# Image Retrieval Based on Edge Classification Method in BTC-VQ Compressed Domain

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***Abstract-*** **Because of high volume of graphic information, retrieval of compressed images is one of the needs of information era. One of the rapid methods for image compression which has the capability to maintain important information of images for retrieval is Block Truncation Coding (BTC). In this article a new method for retrieval of images compressed by BTC has been provided. In our approach, we use some classified patterns, derived from BTC method as a retrieval feature. This method has been examined on a database consisting of 9983 images with different contents and its results have been compared with similar methods.**

## 1. Introduction

Transfer of a digital image has been considered as one of the most important research topics for more than 40 years and today most of the efforts are that firstly to decrease the volume of storage and secondly to make it possible to retrieve the proposed images with acceptable speed and precision. So two sciences of image retrieval and image compression should solve this issue jointly and we use such methods for image compression which have ability for maintaining important information of image for its retrieval [7].

In standard compression methods such as JPEG, image retrieval has not been considered [11] and successful methods like vector quantization despite its power in compression and retrieval have low speed in compression [3] and practically the problem is storing an image with high efficiency in the binary form.

Maintenance of visual and natural features of image in compression and so that efficiency of an image depends on two parameters of 1-Data rate and 2-Distortion. If the retrieved image is completely similar to the original image, it is called "Lossless technique" and otherwise it is called "Lossy technique". One of most usable methods is the method of cutting the image to non-covering blocks. The deficiency of this method is that margins of blocks may be seen at the retrieval time. BTC-VQ method has high speed in compressing, and also in articles [8], [9] it has been shown that this method has suitable capability for images retrieval, because in addition to using the information of block-in connection, it also stores the important information of each block in compressed form.

In this article, BTC-VQ and a new presented method is used for compressing, based on Color Histogram [12] and Block Pattern Histogram [11]. Simultaneous utilization of Color Histogram and BPH provides us suitable information based on color and edges, and this cause an increase in system speed and efficiency. Utilization of color histogram minimizes the limits of browsing images and will cause the block pattern histogram to find the images with higher speed. One of the defects of BTC-VQ is low degree of compressing in comparison to other compressing methods such as JPEG and VQ.

As we proceed dealing with this article, at first BTC-VQ and then retrieval method based on compressing are explained. In the fourth part, results of experiments and in the fifth part, conclusion, are stated.

## 2. BTC-VQ Compressing method

At first BTC method and then its developed method, BTC-VQ is studied. In BTC, first the image is divided separately into 4×4 blocks. If we show each block of image with $x(i,j)$, by considering this point that each block is 4×4, the mean of the existing color in each block is calculated as follows [1]:

$$\bar{x} = \frac{\sum_{i=1}^{4}\sum_{j=1}^{4} x(i,j)}{4*4}$$

By utilization of such mean quantity, we can establish a 4×4 matrix of $bp(i,j)$ block pattern by the use of the following formula:

$$bp(i,j) = \begin{cases} 1 & x(i,j) \geq \bar{x} \\ 0 & x(i,j) \prec \bar{x} \end{cases}$$

Then, we show the mean quantities of zero and one patterns with *M0* and *M1*, respectively:

$$M_0 = \frac{\sum_{i=1}^{4}\sum_{j=1}^{4} bp(i,j)x(i,j)}{\sum_{i=1}^{4}\sum_{j=1}^{4} bp(i,j)}$$

$$M_1 = \frac{\sum_{i=1}^{4}\sum_{j=1}^{4} (1-bp(i,j))x(i,j)}{4*4-\sum_{i=1}^{4}\sum_{j=1}^{4} bp(i,j)}$$

And if we show the decoded block with $y(i,j)$, this block is calculated as follows:



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$$y(i,j)=\begin{cases} M_0 & bp(i,j)=1 \\ M_1 & bp(i,j)=0 \end{cases}$$

Compressing and retrieval of BTC method has been shown as an example in Figure 1[2].

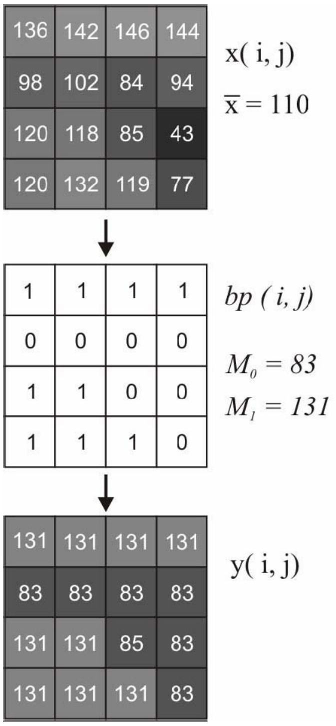


Figure 1. BTC Compression.

