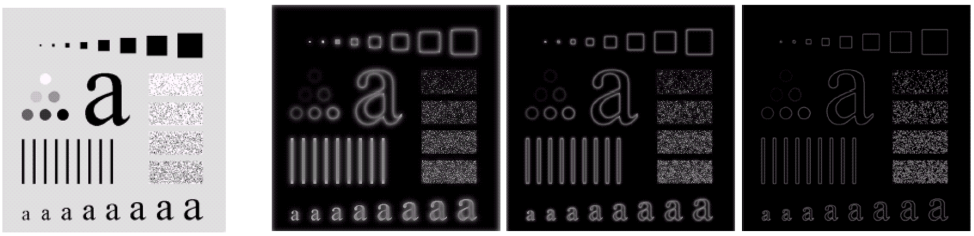
博士班基本學科考試：數位影像處理

2016 年 9 月 30 日

1. (20%)
   (a) (5%) Let $H(u,v)$ be a Gaussian high-pass filter in frequency domain. Please write down its mathematical expression with cutoff frequency D.
   (b) (10%) One original image and three resultant images after applying Gaussian high-pass filters with different cutoff frequencies are given in Fig. 1. According to those images, please draw the radial cross section of these three filters and indicate which one (D_1, D_2 or D_3) has the largest value.



(a) (b) $D = D_1$ (c) $D = D_2$ (d) $D = D_3$

Fig. 1: (a) the original image, (b)(c)(d) resultant images after applying Gaussian high-pass filters with different cutoff frequencies.

   (c) (5%) Is it possible to cause ringing artifacts in the resultant image by applying Gaussian high-pass filters? Why or why not?

2. (40%)
   (a) (10%) Why image transform is necessary in certain cases?
   (b) (10%) What is the difference between local and global histogram equalizations?
   (c) (10%) What is full inverse filter? What is limited inverse filter?
   (d) (10%) What are pros and cons of 1^{st}-order and 2^{nd}-order edge detection methods?

3. (25%) Let $F_I(x,y)$ be a continuous ideal image field and $F_P(x,y)$ be the sampled image. Then we have

$$F_P(x,y) = F_I(x,y)S(x,y), \qquad (1)$$

where $S(x,y) = \sum_{j=-\infty}^{\infty}\sum_{k=-\infty}^{\infty}\delta(x - j\Delta x, y - k\Delta y)$ is the sampling function. If the spectrum of the ideal image is band-limited and Fourier transform is applied to Equation (1), we have

$$\mathcal{F}_P(\omega_x,\omega_y) = \frac{1}{\Delta x\Delta y}\sum_{j=-\infty}^{\infty}\sum_{k=-\infty}^{\infty}\mathcal{F}_I(\omega_x - j\omega_{xs}, \omega_y - k\omega_{ys}), \qquad (2)$$

where $\omega_{xs} = 2\pi/\Delta x$ and $\omega_{ys} = 2\pi/\Delta y$.

   (a) (10%) Please use Equation (2) to explain how to avoid aliasing.

(b) (5%) What is the sampling theorem?

(c) (10%) Given an image as shown in Fig. 2, please explain where and what would be affected if an inappropriate sampling frequency is chosen.

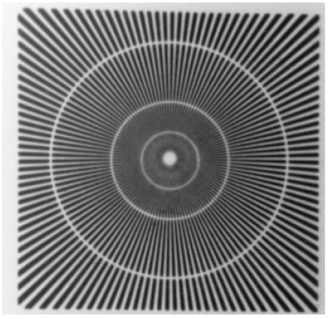


Fig. 2

Fig. 3

4. (15%) Given a low-contrast image corrupted by both uniform and impulse noises in Fig. 3. Design an algorithm to obtain a clear edge map of Fig. 3. Please describe the proposed method in detail.