POSTER PAPER

Issues in Augmenting Image Databases to Improve Processing Content-Based Similarity Searches

Leonard Brown
The University of Texas at Tyler
Department of Computer Science
Tyler, TX, 75799
(903) 565-5677
Leonard_Brown@uttyler.edu

ABSTRACT

Many current multimedia database management systems perform content-based retrieval of images by extracting a set of features from each data object inserted into the underlying database. This allows users to search the database for images that are similar to an input query image where the similarity is determined by comparing the previously extracted features. Thus, the ability of the system to compare images depends upon the features it can extract from them. This also means that the system may fail to correctly match one of its stored images to the query image if their corresponding features do not sufficiently match. One approach to minimize the occurrences of these situations is to add modified versions of the stored image to the database and attempt to match the query image to any one of them. This paper discusses the advantages and applicability of this approach.

Categories and Subject Descriptors

H.2.4 [**Systems**]: Multimedia Databases; H.3.3 [**Information Search and Retrieval**] Search Process.

General Terms

Algorithms, Performance, Theory.

Keywords

Content-Based Search, Similarity Search, Query Processing.

1. INTRODUCTION

One problem in performing Content-Based Retrieval (CBR) in a MultiMedia DataBase Management System (MMDBMS) is that the binary representation of two images of the same object may be very different. Thus, instead of searching for exact matches, an MMDBMS must facilitate similarity searching. To accomplish this, systems typically extract features and generate a signature for each image in the database to represent its content in order to search those features in response to a user's query. Thus, the system can search for images similar to a query image q by first translating q into a set of features, then comparing those features against the ones previously extracted from the images in the database. It is possible, however, that features extracted from two images do not match even though humans consider those two images to be similar. One technique for addressing this problem is to expand a given query image q into several different query images and submit each one individually to the database. The results from all of the query images are then combined together to form one result set. A drawback, however, with using this approach to search images is that the features must be extracted from each query image. Because feature extraction is an expensive process, this approach dramatically increases the query processing time.

As an alternative to the above approach, this paper addresses the problems of feature matching by augmenting the underlying database with new images derived by editing the original images already present. So, for each image object z in the database, the system will store z along with a set of images created by modifying z. This approach can improve the accuracy of CBR systems in any situation when a particular database image, say x, is expected to be retrieved in response to a query image q, but the features extracted from q and x do not sufficiently match. The central idea is that the features of q may sufficiently match op(x), where op(x) is created by applying a series of editing operations on image x. By adding op(x) to the database, it can be returned in response to the similarity search query. Furthermore, as long as the MMDBMS maintains a connection between x and op(x), the system can also return x in response to the query, even though the features of q and x do not match.

One benefit of augmenting a database with edited images becomes apparent when comparing it to existing research in the area of CBR. The current research focuses on either identifying techniques for improving the features extracted from images or improving the process used to compare or classify those features. In order to implement these techniques in an existing CBR system, it is necessary to change the internal procedures used by the MMDBMS to extract and compare features. In contrast, augmenting databases can potentially improve the retrieval accuracy of CBR components of existing MMDBMSs without having to change their internal procedures.

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Several open issues must be resolved to realize the effectiveness of the proposed augmentation approach. The goal of this paper is to describe these issues and present possible solutions for them.

2. STORING EDITED IMAGES

One disadvantage of database augmentation is that it increases the number of images stored in the database. This disadvantage is magnified because one of the characteristics that distinguishes multimedia objects from traditional alphanumeric data is they are typically much larger. Thus, adding more images to the database results in a nontrivial increase in the storage requirements of an MMDBMS.

To minimize the storage increase, one solution is to adopt the technique of storing the edited images as sequences of operations [1] instead of storing them in a conventional binary format such as JPEG [2]. Specifically, if an image e is created by editing an original image object o, e is stored as a reference to o along with the operations used to change o into e. There are two main advantages to using this format. The first is that an image stored as a set of operations would use much less space than the same image stored conventionally [1]. The second is that each edited image would contain a reference to the original image from which it was derived. This connection is necessary in order for the CBR system to determine that a query image, q, is similar to a database image object, o, based on a comparison between q and an edited version of o.

The above storage format solution means that two different types of images would be stored in a CBR system, original and edited images. As a result, it is necessary to determine an effective method for managing both types of images in the same database. Previous work [3] developed and evaluated different algorithms for searching databases that contained both types of images.

The database augmentation approach modifies the current challenges of CBR research. Instead of identifying new feature extraction techniques, the challenge becomes determining what images to add in order to improve retrieval accuracy. Thus, new techniques are required to determine which editing operations should be used to augment an MMDBMS.

Before determining which editing operations should be used, it is first necessary to identify the set of editing operations that are available. One potential set is used in ([1], [4]). The advantage of using this set of editing operations is that previous research [3] developed rules for identifying their respective effects on color-based features obtained from images in order to process color-based retrieval queries. Thus, previous work exists that may be helpful in determining rules for how to augment an image collection to improve the effectiveness of color-based queries. Additional rules will be necessary in order to improve the effectiveness of queries based on other features.

3. AUGMENTING IMAGE COLLECTIONS

The goal of augmenting a database with edited images is to improve the effectiveness of processing retrieval queries by reducing the number of occurrences of false negatives since that is often considered more important than reducing the number of false positives [5]. To achieve this, it is necessary that a similarity search based on query image q will retrieve an edited version of a desired image even though it fails to retrieve the original image. Thus, the goal of augmenting a database can be interpreted as identifying a set of editing operations, op, that can be applied to a database image that is a false negative for a similarity search based on q. After applying those operations to the image, say x, the result, op(x), is retrieved in response to the same query. The challenge, then, is to develop an algorithm that automates the process of finding those operations. A template for such an algorithm is presented in Figure 1. Since it is expected that the methods used to determine the editing operations will be feature-dependent, it will be necessary to identify multiple feature-specific methods for finding op(x).

```
For each image q in a training collection of images
   Let Sq equal the results of a search on q using feature f
   Let S equal the expected results of above search
   For each image x in S
      If x is not in Sq
         Increment falseNegatives[x]
For each image x in DB
   If (falseNegatives[x] > falseNegativeLimit)
      Compute op(x) for feature f
      Add op(x) to ADB
```

Figure 1 –Augmentation Algorithm Template

The difficulty with automating the process for determining the editing operations used to generate new versions of the database images is that a poor selection may increase the number of false positives generated by the system during query processing. A new false positive will occur when a database image is correctly not retrieved as the result of processing a similarity search, but an edited version of the image is retrieved from the same query. In order to minimize the number of times such a situation occurs, each new edited image added to a database should not be very different from the original image from which it is derived. This implies that there needs to be a limit on the amount of change caused by each selected sequence of editing operations.

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