Compressed Domain Image Retrieval Using Thumbnails of Images

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Abstract

The emergence of multimedia, the availability of a large digital archives, and the rapid growth of World Wide Web (WWW) have recently attracted research efforts in providing tools for effective retrieval of image database. Content Based image Retrieval (CBIR) has emerged as a promising approach for image retrieval in last decade. To reduce the storage and transmission requirements in image applications, images are compressed while maintaining acceptable visual quality. In this paper, a unique approach which emphasizes the compressed-domain solutions to image retrieval is explored. A reduced complexity approach for efficient retrieval of images using VQ on thumbnails of images is presented. A VQ codebook is used to represent the image. The similarity is computed in terms of MSE between the thumbnail of query image and all the image thumbnails in the database. The system is tested for various thumbnail sizes. UCID database is used for testing the system.

1. Introduction

Due to advances in data storage and rapid growth of World Wide Web along with image acquisition technologies, there is creation of huge image data sets and digital archives. Images as a norm are now being stored in compressed domain so as to cater to the constraints imposed by storage and transmission costs of managing large amount of image data. Effective and efficient image indexing and accessing tools are of supreme importance in order to fully utilize the huge digital data available on Internet.

Even though so much effort has been spent on image retrieval techniques, one important aspect of image compression has been neglected almost completely. As the amount of image data is ever increasing, whereas hardware and network resources are still somewhat limited. What this means in terms of digital images is that, they are almost always stored in compressed form in order to use as little space as possible. Image compression itself has also been a very active research topic. The large volumes of images necessitate the use of compression techniques. Hence, the visual data in future multimedia databases are expected to be stored in the compressed form. In order to prevent the need to decompress the image data and apply pixel-domain retrieval techniques, it is efficient to perform the retrieval of image in the compressed form**.** Compressed domain image retrieval techniques have a lower cost for computing and storing. Unfortunately this approach has not been followed much, as a recent review [1, 21] reveals.

2. Image retrieval in the compressed domain

Image retrieval in the pixel domain requires pixel information. For color photographs, this means we have to process data consisting of at least 3 channels: red, green and blue. The bit depth of a pixel component is usually 8 bit. For example: a color image of size 512x512 with a sample bit depth of 8 bit needs nearly one megabyte of storage, as opposed to maybe 100-200kB when stored in compressed form. For this reason images are seldom stored in pixel format. To avoid the need to decompress images to apply pixel domain techniques, compressed domain indexing (CDI) techniques have been developed

Ideally, CDI not only saves time, but also improves indexing performance. By definition, compression aims to avoid redundant information while still having vital characteristics of the data at hand. In this respect, compression techniques form the perfect setup for feature extraction.

CDI techniques can be broadly classified into two categories: transform domain techniques and spatial domain techniques. Examples for transform domain techniques are methods based on discrete Fourier transform (DFT), discrete cosine transform (DCT) and techniques based on wavelets. Since JPEG2000 uses

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wavelet transform, JPEG2000 indexing falls into this category. Spatial domain techniques are mainly based on vector quantization (VQ) and fractals.

Vector quantization is a popular image coding technique [2]. Based on the observation that the coding of vectors is more efficient than the coding of scalars, images are divided into sub-images (blocks). Each block is then replaced by an index into a codebook that contains a list of representative image blocks. The codebook is generated according to a minimum distortion rate so as to provide good image quality. Image compression is achieved by transmitting the codebook indices rather than the full data. Decoding of the image is performed through a lookup table operation. Because of this, vector quantization is known as a very efficient compression technique and can hence be used even in applications where processing power is limited.

2.1 Compressed domain image retrieval using VQ

As VQ compresses the image data, we need to generate a feature vector for the image in the compressed domain where we have low volumes of data. This improves the image index generation time. Image retrieval based on VQ compressed data has the following advantages over the basic color histogram based method.

1. During the indexing process, no decompression is required.
2. The number of blocks is significantly less than that of pixels, leading to more efficient indexing and retrieval.
3. The VQ based method should provide higher image retrieval effectiveness. This is because the similarity is based on a block of pixels instead of individual pixels.
4. VQ based method overcome the problem in cases where two blocks of pixels based on individual pixels have the same or similar histograms, but overall appearance of these two blocks are totally different.

