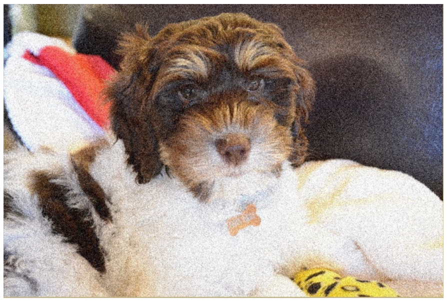
Project #1: Spatial and Frequency Filtering

CSC391: Introduction to Computer Vision

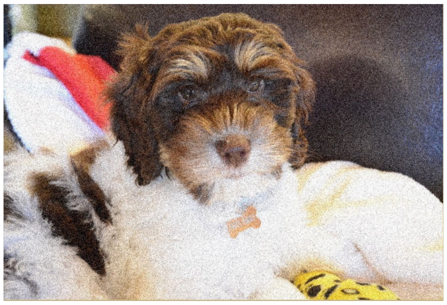
Grace Newman

Due date: Wednesday, February 6

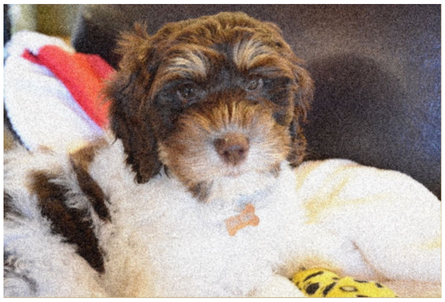
3 Spatial Filtering



Original Noisy

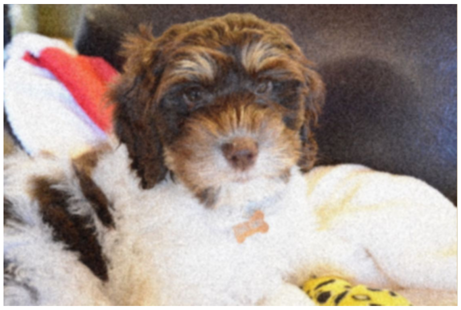


Gaussian (3x3)

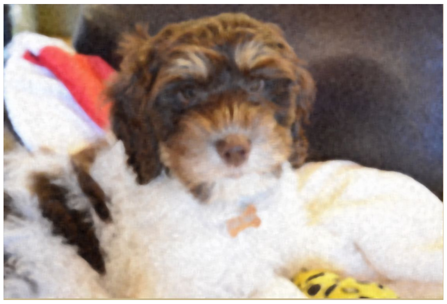


Median (3x3)

Original Noisy

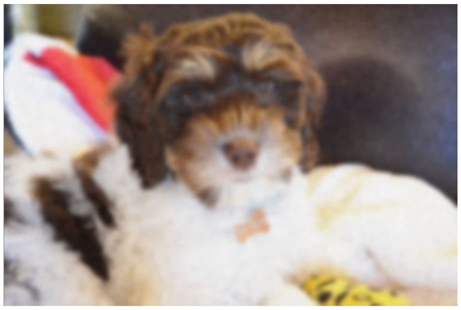


Gaussian (9x9)

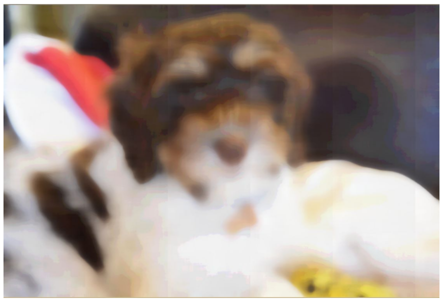


Median(9x9)

Original Noisy



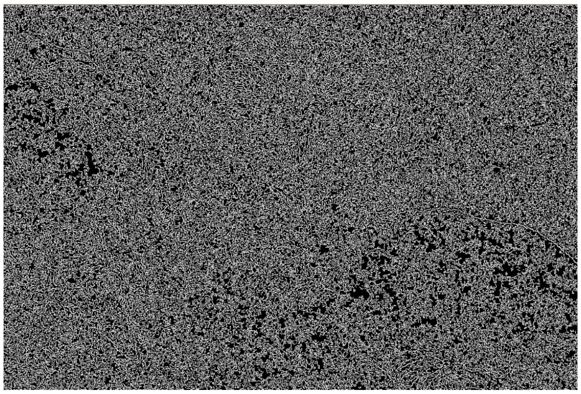
Gaussian(27x27)



Median(27x27)

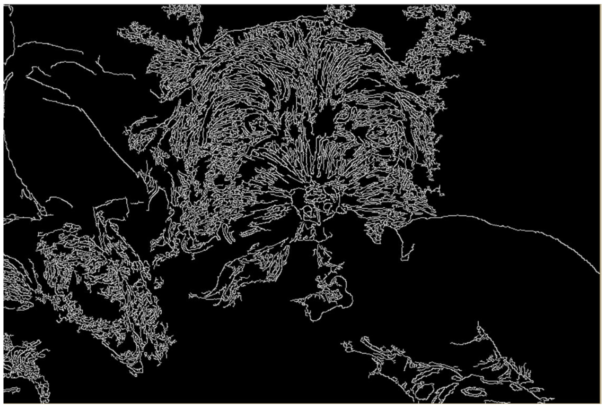
Based off of my experimentation using Gaussian blur and Median blur functions, it appears that Median in each case got rid of more of the noise by smoothing out the image, however the Gaussian filter kept more clarity and smoothed the image out less than the Median. I think that using k=3 as the filter size did not make much of an impact on the noisiness of the photo, however k=27 really compromised the subject of the photo by smoothing it out so much. I think that using k=9 was the best filter size option, and it depends on whether it is better to have less noise or a clearer photo whether to choose Gaussian or Median filter.

