Image Categorization Based Color Detector

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ABSTRACT

Due to the investigation of the images in several parts of the life and the arising of the fast technology make the management of these images an open research area. Basically, the color feature considered as informative information that can be extracted from the image and help in improve the application performance. Based on the literature, this research found that there are several datasets that content images considered as a colorful images but some of these images content poor color information. For that, it's unfair to treat all the dataset images as colorful images and this may lead to unsuccessful classification due to unfair color features that extracted from these images. To overcome this problem, this paper has proposed a color detector that can be used as a pre-processing stage to separate the dataset images into two classes colorful and colorless. The experiments have been carried out by using Caltech 101 dataset and the proposed method shows high level of discriminative power.
Keywords: Color Image, Gray Image, SVM, Caltech 101

INTRODUCTION

Color is the first member of the low level features and it has widely used in several applications such face recognition, content based image retrieval, image segmentation, visual tracking and object categorization in the field of computer vision (Long et al 2003, Ayad et al 2012). Besides, it considered as an important feature that can be used to describe the image content. Based on the literature, several color models have been proposed to describe the colors of the images (Lukac, R. and Plataniotis, K.N. 2007). In fact, RGB color model is the first color model that has been used to describe the color of the images. In addition, there are several color models such as HSV, YUV have been proposed because these color models tried to describe the color of the images as the human vision does (Manjunath et al 2001). Furthermore, the use of the color model is different from one application to other. Therefore, several methods have been proposed to extract the color features such as color histogram, color moment and others. Obviously, color histogram illustrates the distribution of the colors in the image and gives description of how the object distributed in the image (Long et al 2003, Abdulmuim M.E. 2012). Besides, the color moment described as the probability distribution of different orders to the color in the image. Basically, the well-known kind of moment is the central moment with different orders (ex: order one represent the mean, order two represent standard deviation and order three represent Skewness). The main benefits of using different orders of color moment is each one gives an indication in how the image color is distributed (Van de Sande et al 2010, Abdulmuim M.E. & Abed,Z.F. 2015).

Apart from that, most of the standard datasets that used by different applications such as content based image retrieval and visual object categorization contain both colorful and colorless images. Therefore, treating all the images as colorful or colorless images will effect on the features extraction method and the classifier itself to recognize the image content.

However, in this paper a new color detector has been proposed that can be used as a pre-processing stage to separate the images into colorful images and colorless or poor color images. The proposed method promise to improve the effectiveness of the feature extraction method and the classifier job. The experiment result has been run with 500 images picked up from different categories of Caltech 101 dataset.

Proposed Color Detector Method

In this research a new color detector has been proposed to categorize the image if it is colorful or colorless image. Basically, there are some of the images visually considered as color images but they do not have much color in their distribution. This means the images content shaded color and do not have informative colors. Therefore, these kind of images will be treated as a gray scale images.

The main idea behind proposing the color detector is when using an application based on dataset content images with both colorful and colorless images. For that, the color detector will categorize the images into two classes and this lead to improve the performance of the application because the application will work on each class of images individually.

However, the color detector method that proposed by this research is implemented by first, extracting the color components of the image and then apply the standard deviation and the mean equations as features and these features will indicate how much informative color in the image.

To apply the proposed detector, firstly, the max and the min values for each pixel in the image are calculated. Secondly, applying equations 1, 2 and 3 to get the new values that will be used by the stranded deviation and mean to determine the image is colorful image or colorless image.

$$Max = (Red, Green, Blue) \quad (1)$$

$$Min = (Red, Green, Blue) \quad (2)$$

$$Array(i,j) = \begin{cases} 1, & R = 0, G = 0, B = 0 \\ \max - min\,, & Otherise \end{cases} \quad (3)$$

After that, the Mean and the standard deviation is applied on the values that has achieved by subtracting the maximum from the minimum values of the image color components. The main point of using the max and min values of the color components in verifying the image has colorful information or colorless is that if the max and the min values are approximately close to each other, this will indicate that the pixel components are approximately similar, otherwise if one of them are high and the other is low this will indicate that the pixels have big variation in their values. To conclude, the max and the min values will be used as an indication to the pixel if it contents informative colors or less informative colors. Algorithm (1) illustrates the propose method in details:-

