# Assignment 3
# Digital Image Processing
# Monsoon 2024

# Deadline: 8th November

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**General Instructions**

1. Follow the specified repository structure.
2. Make sure you run your Jupyter notebook before submitting to save all outputs.
3. Appropriately label every figure and subplot.
4. Answer any questions asked in a markdown cell in your .ipynb file, as it carries marks.
5. Allowed libraries - numpy, matplotlib, opencv(only basic functions like imread, imwrite, resize, cvtColor)
6. Make an effort to vectorize your code as it contains 20% weight.
7. You have to implement Q1 and Q2 from scratch without using CV2 fft functions. You can use CV2 functions from Q3 onwards

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## 1 Question

1.1 Write a function `dft1` that calculates the DFT of 1D array of arbritrary size. Now use this function to decode the frequencies in the given audio file 1.wav and plot the frequency vs magnitude graph. Note: You may use librosa library to read the wav file.

1.2 Write a function `dft2` that calculates the 2D-DFT of a 2D array, using `dft1`.

1.3 Write a function `fft1` that computes the DFT of a 1D array using the FFT algorithm (you may pad the array with extra values to make its length a power of 2)

1.4 Write a function `fft2` that computes the 2D-DFT of a 2D array using `ff1` and handle the padding.

1.5 Compute the DFT of arrays of different lengths: [128, 256, 512, 1024] using `dft1`, repeat the same using `fft1`. Make a plot of the Time Taken vs length of array and comment on the observed differences.

1.6 Compute the 2D-DFT and 2D-FFT of the following image signals and display the outputs (1) $I = 0.5(1 + \sin x)$, (2) $I = 0.5(1 + \sin x \sin y)$ and (3) $I = 0.5(1 + \sin x^2 + y^2)$

1.7 Compute the 2D-DFT of img1.jpg and display the output. Then, apply the 2D DFT again to the result and display the final output. Provide comments on your observations.

## 2 Question

1. Reconstruct the decoded frequency spectrum of 1.wav by writing a function `ifft1` and plot (1) original signal, (2) frequency spectrum from question 1 and (3) the decoded signal
2. Write a function `ifft2` to compute the 2D inverse fourier transform of a 2D array and use it to reconstruct img1.jpg from fourier spectrum. Plot the (1) original image, (2) it's fourier transform from question 1 (3) reconstructed image.

3. Compute the 2D FFT of ein.jpg and plot the phase and magnitude along with the original image side by side.

4. Now, replace the phase spectrum with a random phase, while keeping the magnitude spectrum unchanged. Then plot (1) The magnitude spectrum, (2) The new random phase, (3) The unchanged magnitude spectrum combined with the random phase, (4) The Inverse Fourier Transform of the combined plot.

5. Now, replace the magnitude spectrum with a constant magnitude while keeping the phase spectrum unchanged. Keep the value of the magnitude equal to the **mean** of original magnitude spectrum. Then plot (1) The new constant magnitude spectrum, (2) The unchanged phase spectrum, (3) The constant magnitude combined with the unchanged phase, (4) The Inverse Fourier Transform of the combined plot.

# 3 Question

Vansh is trying to mark his attendance for the DIP class using a fingerprint scanner. However, because he is in hurry to leave the class, the fingerprint got smudged making it difficult for the system to process his attendance. As a student of DIP, your task is to help Vansh by cleaning the image fingerprint.png. Hint: Can explore Lowpass and Highpass Filters.

# 4 Question

Vansh is facing a frustrating issue: due to his poor internet connection, images on his machine are being rendered in low resolution, making it hard for him to enjoy a clear view. As a solution, you are tasked with writing a code that can enhance the resolution of google.jpeg and restores its clarity.

Hint: Can explore Lowpass and Highpass Filters.

# 5 Question

Vansh recently captured a photograph on his phone, but due to some unintended artifacts introduced during the capture process, the quality of the image has been compromised. Being an amateur photographer, Vansh is disappointed with the imperfections obscuring the beauty of the image. You are his last hope to restore the photograph to its original splendour!

Using the techniques you have learned in your DIP course, identify and remove the artifacts from the bird.png and cart.jpg to reveal the underlying scene. Explain the approach and steps you would take to restore the image and discuss the specific image processing techniques involved in correcting such issues.

# 6 Question

Vansh recently took a picture of some coins scattered on his desk but, being a bit lazy, he doesn't feel like counting the coins manually. Your task is to help Vansh by identifying and counting the number of coins in coin.jpg using morphological operations. The goal is to automate the process, ensuring that Vansh never has to manually count his coins again! Use morphological operations and thresholding techniques to preprocess the image and isolate the coins Calculate the distinct number of white regions in the thresholded image to determine the number of coins present.

# 7 Question

The human skeletal system is a fascinating and complex structure made up of numerous bones, but have you ever wondered if it's the most efficient design? To explore this concept further, you are tasked with performing skeletonization on the human.png.

# 8 Question

Vansh is trying to mark his attendance again. However, because his hands weren't clean this time, the scanned fingerprint image contains various artifacts and noise, making it difficult for the system to process his attendance. Your task is to help Vansh by cleaning the fingerprint2.png and detecting the key edges needed for accurate recognition. Hint: Can explore morphological operations, gabor filter, thresholding, skeletonization.