Color Similarity Definition Based on Quantized Color Histogram for Clothing Identification

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ABSTRACT

In this paper, we present a method to define a color similarity between color images using Octree-based quantization and similar color integration. The proposed method defines major colors from each image using Octree-based quantization. Two color palettes to consist of major colors are compared based on Euclidean distance and similar color bins between palettes are matched. Multiple matched color bins are integrated and major colors are adjusted. Color histogram based on the color palette is constructed for each image and the difference between two histograms is computed by the weighted Euclidean distance between the matched color bins in consideration of the frequency of each bin. As an experiment to validate the usefulness, we discriminated the same clothing from CCD camera images based on the proposed color similarity analysis. We retrieved the same clothing images with the success rate of 88 % using only color analysis without texture analysis.

Keywords: color quantization, color identification, histogram

1. Introduction

The recent moderns have been exposed to a lot of multimedia data in the daily life. Not only image data but also various kinds of sound and movie data related to the everyday life have been dramatically increased. Therefore, the effective and interactive content-based retrieval methods for a large multimedia database have been actively researched in recent years[1-4]. Most of content-based retrieval systems for an image database analyze color and texture information to define the image features and to discriminate the similarity of different images. Especially, the color analysis is a basic core technology for the robust image retrieval.

Color analysis technologies have been also applied to the smart surveillance system to robustly track pedestrians from CCD camera images captured in real-time. In the multiple camera environment, the clothing colors and positions of the pedestrians for each camera are analyzed and compared with the pedestrian information of the different camera in order to discriminate the same pedestrian[5-6]. Especially, the clothing color of the pedestrian is a primary analysis factor for person identification in the multiple camera environment that doesn't include the overlapping FOV(Field of View) of multiple cameras.

In this paper, we propose a novel method to define the color similarity based on the quantized color histogram. Moreover, we suggest the local color histograms to overcome the weakness of the traditional histogram based approaches that can not include the spatial information. Our approach to be applied to clothing identification automatically detects the face and clothing areas in the image and extracts the major clothing colors by applying the Octree-based color quantization. Then, the quantized color histograms for two clothing regions are compared for similarity definition. The advantages of our approach are as follows.

1. Real-time processing for the clothing identification
2. Extraction of the non-distorted quantized colors for each image by applying Octree-based color quantization
3. To represent the spatial color information of the clothing area using local histograms

The organization of this paper is as follows. We introduce the related work in Section 2 and explain the method to define the clothing area in Section 3. The color similarity definition to be proposed is explained in Section 4. The experimental results are presented in Section 5 and we conclude this paper in Section 6.

2. Related Work

Content-based image retrieval methods use the visual information such as color, texture and shape to define the image features and to retrieve the similar images to given query[1-4,7]. Among the visual information, especially color can be a very efficient tool to recognize specific objects and to define the similarity between the objects, since color features are not seriously affected by the direction of object and minute changes of the camera viewpoint.

Histograms are generally used to represent the color information of an image, and the similarity between images is measured by the sum of L1 or L2 distances between matching bins of the histograms[8]. The histogram intersection method[9] also has been widely used. However, histogram-based approaches have a serious limit since histograms do not include the spatial information. CCV(Color Coherence Vector)-based approaches[10] have been researched in order to represent the spatial information with colors. But these approaches usually require the high computation complexity.

Image analysis methods with image quantization have been presented to increase the efficiency of image retrieval. Kang et al.[11] quantized images by 64 color bins. Tous et al.[12] distinguished eight different colors: grey, blue, green, yellow, orange, red, pink and purple. These approaches can extract the distorted quantized colors to be totally different from the original color because they utilize the fixed color palette.

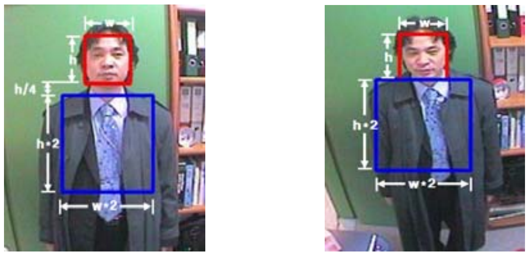
3. Extraction of Clothing Area

To extract the clothing area from the pedestrian image, we first detect the face area. The body area is detected from the face area at a fixed distance in lower direction and its size is decided according to the size of the face area. The clothing area is supposed to be the same as the body area.

We detect the skin blobs from the grid image using CCL(Connected-Component Labeling) algorithm. Background subtraction images usually include the pixel noises or holes in the skin area. Therefore, when we perform the labeling of the skin area by directly applying CCL to the background subtraction image, unexpected labeling results can be acquired due to the noises and holes. On the other hand, we can prevent detecting too small skin blobs by using an image patch as a unit in clustering of skin pixels and increase the performance due to reduction of the resolution by using the grid image[13].

For each skin blob, AdaBoost algorithm is applied to check whether the face features are included. AdaBoost algorithm returns 1 if the input blob includes the face feature. It returns 0, otherwise. If the face feature is detected, the size of the face blob is adjusted to the detected face size. Then, the clothing area is detected by finding the area that is apart from the face blob at a fixed distance in lower direction.

