Homework 03: Fourier Analysis

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Handout: 2025-09-15
Due: 2025-09-22, 11:59pm, on Canvas

General Instructions:

- You should solve the homework and submit your report **individually**. Identical submissions will receive a grade of zero.
- Getting help from others or checking your answers with other students (not the TAs) is okay and encouraged.
- Ask any questions on **Ed Discussion** (instead of emailing).
- **Before** the homework due date, TAs are strictly prohibited from **pre-grading** your homework. Do not expect the TAs to help you verify if your answers are correct or give you the problem solution.
- **After** the homework due date, if you do not know how to solve a problem, reach out to the TAs. They will walk you through the solution and help you understand it. Note that homework solutions will **not** be posted because some problems will be used in next year's class.
- **Exams** may contain questions related to homework, so make sure you learn how to solve the homework problems correctly.
- The deliverables are outlined for each problem, and you should carefully **follow the instructions**. Failing to follow instructions will result in **points being subtracted**.
- You will submit a **single PDF** file to Canvas as your homework report. The PDF must contain your **answers** and any requested **outputs** (e.g., printouts, snapshots of code, or GUIs). If requested, follow the instructions specified by the problem to provide your **code** (e.g., in a compressed .zip or .tar file) in addition to the PDF file.
- **Grading:** Each homework in this class will contribute **5pts** to your final grade (there will be 12 homework assignments, each 5pts, leading to 60pts for all assignments). A detailed grading **rubric** will be posted on **Canvas** after the homework due date. Any bonus points will be added to your overall course bonus points, which will be added to your final grade.
- **Late submission:** Late or missed submission will not be accepted and will receive a grade a zero. Any excused absence must be documented and disclosed to the instructor (extensions will be granted on a case-by-case basis). Three or more missed homework lead to an INC grade.

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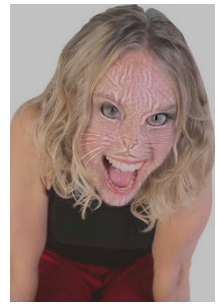
EXERCISE 1 (5pts) – The objective of this homework is to practice Fourier transform and frequency domain representation of images by creating a hybrid image via the approach described in SIGGRAPH 2006 paper by Oliva, Torralba, and Schyns (http://olivalab.mit.edu/publications/OlivaTorralb_Hybrid_Siggraph06.pdf). Do **NOT** rely on generative AI; otherwise, you will not learn to code!



High frequency image content tends to dominate perception but, at a distance, only low frequency (smooth) content is perceived. By blending high and low frequency content, we can create a hybrid image that is perceived differently at different distances. Use images that are well-aligned to ensure perceptual grouping (read the paper for details; this site http://olivalab.mit.edu/hybrid_gallery/gallery.html has several examples). Then, write code to low-pass filter one image, high-pass filter the second image, and add (or average) the two images. For a low-pass filter, the paper suggests using a standard 2D Gaussian filter. For a high-pass filter, they suggest using an impulse filter minus a Gaussian filter (which can be computed by subtracting a Gaussian-filtered image from its original). The cutoff-frequency (http://en.wikipedia.org/wiki/Cutoff_frequency) of each filter (or σ of Gaussian filter) should be chosen with some experimentation to get visually appealing results.

Steps:

- Load the headshot image of ***yourself*** (used in HW01). Convert it to grayscale and appropriate type (e.g., float32) as needed. You can crop or resize your image to have 50-100 pixels in each dimension. Computer & display the Fourier transform ***magnitude*** image of your input image (no need to show the phase image). Apply ***log transform*** to ***all*** your magnitude images (or use log-scale) for better visibility.
- Low-pass filter your headshot image (e.g. using a standard 2D Gaussian filter). Display the filtered image, AND its Fourier magnitude image. You can use an existing filtering function/library and there is no need to implement the filter yourself.
- High-pass filter another image of your choosing. However, the selected image should be (or modified to be) ***well-aligned with your headshot*** (e.g., if you choose a cat picture, the cat's face should match the size and location of your face on the image). High-pass filter can be computed by subtracting a low-pass filtered image from its original. The high-pass image can have negative pixels, so, ***only for visualization,*** rescale the image to the correct range. Display the filtered image, AND its Fourier magnitude image.
- Combine the images (using the method of your choosing, or as described above) and display the result. Display the Fourier magnitude image of the combined image.

Deliverables:

- Snapshot of your entire code.
- Snapshot of your headshot image and its Fourier magnitude image.
- Snapshot of your low-pass headshot image and its Fourier magnitude.
- Snapshot of the 2nd image, its high-pass filtered image, and the Fourier magnitude of the high-pass image.
- Snapshot of combined image and its Fourier magnitude.