Content-based Image Retrieval Combining Shape Recognition, Color and Text

Donggang Yu and Wei Lai
School of Information Technology
Swinburne University of Technology,
PO Box 218, Hawthorn, VIC 3122, Australia

Jiro Tanaka
Institute of Information Sciences and Electronics
University of Tsukuba
Tsukuba, Ibaraki 305-8573, Japan

Abstract

More and more images are used in HTML documents and databases. Effective image information retrieval on the WWW and databases are required to locate relevant images. This paper presents a new method of shape recognition which can be used for image shape based retrieval. The color images are separated by color reduction. The series of structural features of image contour are extracted based on difference codes. The shapes of objects are described and recognized based on morphological structural patterns. The decision and classification of retrieved objects of websites or database are based on the description of shape structures, prior text and color information, which are associated each other.

1 Introduction

More and more images are used in HTML documents and databases. Effective image information retrieval on the WWW and databases are required to locate relevant images. Most of current approaches are text based, color based and texture based [1] [2]. There is few research on shape based. This paper presents a new method of shape recognition which can be used for image shape based retrieval. In Section 2, color separation of color images is introduced, linearization, description features of contours, and structural points are described. The decision and classification of retrieved object images of websites or database are based on the description of shape structures, prior text and color information, which are associated each other. Finally, a conclusion is given. The diagram of processing is shown in Fig. 1.

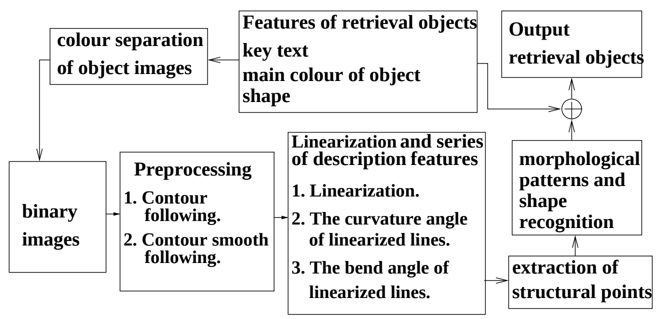
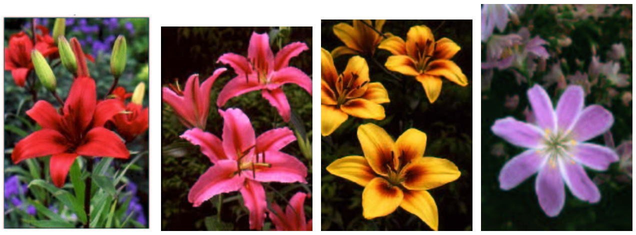


Figure 1. The diagram of processing for information retrieval based on text, color, and shape recognition.

2 Color image separation, extraction of description features and shape recognition

In order to retrieve required information from websites and database, we have to use all possible information such as text, color and image shape to construct a special set in a database or websites. For example, if the set is “flower image”, the following procedures should be done: (a) all flower images are collected; (b) shape of flower is recognized; (c) determine which flower the flower is based on its shape, color and text. Also, it is possible that the same shape is different object in different background which are described by text contents and color. For example, the sample images in

Fig. 2 could be recognized as Indo-Pacific star (starfish) in marine environment or a star in a painting etc.



(1) (2) (3) (4)

Figure 2. Four sample color images of web searching based on the text of flower.