BTC-VQ is the improved method of BTC. In this method instead of using 16-bit to storing a 4×4 matrix (1 bit for each 0 or 1 location), we store one 8-bit matrix. It is the only difference between these methods. For performing this job, VQ method is used. In this method so many images are used for identification of most blocks patterns existing in images. For 4×4 blocks, this job is performed in Vistex Lab in MIT University by utilization of 3,500,000 images and finally 256 most repeated blocks have been elected as figure 2.

Therefore, the BTC-VQ method has two advantages over BTC method:

* More compression; Instead of storing two bytes for each block pattern, we just use one byte.

* Possibility for retrieval with higher quality; because most important features of blocks patterns exist in these 256 patterns and in order to establishing Block Pattern Histogram, all such patterns are used.

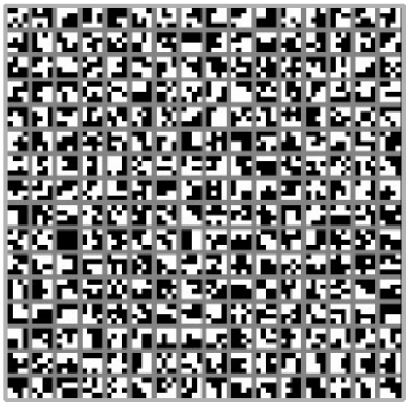

Figure 2. 256 most repeated Block Patterns, elected by VQ method for 4×4 Blocks

BTC Method was first propounded for non color image compression, but in following years, methods for utilization of it in colored images area are propounded [4], [5]. In this article for all three color levels (Red, Green, Blue), BTC-VQ method is applied separately and finally all three color levels have been combined. The Sequences of converting a non compressed image to a compressed image by BTC-VQ is as figure 3.

## 3. Retrieval based on color and block pattern

As explained before, in this research, we use BTC-VQ method for compression and then we use a retrieval method based on utilization of features extracted from images by BTC-VQ method. In this paper, two steps are used for retrieval. First, images are retrieved through comparison of color histogram and then through block pattern histogram. In continuation of this part we study these two methods.

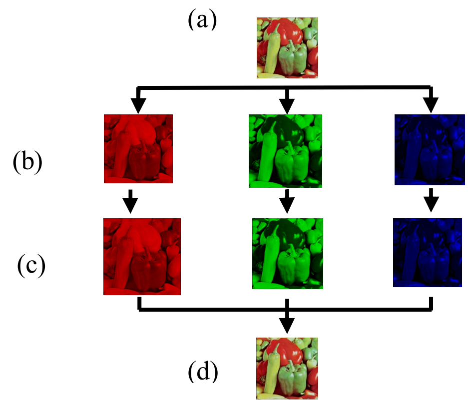


Figure 3. 3-D tags of establishing compressed picture based on BTC-VQ method. (a) Source Image (b) BTC compressed with RGB color system (c) BTC-VQ RGB layer compressed (d) Final BTC-VQ compressed image

### *3.1 Retrieval through Comparison to Color Histogram*

This method is used in the first stage of retrieval and its purpose is finding similar images to desire image from viewpoint of color. In this regard, for each image, three color histograms (R,G,B) are established separately. For comparison of images from viewpoint of similarity, we compare their histograms and for increasing speed in calculation, we use a simple method (because this stage applies on all images and the affects on speed of the algorithm). Therefore for comparison of color histograms, we use Minkowski-form metrics. It means that if $ch_q$ is color histogram of query image, $ch_t$ is color histogram of target image, determining the result of comparison is as below:

$$Color_{q,t} = \left[\sum_{m=0}^{255} \left| ch_{qr}(m) - ch_{tr}(m) \right| \right] + \left[\sum_{m=0}^{255} \left| ch_{qg}(m) - ch_{tg}(m) \right| \right] + \left[\sum_{m=0}^{255} \left| ch_{qb}(m) - ch_{tb}(m) \right| \right]$$

It means that the histograms of all three color levels of red, green and blue of both images are reduced from each other and we calculate color differential of two images.

This method is used for two reasons:
1) For similar images, there is so much probability that hold similar color histogram.
2) Limiting brows area, make the performance of the next stages quicker.

