Ceramic Tile Color Difference Classification System

Based on Color Histogram

Tang Xuri¹, Jiang Mai², Wang Yuping¹, Pi Zhigang¹

¹ Heilongjiang Institute of Science and Technology, Harbin 150027, China
E-mail: tangxuri@163.com

² Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang 110016, China
E-mail: jiangmai@sia.cn

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Abstract: According to the ceramic tile color difference classification detection problem, this paper presents a method for color difference based on Histogram statistical values. First, the color image in RGB color space is converted to HSI color space, median filter was selected for image preprocessing. Then, the ceramic samples HSI Histogram statistical of each channel was calculated respectively. Take the Histogram statistical as the color difference classification character value. For real time requirement, using minimum distance classifier as classification basis. Compared with the S, I channel, the results showed that adopted the H channel Histogram statistical value as feature vector has higher accuracy for ceramic tile color difference classification.

INTRODUCTION

China is a big ceramic tile production country and output is about 50% of total world. There mainly 1000 large and medium enterprises, but there was significant quality difference compared with foreign countries. The color classification of ceramic tiles is the final but important procedure in the whole process which influenced the tile quality degree, decorative effect and customer satisfaction degree. Most domestic enterprises still adopt manual sorting presently, it has at least the following defects: slow speed, great labor intensity, adverse circumstances and human subjective factor. Meanwhile, the well-rounder technique and successful experiences of foreign countries not get practical application because china clay burden, production process and process control in country situation difference, as in [1],[2]. Therefore developing an automated color classification algorithm is of great importance, which can effectively resolve the problems brought by manual activity, and can help to improve the full automation in the tile industry and advance the development of automated color recognition technology in other related industries, as in [3],[4].

SYSTEM STRUCTURE

The ceramic tile surface color difference on-line measurement by using color area array video camera instead of human eyes, can not only improve the detection accuracy, but also increase the measuring speed and efficiency. As Figure 1 shows the whole system structural diagram, fixed the camera right above the ceramic tile transmission belt and set an external synchronous signal photoelectric sensor, the sensor send pulse signals when the ceramic tile moves to the specified position, then using these pulse signals control the camera shutter synchronization photography, as in[5].
In order to eliminate the environmental influence to the imaging system at maximum, we should put the whole imaging system in a closed light box and stability the imaging conditions. From the pinhole model shown in Fig.2, the distance between ceramic tile and optical center is $L$ while distance between the CCD FPA (Focal plane) and optical center is $f$, diagonal length of the CCD FPA and ceramic tile surface is respectively $d$ and $b$, then we get the equation as following:

$$\frac{d}{b} = \frac{f}{L} \Rightarrow L = \frac{b \times f}{d} \quad (1)$$

So we obtained the constraint relationship between optical imaging system and the light box diagonal length or height which can be used as light box design basis.

The light source is one of the most important factors which influence the vision system’s image quality and with 30% ratio of the whole input data, so it is very necessary to equip light source for imaging system which can decrease image processing algorithm difficulty and at the same time increase the system measurement accuracy and reliability.

3 IMAGE PROCESSING ALGORITHMS

3.1 The HSI Color Model

Generally we use gray images in image noise processing, but in the ceramic tile color difference measurement system we get color images firstly, so decomposing image according a certain color model, extracting it gray component and recovering of the image after image filtering. The three subscale’s value of RGB will change after image de-nosing which caused the original images has large changes. From the perspectives of vision system HIS using Hue, Saturation and Intensity described the image color, each component can be expressed as double pyramid shown in Figure 3.
Hue: which means object conduction or reflected wavelength and the value range of H must \(0 \leq H \leq 360^\circ\).

Saturation: which means color strength or purity, which represent the proportion of gray and tonal and the value range of S is \(0\% \leq S \leq 100\%\).

Intensity: which means relative intensity, and the value range of I is \(0\%(black) \leq I \leq 100\%(white)\).

The sensitive degree of intensity is stronger compared with the color dense dilute in Human Visual System (HVS), so the HSI color model always be used in HVS, meanwhile, algorithms in image processing and computer vision can be easily used in HSI color model, the H and S is strong connected with HVS color feeling and the I component is independent with color information. The three components are mutually independent so we can deal with them separately which simplified the image analysis and processing work.

