15-463 Computational Photography (Fall 2023)
Assignment 3

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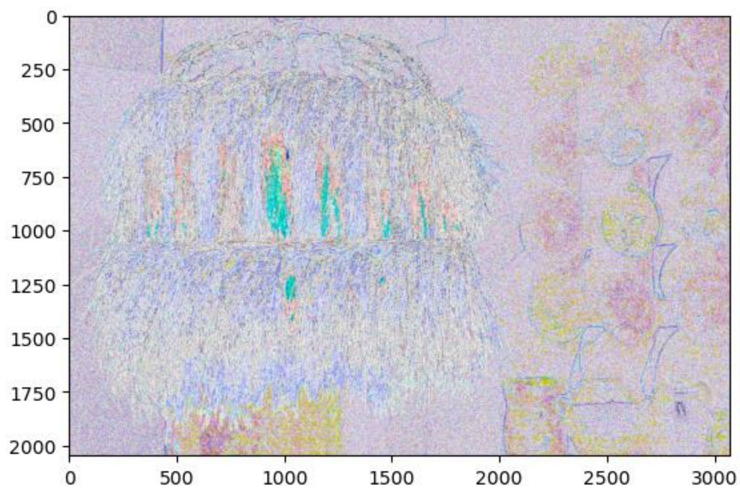
1. Bilateral filtering

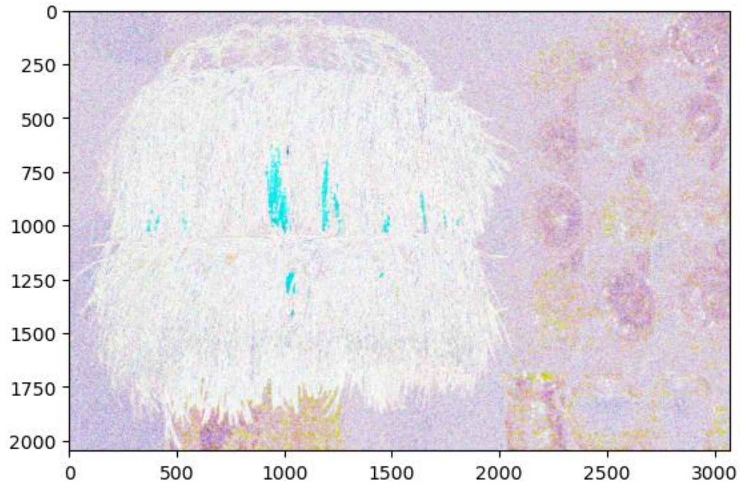
[Implement bilateral filtering]

When I varied sigma_s values following suggested value range in the assignment, sigma_s = 32 gave me satisfying result. Thus, I decided to use the value for the following steps and performed experiments with different sigma_r which is the parameter for the core concept of bilateral filtering. I tried sigma_r = [0.05, 0.15, 0.25]. All difference images are multiplied by 100 to highlight values.

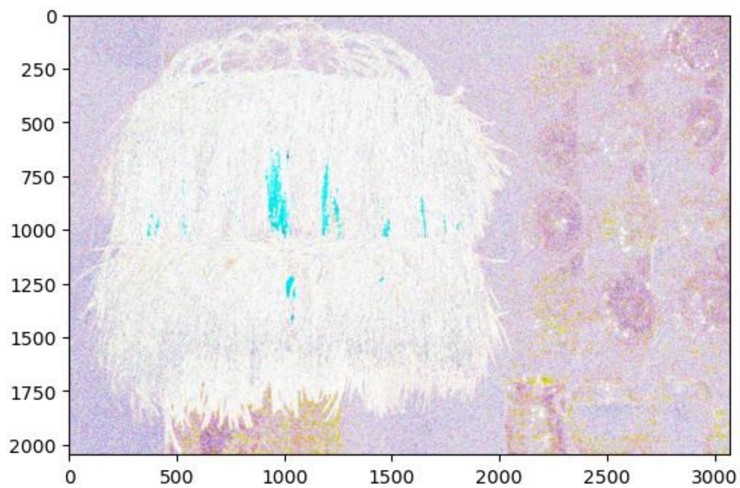
Difference image (ambient img – A_base) w/ sigma_r = 0.05



