IMPROVING THE RESULTS OF THE CONTENT-BASED IMAGE QUERY ON MEDICAL IMAGERY

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Abstract: The article presents a solution for raising the quality of the content-based image query process, namely of the number of the relevant images retrieved from the database for a query image, in the case of the color medical images. The solution combines the content-based image query on color feature with color texture feature. There have been effectuated and presented studies of content-based image query on color images from the field of the digestive apparatus gathered with an endoscope. The color information is represented by the color histograms computed on HSV color space quantized at 166 colors. In order to represent the color texture the co-occurrence matrices are used. To compute the dissimilitude between the images, the histogram intersection has used for the color and the Euclidian distance for the color texture. The union of the results obtained with the two content-based image query methods on color and color texture, performed in parallel, leads to a greater number of retrieved relevant images. The reason is, that, generally, in the case of the considered diseases there are changes in the color and the texture of the sick tissue.

1 INTRODUCTION

The development of the multimedia field, the creation of new images and video archives of large dimensions, have led a series of researchers to turn their attention, over the past decade, towards creating new tools for retrieving the visual data based on their content (Del Bimbo, 2001).

Retrieving the visual information is important in many applications starting with the artistic domain (art galleries, museums), to security and medical fields, which are in fact the most important.

Visual information retrieval represents a new research direction in information technology. Its purpose is to retrieve from a database the relevant images for a query.

It represents in fact, an extension of the traditional process of information retrieval to visual media. For a computer, an image is only a sequence of binary numbers or a bi-dimensional array. Recognizing the images and objects on the computer, in this kind of applications is a difficult matter. This is due to the fact that the information existing in the multimedia data is not structured and therefore it is not possible to use attributes describing its content.

As a result, the extraction of data that describe as accurately as possible the visual content is essential.

Visual elements such as color, texture, shape that directly describe the visual content, and also high-level concepts (for example the significance of the objects) are used for retrieving images with a similar content from the database (Del Bimbo, 2001).

One of the domains in which the use of the content-based visual retrieval is needed is the medical one. This is mainly due to the fact that in the process of patient diagnosis, medical tools that offer images to the doctor are used on a large scale (computer tomograph, endoscope, X-ray, ecograph, etc.). There are hospitals in which more than 10000 images are gathered daily (Muller et al, 2004). This process led to very large medical image databases. Except for the traditional information retrieval in these databases (taking into account the patient name, the doctor name, the diagnosis), it is necessary to have a content-based visual query for the following reasons:

- From the conversation with the doctors, the next situation appears frequently: the doctor visualizes a medical image, doesn't know exactly the diagnosis, but he is aware of the fact that he has seen something similar, but

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doesn't have the means to search for something similar in the database; the problem can be solved establishing that image as query image and the content-based image query will provide the similar images from the database; it is very likely that among the retrieved images should be the searched image together with its diagnosis, observations, treatment; so the content-based image query can be directly used in the diagnosis process;

- It may be necessary in other cases to specify a region of an image as a query and to retrieve all images containing a similar region. In this second case, an automated algorithm for the correct extraction of color regions is very important.
- The education and research activity can be improved by using the access visual methods.
- The visual characteristics allow not only the retrieving of the patients having the same disease, but also the cases where the visual similitude exists, but the diagnosis differs.

There are still few systems that are really integrated into the medical diagnosis process, and the work for the application of the most suitable algorithms in image processing and features extraction continues (Muller et al, 2004).

The research has shown that the methods used in content-based image query on common images (from nature), do not have the same good results on medical images (Stanescu and Burdescu, 2003). Therefore, it is necessary to individualize the methods on the diagnosis level.

So, on the gray-level images can be applied the content-based image query based on texture or shape. A large part of the images given by the medical apparatus are color, in which case the characteristics color, color texture and shape must be considered.

In this article, the research has been effectuated on color images from the field of the digestive apparatus gathered with an endoscope, stored in a database on which is applied the content-based image query on color and color texture features.

The paper emphasizes that using the color and color texture features in content-based image query will lead to better results in some diseases. There are some diseases that are characterized by the change of the color and the texture of the affected tissue, for example: ulcer, colitis, esophagitis, polyps, ulcer, and ulcerous tumor.

2 CONTENT-BASED IMAGE QUERY ON COLOR FEATURE

The color is the visual feature immediately perceived on an image. In content-based visual query on color feature is important the used color space and the level of quantization, meaning the maximum number of colors. This study uses the representation of images in the HSV color space that has the properties of being complete, compact, natural and uniform and its quantization to 166 colors (Smith, 1997).