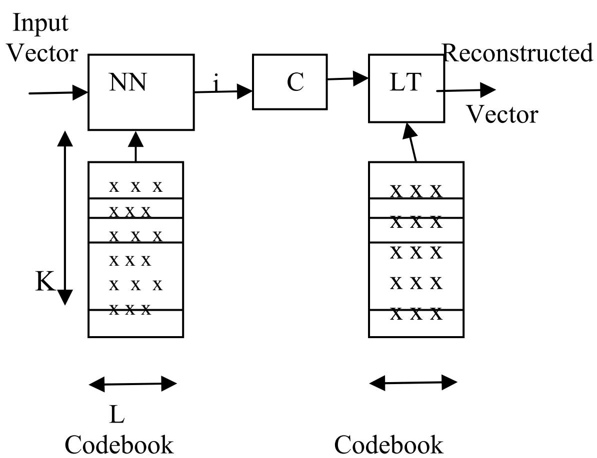
Fig. 1 shows Block Diagram of Vector Quantization Technique.

VQ based image classification and retrieval has been proposed in the past. In VQ based method some spatial information is implicitly included, because quantization is performed on image blocks instead of single pixels [3,4]. It uses VQ to index compressed images and video data. Images are initially compressed using a universal VQ codebook, and then for each code vector in the codebook, a histogram of image pixels is generated (the number of pixels is taken to be the number of colors in the image). Per Pixel histogram of the entire image is approximated by a linear combination of the code vector histograms weighted by the frequency of occurrence of a code vector. Their results are comparable with the methods based on color histograms. Reference [5] proposes another method wherein images are compared based on the use of code vector in those images. This method is based on the reduced complexity similarity evaluation and its performance is equivalent to that of using color histograms. It has employed a universal codebook to represent each image and similarity is computed using the histogram intersection (HI) between code vector usage histograms. In reference [6] global color palettes or color codebooks are built in the HSV color space using Gaussian mixture VQ (GMVQ). After quantizing the images using these colors, a color histogram is created and retrieval is performed by computing the histogram intersection. Results are presented for scalar quantization in RGB (8x8x4), and also for HSV (16x4x4), where VQ is performed on each HSV color channel independently for codebooks of sizes 16 (Hue), 4 (Saturation) and 4 (Value), and GMVQ is performed with the same codebooks sizes as in VQ. GMVQ outperforms VQ because of its ability (covariance structure) to better approximate unseen colors.

The VQ based methods described so far make use of a universal codebook. In this approach, if images with different statistical properties (classes) were to be later added to the database, then the codebook may need to be updated to maintain retrieval accuracy. One way to solve this is to design separate codebooks for each image. In [7], a separate codebook for each image is created, and then images are compared indirectly by computing a modified Hausdorff distance (MHD) between the image codebooks. This approach is of very low complexity at the cost of less inherent power of retrieval. In contrast, better performance is achieved by encoding the query image with Gaussian mixture codebooks of each image in the database as described in [8].

In [9] a low complexity approach for content-based image retrieval (CBIR) using vector quantization (VQ) is presented. The VQ codebooks serve as generative image models and are used to represent images while computing their similarity. The hope is that encoding an image with a codebook of a similar image will yield a better representation than when a codebook of a dissimilar image is used. It is empirically found that, encoding an image with a codebook of a similar image yield better representation than when a codebook of a dissimilar image is used Retrieval based on this method compares well with previous work. In this method each image is tagged with a thumbnail and a small VQ codebook of only 8 entries, where each entry is a 6 element color feature vector is generated.

Performance improvement is obtained by augmenting feature vectors with x-y coordinates associated with the entry.



NN- Nearest neighbour,, i – lable, C- channel, LT- lookup table

Figure 1 : Block Diagram of Vector Quantization Technique

The database included the thumbnails of images, the codebooks and links to original images. For the query step, forward compression was used where database codebooks were used to compress the query image. The method was tested with the COREL image database consisting of 1500 JPEG images. All 1,500 images were either 256 x 384 or 384 x 256. The thumbnails were first transformed from the RGB color space to the perceptually uniform *CIE LUV* color space. Then feature vectors are then formed from the mean and variance of each color channel for each 2 x 2 block of a thumbnail. Then the VQ codebook for a thumbnail was constructed using the standard splitting algorithm [2], with MSE as the distance function.

3. IR using thumbnails of images

Our work is extension of [5]. According to the authors of [4], Image Retrieval using VQ on image thumbnails is a reduced complexity and efficient technique, it is further explored. We have tested this on UCID datasets to investigate the relationship between thumbnail size and retrieval performance. Different thumbnail sizes are selected such as 256 X 256, 128 X 128, 64 X 64 and 32 X32. IR is performed using VQ technique. Precision and Recall are used as performance measures.

