A STORAGE AND RETRIEVAL SYSTEM FOR LARGE COLLECTIONS OF REMOTE SENSING IMAGES

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ABSTRACT:

In the area of remote sensing, an immense number of images are continuously generated by various remote sensing systems. These images must then be managed by a database system efficient storage and retrieval. There are many types of image database systems, among which the content-based image retrieval (CBIR) system is the most advanced. CBIR utilizes the metadata of images including the feature data for indexing and searching images. Therefore, the performance of image retrieval is significantly affected by the storage method of the image metadata. There are many features of images such as color, texture, and shape. We mainly consider the shape feature because shape can be identified in any remote sensing while color does not always necessarily appear in some remote sensing. In this paper, we propose a metadata representation and storage method for image search based on shape features. First, we extend MPEG-7 to describe the shape features which are not defined in the MPEG-7 standard. Second, we design a storage schema for storing images and their metadata in a relational database system. Then, we propose an efficient storage method for managing the shape feature data using a Wavelet technique. Finally, we provide the performance results of our proposed storage method.

KEY WORDS: Image Retrieval, Image Metadata, Wavelet, MPEG-7

1. INTRODUCTION

Image retrieval systems are classified into annotation-based retrieval, browsing and CBIR (Content Based Image Retrieval). In remote sensing environments, remote sensors generate numerous sensing images. It is very difficult to apply annotations that distinguish each individual image. Thus, annotation-based retrieval is inadequate. Furthermore, it is impractical to browse through such a vast collection of sensing images. CBIR retrieves similar images based on the image contents contents such as color, shape, and texture.

Image metadata consists of its title, creation time, file format, author, annotation, and content information such as color, shape, and texture. We mainly consider the shape feature because the shape can be identified in any remote sensing while color does not necessarily always appear in some remote sensing. Though the size of image metadata is smaller than image data, a huge amount of remote sensing images make also a very big amount of metadata. Because the performance of an image retrieval system depends on the storage and retrieval of this metadata, an efficient method of storing and retrieving metadata is very essential. We propose an efficient storage and retrieval method for large collections of image metadata in remote sensing systems.

First, we extend MPEG-7 standard(MPEG N4001, 2001; MPEG N4002, 2001) for describing the shape features which are not yet defined. Because MPEG-7 is an international standard for describing multimedia data, metadata described using MPEG-7 can be reused in any multimedia system that conforms to the MPEG-7 standard. Second, we design a storage schema for storing images and their metadata in a relational database system. Relational database systems have been developed through extensive research and stabilized. In addition, many techniques have been devised for storing MPEG-7 documents(D. Florescu, 1999). Then we propose an efficient storage method for managing shape feature data using a wavelet technique(Eric J. Stollnitz, 1996). Wavelet techniques are generally used as a tool for analysing and compressing numerical data. Finally, we provide the performance results of our proposed storage method.

2. METADATA STORAGE

2.1 Metadata description using MPEG-7

MPEG-7 is an international standard for contents description of multimedia data, and metadata which is described in MPEG-7 is easily understandable and compatible in other systems. In addition, it is possible for

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MPEG-7 metadata to be extended by defining new MPEG-7 schema.

In this paper, metadata consists of MPEG-7 document data, image file data, image segment and its feature data. MPEG-7 document information are creation time, author, authoring tool, version, etc. image file information are Media URI, title, annotation, image format, etc. Image segmentation and its feature data are the location and shapes of the objects that we want to retrieve in the image. Shape feature will be explained in the next.

2.2 Extension MPEG-7 for shape features

We extend MPEG-7 for describing shape features. Many shape features are used in our image retrieval system and some of the shape features are defined in the standard MPEG-7. But, some shape features are not defined in the standard. So, we extend the features. Polar projection(Yong-Il Kwon, 2005) data is an example of our extension.

Polar projection is high dimensional data. It describes the overall shape of objects in the image. It approximates the spatial composition of objects without regards to the scale and rotation of objects. Figure 1 represents the polar projection data type. It consists of three vectors which are Projection, maxLength, and ChangeCount. The length of each vector is 72.

```
<complexType name="PolarProjectionType" final="#all">
  <complexContent>
    <extension base="mpeg7:VisualDType">
      <sequence>
        <element name="Projection">
          <simpleType>
            <restriction>
              <simpleType>
                <list itemType="mpeg7:unsigned16"/>
              </simpleType>
              <length value="72"/>
            </restriction>
          </simpleType>
        </element>
        <element name="MaxLength">
          <simpleType>
            <restriction>
              <simpleType>
                <list itemType="mpeg7:unsigned16"/>
              </simpleType>
              <length value="72"/>
            </restriction>
          </simpleType>
        </element>
        <element name="ChangeCount">
          <simpleType>
            <restriction>
              <simpleType>
                <list itemType="mpeg7:unsigned16"/>
              </simpleType>
              <length value="72"/>
            </restriction>
          </simpleType>
        </element>
```

Figure 1. MPEG-7 data type for polar projection

2.3 Storage schema design

MPEG-7 metadata is an XML document. We could design a storage schema for the metadata in a relational database system, because XML schema can be converted into relational database schema by methods proposed by previous research. We have applied one such method to our metadata. In our system, we focus not on storing the structure of MPEG-7 documents, but the data itself.

