Discovering Latent Domains for Multisource Domain Adaptation

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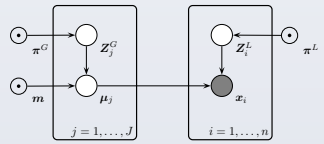
MOTIVATION

Our goal: to separate a heterogeneous data source into multiple latent visual domains.

Using multi-source domain adaptation techniques out-performs single domain adaptation for heterogeneous source. But, most datasets lack *domain labels*.

PROBLEM FORMULATION

We model the domains as a hierarchical mixture model. There is a local mixture for each category in each domain.



- $x_i \sim \prod_j \left[\pi_j^L \mathcal{N}(\mu_j, \sigma)\right]^{Z_{ij}^L}$
- $Z_i^L \in \{0,1\}$ - assigns data to local clusters
- $\mu_j \sim \prod_k \left[\pi_k^G \mathcal{N}(\mu_k, \sigma)\right]^{Z_{jk}^G}$
- $Z_j^G \in \{0,1\}$ - assigns local clusters to global clusters

We solve the following optimization problem using an alternating minimization algorithm.

$$\min_{\boldsymbol{Z}^G, \boldsymbol{Z}^L, \boldsymbol{\mu}, \boldsymbol{m}} \quad \sum_{i=1}^{n}\sum_{j=1}^{J} \boldsymbol{Z}_{ij}^L ||x_i - \mu_j||_2^2 + \sum_{j=1}^{J}\sum_{k=1}^{S} \boldsymbol{Z}_{jk}^G ||\mu_j - \boldsymbol{m}_k||_2^2$$

$$\text{subject to:} \quad \forall j,k: \ \boldsymbol{Z}_{jk}^G \in \{0,1\}, \quad \forall i,j: \ \boldsymbol{Z}_{ij}^L \in \{0,1\}$$

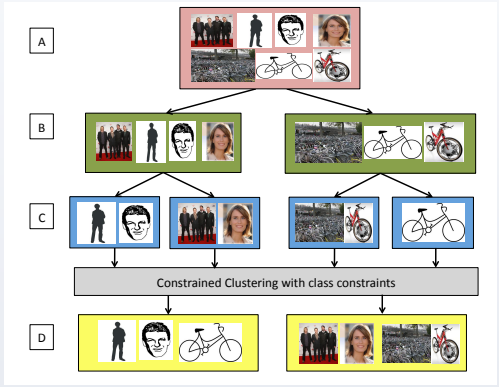
$$\forall j: \ \sum_{k=1}^{S} \boldsymbol{Z}_{jk}^G = 1, \quad \forall i: \ \sum_{j=1}^{J} \boldsymbol{Z}_{ij}^L = 1$$

$$\forall j: \ \sum_{i=1}^{n} \delta(l_i \neq l_j) \boldsymbol{Z}_{ij}^L = 0$$

$$\forall k: \ \sum_{c=1}^{K}\sum_{j=1}^{J} \delta(\text{label}(j) = c) \boldsymbol{Z}_{jk}^G = 1$$

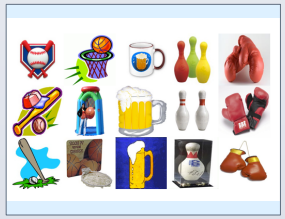
METHOD

1. Separate the data according to category (B)
2. Learn optimal local clusters [blue] using per category datasets (C)
3. Learn optimal global clusters [yellow] from the local clusters [blue] that satisfy the do-not-link constraints for local clusters from same category.
4. Repeat (2) and (3) until convergence.



DOMAIN DISCOVERY RESULTS

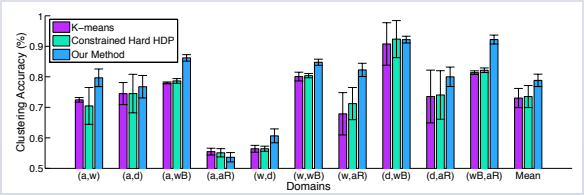
Our algorithm separated web search data into these three domains: (a) cartoon-like images (b) cluttered/natural scenes (c) product style images.



(a)

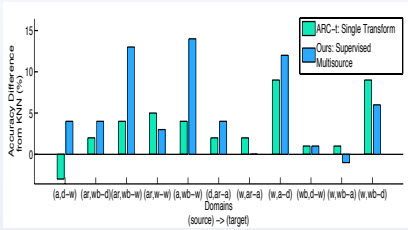
(b)

(c)

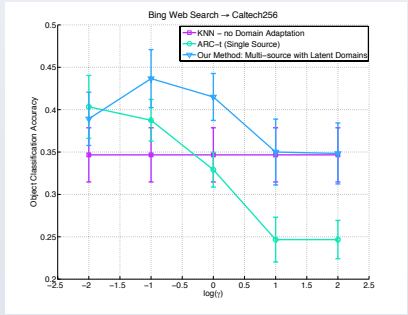


- Discovers domains more accurately than competing hierarchical method.
- Performance drops when domains are very similar.

CLASSIFICATION RESULTS



Our multisource method beats single source when domain labels are known.



We are able to improve classification results for a heterogeneous source dataset with no known domain labels.

FUTURE WORK

- We plan to experiment with different mixture models.
- We plan to incorporate weak category labels into the domain discovery formulation.

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