2357572-suraj-kanwar-worksheet1

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[101]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).
```

1 2.1. Exercise 1 - Basic Image Processing:

[102]:
```
import numpy as np
import matplotlib.pyplot as plt
from PIL import Image
```

1. Read and Display Image:

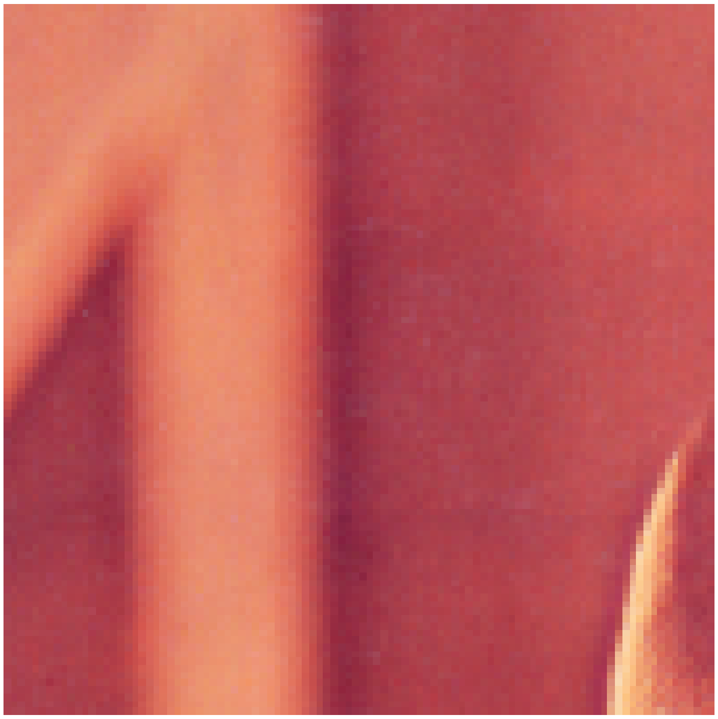
Use Pillow to read and show the image. Optionally, use Matplotlib.

[103]:
```
image_colored = Image.open("/content/drive/MyDrive/Artificial Intelligence and␣
↪Machine Learning/Week:1/unnamed.png")

plt.imshow(image_colored)
plt.axis("off")
plt.show()
```

2. Extract Top-Left (100x100) Pixels:

Display only the top-left 100x100 pixels using NumPy.

[104]:
```
# Convert image to NumPy array
image_array = np.array(image_colored)

# Extract the top-left 100x100 pixels
top_left = image_array[:100, :100]

# Display the extracted section
plt.imshow(top_left)
plt.axis("off")
plt.show()
```



3. Show RGB Channels:

Separate and display the Red, Green, and Blue channels individually.

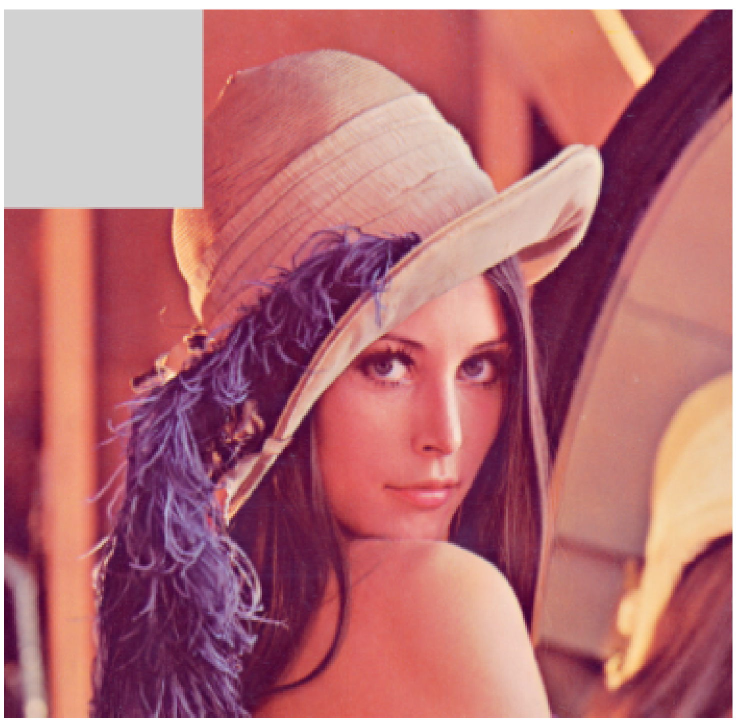
[105]:
```
# Extract individual color channels
red_channel = image_array[:, :, 0]  # Red
green_channel = image_array[:, :, 1]  # Green
blue_channel = image_array[:, :, 2]  # Blue

