Homework 03: Fourier Analysis

Kaveh Fathian, Email: fathian@ariarobotics.com

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 the <u>SIGGRAPH 2006 paper by Oliva, Torralba, and Schyns</u>. 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 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 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 logscale) 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.