Assessment Type: Complex Engineering Problem / Course Project	**Course Name / Code:** Linear Algebra II / ES-304
Section: A/B	**Instructor:** Dr. Asad Mahmood/ Mr. Muti-ur-Rehman
Semester: Fall 2022	**Weightage: 10%**

Concerned CLOs:

1. CLO4 - Analyze and solve applied engineering problem requiring tools from advanced linear algebra. PLO-4 (Investigation)
2. CLO5 - Efficiently work in a team to investigate and solve problems related to applied linear algebra. PLO-9 (Individual and Teamwork)

Instructions:

- Please **form a team of 4 students and email the names and reg. nos. of the students to the instructor via email by the 'team submission deadline'**. Late submissions will be penalized as per the late submission policy.
- The **final submission should include the report as well as the source code**. All the **submissions should be done via the MS Teams** platform. Late submissions will be penalized as per the late submission policy.
- **Viva will be conducted afterwards**, and each team member can be asked/ given a small task regarding any aspect of the project, and marks will be awarded accordingly.

Team submission deadline: November 16th, 2022	**Project Report Deadline: December 14th, 2022**

Title:

How to handle Large Datasets? → PCA comes to rescue!

Background:

Many satellites continuously roam around the earth and an important type of satellites is known as the **'Earth observation Satellites'** [1] which observe the earth from the space using several sensors, such as cameras etc. This largely falls in the discipline of **'Remote Sensing'** [2]. The images from the cameras onboard the satellites can be used for several purposes, and one important application is known as **'land mapping'** [3], in which different areas on the land are mapped to different classes such as water, forests, crops, buildings, snow etc. Such information is useful in applications such as urban planning, water and crops monitoring, disaster management etc.

The earth observation satellites use different types of cameras to take pictures of the earth's land cover. One type of camera, which is commonly used in earth observation, is the multispectral camera which takes **multispectral images** [4] of different locations on earth. Multispectral images

are similar in nature to the normal colored images which we use in our everyday life, however instead of just 3 bands (Red, Green and Blue) which are in regular color images, there are more number of bands in a multispectral image (generally between 6 to 30 bands). The large number of bands allows one to distinguish between different land cover types (crops, forests, water, land, etc.) in a better manner as compared to using only the regular colored/RGB images. **Landsat** is one of the world's largest satellite program for earth observation which is run by the US government. Some details about the Landsat program are also given in the introductory example of chapter 7 of your textbook, and more can be obtained from the references [4][5]. The Landsat program keeps an repository of the earth's images taken and allow anyone to download the images for any location using its online platform https://earthexplorer.usgs.gov/ . The details on how to download data can be obtained from the link [7].

Main Objective:

Your main objective is to **perform principal component analysis (PCA)[1] [8] on a multispectral image and perform associated. analyses** that image using any appropriate platform/language (Matlab, Python etc.) and give results on error increase/decrease with respect to different number of principal components chosen to represent that image.

Tasks:

1. Develop understanding of multispectral/multidimensional images, download a Landsat image of a location from USGS website (could be any location of interest in Pakistan, however, images for any 2 groups should not be same – this would be done by mentioning your chosen location on a shared MS Teams files) and **perform basic operations (visualize different bands, crop size in any dimension, concatenate bands etc.) with the image** in any suitable platform (Matlab, Python etc.) **(2 Marks)**

2. Develop understanding of PCA, including how does it help in the processing of multidimensional images and how does PCA relates to the concepts from the course of Linear Algebra II, and **apply PCA to your image** such that you are able to demonstrate that PCA could be performed using any number of principal components by your code. **(4 Marks)**

3. **Perform an error analysis on the use of PCA** on your image by choosing different number of Principal Components and calculate the resulting error in each case. You should be able to demonstrate the usefulness of the PCA approach in comparison to its non-usage based on the error analysis. Also recommend a suitable number of Principal Components to be used based on the error analysis. You can calculate the error by comparing the PCA resulting image with the original image and using any suitable difference metric e.g. mean square error etc. **(2 Marks)**

[1] A brief introduction about PCA is also given in chapter 7 of your textbook

4. **CEP report**, which your team will use to give a viva on your CEP as well. The report should be of standard format with no more than 5 pages in double-column format – preferably use the IEEE Word template for conferences [9]. The report should include the sections of Title, Authors, Abstract, Introduction, Methodology, **Task distribution (this section should be reasonably explained as there is a dedicated CLO regarding it in this assignment)**, Results, Conclusion and References. Any item other than these can be put in the appendices. You can also make a separate PowerPoint presentation for your viva, if it suits you more, but it is not mandatory. **(1+1 = 2 Marks)**

References:

1. https://en.wikipedia.org/wiki/Earth_observation_satellite
2. https://en.wikipedia.org/wiki/Remote_sensing
3. https://www.un-spider.org/links-and-resources/data-sources/daotm-landcover
4. https://en.wikipedia.org/wiki/Multispectral_imaging
5. https://en.wikipedia.org/wiki/Landsat_program
6. https://landsat.gsfc.nasa.gov/
7. https://gisgeography.com/usgs-earth-explorer-download-free-landsat-imagery/
8. https://en.wikipedia.org/wiki/Principal_component_analysis
9. https://www.ieee.org/conferences/publishing/templates.html