Semantic Clustering and Fuzzy SVM Learning for Content Based Image Retrieval

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Why Should We Care?

- The number of pictures available is growing.
- It is too time consuming for humans to label and sort images.
- Current systems like Google Image Search rely on text labels provided by humans, but many images have not been labeled in this way.
- The ability to automatically learn the relationships between images enables effective image searches.
But why is it hard?

- Humans solve this problem all the time, but we have a lifetime of learning about objects and their images.
- Semantic gap between low-level features and the high-level knowledge.
Learning the Semantic Information

- Impractical to label every image, but the computer needs help from humans.

- Compromise: Relevance Feedback
  - The system returns images that it thinks are relevant to the query image.
  - The user labels the returned images as relevant or irrelevant to the query image.
  - The system uses this relevance feedback to learn the semantic information and then returns more images it thinks are relevant. Then, the cycle repeats.
Two Approaches to Learning

Short Term Learning

- Performs learning over a single query.
- Uses the low level features to classify the images.
- Uses support vector machine learning.

Long Term Learning

- Performs learning over many queries.
- Learns the high level connections between images.
- Learns the semantic information about the picture.
Proposed Short Term Learning

- Uses a region based approach using the five region segmentation proposed by Qi and Han.
- Uses pseudo-labeling to increase the size of the training set.
Pseudo-labeling and Fuzzy SVM

- Increases size of training set by propagating the user's labels to similar regions.
- Select regions by using K-means clustering and picking the regions closest to the cluster centers.
- Intuitively, the propagated labels are not as accurate as the user's labels, so apply a fuzzy weight to the labels.
- Calculate the weight by using the distance of the region from the SVM boundary and the distance from the cluster centers.
Results

No Noise 5% Noise – simulated user errors

Performed on a 6,000 image subset from the Corel Database in 60 categories with 25 images returned each iteration and 4 feedback iterations.
Analysis

- The pseudo-labeling improves the early iterations when increasing the size of the training set is vital.

- Using regions improved results, especially in the later iterations when the larger training size allowed the identification of semantically important regions.

- The best method is a combination of the pseudo-labeling for early effectiveness and uses region for improving the later results.
Proposed Long Term Learning

- Create clusters of semantically related images.
- Learn the fuzzy membership of an image to the semantic cluster by tracking the number of times a user has labeled it as relevant to other images in the cluster and how many times it has been returned with other images in the cluster.
- Improves over previous work by only storing the image to cluster relationships rather than storing the image to image relationships.
Results 1

No Noise

5% Noise – simulated user errors

Training was performed on 120 queries (2% of the database)
Results 2

No Noise

5% Noise – simulated user errors

Training was performed on 300 queries (5% of the database)
Results 3

No Noise 5% Noise – simulated user errors

Training was performed on 600 queries (10% of the database)
The proposed method performed similarly when using regular SVM learning to Han et al.'s Memory Learning, but required significantly less storage space.

The proposed method was more resilient to noise.

Improving the short term learning using a region based approach with pseudo-labeling increased the performance of the long term learning algorithm.
Conclusions

- The combination of pseudo-labeling and image segmentation is effective for improving short term learning.
- Semantic clustering is an efficient and effective method for learning semantic relationships over multiple user queries.
- Both short term and long term learning are important and the combination of the two produces the best results.
Future Work

- Apply the semantic clustering to the area of image annotation by propagating user labels to other images in the cluster.
- Test if the proposed semantic clustering technique allows for images to belong to multiple semantic categories.
- Test if the proposed method scales well to very large databases.
Questions?