A Method for Identifying Photo Composition of the Panoramic Image

Yin-De Shin, Tsorng-Lin Chia

Abstract— **This paper presents a novel method to identify the photo composition of the input panoramic image. Considering the difference between the traditional image and the panoramic image, the photo composition used in panoramic image is analyzed from the image database and recommends four types of compositions that suited for the panoramic image. The characteristics of each composition are defined as a set of features in the color and spatial domains. The procedure of feature extraction is simple and effective. The framework of the identification system is organized by four classifiers corresponding each of the considered compositions. Experimental results indicate that the proposed identification method works well and the performance is more than 90% in sensitivity and accuracy at least 87%.**

Index Terms—**Feature extraction, panoramic image, pattern identification, photographic composition.**

I. INTRODUCTION

In recent years, everyone has held some image/video capturing devices, such as camera, smartphone, and tablet PC, due to the technology developing and manufacture improving. However, these devices still have the lack of taking a photo in some applied situations. For example, we are difficult to get a photo to contain the broad beautiful scenery when the image capturing device with the limited field-of-view. In order to overcome thus problems, some novel cameras can direct take a panoramic image by the photographer, or collecting multiple overlapping photos makes a panoramic image by the specialized imaging software.

A following problem is how to make a panoramic image with good aesthetic. The possible solutions include as follows.

(1) The camera provides guidelines in the screen to guide the photographer modifying his viewing angle and rotating the camera in the snapshot stage;

(2) The panoramas-made software provides some recommendations for the user in the after-effect stage;

(3) The aesthetic judgment system makes the aesthetic judgments automatically for generating a panoramic image with high aesthetic value.

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It is, therefore, essential to learn how to define a panoramic image with aesthetically pleasing picture. Most professional photographers indicate that the center of excellent aesthetic photo is composition.

In this paper, we propose a novel method to identify the type of the photo composition for the considered panoramic image based on features of color, shape, and geometry. By ten evaluated features, a panoramic image will be identified as one of the four types of photographic compositions. Therefore, the computational complexity is much lower than that of methods based on frequency features.

II. RELATED WORK

The goal of photo composition is to arrange the location of subjects in the photo for showing the visual balance of the whole photo and guiding the viewer's attention on the main subject. There are many types of photography composition rules that were generalized for the traditional images [1]. Some photographers also provide useful guidelines that can help people to enhance photos and make them more interesting and engaging. Hence, a good photographer shall understand the principle of the photo composition. When the camera is required to guide the photographer taking a well photo, the identification method of the photo composition is needed in the camera or the computer. But most researches about automatic identification of photo compositions mainly still set in the center or sun-like composition [2, 3] that arranges the main subject in the center of the image with a misty background. The rule of thirds or golden mean composition is also studied in [4, 5] that places the main subject in specific positions to enhance the visual attention. For the natural landscape photo, few papers discuss the role of the sky line and the horizon in the photo composition [6]. However, these literatures aim at the photo composition of the traditional photo that is not suited to the panoramic image. Currently, only few researches [7] consider the photo composition that can be used in the panoramic image.

The elements of photo composition are defined by the line direction, the intersection points, and relative position of objects in the photo. Tan *et al*. [8] employed the features of skin color, intensity distribution, and Canny texture to describe and determine the structure of the image. In [9, 10], they used the salient region in the image to identify the photo composition. Mitarai *et al*. [11] proposed an interactive photographic shooting assist system based on salient points, salient line segments, and diagonal lines to identify the photo composition. However, these methods are designed to assist the photographer so that they only consider a few types of the photo composition.

In recent investigation, Chang *et al*. [12] proposed a photography re-composition method that transfers the photography composition of a reference image to an input image automatically. A full study about how to make a good picture was proposed in [13] especially in the photo composition. Chang and Chen [13] use a reference image to find a sub-image in the panoramic image that two images have the similar composition. However, these methods only consider the photo composition based on the case of the traditional image. Besides, some automatic identification methods for modifying the photo composition are proposed in [12, 15-20]. They find salient regions in the image as subjects and then change their locations by the image synthesis to match the predetermined photo composition, for example, the center composition and rule of thirds.

III. PHOTO COMPOSITIONS OF THE PANORAMIC IMAGE

The professional photographer generally considered that composition is one of the key elements of a good picture and consistent identification some standards and rules for photo composition. Therefore, this study aims to investigate the properties of the photo composition for the panoramic image that is seldom in the literatures. In this section, we will consider four kinds of photo compositions. The characteristics of each photo composition are described as follows.

1) *Symmetrical Composition* (*SC*)

The symmetrical composition of the traditional image usually employs the mirror, water, or metal material to generate the reflected image. There is a horizontal or a vertical line to divide the photo into two parts showing a symmetrical image with each other. The shape of the main subject can be emphasized, and the photo can achieve the perfect visual balance. However, due to a wider viewing angle, the reflected surface in the panoramic image is frequently the water, i.e., lake or river, which can provide a relative large reflected effect illustrated in Fig. 1(a).

2) *Center Composition* (*CC*)

In the traditional photography, the main subject often arranged in the middle of the image that can achieve the visual effect of emphasizing the main subject. Thus composition is called the center or sun-like composition shown in Fig. 1(b). However, the shape of the panoramic image is a long, narrow rectangle that is difficult to generate the same characteristic of *CC* in the traditional photo. So, the panoramic image using the *CC* is not only to enhance the visual focus in the main subject, but also making the high brightness and color contrast surrounding the main subject.

