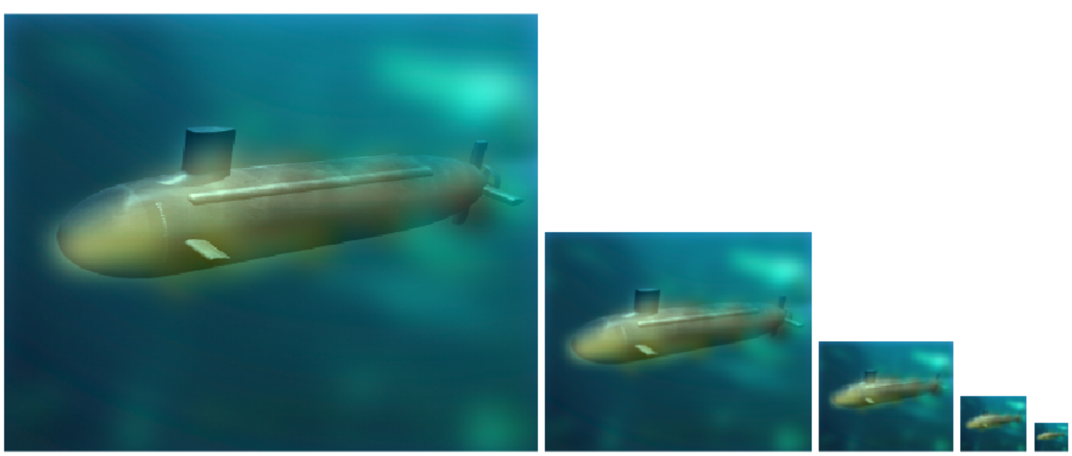
Part 1

Firstly, we provide three hybrid images as shown below. For convenience, we also show the image pyramid to better illustrate the hybrid image effects.

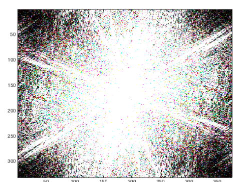
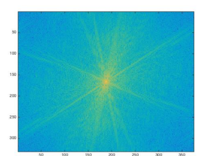
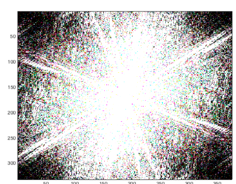
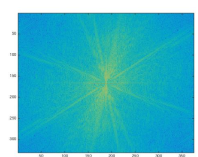
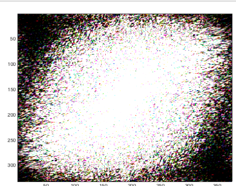
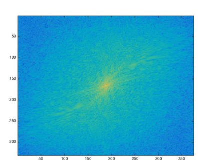
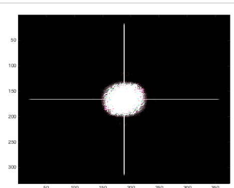
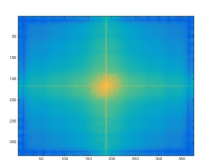
Cat Dog
High frequency image: cat
Low frequency image: dog
Gaussian Blur SD: 4.5

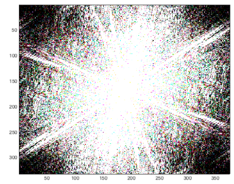
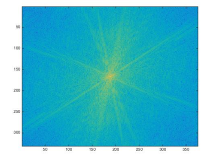
Submarine Fish
High frequency image: submarine
Low frequency image: fish
Gaussian Blur SD: 10.5

