

频率域平滑滤波器



一、理想低通滤波器

$$H(u, v) = \begin{cases} 1 & D(u, v) \leq D_0 \\ 0 & D(u, v) > D_0 \end{cases}$$

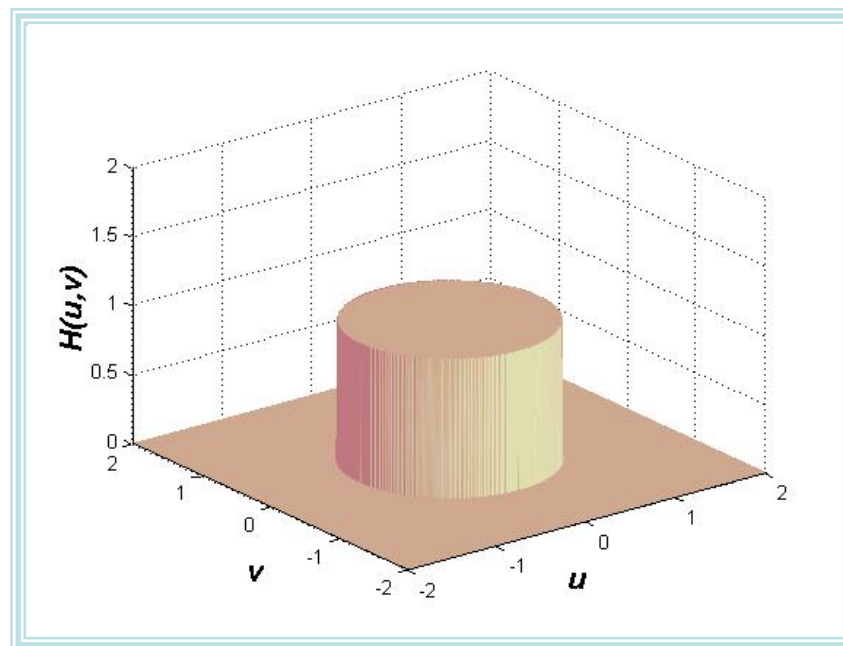
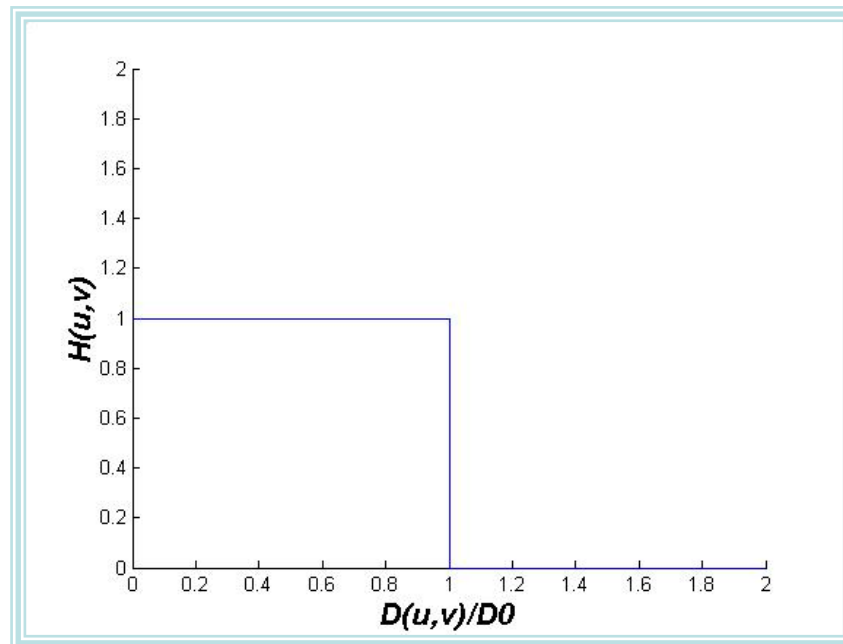
D_0 为截止频率,

