Study on the Textural Complexity of Black Thang-ga Image

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Abstract. In order to study the characteristics of Thang-ga image, this paper studied the textural complexity of black Thang-ga image. The complexity model of image texture was constructed. The textural complexity of black Thang-ga image was calculated by using the textural complexity model. Furthermore, 113 images in the black Thang-ga data set were analyzed. The maximum, minimum and mean of texture complexity of Thang-ga image in data set were calculated. The data shows that the black Thang-ga image is a kind of textural complex images.

1. Introduction

Thang-ga is a flat and broad scroll painting and it is a unique and ancient art of Tibetan nationality in China. Since the 7th century AD, it has been born in the Qinghai-Tibet plateau for 1300 years. Until now, it has been created and collected. To this day, it is regrettable that Thang-ga has not been further studied with image processing. Texture of the black Thang-ga image is very complex from the visual point of view [1].

Four feature parameters were extracted by GLCM matrix, such as energy, entropy, contrast and correlation. On this basis, textural complexity model was built. In RGB color space, Gaussian algorithm was used to filter the black Thang-ga image. The filtered image was extracted by Canny edge-detection. Counting the edge pixels of the edge image, then the edge pixel ratio were calculated. All parameters were substituted into the model and output as the textural complexity of image. Using the above method, 113 Thang-ga images were processed to determine the value range of textural complexity of Thang-ga image. Comparing texture image with the black Thang-ga image, determined textural complexity of Thang-ga image. The maximum, minimum and mean of texture complexity of Thang-ga image in data set were calculated.

2. Textural complexity model

2.1 Introduction of the black Thang-ga image

According to the classification of Thang-ga, the background color of the black thang-ga is black.

The texture of the black Thang-ga image is different from that of natural image’s one and it’s different from artificial texture. The texture of Thang-ga image belongs to the natural texture created by the painter. Among all kinds of Thang-ga images, the texture of black Thang-ga image is the most complex. The black Thang-ga image is shown in Figure 1 and Figure 2. Figure 1 shows the black Thang-ga image with circular shape. From the visual point of view, it has about 9 texture trends, and its texture is also very complex. Figure 2 shows the black Thang-ga image with yellow Bodhisattva. There are about 10 texture trends in Figure 2.
Figure 1. The black Thang-ga image with circular shape.

Figure 2. The black Thang-ga image with yellow Bodhisattva.

2.2 Texture complexity model
The parameters extracted by GLCM were energy, contrast, entropy and correlation. The energy value is larger, the texture of the image is coarser. Entropy is a measure of image information and it reflects the complexity or non-uniformity of the texture in the image. When the entropy is larger, the image is fine texture. When the entropy is smaller, the texture is thicker. Contrast is also called moment of inertia. When the contrast is small, the texture has light grooves. When the contrast value is large, the groove is deep and the effect is clear. When the correlation value is larger, the texture complexity of the corresponding image is smaller. The energy parameters is determined by equation 1 [2-3].

\[
Energy = \sum_{i=0}^{L} \sum_{j=0}^{L} p(i, j)^2
\]  
(Equation 1)

In equation 1, \(i\) is the gray level of the \(i\)-th pixel, and \(j\) is the \(j\)-th gray level. \(L\) is the total gray level series. \(p(i, j)\) is the joint probability density between two pixels. The entropy parameter is determined by equation 2.

\[
Con = \sum_{i=0}^{L} \sum_{j=0}^{L} (i - j)^2 p(i, j)
\]  
(Equation 2)

In equation 2, \(Con\) is contrast, other parameters are the same as equation 1. The entropy parameter is determined by equation 3.

\[
S = -\sum_{i=0}^{L} \sum_{j=0}^{L} p(i, j) \log p(i, j)
\]  
(Equation 3)

In equation 3, \(S\) is entropy; \(\log\) is the base 10 logarithm. Other parameters are the same as equation 1. The correlation parameter is determined by equation 4.

\[
Cor = \sum_{i=0}^{L} \sum_{j=0}^{L} \frac{(i - \mu_i)(j - \mu_j)p(i, j)}{\sigma_i \sigma_j}
\]  
(Equation 4)

In equation 4, \(Cor\) is correlation; \(\mu_i\) is the mean value of the row; \(\mu_j\) is mean value of the column. \(\sigma_i^2\) is variance of the row; \(\sigma_j^2\) is variance of the column. Other parameters are the same as equation 1.

