<u>DIP Project Report</u>

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Project title : Transforming and Visualizing images in RGB and HSI Color Spaces.

Input :

The user will give an input color image on which the actions will be performed.

Sample image :

Features :

As our project title suggests, our project involves taking the RGB values of the image and converting them to equivalent HSI values using the formulae learnt in class and performing operations on them.

We hosted everything on a site locally using streamlit.

The features available in our site are as follows:

- Separating the RGB color values and displaying the individual Red, Green and Blue images separately.
- *Converting the RGB values to HSI values by using the following formulae :*

  Hue:
  - If the blue component (B) is less than or equal to the green component (G), then H = arccos(0.5 * ((R - G) + (R - B)) / sqrt((R - G)^2 + (R - B) * (G - B))).
  - If the blue component (B) is greater than the green component (G), then H = 360 - arccos(0.5 * ((R - G) + (R - B)) / sqrt((R - G)^2 + (R - B) * (G - B))).

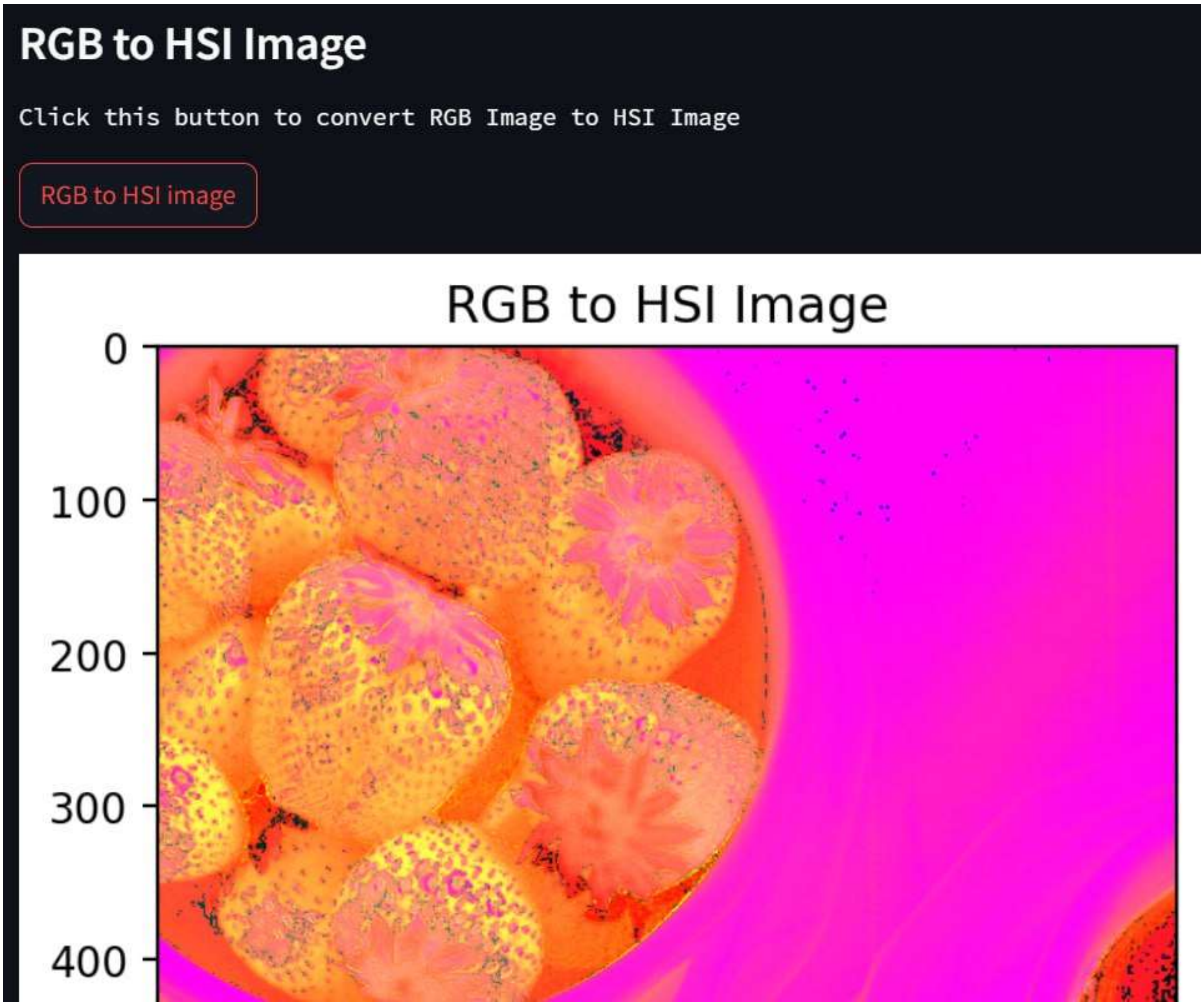
  Saturation:
  - If the maximum of the RGB components is 0, then S = 0.Otherwise, S = 1 - (3 * min(R, G, B)) / (R + G + B).

