Affective property of image and fractal dimension

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Abstract

Affective information processing is an advanced research direction in the AI world. Affective Information of image was taken as the objective of research in this paper. The influence of color vision properties histograms of image on human emotions was analyzed. Then based on fractal theory, the fractal aspect of different kinds of images was analyzed in keeping with the space domain. After that, psychological testing method of semantic difference was applied to verify the uniformity of the objective and subjective evaluations. At last, a conclusion was drawn that image having different affective properties could be classified by their fractal dimensions.

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1. Introduction

In recent years, with the rapid development of signal processing technology, to process image and voice signal freely has been achieved. Beyond that, it is also expected to be able to process affective signal with computer. In early days, research on affections was restricted within psychological area. But now it has been connected with electronics through technologies of signal processing, image processing, computer graphics, audio signal processing, and artificial neural network, etc. Nowadays, many countries, such as the USA and Japan, have begun their research on affection science by utilizing these methods [1–5,8].

This paper aims to analyze the affective characteristics of different images. Firstly, color vision histograms of images and their basic statistical properties are analyzed, and fractal dimensions (FDs) of these images are estimated by wavelet transforming method [6]. Then, semantic difference (SD) method is adopted to evaluate images of different affective features. As a result, the conclusion was drawn that the FDs of images were related with the image’s affective properties.

2. HSV histogram of image and basic statistical analysis of images affective characteristics

Psychological investigation is conducted to 500 images respectively on the three affective characteristics of monotonous, harmony and muss. From them, 300 images are selected and divided into three groups according to different affective features.

The color vision properties of image, namely $H, S, V$, have a direct influence on the harmonious effect of images. This paper takes the $H, S, V$ histograms and their basic statistical properties as a means to judge the affective characteristics of images.
Fig. 1 displays a monotonous image, a mussy image and a harmonious image together with their respective histogram. The hue histogram of Fig. 1(a) (harmonious image) demonstrates that there are two peak points of hue in this image, namely, this image is mainly composed of two kinds of colors. Meanwhile, the saturation histogram shows that the distribution range is wide, reflecting that the shades of this image are rich; and the value histogram shows that the image's brightness value is mainly distributed in the central area and transits smoothly from high brightness to low brightness. From Fig. 1(b) (the mussy image), we can see there are many hue peak points that are distributed in the
whole area while the saturation and brightness value fill up the whole area as well. Fig. 1(c) (monotonous image), however, shows that there are few hues and its hue, saturation and brightness value are all distributed in a relatively narrow range. For each group, $\overline{H}$, mean value of hue peak point number, $\overline{S}$, mean value of saturation distribution range, $\overline{V}$, mean of brightness value distribution range are defined as the statistical variables of image's affective characteristics.

$$\overline{H} = \frac{1}{N} \sum_{i=1}^{N} H_i, \quad \overline{S} = \frac{1}{N} \sum_{i=1}^{N} S_i, \quad \overline{V} = \frac{1}{N} \sum_{i=1}^{N} V_i$$

Here, $N = 100$, is the number of every group's samples, $H_i$, $S_i$, $V_i$ are respectively the number of hue peak points, saturation distribution range and brightness value distribution range of $i$th image.

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The statistical results of 30 images are displayed in Tables 1 and 2. The Table 1 illustrates that, among the three kinds of images, the monotonous image displays the least number of hue peak points and its saturation distribution range and brightness value distribution range are the narrowest as well. This tells us that the color is not rich, shades are few and contrast of brightness is not obvious in this kind of images. Whereas, for the mussy image, there is the largest number of hue peak points, reflecting that the color is rich. Its saturation range and brightness value range are comparatively wide, showing there are conspicuous shades and contrast of brightness. That the number of hue peak points of the harmonious image is between the other two shows that the color of harmonious image is rich but not so much to make people feel mussy. The saturation and brightness value distribution ranges of the harmonious image are the widest, which reflects that the shades and contrast of brightness of harmonious images are the richest.

According to the proceeding analysis, the image’s affective characteristic can be roughly figured out from the image’s HSV histograms and its basic statistical variables. But these characteristics are all “static”. In order to tell the dynamic properties of image’s affective characteristics, the power density spectrum of image’s HSV properties should be further observed.