sigma_r = 0.15



Sigma_r = 0.25



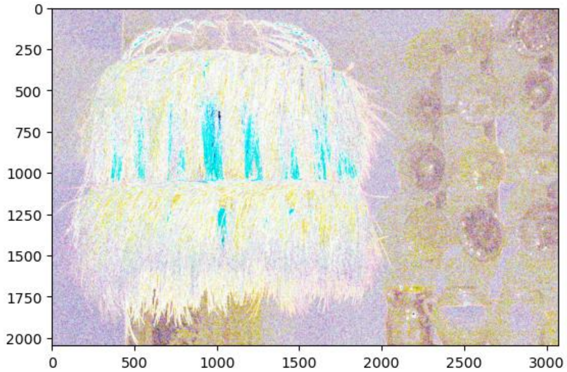
The difference images show that high difference on the hang light with a lot of details and the deem scen with the ornaments on the wall. I noticed that higher sigma_r produce less noisy image on the deem part but the most blurred on the details. Thus I chose sigma_r = 0.15, sigma_s = 32 as the best parameters here.

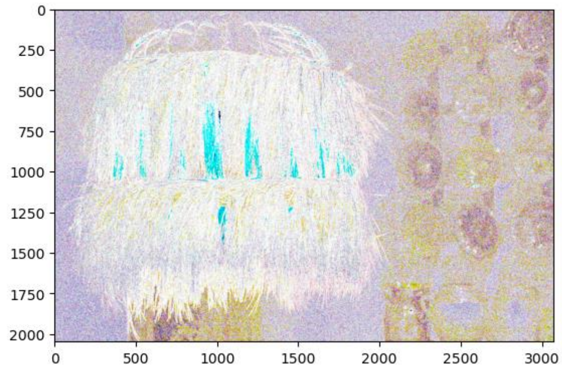
Advantage: it could produce denoised image while preserving edges.

Disadvantage: still blur many details compared to the following advanced techniques.

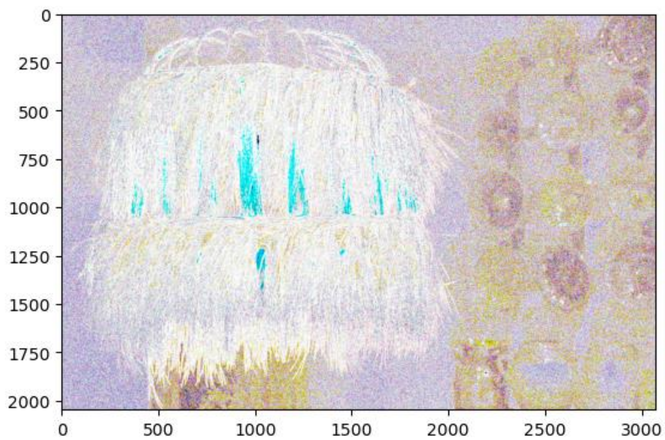
[Implement joint-bilateral filtering]

sigma_r = 0.05, 0.15





sigma_r = 0.25



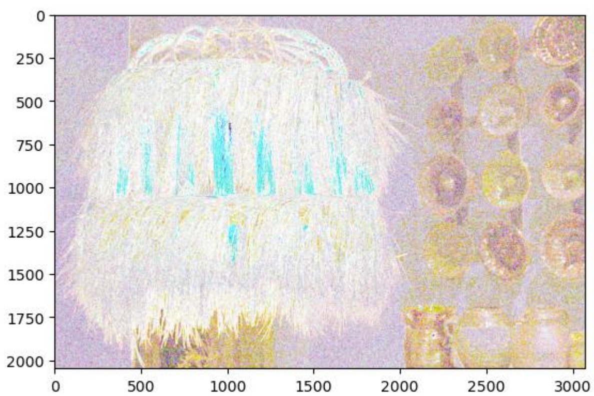
When sigma_r = 0.05, some artifact occurred on the detail part as below:

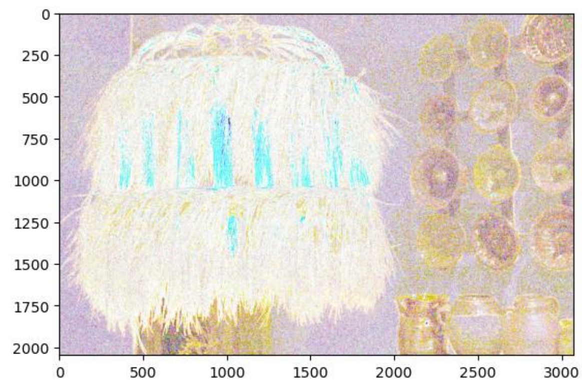
Probably it's because of mismatch of edges in ambient and flash images. Higher sigma_r values mediated the artifact thus I chose sigma_r = 0.25 and sigma_s as my best values here.
Advantage: more preserved details compared to the basic bilateral filtering
Disadvantage: artifacts

[Implement detail transfer]

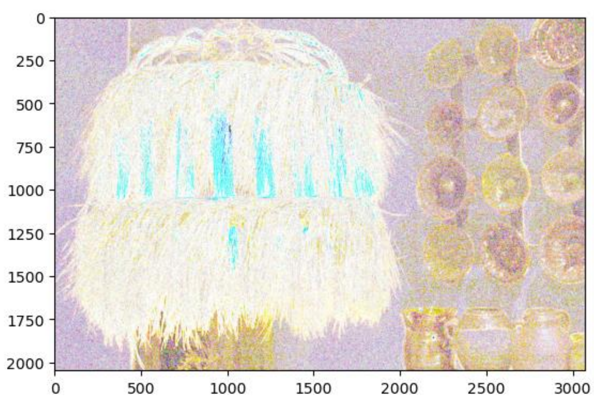
Used same parameters for A_NR with F_Base

Sigma_r = 0.05, 0.15





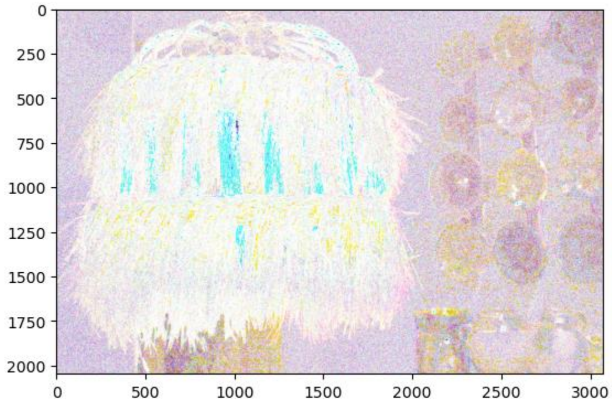
Sigma_r = 0.25

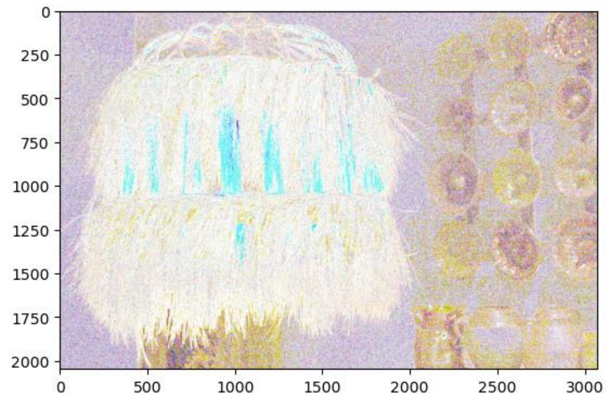


With the enhanced details, the highest sigma_r value produce the most sharper and the least noisy image. The best parameter set is thus sigma_r = 0.25, sigma_s = 32
Advantage: Preserved details with denoising.
Disadvantage: Twice of filtering for F and A.