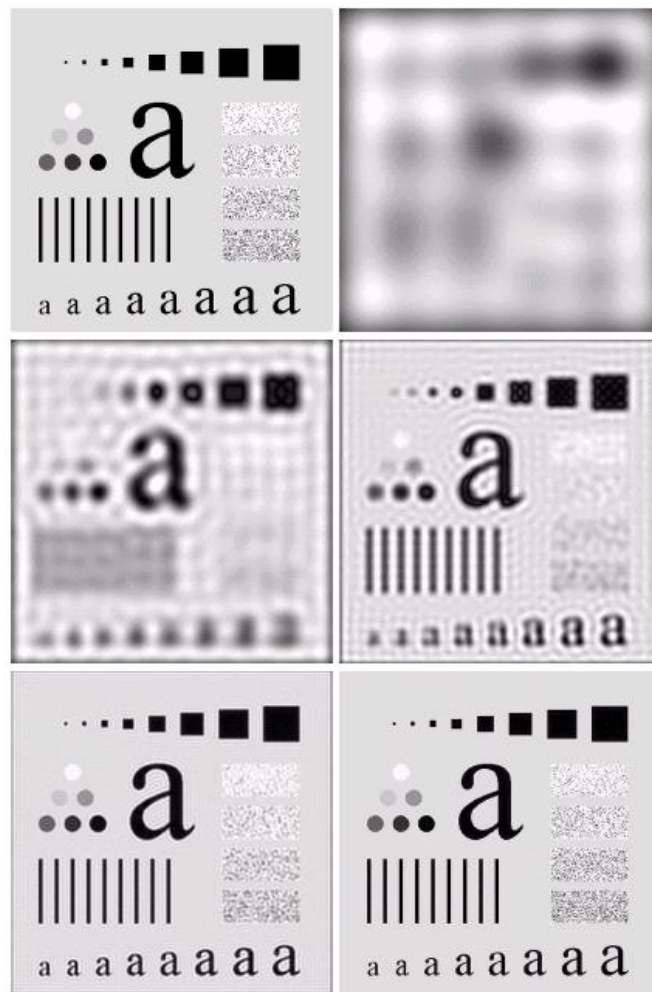
$D(u, v) = (u^2 + v^2)^{1/2}$: 频率平面原点到点 (u, v) 的距离