3) *Rule of Thirds Composition* (*TC*)

Rule of thirds is one of the most recognizable compositions in the traditional photography. The photo is divided into three equal parts by two vertical and two horizontal lines so that the whole photo is divided into nine regions. The main subject is placed in four intersection points formed by two horizontal and two vertical lines where can attract the attention of the viewer displayed in Fig. 1(c). A similar photo composition is golden mean because the split ratio is close to the golden ratio (1:0.618). The main subject will appear in one of four golden points and adjacent areas of the golden point. Due to the long, narrow shape of the panoramic image, the composition of the rule of thirds or the golden mean will lose meaning except when the main subject is placed in the two vertical lines. In order to highlight the main subject, two extra conditions are required: 1) making the high brightness and color contrast surrounding the main subject similar to the *CC*, and 2) avoiding multiple objects in the image as far as possible.

(a) Symmetrical composition.

(b) Center composition.

(c) Rule of thirds composition.

(d) Horizon composition.

Fig. 1. Sample panoramic images of four types of the photo composition.

4) *The Horizon Composition* (*HC*)

When taking a panoramic image, the photographer smoothly turn his camera to capture the sections of the scene that the software will seamlessly stitch to form the big image. Therefore, it is easy showing horizontal lines in the image. The horizontal lines generate stable and peaceful emotion that often applies in the panoramic landscape image shown in Fig. 1(d). Such photo composition usually arranges the sky with the sea or the land to generate a horizontal line dividing the image into two regions. So a clear skyline or the horizon appears in the panoramic image as the major characteristic of the *HC*. When two divided regions with the uniform color and relative large contrast, the horizontal line will be more obvious. In common cases, the sky is placed in the region above the horizontal so that the blue component of the color in this region is higher than the bottom region.

IV. FEATURES BASED ON PHOTO COMPOSITIONS

In the previous section, the four types of photo compositions in the panoramic image have been analyzed. We can find that the significant differences between various photo compositions in both spatial and color domains. In this section, a set of features for the corresponding photo compositions is adopted to

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determine the composition type of the considered panoramic image.

1) ***The Global Symmetry***

The main characteristic of the symmetrical composition in the panoramic image is both the left and right (or top and bottom) areas with similar content. So this characteristic is adopted to determine the symmetrical composition of the panoramic image. The *Symmetry* between two considered areas in the panoramic image means that two areas have similar content or approximate distributions of pixel values. Let $I(x, y)$, $1 \le x \le W$, $1 \le y \le H$, be a panoramic image. Two statistical histograms are generated by averaging the pixel values of each column and row in I that equal to results of vertical and horizontal projections for I. In general, there are messy scenes at the two sides of the large panoramic image that can interfere with the characteristics of the photo composition. Therefore, the range of the projection in vertical or horizontal just take from 1/3 to 2/3 of the image width or height shown in Fig. 2. Two histograms of averaging pixel values in vertical and horizontal directions can be calculated as

$$GV(x) = \frac{3}{H} \sum_{i=H/3}^{2H/3} I(x,i) \tag{1}$$

$$GH(y) = \frac{3}{W} \sum_{i=W/3}^{2W/3} I(i,y) \tag{2}$$

For a panoramic image with the horizontal (or vertical) symmetry, the histogram GH (or GV) will show a shape with approximate symmetry to illustrate the similarity between the top and bottom (or left and right) areas. Unfortunately, the panoramic image frequently includes a broad scenery even 360-degree view that means various illuminations may appear in the panoramic image. For example, the bright sunlight appearing on the left side of the image makes the right side of the image with a darker exposure value. This phenomenon sharply changes the symmetry of histograms. A brightness compensation processing is essential for balancing the illumination condition in the whole panoramic image. Two kinds of the symmetrical composition are described as follows, respectively.

(a) *The image with vertical symmetry*: The sun generally appears in the top area of the panoramic image in this case. We only consider the illumination distribution of the top area that can provide all information about the distribution of the pixel values for the whole image. A new vertical projection

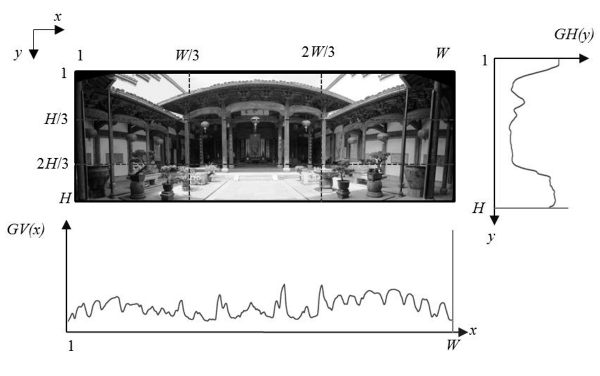

Fig. 2. Calculate histograms of $GV(x)$ and $GH(y)$.

