Distance-based Multimedia Indexing

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ABSTRACT

This tutorial aims at providing an overview of the state-of-the-art approaches to distance-based multimedia indexing. This tutorial presents the fundamentals of (i) object representation, (ii) distance-based similarity models, (iii) efficient query processing, and (iv) indexing. It is intended for a broad target audience starting from beginners to experts in the domain of distance-based similarity search in multimedia databases and adjacent research fields which utilize distance-based approaches.

1. INTRODUCTION

Concomitant with the explosive growth of the digital universe [11], an immensely increasing amount of multimedia data is generated, processed, and finally stored in very large multimedia databases. The rapid expansion of the internet and the extensive spread of mobile devices allow users to generate and share multimedia data everywhere and at any time. As a result, multimedia databases tend to grow continuously without any restriction and are thus no longer manually manageable by humans. Automatic approaches that allow for effective and efficient information access to massive multimedia databases become immensely important.

Multimedia retrieval approaches are one class of information access approaches that allow to manage and access multimedia databases with respect to the users' information needs. These approaches deal with the representation, storage, organization of, and access to information items [2]. In fact, they can be thought of approaches allowing users to *search*, *browse*, *explore*, and *analyze* multimedia databases by means of similarity relations among multimedia objects.

One promising and widespread approach to define similarity between multimedia objects consists in automatically extracting inherent properties of multimedia objects and comparing them with each other. For this purpose, the content-based properties of multimedia objects are modeled by feature representations which are comparable by means of *distance-based similarity measures*. This class of similarity

measures follows a rigorous mathematical interpretation [19] and allows domain experts and database experts to address the issues of effectiveness and efficiency simultaneously and independently. In fact, it has become mandatory for current distance-based similarity measures to be indexable in order to facilitate large-scale applicability.

2. TUTORIAL OUTLINE

In this tutorial, we aim at providing an overview of the state-of-the-art approaches to distance-based multimedia indexing. We intend to cover a broad target audience starting from beginners to experts in the domain of distance-based similarity search in multimedia databases and adjacent research fields which utilize distance-based approaches. No prerequisite knowledge is needed.

2.1 Object Representation

In the first part of this tutorial, we will outline different approaches to object representations in order to answer the question of how to model multimedia data objects in a generic way. We will focus on a unified object representation model including fixed-binning feature histograms and adaptive-binning feature signatures [3]. In addition to these object representations, we will present the idea of probabilistic feature signatures [4, 5] and show how to approximate object representations by means of gradient-based signatures [7].

2.2 Distance-based Similarity Models

In the second part of this tutorial, we will provide an overview of state-of-the-art distance-based similarity measures for feature histograms and feature signatures in order to complete our understanding of a similarity model. Among the multitude of distance-based similarity measures applicable to feature signatures, we will present and discuss the Earth Mover's Distance [15], the Signature Quadratic Form Distance [8], and the Signature Matching Distance [6].

2.3 Efficient Query Processing

The third part of this tutorial is devoted to techniques and algorithms for efficient query processing. After introducing distance-based similarity queries, we show how to process such queries efficiently by means of multi-step filter-and-refinement algorithms including multi-step range query algorithms [10] and optimal multi-step k-NN query algorithms [18]. To this end, we elucidate the idea of lower bound approximations and present state-of-the-art lower bound approximations [1, 20, 21] for the Earth Mover's Distance.

2.4 Indexing

The last part of this tutorial finally covers indexing approaches for distance-based similarity models where we will give an insight into the fundamentals of spatial access methods [16, 22], metric access methods [9, 14, 17, 23], and ptolemaic access methods [12, 13].

3. FURTHER INFORMATION

Further information regarding this tutorial can be found at `http://dme.rwth-aachen.de/en/DBMI`.

4. ACKNOWLEDGMENTS

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