

Webview: A Distributed Geographical Image Retrieval System*

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URL of demo: <http://picasso.cse.buffalo.edu:8080/META/>

Abstract

With the increasing number of geographical image databases on the Internet, it is a very important issue to know about the most relevant image databases for given user queries, in order to achieve high efficiency in retrieving the images. To address this problem, we have developed a novel system, *Webview*, which intelligently ranks the distributed geographical image databases based on their visual content. Our system summarizes the visual content of each database in a metadatabase, which is a collection of automatically generated image templates and statistical metadata. With the metadatabase, our system can guide the user queries toward the most relevant image databases in a distributed environment.

1 Introduction

Geographical images are being gathered from civil, defense, and intelligence satellites at an explosive rate on the Internet. One of the challenging problems for content-based image retrieval (CBIR) systems is to retrieve the relevant images from remote image databases given user queries. Under such a distributed environment, it is impractical for the system to examine all the images in the databases to match for the relevant images. Instead, based on a particular visual query, the system should be able to rank the relevant image databases intelligently by the metadata gathered and summarized from respective image databases. The query is then guided to the respective databases and the relevant images in those databases are returned to users.

Based on our previous works on the data resource selection in distributed visual information systems (Chang *et al*, 1998) and on CBIR (Zhu *et al*, 2000; Sheikholeslami *et al*, 1999), *Webview* is developed to support content-based retrieval on the distributed geographical information system (GIS) image databases. In the following sections, we will first introduce the system architecture of our system, then focus on the design and implementation of the metaserver armed with the metadatabase and the database ranking mechanism, and finally describe the user access applications.

2 System architecture

The system includes three major components. The first component is the remote GIS image databases and respective image retrieving servers. The second component is the metaserver, including the metadatabase, the metasearch agent, and the query manager. The third component is the user access applications at the client machines. The components are illustrated in Figure 1(a).

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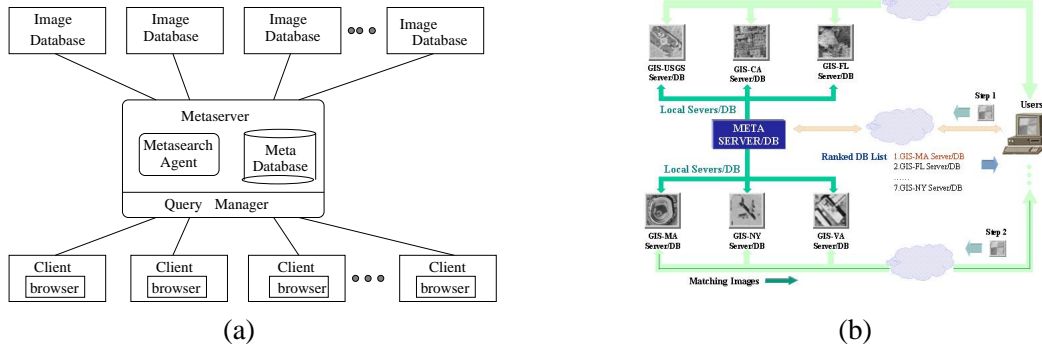


Figure 1: (a) System architecture of the *Webview*, (b) System prototype including 6 remote GIS image databases

Figure 1(b) shows a system prototype hosting six remote GIS image databases. The geographical images in these databases represent the scene of grass, tree, residence, and water. The databases are located in the remote host computers connected by the Internet. As shown in Figure 1(b), at *Step 1* a visual query is sent to the metaserver, which, based on the metadatabase, ranks the relevant databases for the query. At *Step 2*, the query is forwarded to the selected databases. The matched images from each selected database are sent back to users.

3 Metaserver

The metaserver includes a *Query manager* for extracting the image feature vectors from the user queries and for suitable matching of the feature vectors with the metadata housed in the *Metadatabase*, uses the *Metasearch agent* for producing a ranked list of the remote databases relevant to the queries, and guides the queries to the selected databases. We first introduce how to extract the image feature vectors, then describe how to generate the metadatabase and how the database ranking mechanism works to retrieve the relevant images from the remote image databases.

3.1 Extraction of image feature vectors

Based on different approaches, the visual content of each image in the databases can be represented as multiple feature vectors, each corresponding to a different feature class. We use *Wavelet* (Sheikholeslami *et al*, 1999) and *Keyblock*-based methods (Zhu *et al*, 2000) to extract the feature vectors.

For wavelet-based feature extraction, we use Nona-tree (Sheikholeslami *et al*, 1997) to decompose each image to sub-images recursively until a certain sub-image size (in our system, it is 64×64) is reached. Then based on the sub-images as well as the original images, different types of wavelet transforms such as Haar, Daubechies, Cohen-Daubechies-Feauveau(4, 2) (CDF_4) and Cohen-Daubechies-Feauveau(2, 2) (CDF_2) are applied to extract texture feature vectors of images at different scales from coarse to fine.

For the keyblock-based feature extraction, the sub-images (also called blocks) derived using Nona-tree are encoded using a pre-defined codebook and image features are extracted based on the frequency and correlation of representative blocks.

3.2 Generation of metadatabase

The metadatabase records the *image templates* as the summaries of the visual contents of the images for remote image databases. Each template is associated with the *statistical metadata* to characterize its

similarity distributions with the images in various remote databases. We briefly introduce how to generate them as follows:

(1) *Image templates*: The feature vectors of the images in the databases can be classified into clusters. Each cluster can be represented by a single feature vector, denoted as *template*, which is generally the centroid of the cluster. The clusters can be further classified into sub-clusters, which can then be represented by their centroids. The benefit of this approach is that a hierarchical index can be built on the templates to support efficient query retrievals. A template at a higher level represents the coarse features that contain all the features represented by its child templates.