for the upper H / 3 region of the image is estimated as

$$BV(x) = \frac{3}{H} \sum_{i=1}^{H/3} I(x,i), \tag{3}$$

and its brightness average is

$$AV = \frac{1}{W} \sum_{i=1}^{W} BV(i) \quad . \tag{4}$$

Fig. 3 depicts the histogram of a vertical symmetrical panoramic image including the sun appearing on the right side. Therefore, the right part of the histogram has a higher value related to the left side. The brightness weighting function is given for compensating the illumination condition based on the vertical projection BV shown in Fig. 4.

$$WV(x) = 1 - \frac{BV(x) - AV}{255} . \tag{5}$$

Consequently, the histogram GV is modified by multiplying the weight WV as

$$MGV(x) = GV(x) \times WV(x), \quad x = 1, ..., W . \tag{6}$$

(b) *The image with horizontal symmetry*: Since the position of light source, i.e., the sun, may appear anywhere in the horizontal level of the top region in the panoramic image. Therefore, we only need to adopt the vertical brightness distribution (i.e., GH) in the center part of the image that can reflect the illumination distribution of each column in the image. The average of the GH is

$$AH = \frac{1}{H} \sum_{i=1}^{H} GH(i) \quad . \tag{7}$$

The brightness weighting function $WH(y)$ based on the horizontal projection GH is given as

$$WH(y) = 1 - \frac{GH(y) - AH}{255} \tag{8}$$

Similar to the case of vertical symmetry, the compensated histogram GV is written as

$$MGH(y) = GH(y) \times WH(y), \quad y = 1, ..., H \tag{9}$$

In ideal case, the symmetrical axis is arranged in the center column $x = W/2$ (or row $y = H/2$) for a panoramic image with a symmetrical composition. However, that is difficult for the photographer when he faces a broad view of the field. The procedure to find the actual symmetrical axis from the panoramic image is especially necessary for identifying the correct photo composition. By the modified brightness histogram MGV (or MGH), we estimate the difference in the global symmetry between two sides based on

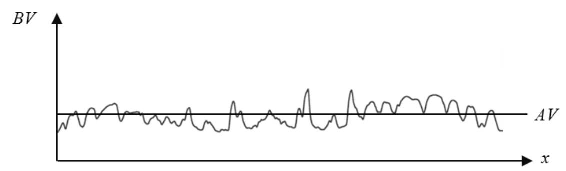

Fig. 3. Example of the histogram of a panoramic image with the sun appearing in the right side.

Fig. 4. The brightness weighting function for compensating the illumination condition.

each bin of the histogram and the width of the sliding window is $2k$ shown in Fig. 5. For reducing search effort, the

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processing only estimates the range from $W / 3$ to $2W / 3$ (or $H / 3$ to $2H / 3$).

The real location of the symmetric axis, denoted by *SAV* (or *SAH*), in case of vertical (or horizontal) symmetric compositions has the minimum of the symmetrical difference that is defined as

$$SAV = \arg\min_x \frac{\sum_{i=1}^{k} |MGV(x-i) - MGV(x+i)|}{k}, \ x = \left[\frac{W}{3}, ..., \frac{2W}{3}\right] \quad (10)$$

$$SAH = \arg\min_y \frac{\sum_{i=1}^{k} |MGH(y-i) - MGH(y+i)|}{k}, \ y = \left[\frac{H}{3}, ..., \frac{2H}{3}\right] \quad (11)$$

2) ***The Local Saliency***

In some photo compositions, the main subject of the photo is frequently arranged in the particular location that can achieve the effect of emphasizing the main subject. Hence, the region including the main subject has significant differences in the distribution of the pixel value and the content related to other regions in the image. Besides, considering the viewer's sight line that is usually along the horizontal direction, the arranged location of the main subject is also defined on the horizontal axis of the image. So, two sides of the region with the main subject appear an abrupt brightness change related to the neighboring regions that can be found from a vertical projection histogram. We apply the modified histogram $MGV(x)$ to examine the salient part in the considered panoramic image. After a smoothing processing for the histogram *MGV* to reduce the effect of the ripper on the curve, we find locations with minimum and maximum *k*-slope along the curve. These two locations *MinSp* and *MaxSp* are given as

$$MinSp = \arg\min_x \left(\sum_{i=-\frac{k}{2}}^{\frac{k}{2}} \left(MGV(x+i) - MGV(x+i-1) \right) \right), \quad x = 2, ..., W-k$$
$$MaxSp = \arg\max_x \left(\sum_{i=-\frac{k}{2}}^{\frac{k}{2}} \left(MGV(x+i) - MGV(x+i-1) \right) \right), \quad x = 2, ..., W-k \quad (12)$$

, and the midpoint of *MinSp* and *MaxSp* is denoted by *MOP* shown in Fig. 6. The corresponding cumulated *k*-slope are expressed as

$$Min\_TotalSp = \sum_{i=-\frac{k}{2}}^{x+\frac{k}{2}} \left(MGV(MinSp+i) - MGV(MinSp+i-1) \right)$$
$$Max\_TotalSp = \sum_{i=-\frac{k}{2}}^{\frac{k}{2}} \left(MGV(MaxSp+i) - MGV(MaxSp+i-1) \right) \quad (13)$$

To evaluate the total difference between the salient region and the neighboring regions, it is measured as

$$TDS = |Min\_TotalSp| + Max\_TotalSp \quad (14)$$

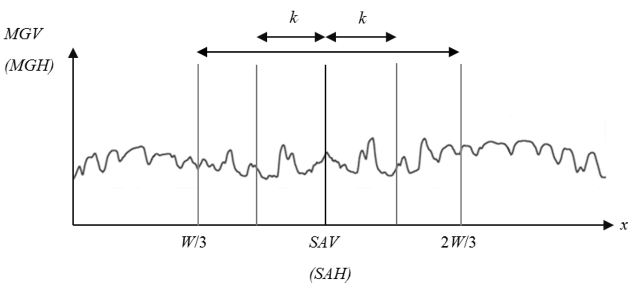

Fig. 5. Illustration of the search window for finding the location with the minimum of the symmetrical difference.

