Expanding Diagnostically Labeled Datasets Using Content-Based Image Retrieval

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Introduction

Pulmonary computed tomography (CT) scans assist radiologists in early detection of lung nodules, and computer-aided diagnosis (CAD) is an effective second opinion for radiologists. For CAD systems, having a diagnostic ground truth is necessary; however, only a limited number of medical image databases contain diagnostic labels. We demonstrate that content-based image retrieval (CBIR) is an effective tool for annotating unlabeled images with diagnoses.

Datasets

- Lung Image Database Consortium (LIDC): 399 CT scans with nodule malignancy ratings from up to 4 radiologists
- LIDC Nodule Dataset: 914 nodules, each annotated with radiologist-predicted and computer-predicted malignancy ratings
- LIDC Diagnosis Dataset: 17 nodules matched to patient-level diagnosis (9 benign, 8 malignant)
- Diagnosed Subset: includes LIDC Diagnosis Dataset and nodules that are subsequently labeled.

Methods

Candidate Identification

CBIR

Query: Diagnosed Subset
Retrieval Set: LIDC Nodule Dataset
3 retrieved per query

New candidates with predicted diagnosis

Verification of Predicted Diagnosis

New Diagnosed Subset
Control expansion

Evaluation with CBIR

Query: 3 sets (Rad., Comp., RadComp.)
Retrieval Set: Diagnosed Subset
3 retrieved per query

Figure 3. Summary of CBIR method of expanding the Diagnosed Subset; CBIR expansion occurs iteratively.

Results

One-tailed t-tests with \( p < 0.05 \) were used to compare the control expansion to CBIR expansion for each of the query sets. CBIR expansion resulted in significantly higher precisions than control expansion after the balanced Diagnosed Subset reached a size of 32. These results indicate that CBIR is a reliable method of expanding labels to undiagnosed images.

Figure 4. Average precision after three images retrieved using the CBIR and control methods to expand the Diagnosed Subset. Each point on the x-axis represents a discrete iteration of expansion.

Conclusion

CBIR is an effective method for expanding diagnostically labeled datasets. By increasing the size of the Diagnosed Subset from 17 to 74 nodules, CBIR expansion provides greater variability in the retrieval set, resulting in retrieved nodules that are more similar to undiagnosed queries. The proposed CBIR expansion method can be applied to other image databases containing large quantities of unlabeled data with few labeled instances. An expanded set of diagnosed images is also useful for non-CBIR CAD systems, which require large datasets for robust and unbiased training and testing.

References


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