Noisy Image



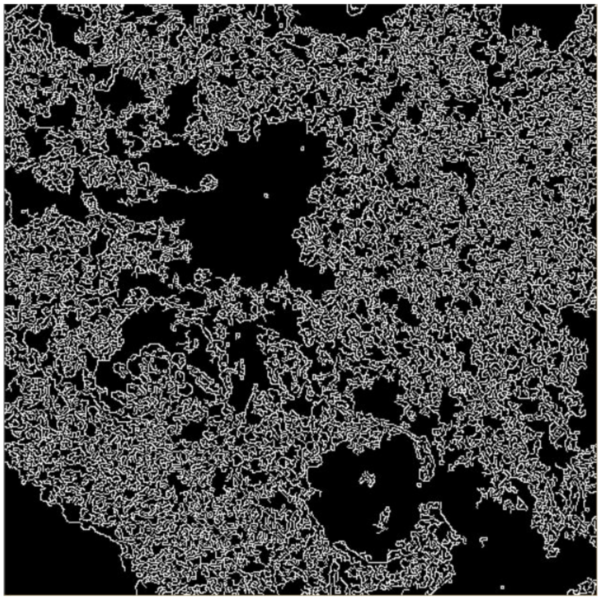
Edges

Not noisy Image



Edges

window-05-05.JPG

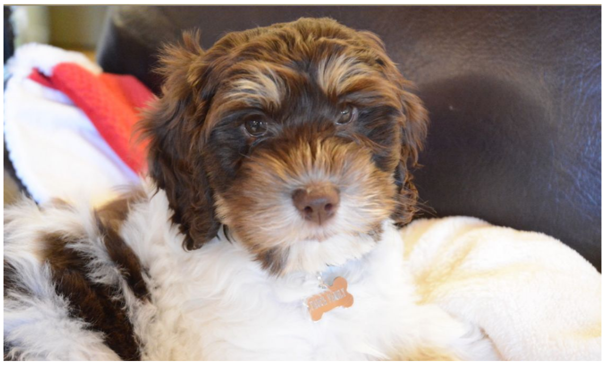


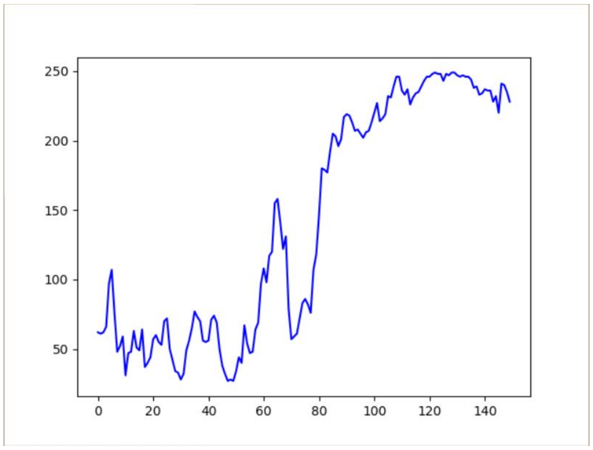
Edges

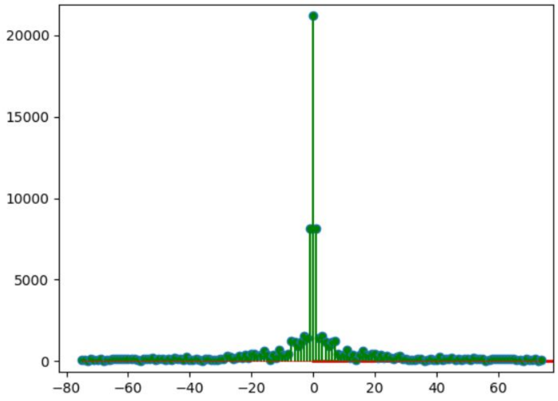
I used cv2 Canny function to obtain these results. On the noisy image of the dog, there edges are more erratic and looks more like static, than having any real outline. The noise distracts the image from the edges and it becomes less clear what the image pattern is. However, in the not noisy image of the puppy, there are more distinct edges of the outlines of the puppy. Also with the other dataset field image used, the main outlines of where the greenery is are distinct, but within those outlines the edges are all over the places because there is more noise in the image data.

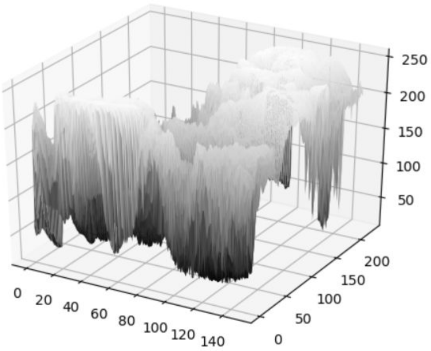
4 Frequency Analysis

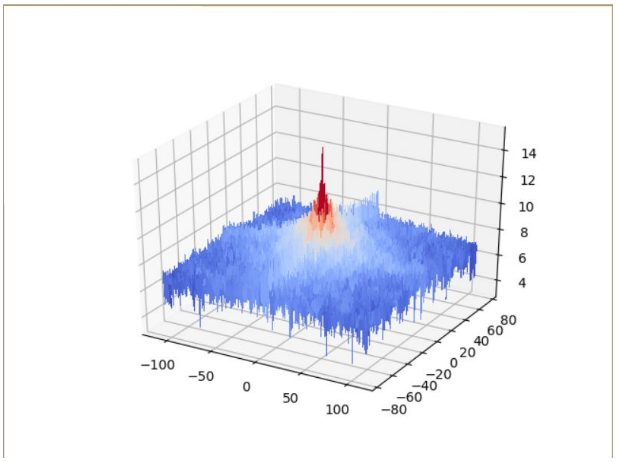
DSC_9259





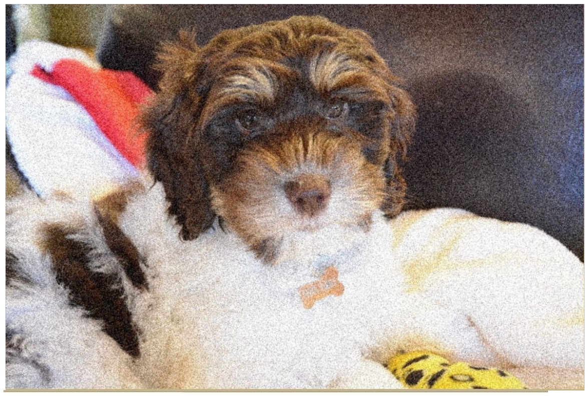


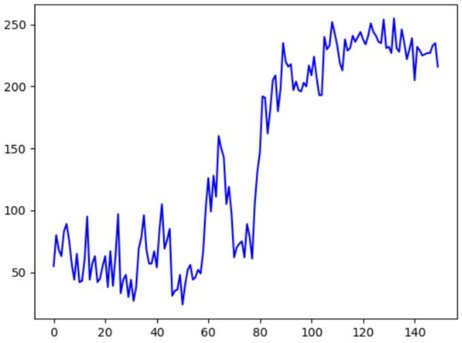


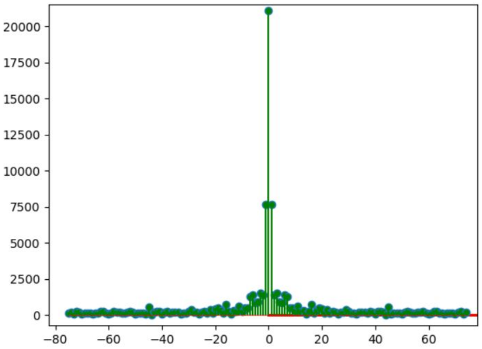


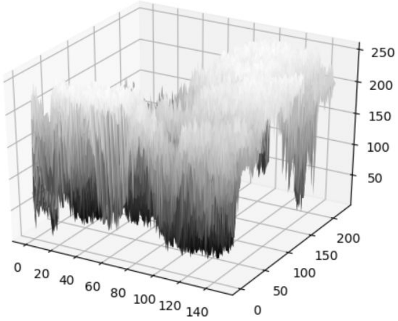
```
[2.11890000e+04 8.14108427e+03 1.43740725e+03 1.54054017e+03
 1.15682117e+03 9.31837939e+02 1.20138002e+03 1.24584656e+03
 4.43294263e+02 3.37862933e+02 3.99265776e+02 6.80224289e+02
 1.79552489e+02 3.57678972e+02 4.62420135e+01 3.64735432e+02
 6.12194182e+02 3.63302659e+02 3.48585959e+02 4.25640458e+02
 4.65188832e+02 1.99034874e+02 4.00807410e+02 1.82676516e+02
 3.28936109e+02 1.85008108e+02 1.61806690e+02 2.71659078e+02
 2.96624991e+02 1.43671621e+02 1.63074367e+02 9.90771948e+01
 7.59351191e+01 8.56745727e+01 1.54601722e+02 1.50233213e+02
 3.40317590e+01 8.92185698e+01 1.18857960e+02 8.86230785e+01
 7.65937015e+01 2.41558226e+02 5.24250582e+01 1.58660954e+02
 1.43532936e+02 1.90659551e+02 1.03653496e+02 1.46768382e+02
 1.04891195e+02 1.24234517e+02 1.32181693e+02 4.66750697e+01 etc.
```

