Combining Spatial Enhancement Methods

Introduction

The purpose of this experiment is to use different methods to sharpen images in Python, such as Laplacian and Sobel gradient, so as to understand the advantages of different sharpening methods.

Methods and Materials

1. show original image

```
import cv2
import numpy as np

# (a) Original image a
image_a = cv2.imread('Resource/BodyScan.jpg')
cv2.imshow('Original', image_a)
```

2. show Laplacian of image(a)

```
# (b) Laplacian of a
kernel = np.array([[0, -1, 0],
                   [-1, 4, -1],
                   [0, -1, 0]])
image_b = cv2.filter2D(src=image_a, ddepth=-1, kernel=kernel)
# image_b = cv2.Laplacian(image_a, -1, ksize=3)
cv2.imshow('Laplacian', image_b)
```

3. add image(a) and (b)

```
# (c) add a and b
image_c = cv2.add(image_a, image_b)
cv2.imshow('Laplacian Scaling', image_c)
```

4. show Sobel gradient of (a)

```
# (d) Sobel gradient of (a)
scale = 1
delta = 0
ddepth = cv2.CV_16S
grad_x = cv2.Sobel(image_a, ddepth, 0, 1, ksize=3, scale=scale, delta=delta,
borderType=cv2.BORDER_DEFAULT)
grad_y = cv2.Sobel(image_a, ddepth, 1, 0, ksize=3, scale=scale, delta=delta,
borderType=cv2.BORDER_DEFAULT)
abs_grad_x = cv2.convertScaleAbs(grad_x)
abs_grad_y = cv2.convertScaleAbs(grad_y)
image_d = cv2.addWeighted(abs_grad_x, 0.5, abs_grad_y, 0.5, 0)
cv2.imshow('Sobel gradient', image_d)
```

5. Sobel image smoothed with a 5 × 5 box filter

```
image_e = cv2.blur(image_d, (5, 5))
cv2.imshow('Sobel gradient2', image_e)
```

6. Mask image formed by the product of (b) and (e)

```
image_f = cv2.multiply(image_b, image_e)
cv2.imshow('mask', image_f)
```

7. Sharpened image obtained by the adding images (a) and (f)

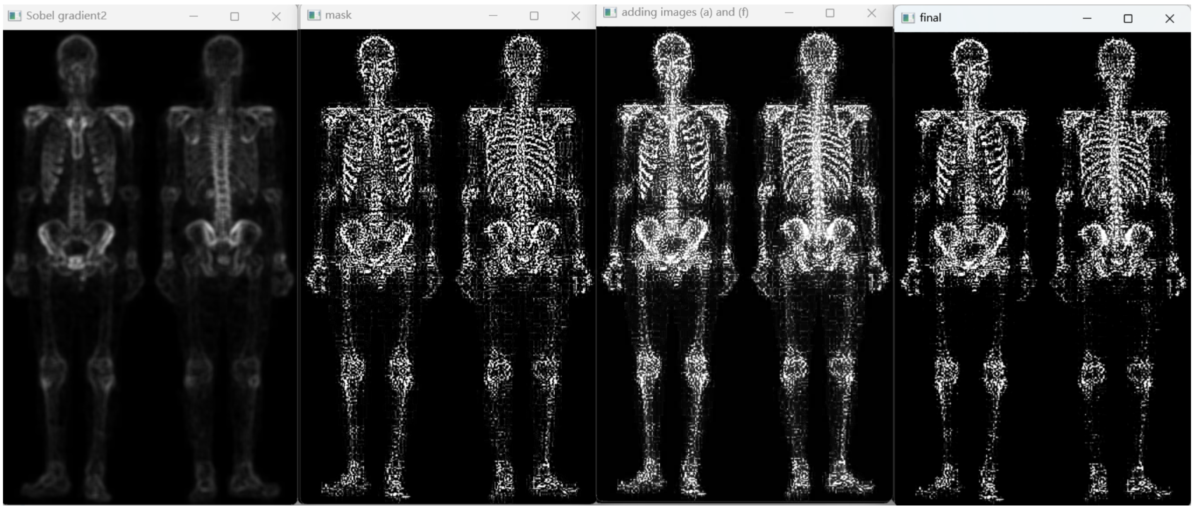
image_g = cv2.add(image_a, image_f)
cv2.imshow('adding images (a) and (f)', image_g)

8. Final result obtained by applying a power law(gamma) transformation to (g)

```
image_h = np.array(255 * (image_g / 255) ** 2.2, dtype='uint8')
cv2.imshow('final', image_h)

cv2.waitKey()
cv2.destroyAllWindows()
```

Results



Conclusion

The Laplacian, is a second-order derivative operator and has the definite advantage that it is superior
for enhancing fine detail. However, this causes it to produce noisier results than
the gradient. This noise is most objectionable in smooth areas, where it tends to be
more visible. The gradient has a stronger response in areas of significant intensity
transitions (ramps and steps) than does the Laplacian. The response of the gradient
to noise and fine detail is lower than the Laplacian's and can be lowered further by
smoothing the gradient with a lowpass filter. The idea, then, is to smooth the gradient
and multiply it by the Laplacian image. We may view the smoothed
gradient as a mask image. The product will preserve details in the strong areas, while
reducing noise in the relatively flat areas. This process can be interpreted roughly as
combining the best features of the Laplacian and the gradient. The result is added to
the original to obtain a final sharpened image.

Image(d) shows the Sobel gradient of the original image. As expected, the edges are much more dominant in this image(d)
than in the Laplacian image. The smoothed gradient image in image(e) was
obtained by using a box filter of size 5 × 5. The fact that image(d) and (e) are
much brighter than image(b) is further evidence that the gradient of an image
with significant edge content has values that are higher in general than in a Laplacian
image.

Image(f) shows the product of the Laplacian and smoothed gradient image.
Note the dominance of the strong edges and the relative lack of visible noise, which
is the reason for masking the Laplacian with a smoothed gradient image. Adding the
product image to the original resulted in the sharpened image in image(g). The
increase in sharpness of detail in this image over the original is evident in most parts
of the image, including the ribs, spinal cord, pelvis, and skull. This type of improvement
would not have been possible by using the Laplacian or the gradient alone.

Because we wish to spread the intensity levels, the value of g in Eq. (3-5) has to be less than 1.
After a few trials with this equation, we arrived at the result in Fig. 3.57(h), obtained
with gamma = 0.5 . and c = 1.

Advantage: In this way, pixels in high gray level areas can occupy more gray levels. Noises in the image are eliminated as well.