COLOR IMAGE PROFILE COMPARISON AND COMPUTING

Imad El-Zakhem[a,c], Amine Aït Younes[a]
[a] *CReSTIC-MODECO, Université de Reims Champagne Ardenne, rue des Crayères BP 1035, 51687 Reims cedex 2, France*

Isis Truck[b], Hanna Greige[c]
[b]*MSH Paris-Nord, Université Paris 8, 4 rue de la Croix Faron, Plaine Saint-Denis, 93210 Saint-Denis, France*
[c]*University of Balamand, P.O.Box 100, Tripoli, Lebanon*

Herman Akdag[d]
[d]*LIP6, Université Paris 6, 104 avenue du Président Kennedy, 75016 Paris, France*

Keywords: Colorimetric profile, Color representation, Perception modeling, Fuzzy logic, Image retrieval.

Abstract: This paper describes a method that analyzes the content of images while building their colorimetric profile as perceived by the user. First, images are being processed relying on a standard or initial set of parameters using the fuzzy set theory and the HLS color space (Hue, Lightness, Saturation). These parameters permit to describe and qualify the colors and their properties. Each image is processed pixel by pixel and is affected to a detailed initial colorimetric profile. Secondly, we present a method that will recalculate the amount of colors in the image based on another set of parameters, so the colorimetric profile of the image is being modified accordingly. Avoiding the repetition of the process at the pixel level is the main target of this phase, because reprocessing each image is time consuming and turned to be not feasible. Finally we present the software that processes images and that recalculates their colorimetric profiles with some examples.

1 INTRODUCTION

Classifying images according to their colors has been studied extensively and many methods and results were presented (Chen and Wang, 2002) (Truck and Akdag, 2003) (Omhover et al., 2004) (Aït Younes et al., 2007). Color is defined as an attribute of visual perception consisting of any combination of chromatic and achromatic content. This attribute can be described by chromatic color names such as yellow, orange, etc., or by achromatic color names such as white, gray, black, and qualified by bright, light, etc., or by combinations of such names (CIE, 1987) (Herrera and Martínez, 2001). Truck *et al.* talked about colors and their qualifiers (Truck and Akdag, 2003). Defining the colorimetric profile of an image is not sufficient since this profile is subjective and differently perceived by other user. On the other hand, a considerable amount of time is needed to process the images of the database, to assign new membership degrees to each color, and to make new colorimetric profiles. Our aim is to develop a method to compute the new profile based on the initial one.

2 STANDARD COLORIMETRIC PROFILE

The main aim of this paper is to construct the appropriate colorimetric profile for images; thus we will be able to define the membership degree of the image I in all perceived colors. For example we say that the membership degree of *red* in the image I is 0.2, of *blue* is 0.15, etc.

2.1 Chromatic Colors

The process adopted by Truck *et al.* consists of modeling the three dimensions of color (hue, saturation and lightness) by using fuzzy membership functions. According to HLS space, the dimension hue varies from 0 to 255 and consists of all perceived colors from red to pink. We denote the set $\mathcal{T}$ of the 9 fundamental colors according to Newton by:

$\mathcal{T} = \{$*red, orange, yellow, green, cyan, blue, purple, magenta, pink*$\}$

Each chromatic color is a fuzzy trapezoidal subset

El-Zakhema I., Aït Younesa A., Truck I., Greigec H. and Akdagd H. (2007).
COLOR IMAGE PROFILE COMPARISON AND COMPUTING.
In *Proceedings of the Second International Conference on Software and Data Technologies - Volume ISDM/WsEHST/DC*, pages 228-231
DOI: 10.5220/0001341802280231

usually denoted by (a,b,c,d) with $[a,d]$ the support and $[b,c]$ the kernel. When the kernel is reduced to one point, it is a triangular subset denoted by (a,b,d). Each subset shall intersect with its adjacent subsets to avoid the colorless zones. For each color t of $\mathcal{T}$ there is a membership function f_t.

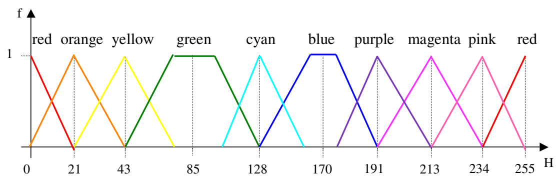

Figure 1: The dimension H.

