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CONTENT-BASED IMAGE RETRIEVAL USING COMPOSITE REGION TEMPLATES METHOD

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Abstract: *This paper presents the composite region templates (CRT) method. The method is implemented and studied in the process of visual and relative spatial query. The efficiency of the method is tested with the help of some experiments effectuated on two imagistic collections: one collection with images from nature and the second collection with synthetic images.*
Keywords: *content-based image retrieval, extraction of color region, querying by color and spatial information, multimedia databases*

Introduction

The objective of the content–based visual query is to search and to retrieve, in an efficient manner those images from the database that are the most appropriate to the image supplied by the user as query [3].The content-based visual query differs from a usual query by the fact that it implies search of similitude.
It is made a distinction between the two modes of the based–content query usage:

- content–based image query
- content–based region query

In the case of the content–based image query, the comparison is done at the level of the whole image, and in the second case, the images are compared on the base of their regions [3]. The content-based region query can be improved by adding the spatial information to the query. There are two types of spatial query: relative and absolute. The strongest system for images retrieval is the one that allows queries in which there are specified both visual characteristics and spatial properties for the desired images. It can talk about the absolute spatial query that integrates the absolute spatial query and the content–based region query [3], and about the visual and relative spatial query that integrates the relative spatial query and the content-based region query [3].
The composite region templates method was implemented and studied in the process of visual and relative spatial query.

Composite Region Templates Method

This method has been described and used by J.R.Smith and Chung-Sheng Li [1], [2] as a very good solution for classifying and querying of images by means of regions' spatial order. The method supplies series of representations for characterizing images:

- A representation by means of region strings (S) that describe the regions' spatial order
- A composite region template (T) which indicates instances of region's precedence in spatial scan of images
- A matrix (M) that allows classifying and searching of images based on spatial information

These representations allow images' searching by comparing the occurrence frequency of each region before the others, in the regions' vertically image scanning precedence sense [1], [2].

The query image can be chosen by the user from the database or can be graphically drawn.

Composite region templates are generating by counting the occurrence number of each region before every other region from the region strings. As we know, in region characterizing are important some characteristics such as: color, texture, shape and so on. Composite region templates are general, meaning that they can store symbols that represent any type of meta-data. The visual characteristics of images can be manually or automatically generated, for example by means of the iterative back-projection algorithm over color sets [3], [4].

The method assumes covering the next steps [1],[2]:

Color regions segmentations

With a view to realizing this first step, the authors had made use the back-projection method [1], [2], [3]. In their opinion, the dividing process assumes the image's conversion from RGB $I_{rgb}[x,y]$ space color to la HSV and quantification to 166 colors, resulting the image $I_v[x,y]$ and the color histogram h[n], $n \in [0..165]$.

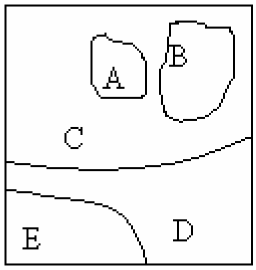
The colors that are represented in histogram with $h[k] > \sigma_c$ ($\sigma_c = 0.025$) are selected in the decreasing order of their importance.

For each color k thus selected, it generates by means of back-projection algorithm over the binary set the image I^k_d [x,y] that will contain only the pixels having the respective color.

The resulting colored regions which have the size less than $\sigma_c = 0.025XY$ where X, Y represent the height and the width of the image are labeled.

Generating the region strings

The second step of the algorithm assumes generating the region strings. These strings capture the color region strings' relative locations generated at the first step. These strings are generated by applying vertical scanning to the image, which orders the regions. The authors have been used 5 vertical scans which are equally spaced out horizontally, as it can be seen in figure 1 [1], [2].



1. Extracting color regions

C	C	C	C	C
A	A	B	B	B
C	C	C	C	C
D	D	D	D	D
E	E	E		

2. Scanning the image in order to generate region strings

	A	B	C	D	E
A	0	0	2	2	2
B	0	0	3	3	1
C	2	3	5	10	6
D	0	0	0	0	3
E	0	0	0	0	0

3. The matrix for composite region templates

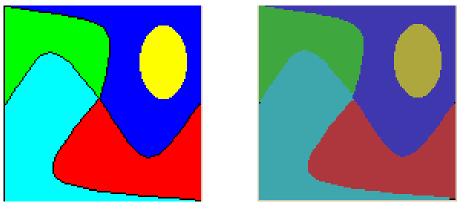
Figure 1. The process of generating composite region templates

Although it can be used any number of vertical scans, five scans gives a better sample to the region content for the most of the images. The authors specify that they use bottom up vertical scans of the images for establishing, vertically, the order of the color regions, because it is provided a better characterization of the images' content than scanning horizontally.