截断频率: 常取使H最大值降到某个百分比的频率为截断频率。

(1) 当 $D(u, v) = D_0$ 时, $H(u, v) = 0.5$ (即降到50%)。

(2) 使H降到最大值的 0.667。





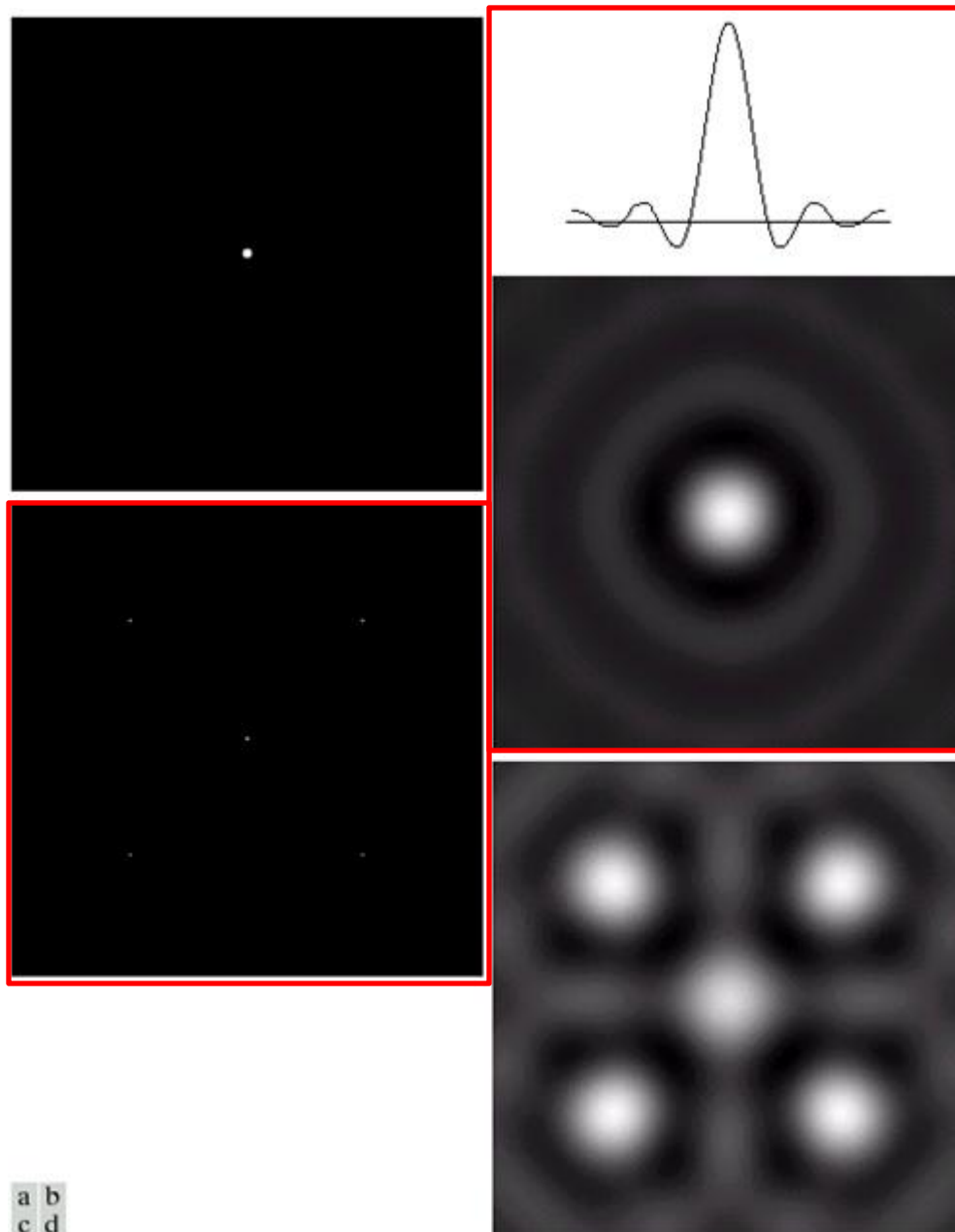
通过该实例，请总结理想滤波器的特点。

a	b
c	d
e	f

FIGURE 4.12 (a) Original image. (b)–(f) Results of ideal lowpass filtering with cutoff frequencies set at radii values of 5, 15, 