Experiment Title: Exploring Intensity Transformation Techniques in Image Processing

Objective:
To understand and implement various intensity transformation techniques for image enhancement, including Image Negatives (Linear), Log Transformations, Power-Law (Gamma) Transformations, and Piecewise-Linear Transformation Functions.

1. Image Negatives (Linear):

- Load a grayscale image into the image processing environment.
- Implement the image negative transformation by subtracting each pixel value from the maximum intensity value.
- Display the original and the transformed image.

2. Log Transformations:

- Load a grayscale image into the image processing environment.
- Implement the log transformation using the formula:

  $$s = c \times \log(1 + r)$$

  where r is the input intensity value, s is the output intensity value, and c is a constant for scaling.
- Experiment with different values of c.
- Display the original and transformed images.

3. Power-Law (Gamma) Transformations:

- Load a grayscale image into the image processing environment.
- Implement the power-law transformation using the formula:

  $$s = c \times r^{\gamma}$$

where r is the input intensity value, s is the output intensity value, c is a constant for scaling, and γ is the gamma parameter.

- Experiment with different values of γ.
- Display the original and transformed images.

4. Piecewise-Linear Transformation Functions:

- Load a grayscale image into the image processing environment.
- Design a piecewise linear transformation function with multiple segments.
- Implement the transformation function to enhance specific regions of interest in the image.
- Display the original and transformed images.

5. Contrast Stretching:

- Apply contrast stretching to a grayscale image to enhance its contrast.
- Experiment with different stretching ranges (minimum and maximum intensity values).

6. Gray-level Slicing:

- Select a specific range of gray levels from an image using gray-level slicing.
- Highlight specific features or regions of interest by setting all other pixel values to zero.
- Experiment with different threshold values to observe their effects on the sliced image.

7. Bit-plane Slicing:

- Perform bit-plane slicing on a grayscale image to decompose it into its binary representations.
- Visualize individual bit-planes to understand the contribution of each bit to the image.
- Combine selected bit-planes to reconstruct the original image with reduced bit-depth.

Assignment 5

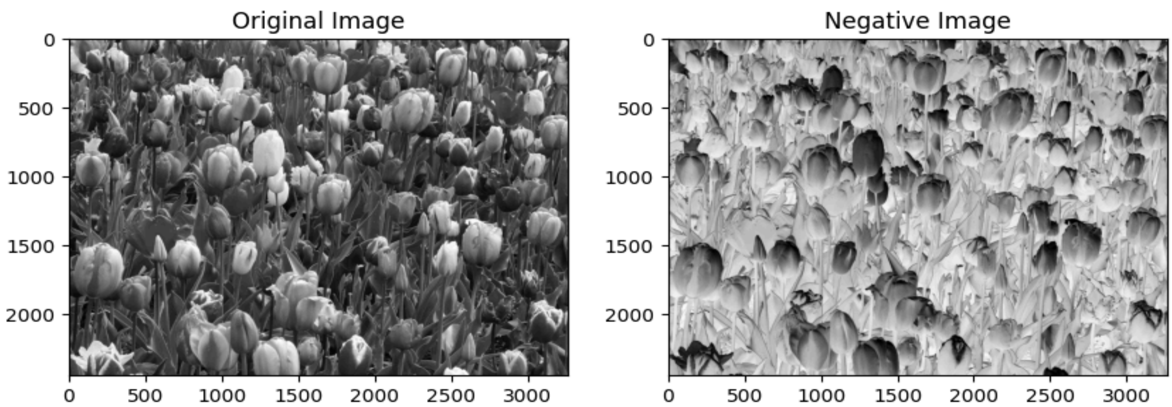
Intensity Transformation

Objective:
To understand and implement various intensity transformation techniques for image enhancement, including Image Negatives (Linear), Log Transformations, Power-Law (Gamma) Transformations, and Piecewise-Linear Transformation Functions.

