Knowledge Propagation in Large Image Databases
Using Neighborhood Information

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Motivation
Practical methods for semantic indexing and querying of large-scale image databases often require that the images be annotated with semantic information beforehand. Unfortunately, due to the high costs associated with human annotation, or the unavailability of cameras with GPS functionality or other special devices, the number of labeled objects is often severely limited. Existing solutions to adding semantic information are labor intensive and not always accurate. The aim of this research is to reduce the level of human intervention in the semantic annotation process of images.

Automated Image Annotation
Objective
A few occurrences of each object of interest (e.g., a person) would be labeled manually, and the labels (e.g., names) would then be propagated automatically to all other occurrences of the object.

Existing Solutions

Query-based baseline:
- The label of an unlabeled object is decided by its nearest labeled neighbor.

Supervised or semi-supervised learning methods:
- Labeled objects are treated as training set and each unlabeled objects are classified.

Influence Graph

*KProp* propagates labels from labeled data objects to new data objects that resemble them through an influence graph derived from neighborhoods of the objects.

- Draw self-edges for labeled objects.
- If an unlabeled object is one of the k-NN of a labeled object, draw an edge from the labeled object to the unlabeled.
- Draw bi-directional edges between two unlabeled objects if either is one of the other’s K-NN.

Approach
We propose a new method, *KProp*, that seeks to propagate labels from initially annotated data objects to new data objects that resemble them, according to a user-supplied measure of similarity. *KProp* builds an influence graph derived from neighborhoods of the objects with respect to the similarity measure, and then propagates knowledge scores through the graph from those nodes corresponding to objects with apriori semantic annotations.

Label Propagation

- Scores measuring the degree of association between labels and objects are computed iteratively. Only labeled objects with the label being propagated are given initial scores of 1 (all others are given initial scores of 0).
- Each object’s score can be computed by averaging all its incoming neighbors’ scores. This procedure can be performed by iterative matrix multiplications:

![Influence Graph](image)

Experiments

- *KProp* (CKProp) is compared with Query-based baseline (Bestmatch), SVM and LapSVM using three datasets:
  - ALOI-100 (simple objects), MNIST (handwritten digits) and Google-23 (faces).
  - *KProp* performs consistently better than the others in ALOI-100 and MNIST.
  - In Google-23, it is outperformed by SVM when label size is sufficiently large.
  - This can be explained in terms of the transitivity of object relationships.