CONSIDERATION OF THE RELATION BETWEEN DISTANCE AND CHANGE OF PANEL COLOR BASED ON AERIAL PERSPECTIVE

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ABSTRACT

Three-dimensional (3D) shape recognition and distance recognition methods utilizing monocular camera systems have been required for field of virtual-reality, computer graphics, measurement technology and robot technology. There have been many studies regarding 3D shape and distance recognition based on geometric and optical information, and it is now possible to accurately measure the geometric information of an object at short range distances. However, these methods cannot currently be applied to long range objects. In the field of virtual-reality, all visual objects must be presented at widely varying ranges, even though some objects will be hazed over. In order to achieve distance recognition from a landscape image, we focused on the use of aerial perspective to simulate a type of depth perception and investigated the relationship between distance and color perception. The applicability of our proposed method was demonstrated in experimental results.

Keywords: distance recognition, aerial perspective, color sensation

1. INTRODUCTION

Recently, three-dimensional (3D) shape recognition and distance recognition methods utilizing monocular camera systems have been required for field of virtual-reality, computer graphics, measurement technology and robot technology. Numerous studies have been conducted on 3D shape and distance recognition based on geometric and optical information. As a result, it is now possible to accurately measure the geometric information of an object [1]. However, these methods are only applicable to the size and shape measurements of a single object observed at short range.

In this study, we aim at recognizing and measuring distant objects which are normally indistinct when observed at long ranges. In order to achieve this goal, we have adopted an aerial perspective that allows us to achieve a type of depth perception. It is based on the principle that the saturation level that represents the vividness of objects varies depending on the scattering and absorption of sunlight in the atmosphere.

In our previous studies [2], we investigated saturation level changes obtained from a landscape image. The results we obtained demonstrated that saturation level of an object decreases as its distance from the camera increases.

In this paper, we propose to investigate the detailed relationship between distance and color variations and to attempt to determine a suitable color system for this method by use of a color panel.

2. DEPTH PERSEPTIONS

People normally recognize depth by integrating various forms of ocular informations. Using these informations, they can estimate object sizes and the distance between various objects seen in a painting or a picture. Various forms of depth perception are categorized as physiological or painterly information. Table 1 shows various depth perception classifications. When people look at a painting or a picture, they integrate the painterly informations, and are thus able to estimate the size and distances between the objects presented.

In this study, we propose to achieve the capability to recognize the distances utilizing a landscape image. To accomplish this, we focused on utilizing aerial perspective, which is useful when attempting to recognize the distance to long range objects. The utility of this method is based on is the principle that the saturation level varies depending on the scattering and absorption of sunlight in the atmosphere.

3. RESEARCH INTO RELATIONSHIP BETWEEN DISTANCE AND COLOR PERCEPTION

To investigate relationship between distance and color perception, we used a color panel and examined the changes to the panel color.

3.1 Shooting Procedure

We began by taking photographs on a seldom-used straight farm road. The color panel used in this research is shown in Figure 1. This panel was green and measured size is 1820 x 920 mm. We measured the color of the panel means of the Yxy color system using a brightness photometer (CS-100A made by Konica Minolta). Figure 2 shows the experimental environment. Table 2 shows the environment, shooting parameters and the color of the panel using the Yxy color system.

Table 1: Ocular information classification.

Physiological information
Accommodation
Ocular convergence
Binocular parallax
Painterly information
Occlusion
Aerial perspective
Texture gradients
Shading & shadows
Linear perspective

Fig. 1: Color panel.

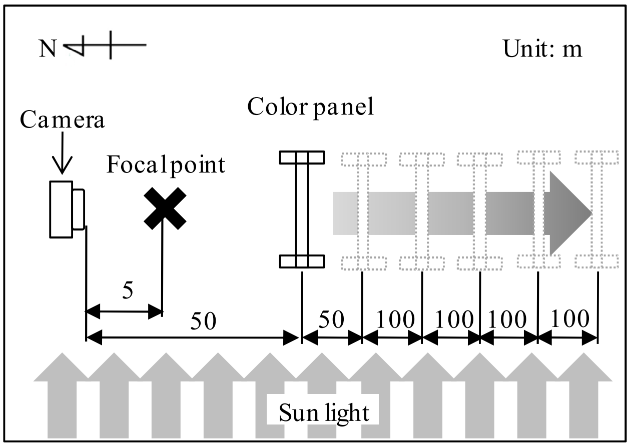


Fig. 2: Experimental environment.