Algorithm (1): Color Detector
Input: Image_i
Output: $\bar{\mu}$, σ

for loop, i=0 to image width -1
for loop, j=0 to image height -1
{
Calculate Max and Min of the image pixels

$$Max = (Red, Green, Blue)$$
$$Min = (Red, Green, Blue)$$
$$Array(i,j) = \begin{cases} 1, & R = 0, G = 0, B = 0 \\ \max - min, & Otherise \end{cases}$$

}
Calculate the Mean and the STD to the Array

$$\bar{\mu} = \frac{\sum_{i=0}^{n} x_i}{n}$$
$$\sigma = \frac{1}{n} \sum_{i=0}^{n} (x - \bar{\mu})^2$$

After calculating the Mean and the STD of each image and determining the best threshold for STD and Mean, the Bose-Einstein distribution equation has been applied on the STD and Mean values of all the images to shows the separation of the images.

$$f(x) = \frac{e^{(x-threshold)*\propto}}{1+e^{(x-threshold)*\propto}} \quad (4)$$

Based on eq.(4), the images with rich color will be above the threshold or get one and images with poor color or gray scale will be nearly close to zero. Figure (1) illustrate eq. (4).

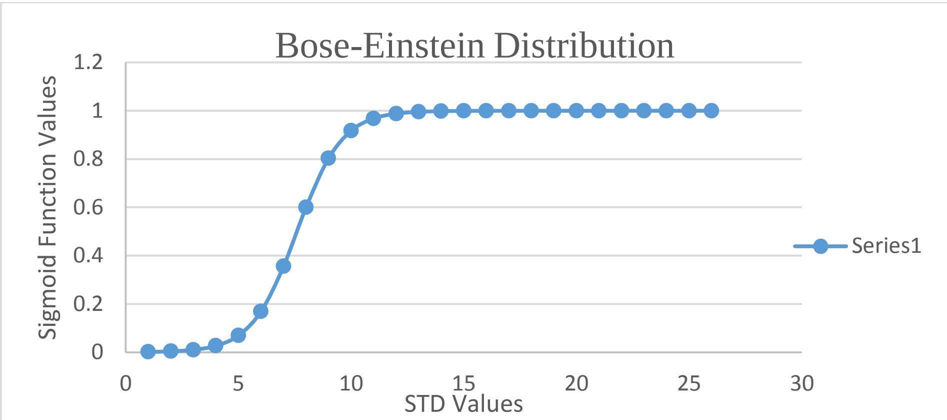


Figure (1).Illustrate an example to the distribution of STD values through using Bose-Einstein distribution equation. The threshold value that used is equal to 8 and the alpha value equal to 1.5.

Experimental Setup

As it mentioned earlier in section 1, the proposed method has been evaluated through using subset of Caltech 101 dataset, the images that have been used around 500 images that contain both colorful and colorless images.

Caltech 101 Dataset

Caltech 101 dataset is a well-known dataset that contain 101 classes of real words images. The images per-class is different from 40 to 800 images. There is some occlusion and interference between the background and foreground. The objects in this dataset are almost located in the center. In addition, the medium resolution of each image is about 300×200 pixels, and all images are in the JPEG format. However, in this paper 500 images have been elected from overall all classes and separated into two classes colorful and poor color images to test the proposed algorithm (Fei-Fei et al 2004) Figure 2. Gives an example to the Caltech 101 dataset images.

Figure (2). Gives an example to the images of Caltech 101 Dataset starting from the left (Dalmatian, Cellphone, Starfish, Ceiling fan, Camera, Laptop, Windsor chair , Crab Chair).

Selecting Optimal Parameters

As it mentioned earlier in section 2 about the proposed color detector algorithm each image process through the propose method and then the final STD of each image used to determine the image contain large scale of color distribution or poor color distribution (shaded colors). To be more precise, there will be some images have STD features located around the threshold, so, these features located in a fuzzy area. Therefore, another matric has been used to determine the images whose STD feature located in the fuzzy area to which class are belong. In fact, the Mean feature has been adopted to help the STD in determining the image is colorful or colorless. The main idea behind using the mean feature is the mean considered as an indication to how much the image contain colors. For example, some images got STD above the threshold but when it extract the mean features it shows that it does not contain large distribution of colors. Figure 3 illustrates and proves our claim.

Figure(3). Test image that its STD value around a specific threshold (8.176) and its Mean value is too small (2.667).