1. Image Negatives (Linear):
- Load a grayscale image into the image processing environment.
- Implement the image negative transformation by subtracting each pixel value from the maximum intensity value.
- Display the original and the transformed image.

```
import cv2
import numpy as np
import matplotlib.pyplot as plt
# Load the grayscale image
image = cv2.imread('image.jpg', cv2.IMREAD_GRAYSCALE)
# Image Negative Transformation
max_intensity = 255  # Maximum intensity for 8-bit image
negative_image = max_intensity - image
# Display the original and transformed images
plt.figure(figsize=(10, 5))
plt.subplot(1, 2, 1)
plt.title('Original Image')
plt.imshow(image, cmap='gray')
plt.subplot(1, 2, 2)
plt.title('Negative Image')
plt.imshow(negative_image, cmap='gray')
plt.show()
```

Output:



2. Log Transformations:

- Load a grayscale image into the image processing environment.
- Implement the log transformation using the formula:

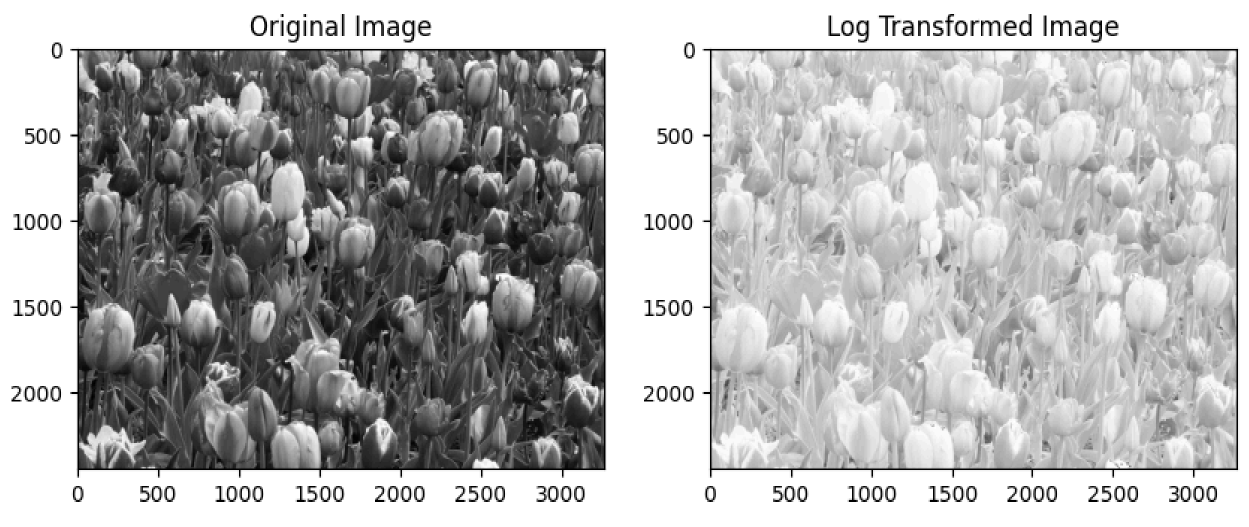
 $s = c \times \log(1 + r)$

where r is the input intensity value, s is the output intensity value, and c is a constant for scaling.

- Experiment with different values of c.
- Display the original and transformed images.

