We present a new approach for improving image retrieval accuracy by integrating semantic concepts. First, images are represented according to various abstraction levels. At the lowest level, they are represented with visual features. At the upper level, they are represented with a set of very specific keywords. At subsequent levels, they are represented with more general keywords. Second, visual content together with keywords are used to create a hierarchical index. A probabilistic classification approach is proposed, which allows the grouping of similar images into the same class. Finally, this index is exploited in order to define three retrieval mechanisms: the first is text-based, the second is content-based, and the third is a combination of both. Experiments show that our combination allows one to nicely narrow the semantic gap encountered by most current image retrieval systems. Furthermore, we show that the proposed method helps to reduce retrieval time and improve retrieval accuracy.
Introduction

The number of images available on the World Wide Web and in the electronic collections is becoming very great, and it continues to grow every day. Image retrieval engines have proved to be very useful tools that allow people to easily access this information and to benefit from it. We can distinguish two main techniques in images retrieval. The first technique, known as text-based image retrieval, dates back to the late 1970s and is due to the database management community (Kherfi, Ziou, & Bernardi, 2004b). In this approach, images first are annotated with text, then text retrieval techniques can be applied. Many commercial systems have adopted this technique; however, it suffers from two main drawbacks. First, images are not always annotated, and their manual annotation may prove very expensive and time-consuming. Second, human annotation is subjective; the same image may be annotated differently by different observers. Furthermore, relying exclusively on text may prove insufficient, especially when the user is interested in visual components of the image that hardly can be described by words. The second approach involves using image content such as color and texture. This approach, known as content-based image retrieval (CBIR), was proposed in the early 1990s and comes from the computer vision community (Kherfi et al., 2004b). The main drawback of current CBIR systems is what is called the semantic gap. This drawback comes from the lack of connection between the visual description extracted from an image and the interpretation that a user assigns to the same image in a given situation. Indeed, people associate a multitude of high-level concepts, such as sensations and moods, to images. However, low-level features (such as color) that can be extracted automatically from images are still unable to derive high-level concepts.

In this chapter, we attempt to overcome the lack of the two mentioned approaches. We propose a new method based on a hierarchical indexing of images. We apply this method to combine visual features with semantics-based ones in order to narrow the semantic gap.

We will start the chapter with a literature review in which we show the importance of each of the approached issues (indexing and semantics retrieval) and review the main existing techniques. In subsequent sections, we respectively explain how we perform image annotation, indexing, and retrieval. In the experimentation section, we show that combining image content with text considerably helps to narrow the semantic gap. We finish the chapter with some conclusions and a discussion on future trends.

Background

Semantic Gap and Combining Visual Features with Text

In addition to low-level features such as color and shape, people use high-level concepts in order to categorize and identify images. This has led to the emergence of two main levels in image retrieval: low-level retrieval and high-level retrieval. Low-level retrieval comprises retrieval by primitive features such as color, texture, shape, and spatial location of image elements. High-level retrieval comprises retrieval of named objects and persons and
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