2.1 Color image separation based on color reduction

In most of cases, it is possible that the object images can be represented and understand with a limited number of colors [3] [4]. Especially, in many cases, the object images can be constructed by one color. For example, we can say the blue sky, white cloud, yellow lily flower, silver plan, red or gold sun and so on. That means the object image could consists of one color. However, the true type color images consist of more than 16 million different colors in a 24 bit full RGB color space. In oder to separate the object image which consists of one color, it is necessary to reduce the number of colors. One method of color reduction [3] [4] is used, which is multi-thresholding (adaptive color reduction) with SOFM neural network. Based on the above algorithm, the optimal number of thresholds of color reduction, c_n, is estimated. That is color set (represented by C_R) of color reduction:

$$C_R = \{c_r([r0, g0, b0]), ...c_r(r[c_n-1], g[c_n-1], b[c_n-1])\} \quad (1)$$

where $c_r([ri, gi, bi])$ is i-th color after reducing the number of colors in an image. For example, the number of colors of images in Figs. 2(3-4) and Fig. 2(1) is reduced, and the processed results are shown in Figs. 3(1), 4(1) and 5(1) respectively. Furthermore,

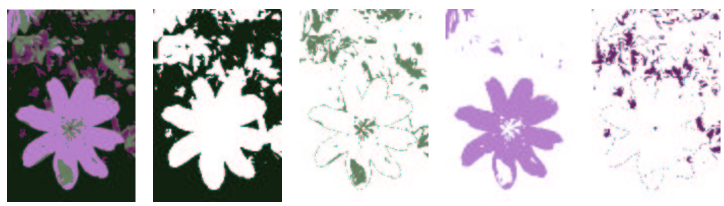
(1) (2) (3) (4)

Figure 3. The color reduction and layer images of the image in Fig. 2(3)

each layer image (object image having one color) can be got based on reduction colors. Let $I(c_r[i])$ is the layer image which is found based on the $c_r[i]$-th color, where the background color is supposed as white color in general cases. Suppose B(r,g,b) is background color, and B(r,g,b)=B(255,255,255). If the object image consists of white color based on prior information (text, color etc.), the background color is black color B(r,g,b)=B(0,0,0). Based on the above algorithm, the set of the layer images (I_{rc}) is

$$I_{rc} = \begin{cases} I_{rc0}[0] & I_{xy}[r,g,b] = c_r[r0, g0, b0] \\ . & \\ . & \\ . & \\ I_{rci}[i] & I_{xy}[r,g,b] = c_r[ri, gi, bi] \\ . & \\ . & \\ . & \\ I_{rci}[c_n-1] & I_{xy}[r[c_n-1], g[c_n-1], b[c_n-1]] \\ & = c_r[r[c_n-1], g[c_n-1], b[c_n-1]] \end{cases} \quad (2)$$

For the images in Figs. 3(1), 4(1) and 5(1), their layer images are shown in Figs. 3(2-4), 4(2-5) and 5(2-5) respectively based on the above algorithm.



(1) (2) (3) (4) (5)

Figure 4. The color reduction and layer images of the image in Fig. 2(4).

(1) (2) (3) (4) (5)

Figure 5. The color reduction and layer images of the image in Fig. 2(1).

2.2 The linearization and description features

All layer images can be transformed into binary images based on two colors of object and background. For example, if a yellow flower need to be retrieved or classified, the binary image is found from the yellow layer image in Fig. 3(3). Its binary image is shown in Fig. 6(1). Similarly, the binary image in Fig. 7(1) is found from red layer image in Fig. 5(5). line segment,

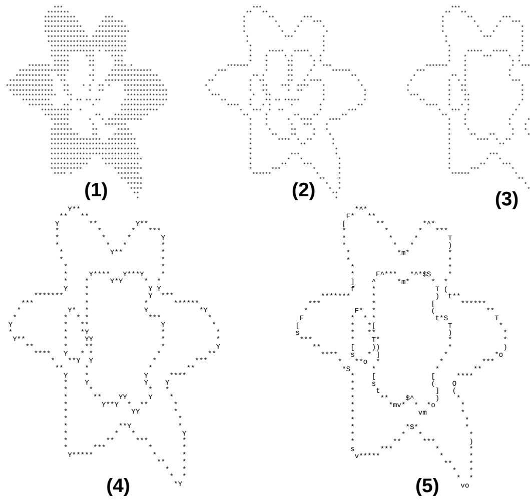


Figure 6. Binary image, contour and smooth following, linearization, and structural points of the image in Fig. 3(3).