  Intensity:
  - *I = (R + G + B) / 3.*
- Displaying the HSI image
- Displaying the individual Hue, Saturation and Intensity as grayscale images separately.
- Then based on the user given values adjust the H, S and I values.

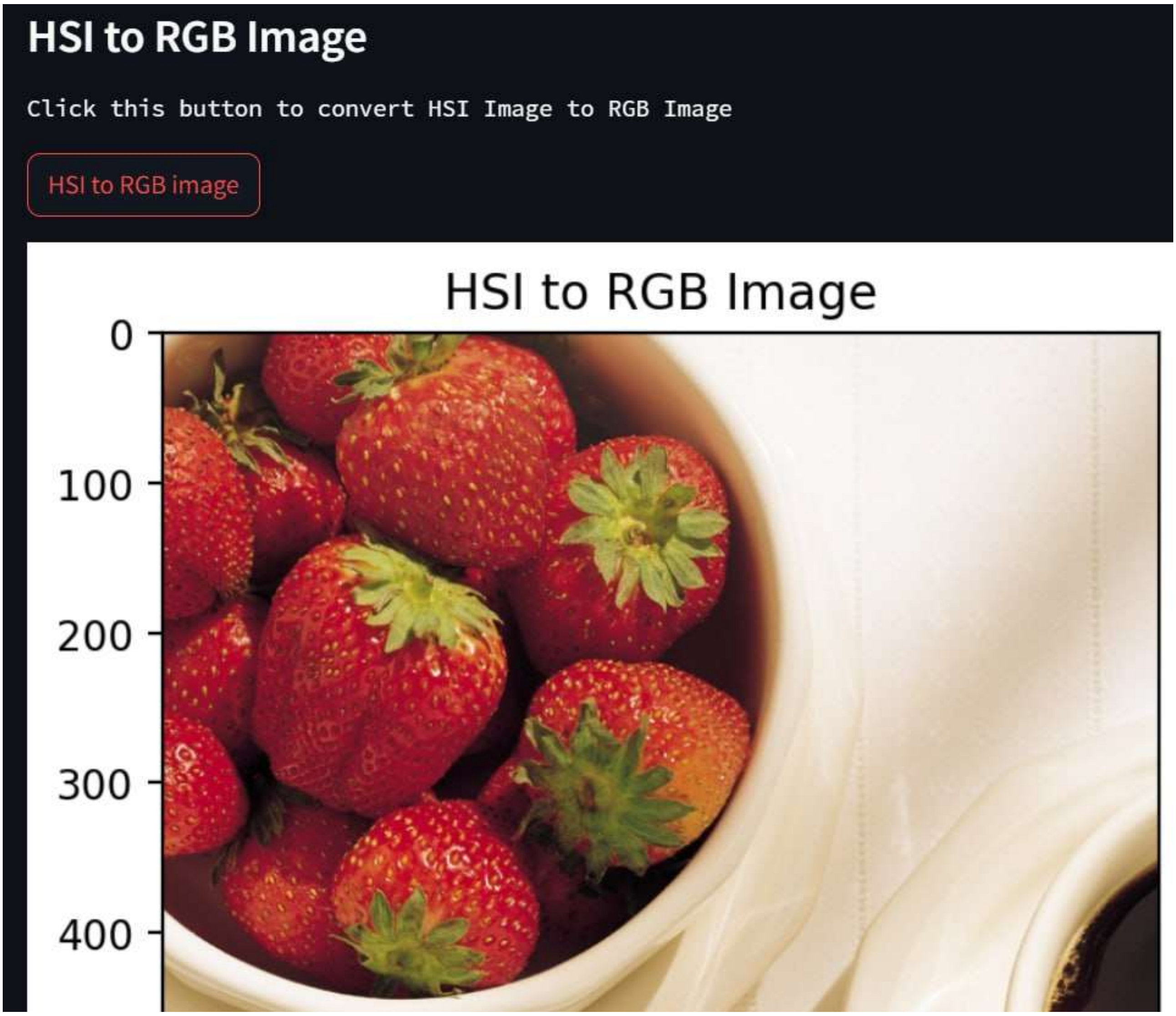
- Now convert the image from HSI color space back to RGB color space and display the color image.
- We apply histogram equalisation to the RGB and HSI images and display the output images.

