COLOR IMAGE SEMANTIC INFORMATION RETRIEVAL SYSTEM USING HUMAN SENSATION AND EMOTION

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ABSTRACT

Most of the content-based image retrieval systems focus on similarity-based retrieval of images by utilizing color, shape and texture features. In this paper we propose a new searching scheme, called FMV Indexing, to guarantee higher retrieval quality. This scheme allows us to retrieve images based on high-level semantic concepts such as "cool," "soft," "strong," etc. Our experimental results show that proposed techniques can facilitate users' searching intentions more accurately and give a more favorable feeling of satisfaction to users.

Keywords: FMV Indexing, Human Sensation and Emotion, Color Image Retrieval System

INTRODUCTION

Recently, usage of multimedia data is ever increasing due to the rapid development of computer hardware and multimedia related technologies. As a multimedia data type and a kind of visual media, color images can deliver information very efficiently. Previous research has investigated how to search color images effectively [1, 2, 3, 4]. QBIC system developed by IBM [6], AMORE system [7], WebSeer system, PikTo Seek system, Safe, VisualSEEK [8], MetaSEEK system [13], WEIIS, SIMPLIcity system [9, 11], Photobook [12], Chabot [10] and Blobworld [14] are representative examples of content-based image retrieval systems [5]. Current systems can extract feature vectors and search images based on these features. But they do not utilize semantics of or sensation on color images that are implied by images themselves.

In this paper a new indexing scheme, called FMV indexing, is proposed to guarantee higher searching quality. By following this scheme, images can be searched by emotional concepts, which are derived from color values in HSI (Hue, Saturation, and Intensity) color space. Emotional concepts, which are kind of semantic interpretation on color images felt by human, are automatically extracted and represented as FMV (Fuzzy Membership Value) within image databases. Using these FMV index values, the proposed system can support image searching by emotional concepts. For example, the emotional queries, such as "find cool images" and "find lovely images," can be directly supported based on the semantic features derived from color information of images. We propose an algorithm to generate FMV index values from color information in HSI color values. We also show how these FMV index values can be used for grouping and searching images by emotional concepts.

COLOR IMAGE ANALYSIS

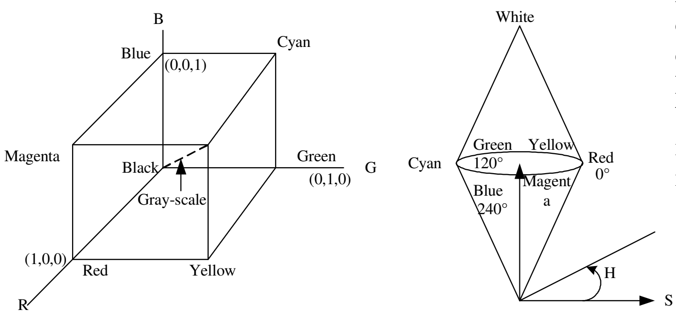
There are many types of color spaces such as RGB (Red, Green, and Black), HSI, CMYK (Cyan, Magenta, Yellow and Black), and so on, but their usage differs from each other. RGB color is used to directly draw the screen with red, green and blue. By the composition of three colors, various colors can be made. CMYK uses color-mixing principles to produce printings. But, HSI is more appropriate from a human point of a view [15, 16]. Therefore, a searching system by emotional concepts is proposed, which decodes feeling of color as an emotional term and exploits FMV index. FMV index plays an important role in efficient image searching with respect to visual images.

Color Perception

When a human perceives the color of images, he/she normally does it by using hue. Hue distinguishes what is red from what is blue. Hue is a kind of feeling about color accepted by human eyes that can catch various spectrums. Saturation represents how much white color is attenuated. When natural color implied in a pure color tone is increased, saturation is also increased. Saturation commonly means how pure the color is. Color with weak saturation is faded or seen dimly. On the other hand, color with strong saturation is seen clearly and lively.

Red color has the most degree of saturation, and pink color has the least degree of saturation. Pure color has one hundred percent degree of saturation and almost no white color. Mingling white and pure color can make various degrees of saturation. Luminance is the intensity of light reflected by an object. This results in an overall range from white to black so that this range is generally called a gray level. However, it could not reflect human visual features, because RGB color could not consider the features of saturation and brightness for human in recognizing images.

