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HIGH LEVEL COLOR SIMILARITY RETRIEVAL

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ABSTRACT: In this paper a new method for image retrieval using high level color semantic features is proposed. It is based on extraction of low level color characteristics and their conversion into high level semantic features using Johannes Itten theory of color, Dempster-Shafer theory of evidence and fuzzy production rules.

1. INTRODUCTION

More and more audio-visual information is available in digital form in various places around the world. MPEG-7, formally called "Multimedia Content Description Interface", was created to describe multimedia documents. The most used features for image description is color. Many of the existing image databases allow users to formulate queries by submitting an example image. The system then identifies those stored images whose feature values match those of the query most closely, and displays them. Color features are usually represented as a histogram of intensity of the pixel colors. Some systems, such as Color-WISE [10], partition the image into blocks and each block is indexed by its dominant hue and saturation values. Color and spatial distribution can be also captured by an anglogram data structure [6].

High level image semantic representation techniques are based on the idea of developing a model of each object to be recognized and identifying image regions which might contain examples of the image objects. One early system aimed at tackling this problem is GRIM_DBMS [9]. The system analyzed object drawings, and use grammar structures to derive likely interpretations of the scene. The concept of the semantic visual template is introduced by Chang et al [3]. The user is asked to identify a possible range of color, texture, shape or motion parameters to express his or her query, which is then refined using relevant feedback techniques. When the user is satisfied, the query is given a semantic label (such as “sunset”) and stored in a query database for later use. The use of the subjective characteristics of color (such as warm or cold) to allow retrieval of images is described in [4].

There is a ‘‘semantic gap’’ between information that can be derived automatically, at archiving time, and what is convenient for usability at querying time. How we can search by painting stiles? Some stiles descriptions follow. The work that distinguishes the Baroque period is stylistically complex, even contradictory. In general, the desire to evoke emotional states by appealing to the senses, often in dramatic ways, underlies its manifestations. Some of the qualities most frequently associated with the Baroque are grandeur, sensuous richness, drama, vitality, movement, tension, emotional exuberance, and a tendency to blur distinctions between the various arts. The Cubist style emphasized the flat, two-dimensional surface of the picture plane, rejecting the traditional techniques of perspective, foreshortening, modeling, and refuting time-honored theories of art as the imitation of nature. Cubist painters were not bound to copying form, texture, color, and space; instead, they presented a new reality in paintings that depicted radically fragmented objects, whose several sides were seen simultaneously.

In this paper a method for image retrieval, based on high level color image semantic features is discuss. It is a generalization of the method described in [11] and gives possibilities for retrieval painting stiles by color contrast. The layout of the paper is as follows. In section 2 we explain the image feature extraction mechanism. In section 3 we describe image retrieval based on high level color semantic features. In section 4 we detail our experiments, and finally in section 5 the conclusions of this paper are formulated.

2. COLOR FEATURE EXTRACTION MECHANISM

In this section the color characteristics extraction technique and transformation of low level color characteristics into high level color features are presented.

2.1. Color characteristics extraction mechanism

Color characteristics are usually represented as a histogram of intensity of the pixel colors. Based on a fixed partition of the image, an image could be indexed by the color of the whole image and a set of image sub regions. In our method the color feature extraction procedure includes color image segmentation. For this purpose ideas from the procedure described in [4] are adopted. Fist the standard RGB image is converted as L*u*v* (extended chromaticity) image, where L* is luminance, u* is redness–greenness, and v* is approximately blueness–yellowness [2]. Twelve hues are used as fundamental colors. There are yellow, red, blue, orange, green, purple, and six colors obtained as linear combinations of them. Five levels of luminance and three levels of saturation are identified. As a result every color is transferred into one of 180 references colors. After that, clustering in the three dimensional feature spaces is performed using the K-means algorithm [8]. After this step the image is segmented as N regions, and each is presented in extended chromaticity space.

