# 第5章 图像复原与重建

# Image Restoration and Reconstruction

# 图像复原与图像增强

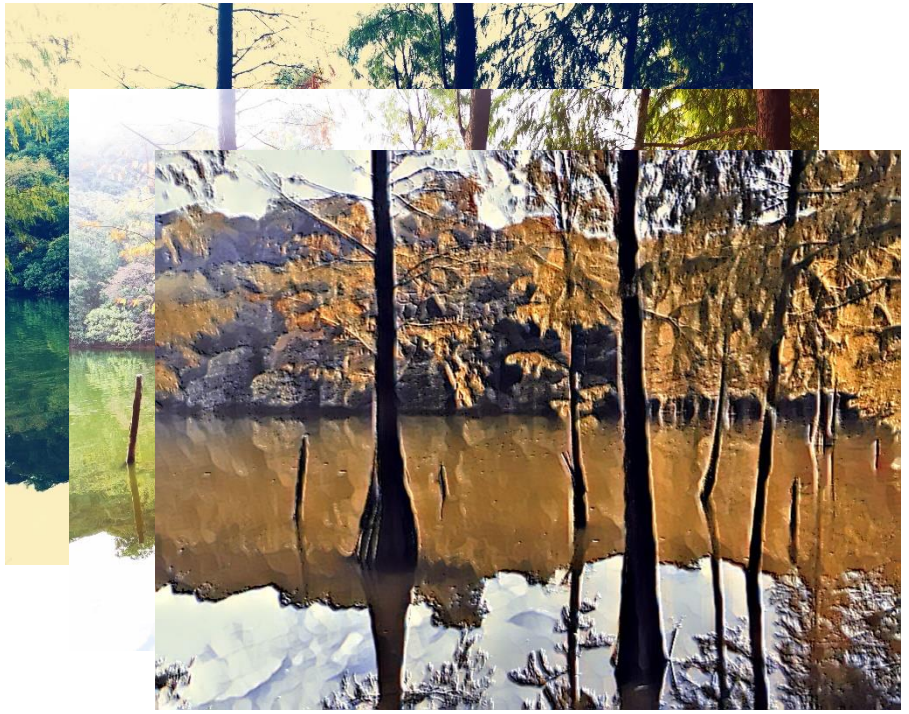
- **图像复原**: Image Restoration 也称图像恢复
- **图像复原vs.图像增强**

