Content-based Image Indexing Using PCA

Young-Dal Yu, Min Gun Jun, Daijin Kim*, Dae-Seong Kang
School of Electrical, Electronic, and Computer Eng., Dong-A Univ
840 Hadan-dong, Saha-ku, Pusan 604-714, Korea
Tel: +82-51-200-7710 Fax: +82-51-200-7712
Dept. of Computer Eng., POSTECH*
E-mail: dskang@daunet.donga.ac.kr

Abstract: In this paper, we propose the method using PCA(principal component analysis) algorithm when proposed algorithm performs multimedia information indexing. After we extract DC coefficients of DCT from MPEG video stream which is an international standard of moving picture compression coding, we apply PCA algorithm to image made of DC coefficients and extract the feature of each DC image. Using extracted features, we generate codebook and perform multimedia information indexing. The proposed algorithm is very fast when indexing and can generate optimized codebook because of using statistical feature of data

1. Introduction

Recently, research of technology which efficiently controls multimedia data like document, image and voice is actively in progress because of communication network which is possible high-speed data transmission, multimedia technology development and compression technology of computer. Especially, image retrieval methods for searching user's request from image database have been in the spotlight as new field overcoming limitation of past text-based retrieval methods[1-6].

Image retrieval methods can divide widely into text-based retrieval and content-based retrieval. Early image database system is text-based retrieval, and this method retrieves as using the information after adding representative notes about each image. But if multimedia information represents with text-based information, it is supervised and has a fault that cannot retrieve image similar to query image. Content-based retrieval, on the contrary, can retrieve using shape, color and texture of objects, there are merits that can extract feature of image and store that information automatically[7-11].

Content-based retrieval methods suggested several methods. Among of them, there are methods using color histogram and projection technique. The method using color histogram shows up well the whole feature of image, but that can recognize same image as other image because of loss of information of image position. And the method using projection technique has a problem for retrieving data of various shapes because image size of creating data is different each other. In this paper, we propose the method applying PCA(principal component analysis) algorithm to multimedia data. PCA algorithm has a merit that is enough to select only initial error properly. And since PCA algorithm does not need training time against neural network, there is a merit to generate codebook for vector quantization with high speed. Besides, PCA algorithm can generate optimized codebook because of using statistical feature of data.

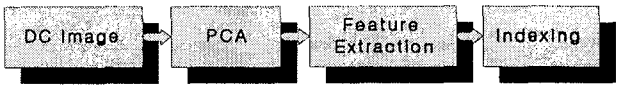
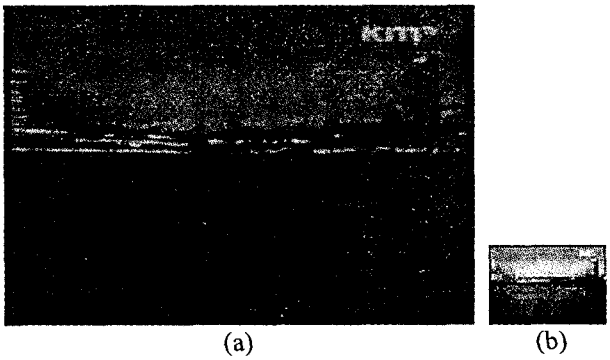


Fig. 1. Total block diagram

This paper is organized as follows. We explain for extraction of DC image in chapter 2 and explain for indexing using proposed principal component analysis in chapter 3. In chapter 4, we discuss experimental result and finally we mention conclusion.

2. Extraction of DC image

MPEG video of international moving picture standard consists of picture of I, P, B type. In this paper, we make DC image after being normalized DCT DC coefficients extracted from I picture of MPEG video streams. At this time, the extracted DC image is constructed after eliminating noisy property through low-pass filter because of being added noisy property. Fig. 2 is a key frame extracted in MPEG video stream and that DC image.



(a) (b)

Fig. 2. (a) I-type picture (b) DC Image

3. Indexing using PCA

This paper applied PCA algorithm for design of vector quantization codebook. PCA algorithm has a merit that can get good result if we select properly initial error and can generate codebook for vector quantization with high

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speed because of no training time against neural network. Besides, PCA algorithm can generate optimized codebook by using statistical feature of data. In this paper, we apply PCA algorithm to important divided regions after implementation of two-dimensional vector. The whole procedure of the proposed PCA algorithm is organized as follow.

