



ELEC 546 Assignment #2 Filtering and Smoothing

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1 Part 1

1.1 Exercise 1

I choose Iron man as my favourite hero. Here is the original image.



Figure 1: Iron man

- Crop the head of the superhero from the image.



Figure 2: Iron man head

- Save the cropped sub-image as a PNG file.
See ironmanhead.png as my image.
- Display the green component of the cropped image.



Figure 3: Iron man green head

- Change the order of the color components to [Green,Red,Blue] for the original image and display the image.



Figure 4: Iron man in GRB channels

1.2 Exercise 2

Here is the original image.

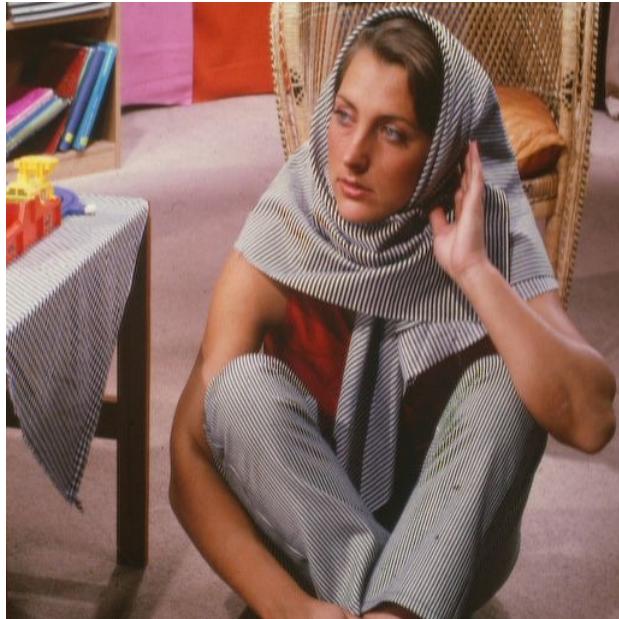


Figure 5: Original Barbara

- Convert the image to gray scale.