# Display each channel
fig, ax = plt.subplots(1, 3, figsize=(15, 5))

ax[0].imshow(red_channel, cmap="Reds")
ax[0].set_title("Red Channel")

ax[1].imshow(green_channel, cmap="Greens")
ax[1].set_title("Green Channel")

ax[2].imshow(blue_channel, cmap="Blues")
ax[2].set_title("Blue Channel")

for a in ax:
    a.axis("off")
```

```
plt.show()
```

4. Modify Top-Left Pixels:

Set the top-left 100x100 pixels to 210 (light gray) and display the image.

[106]:
```
image_array[:100, :100] = 210

modified_image = Image.fromarray(image_array)

plt.imshow(modified_image)
plt.axis("off")
plt.show()
```



2 2.2. Exercise - 2:

1. Load & Display Grayscale Image

- Load a grayscale image (Pillow).
- Display it (Matplotlib).

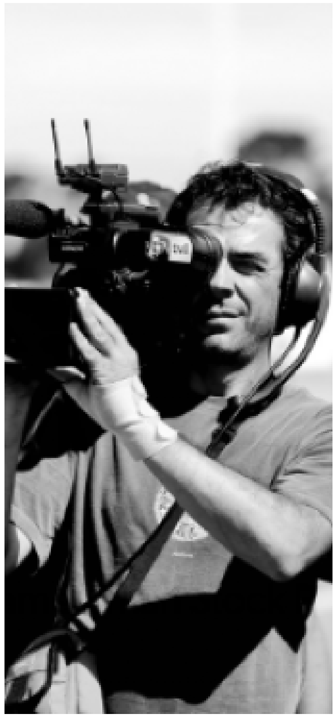
[107]:
```
gray_image = Image.open("/content/drive/MyDrive/Artificial Intelligence and␣
↪Machine Learning/Week:1/camera.png").convert("L")
plt.imshow(gray_image, cmap="gray")
plt.axis("off")

plt.show()
```

2. Extract & Display Middle Section

- Crop a 150-pixel section from the center.
- Display the cropped section.

[108]:
```
gray_array = np.array(gray_image)
middle = gray_array[:, gray_array.shape[1]//2 - 75 : gray_array.shape[1]//2 +␣
↪75]
```