We denote by s_k each input k in a visual characteristics library. For example, for the library D={red, blue, green, black, white}, we have s_0=red, s_1=blue, and so on. Under these circumstances, the authors have defined in [1] a region string like this:

*A region string **S** defines a series of **N** symbols **S**=s[0],s[1],…s[N-1] which supplies the regions' order in a vertically image scanning, where s[n] represents the value of a symbol* *(color's index) of the n-th following region in spatial scanning.*

In figure 2 appears the process of region strings generation for an image. In this example, each symbol represents the color's index $k \in [0..165]$ corresponding to the region's color.
The bottom up vertical scans captures the regions' vertical positions.



V	A	A	A	A
B	V	V	G	G
	B	A	A	A
	R	R	R	R
	B	B	B	B

	144	147	150	153	156
144	0	0	0	4	0
147	2	0	0	2	2
150	2	0	0	4	1
153	1	0	0	1	0
156	7	2	2	8	3

R=144 ; G=147; V=150; B=153; A=156

Figure 2. An example of extracting region strings and generating the matrix for the composite region templates.

Composite Region Templates

The composite region templates are those that make simpler the process of comparing images. If the strings for the regions represent a series of successive symbols, the composite region templates describe only the relative order of these symbols. The authors suggested in [1], [2] the following definition for the composite region template:
A composite region template T defines a relative order of L symbols, that is T=t[0]t[1]…t[L-1], where t[i] precede t[i+j] in the string S for j>0.

For example, the template $T=s_0s_3s_5$ shows that there exists an occurrence of the symbol s_0 before the symbols s_3 and s_5, like in the string $S=\mathbf{s_0}s_2s_1\mathbf{s_3}s_6\mathbf{s_5}$.
The composite region templates can be used for describing, on the whole, the images' spatial color content, by counting the frequency of the composite region templates in the set of region strings. For example, let it be the visual characteristics library D={red, blue, green, black, white, yellow}, then $T=s_2s_1$ is the template which shows that the "green" symbol precedes the "blue" symbol. It can be counted the occurrence I(S,T) for each template T in each string S. For example, in the string $S=s_2s_2s_1s_3s_1$ I(S,T)=4, which shows the four occurrences' existence of the symbol s_2 before the symbol s_1.
In case L=2, the test for $T=t_0t_1$ in the region string S of length N is given by the function I(S,T) which is computed as following:

$$I(S,T)=\sum_{n=0}^{N-1}\sum_{m=n+1}^{N-1} 1 \text{ if } s[n]=t[0] \text{ and } s[m]=t[1] \text{ and } 0 \text{ otherwise.}$$

Generating the matrix for composite region templates

The matrix for the composite region templates sums all the composite region templates' occurrences T_i in symbol strings S_k. With this in view, in [1], [2] there is the following definition:

The composite region templates descriptor matrix M[i,j] for the symbols string S gives the number of $I(S,s_is_j)$ *for each L=2-dimensional CRT,* $T=s_is_j$ *in S.*

The Query

The image query is based on spatial sequences of the color regions, being returned the images that match the best to the querying image. Each target image holds a region string S_t and a matrix for the composite region templates M_t. The query is formed from the query image by extracting region strings $\{S_j\}_q$ and computing the matrix M_q, according to the above described steps. In order to compare the images based on spatial information, it must be computed the similitude between the M_q matrix afferent query and the M_t matrix afferent target, like in [1]:

$$\theta_{q,t} = \sum_{i} \left(1 / (M_q[i,i]M_t[i,i]) \right) \sum_{j} M_q[i,j]M_t[i,j]$$

The system returns the images for it has been obtained the highest values for $\theta_{q,t}$.

Experiments For The Composite Region Templates Method

The first example for using composite region templates method is based on the collection of synthetic images and the second one is based on the collection of images from nature, which, as we mentioned before, are more complex.

Example 1: The query image is the one from figure 3. We wish to retrieve the images that contain a red color region above a yellow color region.

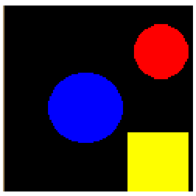


Figure 3. The image containing the regions according to which is implemented the searching taking into account the relative spatial arrangement of the regions having colors 144 (red) and 147 (yellow)

The query's results are the images from figure 4.

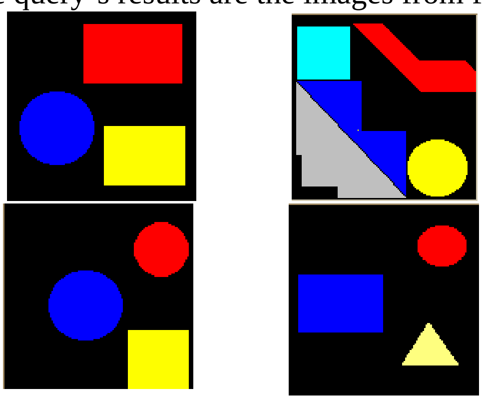


Figure 4. The result of the query specified in figure 3.

