Homework Assignment 3

15-663, Computational Photography, Fall 2022, Carnegie Mellon University

Chenhao Yang

1. Bilateral filtering

In this section, we implemented four algorithms:

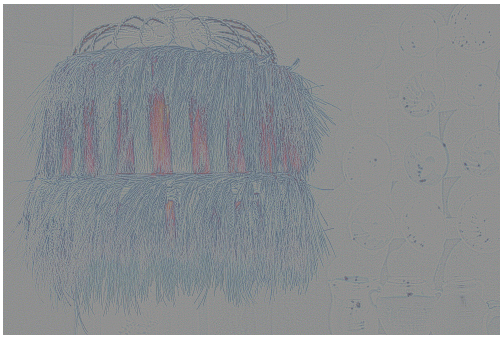
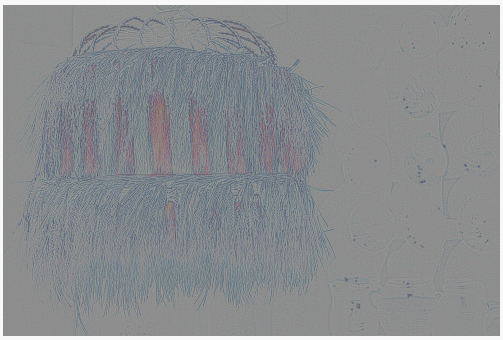
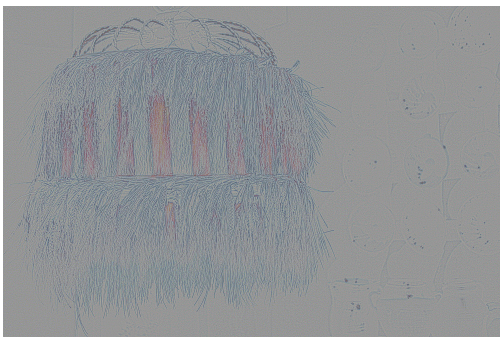
- Piecewise bilateral filtering
- Joint flash / no-flash bilateral filtering
- Detail transfer
- Shadow and specularity mask

The first part **Parameters Evaluation** will present effects of various parameters used in bilateral filtering, as they are essential for noise removal and general quality of the filtered images. The second part **Algorithm Evaluation** will compare the four different algorithms and analyse their pros / cons.

1.1 Parameters Evaluation

σ_r

σ_r is the standard deviation of the intensity Gaussian kernel.

value	Image produced	Difference
0.08		
0.10		
0.12		
0.14		

Smaller σ_r makes edges clearer because the spacial weighting is more concentrated, nearby pixels weights more and farby pixels weights less, thus makes edges clearer.

σ_s

σ_s is the standard deviation of the spatial Gaussian kernel.

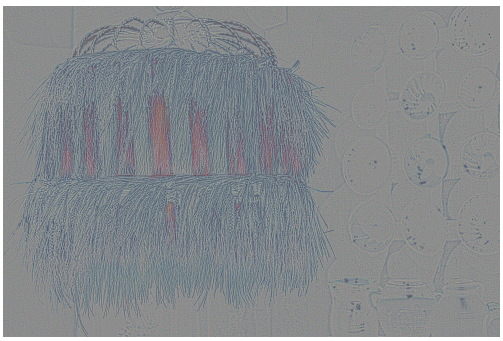
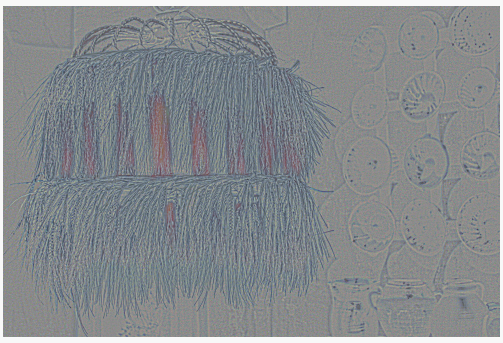
value	Image produced	Difference
0.1		
1.0		
5.0		

10.0		

Larger σ_s removes more noise because the "averaging" effects of gaussian kernel, it is noticable from the noise density from difference maps. However, larger σ_s washes out details of the image and it can be considered as a drawback. Another fact is that the smoothing effect is limited and saturates when σ_s reached some level as we cannot notice significant difference between `sigma_s=50` and `sigma_s=10`.