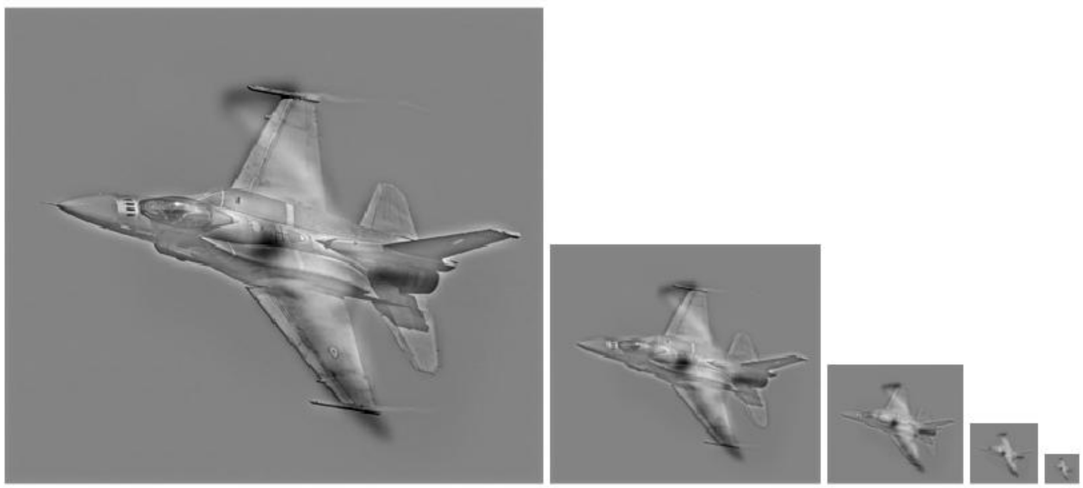


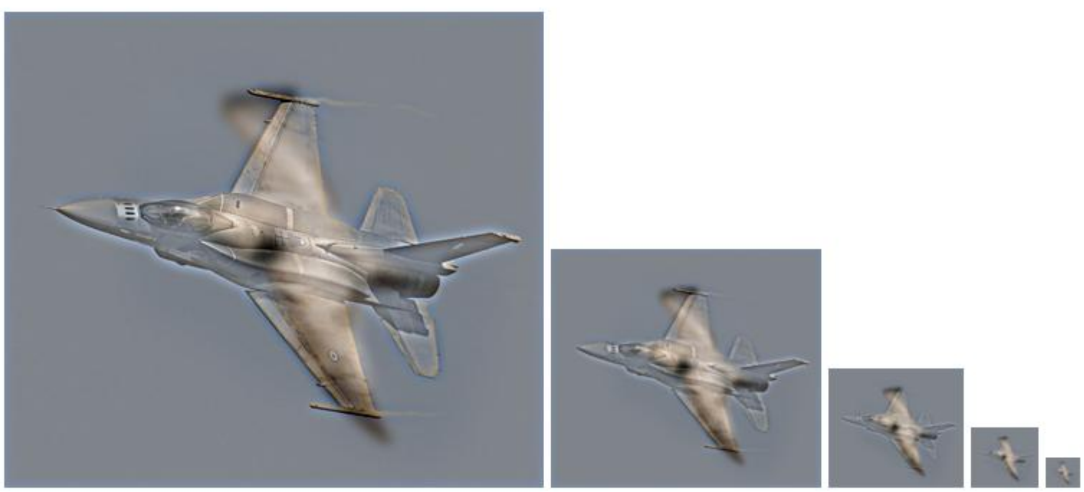
Young/Old Afghan Girl
High frequency image: young afghan girl
Low frequency image: old afghan girl
Gaussian Blur SD: 4.25

Bird Plane
How it works: An image can be thought of as a summation of frequencies. Human eyes can perceive high frequencies well at close distances, and low frequencies well at far distances. However, human eyes cannot perceive low frequencies well at close distances, nor high frequencies at high distances.
To create the “bird-plane” image, we take an image of a plane and an image of a bird, and choose the plane as the high frequency image and the bird as the low frequency image. We then remove the low frequencies from plane image to create a high frequency plane image, and then remove the high frequencies from the bird image, creating a low frequency bird image. You can see in the corresponding fourier transforms, the high frequency plane image loses the data closest to the “center" (low frequencies) of the fourier transform graph while the bird loses data everywhere but the center (high frequencies). These two images are then simply summed together, (each pixel of plane added to corresponding pixel of bird) and thus a hybrid image is created, which holds the high frequenices of a plane and the low frequencies of a bird, making humans perceive the image as a plane up close

	Image	Corresponding Fourier Transform	Corresponding Fourier Transform (Grayscale)
Plane			
Plane (filtered)			
Bird			
Bird (filtered)			