The color histograms represent the traditional method of describing the color properties of the images. They have the advantages of easy computation and up to certain point are insensitive to camera rotating, zooming, and changes in image resolution (Del Bimbo, 2001).

The transformation from the RGB color space to HSV color space is realized with the equations (Smith, 1997): $v_c = (r,g,b)$ represents a color point in RGB color space and $w_c = (h,s,v)$ is the color point transformed in HSV color space, where $w_c=T_c(v_c)$.

For $r,g,b \in [0\ldots1]$, then T_c gives $h,s,v \in [0\ldots1]$:

$$v = \max(r,g,b) \qquad s = \frac{v - \min(r,g,b)}{v}$$

$$r' = \frac{v - r}{v - \min(r,g,b)}$$

$$g' = \frac{v - g}{v - \min(r,g,b)}$$

$$b' = \frac{v - b}{v - \min(r,g,b)}$$

$$ßh = 5 + b' \; if \; , r = \max(r,g,b) \; and \; , g = \min(r,g,b)$$

$$ßh = 1 - g' \; if \; , r = \max(r,g,b) \; and \; , g \neq \min(r,g,b)$$

$$ßh = 1 + r' \; if \; , g = \max(r,g,b) \; and \; , b = \min(r,g,b)$$

$$ßh = 3 - b' \; if \; , g = \max(r,g,b) \; and \; , b \neq \min(r,g,b)$$

$$ßh = 3 + g' \; if \; , b = \max(r,g,b) \; and \; , r = \min(r,g,b)$$

$$ßh = 5r', otherwise \tag{1}$$

The procedure of quantization of the HSV color space to 166 colors is:

```
Proc quantize
color = 0
h_scale = 1 / 18
s_scale = 1 / 3
v_scale = 1 / 3
If s = 0 Then
  color = 162 + Int(v/(1/4))
  If color = 166 Then
    color = color - 1
  End
Else
  If Int(v / v_scale) >= 1 Then
    color=color+54*(Int(v/v_scale))
    If color Mod 3 * 18 * 3 = 0 Then
     color = color - 3 * 18
    End
   End
   If Int(s / s_scale) >= 1 Then
     color=color+18*(Int(s/s_scale))
     If color Mod 3 * 18 = 0 Then
      color = color - 18
     End
   End
   If Int(h / h_scale) >= 1 Then
     color=color+(Int(h/h_scale))
     If color Mod 18 = 0 Then
       color = color - 1
     End
   End
End
End
```

For computing the distance between the color histograms of the query image and the target image, the intersection of the histograms is used (Smith, 1997):

$$d_{q,t} = 1 - \frac{\sum_{m=0}^{M-1} \min(h_q[m], h_t[m])}{\min(|h_q|, |h_t|)} \qquad (2)$$

3 CONTENT-BASED IMAGE QUERY ON COLOR TEXTURE FEATURE

Together with color, texture is a powerful characteristic of an image, present in nature and medical images, where a disease can be indicated by changes in the color and texture of a tissue.

It is difficult to describe in words the image texture. Still, there are representations of the texture based on statistical and structural properties of brightness patterns. A series of methods have been studied to extract texture feature (Del Bimbo, 2001). Among the most representatives methods of texture detection is the one that uses the co-occurrence matrices.

There are many techniques used for texture extraction, but there isn't a certain method that can be considered the most appropriate, this depending on the application and the type of images taken into account.

Although most images coming from nature and other fields are color, the majority of research has been done on grayscale textures, for several reasons: high costs for color cameras, high computational costs for color image processing, large complexity even for grayscale textures. However, over the past few years, research has been done in color textures recognition, proving that taking into account the color information improves the color texture classification (Palm et al.,2000, Zhang et al.,2000).

For an image f(x, y), the co-occurrence matrix $h_{d\phi}$ (i, j) is defined so that each entry (i, j) is equal to the number of times for that $f(x_1,y_1) = i$ and $f(x_2,y_2) = j$, where $(x_2,y_2) = (x_1,y_1) + (d\cos\phi, d\sin\phi)$ (Del Bimbo, 2001).

In the case of color images, one matrix was computed for each of the three channels (R, G, B).

This leads to three quadratic matrices of dimension equal to the number of the color levels presented in an image (256 in our case) for each distance d and orientation ϕ.

The classification of texture is based on the characteristics extracted from the co-occurrence matrix: energy, entropy, maximum probability, contrast, inverse difference moment and correlation (Del Bimbo, 2001).

