# Linear Algebra for Machine Learning

Reference:
1. Chapter 2 (Linear Algebra) of the "*Deep Learning Book*" by Aaron Courville, Ian Goodfellow, and Yoshua Bengio. [deeplearningbook.org/contents/linear_algebra.html](deeplearningbook.org/contents/linear_algebra.html)
2. "*Introduction to Linear Algebra for Applied Machine Learning with Python*." 1 Aug. 2020, [pabloinsente.github.io/intro-linear-algebra](pabloinsente.github.io/intro-linear-algebra).

Courtesy: Md. Tareq Mahmood, Assistant Professor (on leave), CSE, BUET

Find the necessary files here > CSE 472 Assignment 1 Files

## Task 1: Matrix Transformation

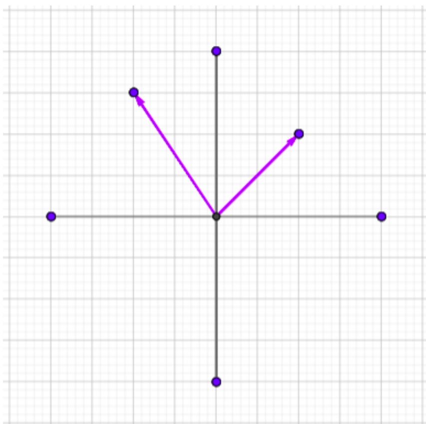
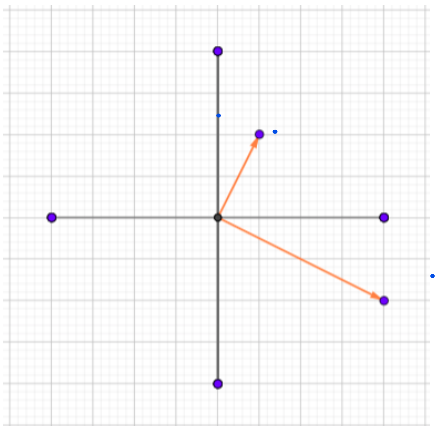
Go through and run the notebook "matrix-transformations-and-eigen-decomposition" to get an intuition about

- How can a matrix transform a vector?
- What do columns of matrices mean in terms of transformation?
- What does eigenvector mean?

(We recommend you also read the whole of Chapter 2 of the Deep Learning Book.)

Then,

- Change the cell values of matrix ***M*** (there can be two such matrices; find one of them) so that it does the following transformation

| Before Transformation | After Transformation |
|---|---|
|  |  |

- Run the whole notebook again and submit.

# Task 2: Eigen Decomposition

## SubTask 2A: Random Matrix (random_eigen.py)

- Take the dimensions of matrix ***n*** as input.
- Produce a random ***n x n*** invertible matrix ***A***. For the purpose of demonstrating, every cell of ***A*** will be an integer.
- Perform Eigen Decomposition using NumPy's library function
- Reconstruct ***A*** from eigenvalues and eigenvectors (refer to Section 2.7).
- Check if the reconstruction worked properly. (np.allclose will come in handy.)
- You should be able to explain how your code ensures that the way you generated ***A*** ensures invertibility.

## SubTask 2B: Symmetric Matrix (symmetric_eigen.py)

- Take the dimensions of matrix ***n*** as input.
- Produce a random ***n x n*** invertible symmetric matrix ***A***. For the purpose of demonstrating, every cell of ***A*** will be an integer.
- Perform Eigen Decomposition using NumPy's library function
- Reconstruct ***A*** from eigenvalues and eigenvectors (refer to Section 2.7).
- Check if the reconstruction worked properly. (np.allclose will come in handy.)
- Please be mindful of applying efficient methods (this will bear marks).
- You should be able to explain how your code ensures that the way you generated ***A*** ensures invertibility and symmetry.

# Task 3: Image Reconstruction using Singular Value Decomposition

## (image_reconstruction.py)

- Take a photo of a book's cover within your vicinity. Let's assume it is named `image.jpg`.
- Use OpenCV or similar frameworks to read `image.jpg`. Transform it to grayscale using functions such as `cv2.cvtColor()`. If you wish, resize to lower dimensions (~500) for faster computation.
- The grayscale image will be an ***n x m*** matrix ***A***.
- Perform Singular Value Decomposition using NumPy's library function.
- Given a matrix ***A*** and an integer ***k***, write a function `low_rank_approximation(A, k)` that returns the ***k***-rank approximation of ***A***.
- Now vary the value of ***k*** from 1 to ***min(n, m)*** (take at least 10 such values in the interval). In each case, plot the resultant ***k***-rank approximation as a grayscale image. Observe how the images vary with ***k***. You can find a sample intended output in the shared folder.

- Find the lowest ***k*** such that you can clearly read out the author's name from the image corresponding to the ***k***-rank approximation.

# Marking Rubric

| | |
|---|---|
| Task 1 | 20% |
| Task 2A | 15% |
| Task 2B | 15% |
| Task 3 | 50% |

Since most of the tasks you have to do here are basically invocations of library functions, it is expected that you understand the underlying concepts properly to get full marks.

# Submission

1805xyz
|-- matrix-transformations-and-eigen-decomposition.ipynb
|-- random_eigen.py
|-- symmetric_eigen.py
|-- image_reconstruction.py
|-- image.jpg

Zip the folder and rename it to **[Student_ID].zip**

**Deadline: November 25, 2023, Saturday, 10 PM**