Hybrid Image			

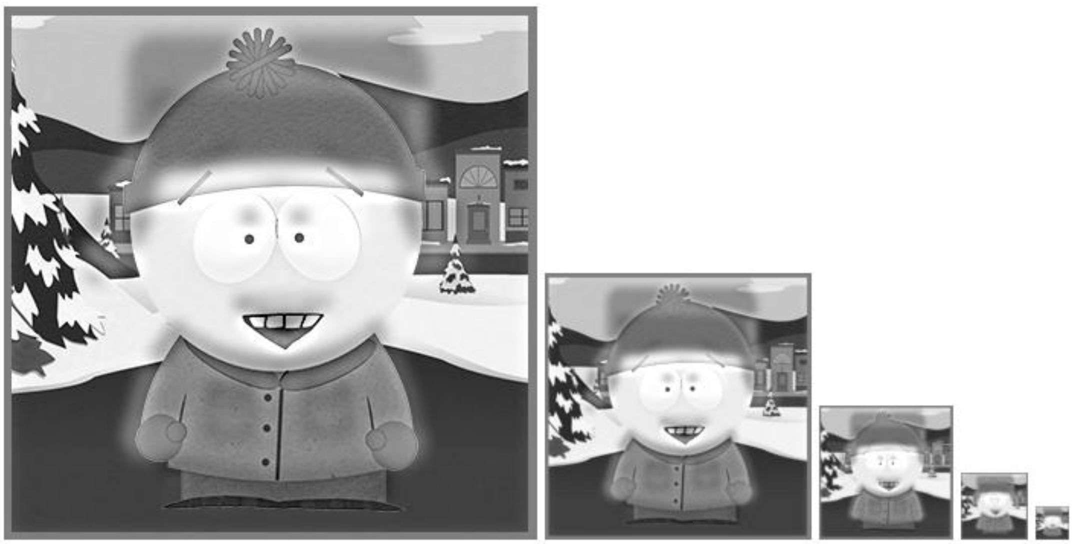




Show us at least two more hybrid image results that are not included in the homework material, including one that doesn't work so well (failure example). Briefly explain how you got the good results (e.g., chosen cut-off frequencies, alignment tricks, other techniques), as well as any difficulties and the possible reasons for the bad results.

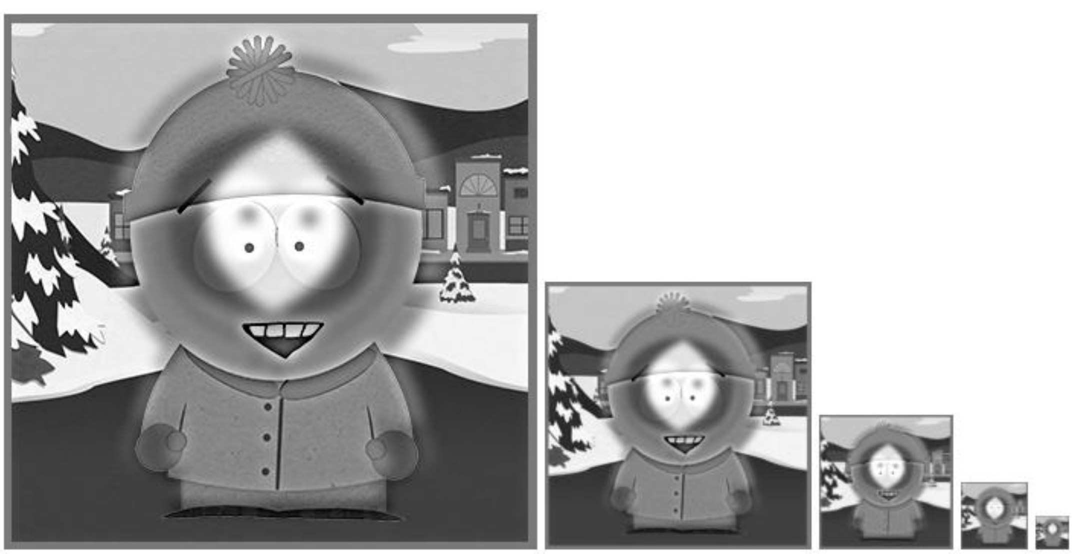
Here we have a mercedes C class and a mercedes E class. This effect really doesn’t work very well for several reasons:

- Although there are two different models of car (with a $20,000 price difference!), the two are very hard to distinguish between because of their:
  - Nearly identical color
  - Nearly identical texture
  - Nearly identical color distribution (black body, silver headlights with distinctive orange spot, red tail light)
- Improper alignment: Although both images are very closely aligned, the E class car is slightly larger, creating a ghosting effect.