3.1 The Algorithm

- Preprocessing database
  - Convert all mages into thumbnails of desired size.
  - Derive feature vector from each thumbnail and construct a VQ codebook
- For every Query image
  - Compress the query image
  - Get its codebook
  - Compare it with each codebook in the database
  - Rank the images of the database in order of the achieved distortion.

4. Implementation

This section presents the simulation results and discusses our scheme. We tested the concept put forth in [9]. The first part demonstrates the components of the test-bed. The second part presents the results of the image retrieval scheme. The above algorithm is implemented in MATLAB. Distance measure used is explained in third part.

The results are as shown below in figure 4 for thumbnail sizes 256, 128 1nd 64

4.1 The test bed

We setup a sample system to evaluate the retrieval schemes. The system consists of a distance measure, an image database, a query image sets and relevant image sets. The GUI of our system is as shown in figure 2**.**

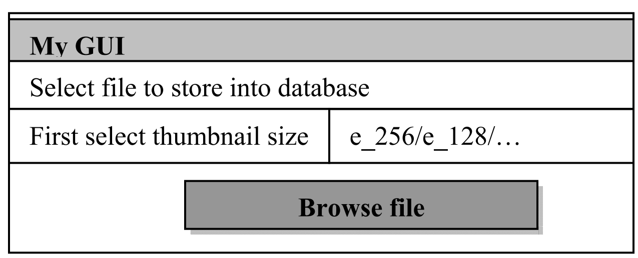


Figure 2 My GUI for preprocessing

This GUI is used to tag each image with thumbnail of desired size (like 256, 128 or 64). Thus output is the files with thumbnails of images in the database of different sizes. It is the preprocessing step.

Our system, first transforms the thumbnails from the RGB color space to the perceptually uniform CIE LUV color space where the Euclidean distance between colors closely approximates their perceptual distance**.** Then Feature vectors of 6 components each are formed from the mean and variance of each color channel for each 2 by2 block of a thumbnail. Feature vector extraction is followed by construction of the VQ codebook for a thumbnail using the standard splitting algorithm with MSE as the distance function.

For image retrieval, the query image is first transformed into desired thumbnail and then feature vector is extracted in the same manner as discussed above. The codebook of query image thumbnail is then compared with the codebooks of all images in database and first 8 results are displayed in their rank order. Euclidean Distance is used as similarity measure.

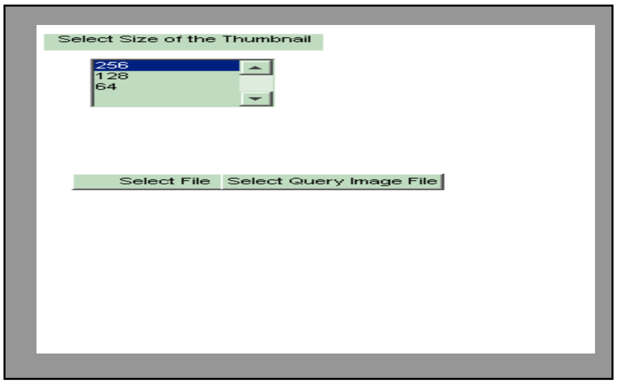


Figure 3 CDIR using thumbnails prototype

4.2 Database used for testing

We used UCID (pronounced "use it")-An Uncompressed Colour Image Dataset [10]. It consists of 1338 uncompressed TIFF images on a variety of topics including natural scenes and man-made objects, both indoors and outdoors. All images were taken with a Minolta Dimage 5 digital colour camera which, in contrast to many other models, also allows images to be captured in uncompressed form. Ground truth on the image set is also defined. Images can be ranked in ascending order of the calculated distance. The larger the calculated distance between two images, the more different the two images. A subset of the images is assigned as query images and for each of these a series of correct matches that an ideal image indexing system would retrieve is specified. The UCID database also represents a good benchmark set for the evaluation of any kind of CBIR method as well as an image set that can be used to evaluate image compression and colour quantisation algorithms. The dataset and the ground truth files are available at http://vision.doc.ntu.ac.uk/

4.3 Distance Measure

Euclidean distance is calculated as defined below.

The distance between the query image Q and an image V can be calculated as follows:

$$d_{L1}(Q,V) = \left| \sum_{i=1}^{k} \sqrt{qi^2 - vi^2} \right|$$

Images can be ranked in ascending order of the calculated distance. The larger the calculated distance between two images, the more different the two images.

5. Result

The results for few sample queries are shown in figure 4.