We classify the camera types into two categories based on the height of camera locations. The height of Type A cameras is low, and that of Type B cameras is high. The viewpoints of Type A cameras are almost at the front of the pedestrian. Type B cameras are located at the higher place than the average height of male adults, possibly at the ceiling. In the case of Type A camera, the distance between the face and clothing areas is 1/4 height of the face blob. For Type B cameras, clothing area is stuck to the face area, so the size of clothing area is decided by scaling twice that of the face area. Fig. 1 compares the camera images of Type A and B by showing the detected clothing areas(blue rectangle) and face areas(red rectangle).



(a) Type A (b) Type B

Fig. 1: The detected face and clothing areas in two types of camera images

4. Definition of Color Similarity

When we define the color similarity, we use the quantized colors for effective color analysis. In this section, we explain the way to define the color similarity based quantized color histograms.

4.1 Octree-based Color Quantization

The objective of color quantization is reducing colors of a full color image to a restricted number without a significant lack of color impression approximation. In our approach, we extract 10 or less major colors for each clothing area by applying Octree-based color quantization[14]. The palette-based algorithm is fairly fast, but suffers from the severe image degradation because it is not an adaptive algorithm. On the other hand, the Octree-based quantization can deal with any image, regardless of the number of different colors in the image. It can produce reasonable results with little degradation when converting from a high number of colors to a restricted number of colors. Even though the Octree-based approach takes longer than the palette algorithm to quantized the same image, the Octree-based approach is more proper in the analysis of the clothing colors because the quantized colors include the similar colors of the original image.

The name Octree comes from the data structure that is used to represent the colors of the image. It is made up of a number of nodes, each of which has up 8 children. The index gives the position of the color in the RGB cube as well as the branch of Octree. Fig. 2 explains the mapping the RGB value (140, 200, 255) into the RGB Cube and Octree. The level of Octree determines which leaf will be traversed from the current node when building the tree, and also when searching for the nearest color value.

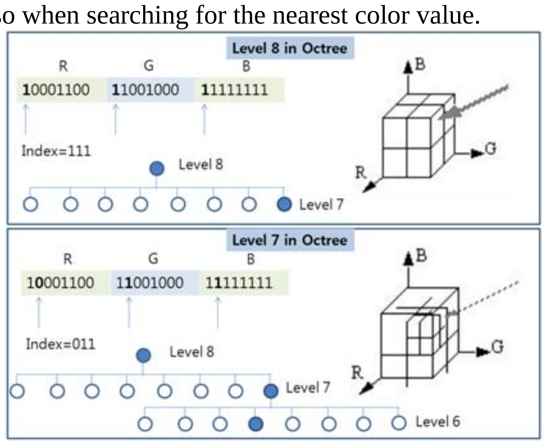


Fig. 2: Mapping an RGB Value into the RGB Cube/Octree

Fig. 3 shows 10 primary colors to be selected from the quantized colors extracted as the result of the Octree-based quantization of the yellow clothing area.

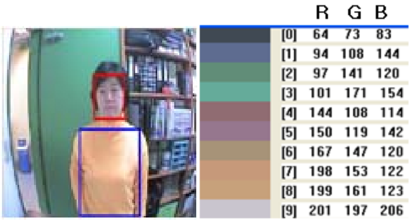


Fig. 3: 10 primary colors of the clothing area to be decided by applying the color quantization

4.2 Histogram based Color Similarity

The histograms based on the extracted major colors are constructed and compared to define the similarity of different clothing images. We divide the clothing area into six sub-regions, and build the histogram for each sub-region based on the primary quantized colors. The example of six sub-regions is shown in Fig. 4.

Fig. 4: Six sub-regions in the clothing area

The histograms for the same sub-region of two images are compared to define the color similarity. The histograms based on the fixed color palette are compared by computing difference between bins of the same index. However, in our histograms, the bins of the same index in different images represent the different colors. Therefore, it is necessary to find the match bins between the histograms of two images. The procedure to find the match bins and to merge the similar colors in one histogram is as follows.

Step 1. Determine the match bins of two histograms by finding the shortest Euclidean distance between bin colors of two histograms. Multiple bins of the histogram for image 1 can be matched to one bin of the histogram for image 2, and vice versa.

Step 2. Find many-to-one matches in the result of Step 1 and merge multiple bins to be matched to one bin. Merging means that frequencies of multiple bins are aggregated together to one bin and other bins are cleared.

Step 3. Compute the weighted Euclidean distance between the match bins to be determined in Step 2 as Eq. 1. This weighed distance is utilized as a color similarity value.

$$S(I,J)=\sum_{i=0}^{m} D(C_{I,i},C_{J,M(i)}) * \frac{MAX\ (H_{I,j},H_{J,M(i)})}{MIN\ (H_{I,j},H_{J,M(i)})} \quad (1)$$

where, m means the number of the color bins of *Histogram I* and $D(C_{I,i},C_{J,M(i)})$ represents the Euclidean distance between the color of the bin i of *histogram I* and the color of the matched bin of *histogram J*. $H_{I,i}$ and $H_{I,M(i)}$ represent the normalized frequency of the bin i of *histogram I* and the normalized frequency of the matched bin of *histogram J*, respectively.

