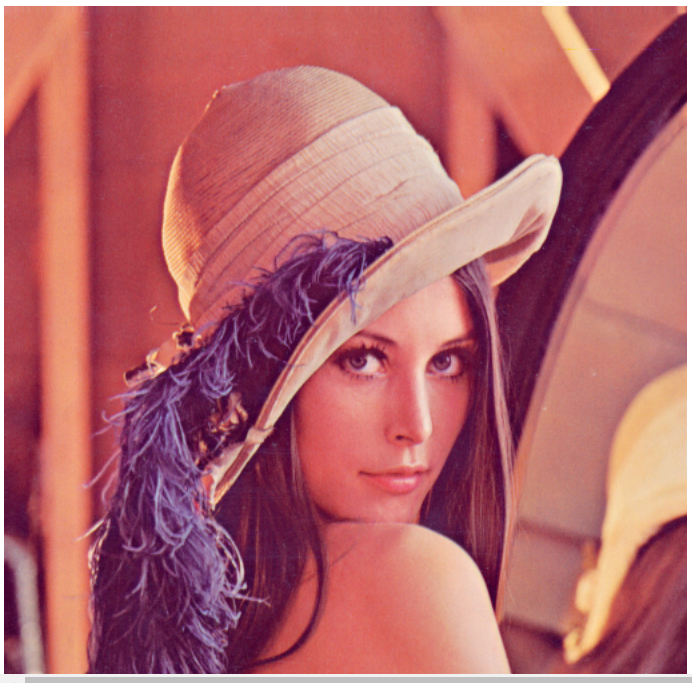
2 Getting Started with Image Processing with Python.

Introduction to Python Imaging Library(PIL)

2.1 Exercise - 1: Complete all the Task.

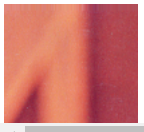
1. Read and display the image.

```
from PIL import Image

# Display image in colab
image_colored = Image.open("/content/Lenna_(test_image).png")
image_colored.show()
display ( image_colored )
```



2. Display only the top left corner of 100x100 pixels

```
import numpy as np
image_np = np.array(image_colored)
top_left_corner = image_np[:100, :100]
display(Image.fromarray(top_left_corner))
```



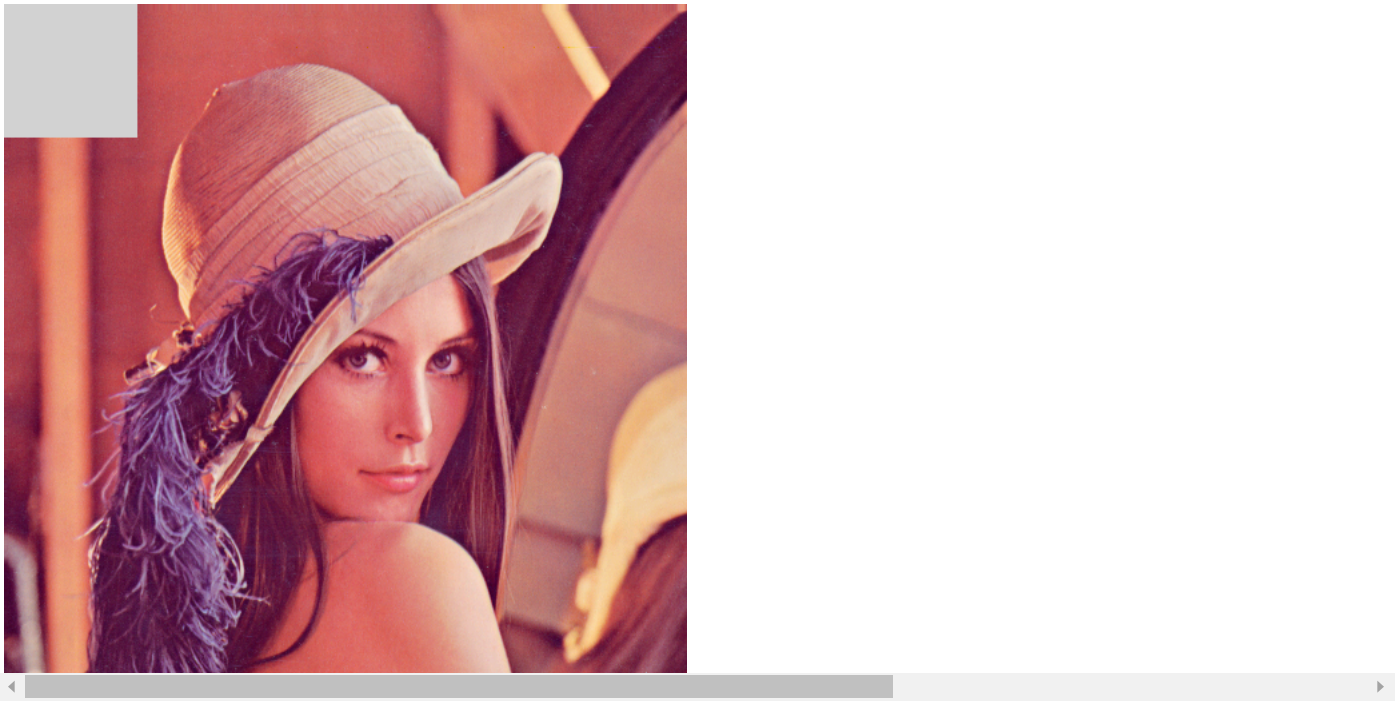
3. Show the three color channels (R, G, B).