The color panel was placed at 50 m and 100 m intervals from the camera. Pictures were taken at each distance at all combinations of F-stop numbers and focal lengths. After all pictures had been taken, the camera was focused on a point 5 m from the lens.

3.2 Method of Analysis

We converted the 16 bit RGB images into following color systems. We then calculated the average of 2 panel images in each color system.

Table 2:Experimental condition.

Environment of shooting	
Time	Afternoon
Weather	Cloudy
Temperature [degrees]	22.4-22.6
Humidity [%]	70-76
Visibility [km]	20-30
Parameter of shooting	
F-stop number	5.6/6.3/8.0/11.0/16.0/22.0
Focal length [mm]	18/24/35/50/70/105/135
Resolution [pixel]	3872 x 2592
Image format	16 bit RAW
Camera height [mm]	1500
Panel color	
Luminous Reflectance: Y[%]	43.3
Chromaticity: x	0.241
Chromaticity: y	0.471

3.2.1 HSV and modified HSV color systems

HSV and modified HSV color systems are often used in computer graphics. These color systems express colors in terms of hue, saturation and brightness. These methods are designed to emulate how the human eye perceives color.

The modified HSV color system was developed in order to accurately show lower color saturation levels [3].

The aerial perspective is based on the principle that the saturation level varies due to the scattering and absorption of sunlight in the atmosphere. Therefore, we focused on S element in the HSV color system and modified S element in the modified HSV color system.

3.2.2 YCrCb color system

The YCrCb color system expresses colors by luminance level, the color difference of blue, and the color difference of red. This method was developed for TV broadcasting. This method also considers the features of human vision. We focused on the Cr and Cb elements that represent the color difference.

3.2.3 Yxy color system

The brightness photometer we utilized measures the object color in the Yxy color system. We used the Yxy color system to obtain the saturation level of the panel image at each distance and compared it to the object's original saturation. Figure 3 shows a chromaticity diagram in the Yxy color system. Using this figure, we defined saturation as distance from the white point. Our definition of saturation using the Yxy color system is shown equation (1).

$$S_{xy} = \sqrt{(x-0.3)^2 + (y-0.3)^2} \quad (1)$$

where S_{xy} is the saturation in Yxy color system and x and y are chromaticity of panel image.

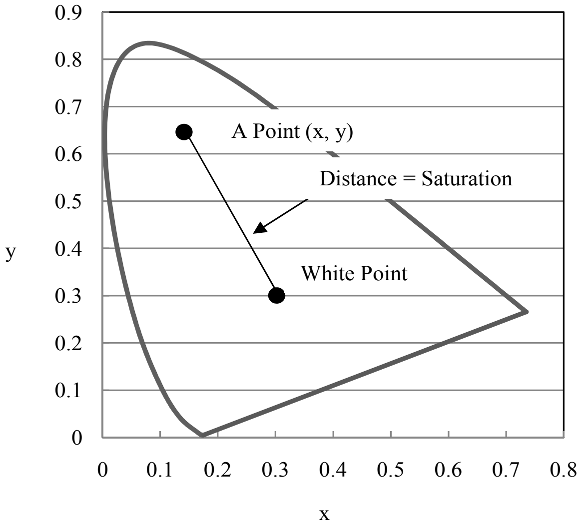


Fig. 3: Our Definition of Saturation.

4. RESULTS

The relationships between saturation variation and distance obtained from the experimental for each color system are shown Figures 4, 5, 6 and 7.

4.1 Saturation variation in the HSV color system

Figure 4 shows the saturation variation when focal length was set at 18 mm for each F-stop number condition in the HSV color system.