2.2. Low level color characteristics translation into high level color semantic features

The purpose of this phase is to compose more complex image semantic interpretation from those derived through the low-level image analysis characteristics. It is accomplished by applying methods for extracting high level features and recursively applied production rules from a set defined for the correspondent application domain. The rules are defining also the degree of recognition (RD) of a high level semantic feature as a distance among characteristics implied in the rule and those found in the image. RD is calculated with the help of fuzzy measures. An interference mechanism based on backward chaining tries to derive from the low level characteristics more general features and to give a recognition degree to the features recognized.

In this phase a generalized inference mechanism is used. After this step a sequence in the form (1) is obtained:

(1) $O_{1\,1}(m_{1\,1}, l_{1\,1}), \ldots, O_{1\,S1}(m_{1\,S\,1}, l_{1\,S\,1}), \ldots O_{n\,1}(m_{n\,1}, l_{n\,1}), \ldots, O_{n\,Sn}(m_{n\,S\,n}, l_{n\,S\,n})$.

Such a sequence describes an image with n distinct high level semantic features. The unit $O_{i\,j}(m_{i\,j}, l_{i\,j})$ is a semantic representation of the image feature i $(i=1,2, \ldots ,n)$ in the *j-th* $(j=1,2, \ldots, s_j)$ recognition. $m_{i\,j}$ and $l_{i\,j}$ are respectively the RD and the list of attributes of the *i-th* semantic feature in the *j-th* recognition.

To reduce the sequence (1) a procedure similar to Barnett's scheme [1], based on the Dempster-Shafer theory of evidence [5] is applied. The results obtained from applying the production rules are converted into a list of new structures containing information for each semantic feature:

(2) O_{11}([$Bel(O_{11}$, $1\text{-}Bel(not\ O_{11})]$, $l_{11})$, ..., $O_{1q1}([Bel(O_{1\ q1}$, $1\text{-}Bel(not\ O_{1\ q1})$], $l_{1\ q1})$, ...,O_{n1}([$Bel(O_{n1}$, $1\text{-}Bel(not\ O_{n1})]$, $l_{n1})$, ..., $O_{\ q1}([Bel(O_{n\ qn}$, $1\text{-}Bel(not\ O_{n\ qn})$], $l_{n\ qn})$,

where $q_i \leq s_i$ $(i=1, 2, ..., n)$.

The function $Bel(Oij$, $1\text{-}Bel(not\ O_{ij})]$ is a belief function. In such sequences, features interpretations with low belief, according to the user understanding are omitted. The belief function $Bel(O_i)$ $(i=1,2, ...,n)$ gives the total amount of belief committed to the features O_i after all evidence bearing on O_i has been pooled. The function *Bel* provides additional information about O_i, namely $Bel(not\ O_i)$, the extent to which the evidence supports the negation of O_i, i.e. $not\ O_{ij}$.

3. RETRIEVAL BASED ON HIGH LEVEL COLOR SEMANTIC FEATURES

In this section we discuss image retrieval based on high level color properties. It uses the theory formulated by Johannes Itten in 1961 [7]. In this theory color aesthetics may be approached from impression (visually), expression (emotionally) and construction (symbolically). Six different types of contrasts are identified:

1. Contrast of hue. It presents undiluted colors in their most intense luminosity. Some color combinations are: yellow/red/blue, red/blue/green, blue/yellow/violet, yellow/green/violet/red/, violet/green/blue/orange/black.
2. Light–dark contrast. It is based on comparison of day and night, light and darkness. Rembrandt paintings are often done with such contrast.
3. Warm–cold contrast. Colors or color combinations such as: yellow, yellow-orange, orange, red-orange and red-violet are referred as warm. Colors combinations like yellow-green, green, blue-green, blue, blue-violet are referred as cold.
4. Complementary contrast. Two colors are called complementary if their pigments mixed together yield in neutral grey. Examples are: yellow-violet, blue-orange, red-green. This contrast gives the effect of a stability fixed image.
5. Simultaneous contrast. It results from the fact that for any given color the eye simultaneous requires the complement color.
6. Contrast of saturation. Saturation relates to the degree of purity of the color.

