

**Department of Artificial Intelligence**

**College of Computer Science and Information Technology**

**Review Lab Exercise II**

**Due Date: Tuesday December 10, 2024 @ 11:59 PM**

**Late Submissions:**

* Q: Can I skip the lab and submit the solution?
  + You will receive a mark of **zero** if you do not attend the lab, even if you complete the exercise. Attending the labs is compulsory for evaluation. If you have a justified excuse, you may receive a partial mark depending on the circumstances. See the next question for information on late submissions.
* **Q:** If I submit it at 12:00am, you’ll still mark it, right?
  + **A:** 11:59pm and earlier is on time. Anything after 11:59pm is late. Anything late will **NOT** be probably marked. If I find you have a legitimate cause, you will be graded according to the following rules (24 hours after deadline 🡪 assignment is marked out of 75% only, 48 hours after deadline 🡪 assignment is marked out of 50% only, 72 hours after deadline 🡪 assignment is marked out of 25% only)

**Objective**

This lab will provide hands-on practice with image processing concepts in preparation for the lab test. Students will:

* Explore image reconstruction and enhancement techniques.
* Experiment with Principal Component Analysis (PCA) for dimensionality reduction.
* Work with frequency-domain filtering methods.
* Practice image manipulation and visualization.

**Instructions**

1. Load the necessary Python libraries, including numpy, skimage, and matplotlib.
2. Load and process the provided images or any suitable substitutes.
3. Answer the embedded questions by implementing solutions and explaining your process.

**Tasks:**

**Task 1: Image Reconstruction**

Perform the following:

1. Fix a damaged image by restoring missing areas using interpolation.

**Question:**

* What are the key challenges in image reconstruction, and how do interpolation and inpainting address these challenges?

**Task 2: Principal Component Analysis (PCA) for Image Compression**

 Use a grayscale image for PCA-based compression.

 Steps:

1. Reshape the image into a 1D array.
2. Normalize pixel values to the range [0, 1].
3. Perform PCA to reduce dimensionality.
4. Reconstruct the image from principal components.
5. Display the original and reconstructed images side by side.

**Question:**

* How does reducing the number of principal components affect the quality of the reconstructed image? Provide examples from your results.

**Task 3: Frequency-Domain Filtering**

Perform the following on an input image (use either Task 1 or Task 2 uploaded images):

* Apply the 2D Fast Fourier Transform (FFT) to convert the image to the frequency domain.
* Implement low-pass filtering to retain smooth areas and remove high-frequency noise.
* Implement high-pass filtering to enhance edges and fine details.
* Use the Inverse FFT to convert the filtered images back to the spatial domain.
* Display the original, low-pass, and high-pass filtered images.

**Question:**

* What is the significance of low-frequency and high-frequency components in an image, and how do these components impact the filtered results?

**Assessment**

1. Each student will demonstrate their solutions to the instructor before the end of the lab.
2. Marks are distributed as follows:

|  |  |
| --- | --- |
| Task(s) | Marks (demo + report) |
| Task 1 | 4 |
| Task 2 | 3 |
| Task 3 | 3 |
| Total | 10 |

1. Students will prepare a report in which they will submit the snapshots taken while they worked on each part. They will explain the figures to make sure that they understood what they did.