Chapter LVI
Probability Association Approach in Automatic Image Annotation

Feng Xu
Tsinghua University, Beijing, China

Yu-Jin Zhang
Tsinghua University, Beijing, China

INTRODUCTION

Content-based image retrieval (CBIR) has wide applications in public life. Either from a static image database or from the Web, one can search for a specific image, generally browse to make an interactive choice, and search for a picture to go with a broad story or to illustrate a document. Although CBIR has been well studied, it is still a challenging problem to search for images from a large image database because of the well-acknowledged semantic gap between low-level features and high-level semantic concepts. An alternative solution is to use keyword-based approaches, which usually associate images with keywords by either manually labeling or automatically extracting surrounding text from Web pages. Although such a solution is widely adopted by most existing commercial image search engines, it is not perfect. First, manual annotation, though precise, is expensive and difficult to extend to large-scale databases. Second, automatically extracted surrounding text might by incomplete and ambiguous in describing images, and even more, surrounding text may not be available in some applications. To overcome these problems, automated image annotation is considered as a promising approach in understanding and describing the content of images.

Automatic image annotation is derived from the manual annotation for CBIR. Since the semantic gap degrades the results of image search, the text descriptions are considered. It is desired that the text and the visual features cooperate to drive more effective search. The text labels, as the high-level features, and the visual features,

as the low-level features, are complementary for image content description. Therefore, automatic image annotation becomes an important research issue in image retrieval. In this chapter, some approaches for automatic image annotation will be reviewed and one of the typical approaches is described in detail. Then keyword-based image retrieval is introduced. The general applications of automatic image annotation are summarized and explained by figure examples.

BACKGROUND

As an effective way to support keyword-based image retrieval, automatic image annotation has been an active research topic in recent years. Since the purpose of image annotation is to bridge the semantic gap between low-level features and high-level concepts, the process of image annotation can be regarded as semantic concept discovery in image collections. Many sophisticated theories have attempted to drive image annotation automatically, such as statistical theory, machine learning (supervised and unsupervised methods), information theory, graph theory, and so forth.

A large number of good results have been reported. Jeon and Manmatha (2004) proposed the use of the maximum-entropy approach for automatic image annotation. Given labeled training data, maximum entropy allows one to predict the probability of a label given test data. Pan, Yang, Faloutsos, and Duygulu (2004) proposed a graph-based approach (GCap) for automatic image captioning. Carneiro and Vasconcelos (2005) introduced a supervised method to automatically annotate and retrieve images using a vocabulary of image semantics. The novel contributions include a discriminate formulation of the problem, a multiple instance learning solution that enables the estimation of concept probability distributions without prior image segmentation, and a hierarchical description of the density of each image class that enables very efficient training.

One of the most important processes is the propagation of the keywords. Jing, Li, Zhang, and Zhang (2004) proposed a keyword propagation framework to seamlessly combine the keyword and visual representations in image retrieval. Shevade and Sundaram (2004) presented a novel annotation paradigm with an emphasis on two facets: (a) semantic propagation and (b) an end-user experience that provides insight. Feng and Chua (2003) analyzed the main limitation of the supervised learning approaches and explored the use of the bootstrapping approach to tackle this problem.

Active learning is also effective in image annotation. Jin, Chai, and Si (2004) proposed a coherent language model for automatic image annotation that takes into account the word-toward correlation by estimating a coherent language model for an image. This new approach has two important advantages: (a) It is able to automatically determine the annotation length to improve the accuracy of retrieval results, and (b) it can be used with active learning to significantly reduce the required number of annotated image examples.

From the semantic discovery, Li, Goh, and Chang (2003) proposed a confidence-based dynamic ensemble (CDE) that can make dynamic adjustments to accommodate new semantics, to assist in the discovery of useful low-level features, and to improve class-prediction accuracy.

Metadata are useful in image annotation. Tsai, McGarry, and Trait (2004) presented a two-level supervised learning framework for effective image annotation. In the first-level induction stage, color and texture feature vectors are classified individually into their corresponding outputs. Then, the color and texture terms as middle-level features are classified into the target high-level conceptual classes during the second-level induction stage.

A suite of the most effective approaches for automatic image annotation is based on statistical learning, in which one of the typical approaches is the probability association method. An annotation

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