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

image_colored = Image.open("/content/Lenna_(test_image).png")
image_array = np.array(image_colored)
r, g, b = image_array[:, :, 0], image_array[:, :, 1], image_array[:, :, 2]
plt.figure(figsize=(10, 5))

plt.subplot(1, 3, 1)
plt.imshow(r, cmap='Reds')
```

```
plt.axis('off')

plt.subplot(1, 3, 2)
plt.imshow(g, cmap='Greens')
plt.axis('off')

plt.subplot(1, 3, 3)
plt.imshow(b, cmap='Blues')
plt.axis('off')

plt.show()
```

4. Modify the top 100 × 100 pixels to a value of 210 and display the resulting image:

```
modified_image = image_np.copy()
modified_image[:100, :100] = 210
display(Image.fromarray(modified_image))
```



2.2 Exercise - 2:

1. Load and display a grayscale image.

```
from PIL import Image
import matplotlib.pyplot as plt

image_gray = Image.open("/content/cameraman.png")
plt.imshow(image_gray, cmap='gray')
plt.axis('off')
plt.show()
```

2. Extract and display the middle section of the image (150 pixels).

```
import numpy as np
image_np = np.array(image_gray)
height, width = image_np.shape
center_x = width // 2
center_y = height // 2
cropped_image = image_np[center_y - 75:center_y + 75, center_x - 75:center_x + 75]
plt.imshow(cropped_image, cmap='gray')
plt.axis('off')
plt.show()
```

3. Apply a simple threshold to the image (e.g., set all pixel values below 100 to 0).

```
import numpy as np

image = Image.open("/content/cameraman.png")
image_array = np.array(image)
thresholded_image = np.where(image_array < 100, 0, 255)
plt.imshow(thresholded_image, cmap='gray')
plt.axis('off')
plt.show()
```

4. Rotate the image 90 degrees clockwise and display the result.

```
rotated_image = image_gray.rotate(-90)
plt.imshow(rotated_image, cmap='gray')
plt.axis('off')
plt.show()
```

5. Convert the grayscale image to an RGB image.

```
image_gray = Image.open("/content/cameraman.png")
image_gray_array = np.array(image_gray)
image_rgb_array = np.stack((image_gray_array, image_gray_array, image_gray_array), axis=-1)

image_rgb = Image.fromarray(image_rgb_array)
plt.imshow(image_rgb)
plt.axis('off')
plt.show()
```

3 Image Compression and Decompression using PCA.

1. Load and Prepare Data:

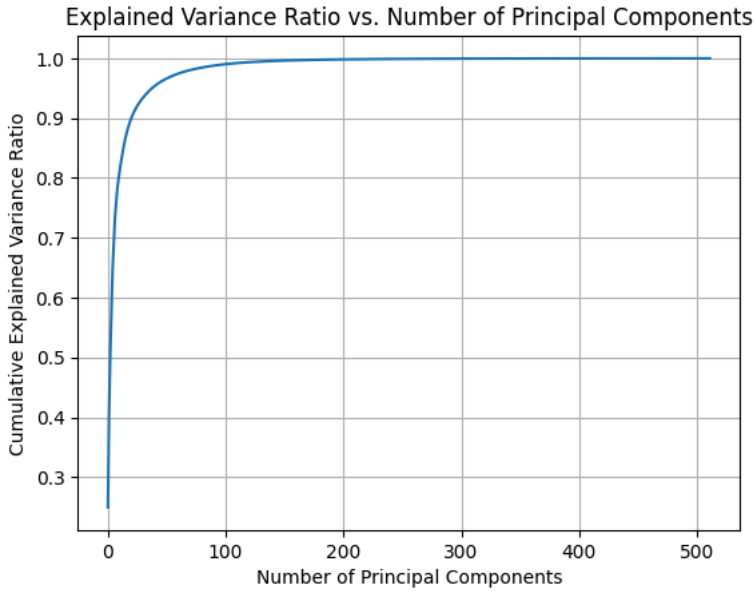
```
import numpy as np
import matplotlib.pyplot as plt
from PIL import Image