不同之处：

**图像恢复**根据相应的退化模型和先验知识重建或恢复原始的图像

**图像增强**借助人的视觉系统特性，目的是改善图像的视觉效果，它可以是一个失真的过程

# 图像复原与图像增强



- **图像复原**: Image
- **图像复原vs.图像**

**不同之处：**

**图像恢复**根据相应的退化模型和先验知识重建或恢复原始的图像

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# 图像复原与图像增强

- **图像复原**: Image Restoration 也称图像恢复

- **图像复原vs.图像增强**

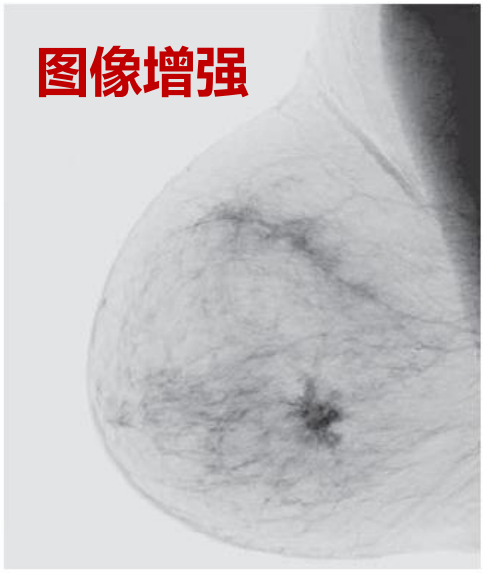
**不同之处：**

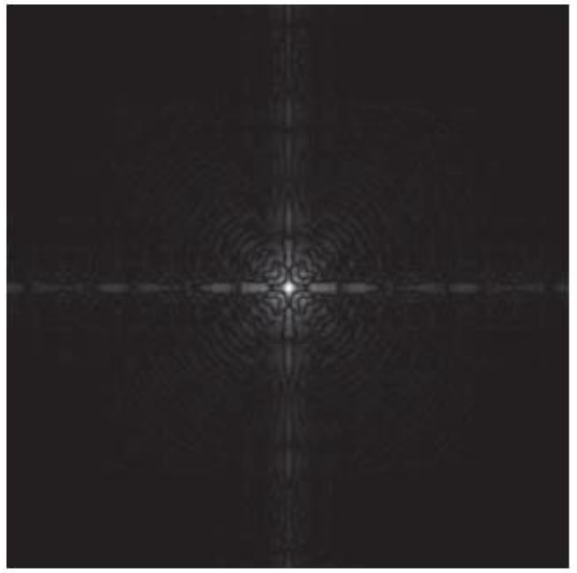
**图像恢复**根据相应的退化模型和先[illegible]原始的图像

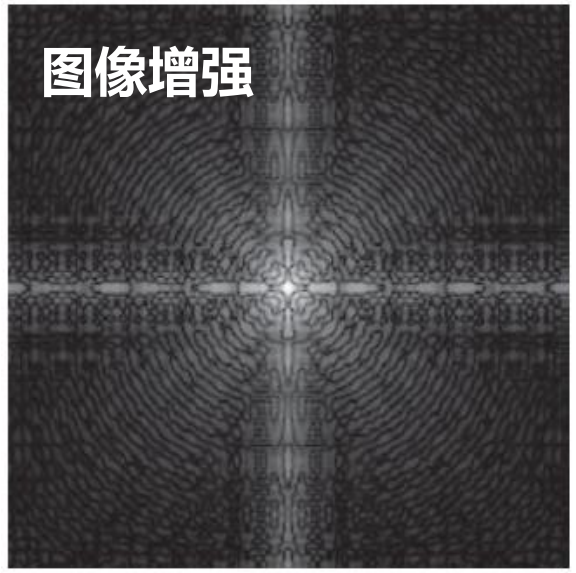
**图像增强**借助人的视觉系统特性，[illegible]
以是一个失真的过程

