**Laplacian Pyramids and Image Blending**

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E27: Computer Vision, Prof. Matt Zucker

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***Final Results:***

* Laplacian Pyramid Blending
  + Sunflower and Matt’s face
  + Brown bear and penguin
* Hybrid Images
  + Obama and Biden
  + Kennedy and Nixon
  + Lincoln and Lincoln Memorial

***Who did what for this project?***

All three team members worked together on generating a Laplacian pyramid and using it to reconstruct an image. Throughout this process, we took turns writing code and looking up documentation. Nhung wrote an image alignment program that geographically centers the object of interest in a given image. The program also detects human faces as objects of interest and geographically centers that onto a black background image. Richard wrote the alpha blend function and fine-tuned the Laplacian program to use images generated by the alignment program. Dan wrote the hybrid image program, and all three members adjusted the parameters defined in the program to fit all the images we tested the program with. Additionally, we all contributed to this project report.

***How did you obtain and align your images for each of the two tasks? Did you use any third party software (e.g. Paintbrush, Photoshop), or write a program to help prepare the images or mask?***

We obtained all of our images using Google Image search. The criterion was that the background was not too complex in terms of colors and shapes— we wanted the object of interest to have visually obvious distinctions from the image background. Often times, we found pairs of images that were compatible (i.e. it made sense to blend them together), but were not the same dimensions. For those cases, we used Microsoft Paint to crop the images to the correct aspect ratio and an online image resizer (<http://resizeimage.net/>) to scale the images. For the Laplacian pyramid blending procedure, our alignment program was used to geographically center the object of interest within a given image. Assuming that a second image contains only one face, the program also detects that face and centers it on a black background image. The resulting image is used for the mask in the Laplacian pyramid program.

***What depth did you choose to build your Laplacian pyramid to, and why?***

***Why does Laplacian pyramid blending blend low-frequency content over a larger distance than high-frequency content? See if you can illustrate this with some carefully chosen input image examples.***

***How did you arrive at good values for the constants σA, σB, kA, and kB for the hybrid image generation? Describe the process.***

Our primary goal while optimizing the hybrid\_image.py function was to create a well-balanced hybrid image. The first major decision we made was to convert the input images to grayscale before merging them into the hybrid. We found that overlaying two colored images with each other tended to dull the colors in each image making the final product largely unrecognizable. Meanwhile, grayscale images blended much more smoothly and created recognizable hybrid images.

The first parameter we optimized was the kernel size for the GaussianBlur() function called in our lopass() function. We wanted a Gaussian kernel that yielded a significant blurring effect in order to create strong low-pass and high-pass filters. However, if the blurring effect was too strong, our input images would be over-filtered and neither would be comprehensible in the hybrid image. For the most part, every set of images required a different set of parameters to optimize their hybrid, but we found that a kernel size of 11 for both the high-pass and low-pass filters worked across the board. This value created a meaningful blur, which could be tweaked further by adjusting the parameters, *σA* and *σB*.

The next set of parameters we tweaked were the standard deviations of the GaussianBlur() function, *σA* and *σB*. The parameter *σA* was related to the low-pass filter. Increasing the value made the low-pass filter stronger, thus blurring the image more. The parameter *σB* was related to the high-pass filter. Increasing it made the high-pass filter stronger, which left behind outlines and shapes, but eliminated less pronounced features. When either of the standard deviation values was increased past 5, it no longer appeared to have a noticeable effect on the filter. We set *σA* = 5 for all sets of images, while *σB* ranged between 2 and 4 depending on how sharp the high-pass filter needed to be.

The last parameter we altered were the weights of each filtered image, *kA* and *kB*, in the final hybrid image. In most scenarios, the low-pass filtered image tended to obscure the high-pass filtered image. To rectify this, the ratio *kB*/*kA* needed to be greater than one; we ended up with values of 2,3 and 5 for our various overlays.

All of these parameters were determined by creating a for loop to iterate over one parameter while all others were held constant. After each iteration, the final hybrid image was displayed and compared against the previous version. In the Obama-Biden overlay, Biden image (low-pass filtered) tended to obscure the Obama image (high-pass) so we set *σB* to be relatively large to emphasize the high frequency features in the Obama image would be highlighted better. This also filtered out more of the image so we had to increase *kB* as well to compensate.

***If you display your hybrid image at full size on your computer screen, how close do you need to be in order to primarly see image B? How far away do you need to get before you only see features from image A? Are these distances fairly consistent between you, your lab partner, and any unsuspecting friends you show your image to?***

The least successful hybrid image we created was the combination of Abraham Lincoln and the Lincoln Memorial. Both images were easily made out at close range and long range since they differed so significantly. Hybrid images of faces were typically far better. In the Obama-Biden hybrid image, Obama stands out when sitting less than 6 ft from the laptop screen and Biden stands out when sitting more than 8 ft from the screen. The same is true for the Nixon-Kennedy hybrid image, with Nixon visible at less than 6 ft and Kennedy visible at greater than 8 ft.

***What does the Laplacian pyramid of your hybrid image look like?***