網媒所博士班基本學科考試：數位影像處理

2012 年 9 月 28 日

1. **(20%)**

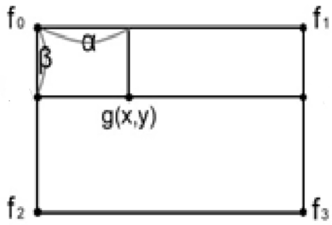
   (i) **(10%)** What is alpha-trimmed filter?

   (ii) **(10%)** What is zero-phase-shift filter?

2. **(20%)** Consider the following figure. The problem of image interpolation is to compute the image value of $g(x,y)$ given the image values of its four neighbors, which are denoted as f_0, f_1, f_2, f_3. One popular interpolation method is the bilinear interpolation. The general form of a bilinear function $g(.)$ of two variables is:

$$g(\alpha,\beta) = A_0 + A_1\alpha + A_2\beta + A_3\alpha\beta \qquad \textbf{(2.1)}$$

where $0 \le \alpha \le 1$ and $0 \le \beta \le 1$.



(i) (10%) You are asked to use the bilinear function given in equation **(2.1)** to derive the following interpolation function:

$$g(\alpha,\beta) = (1-\alpha)(1-\beta)\, f_0 + \alpha(1-\beta)\, f_1 + (1-\alpha)\,\beta\ f_2 + \alpha\beta\ f_3 \qquad \textbf{(2.2)}$$

where $0 \le \alpha \le 1$ and $0 \le \beta \le 1$.

(ii) (10%) Enlarge the following 2x2 image (represented by a matrix) to size of 4x4 with bilinear interpolation. That is, fill in the values of the question marks shown below. (No electronic device is allowed.)

$$\begin{bmatrix} 108 & 72 \\ 36 & 180 \end{bmatrix}$$

$$\begin{bmatrix} 108 & ? & ? & 72 \\ ? & ? & ? & ? \\ ? & ? & ? & ? \\ 36 & ? & ? & 180 \end{bmatrix}$$

3. **(20%)** Explain why mean filtering is a linear operation and median filtering is a non-linear operation.

4. (20%)

Consider the following 500×500 RGB color image, shown in Fig 4, where the squares are pure red, green, and blue, i.e., their RGB values are (255,0,0), (0,255,0), (0,0,255).

(i) (10%) What would the result look like when a blur operation with 49×49 averaging mask is applied to the R component image?

(ii) (10%) Suppose that we convert this image to HSI, blur the H component image with a 49×49 averaging mask, and convert back to RGB. What would the result look like?

Red	Green
Blue	Red

Fig. 4

5. (2**0%)** Given the model of image degradation as follows:

$$g(x,y) = h(x,y) * f(x,y) + \eta(x,y) \Leftrightarrow G(u,\upsilon) = H(u,\upsilon)F(u,\upsilon) + N(u,\upsilon),$$

where *g(x,y)* is the degraded image, *f(x,y)* is the original image, *h(x,y)* is the degradation function, $\eta(x,y)$ is the additional noise function. *G(u,v), F(u,v), H(u,v),* and *N(u,v)* are the Fourier Transform of *g(x,y), f(x,y), h(x,y),* and $\eta(x,y)$, respectively.

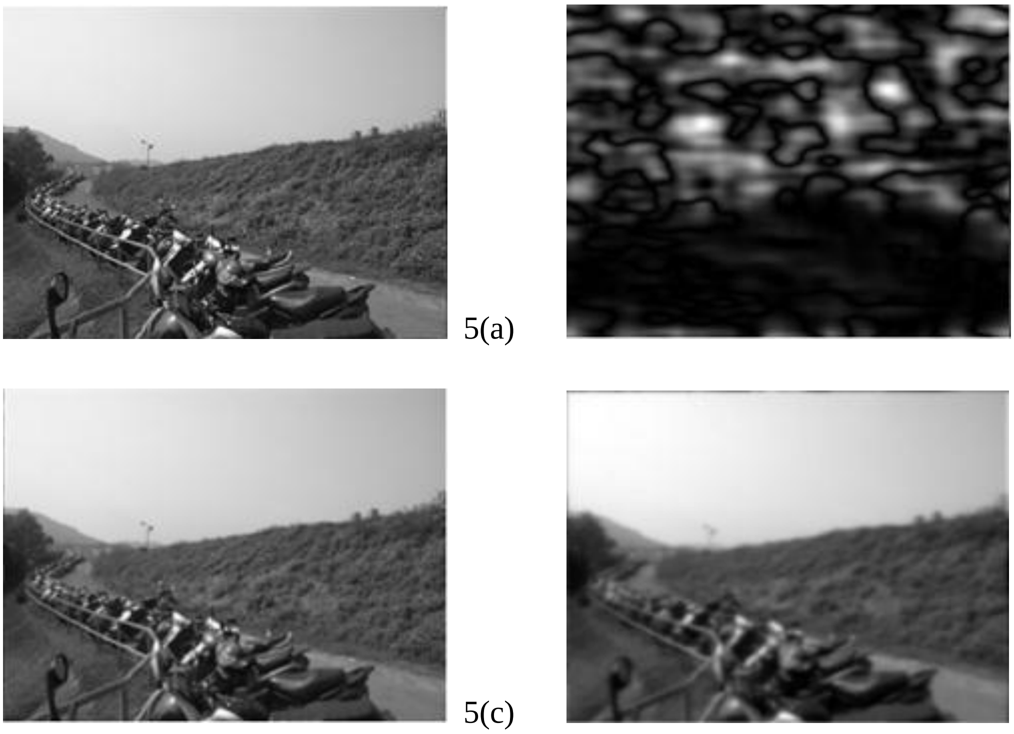
(i) **(5%)** Figure 5(a) shows the original image *f(x,y)*. If we apply *inverse filtering* directly to obtain the restored image $\hat{f}(x,y)$, the result will be the image, as shown in figure 5(b). Please explain why the quality of the restored image is not good.

(ii) **(10%)** To solve the problem described in **(i)**, one can utilize the radially limited inverse filter with proper cut-off radius, *D*, to get a better restored image shown in figure 5(c). However, the restored image becomes blurred when using an improper cut-off radius, as shown in figure 5(d). Please describe the effect of setting a too-small and a too-large cut-off radius, and explain your reasons.

(iii) **(5%)** The *Wiener filter* is considered to be an optimal filter, and can be expressed as below:

$$\left[\frac{1}{H(u,v)}\frac{|H(u,v)|^2}{|H(u,v)|^2+S_n(u,v)/S_f(u,v)}\right]$$

In what condition, can the Wiener filter be reduced to inverse filter?



5(a) 5(b) 5(c) 5(d)

Figure 5.