In the second hybrid image, we choose to not include color, with two images that are more aligned and are more distinct. Here we can see the effect much better. The two images are Kyle B. and Stan M. from South park. In the largest image, the image is unmistakably Stan (high frequency), but in the smallest image, we unmistakably see kyle (particularly by his hat).

Try using color to enhance the effect of hybrid images. Does it work better to use color for the high-frequency component, the low-frequency component, or both?



Here we show how color can effect the outcome of the hybrid image. Taken again from South Park, we see Stan M. (right image) as the high frequency component and Kenny M. (left image) as the low frequency component.

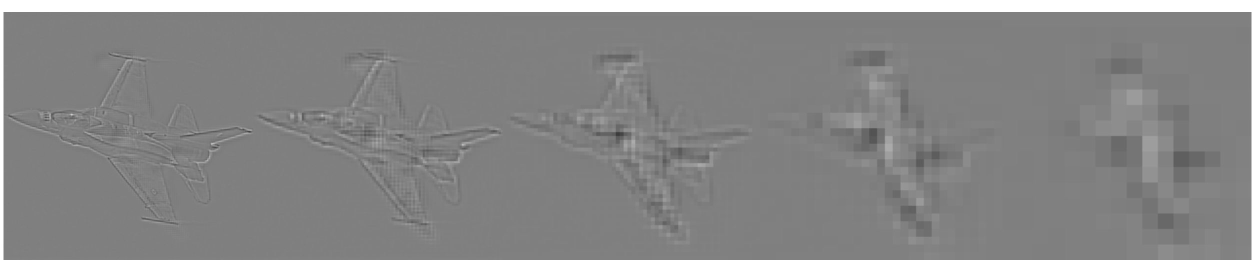
Interesting, we see that the grayscale image achieves a slightly better effect with the introduction of color. Kenny's (low frequency) orange coat dominates the color scheme of the image, and although Stan (high frequency) is still visible in the larger colored images, the dominating orange hue throws off the effect brings out the high frequency component much more strongly. Therefore, at least from this trial, it is clear that color has a much stronger impact with the lower frequency component.

Additionally, this is clear from the bird plane hybrid image, as removing the low frequencies appears to also remove a lot of color from the image.

Illustrate the hybrid image process by implementing Gaussian and Laplacian pyramids and displaying them for your favorite result. This should look similar to Figure 7 in the Oliva et al. paper.

We again use the bird plane hyrbrid image:

Gaussian (above)



Laplacian (above)

Note how in the first step of the Laplacian pyramid the bird (low frequency) component appears to be nearly non-existent.

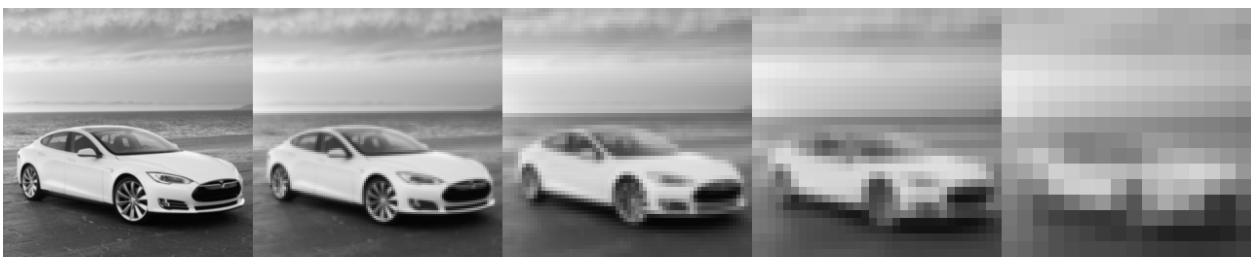
Part 2
In this part of the assignment, we choose to use a picture of a Tesla Model S to display our results. Note: this image is fairly large (1024x1024).

Note: This image is first converted to grayscale before being manipulated.

