Multimedia Databases and Data Management: A Survey

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ABSTRACT

The exponential growth of the technological advancements has resulted in high-resolution devices, such as digital cameras, scanners, monitors, and printers, which enable the capturing and displaying of multimedia data in high-density storage devices. Furthermore, more and more applications need to live with multimedia data. However, the gap between the characteristics of various media types and the application requirements has created the need to develop advanced techniques for multimedia data management and the extraction of relevant information from multimedia databases. Though many research efforts have been devoted to the areas of multimedia databases and data management, it is still far from maturity. The purpose of this article is to discuss how the existing techniques, methodologies, and tools addressed relevant issues and challenges to enable a better understanding in multimedia databases and data management. The focuses include: (1) how to develop a formal structure that can be used to capture the distinguishing content of the media data in a multimedia database (MMDB) and to form an abstract space for the data to be queried; (2) how to develop advanced content analysis and retrieval techniques that can be used to bridge the gaps between the semantic meaning and low-level media characteristics to improve multimedia information retrieval; and (3) how to develop query mechanisms that can handle complex spatial, temporal, and/or spatio-temporal relationships of multimedia data to answer the imprecise and incomplete queries issued to an MMDB.

Keywords: *Multimedia Content Analysis, Multimedia Data Management, Multimedia Database (MMDB), Multimedia Database Management System (MMDBMS), Multimedia Retrieval*

1. INTRODUCTION

Due to the technological advances and widespread adoption of multimedia computing, networking, electronic imaging, video devices, and data storage, a significant amount of multimedia data is being generated across the Internet and elsewhere each day. Multimedia information is ubiquitous and essential in a variety of applications like entertainment, education, digital libraries, manufacturing, marketing, homeland security, medicine, bioinformatics, advertisement, etc. Knowledge of the spatio-temporal phenomena is also of increasing relevance in those applications. Furthermore, the proliferation of social media and the success of many social websites such as Flickr, YouTube, MySpace, Facebook, and Zooomr provide incontrovertible evidence of users' migration to a new Web overwhelmed by

DOI: 10.4018/jmdem.2010111201

multimedia. The availability and popularity of multimedia data, social media, social websites, and their applications have created the needs for multimedia databases (MMDBs) and the supporting methodologies and tools for multimedia data management that make the searching and manipulating the content of such multimedia information a better and more friendly experience in facilitating the multimedia database management systems (MMDBMSs).

Multimedia data come in various media types, including image, video, audio, text, graphics, animation, and a combination of these media types. Conceptually, it seems possible to manage multimedia data in the same manner as the data types such as numbers, dates, and characters in the relational database systems. However, the spatial, temporal, and/or spatio-temporal characteristics of multimedia data have made the design, implementation, and maintenance of multimedia databases more challenging. It is well recognized that the traditional database systems, such as relational database systems, were developed for textual and numerical data, and data retrieval is often based on simple comparisons of text or numerical values. That is, with respect to the management, browsing, and searching of multimedia data, traditional database systems cannot provide adequate supports, since (1) They lack the ability to manage the composition of and the synchronicity among multimedia objects; (2) They lack the facilities to manage the spatio-temporal relations among the multimedia objects; (3) They have limitations in the semantic modeling of time-dependent multimedia data (e.g., video or audio); and (4) They do not cover all features required for multimedia information retrieval (Chen, Kashyap & Ghafoor, 2000; Shyu & Chen, 2005, 2006, 2008). Though there are attempts to support the access to multimedia objects in the forms of pointers to binary large objects (BLOBs) in relational database systems or to enable the definition of the part-of-relationship among objects in an arbitrary structure in object-oriented database systems, their capabilities of accessing the various portions of the multimedia objects interactively using BLOBs or managing the spatio-temporal relations among the multimedia objects using operational transparency are still very limited. Therefore, a new generation of multimedia database systems (MMDBSs) or some kind of multimedia extension to the existing database systems is needed, which must support various media types in addition to providing the facilities for traditional database management system functions like database creation, data modeling, data retrieval, data access and organization, and data independence.

Generally speaking, there have been research studies in the area of multimedia database systems (MMDBSs) since the mid 90s. Some of these MMDBSs relied mainly on the operating system for storing and querying the files and they were all able to handle diverse kinds of data to provide functionalities of querying, retrieval, insertion, and updating of multimedia data. There were MMDBSs that handled multimedia content by providing complex object types for various kinds of media. The object-oriented style provides the facility to define new data types and operators appropriate for the new kinds of media, such as video, image, and audio. Therefore, the broadly used MMDBSs are extensible Object-Relational DBMSs (ORDBMSs). The most advanced solutions are marketed by Oracle 10g, IBM DB2, and IBM Informix. They proposed a similar approach for extending the basic system. For example, a distributed multimedia DBMS called DISIMA is an image database system which enables content-based querying (Oria, Özsu & Iglinski, 2004). Furthermore, some research studies focused on addressing the needs of applications for rich semantic content, which mostly rely on the new MPEG-standards MPEG-7 and MPEG-21 (Kosch, 2003). MPEG-7 is the ISO/IEC 15938 standard for multimedia descriptions and issued in 2002, and it is an XML based multimedia meta data standard, which proposes description elements for the multimedia processing cycle from the capture (e.g., logging descriptors), analysis or filtering (e.g., descriptors of the Multimedia Description Schemes), to the delivery (e.g., media variation descriptors) and interaction (e.g., user prefer-