curvature angle and bend angle between neighboring lines, and their convexity and concavity are useful to describe the shape of binary images. Many methods and algorithms [5], [6], [7], [8] are developed for the description of contours in the past. Let the starting point of an binary image be the upper-left corner. The chain code set of its contour k is represented as:

$$C_k = \{c_0, c_1 ... c_i, ... c_{n-1}, c_n\} \quad (3)$$

where C_k is the chain code set of contour k, and i is the index of the contour pixels. The contour following results of images in Figs. 6(1) and 7(1) are shown in Figs. 6(2) and 7(2) respectively. The difference code is defined as:

$$d_i = c_{i+1} - c_i. \quad (4)$$

In the smoothed contour, $|d_i|$ equals 0 or 1 [9] [10]. The smooth following results of two examples (Figs. 6(2) and 7(2)) are shown in Figs. 6(3) and 7(3) respectively.

2.3 The linearizing lines based on difference codes

Suppose that chain code set of a linearized line is

$$c_k^{ln} = \{c_k^{ln}[0], c_k^{ln}[1] ... c_k^{ln}[i], ... c_k^{ln}[n_k^{ln} - 1]\}, \quad (5)$$

where k is represented as the contour k of an image, ln as the line ln of contour k and n_k^{ln} as the total number

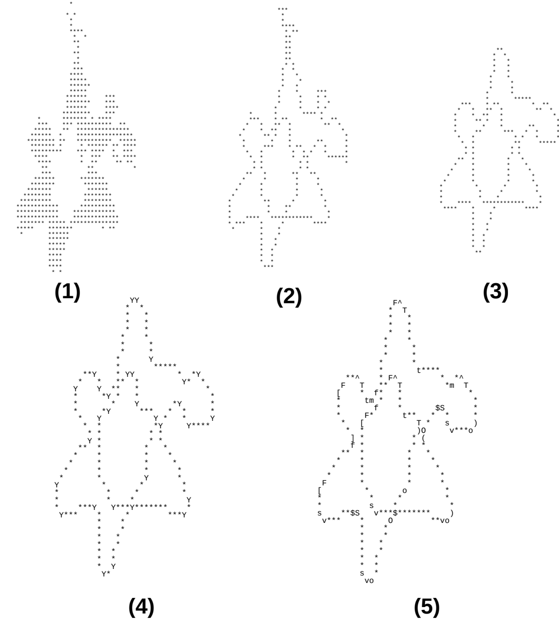


Figure 7. Binary image, contour and smooth following, linearization, and structural points of the image in Fig. 5(5).

of pixels which are contained in the line ln. A linearized line has following property:
if

$$d_{ij} = c_k^{ln}[i] - c_k^{ln}[j] \quad (i = 0, ...[n_k^{ln} - 1]), (j = 0, ..[n_k^{ln} - 1]), \quad (6)$$

then

$$| d_{ij} | \leq 1 (mod 8) \quad (i = 0, ...[n_k^{ln} - 1]), (j = 0, ...[n_k^{ln} - 1]). \quad (7)$$

Therefore, a linearized line contains only two elements. They are called as the element code, and are represented by $cdir1$ and $cdir2$ respectively. A smoothed contour can be linearized based on the above algorithm, and its related chain code set c_k^{ln}, x and y coordinate sets of linearized lines can be found. The linearization results of two examples (Figs. 6(3) and 7(3)) are shown in Figs. 6(4) and 7(4) respectively, and the starting point of each line is represented by character "Y".