For estimating the location of the main subject whether matches with the rule of the corresponding photo composition, a measurement of the location gap *LG* is given as

$$LG = \frac{|MOP - SL|}{W}, \quad (15)$$

where *SL* is the specific location based on the photo composition. For example, the *SL* is $W/2$ for the *CC* and $W/3$ or $2W/3$ for the *TC*.

3) ***The Horizontal linearity***

For some photo compositions, there is a particular line, i.e., in vertical or horizontal, appearing in a photo. For example, in the horizon composition, a horizontal line with an obvious difference between two sides often appears in the center of the image. Besides, the top area of the horizon, i.e., sky or cloud, frequently shows a satiated blue or bright white. According to this characteristic, the feature extraction for finding these lines works in the B-channel of the inputted panoramic image. Let the intensity image from the B-channel be $B(x, y)$，$1 \le x \le W$，$1 \le y \le H$. A histogram *BH* is made for representing the average intensity value of the pixels in each row shown in Fig. 7. Moreover, the smoothed histogram *MBH* is generated from the histogram *BH* after a smoothing processing for erasing the noise or “dirty background”. When a fast change of the slope appears in the histogram, the position *PL* perhaps is the row of the considered line. The measurement of the linearity is given as

$$PL = \arg\max_{\frac{H}{3} \le y \le \frac{2H}{3}} \left[\frac{MBH(y) - MBH(y+d)}{d} \right] \quad (16)$$

This possible location of the skyline or the horizon is limited between $H/3$ and $2H/3$ to match the real situation in the corresponding photo compositions.

Then we check the slope of the found skyline or horizon whether holds in the horizontal direction. The good panoramic image with the horizon composition shall have a horizontal line to divide the image for providing visual pleasing and balance. When the found line is not horizontal, the location of the intensity with the biggest change in each column will not be all the same. Let the biggest change in each column be $CV(x)$, $W/3 < x < 2W/3$. We estimate the standard deviation of *CV* as

$$SDL = \sqrt{\frac{\sum_{x=1}^{W} (CV(x) - M_{CV})^2}{W}}, \quad (17)$$

where M_{CV} is the mean of $CV(x)$. The value of *SDL* is small, which represents the found line is near horizontal.

4) ***The Texture Complexity***

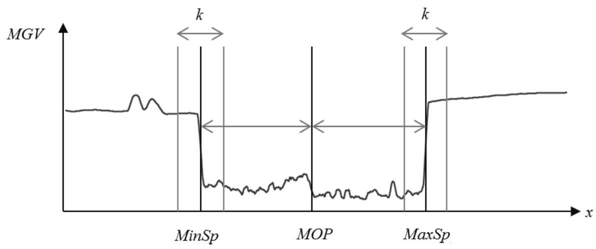

Fig. 6. Illustration of the locations of *MinSp*, *MaxSp*, and *MOP* of the histogram *MGV*.

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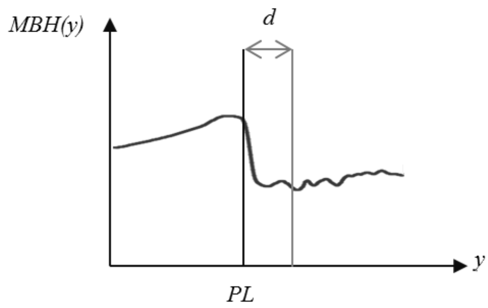


Fig. 7. Illustration of the location of the skyline or the horizon in the image.

In a panoramic image, there are some regions with a uniform color or texture, i.e., sky, cloud, and sea, which can generate aesthetically pleasing image. On the other hand, the image also needs a texture region served as a foil to the uniform region. These characteristics can help to identify the photo composition. Three types of the combination between the uniform and the texture regions in the panoramic image are considered:

(a) *The whole uniform region*: We define two features to measure the texture complexity of the image for avoiding the mistake that indicates the uniform region with good symmetry. Based on the histogram *MGV* (or *MGH*), we calculate the standard deviation of bin's values of the histogram:

$$SDGV = \frac{1}{W^2}\left(W\sum_{x=1}^{W}\left(MGV(x)\right)^2 - \left(\sum_{x=1}^{W} MGV(x)\right)^2 \right) \tag{18}$$

$$SDGH = \frac{1}{H^2}\left(H\sum_{y=1}^{H}\left(MGH(y)\right)^2 - \left(\sum_{y=1}^{H} MGH(y)\right)^2 \right) \tag{19}$$

(b) *The texture region surrounding the uniform region*: In the case of *SC*, the main subject appears in the center of the image and the surrounding region should be uniform or blurring that has a lower texture complexity. If the surrounding region has a higher texture complexity, the main subject will be mixing and don't be emphasized. For examining the texture complexity of the surrounding region of the main subject, the standard deviation of bin's values that belong to the region without the main subject is estimated as:

$$SDNGV = \frac{1}{W_L^2}\left(W_L\sum_{x=1}^{W_L}\left(MGV(x)\right)^2 - \left(\sum_{x=1}^{W_L} MGV(x)\right)^2 \right) + \frac{1}{W_R^2}\left(W_R\sum_{x=1}^{W_R}\left(MGV(x)\right)^2 - \left(\sum_{x=1}^{W_R} MGV(x)\right)^2 \right) \tag{20}$$

where W_L = min{*MaxSp, MinSp*} and W_L = W - max{*MaxSp, MinSp*}.