Based on figure 3, it can be concluded that the Mean features indicate how much the image contain color and the STD feature indicate how the image colors are distributed. Therefore, based on these two metrics we can determine the image is colorful or poor color.

Selecting Best STD Threshold Value

To determine the best STD threshold value the proposed color detector has been run over colorful and poor color classes of Caltech 101 dataset with different runs. Table 1 illustrates the achievement results.

Table(1). Classification accuracy of the proposed method based on different STD threshold with Fixed Mean Threshold.

Run	Mean	STD	Accuracy %
1	12	12	65
2	12	11.5	67
3	12	11	68
4	12	10.5	76
5	12	10	76
6	12	9.5	79
7	12	9	79
8	12	8.5	80
9	12	8	83
10	12	7.5	84
11	12	7	85
12	12	6.5	87
13	12	6	88
14	12	5.5	92
15	12	5	90
16	12	4.5	87
17	12	4	87
18	12	3.5	86

Selecting Best Mean Threshold Value

As it shown in table 1 the best classification result achieved is 92% by using STD threshold equal to 5.5 and Mean threshold equal to 12. The experiments below carried out to select the best Mean threshold. Table 2 shows the classification accuracy based on STD threshold equal to 5.5 and different Mean threshold.

Table(2). Classification accuracy based on different Mean threshold with best STD threshold

Run	Mean	STD	Accuracy %
1	12	5.5	92
2	11.5	5.5	93
3	11	5.5	93
4	10.5	5.5	94
5	10	5.5	95
6	9.5	5.5	98
7	9	5.5	99
8	8.5	5.5	99
9	8	5.5	100
10	7.5	5.5	99
11	7	5.5	97

As it mentioned earlier in section 2 about the Bose-Einstein distribution equation it will be used to visualize the separation of the images into their classes based on the achieved threshold.

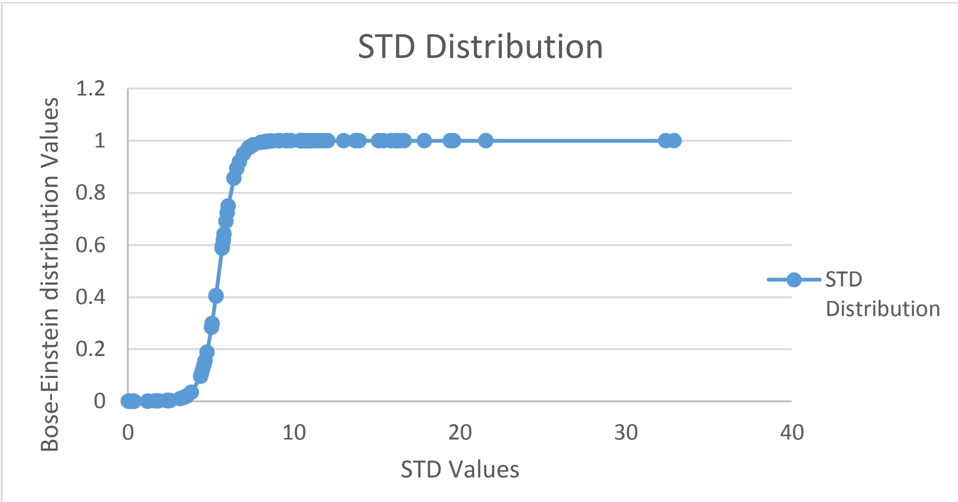


Figure (4). Illustrates the separation of the images based on the best STD threshold and the result has been visualize by Bose-Einstein Distribution equation.