Fig. 5 shows the match bins to be determined in Step 1. In this example, *bin 2* and *bin 6* of *histogram 1* are merged.

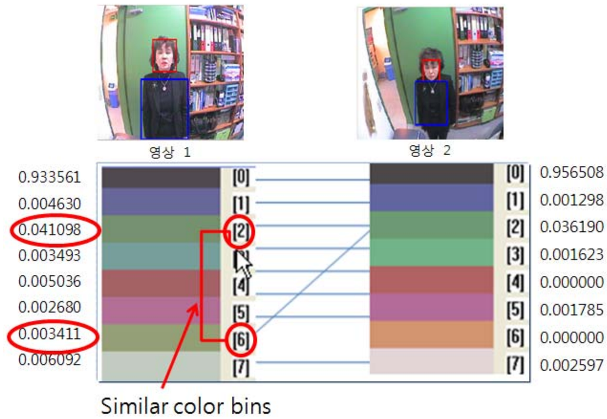


Fig. 5: Match bins between histograms and merging the similar color bins

5. Experimental Results

We captured 5 pictures of 42 different clothing by CCTV camera at the front door and the elevator, respectively. When the movement of pedestrians is detected, five images are selected from a sequence of images captured by a door CCTV camera(Type A). Another five images are selected from the images captured by an elevator CCTV camera(Type B). Let us denote the door and elevator images as $D_s(i)$ and $E_s(i)$, where i is the serial number of the clothing included in the image and s is the serial number of the image ($1 \le s \le 5$). Given one image for clothing i captured by the door camera as a query image, we retrieve five identical clothing images from $E_s(j)$, where $1 \le s \le 5$, $1 \le j \le 42$ by the following procedure.

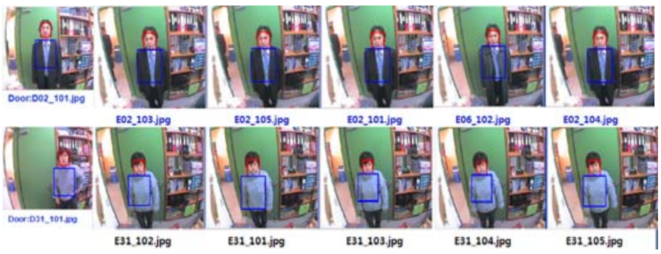
Algorithm: Retrieval of Similar Clothing Images
Input: *Q(i):* Query Image
Camera 2 images set
Output: Five similar clothing images
Begin
    for j = 1 to 42 do
        for t=1 to 5 do
            $D(j,t)$=Similarity($Q(i)$,$E_t(j)$)

    Sort D(j,t) in increasing order
    Store the result to the array $L_s[i]$
    Return *five elements in the front of* $L_s[i]$.
End

Fig. 6 shows the retrieval result images when we use $D_1(2)$, $D_1(31)$ and $D_1(7)$ as query images. In the case of D_1 (2) and $D_1(31)$, the correct elevator images were retrieved with 100 % of success rate. On the other hand, in the case of $D_1(7)$, the correct elevator images corresponding to clothing *C7* were retrieved with only 40 % of success rate. Three images containing clothing *C1* among five retrieval images were selected as the retrieval images for D_1 (7). Clothing *C7* is the male suits with the pink tie of stripe pattern and Clothing *C1* is also the male suits with the pink tie without a special pattern.

Table 1 compares the success rates in the cases of applying a HSV cumulative histogram for one region, local fixed color histograms for six sub-regions and the approach proposed in this paper. The success rates of identical clothing retrieval were 38% and 83.3% when we use a HSV cumulative histogram and local fixed color histograms, respectively. In the case of our approach, the rate of successful retrieval was improved to 88 %.

Query retrieval results



(a) Example of the successful retrieval

(b) Example of the failed retrieval

Fig. 6: Retrieval results of the same clothing images

Table 1: Success rate of identical clothing retrieval

using HSV cumulative histogram for one clothing area	using color index cumulative histogram based on the fixed color palette for six local clothing area	Proposed method
38%	83.3%	88%

6. Conclusion

We present a method to define a color similarity between color images based on the quantized color histogram. The proposed method defines major colors from each image using Octree-based quantization and two color palettes to consist of major colors are compared based on weighted Euclidean distance in consideration of the frequency of each color bin of the histogram.

In order to consider the spatial information, we adopted multiple local color histograms for the clothing area. The multiple local histograms were useful to overcome the weakness of the traditional histogram based approaches that can not include the spatial information. In order to validate the usefulness, we retrieved the similar clothing set to the query image from CCD camera images. The success rate of retrieving the identical clothing is up to 88% using only color analysis without texture analysis in the proposed method.

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