30, 80, and 230, as shown in Fig. 4.11(b). The power removed by these filters was 8, 5.4, 3.6, 2, and 0.5% of the total, respectively.

特点：

- (1) 截断频率越小，滤除噪声效果越好，
但图象细节模糊效应越明显。
- (2) 截断频率越小，振铃现象越明显。
- (3) 物理上不可实现。



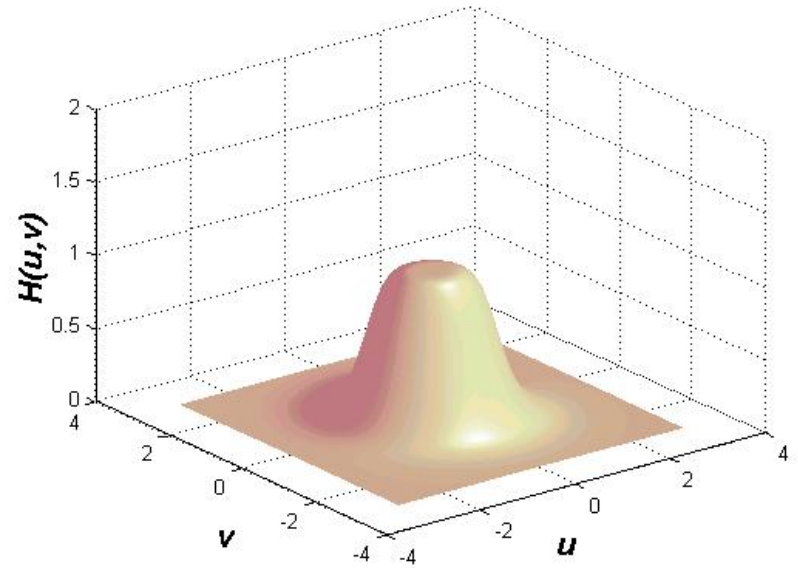
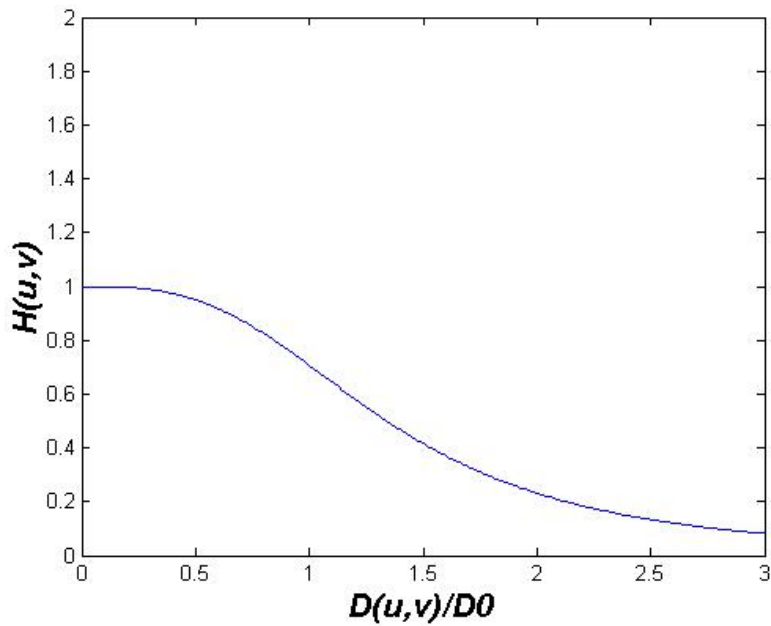
a b
c d