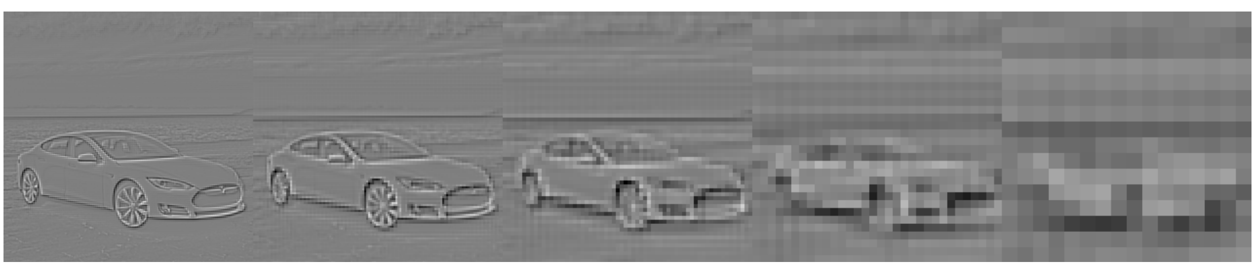
Results:

Gaussian Pyramid: (1024x1024) -> (64x64)

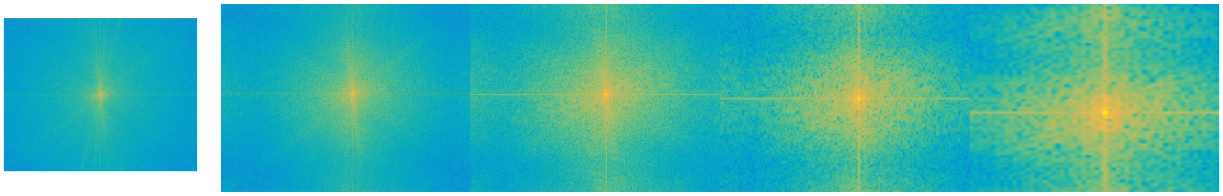
Laplacian Pyramid: (1024x1024) -> (64x64)



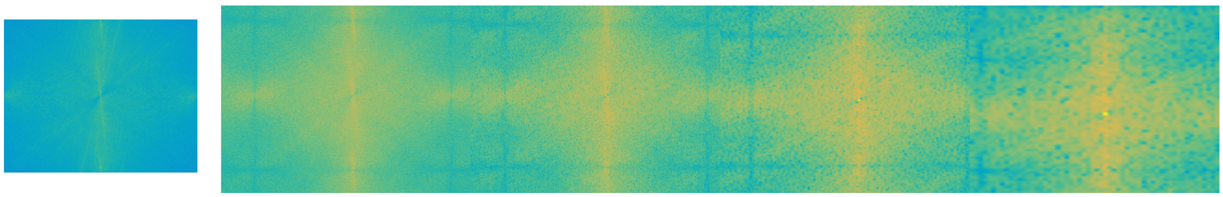
Gaussian Pyramid: (256x256) -> (16x16)



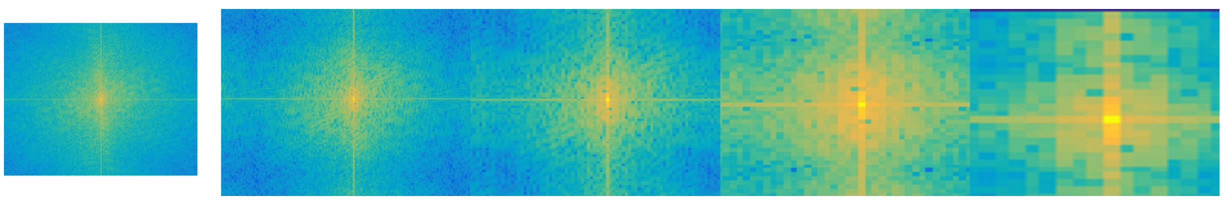
Laplacian Pyramid (256x256) -> (16x16)



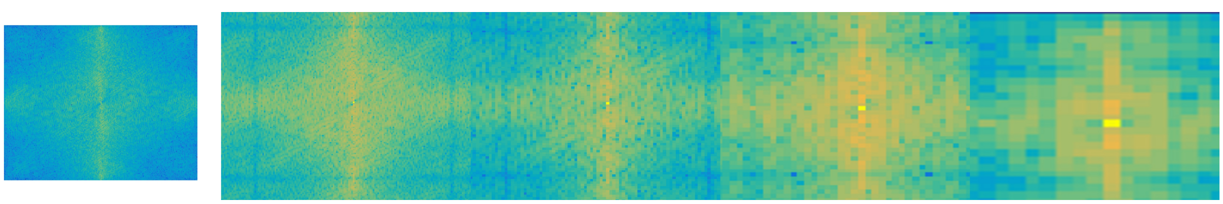
Gaussian FFT (1024x1024) -> (64x64)



Laplacian FFT (1024x1024) -> (64x64)



Gaussian FFT (256x256) -> (16x16)



Laplacian FFT (256x256) -> (16x16)

The Gaussian pyramid is applying a gaussian blur at each level, reducing the high frequency components at each successive iteration.