The defect of this method is that so many pictures are omitted in first stage of retrieval (there are so many similar images but different color, for example lighted images). To solving this problem, the degree of importance of the color is charged by searcher in images base.

### *3.2 Retrieval through comparison to block pattern histogram*

This method is used after first method; it means that in this stage, images which, in the first method, were similar to each other from viewpoint of color are evaluated. As explained, BTC-VQ method uses 8-bit block pattern, it means that it has different 256 block patterns. Therefore in this method simply three separate histograms with 256 levels are established for each image (three colors of red, green and blue, separately) and by comparing these histograms, more similar images are categorized. To compare the texture histograms, Minkowski-from metrics of each level of histogram has been used. It means that if $th_q$ is texture histogram of query image and $th_t$ is texture histogram of target image, the following equation has been used for determining result of comparison:

$$Texture_{q,t} = \left[\sum_{m=0}^{255} \left| th_{qr}(m) - th_{tr}(m) \right| \right] + \left[\sum_{m=0}^{255} \left| th_{qg}(m) - th_{tg}(m) \right| \right] + \left[\sum_{m=0}^{255} \left| th_{qb}(m) - th_{tb}(m) \right| \right]$$

It means that for all three levels of red, green and blue colors, The block pattern histograms of both images are reduced from each other and therefore we calculated the block pattern differential of both images as $Texture_{q,t}$ .

### *3.3 Retrieval through comparison to block pattern histogram by considering priority value of patterns*

As we discussed before, BTC-VQ method uses 8-bit blocks, means it has 256 different block patterns.
In this section we assign a specific value to each of existing 256 patterns by utilization of the following rules:

If collection of black pixels in a specific pattern makes just one island and collection of white pixels in the same pattern makes another island, that pattern has been assigned with the first priority and therefore the greatest degree of importance.

For example,  and  patterns, are two instances of block patterns with the first priority. The importance value of these patterns is 1 and similarly, from among of 256 existing patterns in figure2, there are 45 block patterns with the most important ratio, we elected them by the VQ method.

If collection of black pixels in a specific pattern make two islands and collection of white pixels in that pattern make one island we have been assigned second priority to that pattern and vice versa if collection of white pixels in a specific pattern makes two island and collection of black pixels in that pattern make one island, we have been assigned second priority to that pattern, too.  And  are instances of patterns which have second priority. We have assigned a value between 0 and 1 to each of 256-block patterns base on the following rules:

(Note: QTY (b) is number of black islands and QTY (w) is number of white islands)

- If (QTY(b)=1 and QTY(w) =1) then value =**1**
- (QTY (b) =1 or QTY (w) =1) and (QTY (b) If =2 or QTY (w) = 2) then value = **0.9**
- If (QTY (b) =1 or QTY (w) =1) and (QTY (b) =3 or QTY (w) =3) then value = **0.8**
- If (QTY (b) =1 or QTY (w) =1) and (QTY (b) =4 or QTY (w) =4) then value = **0.7**
- If (QTY (b) =2 or QTY (w) =2) and (QTY (b) =2 or QTY (w) =2) then value = **0.6**
- If (QTY (b) =2 or QTY (w) =2) and (QTY (b) =3 or QTY (w) =3) then value = **0.5**
- If (QTY (b) =3 or QTY (w) =3) and (QTY (b) =3 or QTY (w) =3) then value = **0.4**
- If (QTY (b) =2 or QTY (w) =2) and (QTY (b) =4 or QTY (w) =4) then value = **0.3**
- If (QTY (b) =3 or QTY (w) =3) and (QTY (b) =4 or QTY (w) =4) then value = **0.2**
- If (QTY (b) =3 or QTY (w) =3) and (QTY (b) =5 or QTY (w) =5) then value = **0.1**
- If (QTY (b) =4 or QTY (w) =4) and (QTY (b) =4 or QTY (w) =4) then value = **0.1**
- If (QTY (b)=4 or QTY (w) =4) and (QTY (b) =5 or QTY (w) =5) then value = **0.1**
- If (QTY (b)=1 or QTY (w) =1) and (QTY (b) =0 or QTY (w) =0) then value = **0.0**

Therefore, for the first time, we have considered a priority value for all 256-block patterns, which have elected by the VQ method. You can see these 256 block patterns arranged based on their priorities in figure 4. Assign value of each pattern is shown in a graph as figure 5.

