

Project 1: Hybrid Images



Look at the image from very close and then very far. What do you see?

Overview

The goal of this assignment is to write an image filtering function and use it to create hybrid images. 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. By blending the high frequency portion of one image with the low-frequency portion of another, you get a hybrid image that leads to different interpretations at different distances. You will use your own solution to create your own hybrid images

Implementation Details

This project is intended to familiarize you with Python, NumPy and image filtering. Once you have created an image filtering function, it is relatively straightforward to construct hybrid images.

This project requires you to implement 5 functions each of which builds onto a previous function:

1. `cross_correlation_2d`
2. `convolve_2d`

3. `gaussian_blur_kernel_2d`
4. `low_pass`
5. `high_pass`

Image Filtering. Image filtering (or convolution) is a fundamental image processing tool. See chapter 3.2 of Szeliski and the lecture materials to learn about image filtering (specifically linear filtering). Numpy has numerous built in and efficient functions to perform image filtering, but you will be writing your own such function from scratch for this assignment. More specifically, you will implement `cross_correlation_2d`, followed by `convolve_2d` which would use `cross_correlation_2d`.

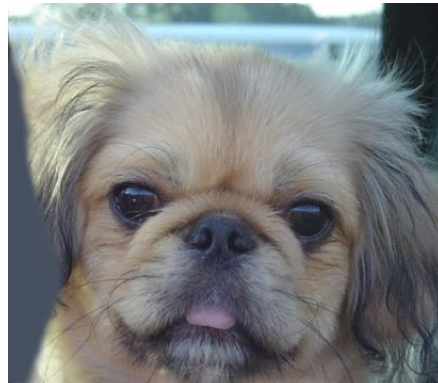
Gaussian Blur. As you have seen in the lectures, there are a few different way to blur an image, for example taking an unweighted average of the neighboring pixels. Gaussian blur is a special kind of weighted averaging of neighboring pixels, and is described in the lecture slides. To implement Gaussian blur, you will implement a function `gaussian_blur_kernel_2d` that produces a kernel of a given height and width which can then be passed to `convolve_2d` from above, along with an image, to produce a blurred version of the image.

High and Low Pass Filters. Recall that a low pass filter is one that removed the fine details from an image (or, really, any signal), whereas a high pass filter only retains the fine details, and gets rid of the coarse details from an image. Thus, using **Gaussian blurring** as described above, implement `high_pass` and `low_pass` functions.

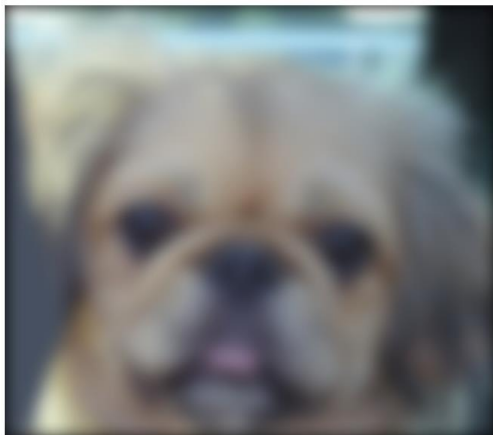
Hybrid Images. A hybrid image is the sum of a low-pass filtered version of the one image and a high-pass filtered version of a second image. There is a free parameter, which can be tuned for each image pair, which controls how much high frequency to remove from the first image and how much low frequency to leave in the second image. This is called the "cutoff-frequency". In the paper (A. Oliva, A. Torralba, P.G. Schyns, "Hybrid Images," SIGGRAPH 2006) it is suggested to use two cutoff frequencies (one tuned for each image) and you are free to try that, as well. In the starter code, the cutoff frequency is controlled by changing the standard deviation (sigma) of the Gaussian filter used in constructing the hybrid images.

Forbidden functions. For just this assignment, you are forbidden from using any Numpy, Scipy, OpenCV, or other preimplemented functions for filtering. This limitation will be lifted in future assignments, but for now, you should use for loops or Numpy vectorization to apply a kernel to each pixel in the image. The bulk of your code will be in `cross_correlation_2d`, and `gaussian_blur_kernel_2d` with the other functions using these functions either directly or through one of the other functions you implement

For the example shown at the top of the page, the two original images look like this:



The low-pass (blurred) and high-pass versions of these images look like this::



Adding the high and low frequencies together gives you the image at the top of this page. If you're having trouble seeing the multiple interpretations of the image, a useful way to visualize the effect is by progressively down sampling the hybrid image as is done below:



Submission

- **hybrid.py**: Submit with all five functions implemented
- **left.png, right.png**: Submit the left and right images you used to create hybrid image. (could be in any format (not necessarily png))
- **hybrid.png**: Submit the hybrid image produced by using your implementation and left, right images
- **README**
 - Must contain high pass and low pass filter parameters (kernel size and kernel sigma) and Mix-in ratio.
 - It should also contain which image's higher/lower frequencies are used.
 - **Optionally** you can add comments on something interesting or different you did in the project.

Acknowledgements

Assignment based on versions developed by James Hays and Derek Hoiem.