According to the values of Figure 1 we can get the function f_t for all colors.

$$\forall t \in \mathcal{T},\ f_t(h) = \begin{cases} 1 & \text{if} \quad h \geq b \wedge h \leq c \\ 0 & \text{if} \quad h \leq a \wedge h \geq d \\ \dfrac{h-a}{b-a} & \text{if} \quad h > a \wedge h < b \\ \dfrac{d-h}{d-c} & \text{if} \quad h > c \wedge h < d \end{cases}$$

2.2 Qualifiers and Achromatic Colors

The qualifiers are defined by the saturation and lightness dimensions. Each colorimetric qualifier is associated to one or both dimension(s). To facilitate the process, each dimension interval is divided into three equal sub-intervals: *low, average and strong value*. As a result, we obtain nine "two dimension-dependent" qualifiers denoted by $Q = \{$ *somber, dark, deep, gray, medium, bright, pale, light, luminous* $\}$.

Each qualifier of Q is associated to a membership function $\tilde{f}_q$ with $q \in Q$. Thus, every function is represented through the 3 dimension-set (cf. Figure 2).

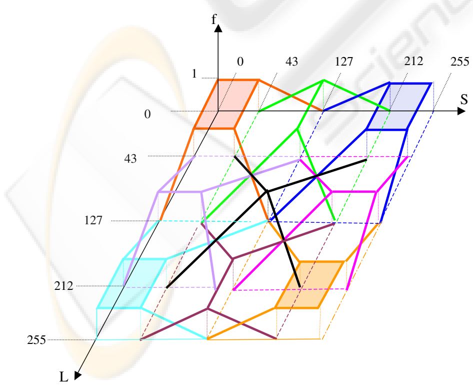

Figure 2: Dimensions L and S.

Black, gray and white are achromatic "colors" that are completely defined through the spaces L and S because they do not contain any hue (h is undefined). Inside the gray color we define three qualifiers: *dark*, *medium* and *light* that are associated to fuzzy membership functions: $\tilde{f}_{dark}$, $\tilde{f}_{medium}$ and $\tilde{f}_{light}$.

The membership degree of an image to a certain class is defined as follows:

Let I be an image and $\mathcal{P}$ be the set representing the pixels of I. Each element p of the set $\mathcal{P}$ is defined by its color coordinates (h_p, l_p, s_p). We can calculate the functions $f_t(h_p)$, $\tilde{f}_q(l_p, s_p)$ for $t \in \mathcal{T}$ and $q \in \mathcal{Q}$.

Let F_t and $\widetilde{F}_{t,q}$ be the following functions, representing the membership degree of I to the classes t and (t,q):

$$\forall t \in \mathcal{T},\ F_t(I) = \frac{\sum_{p \in \mathcal{P}} f_t(h_p)}{|\mathcal{P}|}$$

$$\forall (t,q) \in \mathcal{T} \times \mathcal{Q},$$

$$\widetilde{F}_{t,q}(I) = \frac{\sum_{p \in \mathcal{P}} \tilde{f}_q(l_p, s_p) \times g_t(h_p)}{|\mathcal{P}|}$$

$$\text{with } g_t(h_p) = \begin{cases} 1 & \text{if } f_t(h_p) \neq 0 \\ 0 & \text{otherwise} \end{cases}$$

The use of $g_t(h_p)$ is to assure that a qualifier is not assigned unless the relative hue is positive. Indeed an image can not be "red bright" if it is not "red".

3 COMPARABILITY

Two fuzzy subsets are called comparable if they are close enough to each other. The degree of comparability between 2 subsets will range from 0 (too far or independent) to 1 (equality). Using the notion of comparability with colors we are interested in knowing whether a certain color is said comparable to its adjacent colors or not. The degree of comparability of the subset B denoted by (a_2, b_2, c_2, d_2) to the subset A denoted by $(a_1, b_1, c_1, d_1)$is:

$$\gamma(A,B) = avg(f_A(a_2), f_A(b_2), f_B(c_1), f_B(d_1)) \quad (1)$$

The set of all subsets which are comparable (i.e γ is strictly positive) to A is denoted $\Gamma(A)$.
Considering a new color $t_{i_{new}}$ and an initial color t_i we state: $t_i \in \Gamma(t_{i_{new}})$ iff $\gamma(t_{i_{new}}, t_i) > 0$.

4 COMPATIBILITY

A certain image is characterized by *blue* if one of its dominant colors is blue, in other words, the image is blue if its membership degree in the blue color is high enough. But the same image perhaps wouldn't be characterized by *blue* according to another user, or, if the settings of blue color (variables a,b,c,d) have been changed. Let us suppose that originally an image I has a membership degree *deg* to color *col*, *deg* shall vary as soon as the settings of *col* changes. To obtain the new degree deg_{new}, the only way that gives the exact result is to reprocess I, pixel by pixel. Our approach avoids this long process by simulating the variations of the colors' initial settings by means of some arithmetic calculations. The problem is similar to a coordinate system transformation. So, for each image, we recalculate its colorimetric profile into a new n-dimensional system. The new system is defined according to each user color perception.