The Laplacian pyramid does the opposite, reducing the low frequency components at each successive iteration.

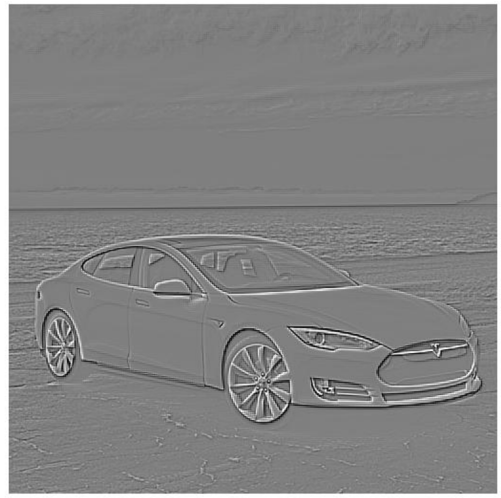
Try mutliply one of the high-frequency bands in a Laplacian pyramid by 2 and then reconstruct. Describe what this operation does to the input image. Explain how is this operation different from a simple 3x3 sharpening filter.

This operation is essentially amplifying the intensity of every single pixel in the image. Because these are laplacian images, most pixels with any value at all are pixels around edges. Therefore, because we are amplifying the intensity of pixels of a laplacian image, we are effectively sharpening the image. It is clear that this is not effective sharpening when applied to the base image, as a "washout" effect begins to happen.

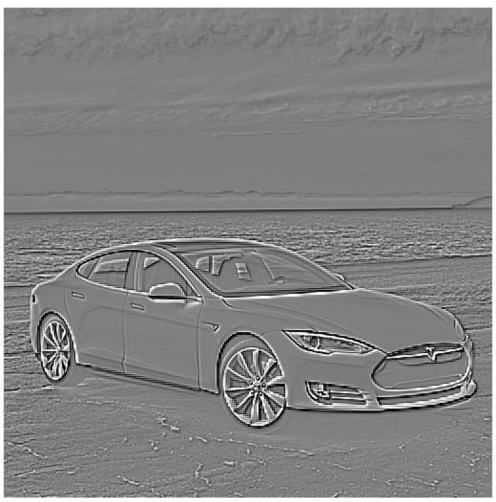
A sample 3x3 filter could be what is shown to the right. This filter is different in that it will only sharpen during intensity changes. For example, imagine our bland image = [1 1 1; 1 1 1; 1 1 1], this filter applied to the center pixel would simply equal itself, thus, no sharpening occurs when there is no intensity change. In this way, it is selective in what it sharpens, which is different than applying a broad multiplication to the entire image.

0	-1/4	0
-1/4	+2	-1/4
0	-1/4	0

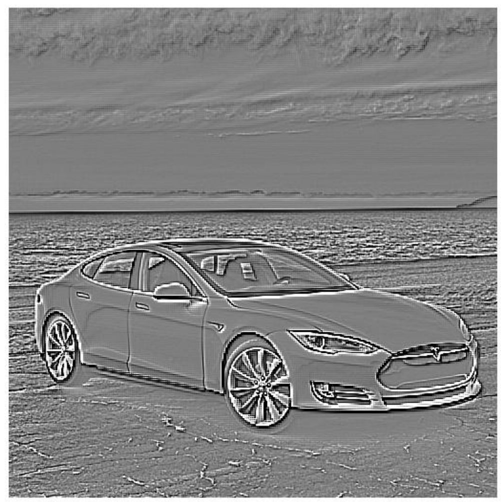
No “sharpen”



