Assignment-I: Image Compression Using Principal Component Analysis.
Herald College, University of Wolverhampton

Siman Giri and 6CS012-Team

19-March-2023

1 Assignment Details

Due	Marks	Submission
March-26, 16:30 NST.	10	Rendered .ipynb and pdf file//see details below

2 Assignment Overview

This assignment is based on the idea of Dimensionality reduction and Eigen Decomposition, that we did in week-3. In this assignment you have to extend the idea of Eigen decomposition (Principal Component analysis) for compression of Image.
This is a **group task.** Please Read below for detail instruction on formation of Group.

3 Learning Outcomes:

Learning outcomes can be following but not limited to:

1. Understand and use the image manipulation library within python.,
2. Better understand the real world example on the use of Eigen Decomposition,
3. Learn to present your work in a professional and academic manner,
4. Learn to build a project in group.

4 Submission Guidelines

The final date for submission is 26-Mar-2023 and 16:30 PM-NST.

4.1 Naming Conventions:

You are supposed to follow naming conventions strictly any file not following the naming conventions will be marked"0".
File Name: WLVIDFullName(firstname+last).ipynb
Example: 00000ABC Sharma.ipynb

4.2 How to submit:

4.2.1 Group Formation:

You are expected to form group among your peers. You can pick 3 -5 members in your group. Group members must be from your own section. No cross section group allowed.

1. In Group: You are allowed to write code in group but should submit individual rendered.IPYNB file converted to pdf file with your individual comments. Comments can not be same for two or more members of the group.

You are expected to submit completely rendered .ipynb file converted to pdf format named after following naming convention.

4.3 Where to submit:

Designated Portal opened at **Canvas**, where you are supposed to upload the **rendered.ipynb** converted to **.pdf**, correctly named before the deadline.
No Late submission allowed.

4.4 Policy on Usage of Pre-built Library:

Please feel free to use any of the pre-built library(for example:sklearn) to solve the task.
But please be advised 2 marks will be penalised
Pre-built library like Numpy and Pillow are allowed.
i.e will be deducted in any case you solve your problem with pre-built library.

4.5 After Submission

There will be individual viva for all group members on the date and time picked by your respected tutors.
Please Note: No marking without Viva.
Consult with your respected tutor for your viva schedule.

5 Tasks and Marks Division

5.1 Load and Prepare the data: [1]

Pick an color image of your choice and do the following.

1. Load the image using image reading library, you can use Pillow or matplotlib or any other library of your confidence.
2. For the simplicity, convert the image into gray scale i.e. black and white.

5.2 Standardize/Scale the data:[1]

To assure all the initial variables are transformed to same scale, it is a most to perform scaling operation before any PCA operation.

5.3 Calculate Covariance Matrix:[1]

Each element of the covariance matrix represents covariance between each ij^{th} element. The covariance between two elements is calculated and stored in the matrix as shown in picture below:

$$
\begin{array}{cc}
 & \begin{array}{cc} \text{x} & \text{y} \end{array} \\
\begin{array}{c} \text{x} \\ \text{y} \end{array} & \begin{bmatrix} var(x) & cov(x,y) \\ cov(x,y) & var(y) \end{bmatrix}
\end{array}
\qquad
\begin{array}{cc}
 & \begin{array}{ccc} \text{x} & \text{y} & \text{z} \end{array} \\
\begin{array}{c} \text{x} \\ \text{y} \\ \text{z} \end{array} & \begin{bmatrix} var(x) & cov(x,y) & cov(x,z) \\ cov(x,y) & var(y) & cov(y,z) \\ cov(x,z) & cov(y,z) & var(z) \end{bmatrix}
\end{array}
$$

5.4 Eigen Decomposition: [2]

Decompose a covariance matrix into eigen values and eigen vectors:

$$\mathbf{A(n{*}n)= PDP}^{I}$$

Where:

1. **A(n*n)**: −**Covariance Matrix**.
2. **P**:- **Eigen Vector of Covariance Matrix**.
3. **D**:- **Diagonal Matrix. Diagonal elements are Eigen Values**.
4. $\mathbf{P}^{I}$: −**Inverse of Eigen Vector**.

5.5 Identify Principal Components:[2]

Determine the **explained variance** by each **principal components**, based on this we can determine how many principal components to pick from.

- Experiment with Principal Components:
  - Pick **three different combination** of principal components with **various explained variance value** and **compare** the result.

5.6 Reconstruction of the image: [3]

Reconstruct the image based on number of principal components you picked in step **4.5**.
Reconstruct all three images and conclude the result based on your observation. Display the reconstructed image, experiment with various number of components.