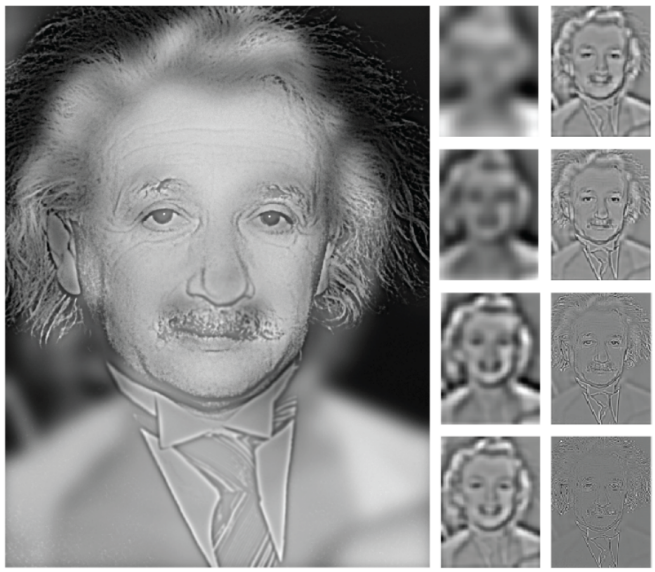
# EE200: Signals, Systems and Networks

**Instructor: Dr. Tushar Sandhan** **Department: EE**
**Topic: Practical** **Marks: 20%**

**Instructions**
- You have to submit a zip file having Python notebook and a report pdf file
- Each question carries 10%, carefully analyze various aspects of the problem
- Corresponding images, audio file and tutorial for signal manipulation are provided in the zip file

**Q1. Frequency mixer: 'Beauty and the Blur'**

Our visual system instinctively selects the appropriate scale to extract relevant details from an image. For instance, signs of aging—like fine wrinkles—are usually captured in the high spatial frequency components of an image. Thus visual system uses various spatial frequencies for different face categorizations. Image $I(x, y)$ is a finite aperiodic 2D discrete signal with intensity variations in both $x$ and $y$ directions. Thus to analyze frequencies, we need to find 2D discrete variable Fourier transform of $I(x, y)$.



When you look into the above image from less proximity (or when you wide open eyes from same distance), you can see Einstein and when you look from far (or when you squeeze eyes keeping only narrow part of the eyelid open from same distance as earlier) you can see Merlyn Monroe. You can observe, low-frequency components carry the overall structure (e.g. color gradients), while high-frequencies capture fine details (e.g. edges).

Write the equations governing 2D discrete variable Fourier transform. Use the Python programming to directly calculate (using available library functions) 2D Fourier transform of any one of the input images given to you, plot its magnitude spectra in normal form and in dB form. Where is this spectrum centered at? Can you shift it to make lower frequencies located at center of 2D transform. Rotate the input image anti-clockwise 90-degrees and plot its 2D Fourier transform magnitude spectra. Compare this spectra with original image's spectra, write your observations.

Write a Python code to creatively fuse the given two images, One provides the fine details and the other provides the overall structure of the image. This will result in a new image where different frequencies contribute to different perceptual information. Write all the details and transfer function 2D plots of your designed system. This system is known as frequency mixer.

**Q2. Frequency de-mixer: 'Unwanted Solo'**

In music production, sound engineers often needs to manipulate audio to restore or enhance recordings. One common challenge is removing unwanted sounds from a mixture, whether it's background noise, an instrument played out of sync, or an element that simply doesn't belong.

You are given a music track that has been corrupted by the presence of an unwanted instrumental beats, disrupting the intended harmony. Your task is to analyze the frequency characteristics of the input, then design and implement an appropriate filtering technique using Python to suppress the interfering component. The goal is to recover the original song as faithfully as possible and export the cleaned version.

Use various analysis tools like Bode graphs, power spectral density, pole-zero plots of your system design and isolate frequency regions, and design filters accordingly to remove unwanted solo instrumental music. Your final submission should include your code, the restored audio file, and a detailed explanation of your method and design choices. This system is known as frequency de-mixer.

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