Output :

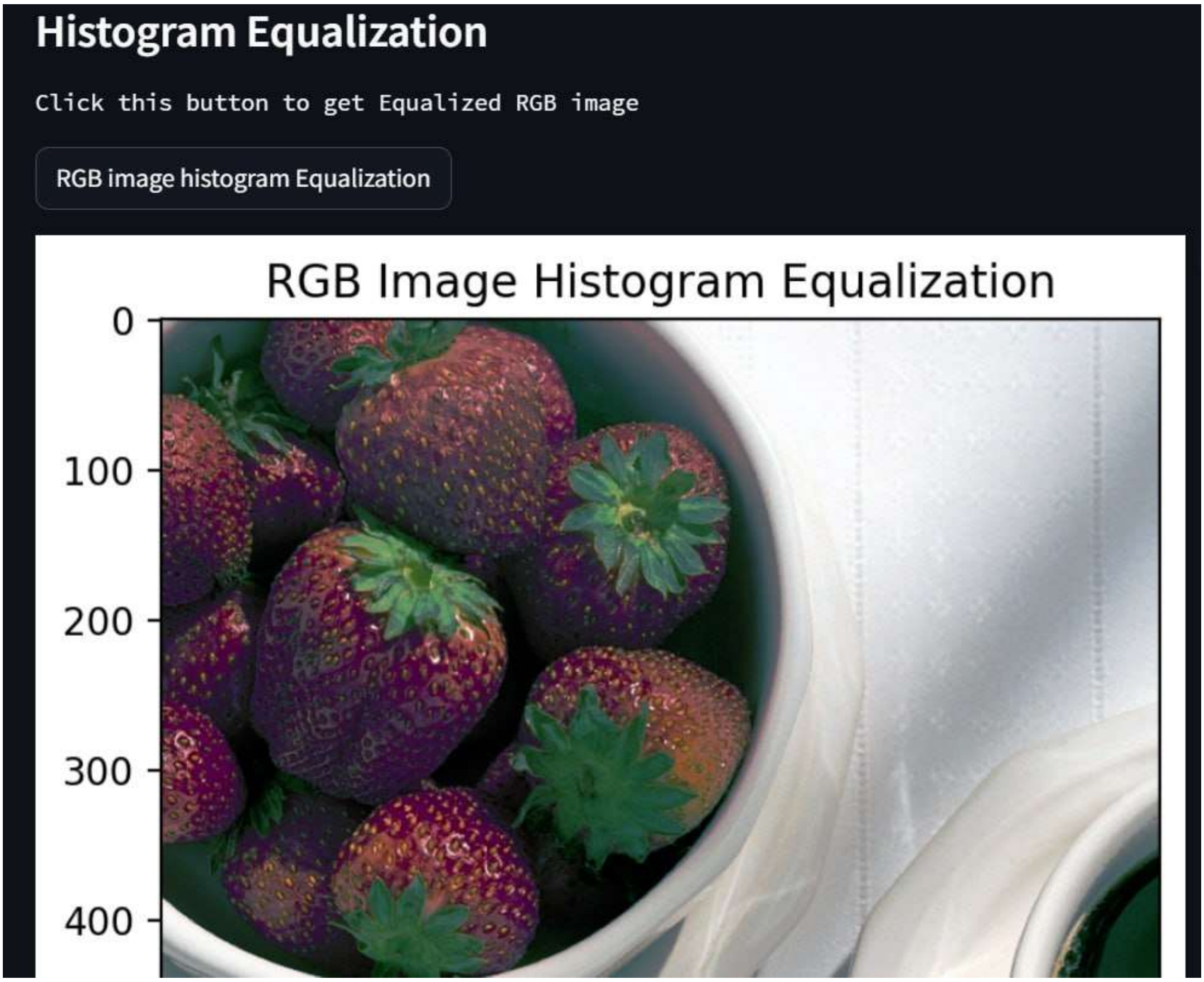
The final RGB image after all the processing, Separate R, G, B, H, S and I images, histogram equalised images.



