Lesson 7 Image Processing---Color Space Conversion

1.Color Space Introduction

Each frame of the picture is arranged by the pixels that are composed of three color components, including B, G and R.

Color model is also called color space which is a mathematical model using an array to describe color.

Besides the familiar RGB picture, there are other color spaces, including GRAY, Lab, XYZ, YCrCb, HSV, HLS, CIEL*a*b*, CIEL*u*v*, Bayer, etc.

Expertise of each color space is different. Therefore, color space conversion can improve the efficiency of tackling a specific problem.

Color space conversion refers to transform the image from one color space to another color space. For example, convert the picture from RGB to Lab. When extracting the feature of the picture, and calculating the distance, we usually covert the picture from RGB into gray color space. In some applications, it is necessary to convert the color space image into binary image.

Some common color spaces are listed below.

2. Common Color Space

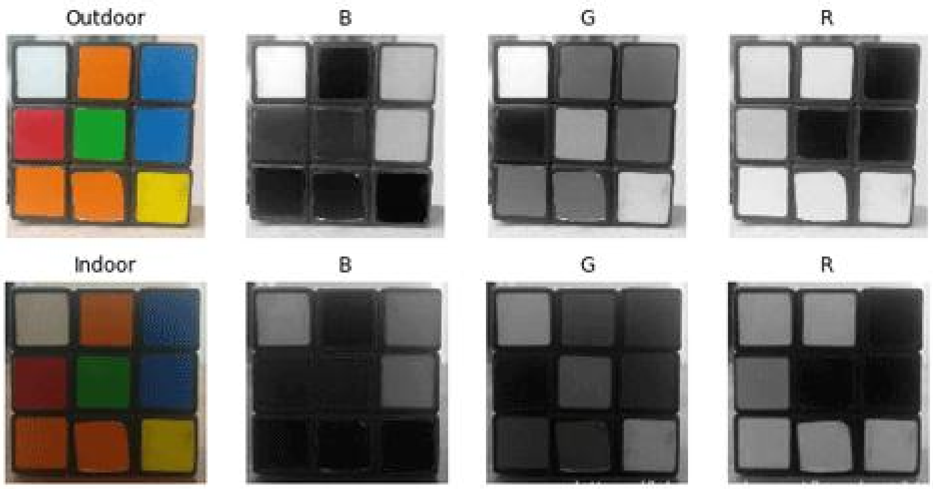
2.1 RGB Color Space

The properties of RGB color space are as follow.

1.An RGB color space is an additive color space and the colors are obtained from linear combination of R(red), G(Green) and B(Blue).

2.The illumination will affect the value of each color channel and these three color channels are related. For better understanding of color space, we can divide the image into R, G and B three components

From the blue channel picture in indoor, blue is similar to white. However, from the blue channel picture in outdoor, there is distinction between blue and white. And this nonuniformity makes color-based segmentation infeasible in color space. In addition, the value of these two pictures are also different. Therefore, there are flaws in RGB color space, including uneven color value and mixed chroma and luminance.



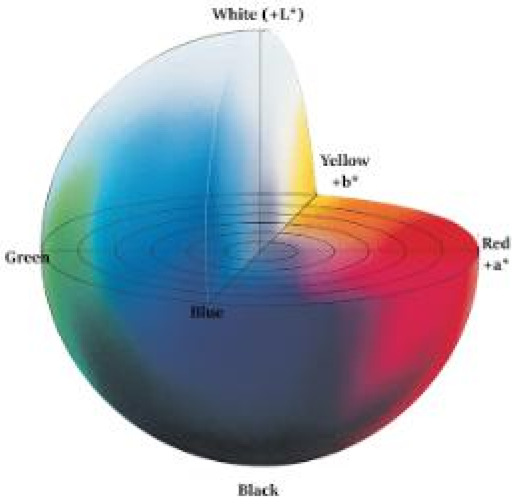
2.2 Lab Color Space

Similar to RGB, Lab also has three image channels.

L：Luminance channel

a：Color channel a representing colors from green to carmine.

b：Color channel b representing colors from blue to yellow.