The occurrence of objects reflects the number of objects in the image. When the number of targets is small, the complexity of the image would reduce. Similarly, when the number of targets are large, the complexity of image texture would increase. The number of targets could be described by edge ratio. Edge ratio is determined by equation 5.
In equation 5, $R$ is edge ratio, $P_{\text{edge}}$ is the total number of edge pixels. $M$ was the row of the image; $N$ was the row of the image. From the perspective of correlation between parameters and texture complexity, the information entropy, edge ratio, and contrast parameters were positively correlated with the texture complexity of the image. Correlation and energy parameters are negatively correlated with image texture complexity. When the parameters are positively correlated, the coefficient is positive. When the parameters are negatively correlated, their coefficients are negative. The complexity of image texture is determined by equation 6.

$$Com = w_1 Con + w_2 R + w_3 S + w_4 \text{ Energy} + w_5 \text{ Cor}$$  \hspace{1cm} (Equation 6)

In equation 6, $Com$ is the complexity of image texture, $w_1$ is the coefficient of contrast; $w_2$ is the coefficient of edge pixel ratio; $w_3$ is the coefficient of entropy; $w_4$ is the coefficient of energy; $w_5$ is the coefficient of correlation. $w_1$, $w_2$ and $w_3$ are all positive numbers. $w_4$ and $w_5$ are all negative numbers. For simplicity of calculation, $w_1$, $w_2$ and $w_3$ are 1 and $w_4$ and $w_5$ are -1. The algorithm of texture complexity of the black Thang-ga image is as follows:

Step1: the black Thang-ga image was converted to gray image, then information entropy, contrast, correlation, and energy were calculated by GLCM matrix.

Step2: The image was filtered by Gauss, then the edge image of gray thang-ga was extracted by Canny algorithm.

Step3: On the basis of edge image, the edge ratio of image was calculated according to equation (5).

Step4: The texture complexity of image was calculated by equation (6).

2.3 Analysis of textural complexity of black Thang-ga image

In order to clearly explain the implementation process of textural complexity, Figure 1 and Figure 2 were processed by the above algorithm. Figure 3 was a grayscale image of Figure 1. Figure 4 was the gray image of Figure 2. The GLCM matrix of Figure 3 and Figure 4 were calculated. 4 parameter values were shown in Table 1. With Canny algorithm, the edge images of Fig. 3 and Fig. 4 are shown in Fig 5 and Fig 6. According to figure 5, the edge pixel ratio was 0.1602. Similarly, the edge pixel ratio of Figure 6 was 0.1900. Using Table 1, substitute all data into equation 6. Textural complexity in Figure 1 was 13.2568. Texture complexity in Figure 2 was 10.7897. Obviously, the value of textural complexity in Figure 1 was greater than that in Figure 2. Despite the analysis of the above two images' textural complexity, this was still not enough. From the perspective of texture complexity, figure 2 was more complex than figure 1[4].
Table 1. Data extracted from figures 3 and 4.

|     | Energy | S      | Con     | Cor    |
|-----|--------|--------|---------|--------|
| Fig3| 0.1124 | 3.6537 | 9.6014  | 0.0461 |
| Fig4| 0.0554 | 4.0112 | 6.7123  | 0.0684 |

3. Discussion

3.1 Textural complexity of the black Thang-ga’s dataset

113 images in the black Thang-ga data set were processed with the above algorithm. The method and steps of all image processing were the same as those of Fig. 1 and Fig. 2. Data of the 16 processed images in the data set was shown in Table 2. Column 1 represented image number, column 2 represented energy, column 3 represented entropy, column 4 represented contrast, column 5 represented correlation, column 6 represented edge pixel ratio, column 7 represented texture complexity. In Table 2, due to the large amount of data processed, other data will not be listed in the paper [5].