1. Energy

$$\sum_{a,b} P_{\Phi,d}^2(a,b) \qquad (3)$$

2. Entropy

$$\sum_{a,b} P_{\Phi,d}^2(a,b) \log_2 P_{\Phi,d}(a,b) \qquad (4)$$

3. Maximum probability

$$\max_{a,b} P_{\Phi,d}(a,b) \qquad (5)$$

4. Contrast

$$\sum_{a,b} |a-b|^k P_{\Phi,d}^{\lambda}(a,b) \qquad (6)$$

5. Inverse difference moment

$$\sum_{a,b;a\neq b} \frac{P_{\Phi,d}^{\lambda}(a,b)}{|a-b|^k} \qquad (7)$$

6. Correlation

$$\frac{\sum_{a,b}\left[(a,b)P_{\Phi,d}(a,b)\right]-\mu_x\mu_y}{\sigma_x\sigma_y} \quad (8)$$

where means and standard deviation are defined as:

$$\mu_x=\sum_a a\sum_b P_{\Phi,d}(a,b)$$

$$\mu_y=\sum_b b\sum_a P_{\Phi,d}(a,b)$$

$$\sigma_x=\sum_a (a-\mu_x)^2\sum_b P_{\Phi,d}(a,b)$$

$$\sigma_y=\sum_b (b-\mu_x)^2\sum_b P_{\Phi,d}(a,b) \quad (9)$$

The three vectors of texture characteristics extracted from the three occurrence matrices are created using the 6 characteristics computed for d=1 and ϕ=0.

The texture similitude between the query image Q and target image T is computed by the Euclidian metric.

The algorithm in pseudo-cod for generating the co-occurrence matrix is:

```
**function computecoMatrix (double
map[][], int xshift, int    yshift, int
height, int width)
begin
   int total = 0, gray1, gray2;
   Matrix coMatrix(256,256);
  for  i = 0; height; do
     for  j = 0; width do
       if (not((j + xshift >= width) ||
       (j + xshift < 0) || (i + yshift
       >= height) || (i + yshift < 0)))
       then
          gray1=map[i][j];
          gray2=map[i+yshift][j+xshift]
          coMatrix.set(gray1, gray2,
          coMatrix[gray1][gray2] + 1);
          total ++;
       end;
     end;
  end;
end;
```

The algorithm that generates the 6 characteristics (entropy, maximum probability, contrast, inverse difference moment and correlation) is:

```
**function analysecoMatrix ()
begin
  double sum=0; double miu_x=0,
  miu_y=0, tau_x=0, tau_y=0,sum_a1=0,
  sum_b1 =0;  double ss1=0;
  double maxProb,inverseDiff, entropy,
  energy, contrast,  correlation;
  String vectorsString; MaxProb =0;
  InverseDiff =0; Energy=0; Contrast=0;
   for  i = 0; i < w  do
     for  j = 0;  h  do
       if (coMatrix.elementAt(i, j) >
       MaxProb) then
         maxProb=
         coMatrix.elementAt(i,j);
       end;
       inverseDiff+=
       coMatrix.elementAt(i,j)/
       (1+Math.abs(i - j));
       energy=+= coMatrix.elementAt(i,
       j) * coMatrix.elementAt(i, j);
       contrast += (i - j) * (i - j) *
       coMatrix.elementAt(i, j);
       if (coMatrix.elementAt(i, j)!=0)
       then
                sum +=
                coMatrix.elementAt(i, j)
                *log(coMatrix.elementAt(
                i, j));
       end;
       entropy=-sum;
       sum_b1 += coMatrix[i, j];
       miu_x += i * sum_b1;
       sum_a1 += coMatrix[i, j];
       miu_y += j * sum_a1;
       tau_x += (i - miu_x)*(i - miu_x)
       * coMatrix[i, j];
       tau_y +=(j - miu_y) * (j -
       miu_y) * coMatrix[i, j];
     end;
  end;
  tau_x = Math.sqrt(tau_x);
  tau_y = Math.sqrt(tau_y);
  for  i = 0; i < w  do
     for  j = 0;  h  do
       sum += (double) Math.abs((i * j
       * coMatrix.elementAt(i,j)-
       miu_x*miu_y))/
       (tau_x* tau_y);
     end;
  end;
```

```
  correlation = sum;
  vectorsString = maxProb + ";" +
  inverseDiff + ";" + entropy + ";" +
  energy + ";"+ contrast + ";" +
  correlation + ";";
  * output  vectorsString;
end;
```

4 EXPERIMENTS

The experiments were performed in the following conditions.