2.4 The set of curvature and bend angles of linearized lines

1. **The curvature angle of linearized lines**
   Let l_{se} is straight line between the starting and end points of each linearized line. The curvature angle is defined as the direction angle between the x coordinate axis and l_{se} of the linearized line, and the angle is formed with starting from the direction of the x coordinate axis to the direction

of linearized line, which is determined by the linearized line's element codes, in anti-clock. It can

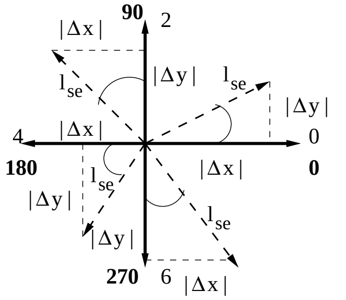


Figure 8. Finding the curvature angle of linearized lines.

be found based on Fig. 8. Suppose $\angle curve$ is the curvature angle, then $\angle curve$ can be found based on four cases (see Fig. 8) which are determined by two element codes of linearized line as following (corresponding four quadrants):

(1) $cdir1$ and $cdir2$ being chain code 0, 1 or 2 (the first quadrant)
let $\angle se$ be the tangent angle of linearized line ln, then

$$\angle se = tag^{-1}(\frac{\Delta y}{\Delta x}), \tag{8}$$

where Δx and Δy are the absolute values of differences of x and y coordinate between starting and end points of line, which are shown in Fig. 8.
If $cdir1$ and $cdir2$ of linearized line ln consist of chain code 0, 1, or 2, then

$$\angle curve = (180°/\pi)\angle se \tag{9}$$

(2) $cdir1$ and $cdir2$ being chain code 4, 5 or 6 (the third quadrant)
In this case, $\angle se$ is found based on Equation (8), and

$$\angle curve = 180° + (180°/\pi)\angle se \tag{10}$$

based on Fig. 8.

(3) $cdir1$ and $cdir2$ being chain code 2, 3 or 4 (the second quadrant)
In this case, $\angle se$ is

$$\angle se = tag^{-1}(\frac{\Delta x}{\Delta y}), \tag{11}$$

and

$$\angle curve = 90° + (180°/\pi)\angle se \tag{12}$$

based on Fig. 8.

(4) $cdir1$ and $cdir2$ being chain code 6, 7 or 0 (the fourth quadrant)
In this case, $\angle se$ is found based on Equation (11), and

$$\angle curve = 270° + (180°/\pi)\angle se \tag{13}$$

based on Fig. 8.

2. **Bend angle and its property**
The bend angle is defined as the angle between the lines j and $(j+1)$. It can be calculated based on Fig. 9.

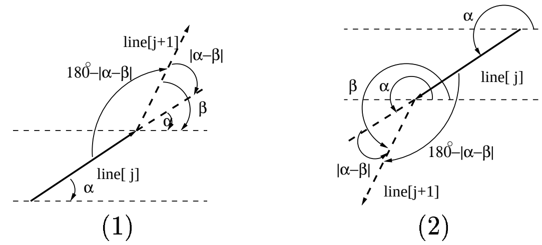


Figure 9. Finding the bend angle between two neighboring linearized lines.

(a) **The bend angle of linearized lines**
Let $\angle curve[j]$ and $\angle curve[j+1]$ be the curvature angle of linearized lines j and $[j+1]$ respectively, and $\Delta[j, j+1]$ be their curvature angle difference, then

$$\Delta[j, j+1] = \angle curve[j] - \angle curve[j+1], \tag{14}$$

where $\angle curve[j]$ is α, $\angle curve[j+1]$ is β, and $\Delta[j, j+1]$ is $|\alpha - \beta|$ in Fig. 9 respectively. Let $\angle angle[j]$ be the bend angle, then:

$$\angle angle[j] = 180° - |\Delta[j, j+1]| \tag{15}$$

based on Fig. 9.

