

Image Deblurring - Meng-Jin Lin

Introduction

Image deblurring is the process to recover a blurred image which caused by camera movement, object movement, out-of-focus, or insufficient depth of field. There are different kinds of image blur listed as bellow.

- **Out-of-focus Blur**
 - Optical effect
 - Smearing characteristics depend on configuration and aperture shape of the lens
- **Gaussian Blur**
 - Post-production effect
 - Take weighted average around the pixel
 - Smooth compared to out-of-focus blur
- **Box Blur**
 - Average all the pixels in the radius of the single pixel together
- **Motion Blur**
 - Caused by object movements

Experiments

1. Use ISETCam to set different f-number to get images with different level of blurriness.
2. Use **NAFNet** for deblurring

a. Result with f number = 30



b.

c. The result is not obvious using NAFNet

- i. It is because NAFNet is more effective for motion-blur image
- ii. Deblur motion-blurred image with NAFNet effectively



iii.

3. Use **Restormer** for deblurring
- a. Result with f number = 30



b.

c. With Restormer, the out-of-focus images can be deblurred to a more clear image effectively compared to NAFNet.

4. Use convolution with sharpen kernel

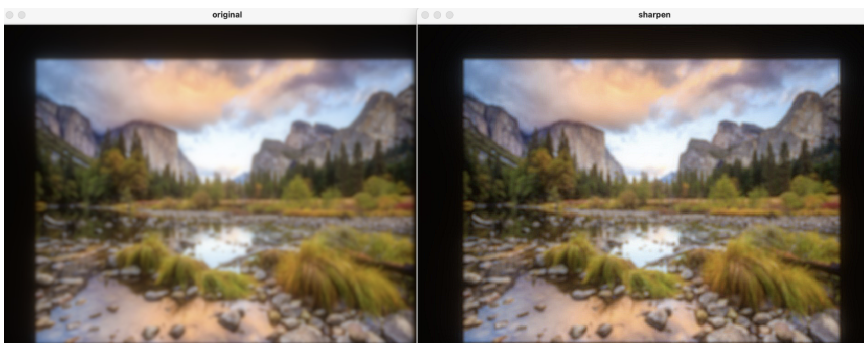
a. The blurriness of the input images is similar to Box blur or Gaussian blur because they are produced from **diffraction limited lens**, so we can also use the method to make convolution with the image and the sharpen kernel to reduce the blurriness in the images.

b. The sharpen kernel is the matrix shown below. It can improve spatial resolution by highlighting fine details and enhancing blurred boundaries.

-1	-1	-1
-1	9	-1
-1	-1	-1

c.

Result with f number = 30



NAFNet (Nonlinear Activation Free Network)

1. Remove nonlinear activation functions such as Sigmoid or Softmax from deep learning image restoration architecture
2. Add Channel Attention Layer
 - a. Increase computational efficiency and brings global information to the feature map
3. Replace ReLU with GLU (Gated Linear Units)

Restormer

1. Efficient Transformer model capturing long-range pixel interactions
 - a. Multi-head attention
 - b. Feed-forward network
2. Apply to
 - a. Motion deblurring
 - b. Defocus deblurring
 - c. Image denoising

Conclusions

Deep learning is not necessarily the best idea to do all image processing tasks. We need to consider the characteristics of the data itself and different methods to choose the best way to process images.

Appendix

1. code to blur the image: <https://github.com/muachilin/image-deblur>

2. codelab for NAFNet testing: [Sign in to access Google Drive Colab Notebook](#)

3. codelab for Restormer testing: [Sign in to access Google Drive Colab Notebook](#)