

Preface

In the past few years there has been a rapid increase in the field of multimedia data, mostly due to the evolution of information technology. One of the main components of multimedia data is its visual content, which includes digital images and video. While the issue of producing, compressing and propagating such media might have been a subject of scientific interest for a long time, in the past few years, exactly due to the increase in the range of data, a large part of the research was turned towards the management of retrieval of such material.

The first steps in automated management and retrieval of visual multi-media, can be traced back to 1992, where the term *Content Based Retrieval* was initially used. Since then, a new research field was created, which, approximately 20 years later, still remains active. And while initially this field of research seemed to be a research element classified under the general spectrum of information retrieval, as the years progressed, it managed to attract scientists from various disciplines.

Even though there is a large number of scientists working in this area, there is still lack of widely accredited solutions, keeping the field active and open to new ideas. The first Chapter of this book¹ introduces the reader in the field by giving the fundamental concepts and tools for Content-Based Image Retrieval. It includes the current standards and a brief description of existing image retrieval software solutions.

From Chapter 2 to Chapter 4, particular emphasis is given in recent computational intelligence techniques for producing compact content based descriptors comprising color, texture and spatial distribution information. They are used for fast image retrieval from large probably distributed inhomogenous databases. These descriptors can be described by the general term *Compact Composite Descriptors (CCDs)*. In contrast to MPEG-7, each type of multimedia data will be described by a specific group of descriptors.

Compact Composite Descriptors can describe the visual content of the following types of multimedia material:

¹This book contains parts of a Ph.D. dissertation material presented at Xanthi, Greece, Democritus University of Thrace, Department of Electrical and Computer Engineering, 2010

- Images/ Video with natural content
- Images/ Video with artificially generated content
- Grayscale Images/ Images with medical content

For the description and retrieval of multimedia material with natural content, 4 descriptors were developed:

- CEDD - Color and Edge Directivity Descriptor
- C.CEDD - Compact Color and Edge Directivity Descriptor
- FCTH - Fuzzy Color and Texture Histogram
- C.FCTH - Compact Fuzzy Color and Texture Histogram

The CEDD includes texture information produced by the six-bin histogram of a fuzzy system that uses the five digital filters proposed by the MPEG-7 EHD. Additionally, for color information the CEDD uses a 24-bin color histogram produced by the 24-bin fuzzy-linking system. Overall, the final histogram has $6 \times 24 = 144$ regions.

The FCTH descriptor includes the texture information produced in the eight-bin histogram of a fuzzy system that uses the high frequency bands of the Haar wavelet transform. For color information, the descriptor uses a 24-bin color histogram produced by the 24-bin fuzzy-linking system. Overall, the final histogram includes $8 \times 24 = 192$ regions.

The method for producing the C.CEDD differs from the CEDD method only in the color unit. The C.CEDD uses a fuzzy ten-bin linking system instead of the fuzzy 24-bin linking system. Overall, the final histogram has only $6 \times 10 = 60$ regions. Compact CEDD is the smallest descriptor requiring less than 23 bytes per image.

The method for producing C.FCTH differs from the FCTH method only in the color unit. Like its C.CEDD counterpart, this descriptor uses only a fuzzy ten-bin linking system instead of the fuzzy 24-bin linking system. Overall, the final histogram includes only $8 \times 10 = 80$ regions.

To restrict the Compact Composite Descriptors' length, the normalized bin values of the descriptors are quantized for binary representation in a three bits/bin quantization.

Experiments conducted on several benchmarking image databases demonstrate the effectiveness of the CCDs in outperforming the MPEG-7 Descriptors as well as other state-of-the-art descriptors from the literature. These descriptors are described in details in Chapter 2.

Chapter 3 describes the Spatial Color Distribution Descriptor (SpCD). This descriptor combines color and spatial color distribution information. Since this descriptor captures the layout information of color features, they can be used for image retrieval by using hand-drawn sketch queries. In addition, the descriptors of this structure are considered to be suitable for colored graphics, since such images contain relatively small number of



color and less texture regions than the natural color images. This descriptor uses a new fuzzy-linking system, that maps the colors of the image in a custom 8 colors palette.

The rapid advances made in the field of radiology, the increased frequency in which oncological diseases appear, as well as the demand for regular medical checks, led to the creation of a large database of radiology images in every hospital or medical center. There is now the imperative need to create an effective method for the indexing and retrieval of these images. Chapter 4 describes a new method of content based radiology medical image retrieval using the Brightness and Texture Directionality Histogram (BTDH). This descriptor uses brightness and texture characteristics as well as the spatial distribution of these characteristics in one compact 1D vector. The most important characteristic of this descriptor is that its size adapts according to the storage capabilities of the application that is using it.

The requirements of the modern retrieval systems are not limited to the achievement of good retrieval results, but extend to their ability for quick results. The majority of the Internet users would accept a reduction in the accuracy of the results in order to save time from searching. Chapter 5 describes how CCDs may be modified, in order to achieve a faster retrieval from databases. Test results indicate that the developed descriptors are in a position to execute retrieval of approximately 100,000 images per second, regardless of dimensions.

In Chapter 6 the procedure of early fusion of the two descriptors which describe visual multi-media material with natural content, is described. Given the fact that this category includes more than one descriptors, the procedure for combining these descriptors in order to further improve on the retrieval results, is analyzed.

Compact Composite Descriptors are capable of describing images with a specific content. The descriptors developed for use with images with natural content cannot be used to retrieve grayscale medical images and vice versa. Due to this, the calculation of the efficiency of each descriptor is made using image databases with homogenous content, suitable for the specific descriptor. However, the databases mostly used in the Internet are heterogeneous, and include images from every category. Chapter 7 describes how late fusion techniques can be used to combine all the CCDs, in order to achieve high retrievals scores in databases of this kind. Linear and non linear methods, which were adopted from the information retrieval field, have proven that the combination of descriptors yields very satisfactory results when used in heterogeneous data bases.

In the same Chapter, a retrieval scenario from distributed image databases is considered. In this scenario, the user executes a search in multiple databases. However, it is possible that each database uses its own descriptor(s) for the images it contains. Adopting once more methods from the information retrieval field and combining them with a method developed in this book it is possible to achieve high retrieval scores.

Chapter 8 describes a relevance feedback algorithm. The aim of this algorithm is to better readjust or even to alter the initial results of the retrieval, based on user preferences.



During this process, the user selects from the retrieved results those images which are similar to his/her expected results. Information extracted from these images is in the sequel used to alter the descriptor of the query image.

Chapter 9 describes the implementation of CCDs into free and open source software packages.

- img(Rummager)
- img(Anaktisi)

img(Rummager) was employed for the demonstration of the results of the research carried out in this book. In addition to the developed descriptors, the software implements a large number of descriptors from the literature (including the MPEG-7 descriptors), so that the application constitutes a platform for retrieving images via which the behaviour of a number of descriptors can be studied. The application can evaluate the retrieval results, both via the use of the new image retrieval evaluation method as well as via MAP and ANMRR. The application was programmed using C# and is freely available via the “Automatic Control, Systems and Robotics Laboratory” webpage, Department of Electrical and Computer Engineering, Democritus University of Thrace. The reader of this book may download the latest version of img(Rummager) application from <http://www.img-rummager.com>.

img(Anaktisi) was developed in collaboration with “Electrical Circuit Analysis Laboratory”, Department of Electrical and Computer Engineering, Democritus University of Thrace, and is an Internet based application which possesses the capability of executing image retrieval using the presented in these book tools in a large number of images. The application is programmed in C# . and is available on-line at <http://www.anaktisi.net>.