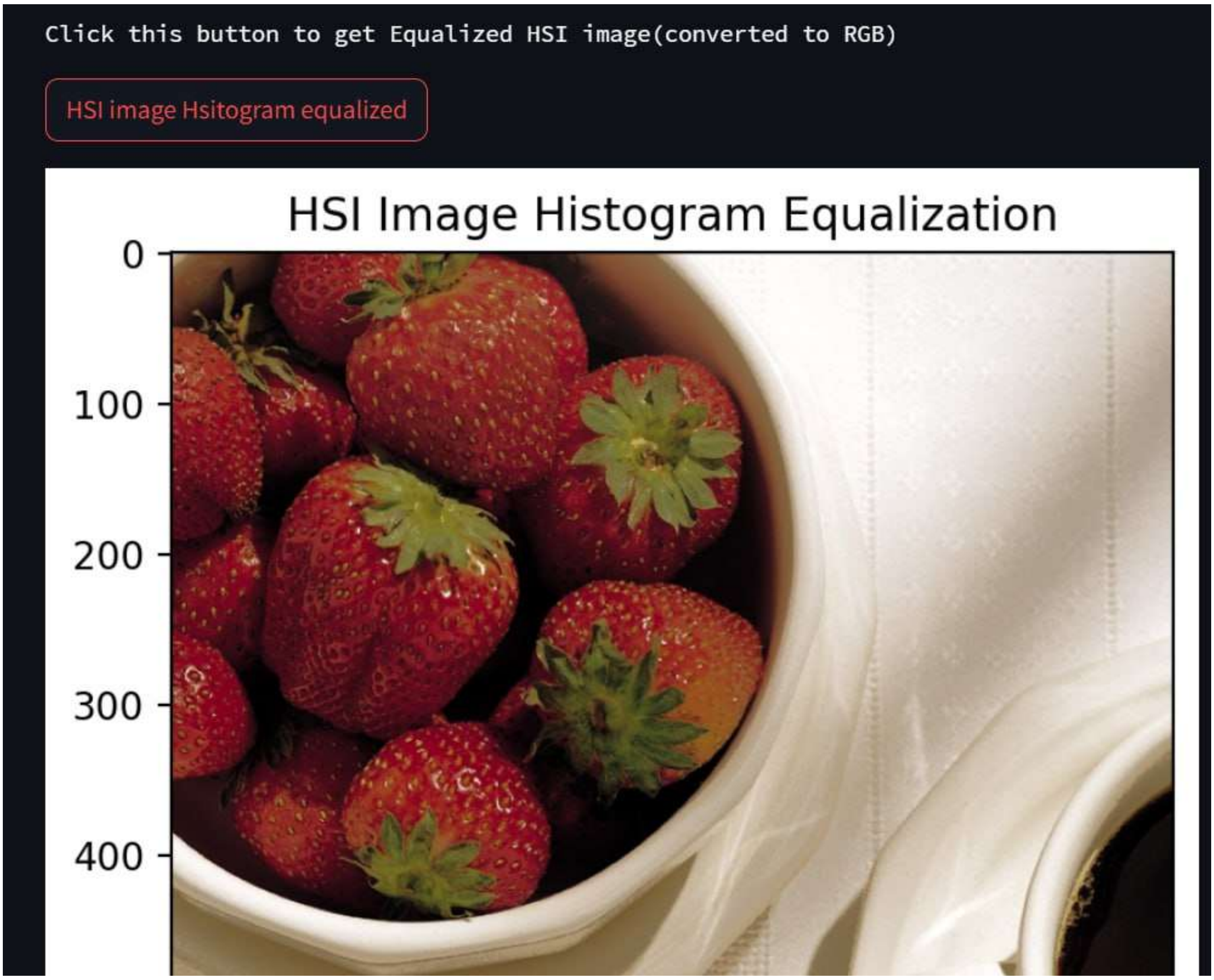
RGB to HSI


HSI to RGB Image
Click this button to convert HSI Image to RGB Image
HSI to RGB image
HSI to RGB Image
0
100
200
300
400