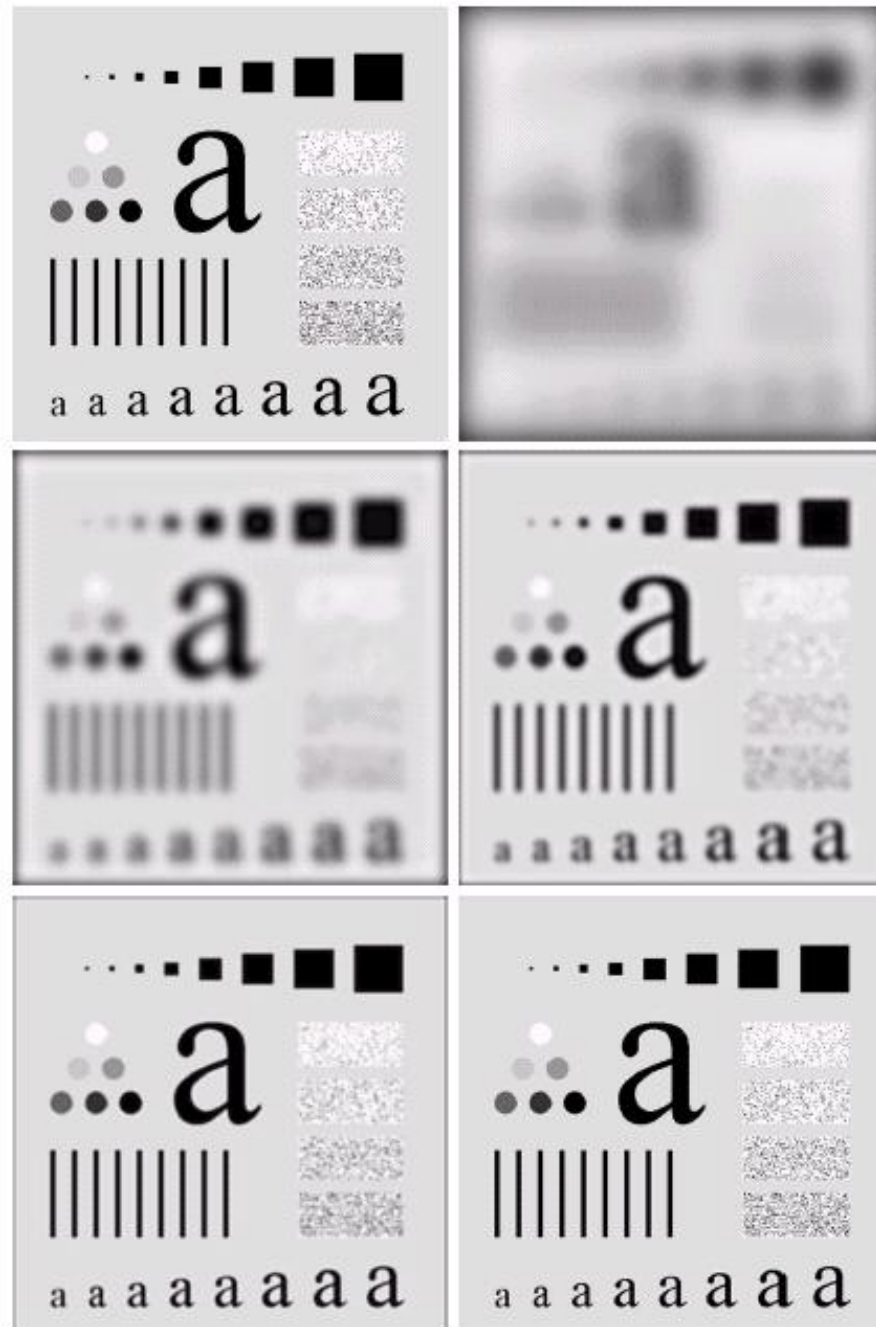
FIGURE 4.13 (a) A frequency-domain ILPF of radius 5. (b) Corresponding spatial filter (note the ringing). (c) Five impulses in the spatial domain, simulating the values of five pixels. (d) Convolution of (b) and (c) in the spatial domain.