We can see in figure 5 some examples of images which have not been returned by the specified query from figure 3, using the composite region templates method.

This happens because these images contain the red region in the left or right side of the yellow region and the composite region templates method scans only vertically and does not take into account the regions' horizontal arrangement.

Figure 5. Meaningful images for the query from example 1 and which have not been returned using the composite region templates method.

Example 2: The query image is that from the figure 6. We wish to retrieve the images containing dark brown, light brown, red and orange color regions in the spatial arrangement from the right picture in which each region is highlighted.

Figure 6. The image containing the regions according to which it is implemented the searching taking into account the relative spatial arrangement of the regions having the colors 36 (dark brown), 90 (lighter brown), 144 (red) and 145 (orange)

The results of the query specified in example 2 are presented in the figure 7.

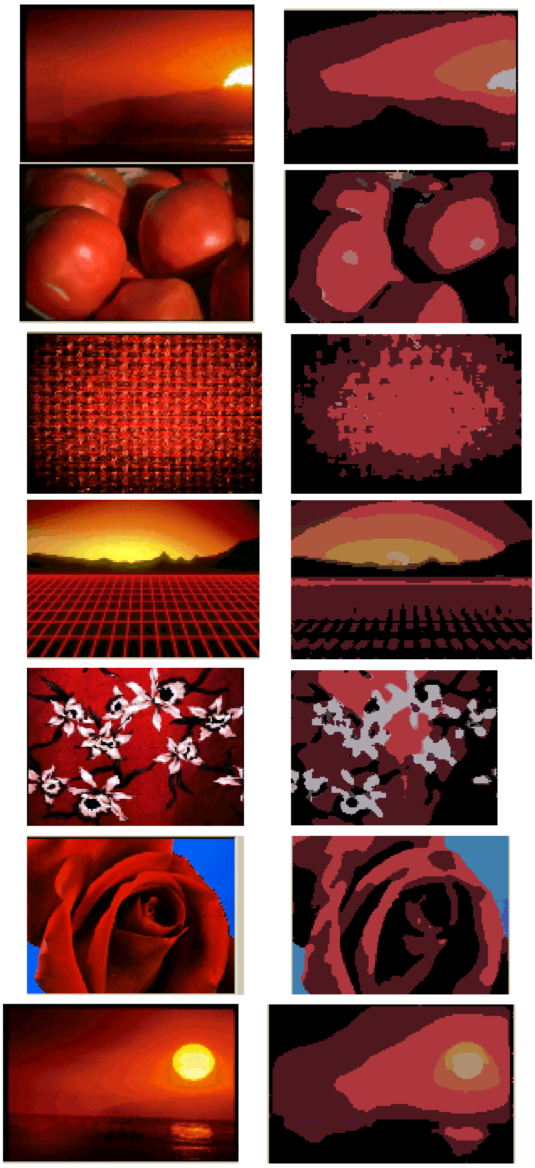


Figure 7. The query's results from example 2

It can be noticed that in the case of this query the results are at the height of our expectations, being returned all the images containing the combination of regions from the query image. These good results are due to the fact that, in general, in the images from nature the regions don't have a rigid geometrical shape, but they cover larger parts from the image, and the vertical scanning on five strips founds well on the relative spatial arrangement of the regions.

Conclusions

The method that uses composite region templates does not consider but the vertical arrangement of the regions and not the horizontal one.

Because of this reason, the multi-regions query over the collection of synthetically images did not return the best results. On the other hand, the results were good in case of the example with images from nature. This method presents the drawback that it involves a complex processing at the preprocessing phase, when it must be built the matrix for the composite region templates (this thing doesn't cause so much trouble because it is accomplished when the image is input in the database and does not alter the query's execution time), as well as at the query's execution time. The calculus of similitude between the array of the query image and the n arrays of the target images is O(n*m^2), where m is the size of the matrix. Another drawback is that of the big number of tuples necessary for storing the matrix. We have noticed that the images have an average of 4, 5 regions, which means 16-25 tuples in the table for each image.

References

[1] Smith J.R.,Li Chung-Sheng (1999), *Image Classification Using Composite Region Templates*, Journal of Computer Vision and Image Understanding

[2] John R.Smith,Chung-Sheng Li (1999), *Decoding Image Semantics Using Composite Region Templates*, IBM T.J. Watson Research Center

[3] Smith J.R (1997), *Integrated Spatial and Feature Image Systems: Retrieval, Compression and Analysis*, Ph.D. thesis, Graduate School of Arts and Sciences, Columbia University

[4] Stanescu L., Cojocareanu C (2000), *The Colour Set Back-Projection Method for Colour Image Retrieval*, Sintes 10, Craiova