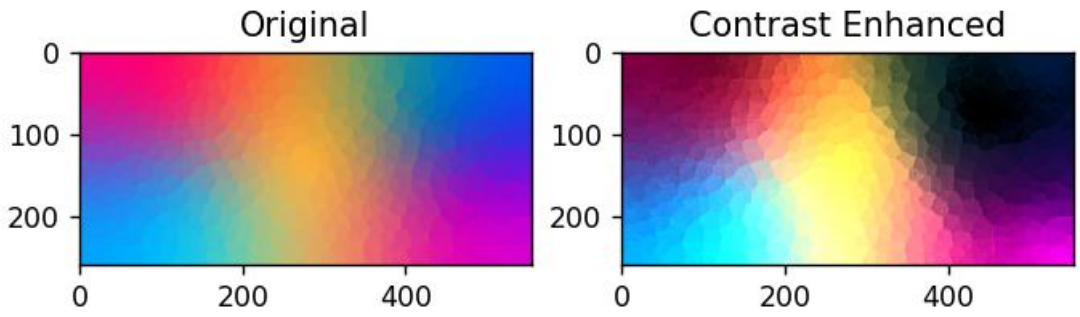
Comment

這次作業是第一次實作 RGB 跟 HSI 之間的轉換，過程中比較有挑戰的是理解 HSI 的公式，尤其是 H 的計算邏輯。用直方圖均衡化處理 I（亮度）通道後，能明顯看出影像對比變得更清楚，而且不會影響原本的色彩，覺得這種分離亮度處理的方式蠻實用的。整體流程從讀圖、轉換、增強到顯示都滿有成就感，也讓我更熟悉色彩空間的概念。

Photo



Program

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import cv2

import numpy as np

import matplotlib.pyplot as plt

from skimage import exposure


# Step 1: 讀取 RGB 圖片

img_rgb = cv2.imread('colorful.jpg')  # BGR

img_rgb = cv2.cvtColor(img_rgb, cv2.COLOR_BGR2RGB)


# Step 2: 歸一化
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rgb = img_rgb.astype(np.float32) / 255.0


# Step 3: RGB to HSI
def rgb_to_hsi(rgb):
    r, g, b = rgb[..., 0], rgb[..., 1], rgb[..., 2]
    num = 0.5 * ((r - g) + (r - b))
    den = np.sqrt((r - g)**2 + (r - b)*(g - b)) + 1e-6
    theta = np.arccos(num / den)
    H = np.where(b <= g, theta, 2*np.pi - theta)
    H = H / (2*np.pi)

    min_rgb = np.minimum(np.minimum(r, g), b)
    S = 1 - 3 * min_rgb / (r + g + b + 1e-6)
    I = (r + g + b) / 3

    HSI = np.stack([H, S, I], axis=-1)
    return HSI

hsi = rgb_to_hsi(rgb)

# Step 4: Histogram Equalization on I channel
h, s, i = hsi[..., 0], hsi[..., 1], hsi[..., 2]
i_eq = exposure.equalize_hist(i)
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# Step 5: HSI to RGB
def hsi_to_rgb(hsi):
    H, S, I = hsi[..., 0]*2*np.pi, hsi[..., 1], hsi[..., 2]
    R = np.zeros_like(H)
    G = np.zeros_like(H)
    B = np.zeros_like(H)

    # Sector 0 to 2π/3
    mask1 = (H >= 0) & (H < 2*np.pi/3)
    B[mask1] = I[mask1] * (1 - S[mask1])
    R[mask1] = I[mask1] * (1 + S[mask1] * np.cos(H[mask1]) / np.cos(np.pi/3 - H[mask1]))
    G[mask1] = 3*I[mask1] - (R[mask1] + B[mask1])

    # Sector 2π/3 to 4π/3
    mask2 = (H >= 2*np.pi/3) & (H < 4*np.pi/3)
    H2 = H[mask2] - 2*np.pi/3
    R[mask2] = I[mask2] * (1 - S[mask2])
    G[mask2] = I[mask2] * (1 + S[mask2] * np.cos(H2) / np.cos(np.pi/3 - H2))
    B[mask2] = 3*I[mask2] - (R[mask2] + G[mask2])

    # Sector 4π/3 to 2π
    mask3 = (H >= 4*np.pi/3)
    H3 = H[mask3] - 4*np.pi/3
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    G[mask3] = I[mask3] * (1 - S[mask3])
    B[mask3] = I[mask3] * (1 + S[mask3] * np.cos(H3) / np.cos(np.pi/3 - H3))
    R[mask3] = 3*I[mask3] - (G[mask3] + B[mask3])

    rgb_out = np.stack([R, G, B], axis=-1)
    return np.clip(rgb_out, 0, 1)

hsi_eq = np.stack([h, s, i_eq], axis=-1)
rgb_eq = hsi_to_rgb(hsi_eq)

# Step 6: 轉換成 [0,255] 並輸出
rgb_out = (rgb_eq * 255).astype(np.uint8)
cv2.imwrite('output.jpg', cv2.cvtColor(rgb_out, cv2.COLOR_RGB2BGR))

# Step 7: 顯示前後影像
plt.subplot(1, 2, 1)
plt.title("Original")
plt.imshow(img_rgb)

plt.subplot(1, 2, 2)
plt.title("Contrast Enhanced")
plt.imshow(rgb_out)
plt.show()
```