In this paper we propose to utilize HSI values, which are converted from RGB values, to generate the FMV-index values. In Figure 1(b), HSI color is described through the range from 0° to 360°. Three color characteristics, hue (H), saturation (S), and intensity (I) or lightness (L), are defined to distinguish color components. Hue describes the actual wavelength of a color by representing the color name, such as red or yellow. Saturation is a measure of the purity of a color, indicating how much white light being added to a pure color. For instance, red is a 100% saturated amount of white in the color. Lightness embodies the intensity of a color. It ranges from black to white.



(a) The RGB Color Space (b) The HSI Color Space

Figure 1. Selection of Color Space

RGB vs HSI Color

One color image Ic(x,y) has RGB representation like the equation (1): $I_c(x,y) = [I_R(X,Y), I_G(X,Y), I_B(X,Y)]$. In this place, original colors are red, green, and blue. They have a range $0 \le [R,G,B] \le I_{\max}$.

As shown in Figure 1(a), RGB model can be described by a three-dimensional cube that has three edges, red, green, and blue. The origin represents black. White is symmetrically apart. Shade degree is located along the line from black to white. In a 24-bit color graphic system, which has 8 bits to each color channel, red is in the point of (1, 0, 0). RGB color is composed of high dimensions. RGB color, having 256 color values per each pixel, can be described by 16,777,216 degree of high dimensional histogram.

FMV-INDEXING TECHNIQUES FOR COLOR IMAGE RETRIEVAL

In this section, the overall process for FMV-index based color image retrieval is explained. At first, the RGB histograms are extracted from color images and are stored into databases. These RGB values are converted into HSI values and FMV-index is produced from it. FMV-index is stored in an emotional categories table. To search an image by emotional concept, FMV-index values are utilized. The detailed procedure is summarized in Figure 2.

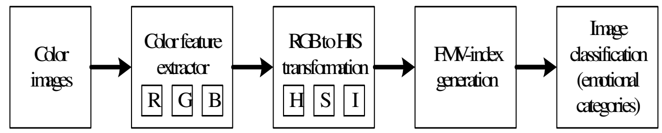


Figure 2. Procedure Diagram for FMV-Indexing and Classification

A High-Level Semantics of Colors

FMV-index represents a conceptual distance between emotional terms as fuzzy membership functions and estimates color semantics based on Hue values. Figure 3 shows twelve classes about emotional terms by hue and tone. According to hue and saturation, an image can give soft or hard feeling. In addition, an image can give dynamic or static feeling by hue.

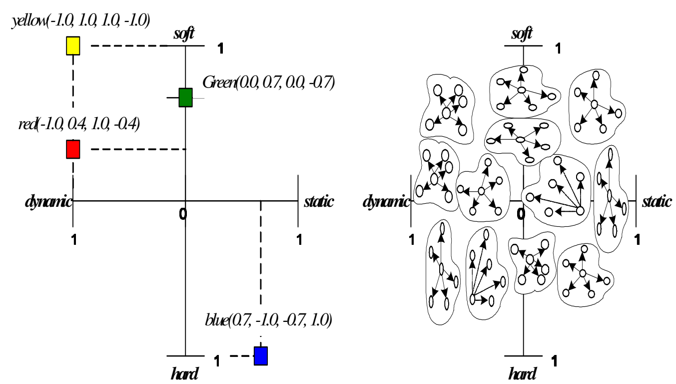


Figure 3. Color Semantics

Such emotional term space for colors represents the term membership degree as fuzzy measures and stores it into databases. Figure 4 shows a graph, which represents emotional term membership degrees as fuzzy membership value, FMV.

Emotional terms, which are felt by humans after looking at color images, are very diverse and ambiguous. But some colors that make their distinction very clear make classification easier. In case of “red,” “warm” or “active” feeling could be made. In this way, “yellow” makes a feeling such as “cute” or “pretty.” On the other hand, “blue” gives a “cool” or “clean” feeling and “green” gives a “natural” or “rural” feeling. But some emotional terms can be used for various and similar colors altogether. For example, a color such as "pink" belongs to the same color family as "red." The term "romantic" can be another example. But, disparity of feeling exists according to each color. Therefore, membership degrees of colors and emotional terms can be measured by the following formula (2):