From this result, we determined that the saturation level decreased significantly at distance over 200 m from the camera, regardless of the F-stop number sets. In addition, we found that the saturation level slight decreased within 200 m regardless of the F-stop number sets.

4.2 Saturation variation in the modified HSV color system

Figure 5 shows the saturation variation when the focal length was set at 18 mm for each F-stop number condition in the modified HSV color system. From this result, we determined that the modified saturation level linearly decreased at each measured range, and that there was no significant difference regardless of the F-stop number sets.

4.3 Color differences variation in the YCrCb color system

Figure 6 shows the color difference of red and blue variation when the focal length was set at 18 mm for each F-stop number condition using the YCrCb color system. From this result, we determined that the Cr and Cb values both tended to increase and that was no significant difference in result regardless of the F-stop number sets.

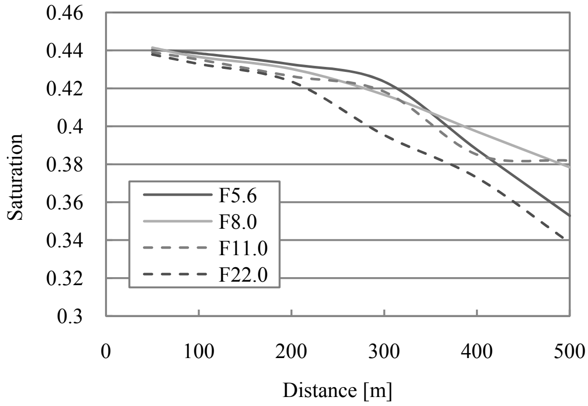


Fig. 4: Saturation variations in the HSV color system.

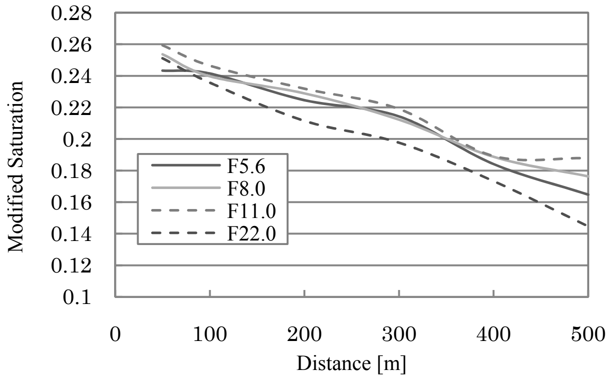
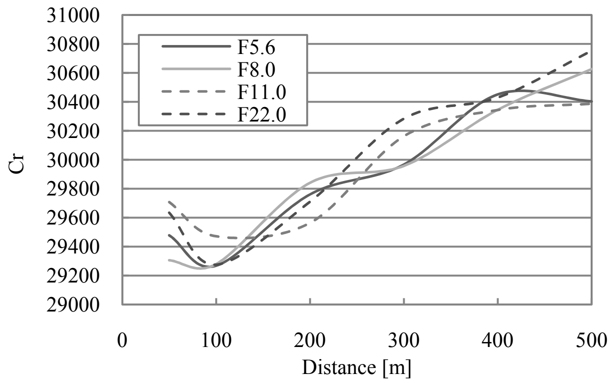
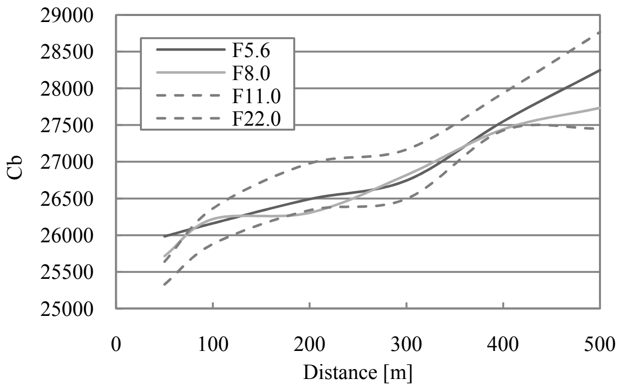


Fig. 5: Modified saturation variations in the modified HSV color system.