Lab is totally different from RGB color space. In RGB, colors are divided into three channels and each channel contains luminance. While in Lab, colors are divided into L channel only containing luminance, a channel and b channel.

L component: represent the luminance of the pixel. The larger L value, the greater the luminance.

a component: represent the range from red to green.

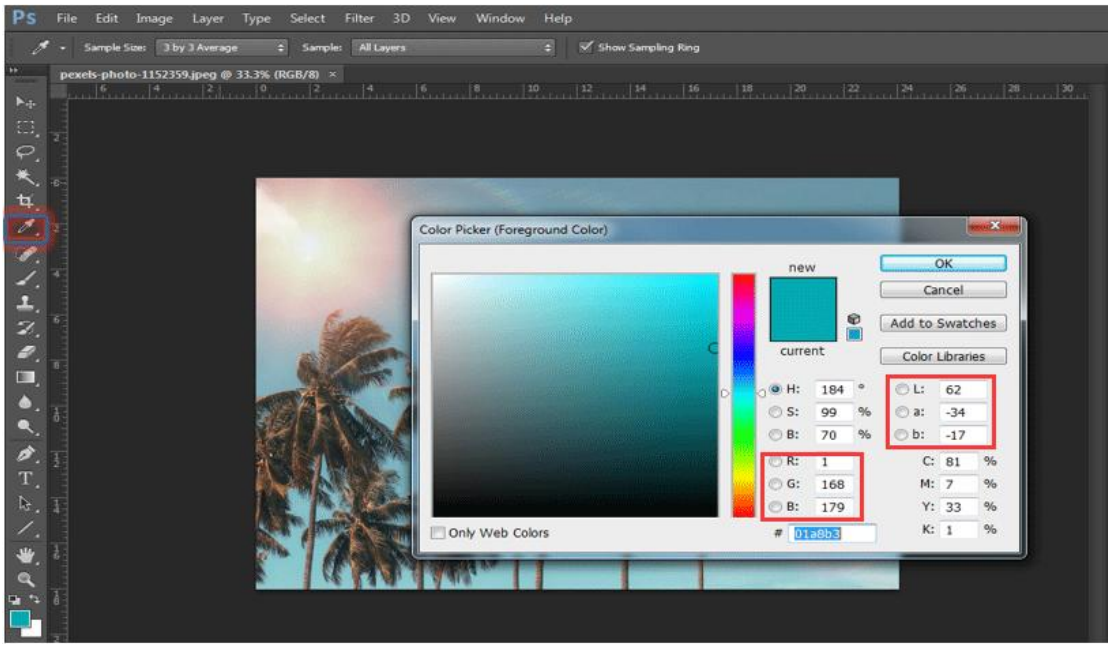
b component: represent the range from yellow to blue.

In OpenCV, R, G and B value in RGB color space all range from 0 to 255. In Lab color space, L ranges from 0 to 100. When L is 0, the color is black and when it is 100, the color is white. a and b values range from -128 to 127. When both a and b are 0, the color is gray.

To better assist in your understanding of the comparison between RGB and Lab, operate on PS.

1）Use eyedropper tool to get the color.

2）Click the color picker at bottom left corner, the correspondence between Lab and RGB is listed below.



Lab color space has these features:

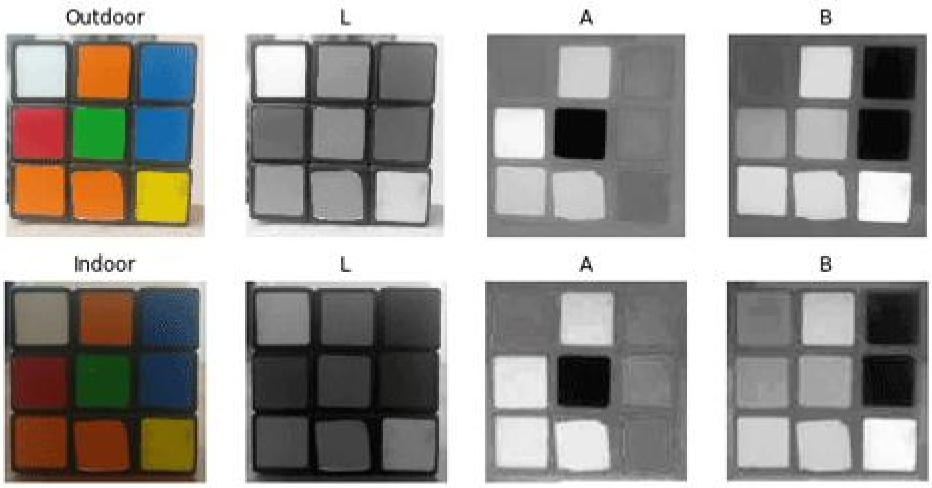
1. A perceptually uniform color space align with the way human perceive color.

