Chapter VII

Design and Evaluation of a Content-Based Image Retrieval System

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The growth in size and accessibility of multimedia databases has changed our approach to information retrieval. Classical text-based systems show their limitations in the context of multimedia retrieval. In this chapter, we address the problem of conceiving and evaluating a content-based image retrieval system. First, we investigate the use of the query-by-example (QBE) paradigm as a base paradigm for the development of a content-based image retrieval system (CBIRS). We show that it should be considered as a complement to the classical textual-based paradigms. We then evaluate the capabilities of the most up-to-date computer vision techniques in contributing to the realisation of such a system. Further, beyond the necessity of accurate image understanding techniques, we show that the amount of data involved in the process of describing image content should also be considered as an important issue. This aspect of our study is largely based on the experience acquired by the text retrieval (TR) community, which we adapt to the context of CBIR. Similarly, the text retrieval community has also developed significant experience in evaluating retrieval systems, where judgements include subjectivity and context dependency. Extending this experience, we study a coherent framework for performing the evaluation of a CBIRS. As a practical example, we use our Viper CBIR system, using a novel communication protocol called MRML (Multimedia Retrieval Markup Language) to pinpoint the importance of the sharing of resources in facilitating the evaluation and therefore the development of CBIRS.

INTRODUCTION

As more and more multimedia data and databases are accessible from the World Wide Web (WWW), it is fundamental to design tools which allow for the efficient browsing of such repositories. We address here the problem of the design and evaluation of a content-based image search engine. The conception of such a system can be approached from a number of viewpoints, ranging from computer vision to software engineering.

A number of image search engines are currently available on the WWW, either as commercial products or as research demonstration prototypes and are described in the related research literature. While they differ in their approaches at various levels, they all have the common goal of providing assistance to a user for retrieving a visual document within a database. In order to ensure the usefulness and usability of such a system, one should look carefully at the system from the user viewpoint and determine what level of assistance the system should provide to different types of users. This in turn allows one to define which technique should be used for formulating image queries. Computer vision procedures remain the core of a content-based image retrieval system (CBIRS) since they provide the representation under which the documents will be compared with one another. While large advances in image analysis techniques have been made, automated image content understanding processes still miss a substantial part of the semantic content of a visual document. This strongly influences the way in which images will be represented internally and therefore the choice of the features that should be extracted. This choice is also inherently very closely related to the internal search strategy taken. The background of database management should fully be exploited here. Finally, the architecture under which all the various components that form a complete CBIRS will communicate should be studied closely in the context of software engineering, in order to take full advantage of the context in which these tools will be developed (e.g. WWW).

In this chapter, we investigate all aspects of a CBIRS, from the usability to its technical development and evaluation. This investigation is done in close relationship with the experience acquired from text retrieval (TR), which is a mature field when compared with that of image retrieval. We study the problem of conceiving a CBIRS from different viewpoints. Typically, a trade-off is to be defined for satisfying the constraints arising from the user, the development and the architecture of the system. Then, we advocate the construction of a consistent framework for the evaluation of all existing CBIRSs. One key point in this framework is the sharing of resources, from a common database associated with validated ground truth to software components allowing one to distinguish between the evaluation of the different characteristics of a system such as retrieval efficiency and usability and to share experimental knowledge. Here, ground truth is understood to consist of real user judgements on image similarities. Another crucial factor is the derivation of a coherent set of quantitative measures so that objective comparison can be performed between the different approaches taken and the assumptions made.

Further, we use the practical example of the *Viper* system which has been under development for several years in our group, to illustrate the construction of a CBIRS and to introduce a novel approach for distributing and sharing multimedia resources and software components via the definition of a communication protocol called MRML (Multimedia Retrieval Markup Language). Practical results are provided to illustrate the evaluation context we recommend. We conclude by identifying the problems that still prevent CBIRSs from being fully effective and sketch some ways of overcoming such deficiencies.

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