

Homework 3

Due on Nov. 6, 2025

Problem I, 30 Points. Consider a 4×4 gray-scale image and a 3×3 filter:

$$Img = \begin{bmatrix} 1 & 2 & 2 & 1 \\ 2 & 3 & 3 & 2 \\ 2 & 3 & 3 & 2 \\ 1 & 2 & 2 & 1 \end{bmatrix}$$
$$Filter = \frac{1}{16} \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

(1). Perform convolution operation on the gray image with the given filter with zero-padding, and show your result.

Note: (a). You need to zero-pad your image by adding two rows on the top, two rows on the bottom, two columns on the left, and two columns on the right.

(b). Since the image size is 4×4 , so you need to crop your result into the same size as the image. (15 Pts)

(2). What effect does this filter have on the image? (5 Pts)

(3). What is the difference between correlation and convolution operation? If we apply correlation operation on this image with this filter, is the result same as that in (1)? If yes, state yes. If no, please show the correlation result. (5 Pts)

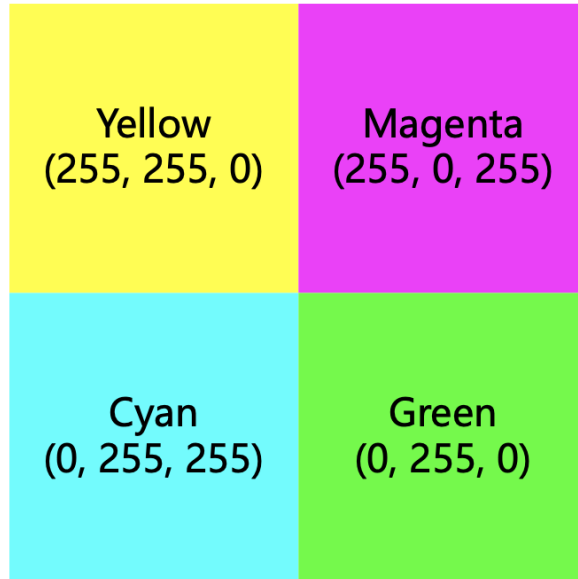
(4). Discuss some applications of this given filter based on what we have discusses in class. (5 Pts)

Problem II, 30 Points. Consider the following 64×64 RGB image, which is divided into 4 non-overlapping blocks (with same size). Each block contains exactly 1 color, which the corresponding RGB value is shown below.

(1). Please convert this image into the HSI color space. Please describe the appearances of the hue channel, the saturation channel and the intensity channel, respectively. Please Compute H, S, I value for 4 blocks, respectively. (20 Pts)

(2). Suppose we blur the saturation channel by a 16×16 arithmetic mean filter, and then convert the HSI image back to the RGB color space. What does the output image look like? Any changes compared with the original RGB image? Describe the appearance of the result (Notice: we ignore image border effects due to filtering). (10 Pts)

Figure 1: Problem II



Problem III, 40 Points, Programming Question. Write your code to complete several tasks. You should submit: (1) your code, (2) a short report including your original image, and the output processed by your code. You may use Python or MATLAB.

(1). Smooth your input image with an averaging filters. In this task, you should create a 3×3 and a 7×7 averaging filters. You can download and read any gray-scale image. The processing steps are same to the steps in Problem I. You should pad image, do convolution on image, and crop image. **Note that this question ask you to code the convolution process. You cannot directly use the convolution function.** (25 Pts)

(2). Do the same steps as in (1), however use Laplacian filter instead:

$$Laplacian = \begin{bmatrix} 2 & 0 & 2 \\ 0 & -8 & 0 \\ 2 & 0 & 2 \end{bmatrix}$$

You are suggested to code (1) as a function with input as (image, kernel). Then you use this function to complete (2). (15 Pts)