```
plt.imshow(middle, cmap="gray")
plt.axis("off")
plt.show()
```



3. Apply Thresholding

- Set pixel values below 100 to 0, above 100 to 255.
- Display the binary image.

[109]:
```
binary_image = np.where(gray_array < 100, 0, 255)
plt.imshow(binary_image, cmap="gray")
plt.axis("off")
plt.show()
```

4. **Rotate Image (90° Clockwise)**

- Rotate the image 90° clockwise.
- Display the rotated image.

[110]:
```
rotated = gray_image.rotate(-90)
plt.imshow(rotated, cmap="gray")
plt.axis("off")
plt.show()
```

5. Convert to RGB

- Convert grayscale to RGB (replicate values across R, G, B).
- Display the RGB image.

[111]:
```
rgb_image = Image.merge("RGB", (gray_image, gray_image, gray_image))
plt.imshow(rgb_image)
plt.axis("off")
plt.show()
```

3 3. Image Compression & Decompression using PCA

1. Load & Prepare Data

- Load an image (convert to grayscale if needed).
- Standardize the data & compute the covariance matrix.

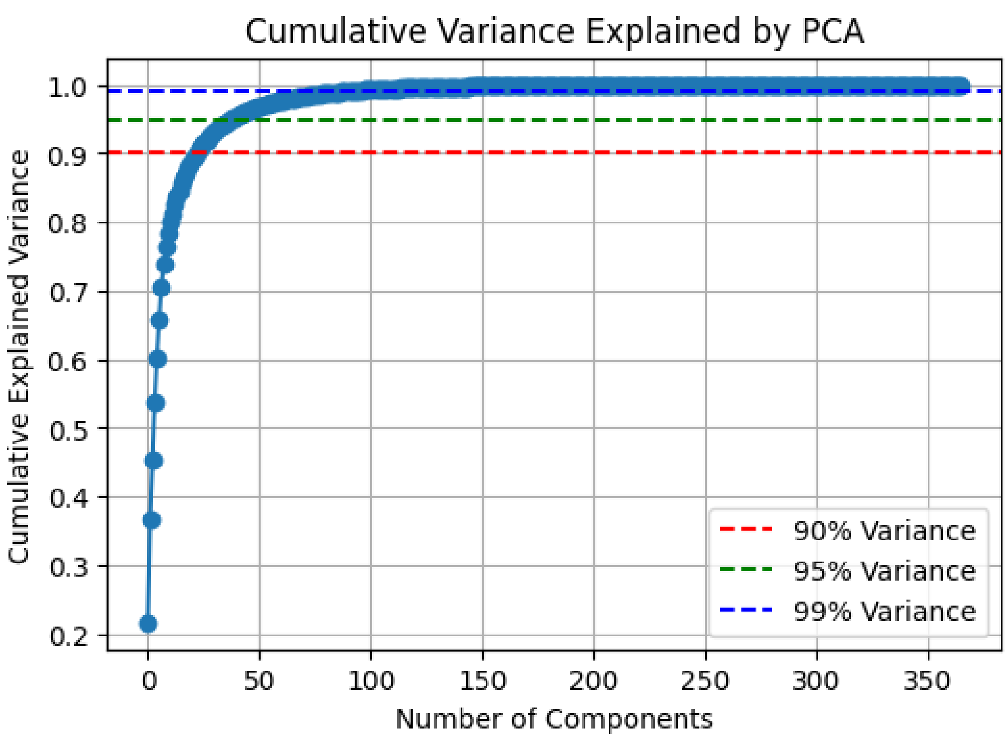
[112]:
```
gray_image = Image.open("/content/drive/MyDrive/Artificial Intelligence and␣
↪Machine Learning/Week:1/unnamed.png").convert("L")
gray_array = np.array(gray_image)

mean = np.mean(gray_array, axis=0)
std = np.std(gray_array, axis=0)
standardized_data = (gray_array - mean) / std
```

2. Eigen Decomposition & PCA Selection

- Compute eigenvalues & eigenvectors.
- Sort eigenvalues, choose top k components.
- Identify principal components using a cumulative sum plot.

[113]:
```
cov_matrix = np.cov(standardized_data, rowvar=False)

eigenvalues, eigenvectors = np.linalg.eigh(cov_matrix)
```

```
sorted_indices = np.argsort(eigenvalues)[::-1]
eigenvalues = eigenvalues[sorted_indices]
eigenvectors = eigenvectors[:, sorted_indices]

explained_variance_ratio = eigenvalues / np.sum(eigenvalues)
cumulative_variance = np.cumsum(explained_variance_ratio)

plt.figure(figsize=(6, 4))
plt.plot(cumulative_variance, marker='o', linestyle='-')
plt.axhline(y=0.90, color='r', linestyle='--', label="90% Variance")
plt.axhline(y=0.95, color='g', linestyle='--', label="95% Variance")
plt.axhline(y=0.99, color='b', linestyle='--', label="99% Variance")
plt.xlabel("Number of Components")
plt.ylabel("Cumulative Explained Variance")
plt.title("Cumulative Variance Explained by PCA")
plt.legend()
plt.grid(True)
plt.show()
```



3. Reconstruction & Experiment

- Reduce dimensions using selected eigenvectors.
- Reconstruct with different principal component combinations.

- Compare results & display outputs.

[114]:
```
def reconstruct_pca(image, eigenvectors, num_components):
    selected_vectors = eigenvectors[:, :num_components]
    compressed = np.dot(image, selected_vectors)
    restored = np.dot(compressed, selected_vectors.T)
    return (restored * std) + mean

components = [0, 10, 20, 50, 100, 150]

fig, ax = plt.subplots(1, len(components), figsize=(15, 6))

for i, n in enumerate(components):
    if n == 0:
        ax[i].imshow(gray_array, cmap="gray")
        ax[i].set_title("Original Image")
    else:
        reconstructed = reconstruct_pca(standardized_data, eigenvectors, n)
        ax[i].imshow(np.clip(reconstructed, 0, 255), cmap="gray")
        ax[i].set_title(f"PCA: {n} Components")

    ax[i].axis("off")

plt.tight_layout()
plt.show()
```