背景:

使用 RGB, HSI, and L*a*b* color spaces.，三種 color spaces 進行 enhancement，在此作法中，因為不能直接呼叫 function，所以我們主要實作的方向為將圖片:

(1) 將圖片的 RGB 直接 enhancement

(2) 將 RGB 轉為 H S I， 對 H S I 做 enhancement，之後把 HSI 變為 RGB。

(3) 將 RGB 變成 XYZ，將 XYZ 變 L*a*b*，對 L*a*b*做 enhancement，之後把 L*a*b*變成 XYZ，再把 XYZ 變為 RGB

依據不同方法總共會有 16 張圖片，包含原圖、RGB 強化、HSI 強化、L*a*b*強化，各四張。

其中 RGB 的 enhancement，我選擇把 R 的部分變為原本的 2 倍、HIS 作法中，我把 S=S+5、LAB 中將 a 變為原本 5 倍，依據不同的的 **enhancement**，我們結果的圖片的顏色會有所不同，在格式各樣的轉換過程中，利用數學的各項規定來進行轉換，後續我會說明各種轉換的方法。

轉換的數學定應與其對應程式碼:

HSI；H、S、I 三參數描述顏色特性，其中 H 定義顏色的頻率，稱為色調；S 表示顏色的深淺程度，稱為飽和度；I 表示強度或亮度

RGB 通過下列方式轉成 HSI

$$H = \begin{cases} \theta & \text{if } B \le G \\ 2\pi - \theta & \text{if } B > G \end{cases}$$

(Krzisnik, 2021)

$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{1/2}} \right\}$$

(Krzisnik, 2021)

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

(Krzisnik, 2021)

$$I = \frac{1}{3}(R+G+B)$$

(Krzisnik, 2021)

```
def RGBtoHSI(rgb):
    r = rgb.R / 255.0
    g = rgb.G / 255.0
    b = rgb.B / 255.0
    denominator = math.sqrt((r - g) * (r - g) + (r - b) * (g - b))
    if denominator == 0:

        theta = 0
    else:
        theta = math.acos(0.5 * ((r - g) + (r - b)) / denominator)
    hsi = HSI()
    hsi.H = theta if b <= g else (2 * math.pi - theta)

    denominator = r + g + b
    if denominator == 0:
        hsi.S = 0
    else:
        hsi.S = 1 - 3 * min(min(r, g), b) / denominator
    hsi.I = (r + g + b) / 3
    return hsi
```

HSI 通過下列方式轉成 RGB

0 and 120 degrees

$$B = I(1 - S)$$

$$R = I\left[1 + \frac{S\cos H}{\cos(60° - H)}\right]$$

$$G = 3I - (R + B)$$

(Krzisnik, 2021)

```
if 0 <= h < 2 * math.pi / 3:
    b = i * (1 - s)
    r = i * (1 + s * math.cos(h) / math.cos(math.pi / 3 - h))
    g = 3 * i - (r + b)
```

120 and 240 degrees

$$R = I(1 - S)$$

$$G = I\left[1 + \frac{S\cos H}{\cos(60° - H)}\right]$$

$$B = 3I - (R + G)$$

(Krzisnik, 2021)

```
elif 2 * math.pi / 3 <= h < 4 * math.pi / 3:
    r = i * (1 - s)
    g = i * (1 + s * math.cos(h - 2 * math.pi / 3) / math.cos(math.pi - h))
    b = 3 * i - (r + g)
```

240 and 360 degrees

$$G = I(1 - S)$$

$$B = I\left[1 + \frac{S\cos H}{\cos(60° - H)}\right]$$

$$R = 3I - (G + B)$$

(Krzisnik, 2021)

```
else:
    g = i * (1 - s)
    b = i * (1 + s * math.cos(h - 4 * math.pi / 3) / math.cos(5 * math.pi / 3 - h))
    r = 3 * i - (g + b)
```

L*a*b*：L*代表感知的亮度、a*和 b*代表人類視覺的四種獨特顏色。

RGB 通過下列方式轉成 L*a*b*

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.412453 & 0.357580 & 0.180423 \\ 0.212671 & 0.715160 & 0.072169 \\ 0.019334 & 0.119193 & 0.950227 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