image = Image.open("/content/Lenna_(test_image).png")
image_gray = image.convert("L")

image_array = np.array(image_gray)
plt.imshow(image_array, cmap='gray')
plt.axis('off')
plt.show()
mean = np.mean(image_array)
centered_data = image_array - mean
std_dev = np.std(centered_data)
standardized_data = centered_data / std_dev
flattened_data = standardized_data.flatten()
flattened_data_2d = flattened_data.reshape(-1, 1)
cov_matrix = np.cov(flattened_data_2d.T)
print("Covariance Matrix:\n", cov_matrix)
```

```
Covariance Matrix:
 1.0000038147118005
```

2. Eigen Decomposition and Identifying Principal Components:

```
import numpy as np
import matplotlib.pyplot as plt
from PIL import Image

image = Image.open("/content/Lenna_(test_image).png")
image_gray = image.convert("L")
image_array = np.array(image_gray)
mean = np.mean(image_array, axis=0)
centered_data = image_array - mean
cov_matrix = np.cov(centered_data.T)
from numpy.linalg import eig
eigenvalues, eigenvectors = eig(cov_matrix)
sorted_indices = np.argsort(eigenvalues)[::-1]
sorted_eigenvalues = eigenvalues[sorted_indices]
sorted_eigenvectors = eigenvectors[:, sorted_indices]
k = 100
top_k_eigenvectors = sorted_eigenvectors[:, :k]
explained_variance_ratio = np.cumsum(sorted_eigenvalues) / np.sum(sorted_eigenvalues)
plt.plot(explained_variance_ratio)
plt.xlabel('Number of Principal Components')
plt.ylabel('Cumulative Explained Variance Ratio')
plt.title('Explained Variance Ratio vs. Number of Principal Components')
plt.grid(True)
plt.show()
```

```
/usr/local/lib/python3.11/dist-packages/matplotlib/cbook.py:1709: ComplexWarning: Casting complex values to real discards the imag
  return math.isfinite(val)
/usr/local/lib/python3.11/dist-packages/matplotlib/cbook.py:1345: ComplexWarning: Casting complex values to real discards the imag
  return np.asarray(x, float)
```



3. Reconstruction and Experiment:

```
import numpy as np
import matplotlib.pyplot as plt
from PIL import Image

image = Image.open("/content/lena_gray.gif")

image_gray = image.convert("L")
image_array = np.array(image_gray)
mean = np.mean(image_array, axis=0)
centered_data = image_array - mean
cov_matrix = np.cov(centered_data.T)
eigenvalues, eigenvectors = np.linalg.eig(cov_matrix)
sorted_indices = np.argsort(eigenvalues)[::-1]
eigenvalues_sorted = eigenvalues[sorted_indices]
eigenvectors_sorted = eigenvectors[:, sorted_indices]

top_k = [10, 20, 50, 100, 150]
```

```
explained_variance = eigenvalues_sorted / np.sum(eigenvalues_sorted)

plt.figure(figsize=(16, 12))

plt.subplot(3, 2, 1)
plt.imshow(image_array, cmap='gray')
plt.title("Original Image")
plt.axis('off')

for i, k in enumerate(top_k):
    selected_eigenvectors = eigenvectors_sorted[:, :k]
    projected_data = np.dot(centered_data, selected_eigenvectors)
    reconstructed_data = np.dot(projected_data, selected_eigenvectors.T) + mean
    reconstructed_data = np.real(reconstructed_data)
    plt.subplot(3, 2, i + 2)
    plt.imshow(reconstructed_data, cmap='gray')
    plt.title(f"{k} components")
    plt.axis('off')

plt.show()
```

Double-click (or enter) to edit