The formula transformed from RGB (Red, Green, Blue) color space to HSI (Hue, Saturation, Intensity) space as following:

\[
H = \begin{cases} 
360 - \theta & B \leq G \\
\theta & B > G 
\end{cases} \quad (2)
\]

\[
S = 1 - \frac{3}{R + G + B} \min(R, G, B) \quad (3)
\]

\[
I = \frac{R + G + B}{3} \quad (4)
\]

### 3.2 The Imaging Preprocessing Algorithm

Generally, image including various noises because the shooting environment and equipment quality etc. influences. These cause image distortion and fuzzy which effect the analysis of image feature. There mainly two treatment principle for image filtering: First, not to damage the image contour and edge etc. important information. Secondly, clearer image with continuous edge. Image noise filtering method can be divided into linear or nonlinear two methods, typical types such as mean filter, median filter and wiener filter. Take different test for real ceramic tile in order to ensure a certain filter. Figure 4(a) was a real ceramic tile gray image added with gaussiannoise(average=0, variance=0.005). Figure 4(b)–(d) represent the filtering results after adopted minimum filter, wiener filter and median filter separately.

![Fig.4 Detection effect of different noise filter](image)

As the Figure 4 shown vividly, compared with minimum filter and wiener, median filter can remove the image noise quite well and very effectively for pulse interference and image scanning noise, meanwhile, overcome the linear filter disadvantage such as image detail blur. In view of the well adaptability for all various noise, this scheme choose median filter for ceramic tile image noise filtering.

### 4 THE CERAMIC TILE COLOR DIFFERENCE CLASSIFICATION METHOD

The ceramic tile color difference classification can be equivalent to a recognition problem under the training samples condition, the primary problem in classified is the feature extraction. The color histogram is the color information function and it represent the pixels number of the same
color degree, which abscissa is color degree and ordinate is color occurrence frequency. It described the percentage of different color in a whole image and the histogram only attention to the color space value distribution position, as in [6],[7]. With the advantage of sift, rotation invariance so it is usually used for ceramic tile surface color information expression.

Figure 5 shows the H, S and I component histograms of two different color (green and red) ceramic tile. Figure 5(a) shows the green ceramic tile original color image, Figure 5(b)~(d) corresponds to the H, S and I component histograms. Figure 5(e) shows the red ceramic tile original color image, Figure 5(f)~(h) corresponds to the H, S and I component histograms.

Using histogram statics value as color difference characteristic value, take each channel gray image as processing and classifying basis. Through concrete environmental and experimental conditions determine which channel is better for our ceramic tile color difference detection.

After feature extraction the next problem is the classifier selecting and designing, there are lots of classified model such as minimum distance, decision tree, decision table, neural network, k nearest neighbors, bayesian method and support vector machine etc. method. Minimum distance classifier has the speed advantage often used in on-line detection system with real-time requires. Firstly, we adopted Euclidean distance as similarity measurement principle between the measured ceramic tile and the standard ceramic tile.

Specific classification scheme as following: draw each component histogram and calculating the area $S_i$ surrounded by histogram, take $S_i$ as the classification eigenvalue, then classification these ceramic tile samples through minimum distance classifier. The training set generated a eigenvalue $U_i$ ($k=1, 2, \ldots, m$; m is the category number) which stand for a certain category according the arithmetic mean, it is the basis of the minimum distance classifier. Calculating the distance $d_i^2$ for each pre-sort data element $S_i$, which the parameter $d_i^2$ is shown as follow

$$d_i^2 = (U_i - S_i)^2 \quad (5)$$

Finally, according to distance parameter $d_i^2$ to decide which category $S_i$ belonged to.

5 THE TEST RESULT ANALYSIS

In this experiment, we chose 18 flower color ceramic tiles for each color (green and red), respectively. The professional sorting engineer divided these ceramic tiles into different color number in advance. The different color ceramic tiles H, S, I component histogram statics value was
calculated respectively, calculated total 50 groups experiment data for each color tiles and take the average value as the final results. Calculating results of each channel component is shown in Figure 6 which three different color curves represent H(red curve), S(green curve) and I(blue curve) channel component, respectively.

![Graphs showing H, S, and I channel component for green and red ceramic tiles.](image)

**Fig.6** The ceramic tile histogram statics value of different color

<table>
<thead>
<tr>
<th>Table1</th>
<th>The color difference detection results</th>
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<tbody>
<tr>
<td>Channel Title</td>
<td>Green ceramic tile</td>
</tr>
<tr>
<td>H</td>
<td>2</td>
</tr>
<tr>
<td>S</td>
<td>4</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
</tr>
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Determined the ceramic tile category region base on the H, S and I channel statics value, the classification standard is error rate of the 18 ceramic tiles after comparing classification results in advance. The imaging system used Guppy PRO F-201 area CCD camera with 1394 interface and resolution, pixel size is 4.4 μm, focal length is 6mm with 1m wording distance.

From the Table 1 we know H channel component histogram static value has higher accuracy compared with two other channels. It is mainly because that S channel stand for color degree not represent the substantial information of color, I channel shows the light and shade of color, so we choose H channel as classification standard which can really reflect the color category.

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