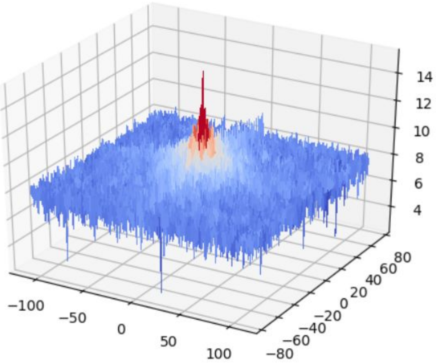
DSC_9259-0.50







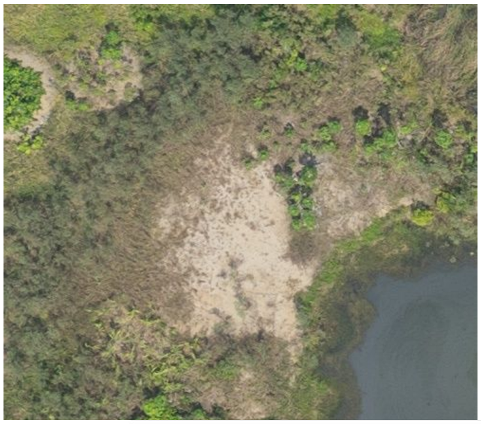


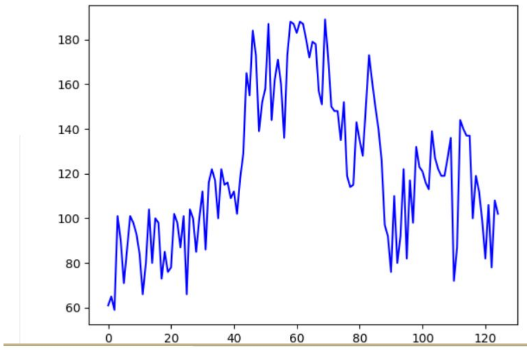


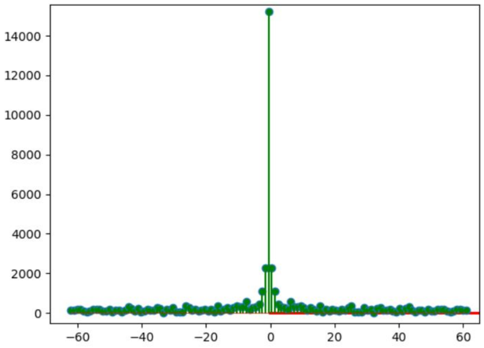
```
[2.10690000e+04 7.68367448e+03 1.38281115e+03 1.53916026e+03
 9.16157673e+02 8.46189667e+02 1.36524584e+03 1.26194032e+03
 5.09518285e+02 4.96841266e+02 2.37488745e+02 5.85316838e+02
 2.69390040e+02 2.84834306e+02 6.56033443e+01 2.70511417e+02
 7.55559154e+02 1.10112896e+02 3.29715824e+02 4.68590929e+02
 4.14161557e+02 1.47460129e+02 3.95599903e+02 9.79702574e+01
 2.35313046e+02 1.77687929e+02 6.99134735e+01 2.11879698e+02
 1.60637844e+02 3.64895952e+02 2.53221146e+02 1.50738747e+02
 1.56416091e+02 5.36024663e+01 1.68735066e+02 1.97773867e+02
 1.61037033e+02 1.37921664e+02 2.76274068e+02 2.04998234e+02
 8.67080941e+01 2.50873734e+02 2.48515810e+02 2.05130296e+02
 4.06009151e+00 5.70523070e+02 7.24198020e+01 1.22733530e+02
 1.54904312e+02 1.02820166e+02 8.97162193e+01 2.09633545e+02
 2.71396365e+02 2.03050468e+02 1.34711202e+02 1.31483206e+02
 1.92541833e+02 1.77399219e+02 2.21314322e+02 1.34146688e+02
 5.82756464e+01 1.14799843e+02 2.39467530e+02 2.62843776e+02
 1.42968808e+02 1.35213576e+02 7.74499482e+01 1.01568067e+02
```

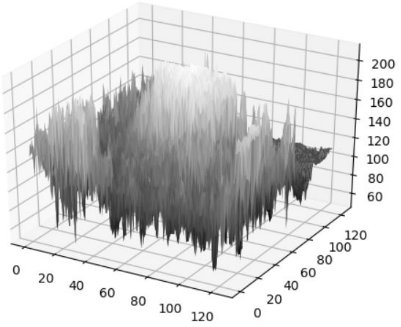
etc.

window-04-04

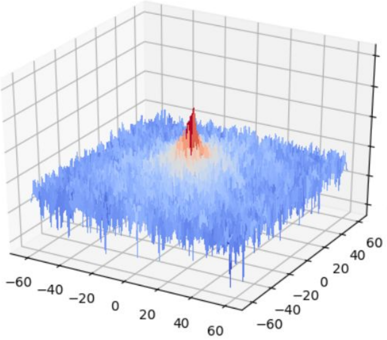




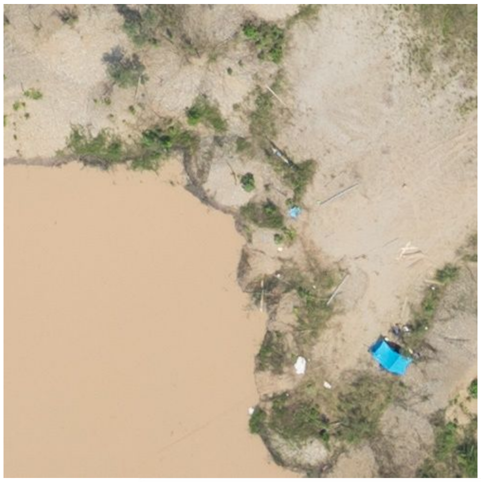


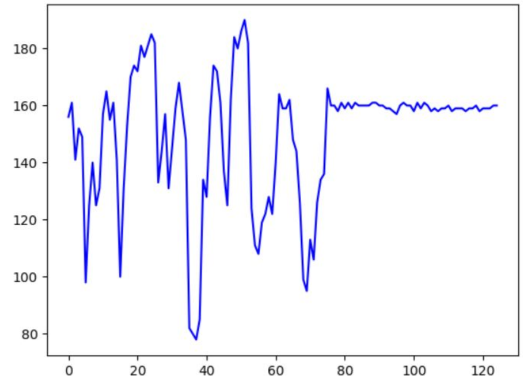


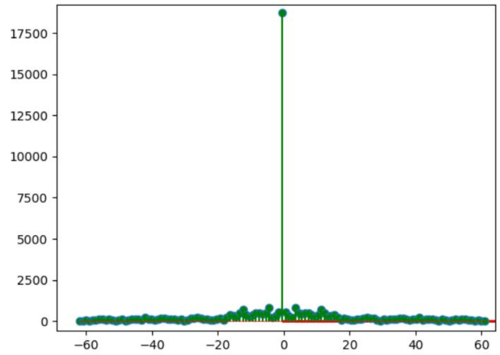
```
[15208.        2274.35791095  1101.50845613   442.53640862
  297.34238327   276.27444121   187.24166578   591.5051107
  305.25659527   298.75431635   363.52565329   256.69247496
  153.52578391   250.39937078   182.06015827    95.68427526
  362.92105258    53.30125013   170.43752909    88.14769692
  179.00667291   154.31599605    96.19787087   192.74902236
  145.21114543   285.6605345    352.64979027    32.58783328
   59.33819835    59.13880589   277.67006717   125.38916145
  161.55429815    22.32403097   237.92609954   247.22797041
  128.72271373   128.80733191   169.91607394    75.31422105
   70.76636116   233.89720789    83.94441839   215.25399799
  290.40909814   155.99535567    51.37822335   143.99725912
  126.65948359    66.12276728   189.42296332    88.29868608
   79.48483899   171.95319908   167.58880762   188.18032201
  106.2785856     35.46414026   112.08829316   171.4842078
  159.70618349   131.3123286    117.32054992   117.32054992
  131.3123286    159.70618349   171.4842078    112.08829316 etc.
```

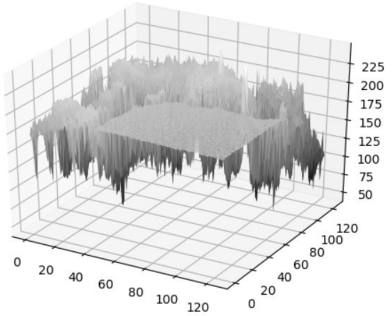


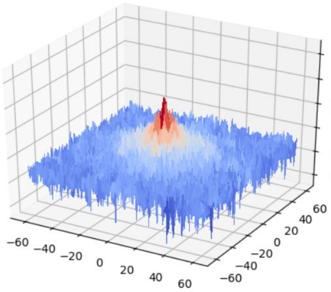
window-06-06











```
[18726.          543.07252214   348.6871283    221.54878374
822.73143348   513.73497202   413.39002994   515.39867836
496.69349419   378.64866613   292.73281737   400.43118954
692.93453777   499.42297141   293.1944987    325.2157066
386.82135726   207.68892166    75.35003405   157.03700719
124.24109997    44.35900216    55.54695083   134.25005573
136.93632461   176.22443496   220.5735916    153.39523754
170.89715165    57.15554133    32.42912037    96.86616351
70.17813206   103.71809823   122.02003838   103.70216122
175.74179083   172.04821135    91.09948827    63.38235213
95.36117845   102.05293641   217.5774609     89.44322131
115.83607152   133.46446008   119.6235896     54.5874227
28.01742042   126.89237635    73.70175387    28.47883746
59.94393353   105.61175301    55.66879093    96.46389377
114.07902688    67.76891769    63.47120949    21.04073333 etc.
```

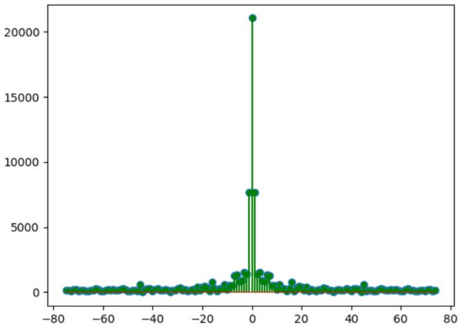
A. The image content appears to affect the decay of the magnitude of the Fourier coefficients, based on the contrast of the contents of the image. In the images of the puppy, the values mostly go from lower magnitude to higher magnitude, and have a more gradual normal curve shape on the 2D DFT. In the image with a mixture of greenery, sandy, and water content, there is more change in the values of the magnitudes. In the image of mostly sand and murkier water that is a consistent color, the magnitudes are sporadic maybe because of the edge created, and then it levels out around 160, probably because of the color consistency.

B. For the noisy and not noisy images of the puppy, the noisy one has a lot more sporadic back and forth and creates a more jagged curve. The original image of the puppy is a much smoother plot, and it's likely because of the lack of noise. However, the majority of the two plots mirrors the same magnitudes and trends.

C. Some of the log plots of the magnitude have higher values around the outside, such as the two puppy images. This happens because of noise in the images because it is a prevalence of the higher frequencies.

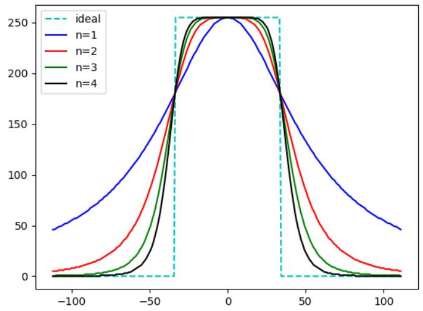
D. If you zero the values of the lower frequencies, it would be useful for edge detection because you are not including the most frequently occurring low valued frequencies. However, when you don't include the high frequencies further away from the center, it smooths the image out because it closely matches the magnitudes coefficients while removing the noise.

5 Frequency Filtering



DSC_9259-0.50

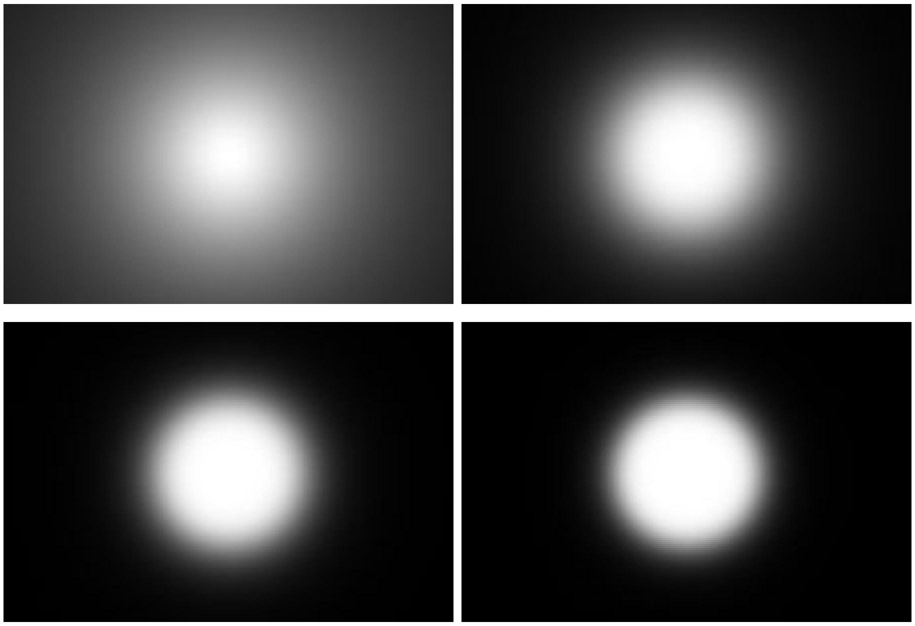
2D DFT



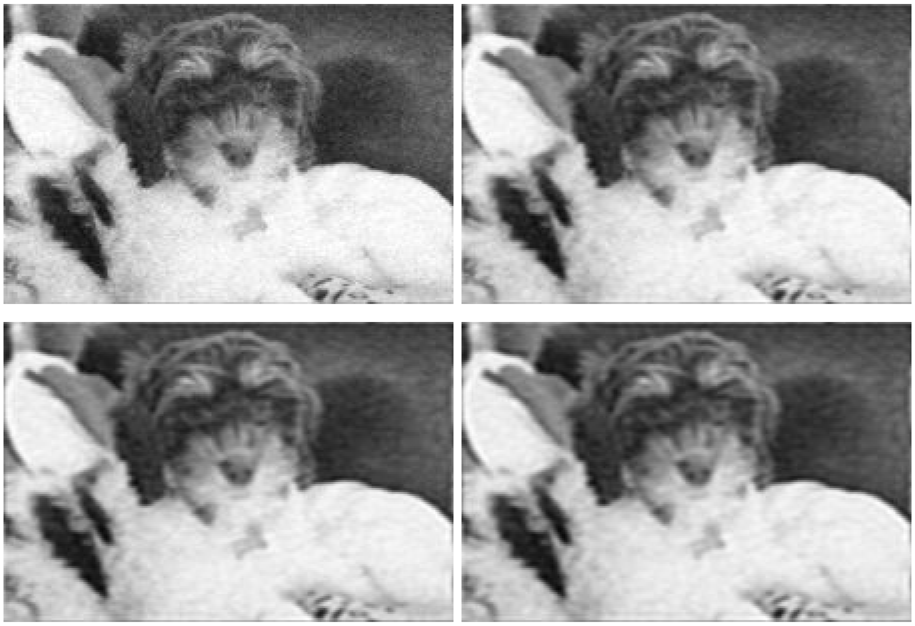
Butterworth scaled Magnitudes (low pass)

Butterworth Low Pass

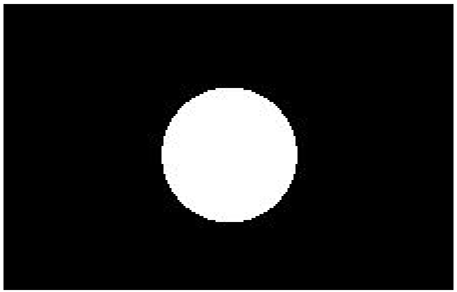
Butterworth filters (low pass) n=1, 2, 3, 4

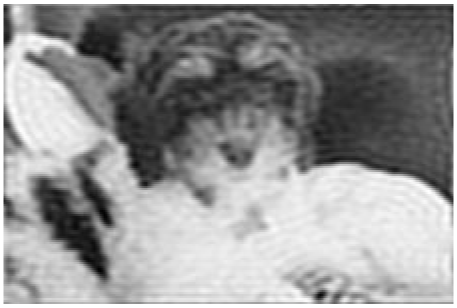


Butterworth (low pass) image gray n=1, 2, 3, 4

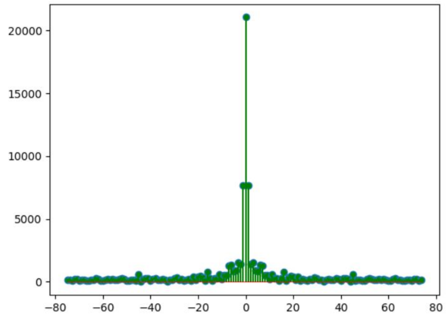


Ideal Low pass gray filter

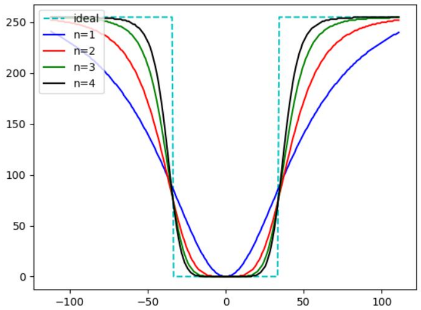




Butterworth High Pass

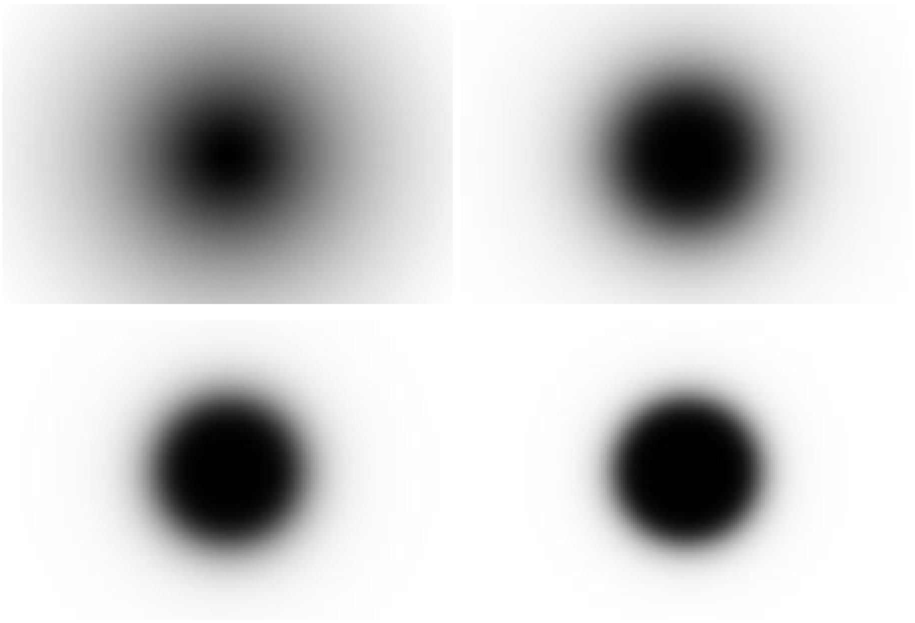


2D DFT

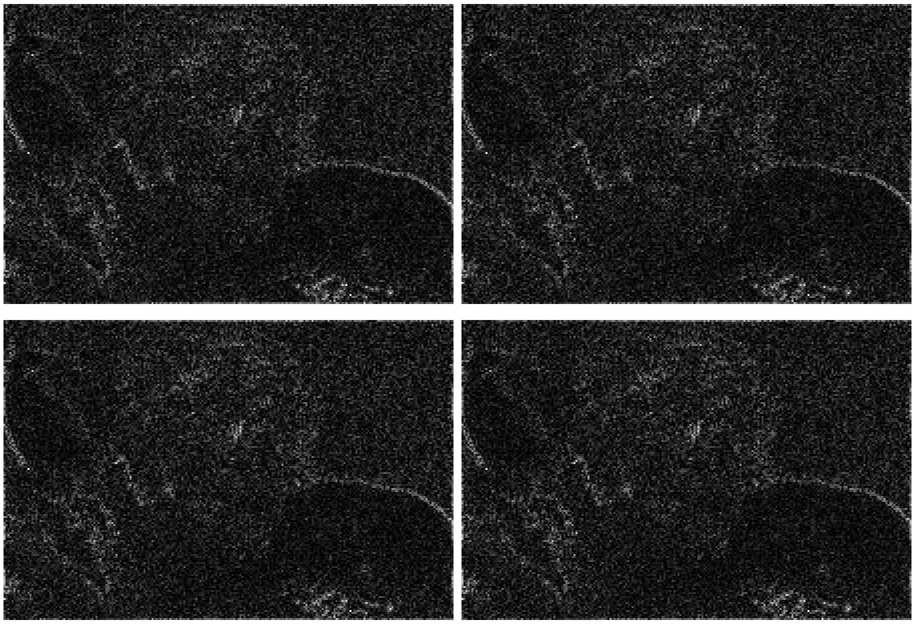


Butterworth Scaled Magnitude (high pass)

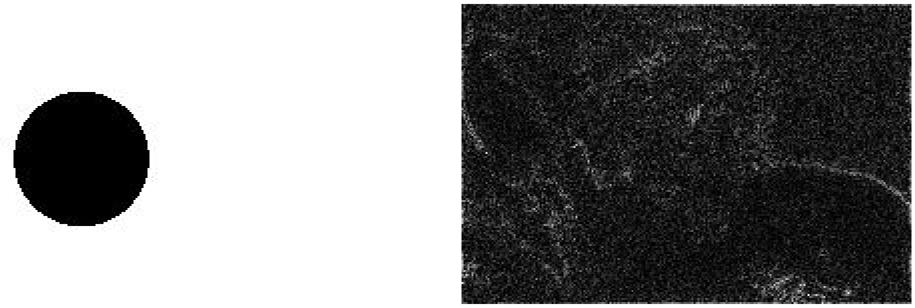
Butterworth (high pass) filter n = 1, 2, 3, 4



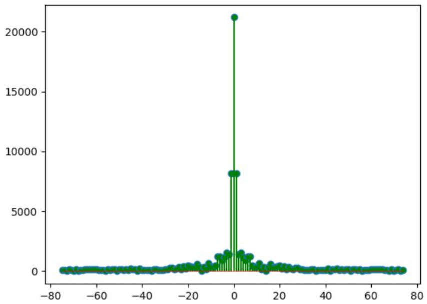
Butterworth (high pass) image grey n = 1, 2, 3, 4



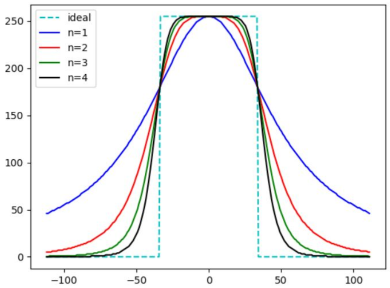
Ideal High Pass gray Filter



Butterworth Low Pass

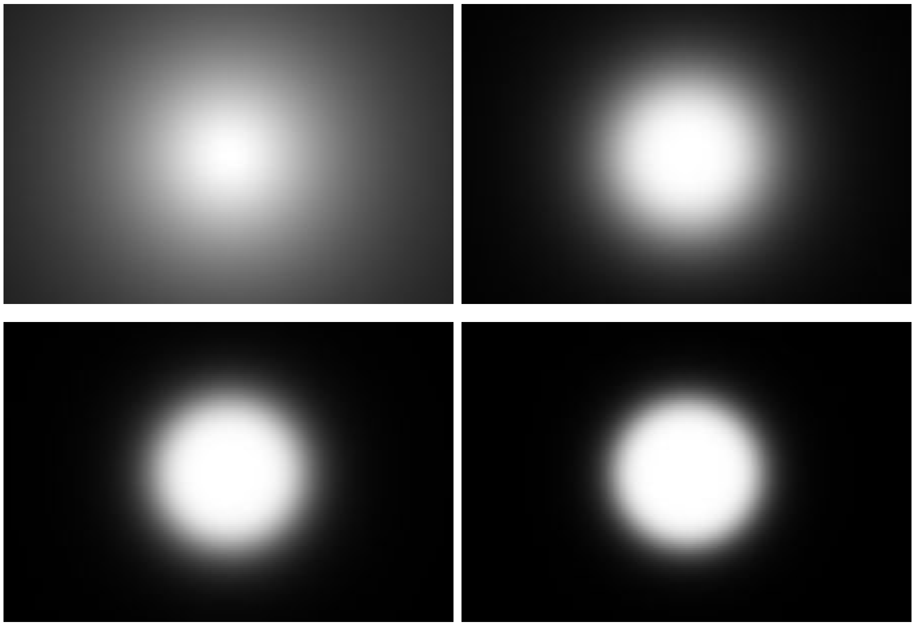


2D DFT

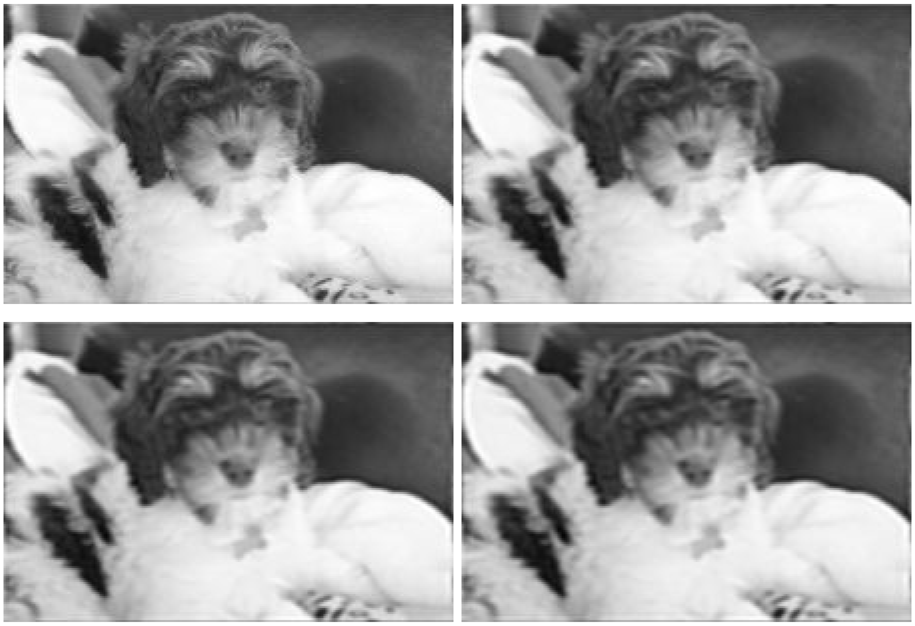


Butterworth scaled magnitudes (low pass)

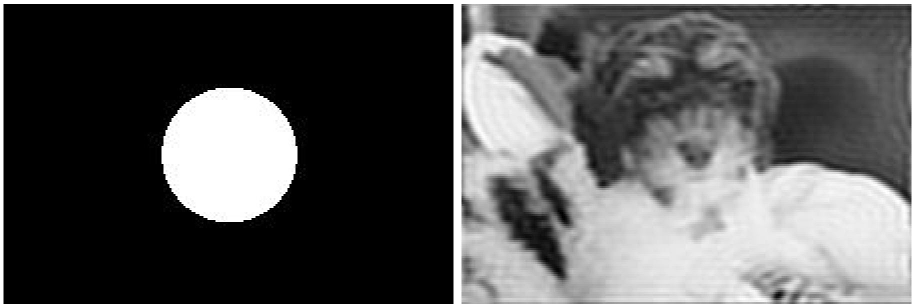
Butterworth low filter pass n = 1, 2, 3, 4



Butterworth low pass image gray n = 1, 2, 3, 4

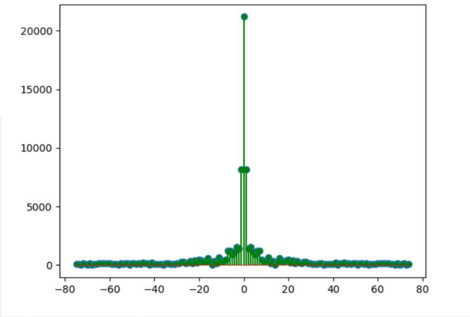


Ideal Low Pass

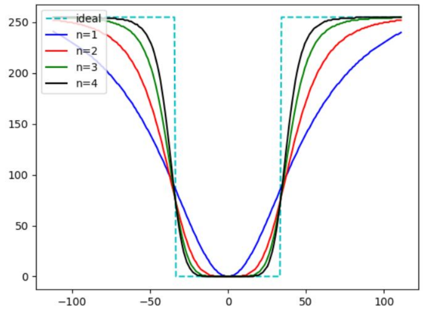


Butterworth High Pass

DSC_9259

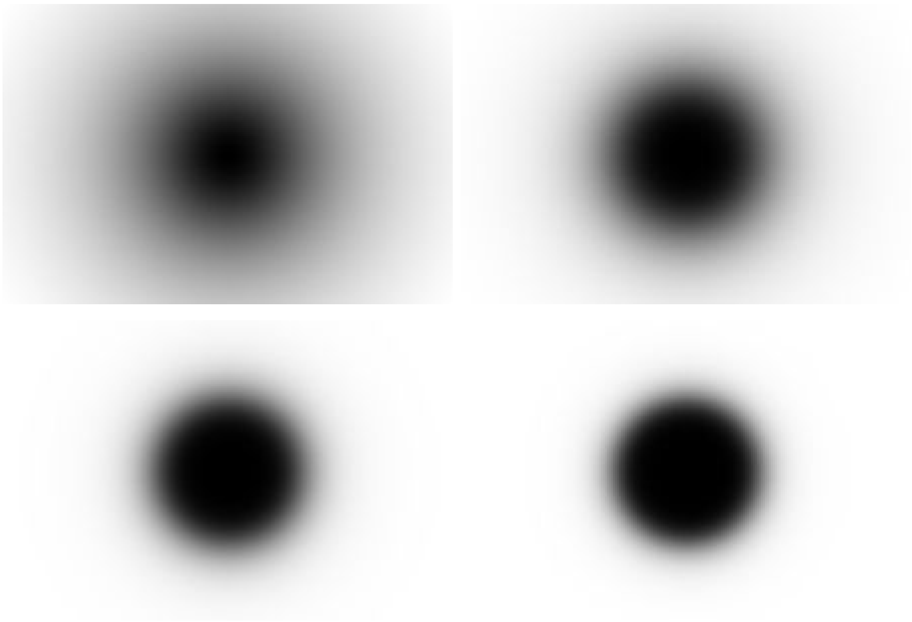


2D DFT

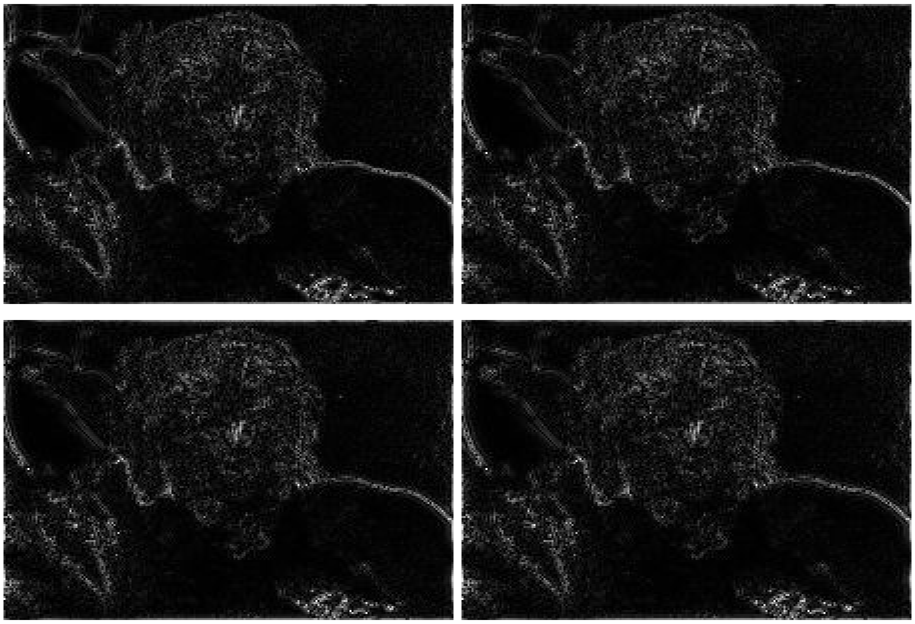


Butterworth Scaled Magnitude (high pass)

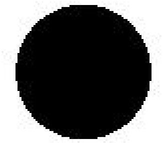
Butterworth Filter High pass n = 1, 2, 3, 4

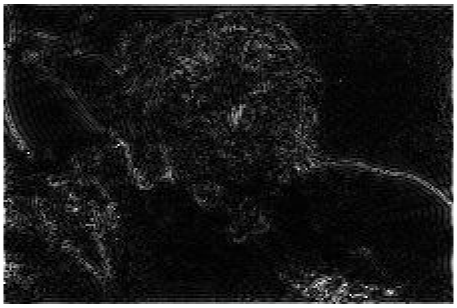


‘Butterworth (high pass) gray image n = 1, 2, 3, 4



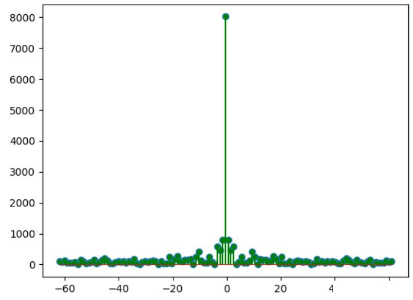
Ideal High Pass



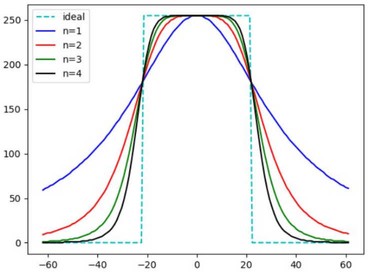


Butterworth Low Pass

Window-05-10

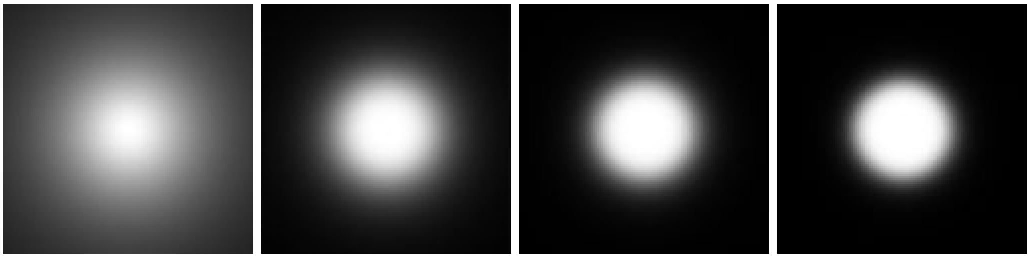


2D DFT

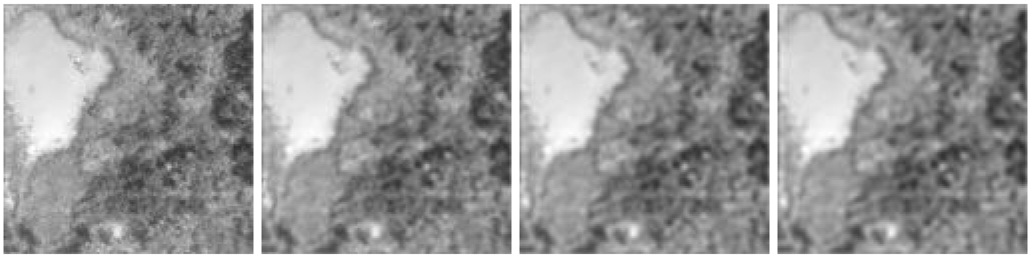


Butterworth scaled magnitude (low pass)

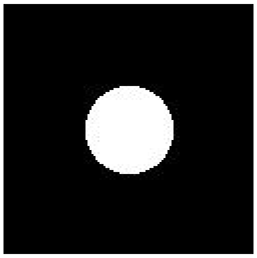
Butterworth Filter low pass n = 1, 2, 3, 4

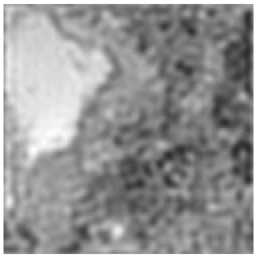


Butterworth low pass image grey n = 1, 2, 3, 4



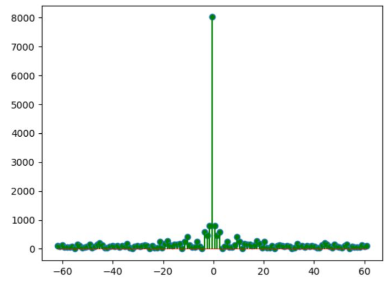
Ideal Low Pass





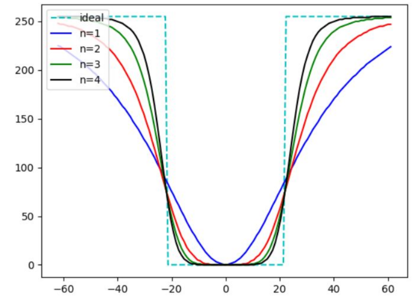
Butterworth High Pass

window-05-10

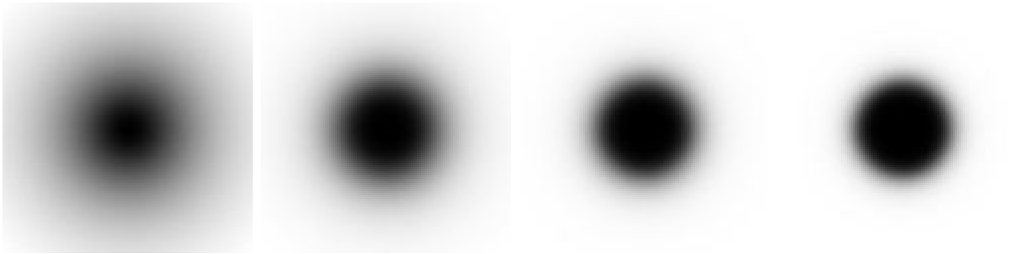


2D DFT

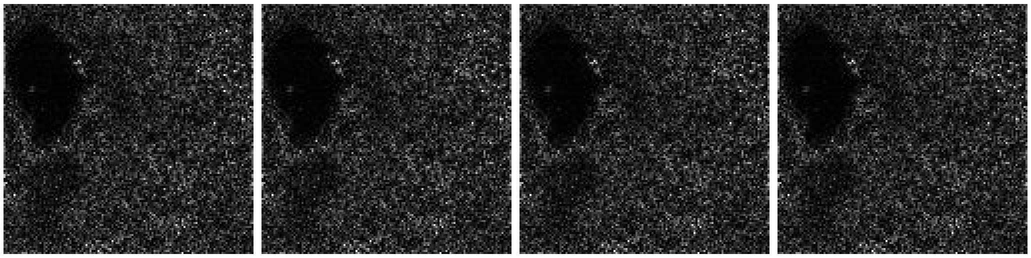
Butterworth scaled magnitude (high pass)



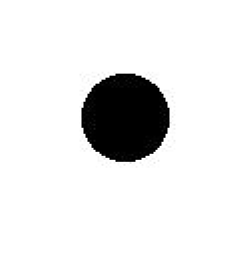
Butterworth filter high pass n = 1, 2, 3, 4

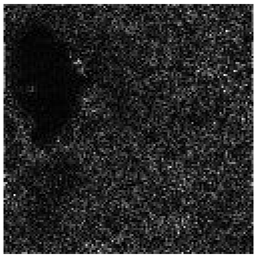


Butterworth high pass image grey n = 1, 2, 3, 4



Ideal High Pass





The ideal low pass filter is a white circle against a black background versus the ideal high pass filter which is a black circle against the white background. These ideal pass filters are different than the Butterworth filters, which blur out the edges of the circle depending on the value of n used. For n = 1, the filter is very blurred out and there is a lot of gray faded out from the white circle in the middle. When n = 4, It only soften the edges of the circle a little bit and the background is still mostly black. This means the butterworth filter does more smoothing to the images. The image after the Butterworth filter for n = 1 is a lot more clear than the image resulting from n = 4 Butterworth filter. However, on the noisy image of the puppy, it leaves a lot more of the noise in the image. The ideal low pass filter makes the image have more ripples than the Butterworth filter does. It looks like it filters the image less smoothly and leaves it blurrier and rippled on each of the ideal low pass images.

For the high pass filtered images, the high pass filter seems to be an edge detector. This is because the high pass filter is zeroing out the low frequencies of the image, which are the important ones. The high pass filters were created by taking (1 - lowPassFilter) for both the ideal high pass filter and the high pass Butterworth filters. The n = 1 Butterworth high pass filter seems to make the image less noisy than the n = 4 Butterworth high pass filter.