2. Independent from device(capture or display)

3. Widely applied in Adobe Photoshop

4. It is related to the RGB color space through complex transformation equations

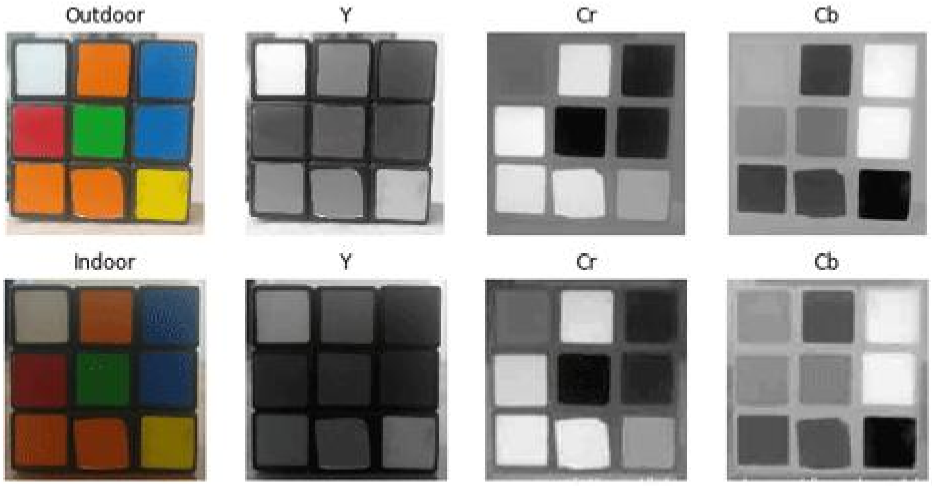
In OpenCV, the image converted into Lab color space is as follow.



2.3 Ycrcb Color Space

HVS (Human Visual System) is less sensitive to color than to luminance. In traditional RGB color space, three primary colors, RGB, bear the same importance, but luminance is overlooked.

In YCrCb color space, Y represents luminance, and Cr and Cb stand for chroma. Cr indicates red component and Cb indicates blue component. Luminance can reflect how bright or dark a color is, which can be calculated through a weighted sum of the light intensity. The green component has the greatest impact on RGB light while the blue component the least.