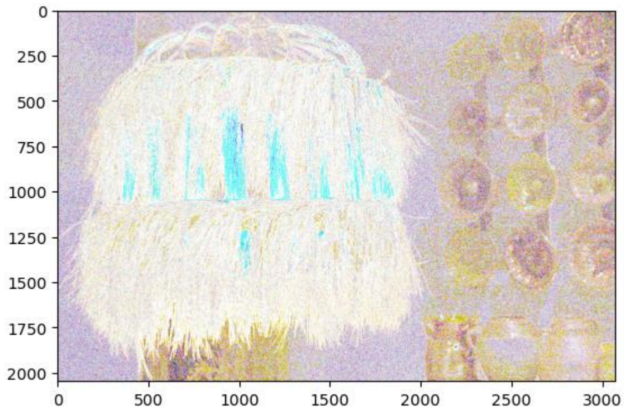
[Implement shadow and specularity masking]

Sigma_r: 0.05, 0.15





Sigma_r: 0.25



As same with the third technique, the highest sigma_r value produced the most sharper and the least noisy image. The best parameter set is thus sigma_r = 0.25, sigma_s = 32. Also, with the shadow/specular mask, it reduced the artifact from only-existing edges in the flash images

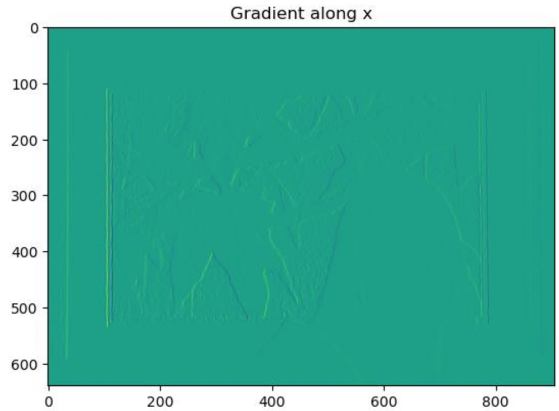
Left: A_detail, Right: A_final

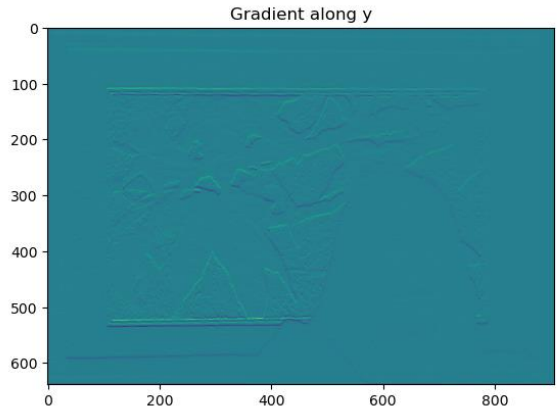
Advantage: Preserved details with denoising, reduced shadow/specular artifacts from flash img

Disadvantage: Computationally heaviest.