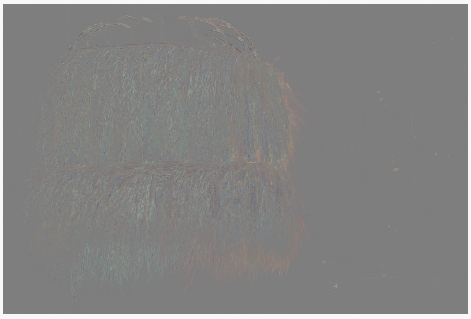
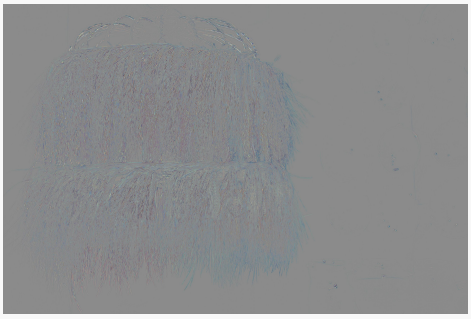
$kernel$

$kernel$ is the kernel size of gaussian filter applied.

value	Image produced	Difference
5		
9		
15		
29		

Larger kernel smoothes out the image better, however it washes out details of the image as well.

1.2 Algorithm Evaluation

Type	Image produced	Difference
Piecewise Bilateral		
Joint Bilateral		
Detail Transfer		
Shadow and specularity Mask		

*The difference map is computed by `normalize(image[i] - image[i-1])`, e.g., difference map for joint bilateral is `image[joint bilateral]-image[piecewise bilateral]`. We believe this makes more sense when comparing two algorithms.

Here are finds of four algorithms:

- Piecewise bilateral filtering

  Advantage: Piecewise bilateral filter removed most of the noises in the scene, especially dark areas where originally contain much noises.

  Disadvantage: removed details of the image

- Joint flash / no-flash bilateral filtering

  Advantage: Details are more significant

  Disadvantage: Allignement between flash / no-flash pairs has to be established; specularities and shadows are not removed

- Detail transfer

  Advantage: details are recovered while removing noises

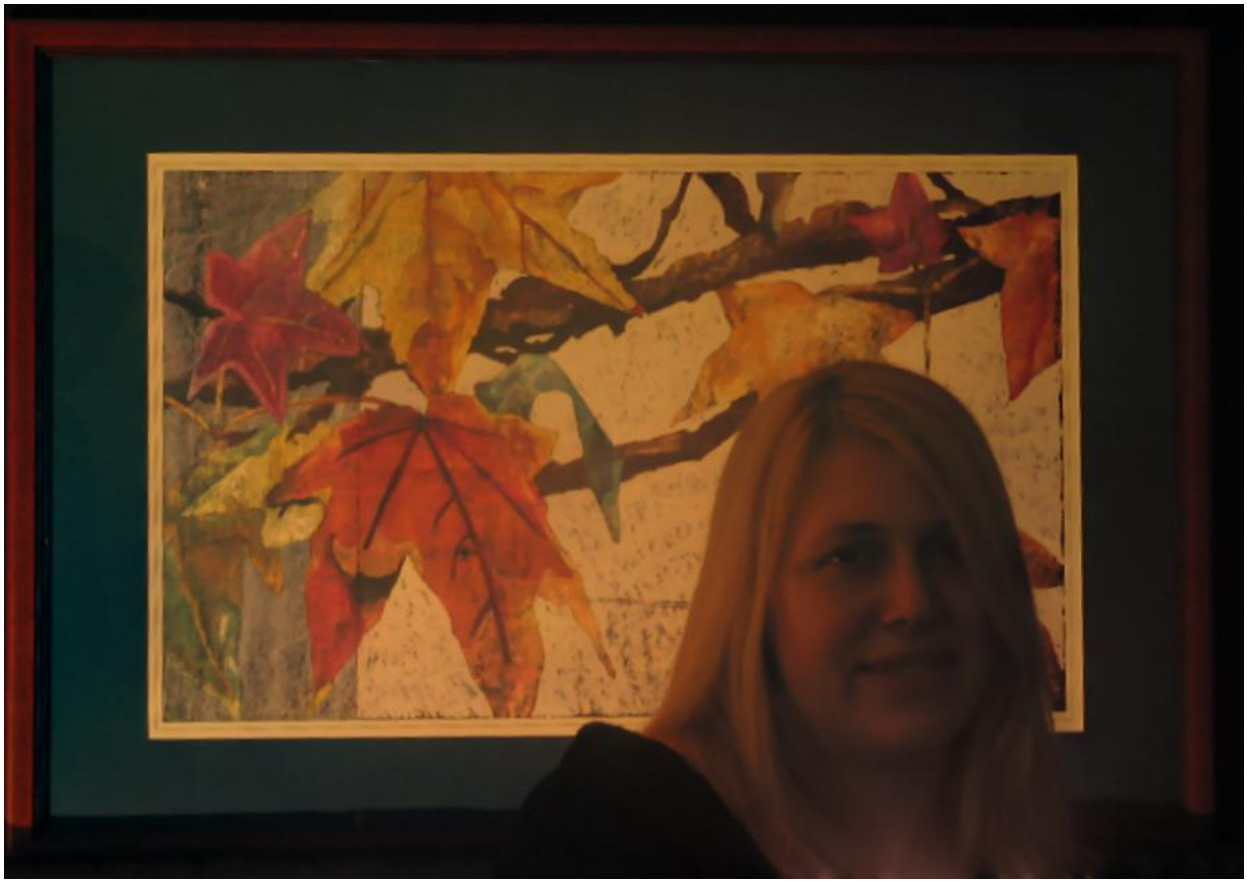
  Disadvantage: Not yet considered shadow and specularity contamination