For each *col* we select the subsets (i.e. the other colors) whose degree of comparability with *col* is high enough. Therefore we define a compatibility degree only if the subsets are comparable. Indeed when dealing with HLS space a small deviation can be acceptable (Boust et al., 2003) (Couwenbergh, 2003). We should always keep in mind that colors are adjacent and that there shouldn't be any hole in the fuzzy partition of H.

We denote the comparability degree Φ as follows:

$$\Phi(B,A) = \frac{\mathcal{S}_A \cap \mathcal{S}_B}{\mathcal{S}_A} \qquad (2)$$

where $\mathcal{S}_A$ is the surface of the initial subset A and $\mathcal{S}_B$ the surface of new subset B being compared to $\mathcal{S}_A$.
It is obvious that $\Phi(B,A) \neq \Phi(A,B)$, see Figure 3.

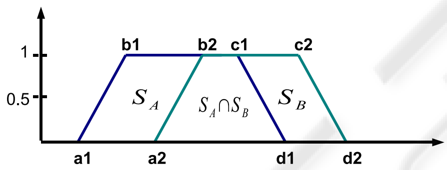

Figure 3: Notion of comparability.

4.1 Hue Compatibility

Let t_i be an initial color represented by a fuzzy membership function f and by a_1, b_1, c_1, d_1, and let $t_{i_{new}}$ be the new color represented by f_{new} and a_2, b_2, c_2, d_2. The new profile of the image will be recalculated and the adjacent colors of t_i will also vary.

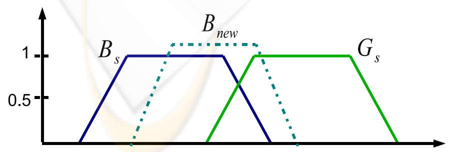

Figure 4: New definition for blue.

For example in Figure 4, the new blue is between the initial blue and the initial green. Thus the membership of the image to the new color blue will be:

$$F_{B_{new}}(I) = \Phi(B_{new}, B_s) \times F_{B_s}(I) + \Phi(B_{new}, G_s) \times F_{G_s}(I) \qquad (3)$$

where B_s is the standard function of Blue, G_s is the standard function of Green and B_{new} is the new function of Blue.

The general function is defined as follows:

$$F_{t_{inew}}(I) = \sum_{t_i \in \Gamma(t_{inew})} \Phi(t_{inew}, t_i) \times F_{t_i}(I) \qquad (4)$$

Assuming that the qualifiers depending on dimensions L and S remain the same, we still have the same values for the 9 qualifiers and only the functions on H are modified, so we state:
$\forall (t_i, q_j) \in \mathcal{T} \times \mathcal{Q}$

$$\tilde{F}_{t_{inew}, q_j} = \sum_{\forall (t_i) \in \Gamma(t_{inew})} \Phi(t_{inew}, t_i) \times \tilde{F}_{t_i q_j}(I) \qquad (5)$$

4.2 Qualifier Comparability

The same reasoning described above with H is intended to be done with the other two dimensions S and L. Each hue is being described by the qualifiers so for each hue t_{inew} we calculate $\tilde{F}_{t_{inew}, q_{jnew}}$

Assuming that the qualifiers depending on S will be modified, then, we have to calculate the new hue qualified according to S thanks to the old hue qualified according to S, so the equation is :

$$\tilde{F}_{t_{inew}, q_{j_{n1}}} = \sum_{\forall (q_j) \in \Gamma_S(q_{j_{n1}})} \Phi(q_{j_{n1}}, q_j) \times \tilde{F}_{t_{inew} q_j}(I) \qquad (6)$$

where $q_{j_{n1}}$ is the modified qualifier on S.
In the same manner, we calculate the new hue and the new saturation together contingent of the new lightness:

$$\tilde{F}_{t_{inew}, q_{j_{n2}}} = \sum_{\forall (q_{j_{n1}}) \in \Gamma_L(q_{j_{n2}})} \Phi(q_{j_{n2}}, q_{j_{n1}}) \times \tilde{F}_{t_{inew} q_{j_{n1}}}(I) \qquad (7)$$

where $q_{j_{n2}}$ is the modified qualifier on L, Γ_L the compatibility for L and Γ_S compatibility for S.
We can demonstrate that the order of calculation of the new saturation and the calculation of the new lightness has no effect. The same results are reached by any order of calculation.

5 THE APPLICATION

An application written in Java and PHP has been developed to test the method of comparability and compatibility. The blue and green colors are represented by trapezoidal fuzzy subset; all other colors are represented by triangular fuzzy subsets.