STEP 1. Two-dimensional vector of divided region
STEP 2. Construction of initial region
STEP 3. Decision of critical error
STEP 4. Calculation for average axis and average error of regions
STEP 5. IF(average error > critical error) then divide two regions
STEP 6. Repeat STEP 4 ~ STEP 5 until average error == critical error

Here, the standard of region-division cuts as grasping the whole characteristics of input data. Namely, determine principal axis of data and set up virtual line which passes average coordinates point of region which is vertical with the principal-axis and divide two group.

1. Algorithm to solve principal axis

① Calculate geometrical mean, M about input vector

$$M = \begin{bmatrix} Mx \\ My \end{bmatrix}$$

$$Mx = \frac{1}{q}\sum_{i=0}^{q-1} Ix_i \quad My = \frac{1}{q}\sum_{i=0}^{q-1} Iy_i$$

Here, q is number of total input vector, and Ix_i and Iy_i is value of x axis and value of y axis of input vector.

② Calculate covariance matrix of image

$$C = \begin{bmatrix} C_1 & C_2 \\ C_3 & C_4 \end{bmatrix}, \text{ where}$$

$$C_1 = \frac{1}{q}\sum_{i=0}^{q-1}(x_i^2 - M_x^2)$$

$$C_2 = C_3 = \frac{1}{q}\sum_{i=0}^{q-1}(x_i y_i - M_x M_y)$$

$$C_4 = \frac{1}{q}\sum_{i=0}^{q-1}(y_i^2 - M_y^2)$$

③ Calculate the largest eigen-value

$$\lambda_{max} = \frac{(C_1 + C_4) + \sqrt{(C_1 + C_4)^2 - 4(C_1 C_4 - C_2 C_3)}}{2}$$

④ Calculate an angle of principal-axis

$$\theta = a\tan\left[\frac{\lambda_{max} - C_1}{2}\right]$$

After calculating angle of principal-axis like this, divide region that calculates division algorithm of region into two equal parts.

2. Region division algorithm

① Calculate average axis of input vector of same region
② Calculate angle(φ) with line passing average coordinates and vertical with principal axis using algorithm of principal-axis angle calculation
③ If ($\cos(\varphi) \leq 0$) then region 1 else region 2

Fig. 3 is to express figure of divided region after calculating principal axis by proposed algorithm

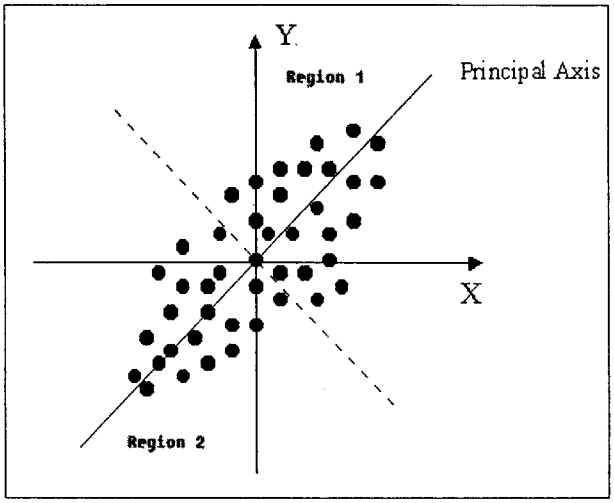


Fig. 3. Region segmentation using principal axis

In this paper, we perform indexing as applying PCA algorithm to MPEG video stream. Here, let's suppose to be extracted key-frame of MPEG video stream and extract that DC image. Then, we make an exception of color value in DC image for data distribution of PCA algorithm. This processing make two-dimensional vector of DC image data. At this time, the extracted DC image is constructed after eliminating noisy property through low-pass filter because of being added noisy property. In this paper, after we regard thirty DC image as one data, make two-dimensional vector. And we can create 300 codewords using algorithm for getting principal axis and algorithm for region division. The proposed counts number of two-dimensional vector value assigned these codewords and uses for indexing of MPEG video stream. Namely, this counting value is characteristic of DC image and make counting value assigned 300 codewords to codebook about each DC image. We compare with MPEG video stream for confirming that results. Here, we apply histogram equalization to each image for improving comparison result between MPEG video stream and DC image. And we scale down MPEG video stream, then after converting color image into gray image, we compare codebook about the same codewords by applying PCA algorithm. This proposed method can create high-speed codebook and can optimize codebook because it uses global property against local property. Fig. 4 represents the proposed algorithm.