二、巴特沃思低通滤波器

$$H(u, v) = \frac{1}{1 + [D(u, v) / D_0]^{2n}}$$

3阶巴特沃斯：剖面图与透视图





a b
c d
e f

FIGURE 4.15 (a) Original image. (b)–(f) Results of filtering with BLPPFs of order 2, with cutoff frequencies at radii of 5, 15, 30, 80, and 230, as shown in Fig. 4.11(b). Compare with Fig. 4.12.

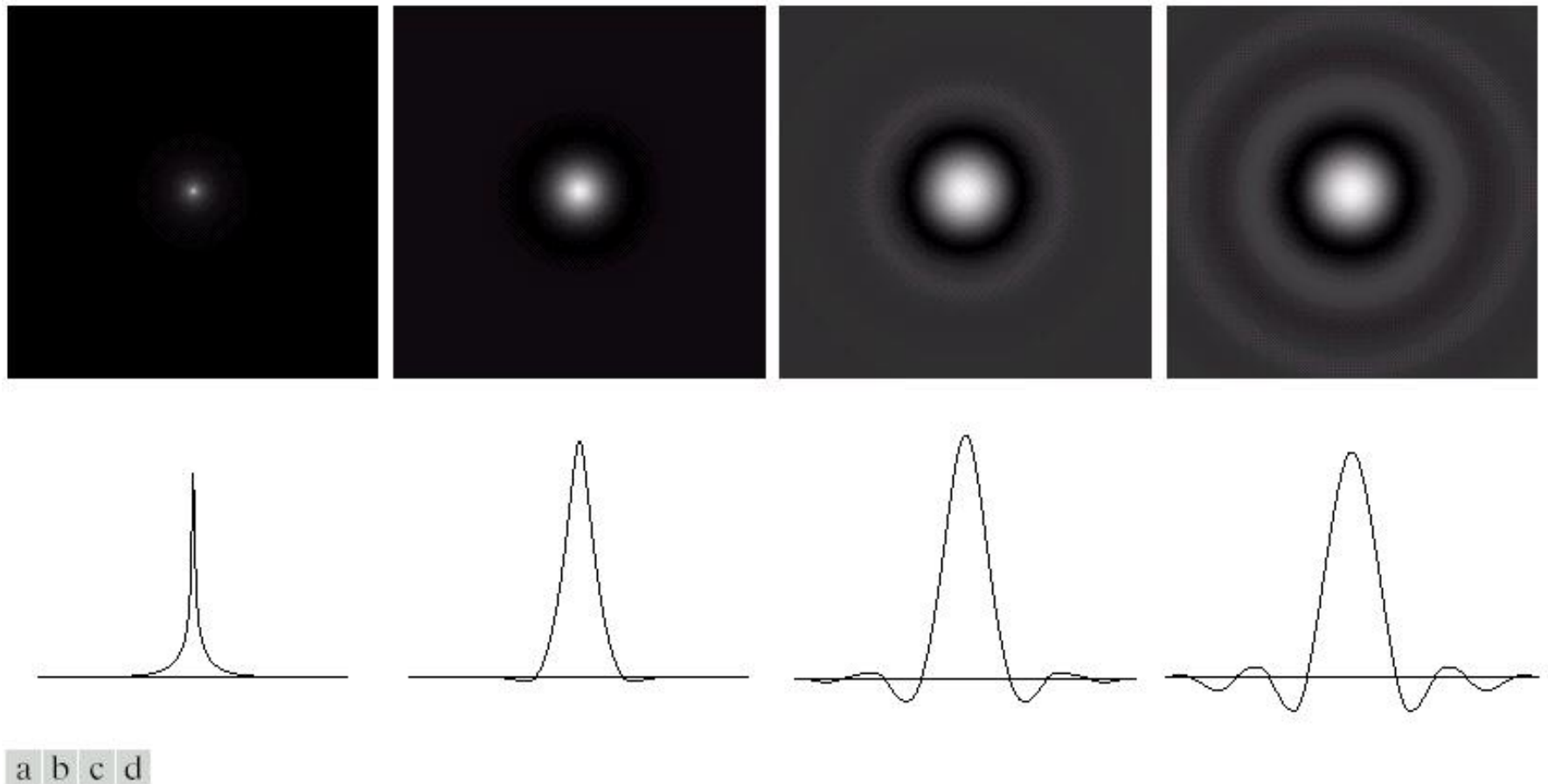


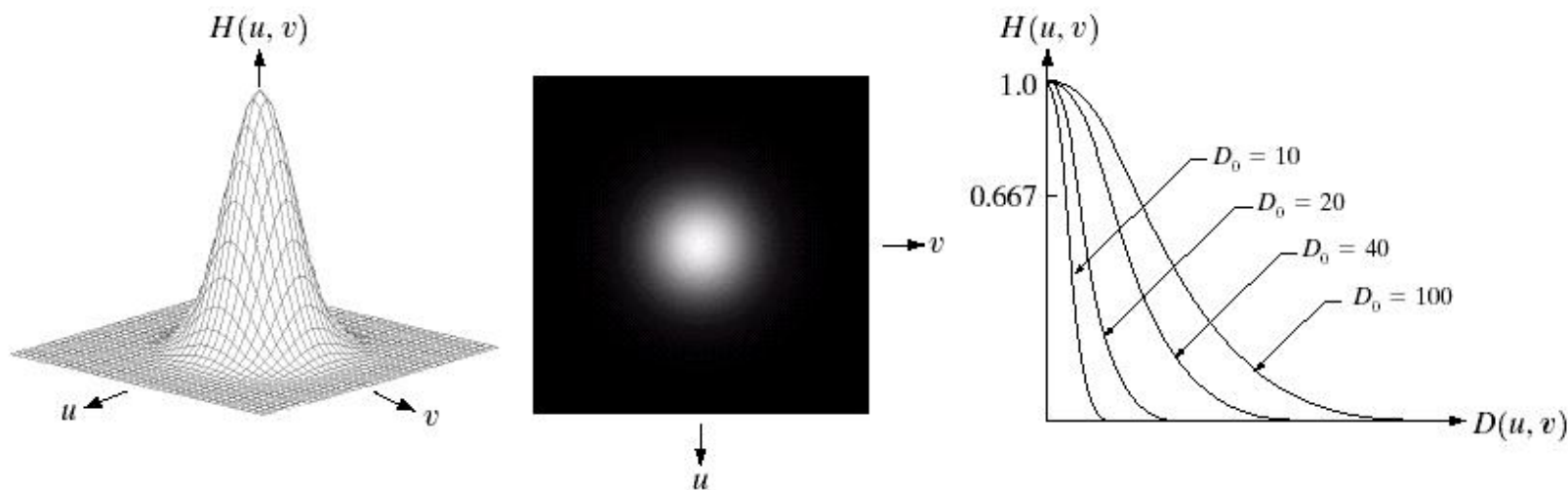
FIGURE 4.16 (a)–(d) Spatial representation of BLPFs of order 1, 2, 5, and 20, and corresponding gray-level profiles through the center of the filters (all filters have a cutoff frequency of 5). Note that ringing increases as a function of filter order.