HSI to RGB



RGB image after Histogram equalization



HSI image after Histogram equalization

Code :

```
### Import necessary libraries
import cv2
import numpy as np
import matplotlib.pyplot as plt
img = "image.jpg"  # Change the filename and path according to your need
rgbimg = cv2.cvtColor(cv2.imread(img,cv2.IMREAD_COLOR), cv2.COLOR_BGR2RGB)
plt.imshow(rgbimg)
import cv2
import numpy as np

def recognize_color_object(image, color_lower, color_upper):
    if image is None:
        print("Error: Unable to load the image.")
        return []

    # Convert the image from BGR to HSI color space
    hsi_image = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)

    # Create a mask based on the color bounds
    mask = cv2.inRange(hsi_image, color_lower, color_upper)
```

```
    # Find contours in the masked image
    contours, _ = cv2.findContours(mask, cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)

    # Recognize objects of the specified color
    recognized_objects = []
    for contour in contours:
        area = cv2.contourArea(contour)
        if area > 100:  # Adjust the minimum area threshold as needed
            x, y, w, h = cv2.boundingRect(contour)
            object_info = {
                'x': x,
                'y': y,
                'width': w,
                'height': h,
                'area': area
            }
            recognized_objects.append(object_info)

    return recognized_objects

# Read the input image
image = cv2.imread('Photo.jpg')

# Check if the image is loaded successfully
if image is None:
    print("Error: Unable to load the image.")
else:
    # Define the lower and upper bounds for the color you want to recognize (in HSV)
    blue_lower = np.array([90, 50, 50])  # Lower bound for blue color
    blue_upper = np.array([130, 255, 255])  # Upper bound for blue color

    # Recognize objects of the specified color
    blue_objects = recognize_color_object(image, blue_lower, blue_upper)

    # Draw bounding boxes around recognized blue objects
    for obj in blue_objects:
        x, y, w, h = obj['x'], obj['y'], obj['width'], obj['height']
        cv2.rectangle(image, (x, y), (x+w, y+h), (0, 255, 0), 2)

    # Display the result
    cv2.imshow('Color Object Recognition', image)
    cv2.waitKey(0)
    cv2.destroyAllWindows()

### Part 1: RGB2HSI Conversion and vice versa
def rgb2hsi(rgbimg):
    # Convert rgb images to hsi images
    # Hint: Normalize Hue value to [0,255] for demonstration purpose.
    rows, cols = rgbimg[:,:,0].shape  # We expect that for each channel image dims are same
    print(rows,cols)
    s = np.zeros((rows, cols), dtype=np.float32)  # Initialize s
```

```
    i = np.zeros((rows, cols), dtype=np.float32)  # Initialize i
    red = rgbimg[:,:,0]/255  # Normalize to 0-1
    green = rgbimg[:,:,1]/255
    blue = rgbimg[:,:,2]/255
    h = []
    for r in range(rows):
        for c in range(cols):
            RG = red[r,c]-green[r,c]+0.001  # Red-Green, add a constant to prevent undefined value
            RB = red[r,c]-blue[r,c]+0.001  # Red-Blue
            GB = green[r,c]-blue[r,c]+0.001  # Green-Blue
            theta = np.arccos(np.clip(((0.5*(RG+RB))/(RG**2+RB*GB)**0.5), -1, 1))  # Still in radians
            theta = np.degrees(theta)  # Convert to degrees
            if blue[r,c] <= green[r,c]:
                h.append(theta)
            else:
                h.append(360 - theta)
    # Hue range will be automatically scaled to 0-255 by matplotlib for display