(b) **The property of bend angle**
The bend angle property, convex or concave, can be determined based on the structure patterns of the element codes between two neighboring linearized lines. Let $l_{cdir1}[j]$ and $l_{cdir2}[j]$ be the first and second element codes of the line j, and $l_{cdir1}[j+1]$ and $l_{cdir2}[j+1]$ be the first and second element codes of the line $(j+1)$ respectively, then there are thirty two detection patterns of the bend angle property (convex or concave). The detection patterns (1-4) and (7-10) are shown in Fig. 9.
One detection rules can be described as following: If $l_{cdir1}[j]$ is chain code 0 and $l_{cdir2}[j]$ is chain code 1 (see Figs. 10(1) and 10(7)), or $l_{cdir1}[j]$ is chain code 1 and $l_{cdir2}[j]$ is chain code 0 (see Figs. 10(2) and 10(8)), then

- If $l_{cdir1}[j+1]$ is chain code 2 or $l_{cdir2}[j+1]$ is chain code 2, then $\angle angle[j]$ is convex (see Figs. 10(1-2)).

- If $l_{cdir1}[j+1]$ is chain code 7 or $l_{cdir2}[j+1]$ is chain code 7, then $\angle angle[j]$ is concave (see Figs. 10(7-8)).

Similarly, other detection rules can be described based on other patterns.

Based on the above algorithms, the series set of the curvature angle, the series of bend angle (including their convexity or concavity) of two sample images, which are shown in Figs. 6(4) and 7(4), can be calculated based on the above algorithm can be found from starting line to end line. These series sets of description features can be used to describe and recognize the shape of contours.

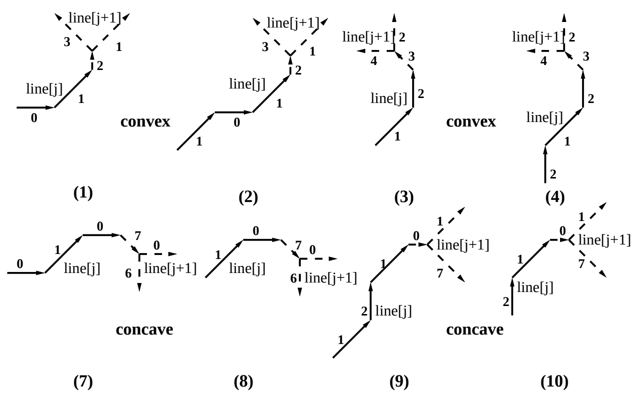


Figure 10. Detecting patterns of bend angle convexity or concavity.

2.5 Structural points of smoothed contours

The structural points are used to represent convex or concave in the direction of chain codes between two neighboring lines along the contour. Assume that $line[ln]$ is the current line and that $line[ln-1]$ is the previous line.

Definition 1: The convex point in the direction of code 4 (represented with the character "$\wedge$")

If the element codes 3, 4 and 5 occur successively as a group of neighborhood linearized lines, then the point corresponding to code 4 is a convex point.

if $cdir1$ of $line[ln]$ is code 4, $cdir2$ is code 5 and the direction chain code of the last pixel of $line[ln-1]$ is code 3, then the first pixel of the current line $line[ln]$ is a convex point.

Definition 2: The concave point in the direction of code 4 (represented with the character "m")

If the element codes 5, 4 and 3 occur successively as a group of neighborhood linearized lines, then the point corresponding to code 4 is a concave point.

if $cdir1$ of $line[ln]$ is code 4, $cdir2$ is code 3 and the direction chain code of the last pixel of $line[ln-1]$ is code 5, then the first pixel of the current line, $line[ln]$, is a concave point.

Similar to Definitions 1-2, other structural feature points can be defined and found. These points are convex points "v", "[', ")", "F", "o", "T", "s", and concave points "$", "]", "(", "f", "O", "t" and "S" which are shown in Fig. 11. These structural points describe the convex or concave change in different chain code directions along the contour, and they can therefore be used to represent the morphological structure of contour regions.