**相同之处：** 改进输入图像的视觉质量

# 图像复原与图像增强



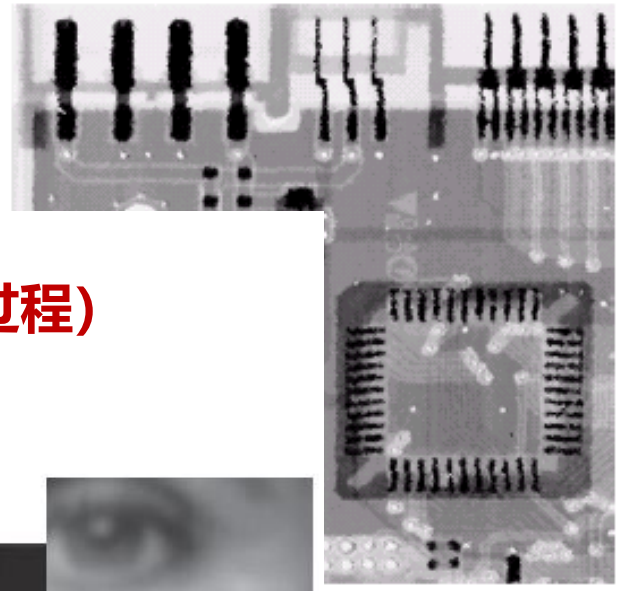




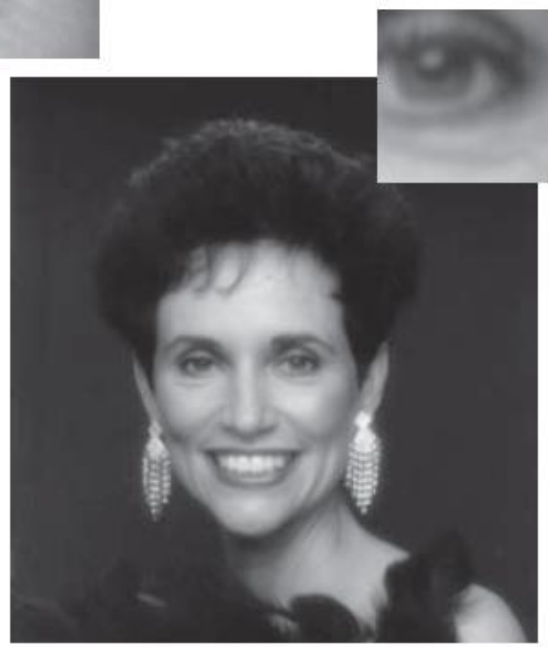
# 图像复原与图像增强

图像增强
/图像恢复

图像增强/图像恢复



图像增强（失真的过程）



# 主要内容

- 图像退化/复原过程的模型
- 噪声模型
- 空间域滤波方法
- 频率域滤波方法
- 退化函数的估计
