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UNIFIED LEARNING PARADIGM FOR IMAGE RETRIEVAL

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Abstract. *Dealing with Relevance feedback (RF) using statistical learning has been a key technique to improve the content-based image retrieval (CBIR) performance. However, there is still a big room to further RF performance since the popular RF methods ignore the cooperation among various learning mechanisms. In this paper, we propose a unified learning paradigm (ULP) that integrates the merits of ensemble learning, semi-supervised learning, active learning and long-term learning into a uniform framework. Concretely, unlabeled examples are exploited to facilitate ensemble learning by helping augment the diversity among the base classifiers, and then, a strong ensemble is used to identify the most informative examples for active learning. In particular, the semantic clues are inferred in the long-term learning setting, which serves as the prior knowledge to validate the effectiveness of the unlabeled examples used by ULP. Finally, a bias-weighting strategy is developed to guide the ensemble of classifiers to pay more attention to the positive examples than the negative ones. An empirical study shows that using multiple learning strategies simultaneously in CBIR is beneficial, and that the proposed scheme is significantly more effective than some existing approaches.*
Keywords: Content-based image retrieval, Relevance feedback, Short-term learning, Long-term learning, Unified learning

1. **Introduction.** With the explosive growth of digital images, content-based image retrieval (CBIR) has drawn substantial research attention in the last decade [1]. In general, images are represented with visual features, such as color, texture and shape in CBIR systems. However, the gap between visual features and semantic concepts usually leads to poor performance. To narrow down the semantic gap, a few works focused on designing sophisticated methods to segment out the meaningful objects from an image [2,3]. However, it is impossible to achieve exact segmentation due to the rich content but subjective semantics of an image. Although it is feasible to bridge the semantic gap by building an image index with textual annotation [4,5], fully automatic image annotation is still a long way off. Relevance feedback, as an alternative and more promising way to mitigate the semantic gap issue, has been intensively investigated in recent years [6].

1.1. **Related works in relevance feedback.** Relevance feedback (RF) focuses on the interaction between the user and the search engine by letting the user provide feedback regarding the retrieval results, i.e., by labeling images returned as either positive or negative in terms of whether they are relevant to the query concept or not. From the interaction loop, the search engine is refined and the improved results are returned to the user. In essence, RF can be regarded as a statistical learning problem, and more precisely as a binary classification task between relevant and irrelevant classes. During the past years, many RF techniques based on statistical learning have been proposed, as for instance Bayesian learning, fuzzy sets, support vector machines (SVM) [7-9]. However, in CBIR