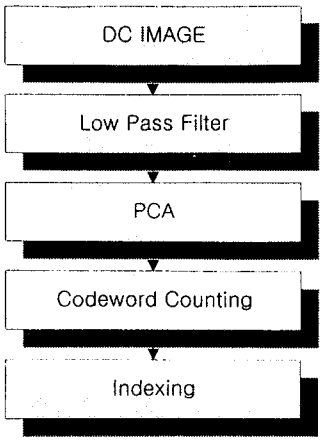
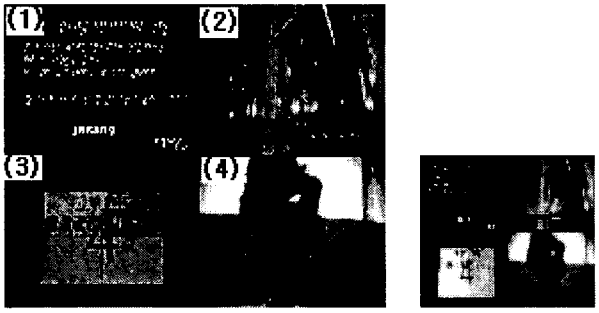


Fig. 4. The whole algorithm using PCA

4. Experimental Result

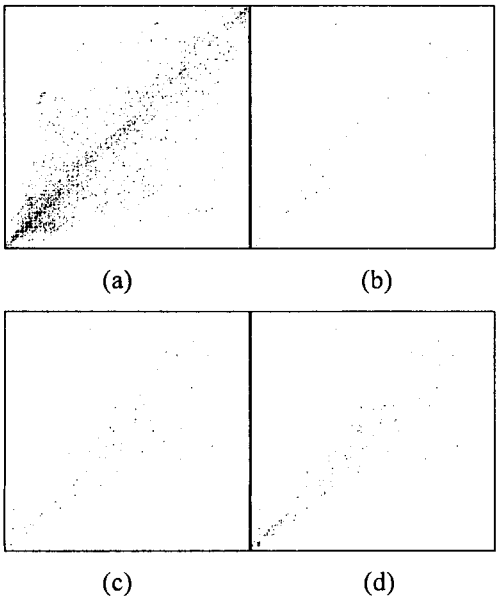
In this experiment, we make key frame extracted MPEG video stream and that DC image to codebook, The number of DC image used experiment is thirty. DC images have noisy property in comparison with MPEG video stream, then made an experiment after eliminating noisy property through low-pass filter.

Fig. 5 (a) is to extract key frame of MPEG video stream and the size is 352 * 240 image and (b) DC image constructed DCT DC coefficients of key frame, 44 * 30 image.



(a) (b)

Fig. 5. (a) MPEG Stream (b) DC Image



(a) (b)

(c) (d)

Fig. 6. (a) two-dimensional vector (b) 50 codeword (c) 100 codeword (d) 300 codeword

Fig. 6 (a) make DC image about key frame of Fig 5 to two-dimensional vector and (b), (c), (d) results in 50, 100, 300 by final node number. In fig (c), each pixels is one codeword and count pixel-number of fig. (a) assigned the codeword, then make codebook. Fig. 7 is plot of codebook about fig. 5 (a). The width is to express 30 codeword because of limited space and the length is to count each codewords. In fig. 7, the reason appearing many counting values in a codeword is to classify definitely black or white like fig. 5 (a)(1).

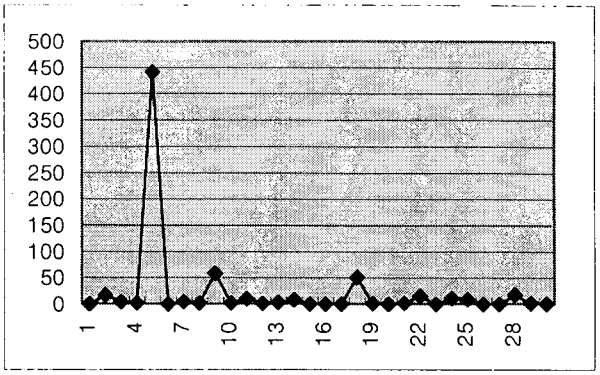


Fig. 7. Codebook of fig. 5 (a)(1)