2.4 Storage using wavelet technique

As we mentioned section 2.2, polar projection data has 216 elements comprised of the 72 dimensional vectors for Projection, maxLength, and ChangeCount. To store this data into a relational database, the schema must generate many columns in the feature data table. As a result, the image retrieval system has to access an excessive number of columns data for polar projection feature information.

To overcome this problem, we propose an efficient storage method for managing polar projection data using a wavelet technique. We transform polar projection data into wavelet form. The resulting data is then distinguished by high-level frequency and low-level frequency. Then, we can approximate the shape of the object by accessing part of the wavelet data. This wavelet technique is similar to vertical partitioning. However, access to all of the polar projection data is not always necessary because accessing a subset of the wavelet data can provide an approximation of the shape data.

3. IMAGE RETRIEVAL

For image retrieval, our system supports K-NN(K-Nearest Neighbor) search. For retrieving similar images, we use metadata of image database. As mentioned in section 2.4, accessing the high dimensional polar projection data is expensive. Therefore, we apply the wavelet technique to the polar projection data.

First, we find similar images using polar projection data in the low level resolution table. At this point, we choose candidate images which are more similar than other images. Then, we repeat the process of finding similar images with the polar projection data of one-step higher resolution. As this process is repeated, polar projection data is restored to its original resolution. This process filters dissimilar images in each iteration. As a result, this process reduces access of polar projection data over each iteration by filtering dissimilar images.

```
q := Polar projection data of the query image;
k := the number of the result images;
do {
      read Polar projection data from storage system;
      compare q with Polar projection data;
      result_set := similar k images to the q;
      n := the number of the candidate images;
      if ( n <= k )
            return   result_set;
} while (increase the resolution of Polar projection)
```

Figure 2. Retrieval algorithm using wavelets

4. EXPERIMENTS

Our image retrieval system stores remote sensing images and its metadata, and retrieves the images similar to the query image on the basis of metadata. To measure the performance of our approach using the wavelet technique, we simulated remote sensing images with SIMPLIcity(James Z. Wang, 2001) images and generated metadata of various degrees using wavelet transformation. We compared four different representations of polar projection data, which includes the original polar projection data, and the 1-step, 2-step, and 3-step transformations using wavelets.

Figure 3 represents the results of using the wavelet technique for image retrieval. The X-axis is the resolution of the polar projection data, and the Y-axis is the R-precision and retrieval time in the first and second graph, respectively. For comparison of the query image to the database images, we use the L1 and L2 functions.

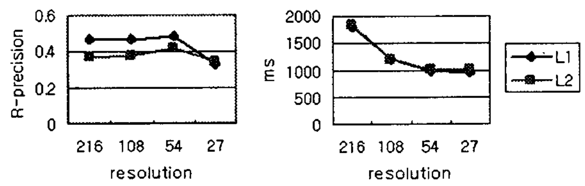

Figure 3. Accuracy and retrieval time using wavelets

For more detailed analysis, we generated additional measures for experimental results. Although a result image may not be a correct result for the K-NN search, it may be in the same class as the query image. So, we also check whether the result is the same class. As long as the result images is in the same class as the query image, we consider it as a correct result for classification. Figure 4 compares classification and similarity using the L1 function.

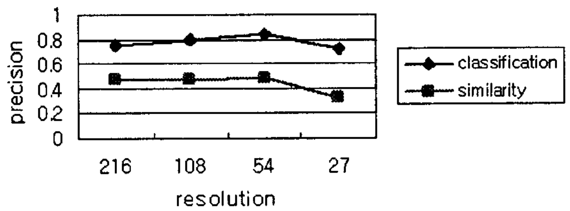

Figure 4. Similarity and classification of

5. RESULTS

Figure 3 shows that the use of the wavelet technique with polar projections improves the accuracy and reduces retrieval time. But, at lower resolutions (e.g. three step transformation) it has difficulty maintaining the original polar projection data. As a result, the three step transformation is less accurate than the other cases. In Figure 4, the query result shows that most of the result images are in the same class as the query image.

6. DISCUSSION

Using the wavelet technique reduces the access to metadata. While high dimensional data requires excessive accesses, the wavelet technique only accesses the metadata of the candidate images. Therefore, search time is also reduced. It is useful for high dimensional data such as polar projection.

The method using the wavelet technique is more accurate than a straightforward comparison, because it can summarize the data. But it suffers at high levels of compression as it cannot summarize the original data.

7. CONCLUSIONS

We extended MPEG-7 to describe the polar projection shape feature and designed a storage schema for storing the metadata in a relational database. Then, we proposed an efficient storage method for managing the shape feature data using a wavelet technique. The experimentation results show the wavelet technique improves accuracy and retrieval time.

8. REFERENCES

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