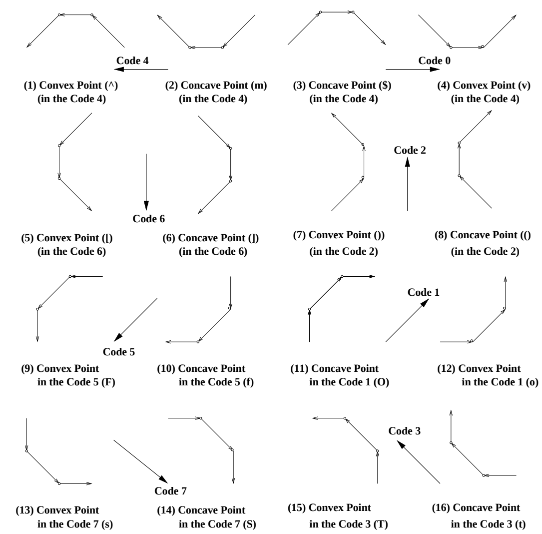


Figure 11. The pattern models of structural points.

2.6 Shape recognition based on structural points, curvature and bend angles

The sets of structural point, curvature and bend angles of contours can be found based on the above algorithms. They can be used to recognize the shape of contours. Based on the above method, all structural points of the contours in Figs. 6(4) and 7(4) can be found, and they are shown in Figs. 6(5) and 7(5).

For morphological structure of the outer contour of Fig. 6(5) there is a series of structural points:

"$\wedge$" → "F" → "[" (convex) → "]" → "f" (concave) → "F"→ "["→ "s" (convex) → "S" (concave) → "s"→ "v" (convex) → "$" (concave) → "v"→ "o"→ ")" (convex) → "("→ "O" (concave) → "o"→ ")"→ "T" (convex) → "t"→ "(" (concave) → ")"→ "T"→ "$\wedge$" (convex) → "m" (concave) →"$\wedge$" (convex).

For morphological structure of the outer contour of Fig. 7(5) there is a series of structural points:

"$\wedge$" → "F" → "[" (convex) → "f" → "m"→ "t" (concave) → "T"→ "∧" →"F"→ "[" (convex) → "]"→ "f" (concave) → "F"→ "["→ "s"→ "v" (convex) → "S" (concave) → "s"→ "v"→ "o" (convex) → "O"→ "$" (concave) → "v"→ "o"→ "s" (convex) → "("→ "O"→ "$"→ "S" (concave) → "v"→ "o"→ ")"→ "T"→ "∧" (convex) → "m"→ "t" (concave) → "F" →"∧" (convex).

It is clear, both outer contours are six angles because of six pairs of convex and concave change. For most sorts of lily flower there are six petals which are constructed by sixangles. For the image in Fig. 4(4), there are eight petals which are constructed by eight-square. Each convex change consists of a group of structural points which can be used to describe convex change in the direction of a chain code. For example, the first group of structural points in Fig. 6(5) is structural points "∧", "F" and "[" which are all convex points to describe the shape of the first convex change, and the first concave change of the contour consists of structural points, "]" and "f" which are all concave points. In some cases, that the shape recognition of other layer images which are in the outer contour is needed. Their colors and shape can describe the property of object image. The series set of linearized lines, curvature and bend angles give the detail of contour description for each convex or concave change. Based on the above similar description, different object image structure patterns can be constructed. Based on these structural patterns, the shape of object images can be recognized. In this paper, the object image structure patterns of some flowers are constructed and used to retrieve on websites or classified. Therefore, if retrieved object image is lily flower, the images in Figs. 2(1-3) are selected. If red lily flower is searched, the images in Figs. 2(1-2) are got. Also, the image in Fig. 2(3) is yellow lily flower. The image in Fig. 2(4) is not lily flower based on the constructed structure patterns of the object images.

3 Conclusion

An efficient and new method is developed to retrieve on websites or classified object images. Color images are separated by color reduction. Layer images are extracted, the related binary images are found. A new method of contour description, linearization, curve and bend angles, and structural points, is introduced based on difference chain codes. The text, color and shape recognition are used. These algorithm can be used to recognize contour shape. Based on text and color information, and shape recognition, the object image which is retrieved or classified can be determined.

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