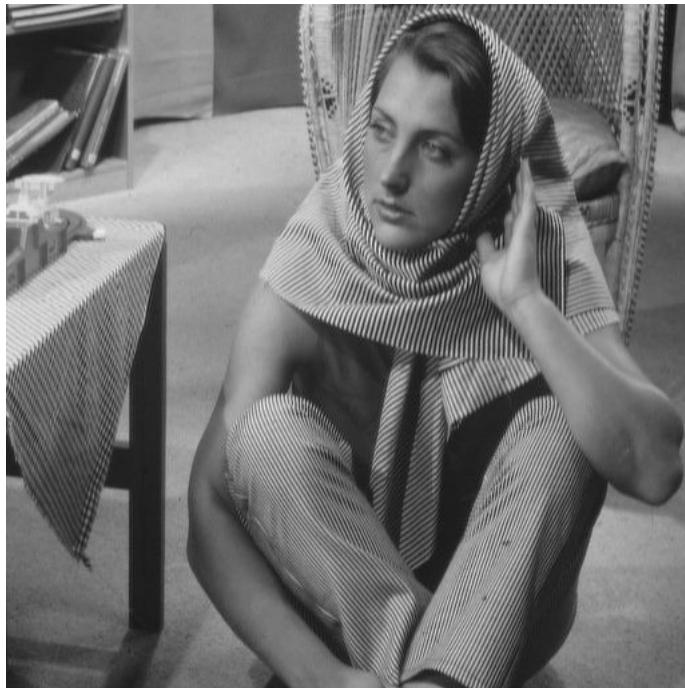


Figure 6: Gray Barbara

- Plot a histogram of gray scale image

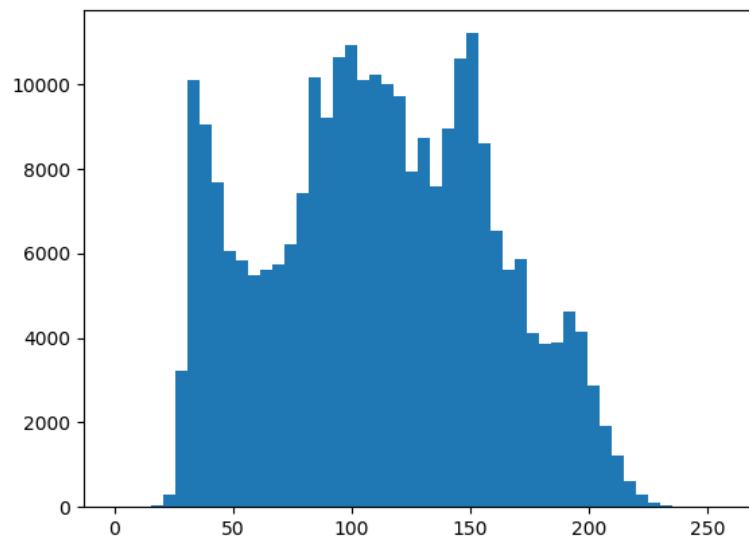


Figure 7: Caption

- Blur the gray scale image



(a) Standard deviation is 2



(b) Standard deviation is 8

Figure 8: Blur by Gaussian filters

- Histograms for the blurred images

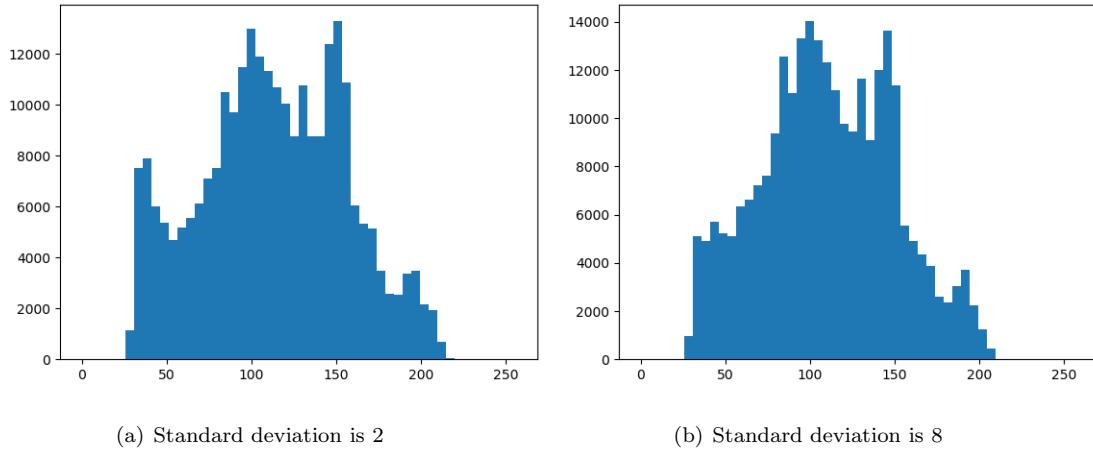


Figure 9: Blur by Gaussian filters

Both of the histograms after filter are more Gaussian-like than the original image. With standard deviation 8, the value of pixel is more likely to stay in the middle.