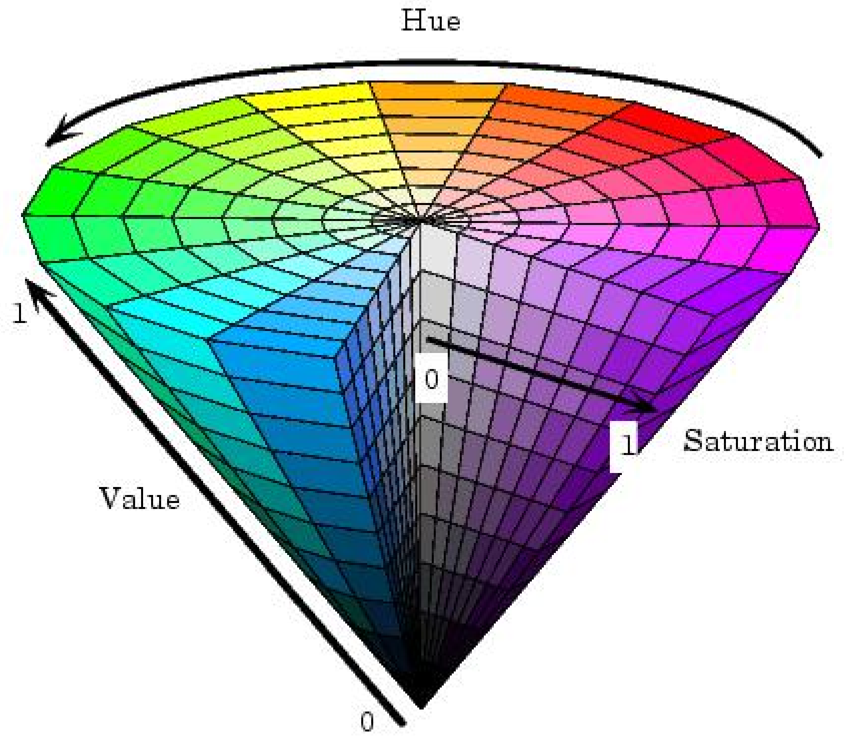


Observations focusing on intensity and color components can be made for LAB for illumination changes. Compared with LAB, the perception difference between red and orange in outdoor is smaller, while white between three components are distinguished.

2.4 HSV Color Space

HSV color space is vision perception oriented color model which is composed of these three components.

H (hue), S (saturation) and V (value)

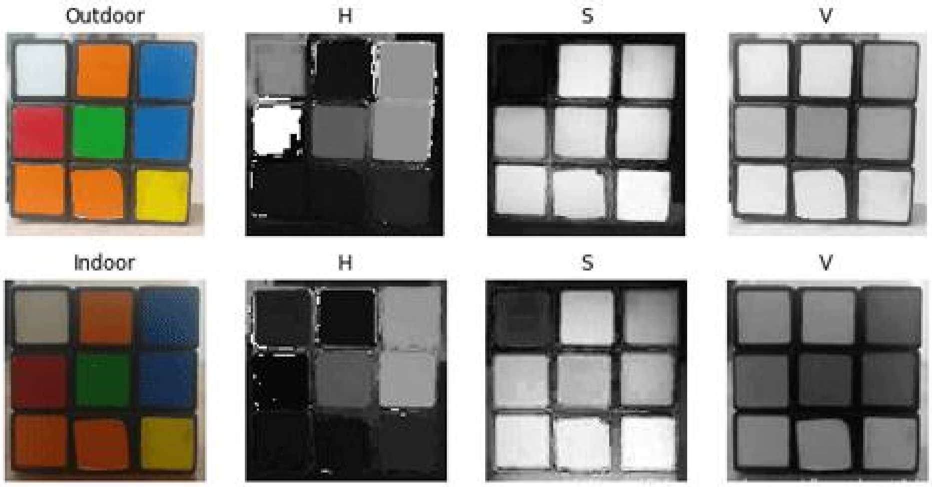


Hue: it is related to the dominant wavelength of light in the mixed spectrum, for example "red orange yellow green blue purple" represents different hues respectively. In the perspective of wavelength, light of different wavelength appear as different colors, i.e. different hues.

Saturation: describes the purity of a color or pertains to the amount of white light mixed with a hue. Pure spectrum is fully saturated, and dark red (red mixed with white) and light purple (purple mixed with white) is not saturated enough. Saturation is inversely proportional to the amount of white light mixed.

Brightness: it reflect the brightness perceived by human and it is relative to the reflection of the object. For a hue, the greater the amount of white mixed in a hue, the greater the value. And the greater the amount of black mixed in a hue, the weaker the brightness.

The most distinguished feature of HSV is that it only employs single channel to describe hue, which make it intuitive to designate a hue. But HSV colors rely on device.



H components in outdoor and indoor are similar, which indicates the color is complete even though the lighting changes.

S components in outdoor and indoor are also similar. V stands for brightness so that it will change as the lighting changes.

The difference of red value between indoor and outdoor is large for the reason that H component represent red by angle ranging from [300,360] and [0,60].

2.5 Gray Color Space

GRAY color space generally refers to grayscale image, monochromatic image, in which each pixel is processed into 256 gray level from black to white.