(a) CDIR with Thumbnail size 256

(b)CDIR with Thumbnail size 128

(c) CDIR with Thumbnail size 64

Figure 4- Output of prototype system for same query with different Thumbnail sizes

6. Conclusion

CDIR using VQ is a low complexity approach. It is fast too as the data is reduced because of use of image thumbnails. It is observed that as the thumbnail size is reduced, the distance value also reduces. This affects the rank of similar image in the output. However it did not work to the expectation for the images having same object with different background. Hence for such images other retrieval technique is required that will extract information about objects. Our aim is to work on a technique to improve accuracy of retrieval.

7. References

[1] Mandal, F. Idris, and S. Panchanathan, "A critical evaluation of image and video indexing techniques in the compressed domain", Image and Vision Computing, 1999, 17(7):513{529.

[2] Gersho and R. Gray, "Vector quantization and signal compression." Kluwer Academic Press, 1992.

[3] F. Idris and S. Panchanathan [1995]. "Storage and Retrieval of Compressed Images", IEEE Transactions on Consumer Electronics, 43:5, 937-941

[4] F. Idris, and S. Panchanathan, "Storage and Retrieval of Compressed images", THAM P1.6, May 5,1995 IEEE, pp 142-143.

[5] G. Lu and S. Teng [1999]. "A Novel Image Retrieval Technique Based on Vector Quantization", Proceedings of International Conference on Computational Intelligence for Modeling, Control and Automation, pp 36-41.

[6] Alexandra Teynor1, Wolfgang M¨uller2, and Wolfgang Kowarschick, "Compressed Domain Image Retrieval Using JPEG2000 and Gaussian Mixture Models", VISUAL 2005, LNCS 3736, 2005. pp. 132–142.

[7] G. Schaefer and W. Naumienko [2003]. "Midstream Content Access by VQ Codebook Matching", Imaging Science, Systems and Technology, 170-176.

[8] Gerald Schaefer, "Compressed domain image retrieval by comparing vector quantization codebooks", Visual Communications and Image Processing, 2002, PP 959-966.

[9] A H Daptardar, J A Storer, "Reduced complexity Content Based Image Retrieval using Vector Quantization", Proc. of the Data Compression Conference, 2006.

[10] G. Schaefer and M. Stich (2004) "UCID - An Uncompressed Colour Image Database", Proc. SPIE, Storage and Retrieval Methods and Applications for Multimedia 2004, pp. 472-480.

[11] Shih-Fu Chang, "Compressed-Domain Content-Based Image And Video Retrieval", Published in Symposium on Multimedia Communications and Video Coding, Polytechnic University, New York, Oct. 1995.

[12] Zhe-Ming Lu,, Su-Zhi Li And Hans Burkhardt,, "A Content-Based Image Retrieval Scheme in JPEG Compressed Domain", ICIC International 2006 ISSN 1349-4198 Volume 2, Number 4, August 2006 pp. 831—839.

[13] Jiang, J., A. Armstrong and G. C. Feng, Direct content access and extraction from JPEG compressed images, Patten Recognition, 2001, pp.1-9.

[14] Lm NI, "A Novel Image Retrieval Scheme in JPEG2000 Compressed Domain Based on Tree Distance", ICICS PCM2003, 15-18 December 2003, pp 1591-1594.

[15] Gerald Schaefer and Simon Lieutaud, "Colour and shape based image retrieval for CVPIC coded images, CISST 2004: 456-461.

[16] Meekal Bajaj and Jose A. lay, "Image Indexing and Retrieval in Compressed Domain Using Color Clusters", IEEE Symposium on Computational Intelligence in Image and Signal Processing,CIISP2007. 1-5 April 2007, pp 271-274.

[17] G. Schaefer and M. Stich, "On the influence of image compression on the performance of content based image retrieval", 6th IC on Visual Information System, 2003, pp 426-431.

[18] Md. M Islam, D. Zhang and G Lu, "Comparison of retrieval effectiveness of different region based image representations**",** 6th International Conference on Information, Communications & Signal Processing, 2007, 10-13 Dec. 2007 pp1-4.

[19] M. Hatzigiorgaki a and A. N. Skodras b,c , "Compressed Domain Image Retrieval: A Comparative Study of Similarity Metrics", VCIP 2003.

[20] S. Jeong and R. M. Gray [2005]. "Minimum Distortion Color Image Retrieval Based On Lloyd-Clustered Gauss Mixtures", Proc. IEEE Data Compression Conference, 279-288.

[21] V R Khapli, A S Bhalchandra, "Compressed Domain Content Based Image Retrieval: State of the Art, Challenges and Open Issues" , PWASET, Volume 36, ISSN2070-3740, December 2008 at Bangkok, Thailand , pp 1335-1339