By compressing some images by the method of pattern classifying, it was clearly indicated that our approach is accurate and actually those patterns with greater priority values, are the most important edges. Figure 6 is a good instance of this step and we can see the edges of the image, clearly.

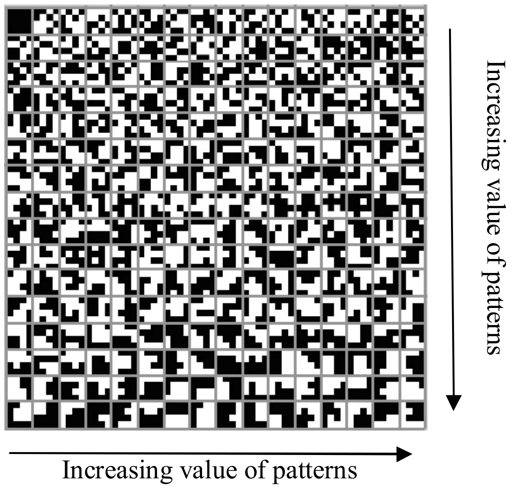


Figure 4. 256 Block Patterns that have been sorted based on their values

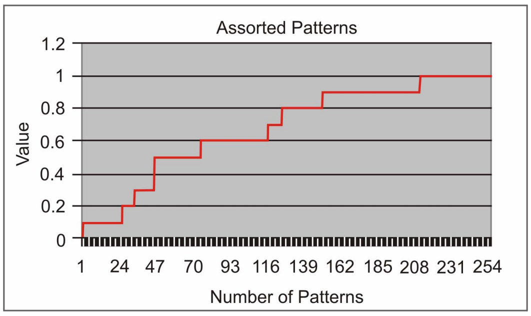


Figure 5. Priority Value of Patterns

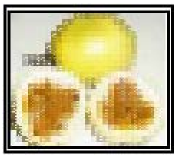

Figure 6. A Compressed image by BTC method

Also by considering that each block is 4x4, we know that we can have $2^{16}$ different blocks, that we reduced them to 256 most repeated blocks by vector quantization and statistical methods. After that, in compression step, we approximate each block of a desire image with one of the most similar blocks within 256 blocks.

In order to increasing the retrieval quality, we save the similarity percentage of each block to the original block at the compression time. For example, if all 16 bits of a block from an image were completely similar to one of 256 blocks, we consider the similarity value as 16/16 (%100), and if 10 bit of them were similar, we consider the similarity value as 10/16 (%62.5). So, for a block such as:  which is exactly same as one of 256 block patterns in figure 2, the similarity percentage is 16/16. For comparison of edge histograms, total fraction of absolute value of each histogram level has been used. It means that if $th_q$ is texture histogram of query image, $th_t$ is texture histogram of base image, *ps(m)* is similarity percentage to that specific pattern and *value(m)* is value of that pattern, then the below equation determines differential value of texture for basic image and the query image:

$$Texture_{q,t} = \left[ \sum_{m=0}^{255} ps(m) value(m) \left| th_{qr}(m) - th_{tr}(m) \right| \right] + \left[ \sum_{m=0}^{255} ps(m) value(m) \left| th_{qg}(m) - th_{tg}(m) \right| \right] + \left[ \sum_{m=0}^{255} ps(m) value(m) \left| th_{qb}(m) - th_{tb}(m) \right| \right]$$

In continuation, similarity coefficient of two images is calculated as below:

$$d_{q,t} = \lambda_1 * texture_{q,t} + \lambda_2 * color_{q,t}$$

λ1 and. λ2 are coefficients of importance of block structure histogram method concerning pattern histogram, and *d q,t* is similarity coefficient of images, that by considering it, final images are classified. Advantages of this method are as follows:

- High speed. Time intricacy algorithm of establishing index of block pattern for each image equals to $O(n^2)$ and time intricacy of comparison of each image with basic image equals to $O(n)$. On the other hand, this stage of retrieval is performed on the images which are limited in the previous stage that causes high increase in speed.
- Utilization of features extracted at the time of image compressing.
- Suitable efficiency in retrieval, which has been shown in Experimental Results.