- Subtract the blurred image

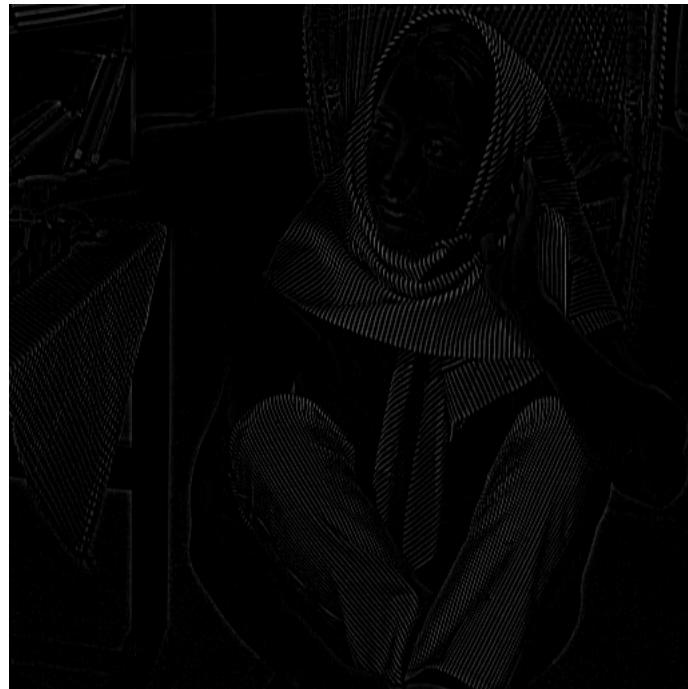


Figure 10: Subtracted image

- Threshold the resultant image at 5% of its maximum pixel value.

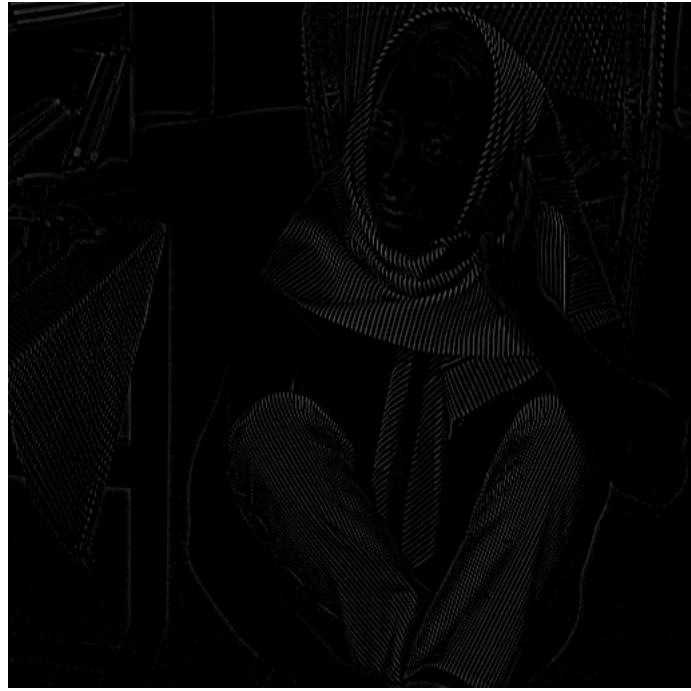


Figure 11: Subtracted image

The final image looks like the texture of her 'cloths'.