The used 180 colors in our method correspond to the colors in the Runge-Itten sphere. The equators, horizontal and vertical views of the sphere are given in Figure 1.

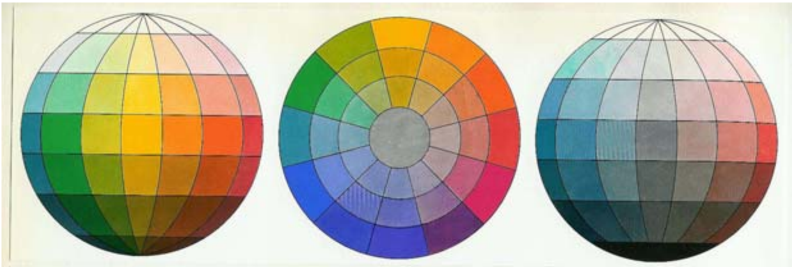

Figure 1. Three views of the Runge-Itten sphere

The color impression is connected with the color effects on our sense of vision. The main color expression properties are the following. Yellow color, the brightest and lightest color suggests power and luminous. It symbolizes knowledge. With combination with dark tones it presents cheerfulness. Red is the color of the cardinals and it is associated with blood and it is always warm. Blue color is always cold and shadowy, and it has retiring nature. Green is the color of the vegetable, the spirit of early summer morning and many different expressions can show by variations in green contrast. Orange color gives radiant feelings. Violet is the color of unconscious, mysterious, chaos, death. The color construction is connected with the juxtapose of two or more colors in such way that they jointly produce a distinct and distinctive expression. Production rules are generated for different painting stiles.

4. THE EXPERIMENTS

The proposed method is a process of realization in a system named “Flint”. In our experiments we use an image database obtained with the help of Google image search engine.

For retrieval based on color features possible query could be: “Find paintings with the following contrasts: Light-dark, cold-warm, and simultaneous”. Parts of the retrieve painting are given in figures 2, 3 and 4.


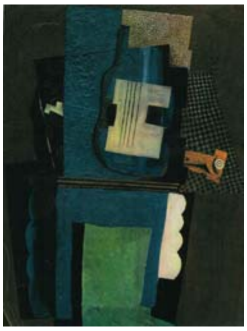

Figure 2. Light-dark contrast: “Dr. Faustus in his study room” sketching by Rembrandt and “Guitar on Mantelpiece” by Paulo Picasso

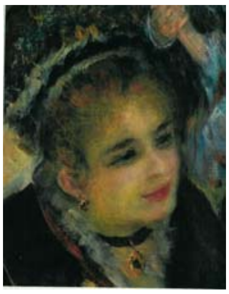
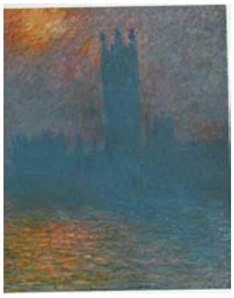

Figure 3. Cold-warm-contrast in “Le Moulin de la Galette” by Auguste Renoir, and “Houses of Parliament” by Clode Monet

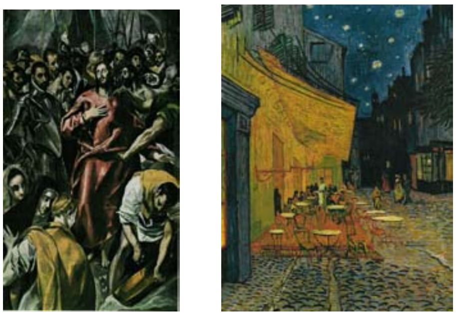

Figure 4. Simultaneous contrast in “Stripping of Christ” by El Greco, and “Café at Evening” by Vincent van Gogh

5. CONCLUSIONS

The main advantage of the proposed method is the possibility of retrieval using high level color semantic features. After the full system realization we will be able to obtain statistical characteristics about the usefulness of the suggested method.

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