$\mu_F(c) = \max(\min(\mu_{ai}(c), \mu_F(ai)))\ for\ all\ c \in U$

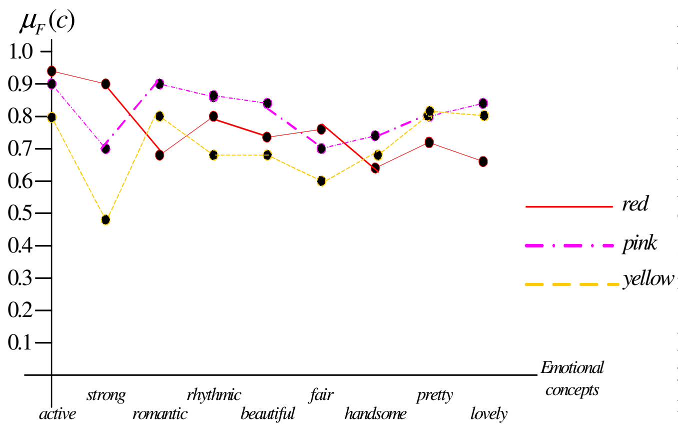
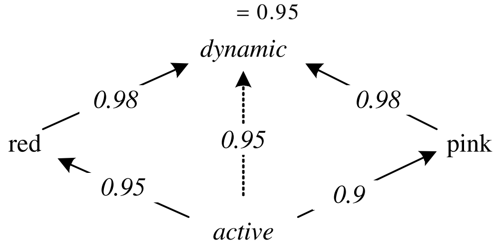


Figure 4. Fuzzy Membership Value for Sensation of Color

If F is related to emotional terms about color, the possibility of "a" being included in F, is calculated. For instance, let's assume that a fuzzy set of emotional terms about "pink" and "red" are pink = { (0.9, active), (0.7, strong), (0.9, romantic), (0.9, beautiful)}, (0.9, pretty)}, red = { (0.98, active), (0.9, strong), (0.7, romantic), (0.75, beautiful), (0.7, pretty)} and a fuzzy set of emotional term "dynamic" is dynamic = { (0.98, red), (0.95, pink), (0.8, orange), (0.5, green), (0.1, blue), (0.9, yellow)}. Then, membership degree of emotional terms such as "active" and "dynamic" can be calculated like this.

$$\begin{aligned}\mu_{dynamic}(active) &= \max(\min(\mu_{red}(active), \mu_{dynamic}(red)),\\ &\quad \min(\mu_{pink}(active), \mu_{dynamic}(pink)))\\ &= \max(0.95, 0.9)\\ &= 0.95\end{aligned}$$



Therefore, an image with a "red" or "pink" color holds "dynamic" feelings and relationship probability, whereas an emotional term such as "active" included in the term "dynamic" can reach to 0.95. As a result, an image having "red" or "pink" color could be an "active" image.

FMV-Index Generation

Color semantics of color images are grouped together according to a distribution of hue. FMV-indexes for classified images are stored into databases. Figure 5 shows the cone-structured algorithm that makes FMV-index based on color. HSI value is composed of 360 degrees on a hue basis.

In this paper, basic color, used to distinguish color by human's eyesight, is classified into twelve categories, Red (r: 0°), orange (o: 30°), yellow (r: 60°), spring (s: 90°), green (g: 120°), teal (t: 150°), cyan (c: 180°), azure (a: 210°), blue (b: 240°), violet (v: 270°), magenta (m: 300°) and pink (p: 330°).

In case of red color, it has a value of range (15>= r >= 0 and, 360>= r >= 345). Twelve colors become more dim or deep in accordance with saturation and more bright or dark according to intensity. For example, if (H, S, I) value of image *In* is (5, 250, 30), value of hue exists between the range 15>= r >= 0, 360>= r >= 345 and concludes a color of the image *In* as red category. But, an important point is that the depth of red color can be lost according to a value of saturation, even if the value of hue lies in the range 15>= r >= 0, 360>= r >= 345. If the value of saturation S lies in the range (20>= S >= 0), it is impossible to recognize a red color. That is, more closely S goes to 0, whiter it becomes. In case S is zero, color becomes totally white unrelated to any value of saturation.

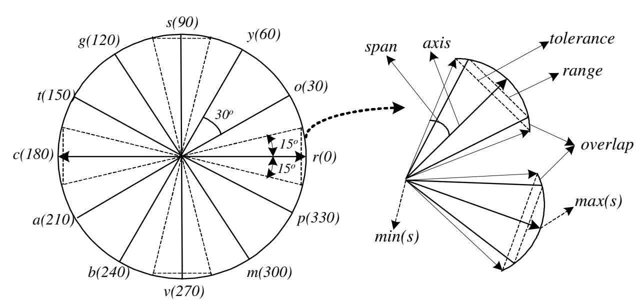


Figure 5. Concepts of Cones for FMV-indexing

In this respect, it can be inferred that the value of saturation plays a key role for human to feel emotions by seeing colors. In addition, a feeling about color could be confused when the value of Hue varies. For example, if a value of Hue becomes 0, distinction of a color is clear because a value of saturation is an axis of color. If a value of Hue lies between 15 and