2 Part 2

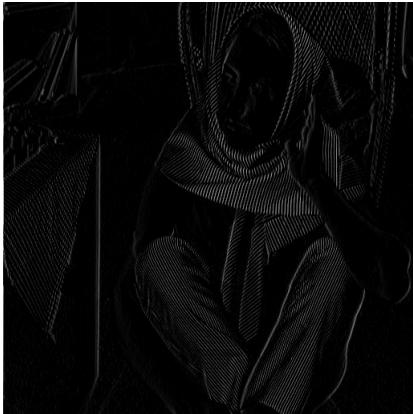
2.1 Filtering

- Use filters to filter I_1 and I_2 .

```
#matrix I1 after filter 1 is
[[ 0. 107. 105. 82. 0.]
 [ 0. 138. 112. 78. 0.]
 [ 0. 98. 68. 38. 0.]
 [ 0. 57. 37. 27. 0.]
 [ 0. 33. 23. 15. 0.]]
#matrix I1 after filter 2 is
[[ 0. 0. 0. 0. 0.]
 [130. 120. 93. 72. 33.]
 [117. 98. 78. 40. 25.]
 [ 82. 65. 42. 22. 17.]
 [ 0. 0. 0. 0. 0.]]
#matrix I1 after filter 3 is
[[ 0. 0. 0. 0. 0.]
 [ 0. 114. 95. 66. 0.]
 [ 0. 98. 72. 48. 0.]
 [ 0. 63. 43. 27. 0.]
 [ 0. 0. 0. 0. 0.]]
#matrix I2 after filter 1 is
[[ 0. 130. 125. 123. 0.]
 [ 0. 138. 142. 138. 0.]
 [ 0. 60. 53. 47. 0.]
 [ 0. 38. 33. 27. 0.]
 [ 0. 17. 17. 15. 0.]]
#matrix I2 after filter 2 is
[[ 0. 0. 0. 0. 0.]
 [112. 108. 108. 103. 97.]
 [ 83. 77. 77. 75. 60.]
 [ 40. 37. 38. 28. 22.]
 [ 0. 0. 0. 0. 0.]]
```

```
#matrix I2 after filter 3 is
[[ 0.   0.   0.   0.   0.]
 [ 0. 109. 107. 103.  0.]
 [ 0.  79.  76.  71.  0.]
 [ 0.  38.  34.  29.  0.]
 [ 0.   0.   0.   0.   0.]]
```

- Apply following filters



(a) Central difference Gradient filter



(b) Sobel filter



(c) Mean filter



(d) Median filter

Figure 12: Apply different filters

3 Smoothing

- Averaging filters.



(a) $2 * 2$



(b) $4 * 4$



(c) $8 * 8$



(d) $16 * 16$

Figure 13: Averaging filters by different sizes

- Gaussian filter.



(a) standard deviation 2



(b) standard deviation 4



(c) standard deviation 8



(d) standard deviation 16

Figure 14: Averaging filters by different sizes

Which filter works best?

Answer: I think Gaussian filter with std 2 works best because it makes the image more smooth but not lose details and edges.

What happens when you vary the box filter size?

Answer: The images after filter become more smooth and vague with the large box filter size. It means the images lose more details and edges information.

What happens when you vary the standard deviation of gaussian filter?

Answer: With the increasing of standard deviation of gaussian filter, the images become more smooth. However, when the standard deviation reaches 4, the images become vague and lose a lot of details and edges which is the same as high box filter size in average filter.

4 Edge preserving smoothing

OpenCV has a function called `bilateralFilter()` with the following arguments:

d: Diameter of each pixel neighborhood.

`sigmaColor`: Filter σ in the color space. A larger value of the parameter means that farther colors within the pixel neighborhood (see `sigmaSpace`) will be mixed together, resulting in larger areas of semi-equal color.

`sigmaSpace`: Filter σ in the coordinate space. A larger value of the parameter means that farther pixels will influence each other as long as their colors are close enough (see `sigmaColor`). When $d > 0$, it specifies the neighborhood size regardless of `sigmaSpace`. Otherwise, d is proportional to `sigmaSpace`.