A database with 960 color images from the field of the digestive apparatus was created.

A software tool that permits the processing of each image was created. The software tool executes the following steps:

1. the transformation of image from RGB color space to HSV color space and the quantization to 166 colors
2. the co-occurrence matrices are computed for each component R,G,B and three vectors containing the 6 sizes (energy, entropy, maximum probability, contrast, inverse difference moment, correlation) are generated; the matrices are computed for d=1 and ϕ=0; in this case the characteristics vector has 18 values
3. the characteristics vectors generated at points 1 and 2 are stored in the database

In order to make the query the procedure is:

- a query image is chosen
- the dissimilitude between the query image and every target image from the database is computed; for each two specified criteria (color histograms with 166 colors and the vector generated on the basis of the co-occurrence matrices);
- the images are displayed on 2 columns corresponding to the 2 methods in ascending order of the computed distance

For each query, the relevant images have been established. Each of the relevant images has become in its turn a query image, and the final results for a query are an average of these individual results.

The experimental results are summarized in table 1. Met 1 represents the query on color feature, Met 2 represents the query on color texture feature using co-occurrence matrices.

The values in the table represent the number of relevant images of the first 5 images retrieved for each query and each of the three methods.

Table 1: The experimental results.

Query	Met 1	Met 2
Polyps	3.3	2.8
Colitis	3.5	1.7
Ulcer	2.8	2.2
Ulcerous Tumor	2.6	1.5
Esophagitis	3.4	2.5

In figure 1 there is an example of content-based image query considering the two specified methods. The first column contains the 5 images retrieved on color feature and the second contains the retrieved images on color texture using the co-occurrence matrices. In the first case there were 4 relevant images and in the second case 3 relevant images.

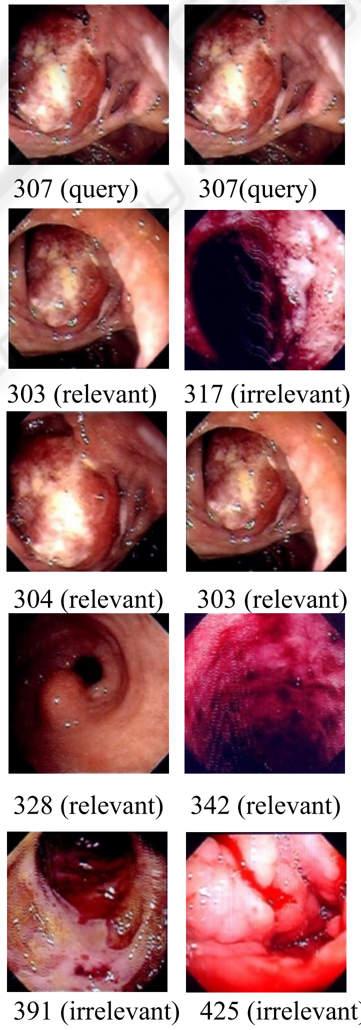

Figure 1: The retrieved images using the three specified methods.

5 CONCLUSION

As the values in the table and other experiments have shown, the best results for medical color images from the field of digestive apparatus have constantly been obtained on color feature.

The color textures obtained by the co-occurrence matrices have poorer results. This is a bad thing because in the case of colitis and esophagitis, the doctors have noticed changes in the tissue texture, such as scratches. These abnormal things could not be detected too well with the implemented method.

An important observation, which leads to the improvement of the quality of the content-based query on this type of images, has to be done.

For each query, at least in half of the cases, the color texture method based on co-occurrence matrices has given at least one relevant image for the query, image that could not be found using the color feature.

Consequently, it is proposed that the retrieval system should use two methods: one based on color feature and the other based on color texture detected with co-occurrence matrices. It is also proposed that the display of the results should be done in parallel, so that the number of relevant images can be increased from an average of 3 to an average of 4 in the first 5 retrieved images. For the example in figure 1, in the case of a union of the images retrieved using the first and the second method, the next relevant distinct images will result: 307, 303, 304, 328 and 342. Both feature detection methods have the same complexity O(width*height), where width and height are the image dimensions (Burdescu, 1998). The two computed distances, the histogram intersection and the Euclidian distance are equally complex O(m*n) where m is the number of values in the characteristics vector, and n is the number of images in the database (Burdescu, 1998).

In addition, a parallel computation of the two distances can be proposed in order to make the execution time for a query shorter.

In the future, this study on color images from other medical fields, for example pathology, where both color and texture are important, will be extended. Also, other methods for detecting texture will be studied.

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