20, distinction of a color could be ambiguous. For that reason, when color varies, a range of error tolerance is ±5 based on twelve colors. Figure 6 shows an algorithm that FMV-index is automatically produced using HSI value stored in a database.

```
Algorithm Generate_fmv_index ( int num, int row_count, float s, float s_value, float h_value, float fmv_index)
begin
    num ← 1;                          // number of images
      row_count ← select_from_imagetable   // record count
      min(s) ← 0 ;  max(s) ← 255  // define saturation minimum value and maximum value
  while  (num <  row_count +1)
    begin
            h_value ← select_from_imagetable(num)
         if  ( h_value == each class(0~360))
            begin
                  s_value ←
          select_from_imagetable(num)
               mvf_index  ←  (( s_value  –  min(s))  /  (max(s) – min(s)))
               update_imagetable(mvf_index, num)
                         num ← num+1
                    end
        else
            begin
                        update_imagetable(0, num)
                      num ← num+1
                    end
    end
end
```

Figure 6. Algorithm for generating FMV-index Values by H and S

Image Grouping and Searching by FMV Index

For each color image, FMV index values are produced by FMV index algorithm and its category is determined according to the predefined twelve emotional grouping classes. Figure 7 shows the process that stores image data into emotional grouping class. Each emotional grouping class is built up of an emotional term thesaurus to support emotional adjectives and search images with a terminology dictionary related to emotional adjectives. In case of a query, "find cool images," emotional adjectives are first scanned. If there is no proper adjective, a resembling word is used as an emotional adjective. That emotional adjective is used to calculate fuzzy membership, which is used to search FMV index in an emotional grouping table. At this moment, a weight (α) can be assigned by affiliated degree.

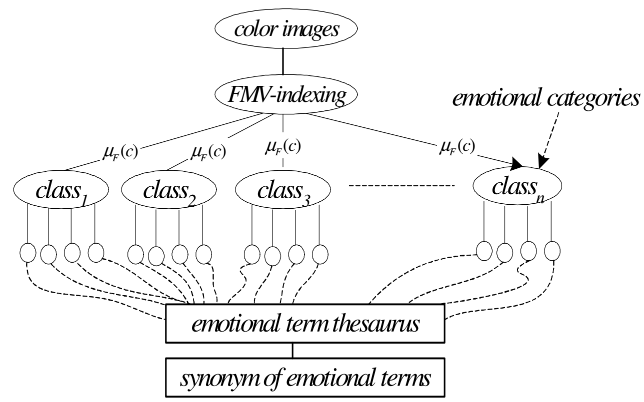


Figure 7. Classification and Searching Images by Emotional Concepts

EXPERIMENTAL RESULTS

A computer with Intel Pentium-4 1.80GHz and 512MB main memory is used to construct our prototype system for image searching by emotional concepts. Microsoft windows 2000 server is used as its OS Development tools are C++ and Delphi.

Randomly selected 1011 images such as scenery, animal and flower images were used in the experiment. Table 1 shows a comparison of a number of searching results according to weight, classified into twelve emotional category classes.

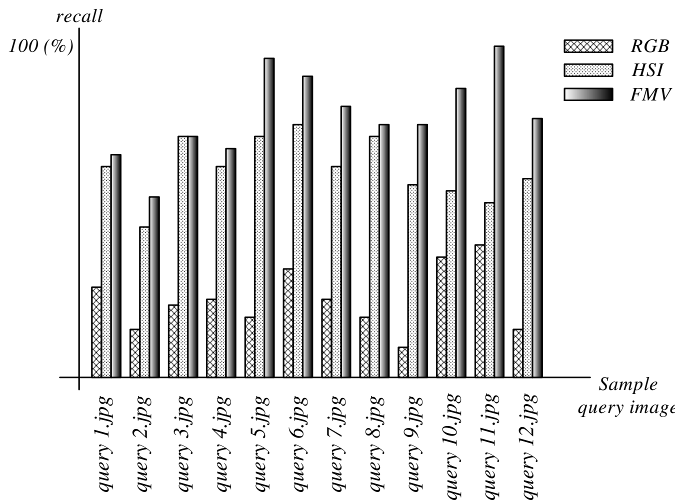
α \ class	U(r)	U(o)	U(y)	U(s)	U(g)	U(t)	U(c)	U(a)	U(b)	U(v)	U(m)	U(p)
α>0.0	208	382	190	135	22	26	57	170	78	27	20	72
α>0.05	196	355	167	126	18	23	47	159	71	19	15	69
α>0.1	187	300	132	115	15	16	40	145	55	8	7	61
α>0.2	153	225	96	101	13	10	20	98	27	0	1	45
α>0.3	115	144	63	86	8	3	5	47	11	0	0	29
α>0.4	83	95	35	66	6	1	2	22	6	0	0	23
α>0.5	54	55	15	27	3	0	1	6	1	0	0	15