- Increasing d, when sigmaColor and sigmaSpace remain same

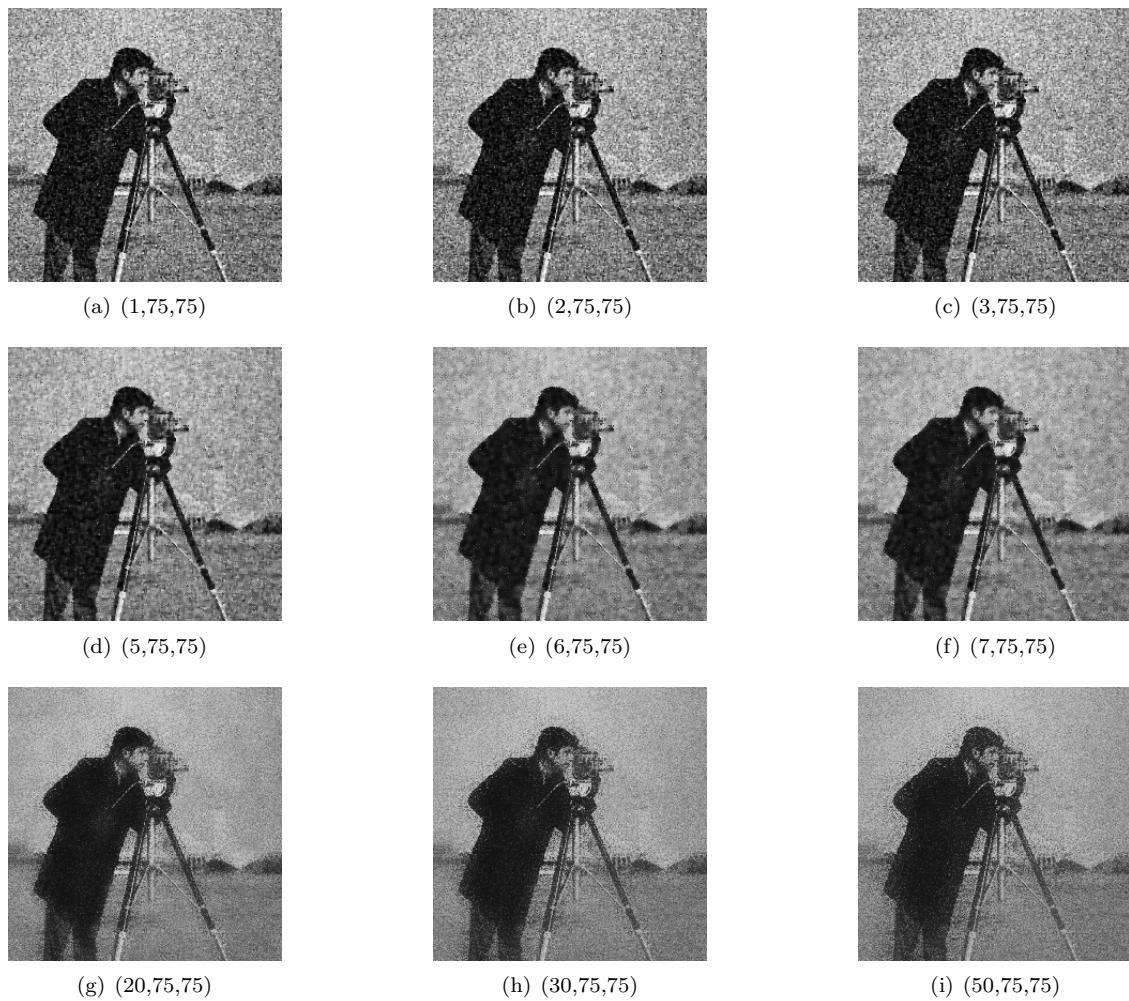


Figure 15: Find best d

So, from the above images, $d = 6$ is the best choice.

- Confirm $d = 6$, changing sigmaColor.