- 逆滤波
- 维纳滤波

# 5.1 图像退化/复原过程的模型

**图像退化 (Degradation)：得到的图像产生失真，未能反应真实内容。**

**举例：噪声、光照变化、运动模糊**

$$g(x,y) = \mathcal{H}[f(x,y)] + \eta(x,y)$$

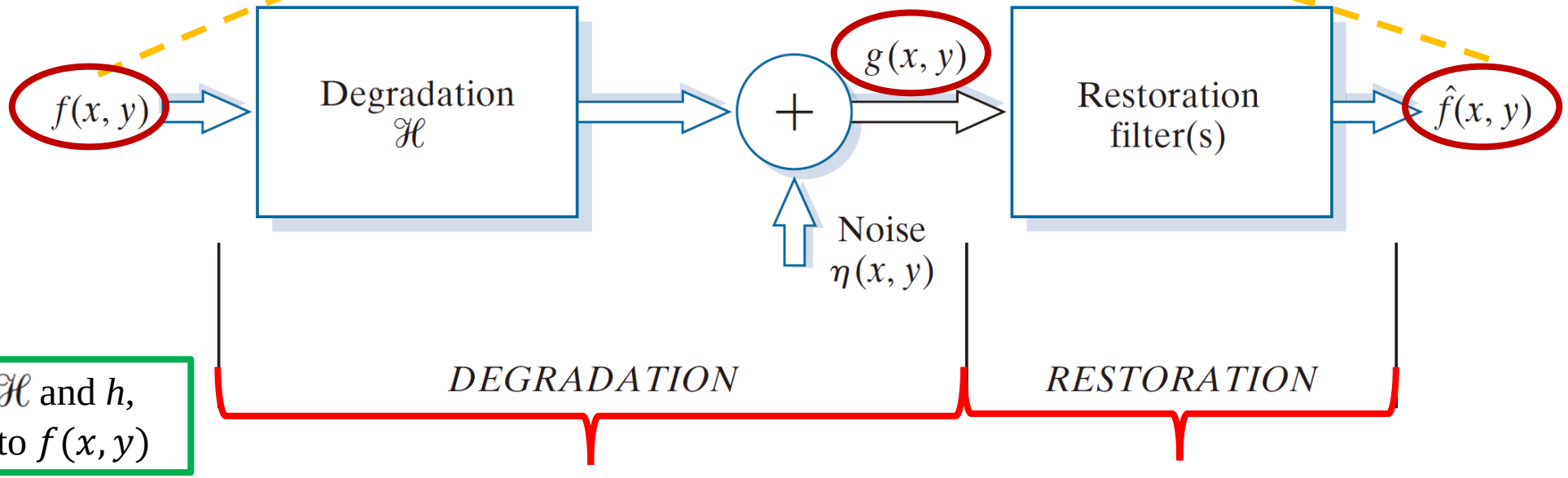
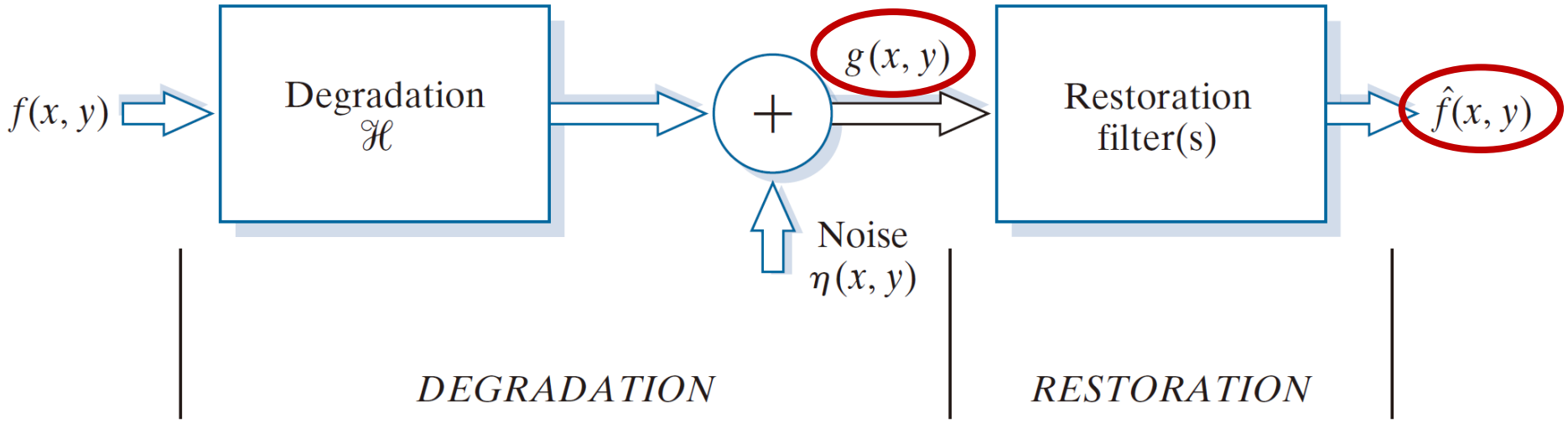