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Load the grayscale image
image = cv2.imread('image.jpg', cv2.IMREAD_GRAYSCALE)
# Log Transformation
c = 1  # Constant for scaling
log_transformed_image = c * np.log(image + 1)
# Normalize to 0-255 for display
log_transformed_image = np.uint8(255 * log_transformed_image /
np.max(log_transformed_image))
# Display the original and transformed images
plt.figure(figsize=(10, 5))
plt.subplot(1, 2, 1)
plt.title('Original Image')
plt.imshow(image, cmap='gray')
plt.subplot(1, 2, 2)
plt.title('Log Transformed Image')
plt.imshow(log_transformed_image, cmap='gray')
plt.show()
```

Output:

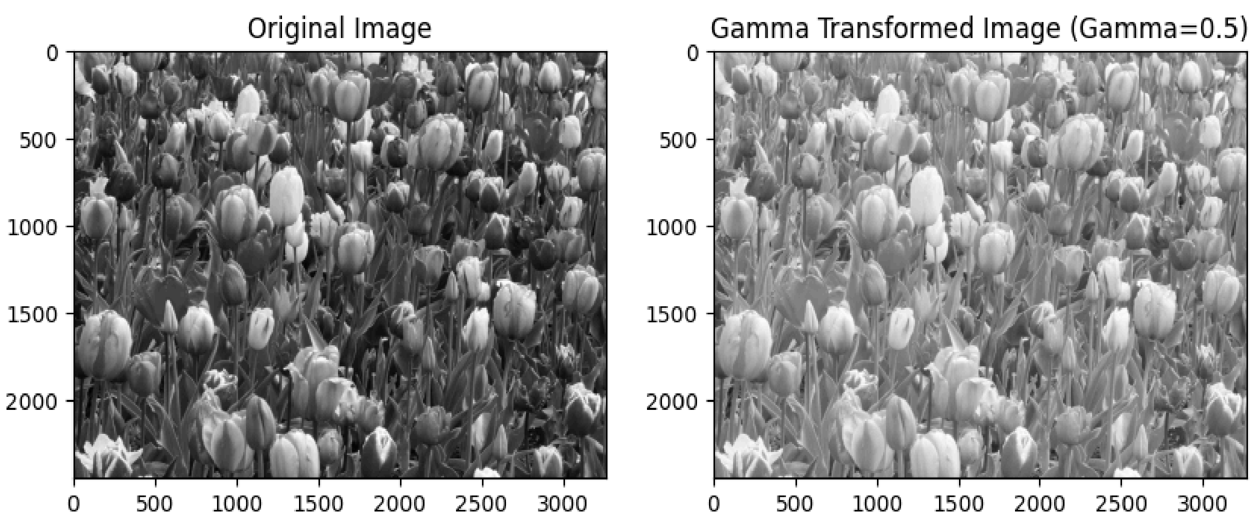


3. Power-Law (Gamma) Transformations:

● Load a grayscale image into the image processing environment.
● Implement the power-law transformation using the formula:
s = c x r^(gamma)
where r is the input intensity value, s is the output intensity value, c is a constant for scaling, and γ is the gamma parameter.
● Experiment with different values of γ.
● Display the original and transformed images.

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Load the grayscale image
image = cv2.imread('image.jpg', cv2.IMREAD_GRAYSCALE)
# Power-Law (Gamma) Transformation
c = 1  # Constant for scaling
gamma = 0.5  # Gamma parameter (try different values)
gamma_transformed_image = c * np.power(image / 255.0, gamma)
# Normalize to 0-255 for display
gamma_transformed_image = np.uint8(255 * gamma_transformed_image)
# Display the original and transformed images
plt.figure(figsize=(10, 5))
plt.subplot(1, 2, 1)
plt.title('Original Image')
plt.imshow(image, cmap='gray')
plt.subplot(1, 2, 2)
plt.title(f'Gamma Transformed Image (Gamma={gamma})')
plt.imshow(gamma_transformed_image, cmap='gray')
plt.show()
```

Output:

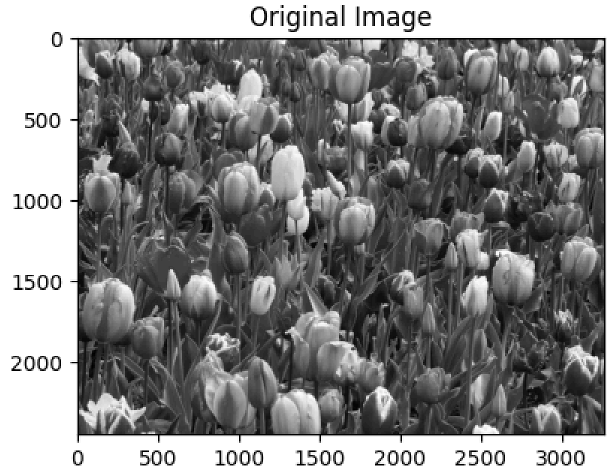


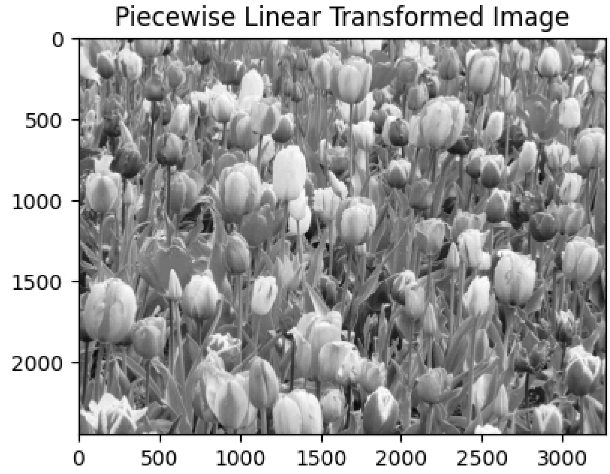
4. Piecewise-Linear Transformation Functions:

- Load a grayscale image into the image processing environment.
- Design a piecewise linear transformation function with multiple segments.
- Implement the transformation function to enhance specific regions of interest in the image.
- Display the original and transformed images.

