CS/ECE 8690 Computer Vision Spring 2023
Homework 1A: Hybrid Images in Python [40 pts]

Out: Thursday Jan 26, 2023

Due: Thursday Feb 2, 2023 (Midnight)

The goals of this first assignment are:
(1) to become familiar with image processing in Python using Numpy and/or OpenCV libraries;
(2) trying out basic image read, write, access, display and plotting functions; and
(3) review of basic image filtering and arithmetic operations. This project will require you to perform 2D convolution, Gaussian blurring (low pass filtering), image sharpening (high pass filtering). Numpy has numerous built in and efficient functions to perform image filtering. See lecture slides Lec03_Filtering on Canvas for image filtering.

Overview of Hybrid Images

The goal of this assignment is to create a simplified version of hybrid images described in [1]. Hybrid images are static images that change in interpretation as a function of the viewing distance. The basic idea is that high frequency tends to dominate perception when it is available, but, at a distance, only the low frequency (smooth) part of the signal can be seen.

Hybrid images are generated by superimposing two images at two different spatial scales as illustrated in Figure 1 [1]:

1. The low-spatial scale is obtained by filtering one image with a low-pass filter,
2. The high spatial scale is obtained by filtering a second image with a high-pass filter,
3. The final hybrid image is composed by adding these two filtered images.

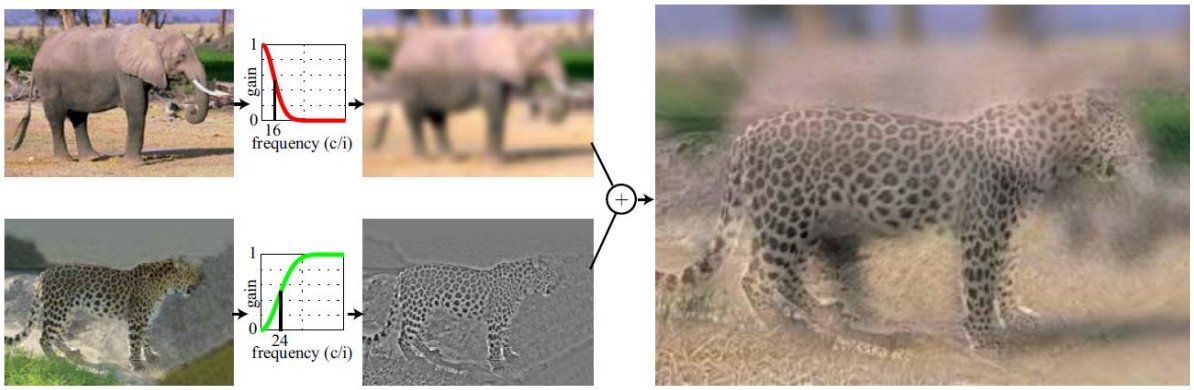

Figure 1. Hybrid images are generation process [1].

Blending the high frequency portion of one image with the low-frequency portion of other leads to different interpretations at different distances.

Assignment

Given the two test images:

1. For both input images, generate and display: (a) low pass filtered (smooth) image; (b) difference between original image and smooth image; (c) sharpened image.
2. For both input images and their smooth and sharpened versions, compute and plot red, green, blue channel histograms.
3. Compute and display hybrid images for two sigma values.

Implementation details:

High and Low Pass Filters: low pass filter is one that removed the fine details from an image, whereas a high pass filter only retails the fine details, and gets rid of the coarse details from an image. You will be using Gaussian blurring to implement high pass and low pass filtered images.

Hybrid Image: is the sum of a low-pass filtered version of the one image and a high-pass filtered version of a second image. There is a free parameter, which can be tuned for each image pair, which controls how much high frequency to remove from the first image and how much low frequency to leave in the second image. This is called the "cutoff-frequency". In the paper it is suggested to use two cutoff frequencies (one tuned for each image) and you are free to try that, as well. In your code, since you will be using spatial domain filtering, the cutoff frequency will be controlled by changing the standard deviation (sigma) of the Gausian filter used in constructing the hybrid images.

Implementation issues to consider and be aware of:

- input pixel data type (unsigned char vs float vs double),
- computation pixel data type,
- output pixel data type,
- accessing color channels,
- image dimensions,
- row-column indexing,
- zero vs one convention (array vs matrix representation),
- input and output image file formats

Report Structure: Your Written Report must conform to the following format.

1. Header
    - Course number and name
    - Assignment number and title
    - Your name
    - Date
2. Abstract (2 to 3 sentences describing the problem and the major results obtained)
3. Introduction (A brief statement of the experiments to be performed and the goal of the assignment)

4. Experiments and Results (figures, tables, graphs, …). You need to use given test images.
5. Discussion/Conclusions
6. References/Appendix (As needed)

Submission Instructions: Submit electronic version from Canvas (https://courses.missouri.edu/). Submit an archive (tar) file that contains the following directories and files:

1. src - should contain all python files
2. A report in PDF format (not Word or other formats that are difficult to handle with images and equations). Note that you can print to PDF.
3. Images (if any) should be in a separate folder - for example if you tried your own images

Tar file naming convention: CVSpring2023_LastName_FirstName_Assignment#

Windows users can use 7zip to create tar files.

Acknowledgements

This assignment was based on versions developed by James Hays (Gatech), Derek Hoiem (UIUC), and Noah Snavely (Cornell).

References

1. Oliva, Aude, Antonio Torralba, and Philippe G. Schyns. "Hybrid images." ACM Transactions on Graphics (TOG) 25, no. 3 (2006): 527-532.
2. General tools that are useful to look at your input and output images: NIH ImageJ or Fiji which is an extension of ImageJ (opensource Java), imageMagick (opensource), gimp (opensource C++), Paint.Net, irfanview (shareware), Adobe Photoshop, Preview (MacOS), Windows PhotoViewer.
3. Lect03_Filtering_FB.pdf
4. Canvas\Modules\ Tutorials