**FIGURE 5.1**
A model of the image degradation/ restoration process.

the more we know about $\mathcal{H}$ and $h$, the closer $\hat{f}(x,y)$ will be to $f(x,y)$

# 5.1 图像退化/复原过程的模型

**FIGURE 5.1**
A model of the image degradation/ restoration process.




**若系统 $\mathcal{H}$ 是一个线性，位置不变的退化系统，那么退化图像可表示为**

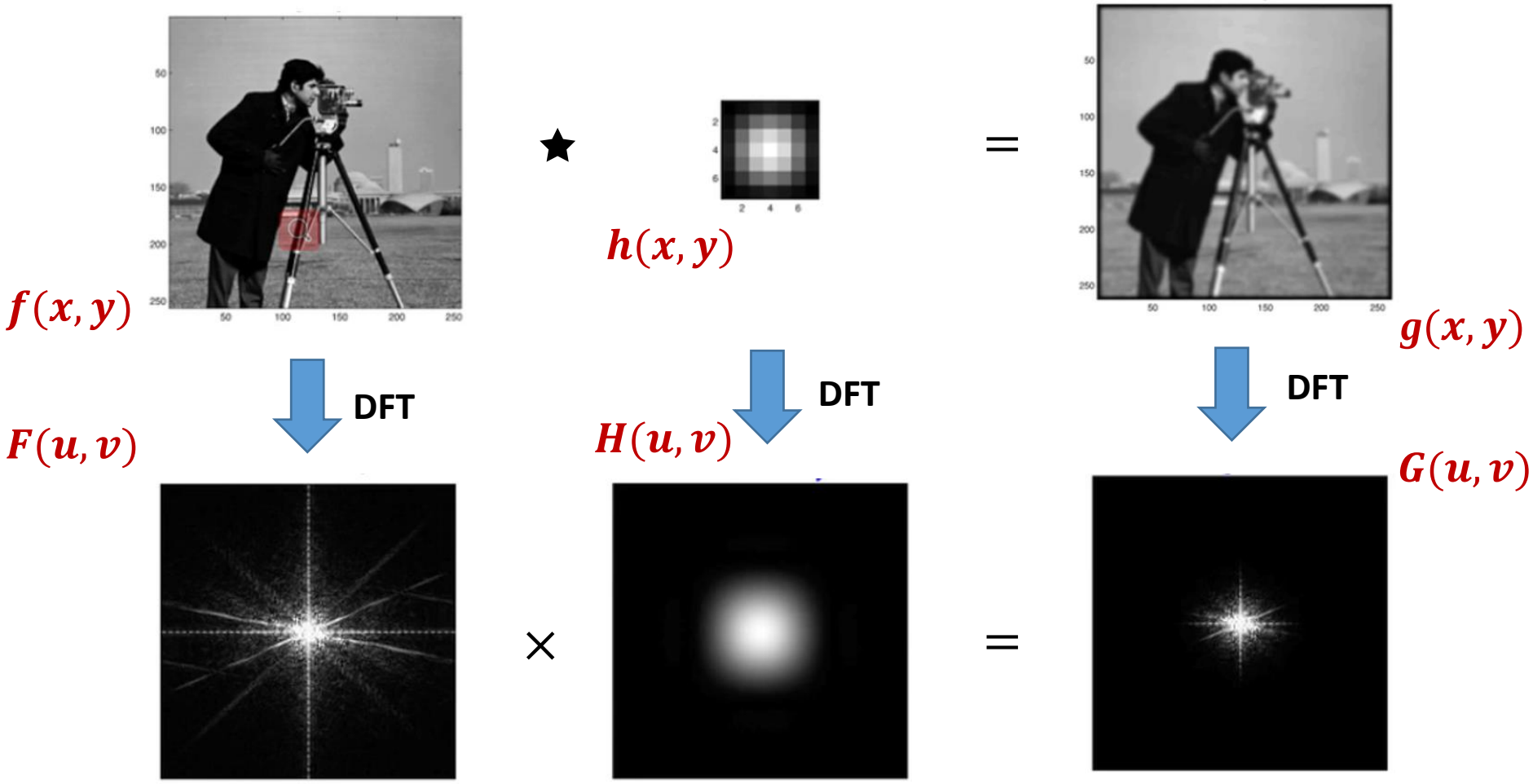
$$g(x,y) = \mathcal{H}[f(x,y)] + \eta(x,y)$$