Table 1. Query Results for Emotional Categories

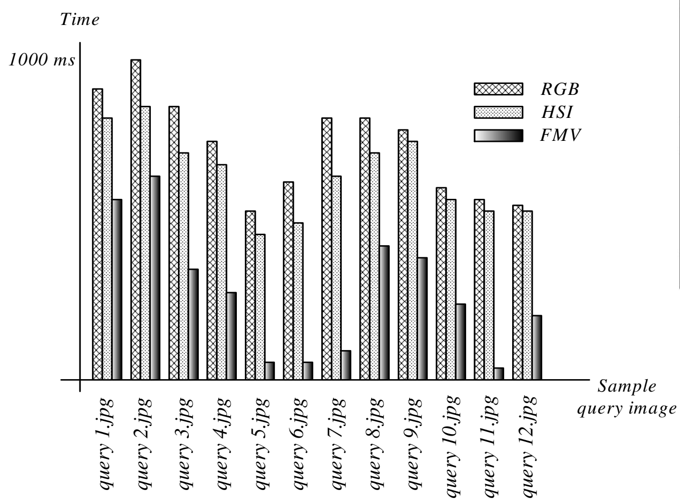
Image searching techniques with emotional concepts uses similarity-based matching technique instead of exact-matching technique. For this reason, a different evaluation method should be applied. For evaluating systems using similarity-matching techniques, Equation 3, having parameters, such as precision and recall, is generally used (3):

$$precision = \frac{R_r}{T_r} \qquad recall = \frac{R_r}{T}$$

In Equation 3, T represents the total number of images associated with a query searching for a target image. Tr and Rr means the total number of items and the number of similar images related to the query in search results. Figure 8 shows the evaluation of precision and recall according to the proposed FMV index method, HSI average histogram method, and RGB average histogram method. In addition, the speed of each searching method is presented. Figure 9 shows some examples of FMV index searching results by emotional concepts.



(a) comparison of recall



(b) comparison of retrieval time

Figure 8. Performance Comparison of RGB, HIS and FMV-index

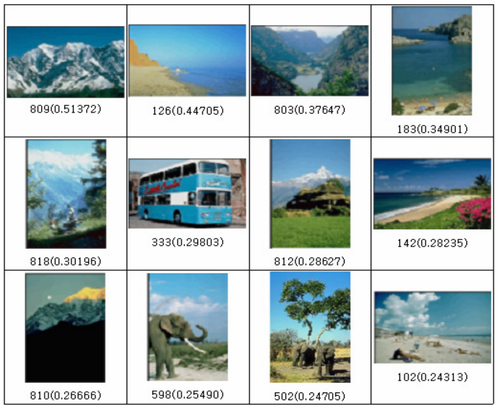
CONCLUSION

In this paper, FMV indexing techniques, with related grouping and searching algorithms, are proposed to allow image searching by emotional concepts. An efficient method is proposed, where emotional adjectives are applied to color images and fuzzy values are automatically obtained based on human visual features. The proposed FMV index searching scheme does support semantic-based retrieval that depends upon human sensation (e.g., "cool" images) and emotion (e.g., "soft" images), as well as traditional color-based retrieval. Emotional concepts are classified into twelve classes according to emotional expression and images are classified into these categories as well. Image searching speed can be improved by assigning FMV index value to each class. As a result, more user-friendly and accurate searching, with emotional expression, can be realized. The efficiency of the proposed techniques is compared with RGB and HSI-based methods.

We believe that there should be further research on how to finely categorize color information so that searching efficiency based on FMV index can be further improved. To guarantee much higher searching quality, research on how to adopt other image features, such as shape and texture, within FMV indexing scheme are also required.

(a) "active" or "strong"

(b) "rural" or "natural"



(c) “bracing” or “refreshing”

(d) “romantic” or “lovely”

Figure 9. Results of queries on Images by Emotional Concepts

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