3. Fractal dimension estimation of images

Image is consisted of color, line and light shade and has huge information. But there are various images that have similar or even the same affective feeling to people. What is the main reason of this phenomenon?

This paper analyzes images from the angle of fractal random filed based on fractal Brownian motion (fBm) model which is proposed by Mandelbrot. Through wavelet transforming, the fBm’s wavelet coefficient series follow the rule [6]

$$\text{var}(d_{mk}^k) = \sigma^2 2^{-k(\gamma-2)}$$

(2)

here, $d_{mk}^k$ is the wavelet coefficient series of Kth order wavelet decomposition.

The coefficient $\gamma$ is related with FD $D$ of 2D fBm

$$D = (8 - \gamma)/2$$

(3)

Taking the logarithm of Eq. (2) yields a linearized equation:

$$\log_2(\text{var}(d_{mk}^k)) = C - k(2 - \gamma)$$

(4)

where $C$ is a constant. To estimate $\gamma$, and thus $D$, the quantities $\text{var}(d_{mk}^k)$ for different wavelet coefficient series are computed, and a least-squares regression on Eq. (4) is used.

This paper used the wavelet transforming method to estimate the FD of three groups of images that have different harmonious affective feelings: monotonous, harmonious and mussy. The following are three images, which have respectively the three affective feelings, and their FD figure shows.

The Figs. 2–4 are respectively the monotonous, harmonious, mussy image and their FD estimation sketch map. From the results of analyzing, it can be seen that the monotonous images have the least FD, the harmonious images have the medium FD and the mussy images have the largest FD.

![Monotonous image](image1)

![FD estimation sketch map](image2)

**Fig. 2.** Monotonous image (a) and its FD estimation. (b) FD fitted line $\gamma = 3.45, D = 2.27$. 

From the Table 2, it can be seen that the FD of monotonous image is the least which is 2.37, the FD of mussy images is the largest, 2.91 and the FD of harmonious images is the medial, 2.68. So it can be concluded that the affective property of images is related with their FD, and more FD will make people feel more mussy.

4. The psychological evaluation on images

The proceeding analysis is an objective evaluation of images. However, before we can decide whether the objective evaluation really reflect the feelings of people, the subjective analysis must be carried out as well. Different people have different characters and live in different environments, which would result in the differences of evaluations on the same thing. Hence, the feeling of harmony is subjective. Even for the same person, his or her feeling will change in accordance with different emotions. It is very difficult to decide a universal criterion for feeling of harmony. Thus, it is quite necessary to seek a method of evaluation that can take into account differences of various people.


We selected 42 male and female undergraduates between 20 and 26 years old to evaluate images when the temperature is about 20 °C. The relative evaluation method is adopted to evaluate images that their FDs are respectively closed to 2.37, 2.68 and 2.91.

The evaluation on one thing is made after considering various factors. We investigate these factors respectively with SD scale method. We choose the following seven factors that can be described with pairs of antonym: monotonous–mussy, noisy–quiet, depressive–joyful, worldliness–elegant, decadent–inspiring, artificial–natural, ugly–beautiful. Each factor is divided into five levels (−2, −1, 0, +1, +2). By means of investigated results of these factors from the 42 undergraduates, we can assess feelings of images. Fig. 5 shows the results of the three images in Figs. 2–4.

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Fig. 3. Harmonious image (a) and its FD estimation. (b) FD fitted line $\gamma = 2.73$, $D = 2.64$.

Fig. 4. Mussy image (a) and its FD estimation. (b) FD fitted line $\gamma = 2.07$, $D = 2.97$.

In Fig. 5, it can be seen obviously that Picture 2 whose FD is close to 2.91 was mussy, noisy and unnatural, so that this picture will make people upset; Picture 3 whose FD close to 2.37 has properties of monotonous, so that it will give...
people feeling of being dull; the FD of Picture 1 was between monotonous image and mussy image, it had the characters of being natural and beautiful, thus rendering to people a feeling of harmony and making people feel comfortable.

5. Conclusion

The study proved that different kinds of images could be discriminated by their FD. By the wavelet transform method used, the FD were estimated and the results showed that more mussy a image was, larger its FD were. Finally, the result of utilizing SD method to conduct psychological tests on different kinds of images proves the consistency between subjective evaluation and objective evaluation.

References