

Chapter XIV

A Content-Based Approach to Medical Image Database Retrieval

Chia-Hung Wei

University of Warwick, UK

Chang-Tsun Li

University of Warwick, UK

Roland Wilson

University of Warwick, UK

ABSTRACT

Content-based image retrieval (CBIR) makes use of image features, such as color and texture, to index images with minimal human intervention. Content-based image retrieval can be used to locate medical images in large databases. This chapter introduces a content-based approach to medical image retrieval. Fundamentals of the key components of content-based image retrieval systems are introduced first to give an overview of this area. A case study, which describes the methodology of a CBIR system for retrieving digital mammogram database, is then presented. This chapter is intended to disseminate the knowledge of the CBIR approach to the applications of medical image management and to attract greater interest from various research communities to rapidly advance research in this field.

INTRODUCTION

John Doe, a radiologist in a university hospital, takes X-rays and MRI scans for patients producing hundreds of digital images each day. In order to facilitate easy access in the future, he registers each image in a medical image database based on the modality, region, and orientation of the

image. One day Alice Smith, a surgeon, comes to discuss a case with John Doe as she suspects there is a tumor on the patient's brain according to the brain MRI. However, she cannot easily judge if it is a benign or malign tumor from the MRI scan, and would like to compare with previous cases to decide if this patient requires a dangerous operation. Understanding Alice's needs, John

helps Alice find similar-looking tumors from the previous MRI images. He uses the query-by-example mode of the medical image database, delineates the tumor area in the MRI image, and then requests the database to return the brain MRI images most similar to this one. Alice finds eleven similar images and their accompanying reports after reviewing the search results. Alice compares those cases and verifies the pattern of the tumor. Later on, she tells her patient that it is a benign tumor and the operation is unnecessary unless the tumor grows.

This scenario briefly describes the creation of medical images, categorization of medical images, and a content-based access approach. Although a mature content-based access technology has not appeared yet, this field is developing actively. In the last decade, a large number of digital medical images have been produced in hospitals. Large-scale image databases collect various images, including X-ray, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (US), nuclear medical imaging, endoscopy, microscopy, and scanning laser ophthalmoscopy (SLO). The most important aspect of image database management is how to effectively retrieve the desired images using a description of image content. This approach of searching images is known as content-based image retrieval (CBIR), which refers to the retrieval of images from a database using information directly derived from the content of images themselves, rather than from accompanying text or annotation (El-Naqa, Yang, Galatsanos, Nishikawa, & Wernick, 2004; Wei & Li, in press).

The main purpose of this chapter is to disseminate the knowledge of the CBIR approach to the applications of medical image retrieval and to attract greater interest from various research communities to rapidly advance research in this field. The rest of the chapter is organized as follows: The second section addresses the problems and challenges of medical image retrieval and describes potential applications of medical

CBIR. The third section reviews the existing medical CBIR systems. The fourth section provides greater details on the key components of content-based image retrieval systems for medical imaging applications. The fifth section presents a case study, which describes the methodology of CBIR systems for digital mammograms. The sixth section discusses potential research issues in the future research agenda. The last section concludes this chapter.

MEDICAL IMAGE DATABASE RETRIEVAL

This section will discuss the problems of image retrieval using the conventional text-based method and addresses the challenges of the CBIR approach. Potential applications of the CBIR approach will also be discussed.

Challenges in Medical Image Retrieval

Before the emergence of content-based retrieval, medical images were annotated with text, allowing the images to be accessed by text-based searching (Feng, Siu, & Zhang, 2003). Through textual description, medical images can be managed based on the classification of imaging modalities, regions, and orientation. This hierarchical structure allows users to easily navigate and browse the database. Searching is mainly carried out through standard Boolean queries.

However, with the emergence of massive image databases, the traditional text-based search suffers from the following limitations (Shah et al., 2004; Wei & Li, 2005):

- Manual annotations require too much time and are expensive to implement. As the number of images in a database grows, the difficulty in finding desired images increases. Muller, Michous, Bandon, and Geissbuhler

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