To find the templates, we first select sample images from remote databases. By using the hierarchical clustering method, we build a tree-like structure called dendrogram. We can cut the dendrogram at different levels resulting in different sets of clusters. We then use the centroids of the resulting clusters as the templates. The process is applied for each feature class to find the corresponding templates. Thus these templates can represent the images in the entire remote database concisely.

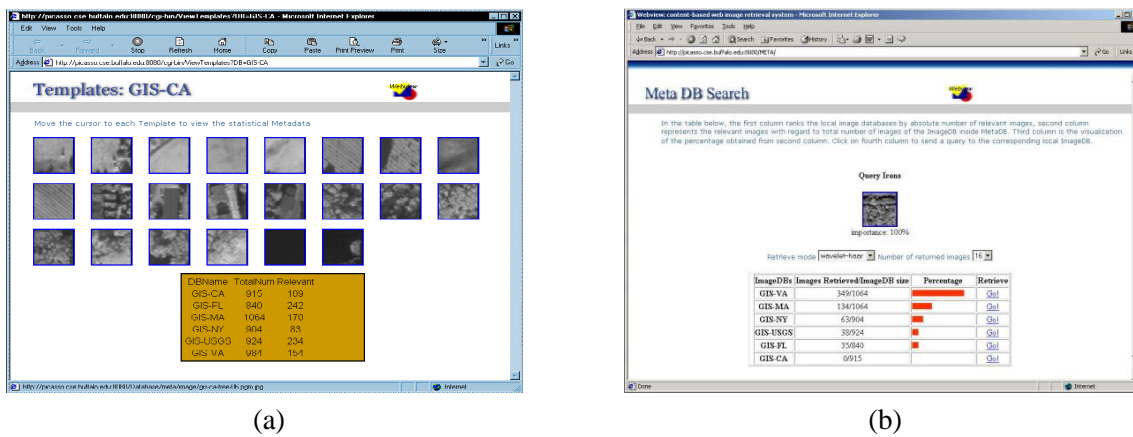


Figure 2: (a) Visualization of templates and statistical metadata for the database GIS-CA, (b) Database ranking result by Metaserver

(2) *Statistical metadata*: Based on the templates collected from individual databases, we can measure the similarity of images in the databases to the templates. We assume that the similarity of feature vectors between a certain image and a template indicates their similarity of visual content. More specifically, given a template (which is a feature vector, denoted T) and its corresponding image (denoted I_T), and an image I_{FV} with feature vector FV , the degree of similarity between T and FV will reflect the similarity of visual content between I_T and I_{FV} .

By the distributions of the similarities between database images and the templates, statistical metadata can be computed to represent the visual relationships between the databases and templates, i.e. the likelihood of a database containing images that are relevant to a template.

In our system, we visualize the templates and statistical metadata for each remote database. Figure 2(a) shows the templates (shown in the template images) and the statistical metadata (shown in the yellow box, for a certain template) in the database GIS-CA.

3.3 Remote database ranking mechanism

Based on the metadatabase, the remote image databases can be ranked by the metasearch agent with regard to a particular visual query. The similarity between the feature vector of the query image and all the templates in the metadatabase will be calculated to determine the most relevant template(s) for the query. Based on the statistical metadata associated with the template(s), the *Mean-Based approach* (Chang *et al*, 1998) is applied to rank the databases. In Figure 2(b), the table un-

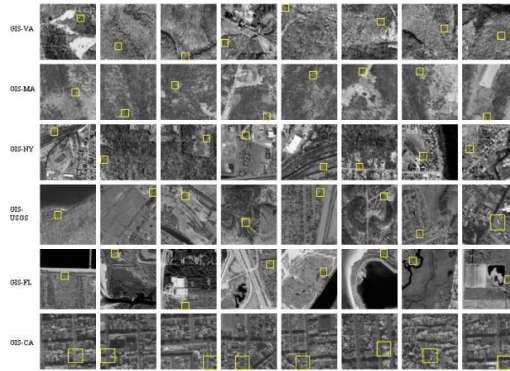


Figure 3: Retrieval results from all the remote databases for a given query

der the query icon shows the result of ranking the databases with the red bars indicating the **Percentage**: $(Relevant_images)/(Number_of_images_in_DB)$. The larger the percentage, the higher the rank of database will be. Once the ranked list of the remote databases with regard to a certain query is generated, the metaserver will pose the query to the relevant databases selected by users. The CBIR techniques will be conducted in the remote database image retrieving servers to obtain the relevant images back to users.

4 User access applications

Users can choose the query images either from the databases or from the Internet using an image URL. The relevant images are then retrieved in the process described above. For the query shown in Figure 2(b), the final retrieval results from all the remote databases are shown in Figure 3. Users can also view the templates and statistical metadata for each remote database, as shown in Figure 2(a).

5 Conclusion

We have developed the *Webview* to support image retrieval from distributed geographical image databases over Internet. Based on the queries, the system ranks the remote images databases by the information collected in the metadatabase, then guides the queries to the most relevant databases to retrieve the relevant images back to users. Experimental results demonstrate the effectiveness of our system.

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