Each image inserted in the database is processed according to the standard setting of colors; each pixel is accessed and the RGB values are converted into the HLS color space. By applying the functions f_i and $\tilde{f}_q$, the coordinates of each pixel in HLS are transformed into membership degree in colors and qualifiers. So a pixel may be considered 0.7 red and 0.3 orange. At the end, the colorimetric profile of the image is constructed. We store all values of the profile in the table *prof*. In the application, we can see for each image in the menu *visit* the detailed colorimetric parameters. In the menu *search* we can retrieve images by supplying an argument such as blue, red pale etc. To test our method of comparability and compatibility we insert in the table *HLS* a new row. For example we keep all values except for the colors cyan and blue: cyan is shifted to the right while blue is shrunk. We apply the rules of comparability and compatibility on a image/row in table *photo*. Now any image containing some blue has a new colorimetric profile: the values for cyan increase. Figure 5 shows the results.

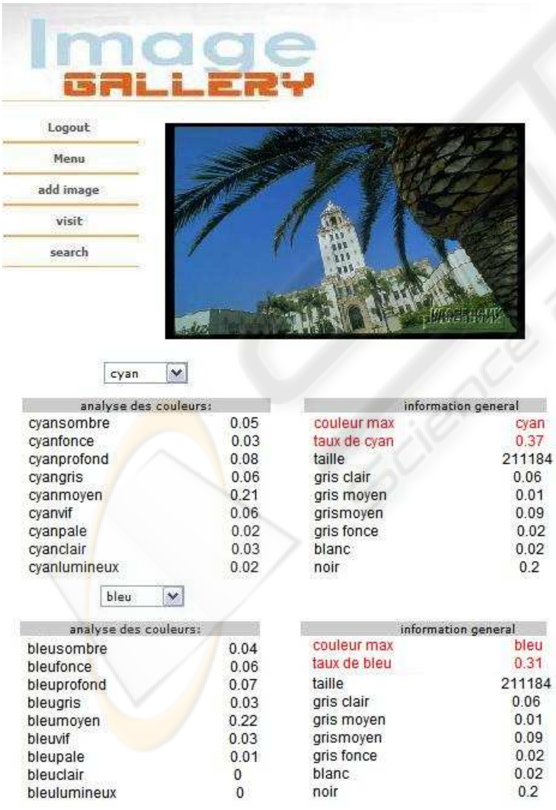

Figure 5: When modifying blue and cyan settings.

6 CONCLUSION

In this paper a new method is proposed to calculate the membership degree of colors in an image. Initially we start building a colorimetric profile of the image based on an initial set of colors and qualifiers. Since this initial set may vary according to the user's perception, we developed an algorithm that shall compute the new colorimetric profile. The computation of the new profile is based on the profile constructed in the initial phase and not on the image itself. Future work, which has been already started, is to model the user's perception. The fuzziness of perception makes its modeling a challenge and gives motivation to use the fuzzy logic terms to do mapping between abstract and concrete objects. We will focus on the dynamic construction of the users' profiles, which will increase their satisfaction by being more personalized and accommodated to their particular needs. Our work will not affect only the image retrieving domain, but all themes that rely on subjectivity and perceptions.

REFERENCES

Aït Younes, A., Truck, I., and Akdag, H. (2007). Image retrieval using fuzzy representation of colors. In *Soft Computing - A Fusion of Foundations, Methodologies and Applications, 11 (3), pp 287-298*. Springer.

Boust, C., Chahine, H., Viénot, F., Brettel, H., Chouikha, M. B., and Alquié, G. (2003). Color correction judgements of digital images by experts and naive observers. In *Proceedings of PICS 2003, pp. 4-9*. PICS 2003.

Chen, Y. and Wang, J. Z. (2002). A region-based fuzzy feature matching approach to content-based image retrieval. In *IEEE Transactions on Pattern Analysis and Machine Intelligence 24(9), pp. 1252-1267*.

CIE (1987). Cie international lighting vocabulary. In *CIE International Lighting Vocabulary*. CIE Publ.

Couwenbergh, J. P. (2003). *Guide complet et pratique de la couleur*. Eyrolles, Paris, 2nd edition.

Herrera, F. and Martínez, L. (2001). A model based on linguistic two-tuples for dealing with multigranularity hierarchical linguistic contexts in multiexpert decision-making. In *Transactions on Systems, Man and Cybernetics, Part B, 31(2), pp.227-234*. IEEE.

Omhover, J. F., Detyniecki, M., and Bouchon-Meunier, B. (2004). A region-similarity-based image retrieval system. In *Proceedings of IPMU'04*.

Truck, I. and Akdag, H. (2003). Supervised learning using modifiers: Application in colorimetrics. In *Proceedings of the ACS/IEEE International Conference on Computer Systems and Applications*.