(c) *The uniform region connecting the texture region in the vertical*: In the case of the horizon composition, the top area often is a uniform region. Moreover, a texture region below the partition line connects the uniform region for providing higher contrast. For examining thus distribution of the intensity in the image, this relationship can be summarized using a function as the feature given by

$$BC(PL) = (BC_D - BC_U)\left[1 + \frac{BM_U - BM_D}{256}\right] \tag{21}$$

where

$$BM_U = \frac{1}{PL-d}\sum_{y=1}^{PL-d} MBH(y) \quad , BM_D = \frac{1}{H-PL-d}\sum_{i=PL+d}^{H} MBH(y)$$

$$BC_U = \frac{1}{PL-d}\sum_{y=1}^{PL-d}\left|MBH(y) - MBH(y+d)\right|$$

$$BC_D = \frac{1}{H-PL-d}\sum_{i=PL}^{H-d}\left|MBH(y) - MBH(y+d)\right|$$

and d is a small separate gap.

In summary, all features for a panoramic image can be formed a feature vector F as represented as follows:

$$F = (SAV, SAH, TDS, LG, PL, SDL, SDGH, SDGV, SDNGV, BC) = (f_1, f_2, f_3, f_4, f_5, f_6, f_7, f_8, f_9, f_{10}) \tag{22}$$

V. Composition Identification

By the above feature extraction, our method can identify the composition type of the inputted panoramic image. Each the photo composition can be defined by some decision rules in the feature space, and the corresponding method is described as follow.

1) *Identification of SC*

The symmetrical composition of the image forms a horizontal or vertical line in the center of the panoramic image, such that two sides of the line appear symmetrical content. Therefore, the feature *SAV* (or *SAH*) is to examine the symmetrical axis whether located near the middle of the image.

Besides, these two divided regions shall include obvious texture for making the meaning symmetrical scenery. We adopt the feature *SDGH* (or *SDGV*) to examine the texture complexity of areas on two sides of the horizontal (or vertical) symmetrical line. If *SDGH* (or *SDGV*) is larger than the predefined threshold T_{SDGH} (or T_{SDGV}), the considered panoramic image is identified as the symmetrical composition.

2) *Identification of CC*

If the panoramic image matches with the center composition, the main subject of the image contrasts sharply with his surrounding region. The size of the main subject is also larger enough than the other objects in the image. Also, the location of the main subject must be near the center of the image. In summary, the main subject shall meet the three rules:

(a) *Location rule*: The feature *LG* can be applied to measure the distance between the main subject and the center of the image. The *MOP* is the center of the main subject and the *SL* is set to *W* / 2 in Eq. 15. If the *LG* is smaller than the threshold value T_{LG}, we can assume the main subject that is in the center of the panoramic image.

(b) *Saliency rule*: One key condition of the *CC* is the main subject with the salient texture or brightness related to its surrounding region. This characteristic can be measured by the feature *TDS* that a high value represents the large difference in brightness between the main subject and its surrounding region. A predefined threshold value T_{TDS} is adopted to determine the condition existing.

(c) *Contrast rule*: The surrounding region of the main subject shall have a low contrast that can be measured by the feature *SDNGV*. When the *SDNGV* is smaller than the scale T_{SDNGV}, the main subject has a significance contrast with its surrounding region.

3) *Identification of TC*

The main subject in the *TC* is located in the *W*/3 or 2*W*/3 of the horizontal axis and shows a large difference in texture or brightness with its surrounding region. Similar to the sun composition, three features *LG*, *TDS*, and *SDNGV* are applied to determine the matching composition. The only difference between two compositions is the *SL* that is set as *W*/3 or 2W/3 in Eq. 15.

4) *Identification of HC*

A standard horizon composition in the corresponding panoramic image has the following characteristics:

(a) There is an obvious horizontal line between the sky region and the land or sea region. The feature *PL* is adopted to examine the position of the line.

(b) The partition line is a horizontal line. The feature *SDL* can estimate the characteristic.

(c) The top region of the horizon frequently is the sky or the cloud with the uniform and bright intensity. The bottom side of the horizon is the land or sea that has texture content or the significant difference in the content of the top region. The characteristic use the feature *BC* to evaluate.

The relationship between the ten features and the types of the composition is summarized in Table 1.

After feature extraction for each panoramic image, these captured values are combined as a feature vector *F*. The framework of the identification system is organized by four classifiers corresponding each of the considered compositions.

Table 1 Summary of The relationship between the features and the types of the composition.