特点:

- (1) 在频域，阶次较小时，比较平坦。阶次较大时，比较尖锐，接近理想滤波器。
- (2) 在时域，除一阶外，阶次越高，振荡现象越明显。
- (3) 截断频率越小，滤除噪声效果越好，但图象细节模糊效应越明显。

三、高斯低通滤波器

$$H(u, v) = e^{-D^2(u, v) / 2D_0^2}$$



a b c

FIGURE 4.17 (a) Perspective plot of a GLPF transfer function. (b) Filter displayed as an image. (c) Filter radial cross sections for various values of D_0 .

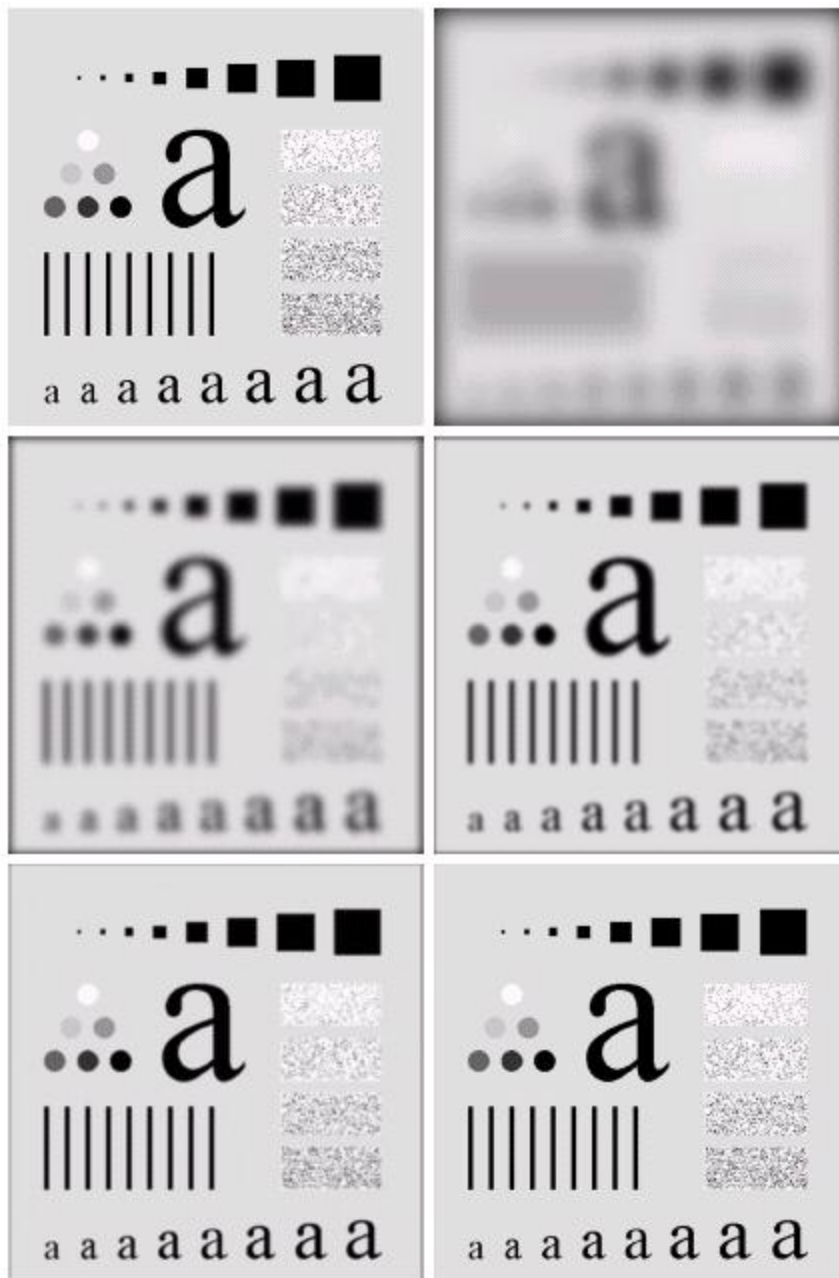


FIGURE 4.18 (a) Original image. (b)–(f) Results of filtering with Gaussian lowpass filters with cutoff frequencies set at radii values of 5, 15, 30, 80, and 230, as shown in Fig. 4.11(b). Compare with Figs. 4.12 and 4.15.

a	b
c	d
e	f

高斯低通滤波器的傅里叶反变换也是高斯型的，因此没有振铃现象。

休息一下