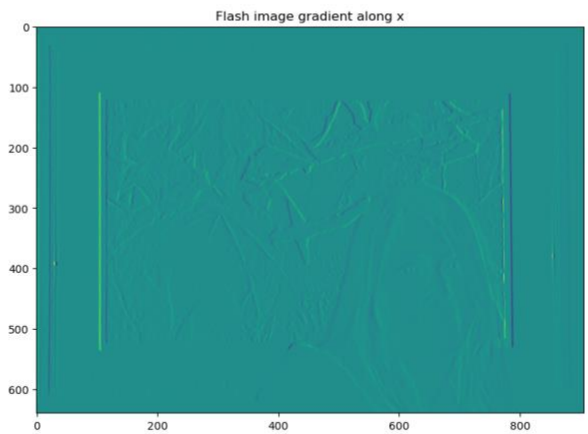
2. Gradient-domain processing

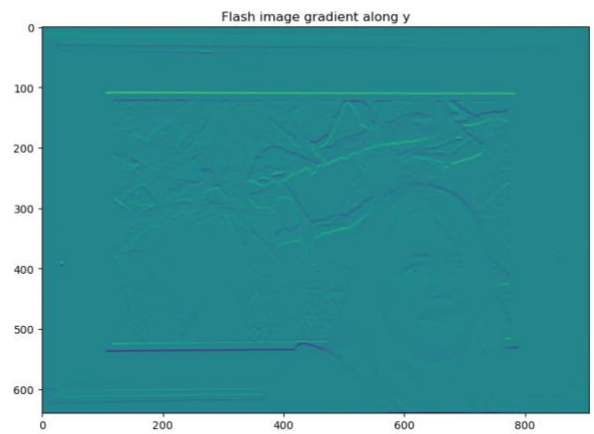
Gradient of a in R channel



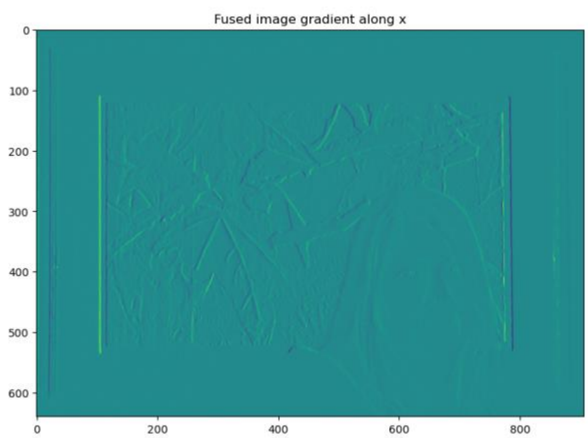


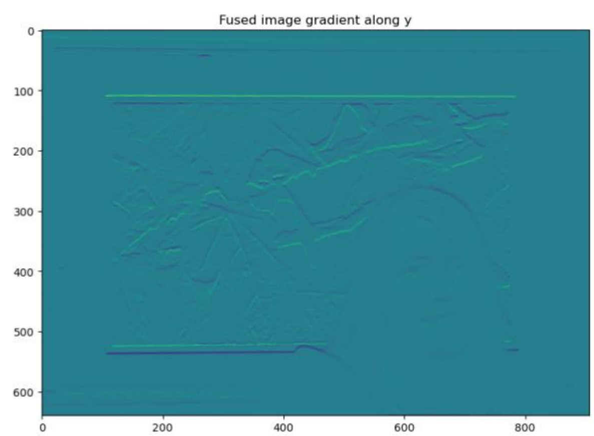
Gradient of a in phi_dash in R channel



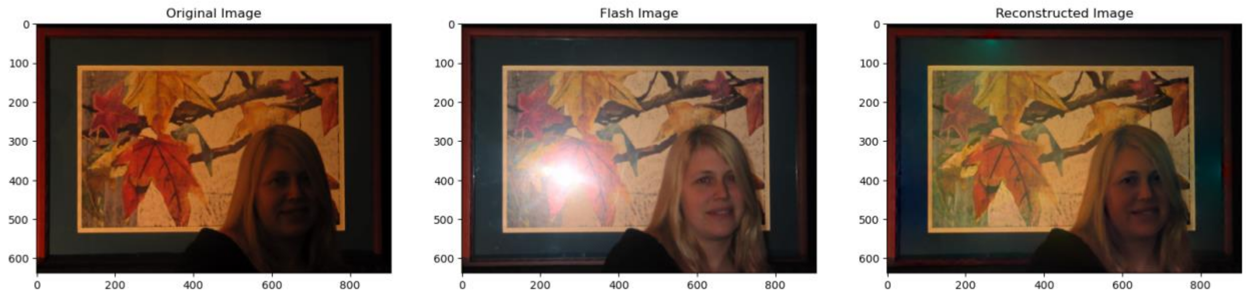


Gradient of a in phi_star in R channel





Changing sigma and tau didn't make big change in image on visible level, thus decided to use the presented values (sigma = 40, tau=0.9).