(Work, 2012)

```
def RGBtoXYZ(rgb):
    RR = gamma(rgb.R / 255.0)
    GG = gamma(rgb.G / 255.0)
    BB = gamma(rgb.B / 255.0)
    xyz = XYZ()
    xyz.X = 0.4124564 * RR + 0.3575761 * GG + 0.1804375 * BB
    xyz.Y = 0.2126729 * RR + 0.7151522 * GG + 0.0721750 * BB
    xyz.Z = 0.0193339 * RR + 0.1191920 * GG + 0.9503041 * BB
    return xyz
```

$$L^* = \begin{cases} 116 \times \left(\frac{Y}{Yn}\right)^{\frac{1}{3}} - 16, & \frac{Y}{Yn} > 0.008856 \\ 903.3 \times \frac{Y}{Yn}, & \text{otherwise} \end{cases}$$

$$a^* = 500 \times \left(f\left(\frac{X}{Xn}\right) - f\left(\frac{Y}{Yn}\right) \right)$$

$$b^* = 200 \times \left(f\left(\frac{Y}{Yn}\right) - f\left(\frac{Z}{Zn}\right) \right)$$

(Work, 2012)

where

$$Xn = 0.9515$$

$$Yn = 1.0000$$

$$Zn = 1.0886$$

$$f(t) = \begin{cases} t^{\frac{1}{3}}, & t > 0.008856 \\ 7.787 \times t + \frac{16}{116}, & \text{otherwise} \end{cases}$$

(Work, 2012)

```
def XYZtoLAB(xyz):
    x = xyz.X / 95.047
    y = xyz.Y / 100.000
    z = xyz.Z / 108.883

    x = x ** (1 / 3) if x > 0.008856 else (903.3 * x + 16) / 116
    y = y ** (1 / 3) if y > 0.008856 else (903.3 * y + 16) / 116
    z = z ** (1 / 3) if z > 0.008856 else (903.3 * z + 16) / 116

    lab = LAB()
    lab.L = 116 * y - 16
    lab.A = 500 * (x - y)
    lab.B = 200 * (y - z)
```

L*a*b*通過下列方式轉成 RGB

$$f_y = \frac{L^* + 16}{116}$$

$$f_x = f_y + \frac{a^*}{500}$$

$$f_z = f_y - \frac{b^*}{200}$$

(Work, 2012)

$$\text{if} \quad f_y > 0.008856 \quad \text{then} \quad Y = Yn \times f_y^{\,3}$$

$$\text{else} \quad Y = \left(\frac{f_y - 16}{116}\right) \times 3 \times 0.008865^2 \times Yn$$

$$\text{if} \quad f_x > 0.008856 \quad \text{then} \quad X = Xn \times f_x^{\,3}$$

$$\text{else} \quad X = \left(\frac{f_x - 16}{116}\right) \times 3 \times 0.008865^2 \times Xn$$

$$\text{if} \quad f_z > 0.008856 \quad \text{then} \quad Z = Zn \times f_z^{\,3}$$

$$\text{else} \quad Z = \left(\frac{f_z - 16}{116}\right) \times 3 \times 0.008865^2 \times Zn$$

(Work, 2012)

```
y = (lab.L + 16) / 116
x = lab.A / 500 + y
z = y - lab.B / 200

x = x ** 3 if x ** 3 > 0.008856 else (x - 16 / 116) / 7.787
y = y ** 3 if y ** 3 > 0.008856 else (y - 16 / 116) / 7.787
z = z ** 3 if z ** 3 > 0.008856 else (z - 16 / 116) / 7.787

xyz = XYZ()
xyz.X = 95.047 * x
xyz.Y = 100.000 * y
xvz.Z = 108.883 * z
```