Photo composition		SC	CC	TC	HC
Global Symmetry	***SAV***	●			
	SAH	●			
Local Saliency	***TDS***		●	●	
	LG		●	●	
Horizontal linearity	***PL***				●
	SDL				●
Texture Complexity	***SDGV***	●			
	SDGH	●			
	SDNGV		●	●	
	BC				●

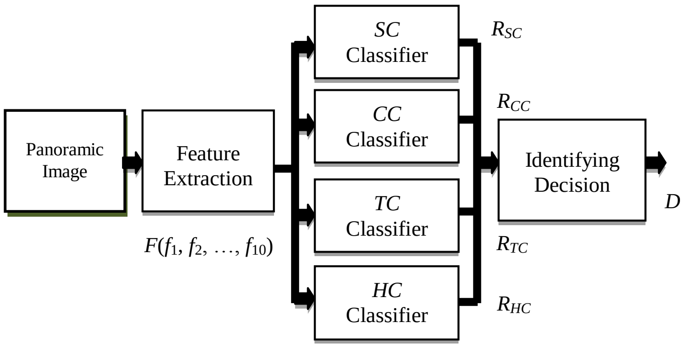


Fig. 8. The schematic representation of our proposed framework.

The schematic representation of our proposed framework is shown in Fig. 8. The output of the classifier is a response vector:

$$R_j = (r_{j1}, r_{j2}, r_{j3}, r_{j4}, r_{j5}, r_{j6}, r_{j7}, r_{j8}, r_{j9}, r_{j10}) \tag{23}$$

where *j* is one of the elements in the set of photo compositions *C*={*SC*, *CC*, *TC*, *HC*},

$$r_{ji} = \begin{cases} 1, & f_i \in t_{ji} \text{ or } t_{ji} = Null \\ 0, & f_i \notin t_{ji} \end{cases}, \quad i = 1, 2, \ldots, 10.$$

and t_{ji} is *i*th feature threshold value of the *j*th composition. All used threshold values are represented as a threshold vector:

$$\begin{aligned} T_j &= (T_{SAV,j}, T_{SAH,j}, T_{TDS,j}, T_{LG,j}, T_{PL,j}, T_{SDL,j}, T_{SDGH,j}, T_{SDGV,j}, T_{SDNGV,j}, T_{BC,j}) \\ &= (T_{j1}, T_{j2}, T_{j3}, T_{j4}, T_{j5}, T_{j6}, T_{j7}, T_{j8}, T_{j9}, T_{j10}) \end{aligned} \tag{24}$$

Next, the identifying decision is based on these four response vectors to output the composition type of the input panoramic image as a vector:

$$D = (c_{SC}, c_{CC}, c_{TC}, c_{HC}) \tag{25}$$

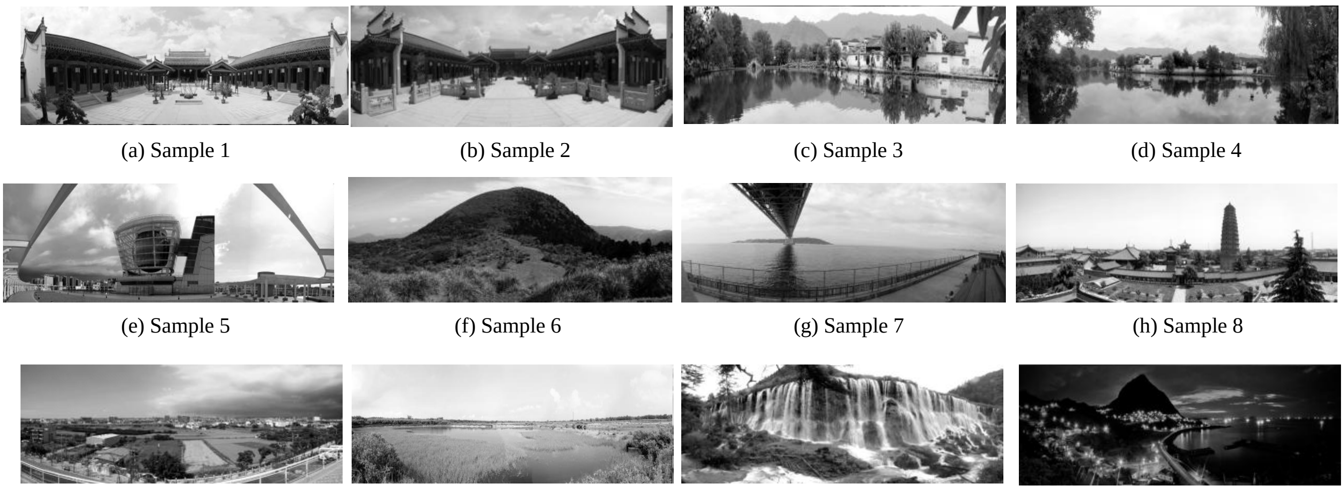
where

$$c_j = \begin{cases} 1, & \|R_j\| = 1 \\ 0, & \|R_j\| \neq 1 \end{cases}.$$

If c_j is 1, the input panoramic image is deemed including the *j*th type of the photo composition.

