Problem



Approach Overview



Formulation

Joint optimization for discovering discriminative attributes and unlabeled samples

$$\min_{I_c \in I, w_c^v, w_c^a} \sum_c (\alpha J_c^v(I_c, w_c^v) + \beta J_c^a(I_c, w_c^a)) + M(I)$$

subject to

$$J_c^v(I_c, w_c^v) = \|w_c^v\|_2^2 + \lambda_v \sum_{i=1}^n \xi_{c,i}$$

$$I_{c,i} \cdot y_{c,i}(w_c^v x_i) \geq 1 - \xi_{c,i}, \quad \forall i \in \{1, \dots, n\}$$

$$J_c^a(I_c, w_c^a) = \|w_c^a\|_2^2 + \lambda_a \sum_{j=1}^n \zeta_{c,j} - \sum_{k=l+1}^n I_{c,k}(w_c^a \phi(x_k))$$

$$I_{c,j} \cdot y_{c,j}(w_c^a \phi(x_j)) \geq 1 - \zeta_{c,j}, \quad \forall j \in \{1, \dots, n\}$$

$$\sum_{k=l+1}^n I_{c,k} \leq \gamma, \quad I_{c,k} = 1, \quad \forall k \in \{1, \dots, l\}$$

Top-Lambda Selector

$$M(I) = \sum \sum_{c_1 \neq c_2} I_{c_1} \cdot I_{c_2}.$$

Mutual Exclusion

Max-margin Classifier on visual feature space

Attribute Mapper

How to Add Samples

- Active learning
 - Require **human in the loop**
- Semi-supervised learning
 - Unlabeled samples are assumed to **follow the same distribution of labeled samples**

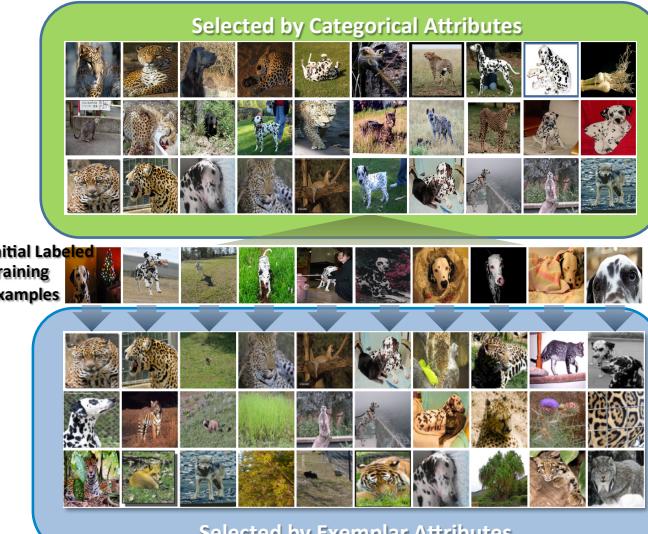
Our Solution

By learning data driven attributes based on [2]

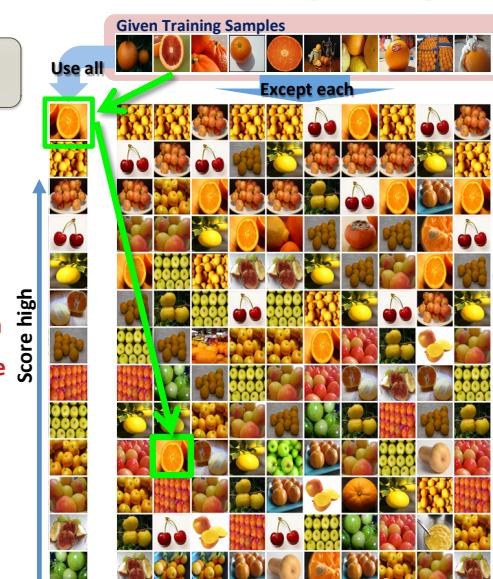
- No human required**
- No underlying distribution assumed**