$$g(x,y) = f(x,y) \bigstar h(x,y) + \eta(x,y) \quad \text{空间域退化模型}$$

$$G(u,v) = F(u,v)H(u,v) + N(u,v) \quad \text{频率域退化模型}$$

# 5.1 图像退化/复原过程的模型

$$g(x,y) = f(x,y) \bigstar h(x,y) + \eta(x,y) \qquad G(u,v) = F(u,v)H(u,v) + N(u,v)$$



# 主要内容

- 图像退化/复原过程的模型
- 噪声模型
- 空间域滤波方法
- 频率域滤波方法
- 退化函数的估计
- 逆滤波
- 维纳滤波

# 5.2 噪声模型

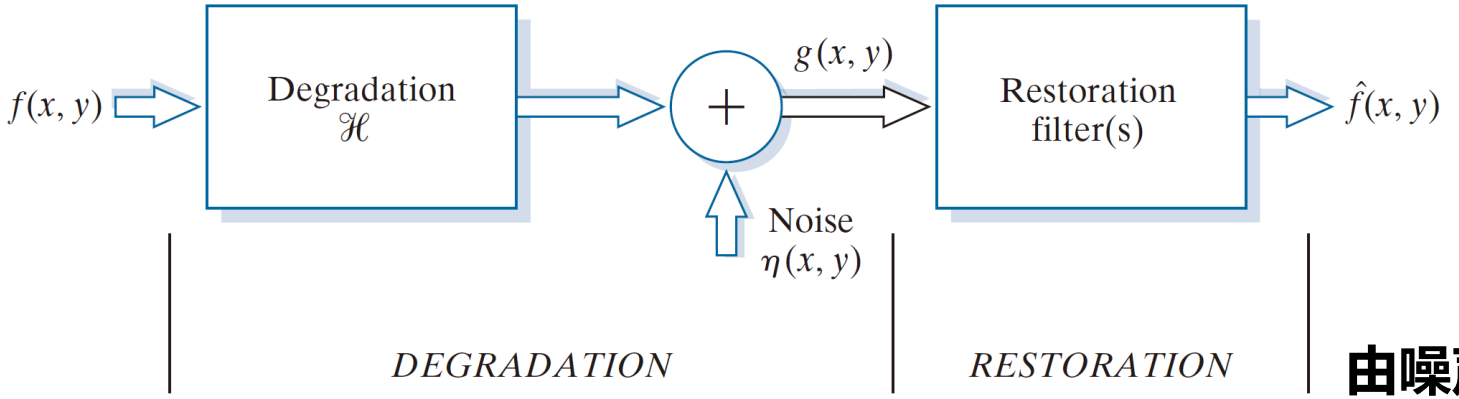
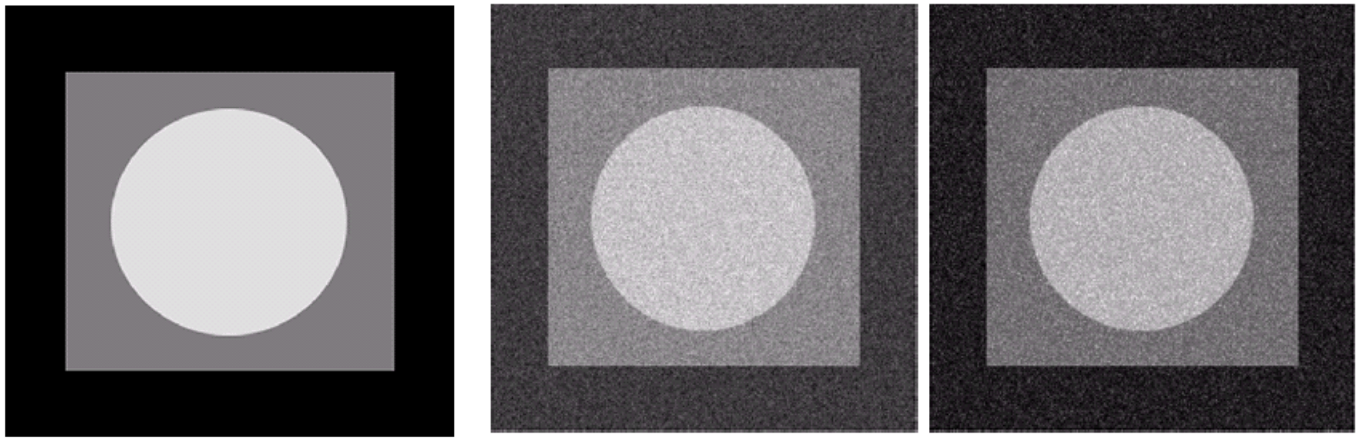