VI. Experimental Results

In this section, we evaluate the proposed method on a test image database which contains 73 panoramic images with 4



(a) Sample 1 (b) Sample 2 (c) Sample 3 (d) Sample 4
(e) Sample 5 (f) Sample 6 (g) Sample 7 (h) Sample 8
(i) Sample 9 (j) Sample 10 (k) Sample 11 (l) Sample 12

Fig. 9. The set of test panoramic images.

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types of considered photo compositions and the other compositions. All images are identified by photography experts into the most match composition or are labeled as the others. Without losing generalization, we select randomly two sample images from each class of the image database. The total of 10 sample images are shown in Fig. 9 in which the vertical *SC* as Samples 1 and 2, horizontal *SC* as Samples 3 and 4, *CC* as Samples 5 and 6, *TC* as Samples 7 and 8, *HC* as Samples 9 and 10, and incompatible composition as Samples 11 and 12.

The optimal threshold values used in each classifier are described as:

T_{TC} = (17, 19, 72, 0.14, 35, 0.25, 20, 20, 0.22, 1.4);

T_{CC} = (17, 19, 72, 0.08, 35, 0.25, 20, 20, 1.3, 1.4);

$T_{SC} = T_{HC}$ = (17, 19, , , 35, 0.25, 20, 20, , 1.4).

The features of the sample images are evaluated and shown in Table 2.

Table 2 Feature values of the sample images.

sample	***SAV***	***SAH***	***TDS***	***LG***	***PL***	***SDL***	***SDGH***	***SDGV***	***SDNGV***	***BC***
1	6.897	24.576	50	0.177	21.485	0.217	38.379	95.820	0.574	0.268
2	14.026	27.59	27	0.159	19.123	0.212	47.519	81.453	8.423	1.009
3	35.555	5.306	130	0.173	4.217	0.284	44.199	47.691	2.032	-0.141
4	21.173	11.745	48	0.153	11.319	0.232	41.859	39.665	0.365	0.882
5	11.881	23.767	92	0.014	59.672	0.255	8.642	37.397	0.014	0.971
6	15.112	19.138	96	0.049	6.294	0.387	35.6	90.851	0.204	-0.349
7	11.235	19.824	83	0.003	32.629	0.278	22.682	18.793	0.102	0.63
8	19.296	37.490	89	0.101	34.65	0.441	29.091	40.356	0.005	2.744
9	29.75	26.034	22	0.179	102.74	0.19	17.168	6.951	3.685	1.422
10	3.434	9.346	12	0.158	93.060	0.125	12.089	16.201	1.815	1.359
11	17.565	15.061	102	0.22	13.743	0.325	6.082	45.995	0.997	0.173
12	39.289	27.15	59	0.059	21.789	0.179	16.23	40.379	2.575	-0.517

Table 3 shows the results of the identification of our identification system and the human experts. It demonstrates our identification system has a similar performance to identify the photo composition of the panorama images. Especially when the experts have different identification for samples 5 and 6, our system can also identify with simultaneous photo composition.

Table 3 The results of the identification of our identification system and the human experts. (Experts / System)

composition / sample	***V-SC***	***H-SC***	***CC***	***TC***	***HC***
1	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0
2	1 / 1	0 / 0	0 / 0	0 / 0	0 / 0
3	0 / 0	1 / 1	0 / 0	0 / 0	0 / 0
4	0 / 0	1 / 1	0 / 0	0 / 0	0 / 0
5	1 / 1	0 / 0	1 / 1	0 / 0	0 / 0
6	1 / 1	0 / 0	1 / 1	0 / 0	0 / 0
7	0 / 0	0 / 0	0 / 0	1 / 1	0 / 0
8	0 / 0	0 / 0	0 / 0	1 / 1	0 / 0
9	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1
10	0 / 0	0 / 0	0 / 0	0 / 0	1 / 1
11	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
12	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0

To evaluate the effectiveness and efficiency of the proposed method, an extensive experiment is conducted the whole test database. We have used True Positive (*TP*), False Positive (*FP*), False Negative (*FN*) and calculated Sensitivity and Precision as follows:

$$Sensitivity = \frac{TP}{TP + FN} \tag{26}$$

$$Precision = \frac{TP}{TP + FP} \tag{27}$$

Table 4 summarizes the evaluation results of the 73 panoramic images using the optimized threshold values. Each image is labeled a proper composition by photographic experts that the result is like the ground truth of the experiment. Experimental results show that the performance of the proposed method is more than 94% in sensitivity and accuracy at least 87%.

Table 4、Performance analysis of experimental results.

Composition	***TP***	***FP***	***FN***	***Sensitivity***	***Precision***
Horizontal *SC*	11	1	0	1.00	0.91
Vertical *SC*	17	2	1	0.94	0.89
CC	6	0	0	1.00	1.00
TC	4	0	0	1.00	1.00
HC	21	3	1	0.95	0.87

VII. Conclusion and Future Work

In this paper, we present a novel composition identification method based on color, structure, and texture features for panoramic images, which can accurately describe the characteristics of a panoramic image's composition. We get four most common types of photo compositions used in panoramic images from a large image database. Our method extracts a set of features based structure and texture characteristics of the considered photo compositions and to identify the type of the photo composition by a simple identification method. Experimental results show that the photo composition defined by a set of the small number of features can efficiently complete the automatic identification, and have the approximate identification results with human experts.