Adding by Two Kinds of Attributes



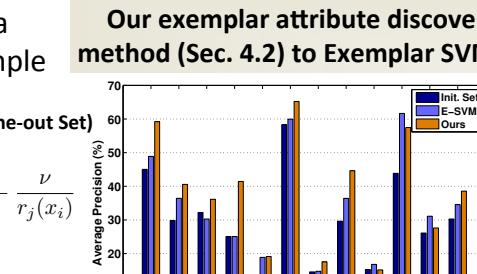
How to Select by Exemplar-Attributes



Retrieval rank change by the absence of a training sample

Our exemplar attribute discovery method (Sec. 4.2) to Exemplar SVM[3]

(Full-set vs Leave-one-out Set)



More stable than
Exemplar-SVM w/o
large negative set

Our method outperforms the exemplar SVM in terms of category recognition accuracy by APs without the extra large negative example set (size = 50,000).

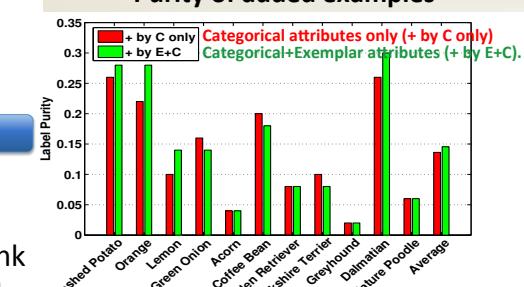
Experimental Results

Comparison with other methods

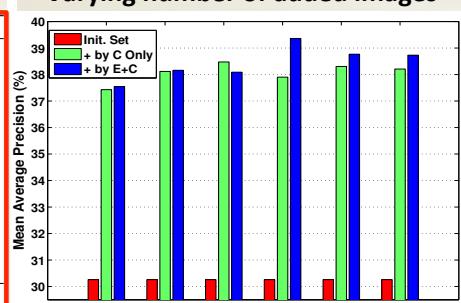
Category Name	Init.	NN	ALC	Cat.	E+C
Mashed Potato	45.03	34.02	51.15	61.39	63.92
Orange	29.84	16.29	26.97	40.61	41.05
Lemon	32.21	27.58	32.43	35.37	34.23
Green Onion	25.06	16.50	19.66	38.57	40.20
Acorn	13.09	11.05	15.41	19.35	20.10
Coffee bean	58.29	43.89	56.62	64.65	66.54
Golden Retriever	14.54	15.57	12.61	17.54	18.61
Yorkshire Terrier	29.62	13.62	27.63	41.41	45.65
Greyhound	15.24	15.73	15.64	14.75	15.22
Dalmatian	43.84	27.97	37.91	54.42	57.23
Miniature Poodle	26.10	12.50	21.16	28.87	30.21
Average	30.26	21.34	28.84	37.90	39.36

- 'Init.': initial labeled training set.
- 'NN': addition by 'nearest neighbor' in visual feature space
- 'ALC': addition by 'active learning criteria (ALC)' that finds the examples close to the current decision hyper-planes
- 'Cat.': our method of select examples using categorical attributes only.
- 'E+C': addition using both categorical and exemplar attributes.

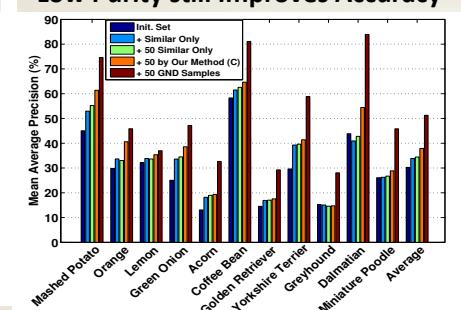
Purity of added examples



Varying number of added images



Low Purity still Improves Accuracy



- Navy: using the initial labeled set (baseline).
- Blue: using only similar examples among the selected 50 examples
- Green: using 50 similar examples to compare with the result of our selected 50 examples
- Orange: including both similar and exact examples.
- Red: using a set of 50 ground truth images, which is the best achievable accuracy (upper bound).

Size of Initial Labeled Set