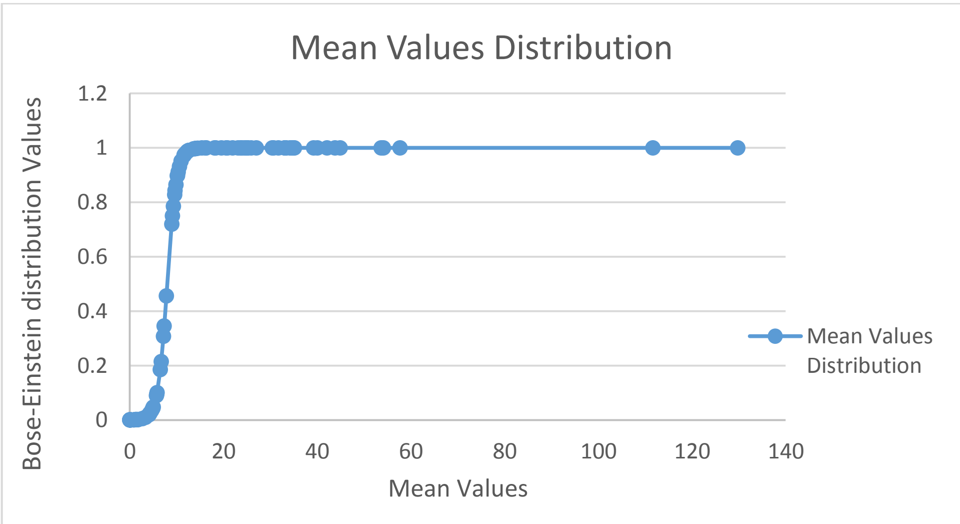


Figure (5). Illustrates the separation of the images based on the best Mean threshold and the result has been visualize by Bose-Einstein Distribution equation.

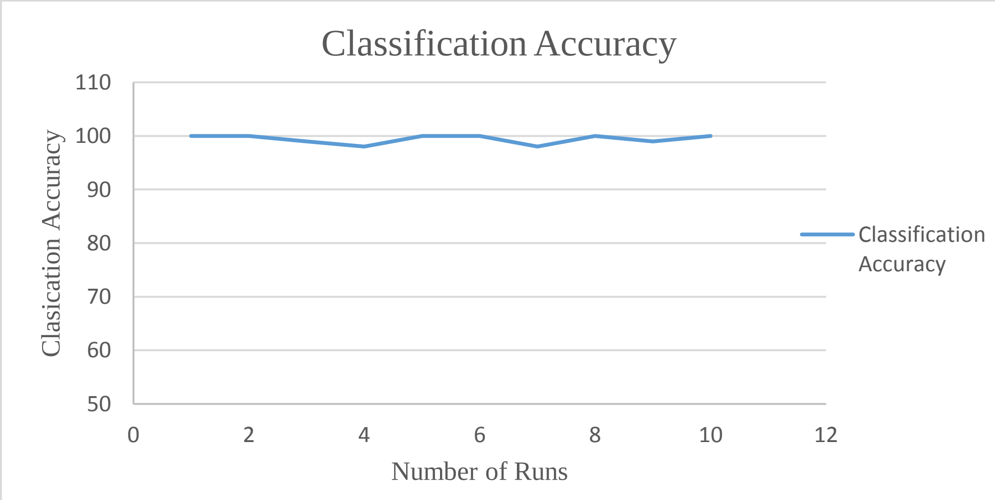
Based on figures 4 and 5, when using individual feature to classify the images, it is very clearly to see that there are still some images around the threshold and this means they are located in a fuzzy area. Therefore, this research focused in extracting the STD and the Mean features to classify the images accurately and overcome the limitation when using single feature.

Result and Discussion

The final classification accuracy has done by using 10 different runs selected randomly from the datasets with 200 images per-class. Table 3 and figure 6 illustrates the result of the proposed method.

Table (3). Discuss the classification result of the proposed method over 10 different random dataset.

Run	1	2	3	4	5	6	7	8	9	10
Classification Accuracy %	100	100	99	98	100	100	98	100	99	100
Average %	99.4									
STD	0.843274									



Figure(6). Shows the Classification accuracy of the proposed method over 10 different runs of two classes of Caltech 101 dataset.

Based on the average of classification accuracy and the standard deviation of 10 different runs, the proposed system gives higher and stable classification accuracy in separating the images into two classes.

CONCLUSIONS

This paper has present a new color detector that based on the STD and Mean features of the max and min difference between the pixels values. The proposed method has been run over 500 images picked up from different classes of Caltech 101. Based on the achievement in section 3, the best threshold values for STD and Mean set to 5.5 and 8 consecutive. After setting the best threshold, the proposed method shows higher level of accuracy in separating the images into two classes namely colorful and colorless with average classification accuracy 99.4 with STD equal to 0.843274. Obviously, the proposed method promises to provide fair training and testing to any dataset because the images with the same class (ex: colorful and colorless) are going to be trained and tested separately from the other class. In conclusion, the proposed method will improve the system performance and lead to raise up the performance of the feature extraction and classification methods.

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