- Shadow and specularity mask

  Advantage: can be considered as optimized solution of above

  Disadvantage: need manual inspection and selection of mask threshold

2. Gradient-domain processing



2.1 Differentiate and then re-integrate an image

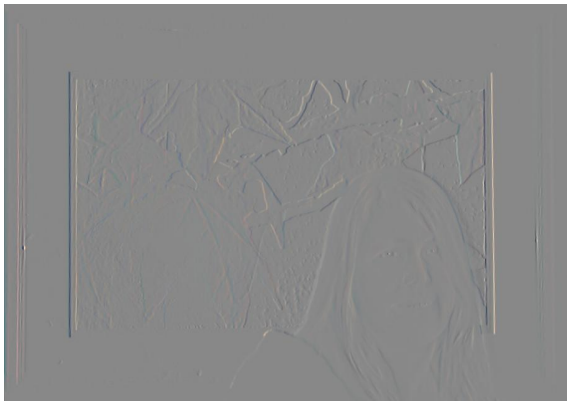
Implemented using both gradient and Laplacian filtering, re-integrated images with no artifacts.

2.2 Create the fused gradient field

Gradient fields of ambient image:

I_x	I_y
	

Gradient fields of flash image:

I_x	I_y
	

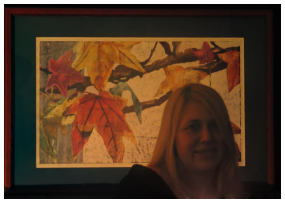
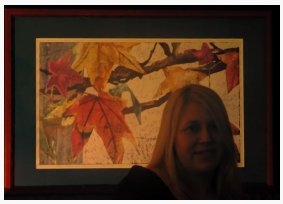
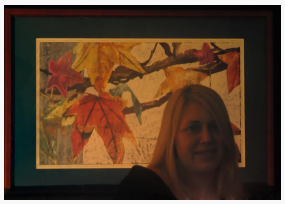
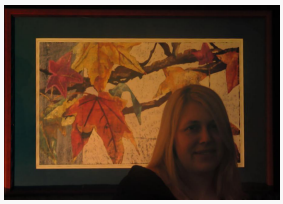
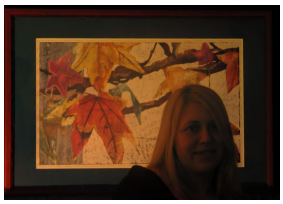
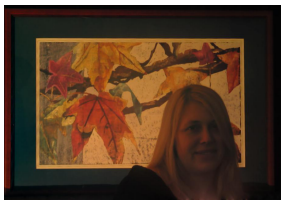
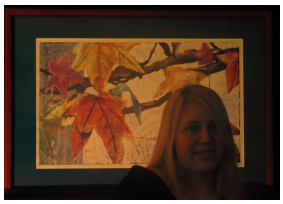
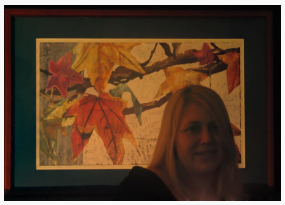
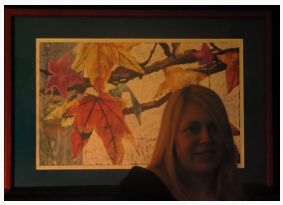
Gradient fields of fused image:

I_x	I_y
	

Parameters:

τ_s	σ	ϵ	**N**
1.0	40	0.001	1000

With different boundary conditions:

	I_bound=ambient	I_bound=flash	I_bound=average
I_init=ambient			
I_init=flash			
I_init=average			
I_init=zeros			

The initialization doesn't matter: the poission solver will converge to desired results from any initialization. However, good initialization helps computation time.

The boundary condition will be different, in our case boundary with flash is slightly brighter than ambient boundary, and average is in between.

3. Capture your own flash/no-flash pairs

3.1 Bilateral filtering

Captured image pair:

Ambient	Flash
	

Fused result:

To reproduce:

```
python bilateral_filtering.py --scene 'kitchen' --kernel 5
```

3.2 Gradient domain image fusion

Captured image pair:

Ambient	Flash
	

Fused:


bath & body works
WHITE TEA & SAGE