Chapter 15

Design of a CBIR System Supporting High Level Concepts

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Content Based Image Retrieval (CBIR) systems that are able to “retrieve images of Clinton with Lewinsky” are unrealistic at present. However, this area has seen much research and development activity since IBM’s QBIC announcement in 1994. The CHITRA CBIR system under development at the RMIT and Monash Universities, addresses the need for a test bed system. Users can dynamically incorporate new features and similarity measures into the system, enabling it to act as a testbed for CBIR research. The system uses a 4-level data model we have developed and supports definition and querying of high level concepts such as MOUNTAIN and SUNSET. These advanced capabilities are supported by a powerful graphical query mechanism and a high-dimensional indexing structure based on linear mapping. In this paper we describe the design of the system, our contributions to the state of the art and provide some implementation details.

INTRODUCTION

Content-Based Image Retrieval (CBIR) has received much interest in recent times. Many prototype systems, such as QBIC (Flickner, Sawhney, Niblack, Ashley, Huang, Dom, Gorkani, Hafner, Lee, Petkovic and Steele, 1995), MARS (Ishikawa, Subramanyan and Faloutsos, 1998), and VisualSEEK (Smith and Chang, 1998) have been developed.
have been developed, and several have been released commercially. Though unable to handle queries as complex as “retrieve images of Clinton with Lewinsky,” current systems partially satisfy the requirements of general content-based image retrieval. The problems faced by CBIR researchers include lack of a common test-bed for testing new image feature extraction algorithms, new similarity measures, the absence of a standard image collection for judging competing techniques. These would allow competing strategies to be evaluated in a single environment, with little variation in parameters such as in machine speed and coding standards.

The prototype CHITRA CBIR system we are building jointly at RMIT and Monash Universities addresses these issues and provides a modular test-bed for CBIR research. In this paper, we describe our present design, our contributions to the state of the art, and the present state of implementation. The salient features of the system and the ideas we have contributed are as follows:
1. a four-layer data model which allows progressive levels of abstraction from the raw image data to high-level semantics (Nepal, Ramakrishna and Thom, 1998).
2. modular design enabling the user to plug in custom features, indexing methods, distance measures, and combining functions. Collections can be changed at will, and even used concurrently.
3. support for high-level concept definition: The user can define high-level semantics, such as “sunset” or “mountains” based on particular features or examples (Nepal et al., 1998).
4. support for querying by multiple examples, multiple features, or both (Nepal and Ramakrishna, 1999). The issue of processing such queries, our techniques and results are discussed in the following section.
5. user-modifiable weights for merging multiple sorted lists (Kerr and Ramakrishna, 1999).
6. purpose-designed index system, using linear-mapping to overcome the inherent limitations of R-tree based high-dimensional indexing schemes (Sumanasekara and Ramakrishna, 2000).

ARCHITECTURE AND DATA MODEL OF CHITRA

Existing CBIR systems allow relatively weak querying by content. The functions used compute the similarity between feature vectors are usually “hardwired” during the design stage. A user should be able to incorporate new similarity functions dynamically, or even redefine the schema and use new features. Both the system designer and the user should be involved in defining and storing semantic information; the system designer while defining the database schema, and the user while posing the query. These issues of semantics and flexibility are addressed by the CHITRA image data model.
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