These 256 gray levels are represented by the number within [0,255]. “0” indicates pure black, and “255” represents white. Number from 0 to 255 denote dark gray or light gray of different brightness (shade of hue).

3.Color Conversion

The function below is used to transform color.

```
dst = cv2.cvtColor( src, code [, dstCn] )
```

dst represents the output image whose data type and depth are similar to the original input image. src refers to original input image.

code is the flag of color space conversion.

dstCn is the number of channel of the target picture, 0 by default.

Flag	Shorthand	Function
cv.COLOR_BGR2BGRA	0	Add alpha channel for RGB
cv.COLOR_BGR2RGB	4	change the order of color channels
cv.COLOR_BGR2GRAY	10	convert color picture into gray image
cv.COLOR_GRAY2BGR	8	convert the color picture into gray image
cv.COLOR_BGR2YUV	82	convert RGB color space into YUV color space
cv.COLOR_YUV2BGR	84	convert YUV color space into RGB color space
cv.COLOR_BGR2HSV	40	Convert RGB color space into HSV color space

cv.COLOR_HSV2BGR	54	Convert HSV color space into RGB color space
cv.COLOR_BGR2Lab	44	Convert RGB color space into Lab color space
cv.COLOR_Lab2BGR	56	Convert Lab color space into RGB color space

Take cv2.cvtColor(frame, cv2.COLOR_RGB2LAB) for example.

"frame" is the picture to be processed. "cv2.COLOR_RGB2LAB" is the designated conversion model, referring to convert the picture from RGB color space into LAB color space.

Follow the following steps to transform the pictures into some common color spaces.

3.1 Operation Steps

Before operation, please move to "**4. OpenCV Computer Vision Lesson->Lesson 7 Image Processing---Color Space Conversion->Sample Code**", and copy the sample routine "**color_conversion.py**" and picture "img1.jpg" into the shared folder

For how to configure the shared folder, please refer to the file in "**2. Linux Basic Lesson->Lesson 3 Linux Installation and Source Replacement**".

Note: the input command should be case sensitive and the keywords

can be complemented by “Tab” key.

1） Open virtual machine and start the system. Click “”, and then “” or press “**Ctrl+Alt+T**” to open command line terminal.

2） Input command “**cd /mnt/hgfs/Share/Image**” and press Enter to enter the shared folder.

3） Input command “**python3 color_conversion.py**” and press Enter to run the code.

3.2 Program Outcome

After execution, the final processed result is as follow.

3.3 Program Analysis

1) Firstly, import the required module with import statement.

```
import numpy as np
import cv2 as cv
```

2) Call imread() function in cv2 module to read the image to be processed.

```
src = cv2.imread("img1.jpg")
```

3) Next, set the size of the inserted picture. And in the bracket is the name of the picture.

```
src = cv2.resize(src, (int(src.shape[1] / 2), int(src.shape[0] / 2)))
```

4) Create four functions in sequence to convert the image into Gray, Lab, Ycrcb amd HSV respectively.

```
GRAY = cv2.cvtColor(src, cv2.COLOR_BGR2GRAY)
Lab = cv2.cvtColor(src, cv2.COLOR_BGR2LAB)
YCrCb = cv2.cvtColor(src, cv2.COLOR_BGR2YCrCb)
HSV = cv2.cvtColor(src, cv2.COLOR_BGR2HSV)
```

5) Display the image before and after conversion respectively.

```
cv2.imshow("src", src)
cv2.imshow("GRAY", GRAY)
cv2.imshow("Lab", Lab)
cv2.imshow("YCrCb", YCrCb)
cv2.imshow("HSV", HSV)
```

6) Lastly, close the window through the function.

```
cv2.waitKey(0)
cv2.destroyAllWindows()
```

cv2.waitKey() is a keyboard binding function. Its time unit is milliseconds (ms). The function will wait n ms set in bracket to check if there is any keyboard input. If there is, the ASCII value of the key is returned. -1 will be returned if there is no keyboard input. Generally we set it to 0, the function will wait for keyboard input endlessly.

cv2.destroyAllWindows() is used to delete the window. If there is no parameter in the bracket, all the windows will be deleted. If you input the specific value of the window, the designated window will be removed.