    # We will need to convert manually to range of 0-360 in hsi2rgb function
    h = np.array(h, dtype=np.int64).reshape(rows, cols)  # Convert Hue to NumPy array
    h = ((h - h.min()) * (1/(h.max() - h.min()) * 360))  # Scale h to 0-360
    minRGB = np.minimum(np.minimum(red, green), blue)
    s = 1-((3/(red+green+blue+0.001))*minRGB)  # Add 0.001 to prevent divide by zero
    i = (red+green+blue)/3  # Intensity: 0-1
    return h, s, i

def hsi2rgb(hsiimg):
    # Convert hsi images to rgb images
    rows, cols = hsiimg[:,:,0].shape  # We expect that for each channel image dims are same
    h = hsiimg[:,:,0]  # 0-360
    h = ((h - h.min()) * (1/(h.max() - h.min()) * 360))  # Scale h to 0-360
    s = hsiimg[:,:,1]  # 0-1
    i = hsiimg[:,:,2]  # 0-1
    rd, gr, bl = [], [], []  # Initialize r, g, and b as empty array
    for r in range(rows):
        for c in range(cols):
            if (h[r,c] >= 0 and h[r,c] <= 120):
                red = (1+((s[r, c]*np.cos(np.radians(h[r, c])))/np.cos(np.radians(60-h[r, c]))))/3
                blue = (1-s[r, c])/3
                rd.append(red)
                gr.append(1-(red+blue))
                bl.append(blue)
            elif (h[r,c] > 120 and h[r,c] <= 240):
                h[r, c] = h[r, c]-120
                red = (1-s[r, c])/3
                green = (1+((s[r, c]*np.cos(np.radians(h[r, c])))/np.cos(np.radians(60-h[r, c]))))/3
                rd.append(red)
                gr.append(green)
                bl.append(1-(red+green))
            elif (h[r,c] > 240 and h[r,c] <= 360):
                h[r, c] = h[r, c]-240
                green = (1-s[r, c])/3
```

```
            blue = (1+((s[r, c]*np.cos(np.radians(h[r, c])))/np.cos(np.radians(60-h[r, c])))))/3
            rd.append(1-(green+blue))
            gr.append(green)
            bl.append(blue)
    rd = np.multiply(rd, 3*i.flatten()).reshape(rows, cols)  # R = r*3*i, where r = rd in previous row
    gr = np.multiply(gr, 3*i.flatten()).reshape(rows, cols)
    bl = np.multiply(bl, 3*i.flatten()).reshape(rows, cols)
    return rd, gr, bl
h, s, i = rgb2hsi(rgbimg)
print(h,s,i)
# Construct hsi images
HSIimg = np.zeros((rgbimg.shape[0], rgbimg.shape[1], 3))
HSIimg[:,:,0] = h
HSIimg[:,:,1] = s
HSIimg[:,:,2] = i

r, g, b = hsi2rgb(HSIimg)
# Construct rgb images
RGBimg = np.zeros((rgbimg.shape[0], rgbimg.shape[1], 3))
RGBimg[:,:,0] = r
RGBimg[:,:,1] = g
RGBimg[:,:,2] = b

# Show the result

plt.figure(figsize=(15,5))
plt.subplot(1,3,1)
plt.imshow(h,cmap='gray')
plt.title("Hue Component")
plt.subplot(1,3,2)
plt.imshow(s,cmap='gray')
plt.title("Saturation Component")
plt.subplot(1,3,3)
plt.imshow(i,cmap='gray')
plt.title("Intensity Component")
plt.suptitle("RGB to HSI Image Conversion", fontsize=16)

plt.figure(figsize=(15,5))
plt.subplot(1,3,1)
plt.imshow(r,cmap='gray')
plt.title("Red Component")
plt.subplot(1,3,2)
plt.imshow(g,cmap='gray')
plt.title("Green Component")
plt.subplot(1,3,3)
plt.imshow(b,cmap='gray')
plt.title("Blue Component")
plt.suptitle("HSI to RGB Image Conversion", fontsize=16)

# Display original RGB image, RGB2HSI, and HSI2RGB images
plt.figure(figsize=(15,5))
plt.subplot(1,3,1)
```

```
plt.imshow(rgbimg)
plt.title("Original RGB Image")

plt.subplot(1,3,2)
plt.imshow(HSIimg)
plt.title("RGB to HSI Image")
plt.subplot(1,3,3)
plt.imshow(RGBimg)
plt.title("HSI to RGB Image")
plt.suptitle("RGB to HSI and HSI to RGB Image Conversion", fontsize=16)
### Part 2: Color Histogram Equalization
def histogram_equalization(img, mode="rgb"):
