Image Processing Experiments

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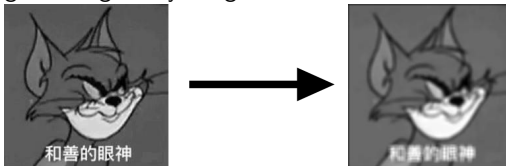
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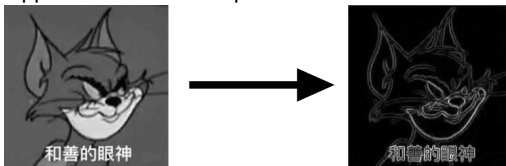MATHEMATICS
THE CHINESE UNIVERSITY OF HONG KONG

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Overview

1. Image processing on the spatial domain
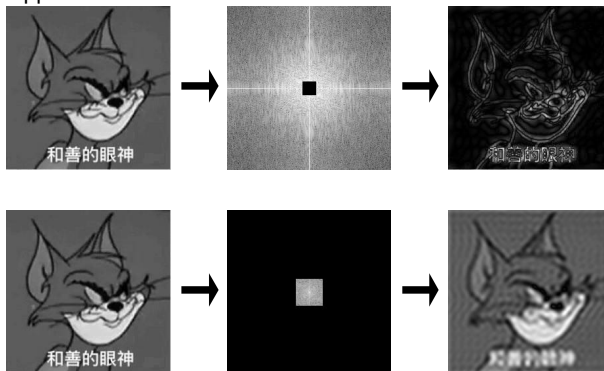
    1.1 generating blurry images

    1.2 Application of Sobel operator

Overview (cont.)

2. Image processing on the spectral domain

    2.1 Application of FFT

Scientific computation tools:

- ▶ MATLAB: MATLAB is a powerful scientific computing software developed by MathWorks. The MATLAB environment integrates graphics illustrations with precise numerical calculations, and is an easy-to-use tool for performing all kinds of computations and data visualization. CUHK Campus-wide License

- ▶ Octave: GNU Octave is an open source software primarily intended for numerical computations. Its programming language is mostly compatible with MATLAB. Octave Downloading page

- ▶ Python: Python is a general-purpose programming language. It be can utilized in scientific computing with third party libraries such as NumPy, SciPy, PyTorch, scikit-learn, TensorFlow, OpenCV, Matplotlib, etc.

- ▶ ...

Executing Python Codes

There are several ways to execute Python code.

1. Interactive Mode: Directly open terminal software ("Terminal" in macOS, "PowerShell" or "CMD" in Windows), type "python" command. Windows users need to install it before using it.

2. Script Mode: Create a text file with file extension ".py", and then use "python" command to run it. (i.e. python abc.py)

3. Using Jupyter notebook: First install Jupyter, and then run "jupyter notebook" from terminal softwares to open port. Then we can use browser, such as Chrome and Firefox, to access it.

4. Google Colab: Similar to Jupyter notebook. You can run code on Google Colab and save experimental results in your Google drive. Google provides computational resources such as TPU and GPU freely.

5. ...

Anaconda

Anaconda is a tool that makes Python package management easier. It is designed for scientific computation. It includes NumPy, Matplotlib and SciPy by default. You can download it from here and install it according to the official instruction.
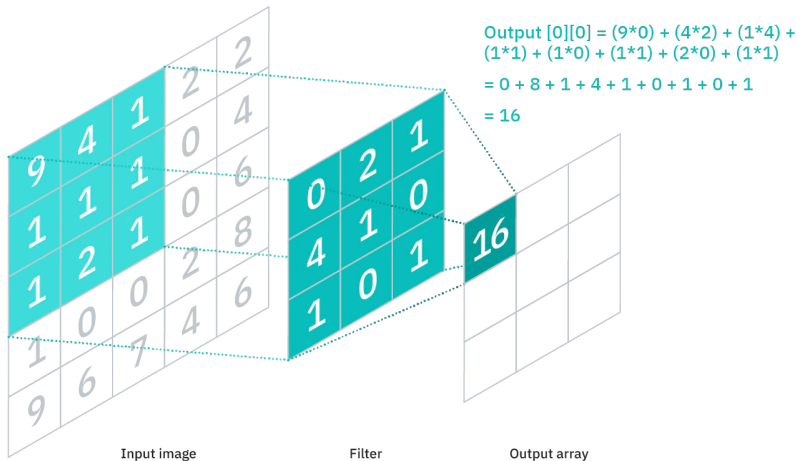
1.1 generating blurry image
The idea is to apply an average kernel to the image.

$$kernel = \frac{1}{25} \times \begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{pmatrix} \tag{1}$$

Convolution:

Output [0][0] = (9*0) + (4*2) + (1*4) +
(1*1) + (1*0) + (1*1) + (2*0) + (1*1)

= 0 + 8 + 1 + 4 + 1 + 0 + 1 + 0 + 1

= 16

Input image   Filter   Output array

Sobel operator consists of two kernels:

$$ker1 = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} \quad and \quad ker2 = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix} \qquad (2)$$

Suppose the input image is denoted as I, then the output image G can be computed as follows:

$$G = \sqrt{(ker1 * I)^2 + (ker2 * I)^2} \qquad (3)$$

Later in this course, we would like to introduce image processing techniques in the frequency domain. Here we briefly show some examples.

1. Use Fast Fourier Transform to obtain the spectrum of the image.

2. Perform some manipulation on the spectrum.

3. Use inverse Fast Fourier Transform to obtain the resulting image.

Here we simply use np.fft.fft2, np.fft.fftshift, np.fft.ifft2 and np.fft.ifftshift to conduct the experiment. For details, please click the hyperlinks of the 4 functions.