

Abstract

Color technology and color measurement will be allow encode the color of a painting, which is a tangible cultural heritage, and create a color database based on the color measurement values. When move the painting from the premises to international and domestic exhibitions, we can compare to the previous color measurement value and last color measurement value by color data processing of painting using the color database, data analysis and machine learning to verify the original image intended.

The aim of this work was to implement a method of recognizing paintings using a data analysis and machine learning methods based on color data. Data analysis methods such as spectral curve testing, distribution testing, hypothesis testing, T, F, Z testing, and ANOVA testing were tested. The machine learning method was performed in comparing the data, and the results need to be confirmed by further measurements.

Introduction

We created a color database by making color measurements on five unique historical and cultural heritages of the Mongolian Art Gallery such as Azarganii notsoldoon, Ajiilin daraa, Lenin bagsh, Uvgun huurch, Taliin ail and experimented with color data on several paintings as an example. The color data of these unique historical and cultural paintings was encoded in two different methods with a colorimeter to create a color database of paintings. The color data analysis methods that we developed using this database, it will be possible to determine whether a painting is original or damaged by comparing it with measurements before and after the painting is sent to the exhibition. This research is very important to introduce data analysis methodologies in the field of cultural heritage.



Figure 1. Painting Azarganii notsoldoon.

Figure 2. Painting Ajiilin daraa.



Figure 3. Painting Taliin ail.

Figure 4. Painting Lenin bagsh.

Figure 5. Painting Uvgun huurch.

Methods and Materials

General methods of paintings recognition:

- Measure the color data of the paintings by above two methods
- Create a color database
- Make the descriptive analysis
- Compare statistical parameters with the before and after measurement of paintings.

Methods for analyze color measurement data:

- Analyze by spectral curve method
- Analyze by distribution histogram
- Analyze the hypothesis test with T, F, Z
- Analyze with ANOVA test

We performed the color measurement in two methods.

Measurement method 1: Measure by color and object

Measurement method 2: Create a color matrix depending on the size

Data size information:

- Total measurements: 1752
- One measurement number of back values: 40
- Total numerical values of measurements: 70080

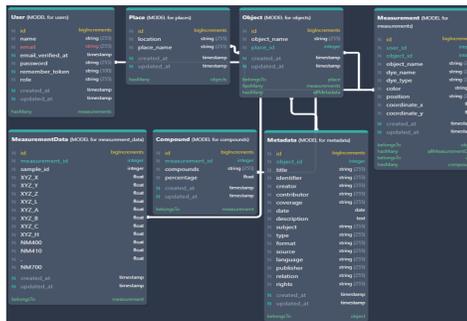


Figure 6. Structure of color database.

Table 2. Descriptive analysis.

No	Painting name	parameter	Max and min value	Mean	Std deviation	Correlation coefficient
1	Ajiilin daraa n=345	x	44.748 3.188	17.431	11.529	$r(x,y)=0.9914$, $a=4.577$, $b=-43.701$
		y	92.210 6.338	36.091	26.765	$r(x,z)=0.6753$
		z	62.807 0.122	22.332	17.505	
2	Ajiilin daraa n=285	x	34.681 2.134	11.845	8.733	$r(x,y)=0.9974$, $a=1.148$, $b=-1.486$
		y	37.362 2.214	12.123	9.360	$r(x,z)=0.9246$
		z	26.748 1.820	9.129	7.848	
3	Taliin ail n=105	X	38.636 7.748	21.978	8.023	$r(x,y)=0.9811$, $a=1.117$, $b=-0.7789$
		Y	37.750 9.039	23.779	8.481	$r(x,z)=0.8547$
		Z	28.057 4.900	17.543	8.251	
4	Uvgun huurch n=165	X	61.547 4.890	39.833	16.156	$r(x,y)=0.9733$, $a=1.0597$, $b=-4.7075$
		Y	61.245 4.950	37.501	16.631	$r(x,z)=0.6752$
		Z	45.604 3.878	17.872	14.989	
5	Lenin bagsh n=126	X	56.663 3.390	17.806	12.150	$r(x,y)=0.9814$, $a=1.098$, $b=-2.452$
		Y	58.519 3.415	17.100	12.732	$r(x,z)=0.6752$
		Z	40.535 2.911	10.661	8.676	

Table 1. Measurement amount.

Painting name	matrix	object
Ajiilin daraa	285	290
Taliin ail	105	60
Azarganii notsoldoon	322	130
Lenin bagsh	165	120
Uvgun huurch	165	110
Total	1042	710

Results and Discussion

In this study, a comprehensive data analysis of the above 5 paintings was performed, and four types of data analysis methods were experimented using the general methods described in the materials and methods section. In this research, the paintings are analyzed with examples of each of the above methods. Figure 7 shows the construction of the image spectral curve of painting Ajiilin daraa, and this curve is compared after overlapping two measurements, which is the most general method to check the image. The next example is the T-test, which is painting Azarganii notsoldoon with two different data. In Table 3, we see that the P value is less than 0.05 and the t stat is -2.00507, which is much lower than critical level. This means that in a hypothesis testing analysis, the zero hypothesis rejects (H0) and the opposite hypothesis (H1) is accepted. These two values are considered incompatible. In Figure 8, painting Lenin bagsh established a distribution histogram, and the two measurements can be compared in terms of their distributions. Table 4 shows the analysis of painting Taliin ail using the ANOVA test, which means that the two data are compared by variance. Using these data analysis methods, it is possible to analyze a wide range of paintings.

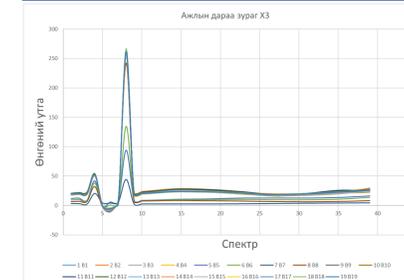


Figure 7. Spectral curve of Ajiilin daraa.

Table 3. Predictive analysis T test of Azarganii notsoldoon.

	XYZ_X	XYZ_Y
Mean	27.52257	29.88787
Variance	21.08288	10.92387
Observations	23	23
Pooled Variance	16.00337	
Hypothesized Mean Difference	0	
df	44	
t Stat	-2.00507	
t [Critical one-tail]	0.025566	
t [Critical one-tail]	1.68023	
t [Critical two-tail]	0.051131	
t [Critical two-tail]	2.015368	

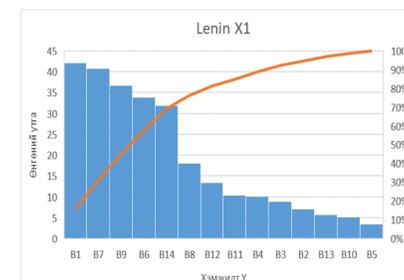


Figure 8. Distribution histogram of Lenin bagsh.

Table 4. ANOVA test of Taliin ail.

Source	SS	df	MS	F	P-value	F crit
Rows	169.9	9	18.87922	10.533	1.58E-05	2.45628
Columns	218.8	2	109.4246	61.053	9.53E-09	3.55455
Error	491	18	27.27778			
Total	880.5	29				

Conclusions

We made color measurements on 5 unique historical and cultural artifacts of the Art Gallery and created a color database. In this work, experiments were conducted to introduce a method of recognizing paintings using a number of data analysis methods based on color data, and the results were explained. Testing of spectral curves, comparative testing, hypothesis testing, T, F, Z testing, and ANOVA testing has been successful and needs to be repeated the measurement.

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