(a) Color difference of red vaiations.



(b) Color difference of blue vaiations.

Fig. 6: Color differences variations in the YCrCb color system.

4.4 Saturation variation from the original panel color in the Yxy color system

Utilizing the original panel color data measured with a brightness photometer, we calculated the original saturation and declining saturation proportion of the color panel. Figure 7 shows the results of this experiment. From this ,we determined that at a distance of 50 m from the camera, the saturation level equaled approximately 50% of original saturation level that the saturation level tended decrease linearly.

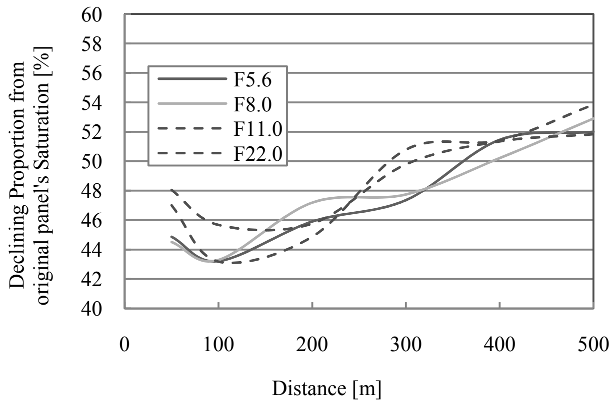


Fig. 7: Saturation variations from the original panel color in the Yxy color system.

5. DISCUSSION

Based on experimental results, we determined that the saturation level decreased in the HSV, modified HSV and Yxy color systems. These results closely match the depth perception of normal human eyes. Therefore, we determined that these color systems are suitable for use with a method that is based on aerial perspective. However, we also found that the Cr and Cb elements that represent the color difference of red and blue increased. This indicates that it would be difficult to adopt the YCrCb color system to our method because this color system shows different trends from the aerial perspective.

The modified HSV color system and Yxy color system showed linearly decreasing saturation levels. We found that the use of these color systems provide a simple method for determining the relationship between color variation and the distance to objects. However, in this experiment, we only used a green color panel, which is significant because the modified HSV color system and the Yxy color system have different expressible saturation ranges. That is the modified HSV color system has a uniform saturation range, while the Yxy color system has a non-uniform saturation range. Therefore, we will need to conduct further comparisons of these color systems using various colors and conduct further studies suitable to our method.

In general, we found the aerial perspective to be useful in recognizing the distance to objects at long range. However, our experimental results into saturation variations from original panel color using the Yxy color system also suggested that the aerial perspective could be useful at distances less that 50 m from the camera.

In these experiments, we took pictures using five different F-stop numbers to investigate the influence of depth of field on saturation level variations. From our experimental results, we determined there were no significant differences in results regardless of the F-stop number sets. This result indicates that our method was not influenced by depth of field.

6. CONCLUSION

In this paper, we proposed a method for recognizing and measuring distant objects that tend to be indistinct long range distance. In order to accomplish this, we adopted the use of aerial perspective, which is a type of depth perception, and investigated the detailed relationship between distance and color variations. We also investigate the color system most suitable for this method using a color panel.

From our experimental results, we determined that the saturation level decreased in the HSV, modified HSV and Yxy color systems. These results closely match the depth perception of normal human eyes. It was especially noteworthy that the modified HSV color system and Yxy color system showed linearly decreasing saturation levels.

In addition, we found that while use of the aerial perspective is generally useful in recognizing the distance to a long range objects, our experimental result also suggested that the aerial perspective could be useful at ranges less than 50 m from the camera.

In these experiments, we took photographs at five different F-stop settings. The results obtained indicated that our method was not influenced by depth of field changes.

In our future work, we intend to conduct investigations in various other shooting environments and show the applicability of this method by using various other color indexes.

This research has been partially supported by Grant-in-Aid for Scientific Research (No.19700202) from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

7. REFERENCES

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