Chapter 13
Fuzzy Logic for Image Retrieval and Image Databases: A Literature Overview

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ABSTRACT

Fuzzy set theory has been extensively applied to the representation and processing of imprecise and uncertain data. Image data is becoming an important data resource with rapid growth in the number of large-scale image repositories. However, image data is fuzzy in nature, and imprecision and vagueness may exist in both image descriptions and query specifications. This chapter reviews some major work of image retrieval with fuzzy logic in the literature, including fuzzy content-based image retrieval and database support for fuzzy image retrieval. For the fuzzy content-based image retrieval, we present how fuzzy sets are applied for the extraction and representation of visual (colors, shapes, textures) features, similarity measures and indexing, relevance feedback, and retrieval systems. For the fuzzy image database retrieval, we present how fuzzy sets are applied for fuzzy image query processing based on a defined database models, and how various fuzzy database models can support image data management.

INTRODUCTION

Very large collections of images are growing rapidly due to the advent of cheaper storage devices and the Internet. For example, satellites send tens of images of earth each second and these images are stored in huge databases for future retrieval. The rapid growth in the number of large-scale image repositories in many domains such as medical image management, multimedia libraries, document archives, art collections, geographical information systems, law enforcement agencies, and journalism has brought about the need for

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efficient and effective content-based image retrieval mechanisms.

Finding an image from a large set of images is an extremely difficult problem. One solution is to label images manually, but this is very expensive, time consuming and infeasible for many applications. Furthermore, the labeling process depends on the semantic accuracy in describing the image. Therefore many content based image retrieval (CBIR) systems are developed to extract low-level features for describing the image content. For an overview of content based image retrieval, ones can refer to some recent survey papers, for example, (Müller, Michoux, Bandon and Geissbuhler, 2004), (Datta, Joshi, Li and Wang, 2008) and (Shandilya and Singhai, 2010).

In real-world applications, information is often imprecise or uncertain (Parsons, 1996). Many sources can contribute to the imprecision and uncertainty of data. It has been pointed out that in the future, we need to learn how to manage data that is imprecise or uncertain, and that contains an explicit representation of the uncertainty (Dalvi and Suciu, 2007). As pointed in (Gokcen, Yazici and Buckles, 2000), image data is fuzzy in nature and in content-based retrieval this property creates some problems such as:

1. Descriptions of image contents usually involve inexact and subjective concepts. For the diversity of image contents, different people would have different understandings and descriptions.
2. Usually imprecision and vagueness exist in descriptions of the images and in some of the visual features. The descriptions, which is associated with each stored image so as to retain the important visual characteristics, are generally imprecise and quantization of visual features (object features) can also be vague.
3. User's needs to image retrieval may be naturally fuzzy. User may specify linguistic qualifiers for his/her retrieval specification and preference.
4. Finite set of recognizable feature values by human is a restricted subset of what the image actually may have.

Due to subjectivity of human perception, imprecision and vagueness exist in both image descriptions and query specifications, which usually impair a definite decision about the satisfaction of a query. To overcome this limit, it is needed to introduce a score, and quantify the degree of truth, by which the available description permits a decision about a given query. It is true in image retrieval that user is not only looking for an exact match but also looking for the nearest matches. Some previous studies have been done on applying fuzzy processing techniques to CBIR. Among them, some tried to define an efficient way of fuzzy query processing and similarity computation between the query and images in the database, and some worked on the limited values of visual properties and defined representation systems for that task (Gokcen, Yazici and Buckles, 2000).

Databases are designed to support the data storage, processing, and retrieval activities related to data management. Nowadays rapid advances in computing power have brought opportunities for databases in emerging applications such as multimedia, knowledge engineering, geographic information systems, and etc. Image databases can be viewed as controlled collections of images. It is desired by users that image databases manage a great amount of image data and provide fast query resolution. Currently some researchers tried to apply advanced database technology to support image data management. It is noted that while some work has been done on fuzzy content-based image retrieval, working on fuzzy query processing based on a defined database model and fuzzy image database models are emerging.

In this chapter, we review two aspects of existing work in area of image retrieval with fuzzy logic. The first one is the fuzzy content-based