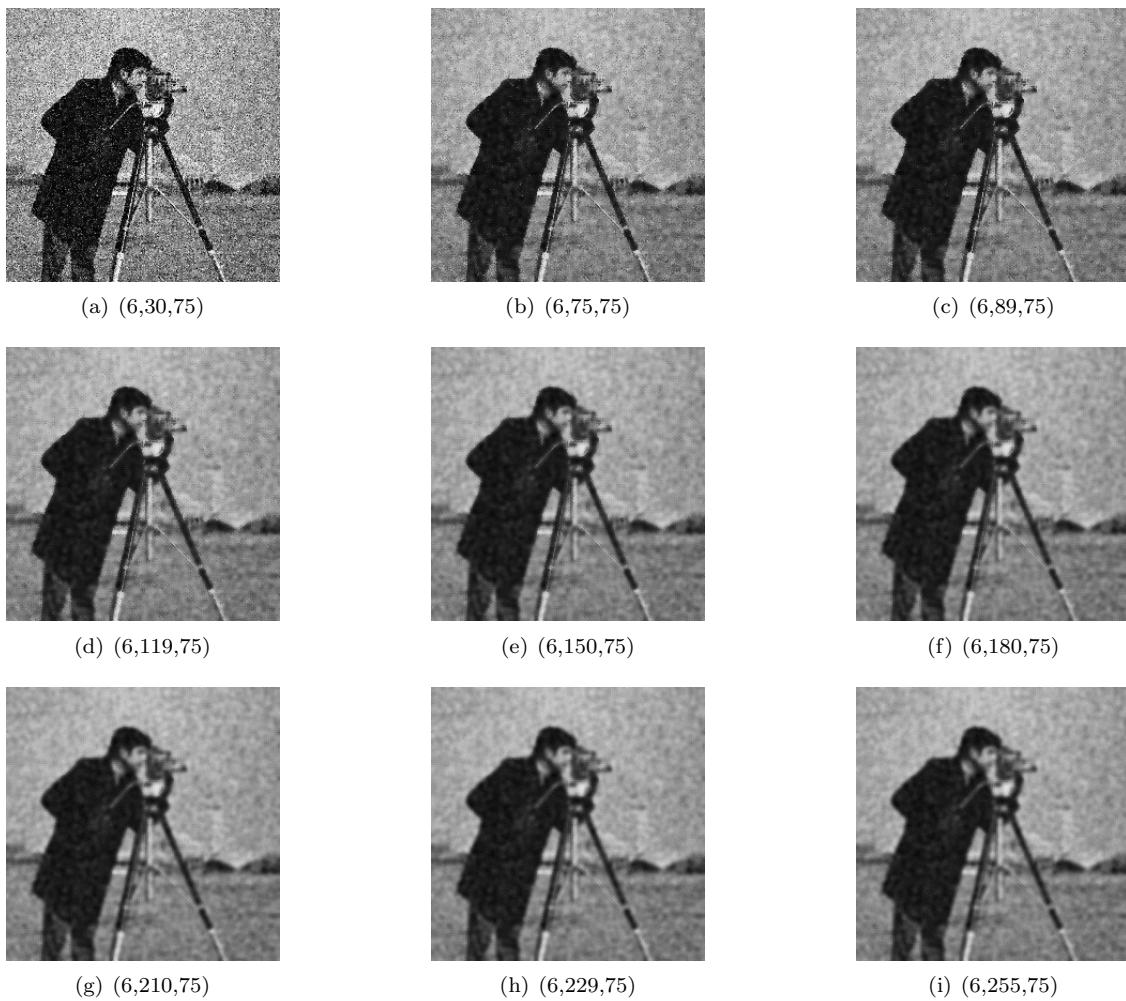


Figure 16: Find best SigmaaColor

From the above images, in my opinion, $\text{sigmaColor} = 119$ is the best.

- Compare bilateral and Gaussian.

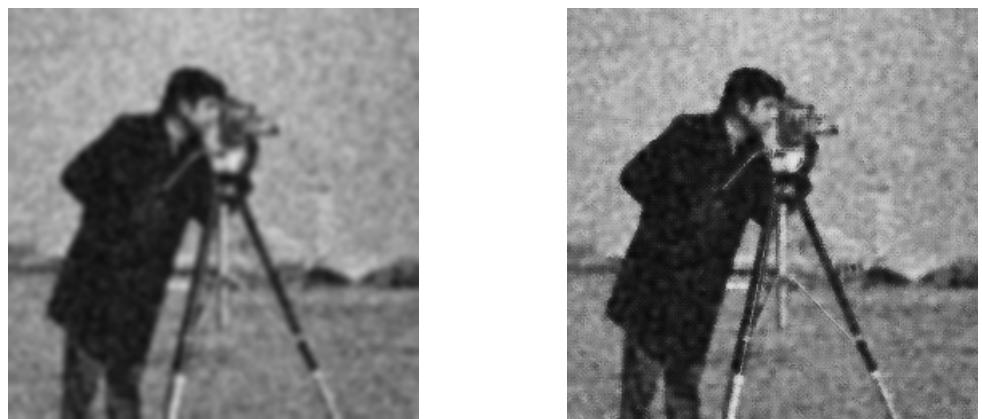


Figure 17: Compare bilateral and Gaussian.

As we can see, bilateral filter preserves the edge information when comparing to Gaussian filter.