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Major Project 1 – Hybrid Images

Hybrid Images

In this project we explored the idea of hybrid images. The goal was to create a new output image from two input images so that depending on the viewing distance or size of the image one could change which image they saw. This works do to how our eyes perceive imaging in terms of frequencies. When higher frequencies are available to our eyes, such as when we are near an object, or the object is large, we will see those frequencies. However, when viewing something at a further distance we do not have access to those higher frequencies and perceive only the lower frequencies. In order to complete this project one of the input images needed to be passed through a high pass filter to preserve only the high frequencies (the image the viewer should see at closer viewing distances or when the image is enlarged) and the other through a low pass filter, preserving the lower frequencies while discarding the higher ones (the image the viewer will see at further viewing distances or when the image is shrunk. The way we filtered these is using a Gaussian filter. This filter was tuned using a variable sigma which seeded the kernel used. The Gaussian filter smooths images, in other words is a low pass filter. In order to create a high pass filter, we must remove the Gaussian filter's output from the original image, effectively discarding all low frequencies while maintaining the higher ones.

We can better understand this through the illustrations below:

[Loftus, G.R., Harley, E.M. Why is it easier to identify someone close than far away?. *Psychonomic Bulletin & Review* **12**, 43–65 (2005). https://doi.org/10.3758/BF03196348]

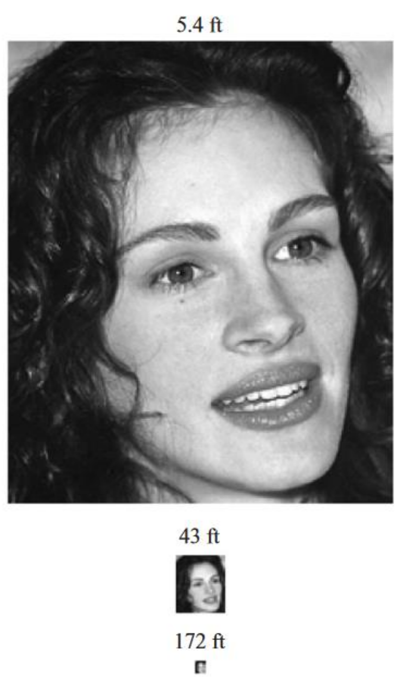
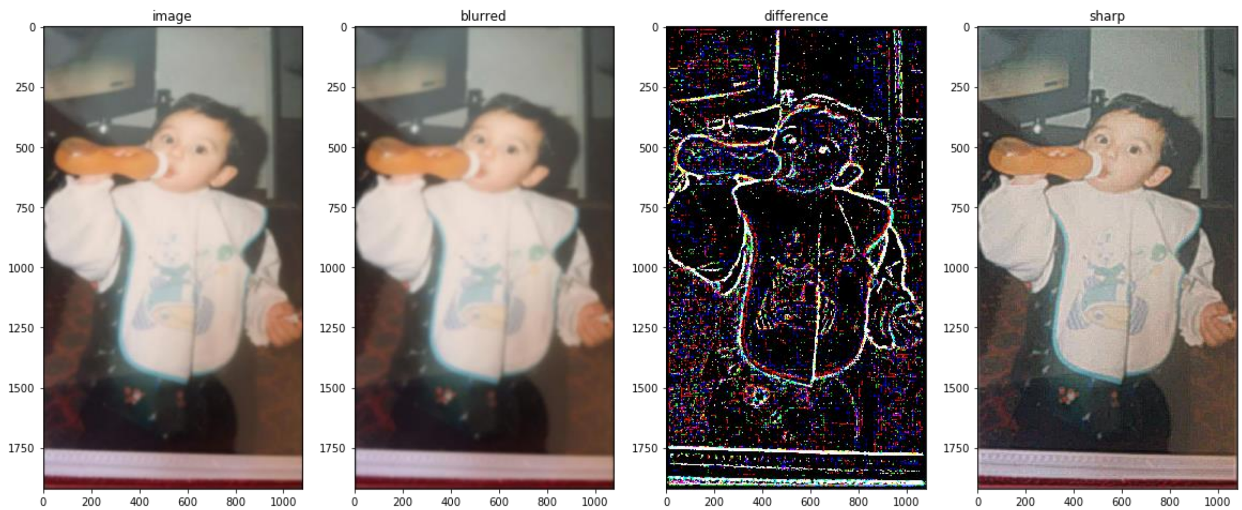


Figure 1. Representation of distance by reduction of visual angle. The visual angles implied by the three viewing distances are correct if this page is viewed from a distance of 22 in.

In the above image the woman's face is depicted as would be seen from several different viewing distances. As we can see as we move further from the person/image we begin to lose details (higher frequencies) and there is a smoothing effect that takes place. And this is the physics and anatomy that we are able to take advantage of in order to develop hybrid images.

To understand more about Gaussian blurring and how it can be used to get the high and low frequencies of an image we can see the image below where the blurred image is the Gaussian filtered image and the difference is the image with the Gaussian filtered image subtracted:

[CS194-26 Image Manipulation and Computational Photography – Project 3: Fun with Frequencies and Gradients – Morad Shefa cs194-26-adx]



Contrast Enhancement

For contrast enhancement we have a few options. The two I decided to explore were color adjustment to fit the "gray world" assumption combined with gamma adjustment to adjust the brightness level of the image. Color balancing with the "gray world" assumption is done by taking the average (mean) of the entire image, we than get a modifier for the R, G, and B channels by taking the average of each of those channels and dividing the average of the entire image by those individually. These modifiers will then be applied to each pixel in those channels and recombined to get an image. After this we can adjust the gamma by taking that image to the power of something (the smaller the gamma, the brighter the image).

Another method I used in this was histogram equalization. For this I used the HSV color space. I did this so I could use the built in cv2.equlaizeHist function and equalize the histogram along the hue (h channel) which contains the chroma information.

Using both these methods, I preferred the outcome from the color balanced and gamma adjusted image. The colors seem to be more "realistic" or true to life than the image produced from histogram equalization.

Color Enhancement

With color enhancement we are trying to make the image more vivid or vibrant by making the colors brighter, without changing the intensity of the image itself. Again I chose the HSV color space so that I could take advantage of the saturation (s channel). We need to be aware that the values in this channel are mapped to values between 0 And 255, so we are not able to perform linear scaling. In order to preserve this I initially remapped the values in the s channel to be between 0 and 1 by dividing the channel by 255. After this we can now increase the saturation levels by taking the square root of each pixel, while still preserving the 0 to 1 mapping of the values. Once we have the increased saturation we can multiply the channel by 255 to remap it back to the original range and combine the new s channel with the original h and v channels to produce a more vibrant and vivid image without increasing the brightness of the image.

Color Shift

In this part of the project we want to produce two new images, one with more red, and one with less yellow. For this portion I chose to work in the L*a*b color space so I could adjust the chroma without effecting the luminance of the image. The a channel is mapped for red/green with a higher a value representing more red and less green, and a lower a value meaning more green and less red. The b channel is mapped similarly with a higher value meaning more yellow and less blue, with the lower values being more blue and less yellow. To produce the image with more red, we once again remap the values to be between 0 and 1 and take the square root before remapping the values back to 0-255. And for the less yellow image we also remap to 0-1 but this time instead of the taking the square root, since we want smaller values we square the values, and once again remap back to 0-255. When these images are combined back into the initial images we can get the desired effect.