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Load the grayscale image
image = cv2.imread('image.jpg', cv2.IMREAD_GRAYSCALE)

# Piecewise-linear transformation function
def piecewise_linear_transform(image):
    # Define thresholds for intensity ranges
    t1, t2 = 50, 150
    s1, s2 = 100, 200

    # Apply transformation for each range
    transformed_image = np.zeros_like(image)
    transformed_image[image < t1] = (image[image < t1] / t1) * s1
    transformed_image[(image >= t1) & (image <= t2)] = ((image[(image >=
t1) & (image <= t2)] - t1) / (t2 - t1)) * (s2 - s1) + s1
    transformed_image[image > t2] = ((image[image > t2] - t2) / (255 -
t2)) * (255 - s2) + s2

    return np.uint8(transformed_image)

# Apply piecewise-linear transformation
transformed_image = piecewise_linear_transform(image)

# Display the original and transformed images
plt.figure(figsize=(10, 5))

plt.subplot(1, 2, 1)
plt.title('Original Image')
plt.imshow(image, cmap='gray')
plt.subplot(1, 2, 2)
plt.title('Piecewise Linear Transformed Image')
plt.imshow(transformed_image, cmap='gray')

plt.show()
```

Output:





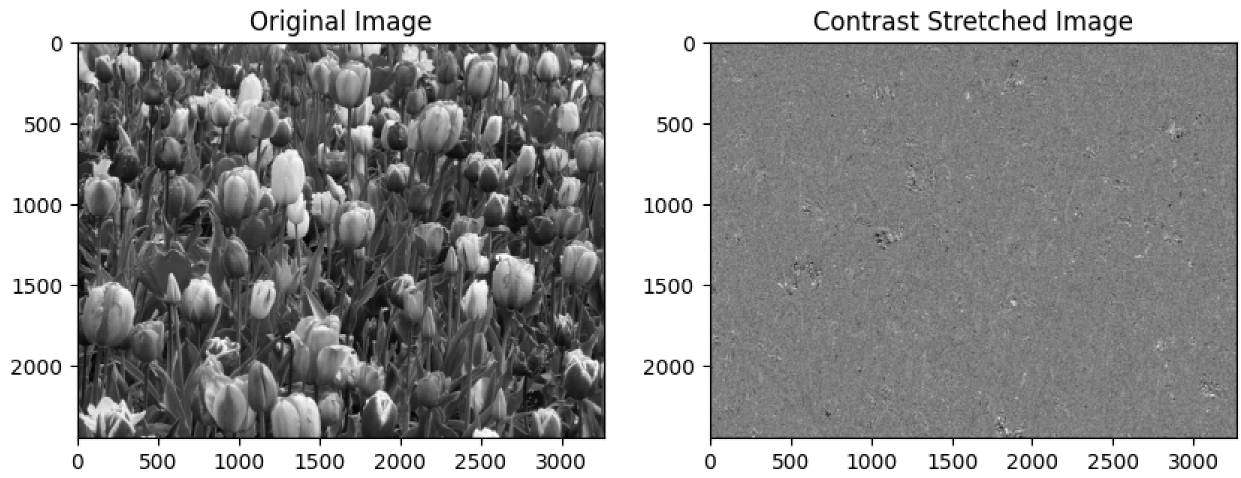
5. Contrast Stretching:

● Apply contrast stretching to a grayscale image to enhance its contrast.

● Experiment with different stretching ranges (minimum and maximum intensity values).

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Load the grayscale image
image = cv2.imread('image.jpg', cv2.IMREAD_GRAYSCALE)

# Contrast Stretching Transformation
min_intensity = np.min(image)
max_intensity = np.max(image)

# Define the new intensity range for contrast stretching
new_min = 50
new_max = 200
contrast_stretched_image = (image - min_intensity) * (new_max - new_min) /
(max_intensity - min_intensity) + new_min
# Display the original and transformed images
plt.figure(figsize=(10, 5))
plt.subplot(1, 2, 1)
plt.title('Original Image')
plt.imshow(image, cmap='gray')
plt.subplot(1, 2, 2)
plt.title('Contrast Stretched Image')
plt.imshow(contrast_stretched_image, cmap='gray')
plt.show()
```