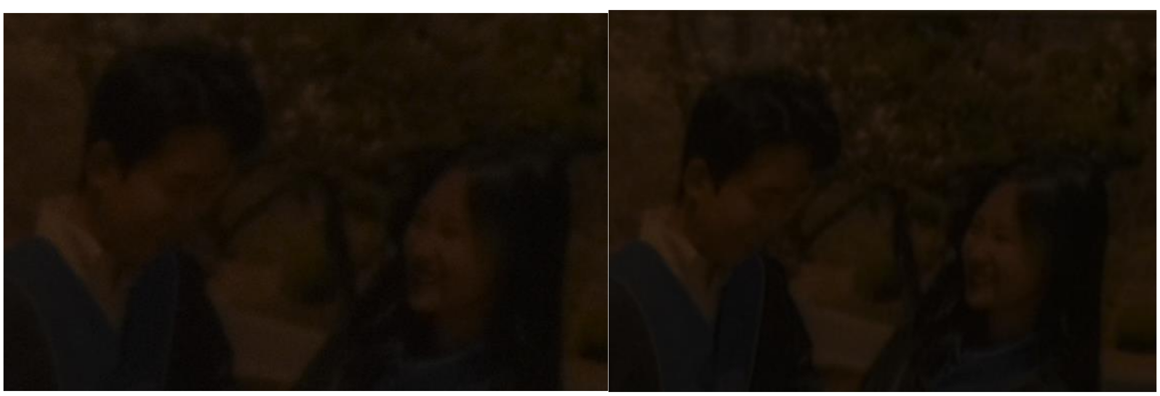


When tri to decrease boundary size with initialization from 50 to 1, poisson solver seems to reconstruct the image well enough.

3. Capture your own flash/no-flash pairs

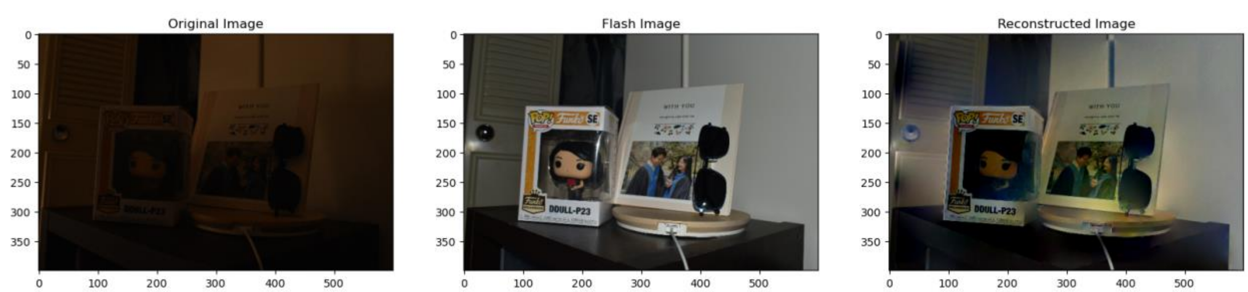
1) Bilateral filtering

Left: ambient image, Right: denoised image



Improvement wasn’t dramatic but the filtered image showed less noisy and preserving more details.

2) Gradient based processing



The process seemed to successfully remove reflection from specular materials but has some hollow artifacts. Probably it might be originated from very dark ambient image which has very low gradient values.

4. Bonus: Reflection removal in flash/no-flash photography

Improvement was not drastic but can see that the reflection was reduced from flash image.