Currently, the developed identification algorithm has been able accurately to determine the category of the photo composition. However, some of the panoramic images have multiple properties of photo compositions. So the image also can be assigned to different compositions by a human expert. Therefore, the method using fuzzy logic to identify the photo composition is developed in the future, such that the result is not limited to a single type of photo composition. This method can also demonstrate the relationships between each photo composition by numerical value for the considered panoramic image. The aesthetic judgment system can be designed based on features for estimating the properties of the photo composition. In addition, the aesthetic judgment system extends to assessing aesthetic value or providing a guide for the photographer in shooting a panoramic image. During the stage of producing a panoramic image, the aesthetic judgment system automatically makes some suggestions for user to generate a panoramic image with higher aesthetic value in photo composition.

References

[1] B. Krages, *Photography: art of composition*, Skyhorse Publishing Inc., 2012.

[2] S. Banerjee and B. L. Evans, "A novel gradient induced main subject segmentation algorithm for digital still cameras," in *Proc. of IEEE 37th Asilomar Conf. on signals, Systems, and Computers*, 9-12 Nov. 2003, vol. 2, pp. 1640-1644.

[3] P. Obrador, L. Schmidt-Hackenberg, and N. Oliver, "The role of image composition in image aesthetics," in *Proc. of the 17th IEEE International Conference on Image Processing* (*ICIP*), 2010, pp.3185-3188.

[4] L. Liu, R. Chen, L. Wolf, and D. Cohen, "Optimizing photo composition," *Computer Graphics Forum*, vol. 29, issue 2, May 2010, pp. 469-478.

[5] S. Banerjee and B. L. Evans, "Unsupervised automation of photographic composition rule in digital still cameras," in *Proc. of the SPIE Conf. Sensors, Color, Cameras, Systems for Digital Photography VI*, 2004, pp.364-373.
[6] M. Bautell, J. Luo, and R. T. Gray, "Sunset scene classification using simulated image recomposition," in *Proc. of 2003 Intl. Conf. on Multimedia and Expo*, 6-9 July 2003, pp. I:37-I:40.
[7] R. Debra, *5 tips for panoramic photography*. <http://electronics.howstuffworks.com/cameras-photography/tips/5-tips-for-panoramic-photography.htm>
[8] W. Tan, T. Fan, X. Chen, Y. Ouyang, D. Wang, and G. Li, "Automatic matting of identification photos," in *Proc. of 2013 IEEE International Conference on Computer-Aided Design and Computer Graphics* (*CAD/Graphics*), Nov. 2013, pp. 387-388.
[9] C. L. Wen and T. L. Chia, "The fuzzy approach for classification of the photo composition," in *Proc. of IEEE International Conference on Machine Learning and Cybernetics*, Xian, China, July 15-17 2012, vol. 4, pp. 1447-1453.
[10] P. Obrador, M. Saad, P. Suryanarayan, and N. Oliver, "Towards category-based aesthetic models of photographs advances in multimedia modeling," *Advances in Multimedia Modeling*, vol. 7131, 2012, pp. 63-76.
[11] H. Mitarai, Y. Itamiya, and A. Yoshitaka, "Interactive photographic shooting assistance based on composition and saliency," in *Proc. of International Conference on Computational Science and Its Applications* (ICCSA 2013), Part V, LNCS 7975, 2013, pp. 348-363.
[12] H. T. Chang, Y. C. Wang, and M. S. Chen, "Transfer in photography composition," in *Proc. of the ACM International Conference on Multimedia*, Nov. 2014, pp. 957-960.
[13] J. Faria, *What makes a good picture*?, Master of Sciences Thesis, Cranfield University, 2012.
[14] Y. Y. Chang and H. T. Chen, "Finding good composition in panoramic scenes,"in *Proc. of IEEE 12th International Conference on Computer Vision*(*ICCV*), Sept. 2009, pp. 2225-2231.
[15] C. Fang, Z. Lin, R. Mech, and X. Shen, "Automatic image cropping using visual composition, boundary simplicity and content preservation models," in *Proc. of the ACM International Conference on Multimedia*, Nov. 2014, pp. 1105-1108.
[16] C. S. Cavalcanti, H. M. Gomes, and J. E. R. De Queiroz, "A survey on automatic techniques for enhancement and analysis of digital photography," *Journal of the Brazilian Computer Society*, vol. 19, no. 3, 2013, pp.341-359.
[17] H. H. Su, T. W. Chen, C. C. Kao, W. H. Hsu, and S. Y. Chien, "Scenic photo quality assessment with bag of aesthetics-preserving features," in *Proc. of the 19th ACM international conference on Multimedia*. Nov. 2011, pp. 1213-1216.
[18] Y. Luo and X. Tang, "Photo and video quality evaluation: focusing on the subject," in *Proc. of European Conference on Computer Vision*, 2008, pp. 386-399.
[19] P. Obrador, L. Schmidt-Hackenberg, and N. Oliver, "The role of image composition in image aesthetics," in *Proc. of 2010 17th IEEE International Conference on Image Processing* (*ICIP*), Sept. 2010, pp. 3185-3188.
[20] S. Zhao, Y. Gao, X. Jiang, H. Yao, T. S. Chua, and X. Sun, "Exploring principles-of-art features for image emotion recognition," in *Proc. of the ACM International Conference on Multimedia*, Nov. 2014, pp. 47-56.

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