    # Choose the color model that is most suitable for histogram equalization.
    if mode=="rgb":
        # We will equalize per color channel in RGB equalization
        ch = []
        for it in range(3):
            val, count = np.unique(img[:,:,it], return_counts=True)
            pdf = np.divide(count, sum(count))  # Probability Density Function pr(rk)
            cdf = (val.max()*np.cumsum(pdf)).astype(np.int32)  # Cummulative Density Function
            mp = np.arange(0, val.max()+1)
            mp[val] = cdf  # Map old pixel values to new pixel values
            ch.append(mp[img[:,:,it]])  # Update the pixel values
        heimage = np.zeros((img.shape[0], img.shape[1], 3), dtype=np.int32)  # img must be a
NumPy array
        heimage[:,:,0] = ch[0]  # Red channel
        heimage[:,:,1] = ch[1]  # Green channel
        heimage[:,:,2] = ch[2]  # Blue channel
        return heimage
    elif mode=="hsi":
        val, count = np.unique(img[:,:,-1], return_counts=True)  # Equalize on Intensity channel
        val = (val*255).astype(np.uint8)  # Convert val to 255
        pdf = np.divide(count, sum(count))  # Probability Density Function pr(rk)
        cdf = (val.max()*np.cumsum(pdf)).astype(np.int32)  # Cummulative Density Function
        mp = np.arange(0, val.max()+1)
        mp[val] = cdf  # Map old pixel values to new pixel values
        mul = np.multiply(img[:,:,-1], 255).astype(np.uint8)  # Temporarily convert to 255
        img[:,:,-1] = mp[mul]  # Update the pixel values
        img[:,:,-1] = img[:,:,-1]/255  # Convert back to 0-1
        r, g, b = hsi2rgb(img)  # Convert HSI color space to RGB color space
        heimage = np.zeros((img.shape[0], img.shape[1], 3))  # img must be a NumPy array
        heimage[:,:,0] = r  # Red channel
        heimage[:,:,1] = g  # Green channel
        heimage[:,:,2] = b  # Blue channel
        return heimage
    else:
        raise Exception("Please use either RGB/HSI mode")
heimgrgb = histogram_equalization(rgbimg, "rgb")  # Choose the color model you want to use as
input here (rgbimg or hsiimg)
heimghsi = histogram_equalization(HSIimg, "hsi")

plt.figure(figsize=(15, 5))
```

```
plt.subplot(1,3,1)
plt.imshow(rgbimg)
plt.title("Original RGB Image")
plt.subplot(1,3,2)
plt.imshow(heimgrgb)
plt.title("RGB Image Histogram Equalization")
plt.subplot(1,3,3)
plt.imshow(heimghsi)
plt.title("HSI Image Histogram Eq (converted to RGB)")
### Part 3: Noisy RGB and HSI images
# Converting noisy RGB images HSI
gaussian = np.random.normal(0, 28, (rgbimg.shape[0],rgbimg.shape[1],3))
noisy_rgb = rgbimg + gaussian
r, g, b = cv2.split(noisy_rgb)
# Need to cast the noisy RGB back to uint8, otherwise we can't do rgb2hsi conversion
noisy_h, noisy_s, noisy_i = rgb2hsi(noisy_rgb.astype(np.uint8))

plt.figure(figsize = (15, 5))
plt.subplot(1, 3, 1)
plt.imshow(r,cmap='gray')
plt.title("Noisy Red Channel")
plt.subplot(1, 3, 2)
plt.imshow(g,cmap='gray')
plt.title("Noisy Green Channel")
plt.subplot(1, 3, 3)
plt.imshow(b,cmap='gray')
plt.title("Noisy Blue Channel")
plt.suptitle("Noise in RGB Image (per Channel)", fontsize=16)

plt.figure(figsize = (15, 5))
plt.subplot(1, 3, 1)
plt.imshow(noisy_h,cmap='gray')
plt.title("Noisy Hue Channel")
plt.subplot(1, 3, 2)
plt.imshow(noisy_s,cmap='gray')
plt.title("Noisy Saturation Channel")
plt.subplot(1, 3, 3)
plt.imshow(noisy_i,cmap='gray')
plt.title("Noisy Intensity Channel")
plt.suptitle("Noise in HSI Image (per Channel)", fontsize=16)
```