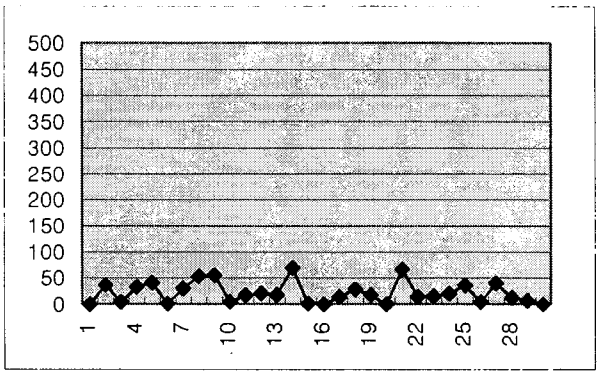


Fig. 8. Codebook of fig. 5 (a) (2)

Fig. 8 is the codebook of fig. 5 (a)(2). The reason that values of each codeword spreads out equally is to spread out equally from 0 to 255 like fig. 5 (a)(2). Fig. 9 is the codebook of fig. 5 (a)(3). Fig. 10 is similar to the fig. 8.

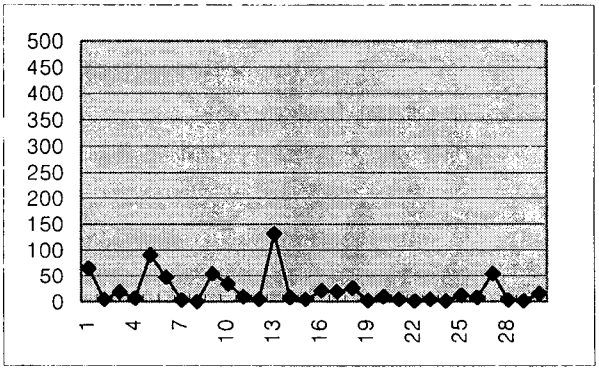


Fig. 9. Codebook of fig. 5 (a) (3)

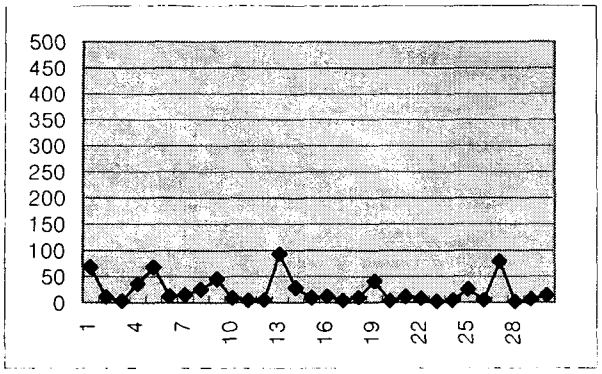


Fig. 10. Codebook of fig. 5 (a) (4)

In this paper, we perform histogram equalization before creating codebook for improving retrieval result. This is equal to brightness of MPEG video stream and DC image. Fig. 11 (a) is original DC image and (b) is to perform histogram equalization.

(a) (b)

Fig. 11. The comparison (a) DC image (b) DC image performing histogram equalization

Table 1. Retrieval result about each codebook size

CodeBook / Image	100	200	300
1	55.2%	55.2%	51.7%
2	90.0%	90.0%	93.1%

Table 1 is the retrieval result between DC image and MPEG video stream. Image 1 of table 1 is retrieval result of original DC image and MPEG video stream only. And Image 2 is retrieval result after performing histogram equalization. Codebook size 300 is the best performance.

5. Conclusion

In this paper, the proposed algorithm is organized as follows. First, we make DC image after being normalized DCT DC coefficients extracted from I picture of MPEG video streams. And we applied DC image extracted as this way to design algorithm of codebook for vector quantization using PCA algorithm, then three hundred codewords are generated in this paper. Indexing step of MPEG video streams apply two-dimensional vector value of each DC image to the created codewords, and count codeword that has minimal error. The count numbers are a feature of DC image, in this paper, thirty DC images were simulated and retrieval efficiency of 93.1%. In this paper, when proposed algorithm performs multimedia information indexing, we can create high-speed codebook and if we select only initial error, can create codebook desired and can optimize codebook because it uses global property against local property.

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