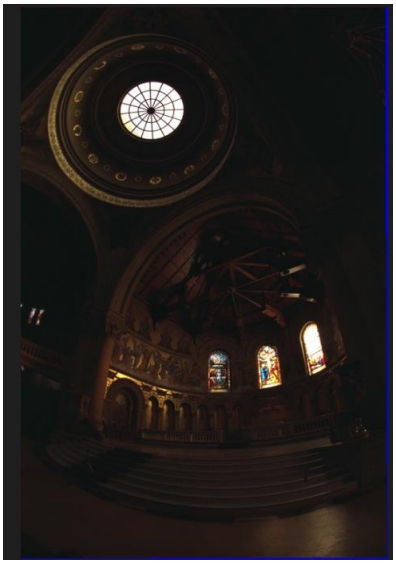
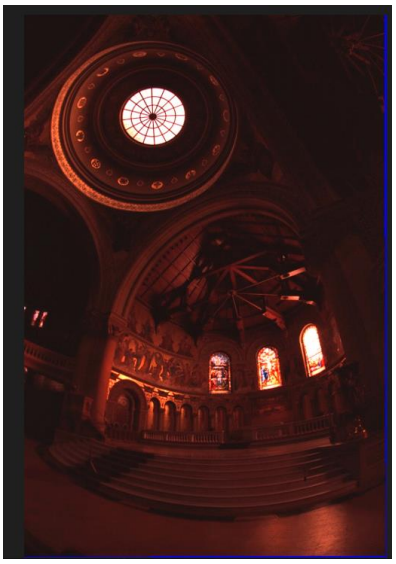
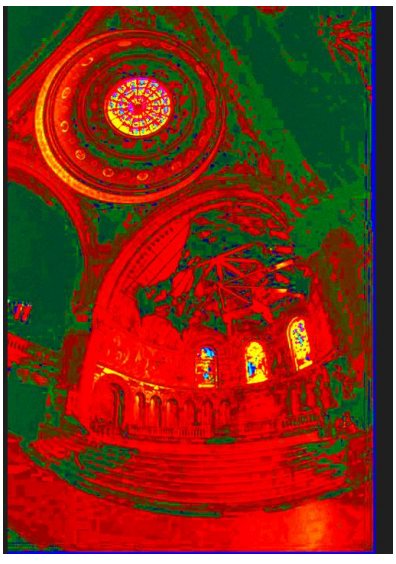
$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 3.240479 & -1.537150 & -0.498535 \\ -0.969256 & 1.875992 & 0.041556 \\ 0.055648 & -0.204043 & 1.057311 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$ (Work, 2012)

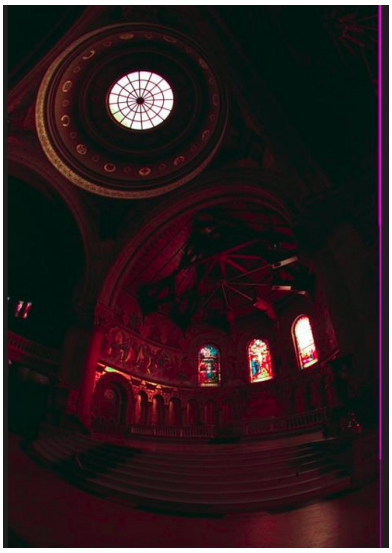
```
r = 3.2404542 * x - 1.5371385 * y - 0.4985314 * z
g = -0.9692660 * x + 1.8760108 * y + 0.0415560 * z
b = 0.0556434 * x - 0.2040259 * y + 1.0572252 * z

r = 1.055 * (r ** (1 / 2.4)) - 0.055 if r > 0.0031308 else 12.92 * r
g = 1.055 * (g ** (1 / 2.4)) - 0.055 if g > 0.0031308 else 12.92 * g
b = 1.055 * (b ** (1 / 2.4)) - 0.055 if b > 0.0031308 else 12.92 * b

rgb = RGB(int(r * 255), int(g * 255), int(b * 255))
return rgb
```