## 4. Experimental results

To studying efficiency of the method presented in former sections, a database with 9983 images was selected. This database usually consists of 96×128 and 128×85 images with wide variety. This database has been used in articles [6], [13] and exists in Stanford University website as following address link:
www.Infolab.Stanford.edu/~wangz/image.vary.jpg.tar
In the first stage of experiment, the images have been changed to BTC-VQ compressed area, then 100 different images from database and 10 similar images to each of them (from viewpoint of human eye) were selected as search images. In continuation, considering initial experiments, it was found that by the color histogram method, 95.3% of similar images to the base image are located in the first 500 priorities search. On the other hand, it was cleared that, using both color and block pattern histograms to the whole database, to find 4.7% missed images, does not perform good results but applying block pattern histograms to the 500 found images (found in the former step), makes better results with more speed.

Therefore considering such experiments on the first stage of retrieval, That is, through color histogram, more similar images to the search images are selected for continuing retrieval stage. In the second stage, that is retrieval through comparison of Block Pattern Histogram, similarity coefficient of both images is reached by adding the result of comparison in color histogram and block pattern histogram. In this experiment, considering initial experiments, in similarity coefficient formula, the amount of color importance is considered twice as much as amount of pattern importance. It means:

$$d_{q,t} = 2 * Color_{q,t} + 1 * Texture_{q,t}$$

As a sample of experiment, in figure 7, the basic image has been shown in the left above of other pictures and in figure 8, the related images found by comparison of color histogram, is shown.

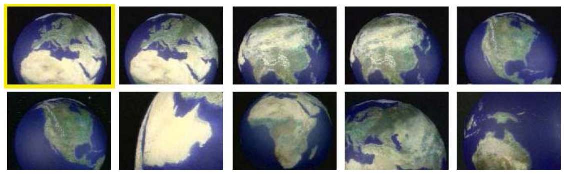

Figure 7. 10 Related images that have maximum similarity to proposed image from viewpoint of human eye

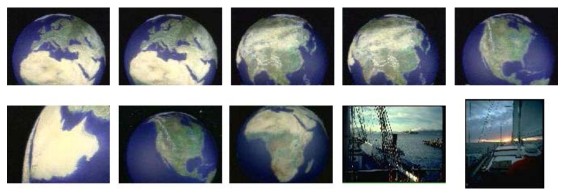

Figure 8. 10 Related images found by comparison of color histogram.

In this example, it is shown that, we have gained 80% of those 10 images that must be in our result. For refining our result we combine pattern histogram with color histogram and the results of this stage have been shown in the following figure:

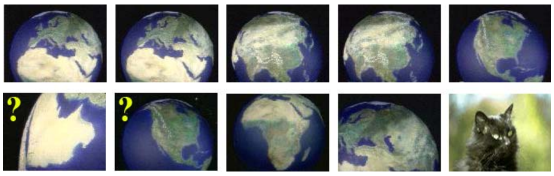

Figure 9. 10 Related images found by comparison of color histograms and block pattern histogram.

In figure 9, 90% of images are correct. Although this combination method generally has improved our result in relation to color histogram, but two of these images are in mistake location and our essential aim is improving the result more than this, so that the results match to query image. For this reason we have applied our new method that described in the section 3.3. It means that we have combined color histogram method with new edge classification method. Finally, 10 found related images have been shown in figure 10.

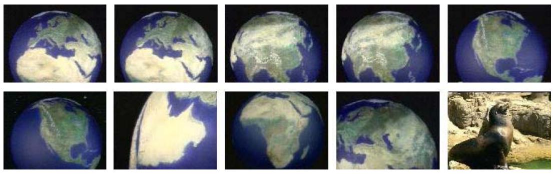

Figure10. 10 Final images found by comparison of color histogram and the new edge classification method

Comparison to stages 1 and 2, although this new edge classification method (stage3) doesn't have much positive effect on recall rate, but as you see, it has much improved than our previous accepted paper [10] in precision rate (table 1).

**Table1. Recall Rate and Precision Rate of all Presented Methods**

| | Color Histogram Method | BP Histogram Method | Combining CH & BPH Method | Applying Edge Classification Method |
|---|---|---|---|---|
| Precision Rate Average | 0.194 | 0.351 | 0.467 | 0.572 |
| Recall Rate Average | 0.482 | 0.574 | 0.822 | 0.853 |

Since this method has been presented in compressed area and is simple and quick, the amounts of recall rate and precision rate are acceptable.

## 5. Conclusion

In this article, based on BTC compressing method, a new method of retrieval is proposed, and it is shown that how we can, based on features by which compressing methods are presented, provide a retrieval method. In this method, two methods of CH and BPH are propounded as compound and are studied on a big database and results of recall rate and precision rate have been acceptable. It is also shown that methods based on texture images can be used effectively on non-texture images.

## 6. References


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