Output:

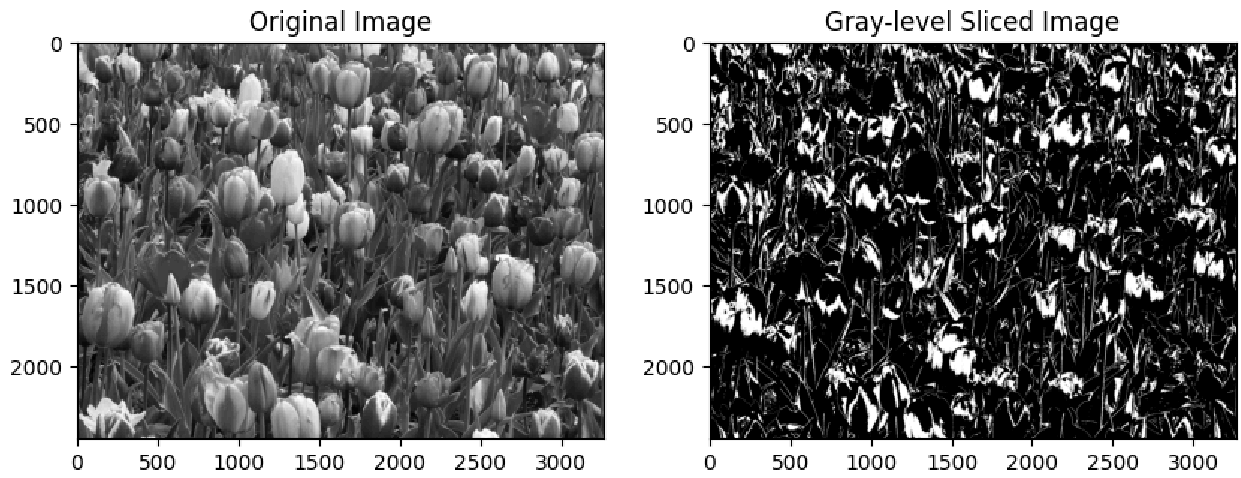


6. Gray-level Slicing:

- Select a specific range of gray levels from an image using gray-level slicing.
- Highlight specific features or regions of interest by setting all other pixel values to zero.
- Experiment with different threshold values to observe their effects on the sliced image.

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Load the grayscale image
image = cv2.imread('image.jpg', cv2.IMREAD_GRAYSCALE)

# Gray-level Slicing
lower_threshold = 100
upper_threshold = 150
sliced_image = np.zeros_like(image)
sliced_image[(image >= lower_threshold) & (image <= upper_threshold)] =
255

# Display the original and sliced images
plt.figure(figsize=(10, 5))
plt.subplot(1, 2, 1)
plt.title('Original Image')

plt.imshow(image, cmap='gray')
plt.subplot(1, 2, 2)
plt.title('Gray-level Sliced Image')
plt.imshow(sliced_image, cmap='gray')
plt.show()
```

Output:



7. Bit-plane Slicing:

● Perform bit-plane slicing on a grayscale image to decompose it into its binary representations.

● Visualise individual bit-planes to understand the contribution of each bit to the image.

● Combine selected bit-planes to reconstruct the original image with reduced bit-depth.

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Load the grayscale image
image = cv2.imread('image.jpg', cv2.IMREAD_GRAYSCALE)

# Perform bit-plane slicing
bit_planes = []
for i in range(8):
    bit_plane = (image >> i) & 1
    bit_planes.append(bit_plane * 255)
# Display individual bit-planes
plt.figure(figsize=(15, 10))
for i in range(8):
    plt.subplot(2, 4, i+1)
    plt.title(f'Bit Plane {i}')
    plt.imshow(bit_planes[i], cmap='gray')
    plt.show()
# Combine selected bit-planes to reconstruct image (reduce bit depth)
reconstructed_image = sum([bit_planes[i] for i in range(4)])  # Using
lower bit planes (0-3)
reconstructed_image = np.uint8(reconstructed_image)
# Display the original and reconstructed images
```

```python
plt.figure(figsize=(10, 5))
plt.subplot(1, 2, 1)
plt.title('Original Image')
plt.imshow(image, cmap='gray')
plt.subplot(1, 2, 2)
plt.title('Reconstructed Image')
plt.imshow(reconstructed_image, cmap='gray')
plt.show()
```

Output: