

Image Denoising

Median + Non Local Means Filter

CHAPTER 1

Filter Introduction

X

X

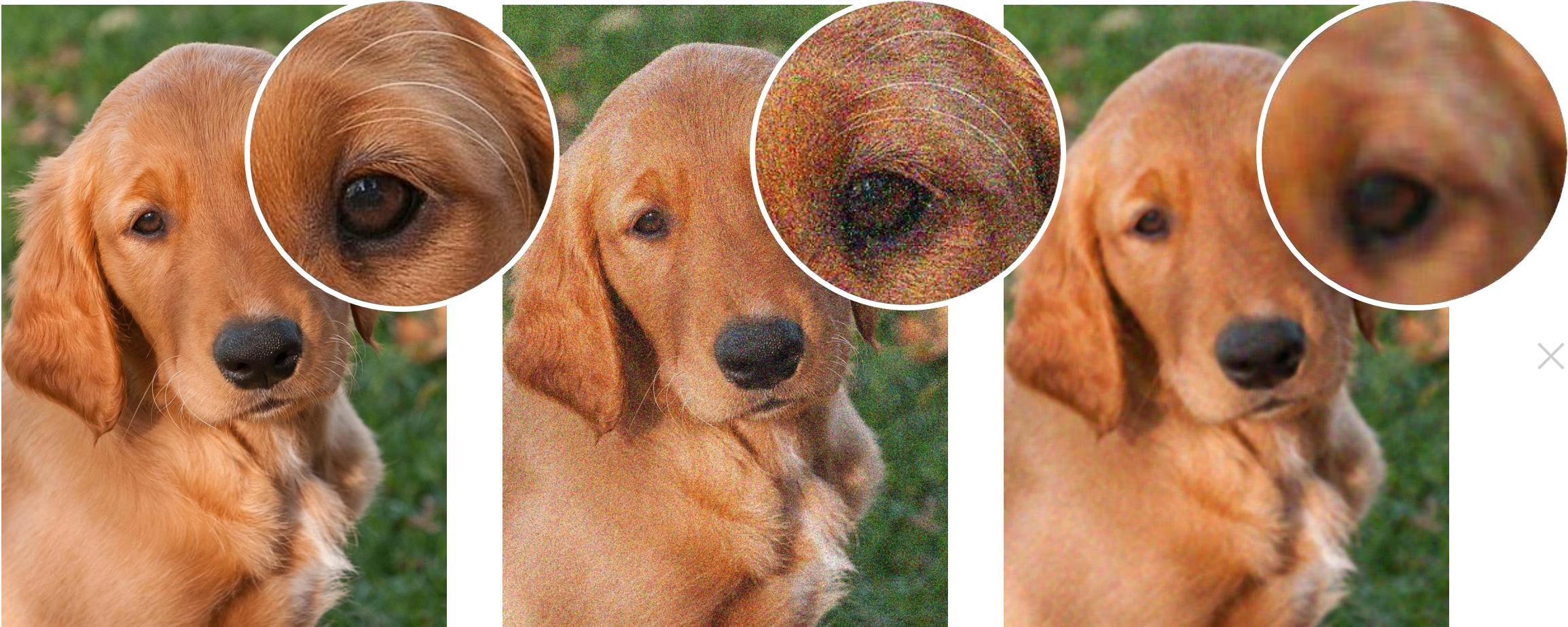
01

Median filter

02

Non Local Means filter

01 Median filter



original

noisy

result

Filter Size : 13

PSNR: 26.7191653dB

01 Median filter

Filter size	baby	bagles	beach	book	dog	girl_ani	house	kitty	lego	street	평균
1	14.28913987	14.28070255	14.24204556	14.24614066	14.23137268	14.32162018	14.27671196	14.24103284	14.22628492	14.23250381	14.2587555
3	22.79263426	21.89216571	22.22733464	22.29441025	21.99450419	22.75998767	20.16101857	22.50146344	21.91052743	20.90187232	21.94359185
5	26.2336116	23.58204748	24.90451717	25.14008159	24.65136077	25.13841179	20.41600969	25.86407596	24.04394086	21.75852401	24.17325809
7	27.46914533	23.70984376	25.6939136	25.99141081	25.88531448	25.4244624	20.35670921	27.2057614	24.25064128	21.75921921	24.77464215
9	27.76664897	23.48317573	25.76121568	26.20835253	26.43343828	25.08634478	20.14439755	27.58183369	23.87766015	21.52656448	24.78696318
11	27.74774489	23.16362945	25.62190147	26.20440639	26.65589963	24.60818258	19.87095781	27.51344946	23.35282804	21.26540648	24.60044062
13	27.60264115	22.83495075	25.44003211	26.0828691	26.7191653	24.13535618	19.6380803	27.27399102	22.81731358	21.02611381	24.35705133
15	27.42582892	22.53003486	25.24896795	25.89830159	26.70004305	23.68132301	19.4614796	26.98390112	22.34851744	20.80473686	24.10831344
17	27.2832257	22.24491246	25.05402062	25.69230154	26.63238397	23.240627	19.3058816	26.68877675	21.9549898	20.58894055	23.868606
19	27.19747375	21.98847819	24.85758999	25.4795184	26.53445352	22.8363306	19.16356219	26.40020121	21.62427927	20.38500237	23.64668895
21	27.15156519	21.7601034	24.66409393	25.27044946	26.41832914	22.46807569	19.04641966	26.12343892	21.33737414	20.19892416	23.44387737
23	27.1083101	21.55000232	24.4676373	25.07170743	26.29039519	22.13243948	18.95064845	25.85688984	21.08689244	20.03040135	23.25453239
25	27.03820328	21.35178234	24.27529682	24.8813221	26.1544572	21.82206109	18.86447066	25.59928262	20.86521572	19.87169494	23.07237868
27	26.93439424	21.16626919	24.101406	24.69535326	26.01324855	21.53350353	18.7876275	25.3494609	20.66483638	19.72078147	22.8966881
29	26.80914819	20.99251632	23.93638945	24.51347836	25.86837098	21.2668311	18.71984674	25.10392376	20.47967683	19.57329484	22.72634766

01 Median filter

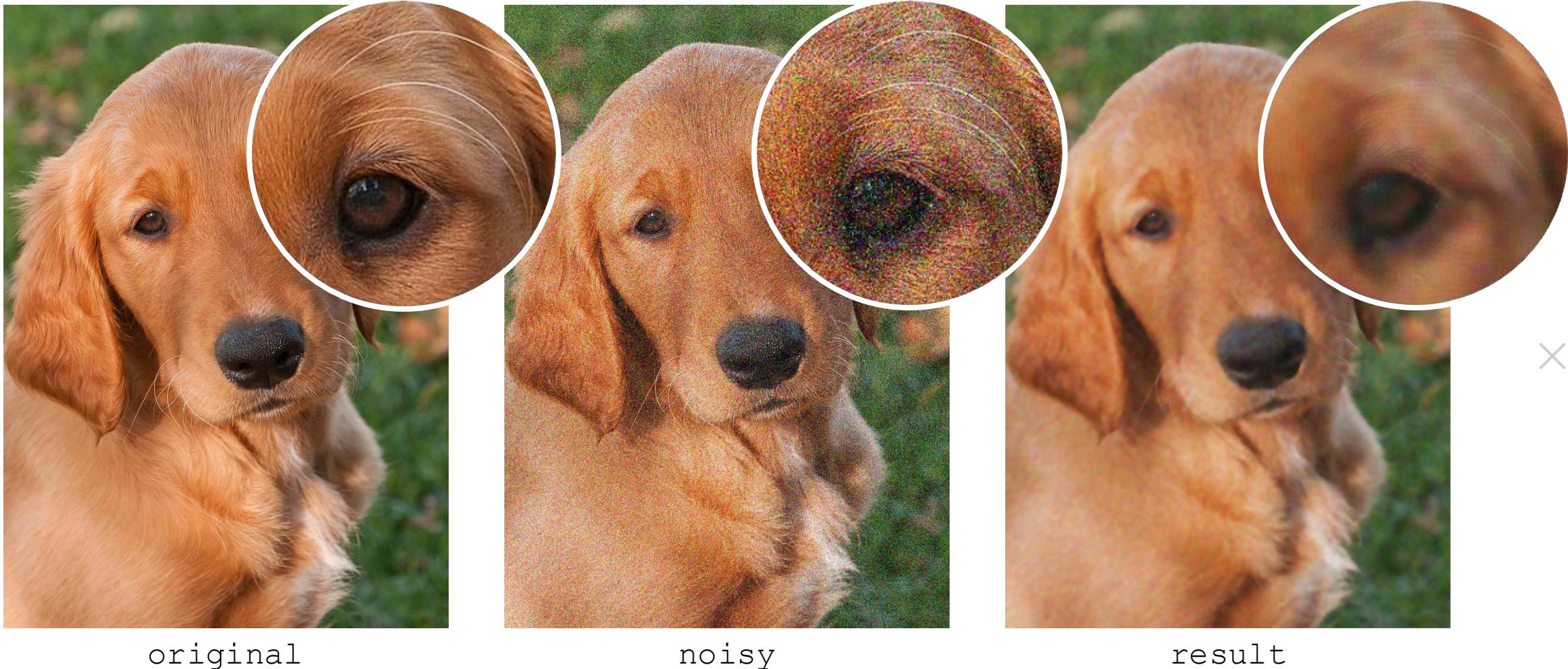


```
import numpy as np

def median_filter(img, filter_size):
    height, width, chan = img.shape
    result = np.zeros_like(img)
    pad = filter_size // 2
    img_padded = np.pad(img, ((pad, pad), (pad, pad), (0, 0)), mode='edge')

    for i in range(pad, height + pad):
        for j in range(pad, width + pad):
            for c in range(chan):
                result[i-pad, j-pad, c] = np.median(
                    img_padded[i-pad:i+pad+1, j-pad:j+pad+1, c])
    return result
```

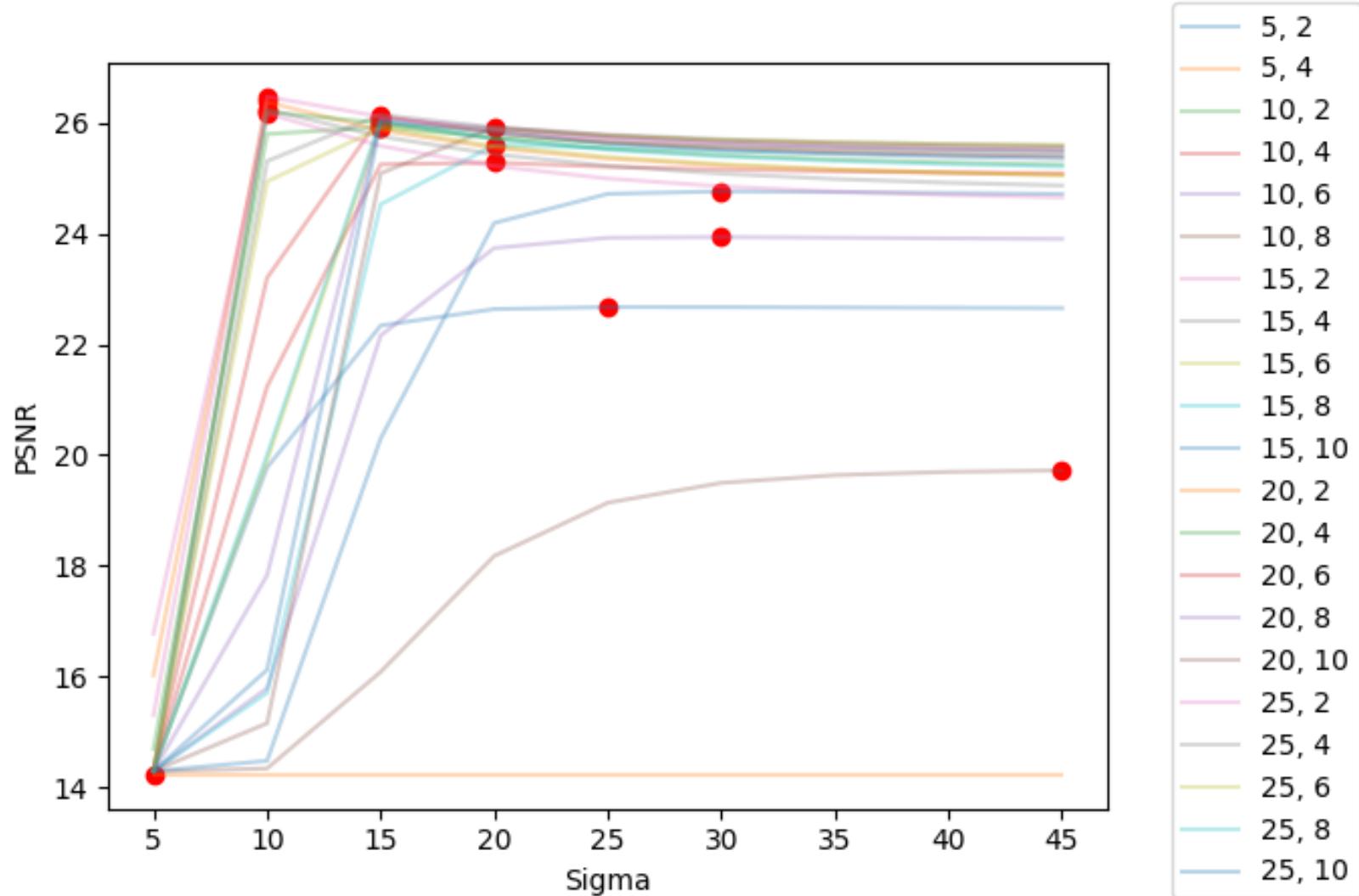
02 Non Local Means filter



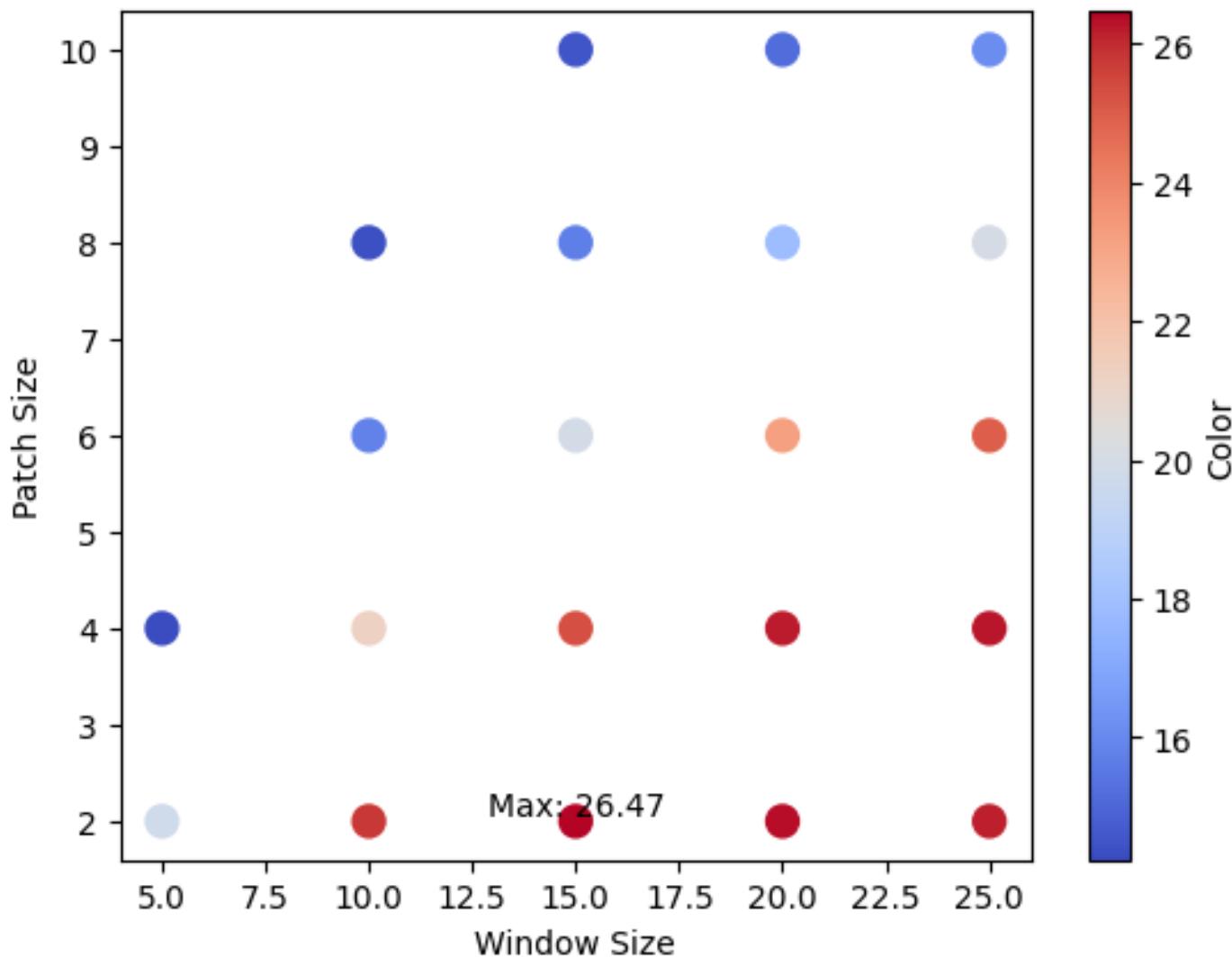
Window Size : 15, Patch Size: 2, Sigma : 10

PSNR: 26.4723822dB

02 Non Local Means filter



02 Non Local Means filter



02 Non Local Means filter

```
● ● ●  
import numpy as np  
  
def nonLocalMeans(img, windowSize, patchSize, sigma):  
    height, width, chan = img.shape  
    padwidth = windowSize // 2  
    patchRad = patchSize // 2  
    paddedImage = np.zeros((height + windowSize, width + windowSize, chan), dtype=np.uint8)  
    paddedImage[padwidth:padwidth + height, padwidth:padwidth + width, :] = img  
    outputImage = paddedImage.copy()  
    for h in range(padwidth, padwidth + height):  
        for w in range(padwidth, padwidth + width):  
            winw = w - padwidth  
            winh = h - padwidth  
            pixelColor = np.zeros(chan)  
            totalWeight = 0  
            originalPatch = paddedImage[h-patchRad:h+patchRad+1,w-patchRad:w+patchRad+1,:]  
            for patchh in range(winh, winh + windowSize - patchSize):  
                for patchw in range(winw, winw + windowSize - patchSize):  
                    compPatch=paddedImage[patchh:patchh+patchSize+1,patchw:patchw+patchSize+1,:]  
                    euclideanDistance = np.sqrt(np.sum((compPatch - originalPatch) ** 2))  
                    weight = np.exp(-euclideanDistance / (sigma**2) / 2)  
                    totalWeight += weight  
                    pixelColor += weight * paddedImage[patchh + patchRad, patchw + patchRad, :]  
            pixelColor /= totalWeight  
            outputImage[h, w, :] = pixelColor  
    return outputImage[padwidth:padwidth + height, padwidth:padwidth + width, :]
```

CONCLUSION

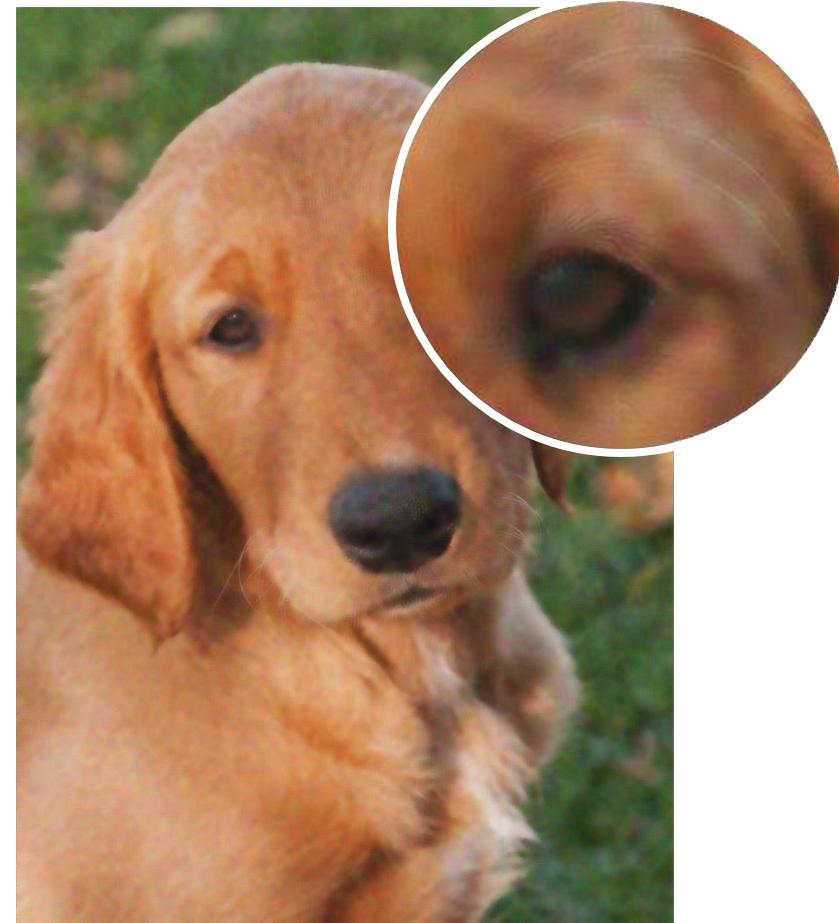


Median

PSNR: 26.7191653dB

>

0.24



Non Local Means

PSNR: 26.4723822dB

CHAPTER 2

Filter Combination

X

X

01

Median + Laplacian filter

02

Median + Non Local Means filter

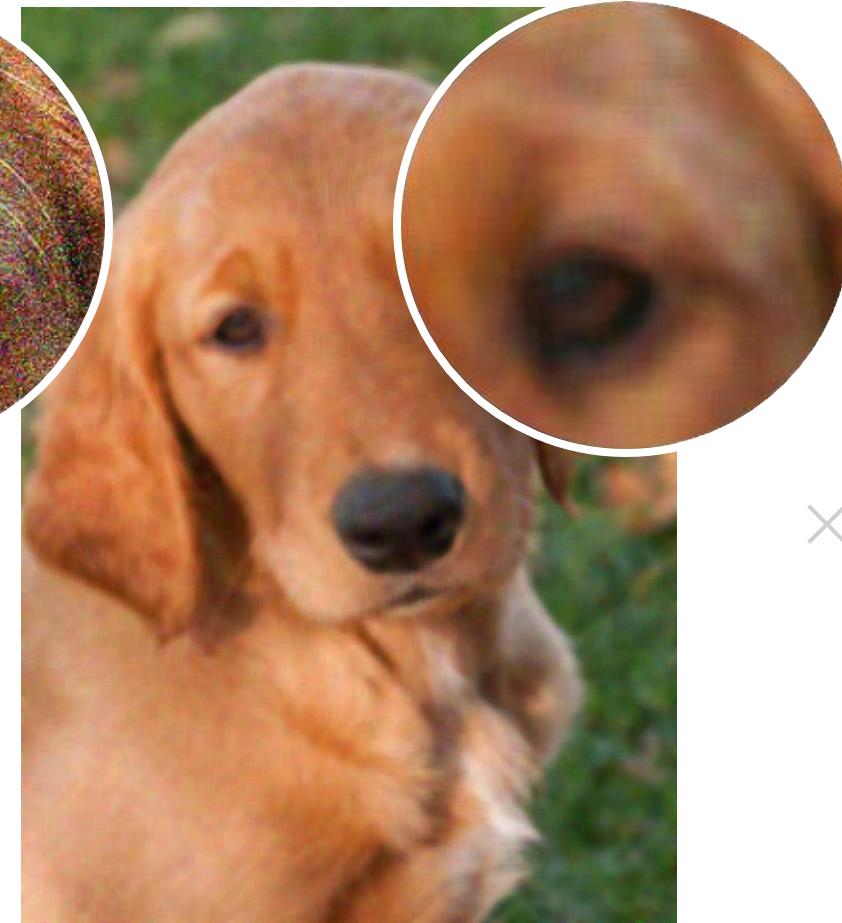
01 Median + Laplacian filter



original



noisy



result

Filter Size : 17

PSNR: 26.4195142dB

01 Median + Laplacian filter

Filter size	baby	bagles	beach	book	dog	girl_ani	house	kitty	lego	street	평균
1	8.858309241	8.807352694	8.723838467	8.719564485	8.660451248	9.094224129	8.903855161	8.695565129	8.654247159	8.724089156	8.784149687
3	17.19617192	16.72773601	16.7675176	16.79436508	16.5725567	17.51073251	15.94845597	16.81113414	16.47079977	16.08931408	16.68887838
5	22.38104453	20.79763656	21.51665917	21.64554855	21.29105592	22.06431139	18.56068693	22.024788	21.00946635	19.49919377	21.07903912
7	25.12365784	22.41582207	23.863212	24.04756221	23.94272334	23.95364041	19.6058729	24.87641341	22.85985501	20.78947017	23.14782294
9	26.39517999	22.88002148	24.77901244	25.15178742	25.29492754	24.42547192	19.81875777	26.25282923	23.27171654	21.0554963	23.93252006
11	26.93778471	22.861034	25.06727801	25.6225788	25.95902892	24.30363069	19.68911761	26.75597579	23.07653866	21.00876233	24.12817295
13	27.10192713	22.66894348	25.10935601	25.74820791	26.27153952	23.99717811	19.51747082	26.82350224	22.67125514	20.88063164	24.0790012
15	27.0858658	22.43846862	25.04281409	25.69495517	26.3983091	23.62156629	19.39071109	26.70359904	22.26154735	20.72049011	23.93583267
17	27.03179237	22.18725728	24.91975482	25.56655834	26.4195142	23.21422753	19.25991072	26.50704546	21.89878797	20.53318317	23.75380319
19	27.0053025	21.95011828	24.76571837	25.39914276	26.37855656	22.82501395	19.12339943	26.27668046	21.58535924	20.34302834	23.56523199
21	27.00721116	21.73674602	24.60125479	25.21672413	26.29929394	22.46270274	19.01408593	26.03616601	21.30916587	20.16551579	23.38488664
23	27.00186035	21.53595391	24.41982248	25.03649346	26.196984	22.12927315	18.92841251	25.79280044	21.06432155	20.0058694	23.21117913
25	26.95760512	21.341319	24.23191653	24.85939431	26.07891887	21.8210643	18.84554651	25.55019288	20.84803323	19.85272177	23.03867125
27	26.86846516	21.15794799	24.0688685	24.68038072	25.9507225	21.53423496	18.77089559	25.31174743	20.65204804	19.70646214	22.8701773
29	26.75157519	20.98650762	23.91200669	24.50145683	25.81529252	21.26831666	18.70742591	25.07534464	20.46859073	19.56216471	22.70486815

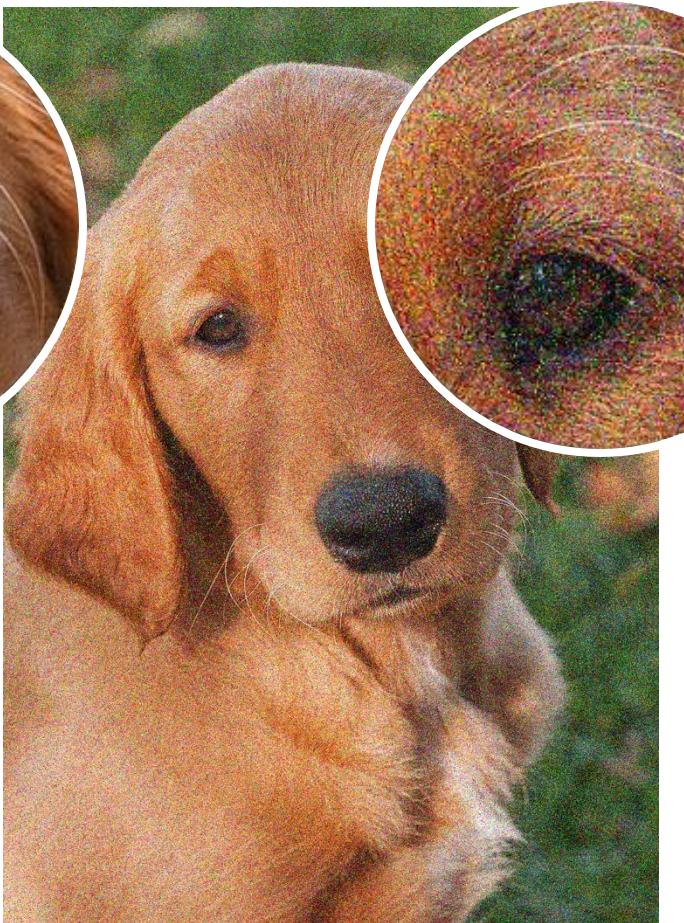
01 Median + Laplacian filter

Filter size	baby	bagles	beach	book	dog	girl_ani	house	kitty	lego	street	평균
1	-5.4308306	-5.4733499	-5.5182071	-5.5265762	-5.5709214	-5.2273961	-5.3728568	-5.5454677	-5.5720378	-5.5084147	-5.4746058
3	-5.5964623	-5.1644297	-5.459817	-5.5000452	-5.4219475	-5.2492552	-4.2125626	-5.6903293	-5.4397277	-4.8125582	-5.2547135
5	-3.8525671	-2.7844109	-3.387858	-3.494533	-3.3603049	-3.0741004	-1.8553228	-3.839288	-3.0344745	-2.2593302	-3.094219
7	-2.3454875	-1.2940217	-1.8307016	-1.9438486	-1.9425911	-1.470822	-0.7508363	-2.329348	-1.3907863	-0.969749	-1.6268192
9	-1.371469	-0.6031542	-0.9822032	-1.0565651	-1.1385107	-0.6608729	-0.3256398	-1.3290045	-0.6059436	-0.4710682	-0.8544431
11	-0.8099602	-0.3025955	-0.5546235	-0.5818276	-0.6968707	-0.3045519	-0.1818402	-0.7574737	-0.2762894	-0.2566442	-0.4722677
13	-0.500714	-0.1660073	-0.3306761	-0.3346612	-0.4476258	-0.1381781	-0.1206095	-0.4504888	-0.1460584	-0.1454822	-0.2780501
15	-0.3399631	-0.0915662	-0.2061539	-0.2033464	-0.3017339	-0.0597567	-0.0707685	-0.2803021	-0.0869701	-0.0842468	-0.1724808
17	-0.2514333	-0.0576552	-0.1342658	-0.1257432	-0.2128698	-0.0263995	-0.0459709	-0.1817313	-0.0562018	-0.0557574	-0.1148028
19	-0.1921712	-0.0383599	-0.0918716	-0.0803756	-0.155897	-0.0113166	-0.0401628	-0.1235207	-0.03892	-0.041974	-0.081457
21	-0.144354	-0.0233574	-0.0628391	-0.0537253	-0.1190352	-0.005373	-0.0323337	-0.0872729	-0.0282083	-0.0334084	-0.0589907
23	-0.1064497	-0.0140484	-0.0478148	-0.035214	-0.0934112	-0.0031663	-0.0222359	-0.0640894	-0.0225709	-0.024532	-0.0433533
25	-0.0805982	-0.0104633	-0.0433803	-0.0219278	-0.0755383	-0.0009968	-0.0189241	-0.0490897	-0.0171825	-0.0189732	-0.0337074
27	-0.0659291	-0.0083212	-0.0325375	-0.0149725	-0.0625261	0.00073143	-0.0167319	-0.0377135	-0.0127883	-0.0143193	-0.0265108
29	-0.057573	-0.0060087	-0.0243828	-0.0120215	-0.0530785	0.00148555	-0.0124208	-0.0285791	-0.0110861	-0.0111301	-0.0214795

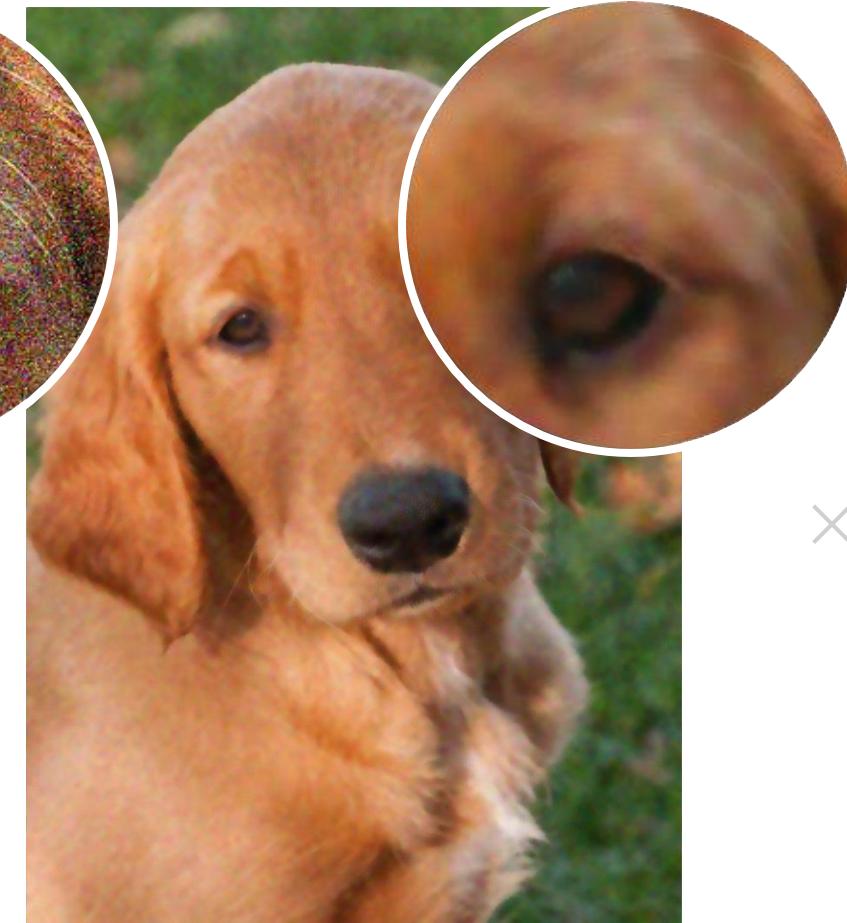
02 Median + Non Local Means filter



original



noisy



result

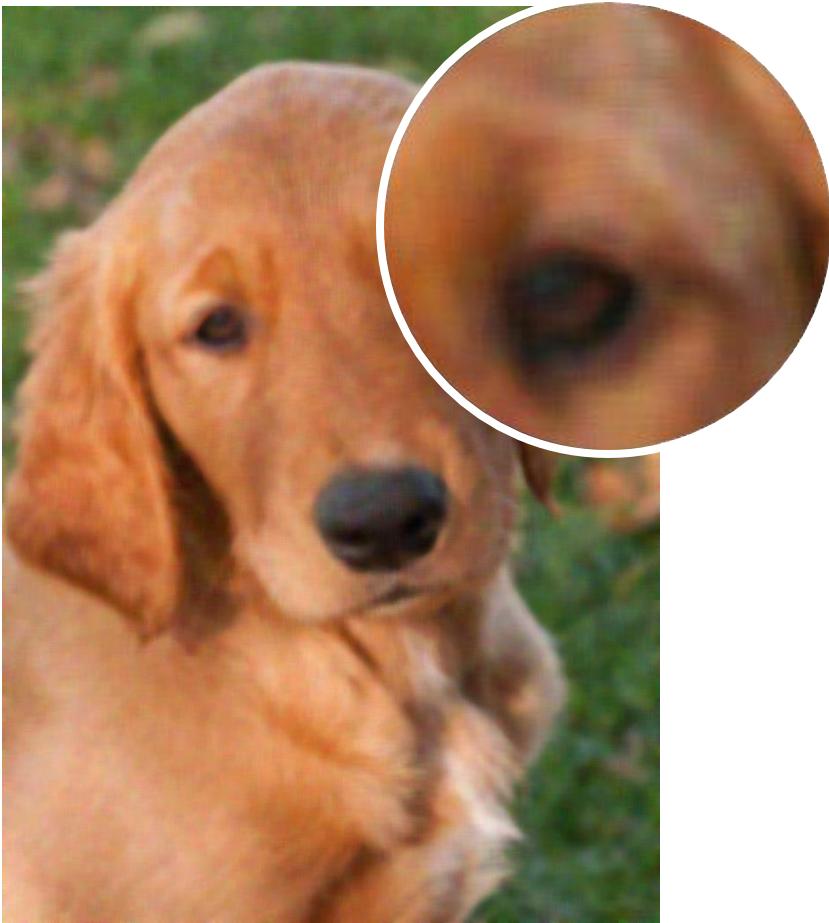
Filter Size : 3
Window Size : 15, Patch Size: 2, Sigma : 10

PSNR: 27.2751482dB

02 Median + Non Local Means filter

Filter size	baby	bagles	beach	book	dog	girl_ani	house	kitty	lego	street	평균
1	25.77851908	23.91851644	26.10827065	26.76467666	26.47238221	23.38467908	20.85793036	26.97968678	24.52539745	22.42324005	24.72132988
3	28.83403411	24.81093934	27.41744221	28.21774749	27.27514808	26.80818347	20.97810292	29.39167908	25.34915641	22.61899441	26.17014275
5	28.64674319	24.22437825	26.82985916	27.50404193	27.12931435	26.35718477	20.4888831	28.97639838	24.71752102	22.10266857	25.69769927
7	28.33985482	23.73589591	26.36719883	27.02828295	27.0516496	25.67430645	20.1521583	28.47545661	24.10224543	21.72156371	25.26486126
9	28.09294502	23.35742272	26.02790028	26.71121175	26.99530093	25.05127351	19.9167984	28.03475288	23.55767014	21.42431181	24.91695874
11	27.90642162	23.03590068	25.75321688	26.44988531	26.93023251	24.50078481	19.73814576	27.64245423	23.07219148	21.17287482	24.62021081
13	27.75778758	22.73244542	25.50631159	26.19114423	26.84322844	24.00388303	19.58054846	27.2777101	22.62209864	20.94311498	24.34582725
15	27.61671555	22.43550916	25.26522263	25.92330862	26.72758064	23.54979159	19.42600819	26.93005032	22.21474818	20.71863766	24.08075725
17	27.47591235	22.15843273	25.03425642	25.66361455	26.59952069	23.12228324	19.28501081	26.6036782	21.85845391	20.50917115	23.83103341
19	27.34113012	21.90798955	24.81484972	25.4214372	26.4662143	22.72569554	19.16062352	26.29879603	21.54882485	20.3163064	23.60018672
21	27.2120173	21.68064407	24.60510986	25.19716676	26.32837706	22.36564423	19.05017103	26.0127594	21.27616847	20.13757011	23.38656283
23	27.08514674	21.47113031	24.40203735	24.98774217	26.18698835	22.03768447	18.9521172	25.7407974	21.03583867	19.97028683	23.18697695
25	26.95948349	21.27640252	24.20925506	24.7911867	26.04341587	21.73410027	18.86484179	25.48021401	20.81921621	19.81166349	22.99897794
27	26.83470664	21.09480678	24.02987964	24.60526514	25.8982285	21.45151198	18.78601385	25.22795465	20.62146213	19.660504	22.82103333
29	26.71100836	20.92455991	23.86017757	24.42789136	25.75240371	21.1899691	18.7136803	24.98213239	20.44054494	19.5142243	22.6516592

CONCLUSION

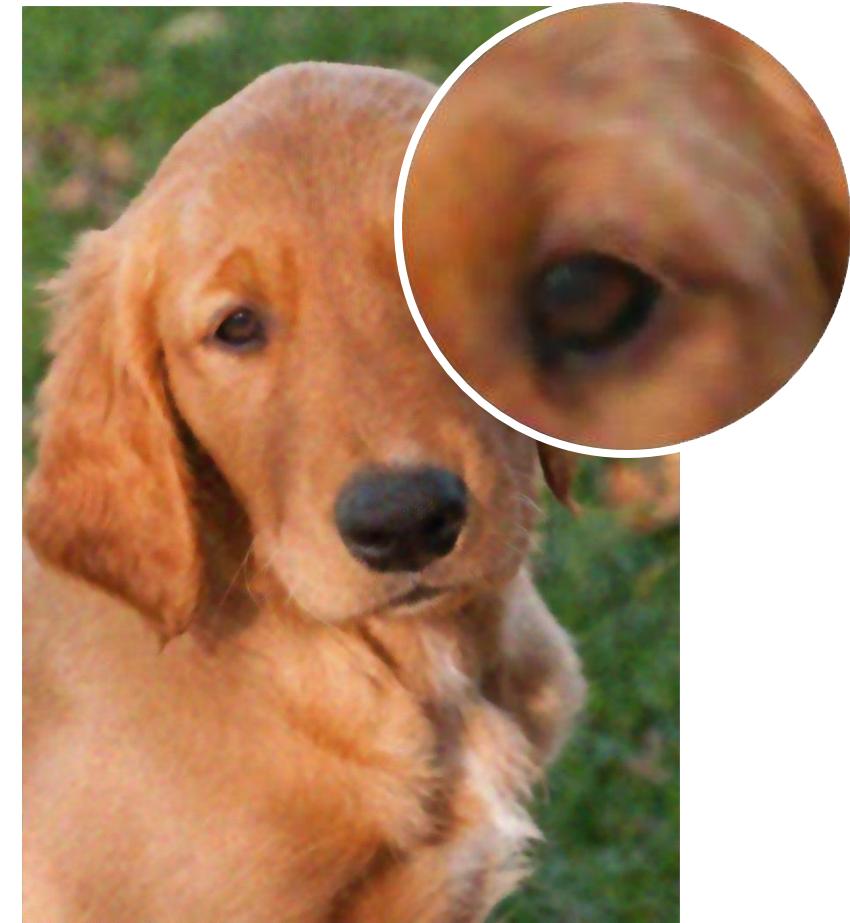


Median + Laplacian

PSNR: 26.4195142dB

<

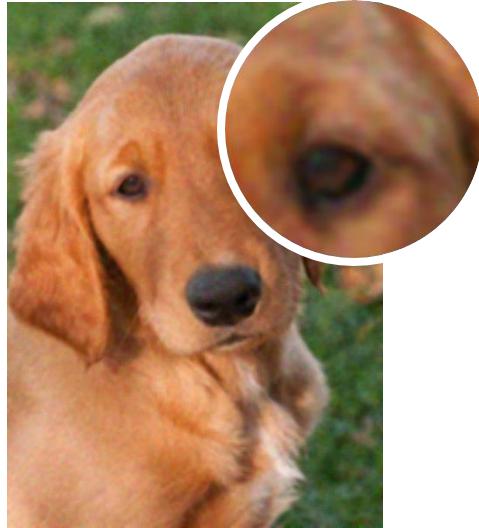
0.86



Median + Non Local Means

PSNR: 27.2751482dB

CONCLUSION



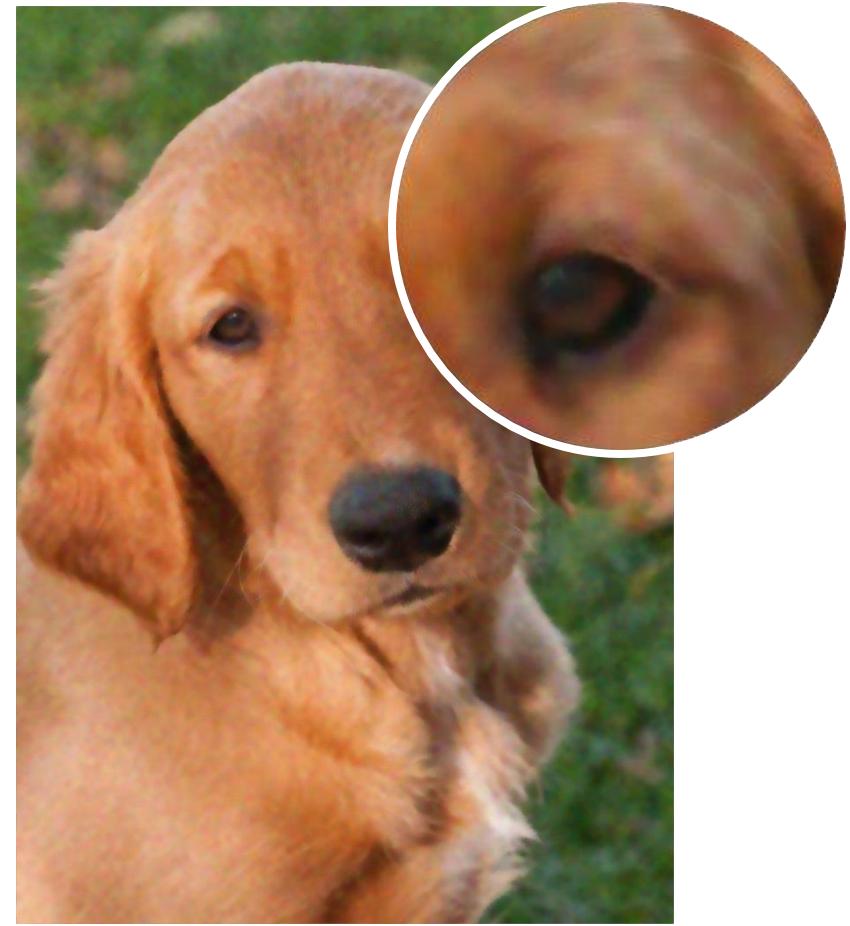
Median

PSNR: 26.7191653dB



Non Local Means

PSNR: 26.4723822dB



Median + Non Local Means

0.56

PSNR: 27.2751482dB

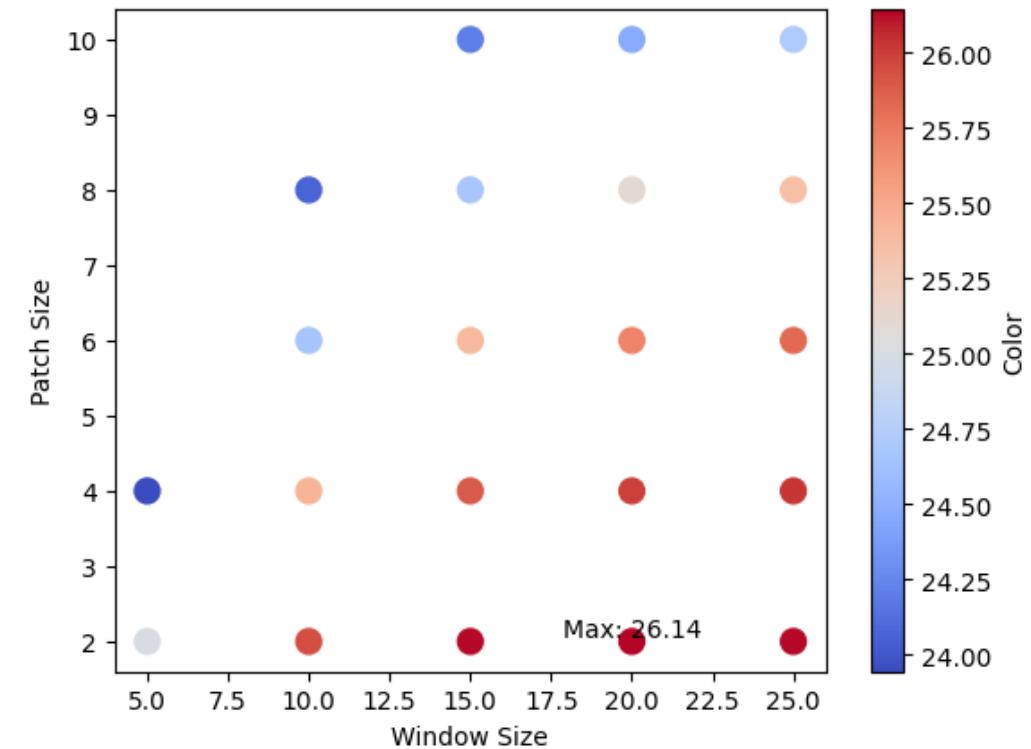
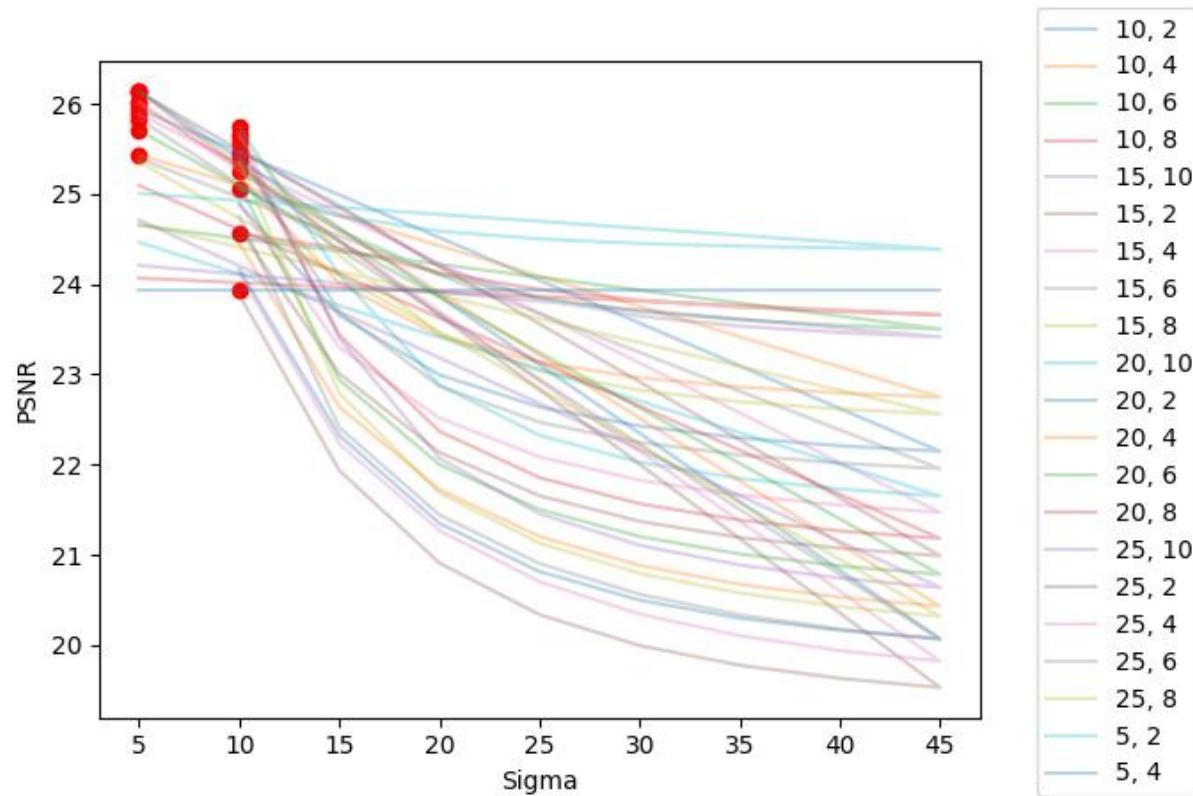
CHAPTER 3

Final Conclusion

01

Median + Non Local Means filter

Before Final Conclusion



Final Conclusion

Median + Non Local Means filter

Filter Size : 3

Window Size : 20

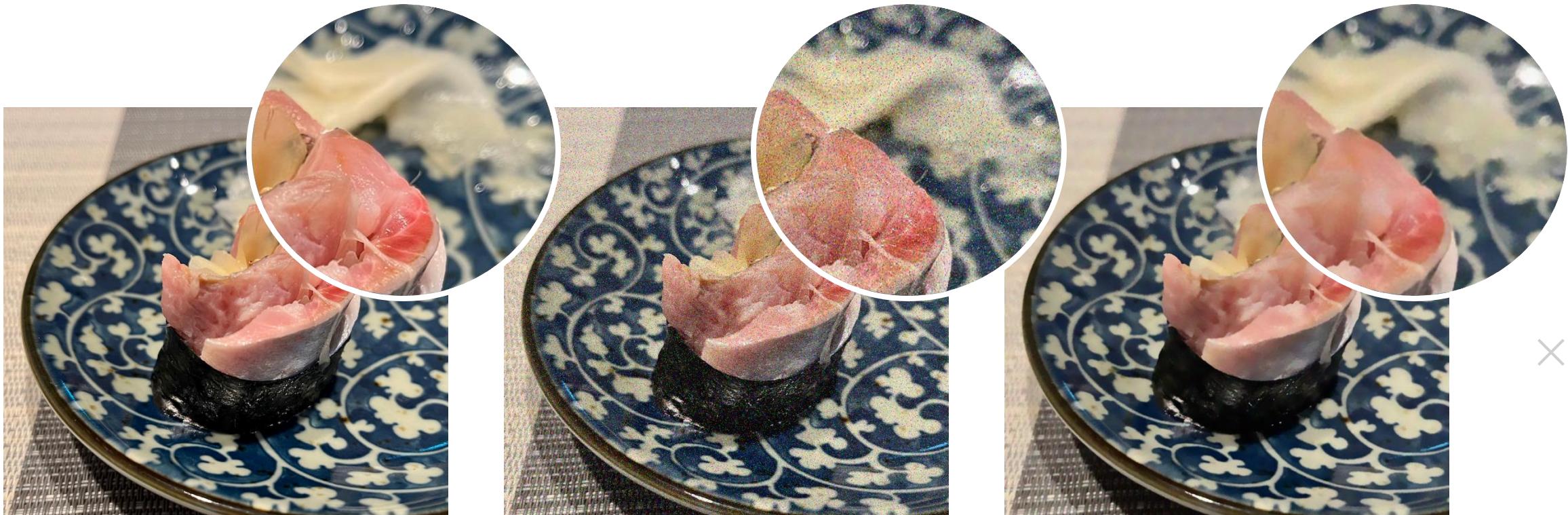
Patch Size: 2

Sigma : 5

Dataset 2

Name	PSNR
card	26.1433718
child	28.4849163
gallery	28.4397122
love	25.8326079
plate	30.0574263
rain	21.5853902
roof	28.9187422
room	25.6707904
sky	28.9764394
train	27.1232033

Final Conclusion



original

noisy

result

PSNR: 30.0574263dB

Final Conclusion

Name	PSNR
baby	28.83403411
bagles	24.81093934
beach	27.41744221
book	28.21774749
dog	27.27514808
girl_ani	26.80818347
house	20.97810292
kitty	29.39167908
lego	25.34915641
street	22.61899441

before



Name	PSNR
baby	30.0227362
bagles	26.4687331
beach	28.7449572
book	29.7585038
dog	27.5945485
girl_ani	28.4290514
house	22.2518124
kitty	30.4393410
lego	27.0374887
street	23.9614888

after

Final Conclusion



original

noisy

result

PSNR: 30.4393410dB

Final Conclusion



original



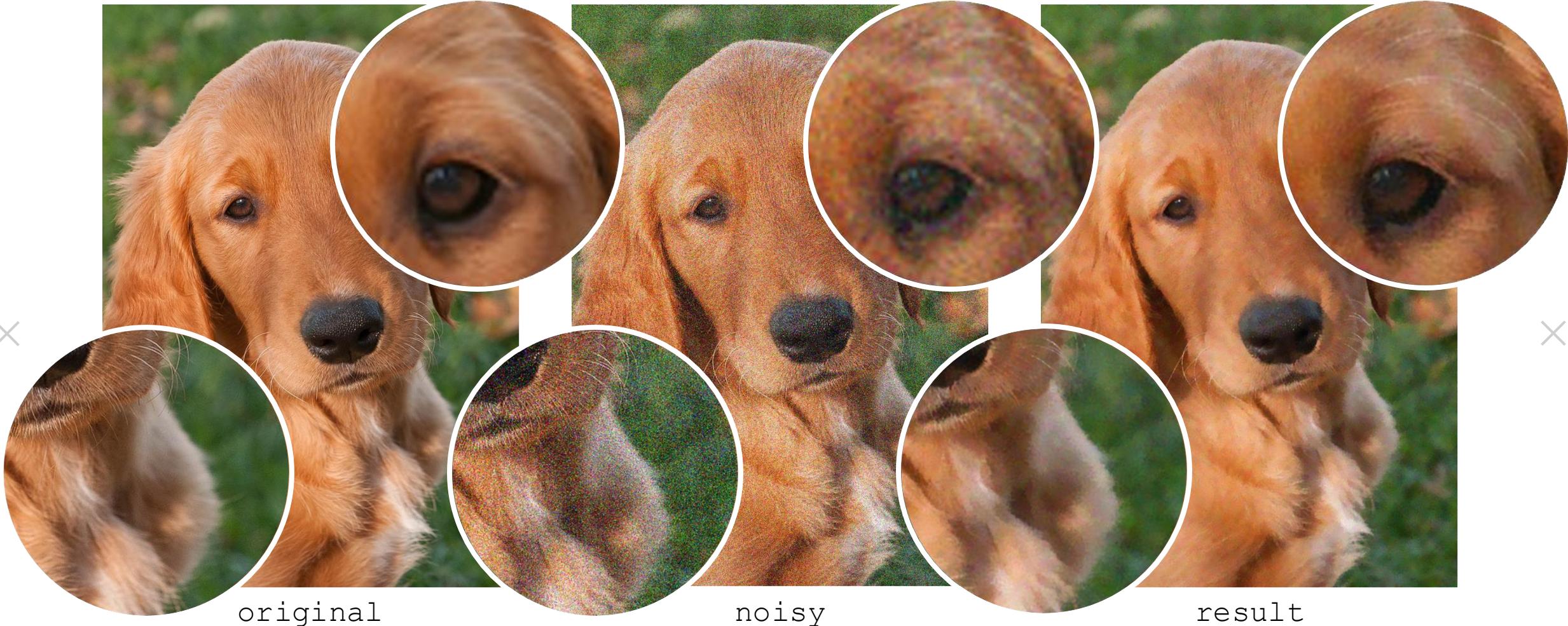
noisy



result

PSNR: 30.0227362dB

Final Conclusion



PSNR: 27.5945485dB

Final Conclusion



PSNR: 26.4687331dB

Final Conclusion



original



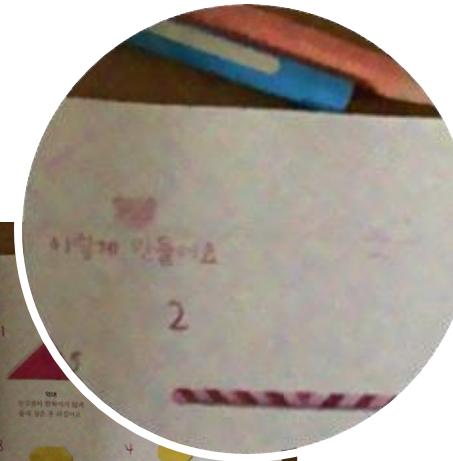
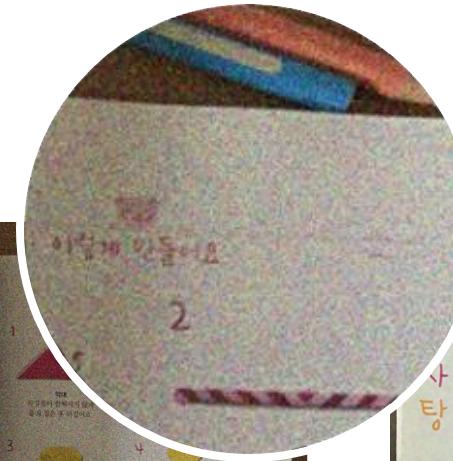
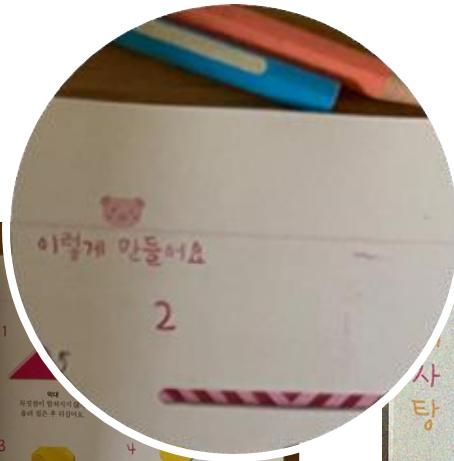
noisy



result

PSNR: 28.7449572dB

Final Conclusion



original

noisy

result

PSNR: 29.7585038dB

Final Conclusion



original



noisy



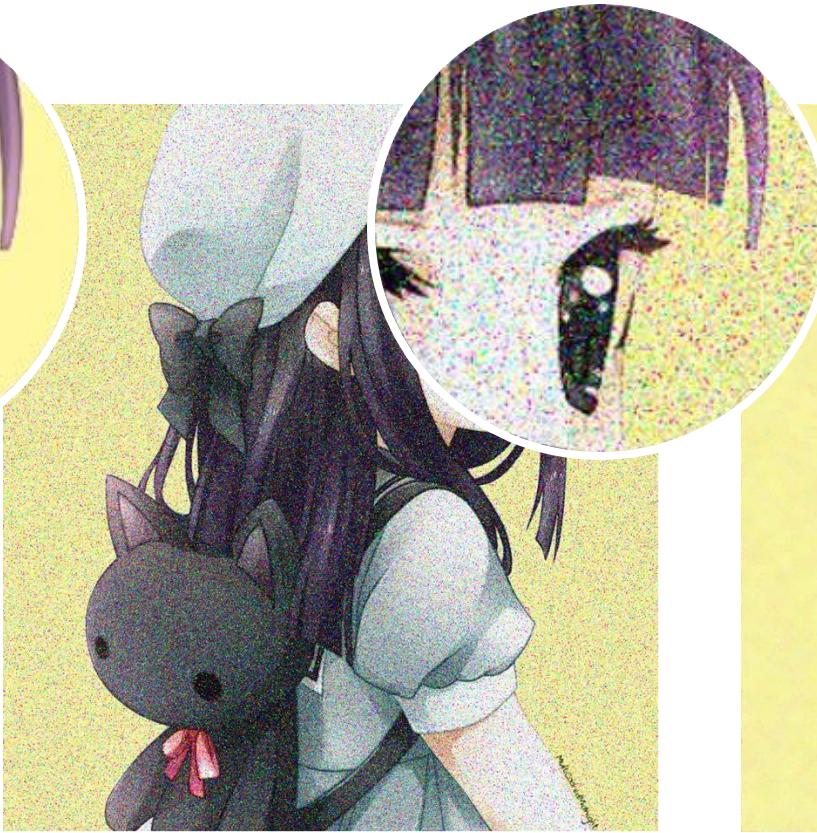
result

PSNR: 22.2518124dB

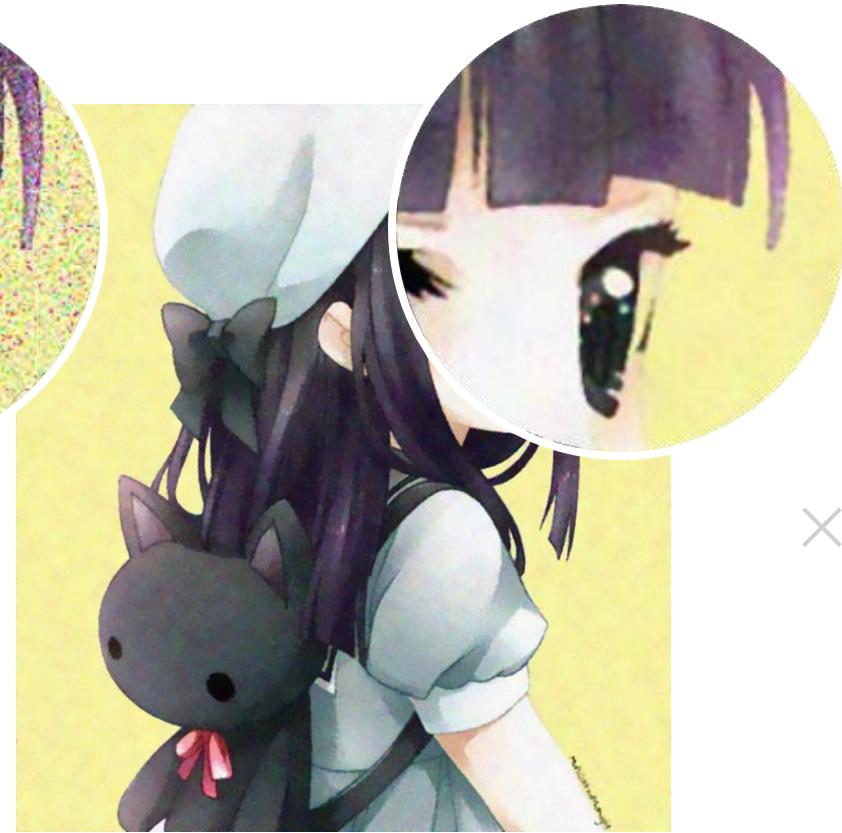
Final Conclusion



original



noisy



result

PSNR: 28.4290514dB

Final Conclusion



original



noisy



result

PSNR: 27.0374887dB

Final Conclusion



original



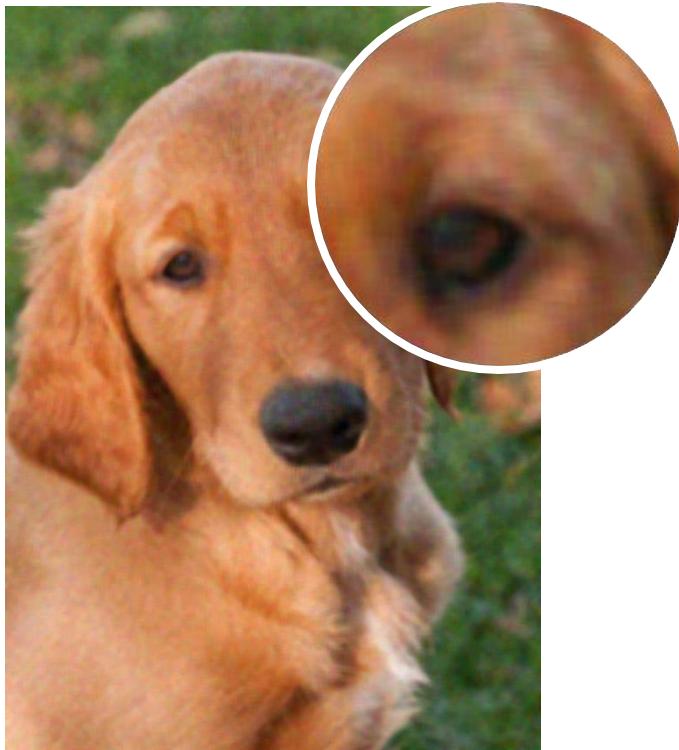
noisy



result

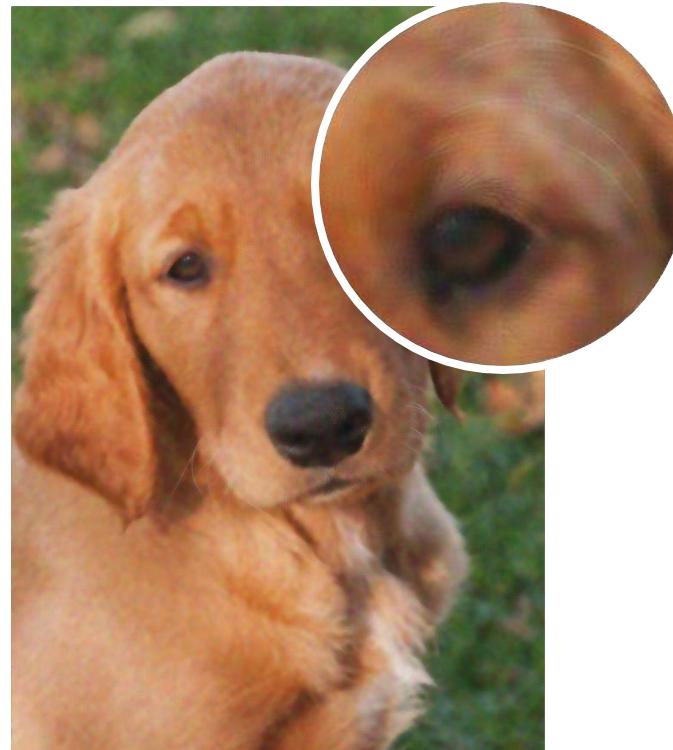
PSNR: 23.9614888dB

Final Conclusion



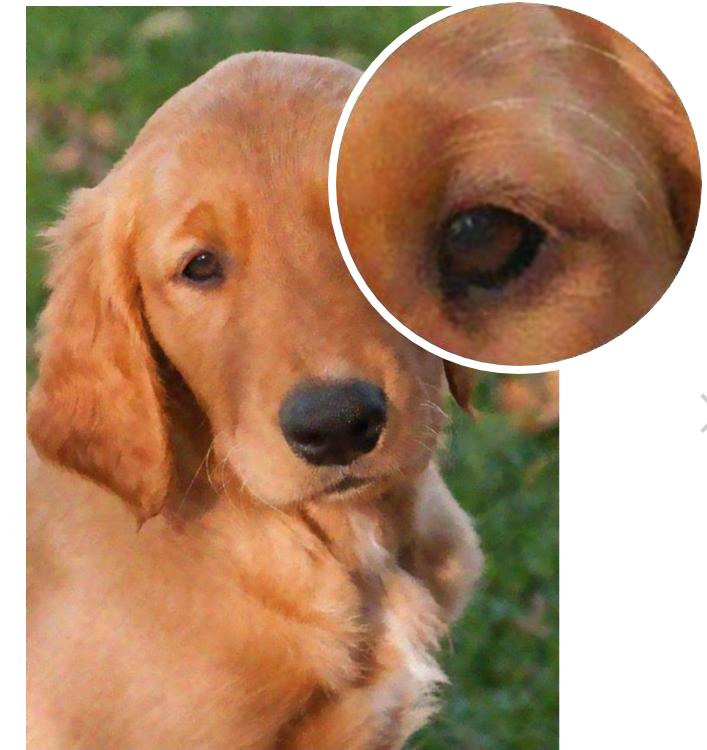
Median

PSNR: 26.7191653dB



Non Local Means

PSNR: 26.4723822dB



Median + Non Local Means

PSNR: 27.5945485dB

**THANK
YOU**