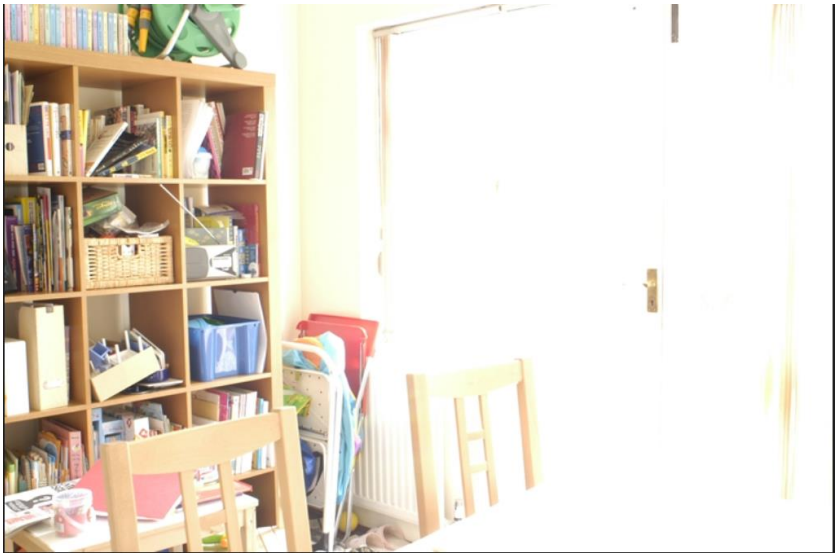
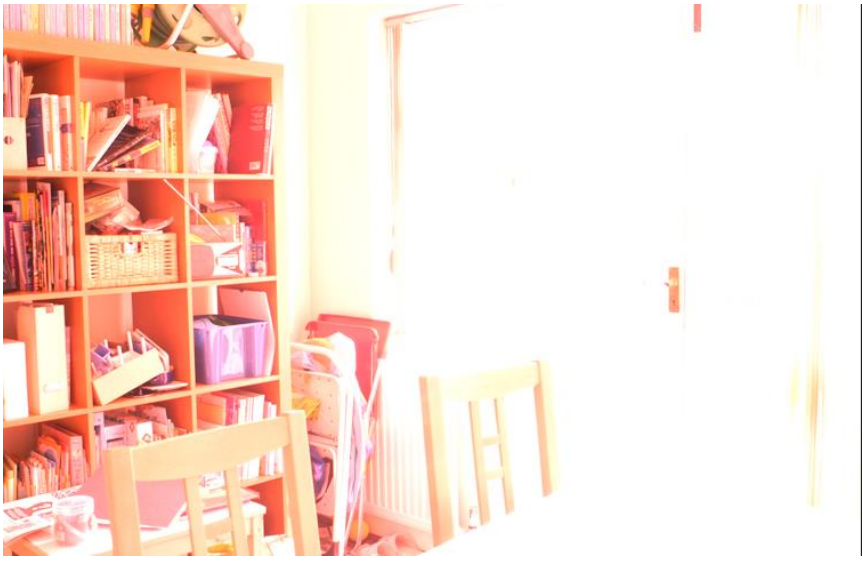
實驗結果:

Aloe 原圖:	
RGB enhancement (R 變 2 倍)	

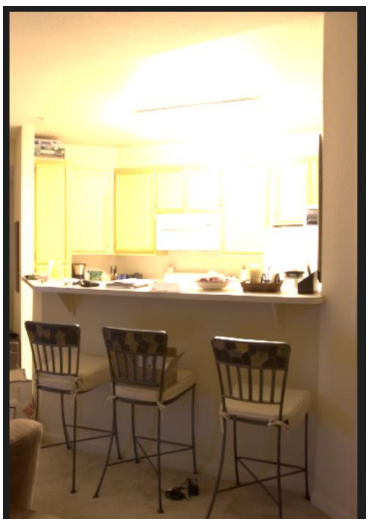
HSI enhancement (s+5)	
L*a*b Enhancement (a 變 5 倍)	

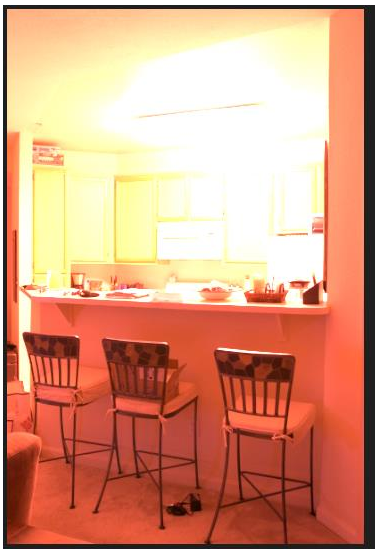
church 原圖:	
RGB enhancement (R 變 2 倍)	
HSI enhancement (s+5)	

L*a*b Enhancement (a 變 5 倍)	

house 原圖:	
RGB enhancement (R 變 2 倍)	

HSI enhancement (s+5)	
L*a*b Enhancement (a 變 5 倍)	

kitchen 原圖:	

RGB enhancement (R 變 2 倍)	
HSI enhancement (s+5)	
L*a*b Enhancement (a 變 5 倍)