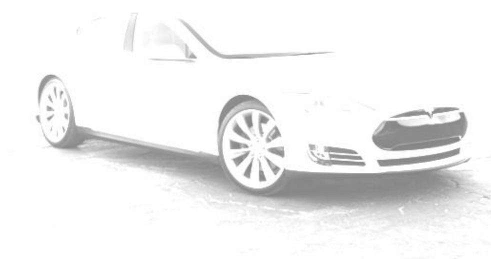
2x “sharpen”



4x “sharpen”

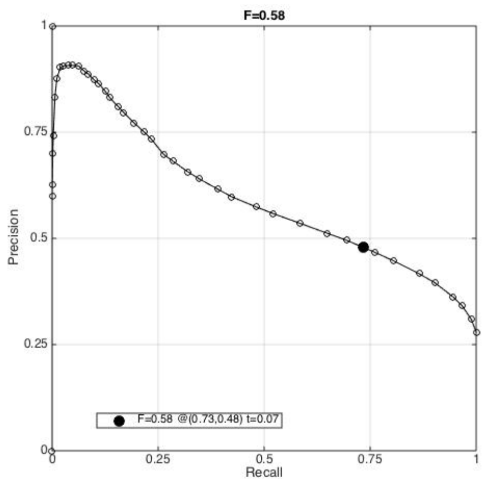


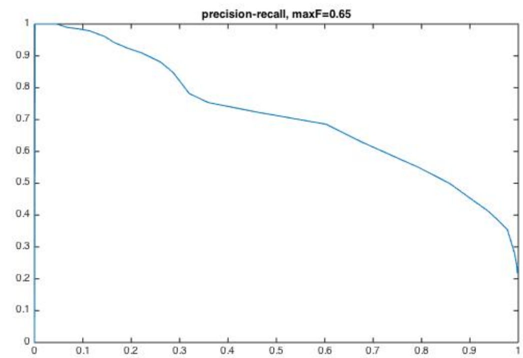
8x “sharpen”

	
2x “washout”	4x “washout”
	
Original	Reconstructed with 2x high frequency band.

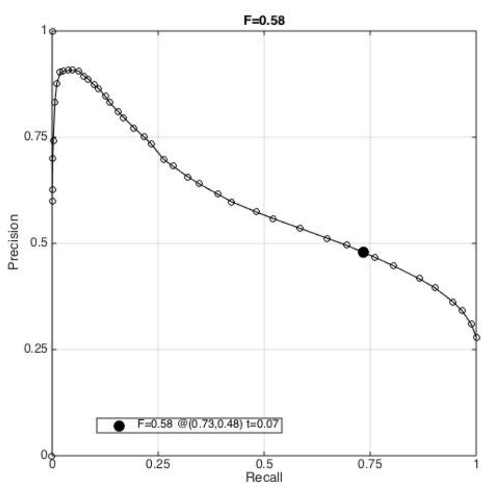
Part 3 Results:

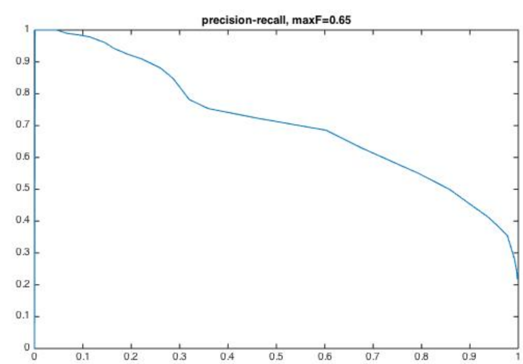
Method gradient: overall F-score = 0.579 average F-score = 0.615





Method oriented: overall F-score = 0.564 average F-score = 0.608





Describe at least one idea for improving the results. Sketch an algorithm for the proposed idea and explain why it might yield improvement. Improvements could provide, for example, a better boundary pixel score or a better suppression technique. Your idea could come from a paper you read, but cite any sources of ideas.

Idea: Modify sigma: 1 -> 1.5.
It is suggested that using this sigma is more standard, and performs the best when there is no noise, which there isn't in most of the photos.

Idea: Calculate "edge orientation" by doing calculating a least squares approximation of n consecutive points by a line or higher order cruve.

Paper:
http://dev.ipol.im/~morel/Dossier_MVA_2011_Cours_Transparents_Documents/2011_Cours1_Document1_1995-devernay--a-non-maxima-suppression-method-for-edge-detection-with-sub-pixel-accuracy.pdf