Table 2. Processing data of 20 Thangka images

|     | Energy | S      | Con     | Cor    | Edge pixel ratio | Textural complexity |
|-----|--------|--------|---------|--------|-----------------|---------------------|
| 1   | 0.0131 | 4.8571 | 10.4785 | 0.0445 | 0.1955          | 15.4735             |
| 2   | 0.0415 | 4.0506 | 5.2404  | 0.0701 | 0.1929          | 9.3723              |
| 3   | 0.0442 | 4.3188 | 11.2192 | 0.0441 | 0.2234          | 15.6731             |
| 4   | 0.0467 | 4.3544 | 12.5313 | 0.0397 | 0.2288          | 17.0581             |
| 5   | 0.0407 | 4.2556 | 9.7504  | 0.0502 | 0.2200          | 14.1351             |
| 6   | 0.0456 | 4.2776 | 10.9421 | 0.0452 | 0.2208          | 15.3497             |
| 7   | 0.0361 | 4.1869 | 6.6563  | 0.0676 | 0.2266          | 10.9660             |
| 8   | 0.0540 | 4.2011 | 9.4408  | 0.0507 | 0.2217          | 13.7589             |
| 9   | 0.1350 | 3.4841 | 6.3269  | 0.0539 | 0.1854          | 9.8075              |
| 10  | 0.0457 | 4.3306 | 11.2616 | 0.0437 | 0.2195          | 15.7223             |
| 11  | 0.0228 | 4.4838 | 5.9640  | 0.0602 | 0.1677          | 10.5325             |
| 12  | 0.0143 | 4.6964 | 8.0643  | 0.0562 | 0.2120          | 12.9022             |
| 13  | 0.0233 | 4.4114 | 6.0814  | 0.0576 | 0.2123          | 10.6243             |
| 14  | 0.0130 | 4.7167 | 6.3777  | 0.0585 | 0.2005          | 11.2234             |
| 15  | 0.0660 | 3.7756 | 4.0421  | 0.0717 | 0.1300          | 7.8100              |
| 16  | 0.1004 | 3.4110 | 2.6903  | 0.0904 | 0.1270          | 6.0376              |
The minimum textural complexity of the black Thang-ga image was 4.0366, the maximum textural complexity of black Thang-ga image was 17.3408. The mean of textural complexity of black Thang-ga image was 10.8922. Texture complexity of image in data set were between the minimum and maximum. The textural complexity and number of 113 images were shown in Figure 7.

![Figure 7. Textural complexity distribution of 113 black Thangka images.](image)

In Figure 7, the abscissa was the number of the images and Vertical coordinate was the textural complexity of images. According to the Figure 7, the data was scattered in the plane. The absolute difference between the minimum and the maximum of black Thang-ga was also large. This showed that the texture of black Thang-ga’s images changed greatly. It reflected the diversity and complexity of texture of black Thang-ga.

4. Conclusion

The following conclusions could be drawn from the analysis of texture complexity of black Thang-ga’s image.

1) The mean of textural complexity of black Thang-ga image was 10.8922 in the black Thang-ga data set. The maximum of textural complexity of black Thang-ga image was 17.3408 in the black Thang-ga data set. The minimum of textural complexity of the black Thang-ga image is 4.0366 in the black Thang-ga data set.

2) The Black Thang-ga image belongs to texture complex image.

Acknowledgments

Thank Professor Weilan Wang for providing the data set of Thang-ga. Thank Professor Hongshe Dang for his guidance and constructive opinions on this paper.

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