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Finding intrinsic color themes in images with human visual perception

Zunlei Feng, Wolong Yuan, Chunli Fu, Jie Lei, Mingli Song*

College of Computer Science, Alibaba-Zhejiang University Joint Research Institute of Frontier Technologies(AZFT), Zhejiang University, Hangzhou 310027, China

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ABSTRACT

Extracting color themes from an image is to get a color palette that consists of dominant colors of the image. In this article, we construct a color network to build the intrinsic connections of color information of pixels. By applying improved linear iterative clustering (SLIC) algorithm [1,2], we obtain initial color themes. In the following stage, with learning from human-extract color themes, we can get the final sorted color themes result. Experimental results demonstrate that our model outperforms previous approaches in terms of the number of themes, span and accuracy.

1. Introduction

Pictures of natural scenery always have a harmonious and consistent distribution of color. However, in many graphic design applications, it is very hard for amateur designers to pick out appropriate colors to produce visual effect as in nature. So extracting themes accurately and automatically plays a significant role in above graphic design applications [3]. Extracting color themes has extensive applications in many research areas, such as image classification, image retrieval, image recoloring and so on. It is very challenging to extract satisfactory color themes from an image. Currently, there are many approaches to extracting color themes that can be found in the literature and online communities, including Adobe Kuler and COLOURLovers, which are designed to creating and sharing color themes. But, previous approaches always fail to get an appropriate number of colors or obtain accurate color themes.

There are many basic color quantization approaches, such as Median cut methods [4–6], octree methods [7], traditional clustering techniques [8–10] and color histogram-based methods [11,12]. They extract mean colors of an image rather than accurate colors appearing in the image regions. Color feature modeling methods also cannot get pleased color themes in the aspects of number and span of extracted themes. Under normal conditions, different images have different number of color themes, as exemplified in Fig. 1. As a sequence, it is not appropriate to extract fixed number of color themes.

In this article, with considering three main factors: number, accuracy and span, we employ community finding algorithm to extract color themes from an image. First, we segment the image into uniform superpixels and get representative pixels from them. Second, we build a color network with the representative pixels as vertices and define weighted links between vertices. Through improved linear iterative clustering (SLIC) algorithm [1,2], we get an initial color theme set. Finally, for each theme in the theme set, we calculate its score and sort these colors by their scores. The scoring mechanism is learned from color themes extracted by humans. To the best of our knowledge, we are the first to develop a network model which incorporates pixels color information.

Our work has two main contributions. Firstly, we present a method to extract color themes and rate them utilizing the comparability principle of human visual perception. Secondly, we construct a color network to represent the relationship among pixels' color information, which is vital in getting color themes with broad span, appropriate number and high accuracy.

2. Related works

As described above, there are many approaches to extract color themes from images. Those approaches can be roughly classified into two categories: color quantization methods and feature modeling methods.

* Corresponding author.
E-mail address: brooksong@zju.edu.cn (M. Song).

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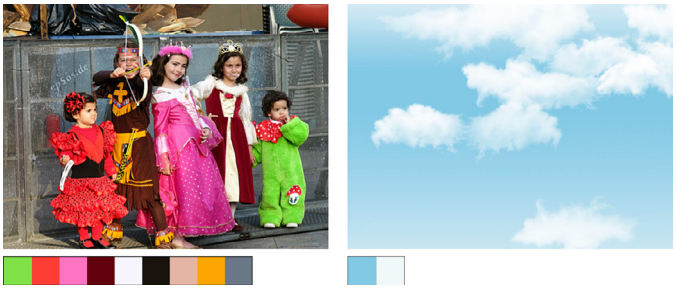

Fig. 1. Different images have different number of themes. The left image has more than 9 themes while the right one has only 2 main themes.

2.1. Color quantization methods

Vector quantization technique, which can model the distribution of pixels information of images, is a common way to extract representative color themes from images. It mainly includes popularity method, Median cut method, octree method, basic histogram-based and clustering-based methods.

Popularity method, median cut method and octree method. The popularity method [4,13] extracts themes by simply selecting colors from the color space. It has two serious drawbacks. First, it will have a poor performance when using dithering. Second, if the image has too many different colors, it will perform badly on those colors far from selected ones in color table. Median cut method, originally described by Hackbert [4], is implemented by repeatedly dividing the space in planes perpendicular to one of the color axes. The region to be divided is chosen as the one with majority pixels, and the division is made along the largest axis. Two subsequent variations include those of Kruger [5] and open source JFIF jpeg library [6]. However, in low density part of color space, divided volume can be very large, which can result in serious color errors. Octree method [7,14,15] is a hierarchical algorithm that merges regions of color space. Although simple and fast, it is not easy to understand how to spread colors through the full color space and the number of color themes is not under control.

Basic histogram-based and clustering-based methods. Other traditional color themes extraction methods include histogram-based and clustering-based approaches. Histogram-based methods [11,12] extract color themes by finding meaningful peaks in hue, saturation, and value histogram of the image. However, color themes extracted by those methods are redundant in most cases. Clustering-based methods include k-means [8,9] and fuzzy c-means [10], which need the number of clusters k as an input parameter. As described above, different images usually have different number of color themes. So it is important to choose an appropriate value for this input parameter since an inappropriate choice may lead to poor color themes. Besides, these two methods do not take spatial arrangement of the colors in the image into account, which may cause color missing in some regions.

2.2. Feature modeling methods

Shapira et al. [16] describe a method for clustering image pixels based on Gaussian mixture model (GMM). It is very slow at interactive operations on moderately large images. O'Donovan et al. [17] devise a method for extracting themes from an image an propose a measure of compatibility of a set of colors. Since the dataset they use is targeted at graphic design applications, their method tends to produce low-quality themes for natural photographs. Besides, O'Donovan et al. [17] do not focus on extracting color themes from an single image. Lin et al. [18] describe a method for creating color themes which works well for natural photos with make use of a study of how people do so. Nevertheless, in this method, colors extracted fail to span the whole color space. In short, feature modeling methods suffer from extracting fixed number of color themes. However, we find that for many editing goals adjustable number of themes works better.

Fig. 2. An example of original image and its associated superpixels segmentation image with SLIC algorithm.

3. Gathering themes with visual comparability

There are many datasets of color themes. O'Donovan et al. [17] derived two datasets from Kuler and COLOURLovers, and created their own dataset using Amazon Mechanical Turk("MTurk"). Kuler dataset comprises 104,426 5-color themes with rating created by visitors to Kuler website. The COLOURLovers includes over one million 2–5 color themes without rated by users. However, color themes in those datasets are mostly extracted by letting people pick important colors directly. In this process, people may be confused in some cases with deciding which color is more important. However, people can make decisions more easily in the contrast of two or more choices according to HA David's research [19], which states that the method of paired comparisons is used primarily in cases when the objects to be compared can be judged only subjectively. In addition, the color themes are those which play important roles in enhancing expression force of the image, which means if we remove a specified color, the expression force will be reduced accordingly. Considering above factors, we propose a color theme extraction method based on paired comparisons.

We conduct image segmentation first using SLIC method [1,2], as shown in Fig. 2.

3.1. Select candidate color themes

We need to select candidate color themes properly, i.e., including all possible color themes and maintaining diversity among them. In Lin and Hanrahan's work [18], they generate 40 color swatches by running k-means clustering on the image. However, this approach will cause two problems. One is omitting some color themes with narrow distribution ranges but high saliency to human eyes. Another is failing to maintain diversity of colors among these swatches. To solve these, we first find a representative pixel in each superpixel so as to get enough candidate color themes for further processing.

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