**FIGURE 5.1**
A model of the image degradation/ restoration process.

**由噪声$\eta$引起的图像退化**



**原图** **高斯** **瑞利**

$$G(u,v) = F(u,v)H(u,v) + N(u,v)$$

$$g(x,y) = f(x,y) \bigstar h(x,y) + \eta(x,y)$$

$$G(u,v) = F(u,v) + N(u,v)$$

$$g(x,y) = f(x,y) + \eta(x,y)$$

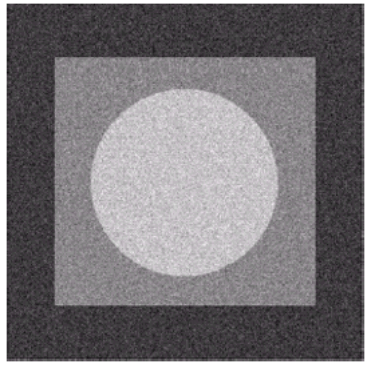
# 5.2 噪声模型

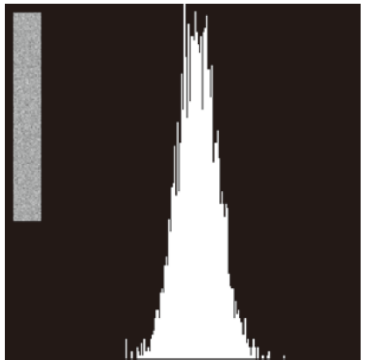
## 噪声

数字图像中，噪声主要源于图像的获取和/或传输过程

最常见退化原因之一，对讲机，手机通话，电视上的雪花点，手机对音响、电视的干扰

- 随机性
- 规律性





# 噪声概率密度函数—空间独立的噪声

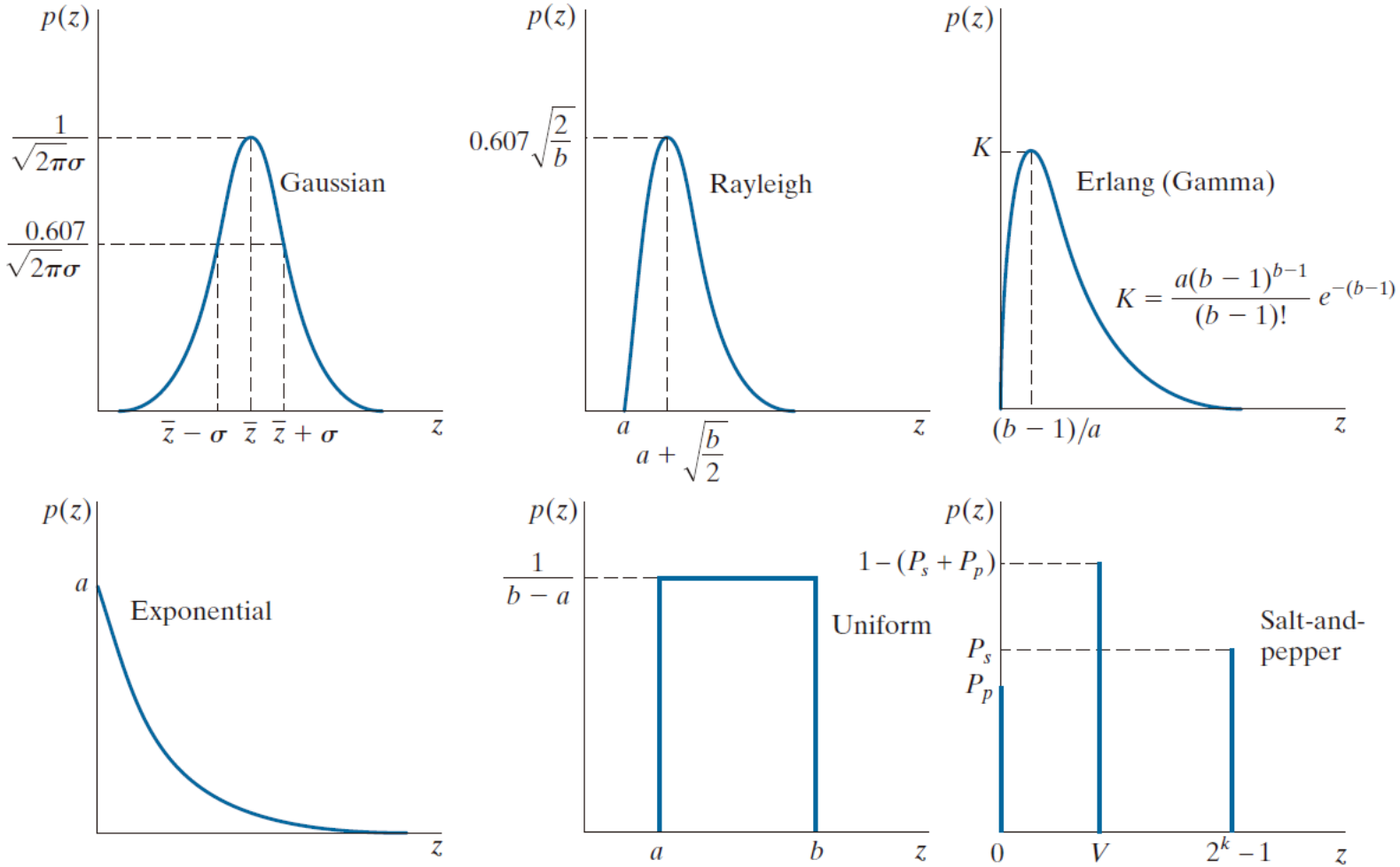
## 高斯噪声

$$p(z) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(z-\bar{z})^2}{2\sigma^2}}$$

$\bar{z}$ 为$z$的平均值，$\sigma$为$z$的标准差

70% $[\bar{z}-\sigma, \bar{z}+\sigma]$

95% $[\bar{z}-2\sigma, \bar{z}+2\sigma]$




a b c
d e f

**FIGURE 5.2** Some important probability density functions.

# 噪声概率密度函数—空间独立的噪声

## 瑞利噪声

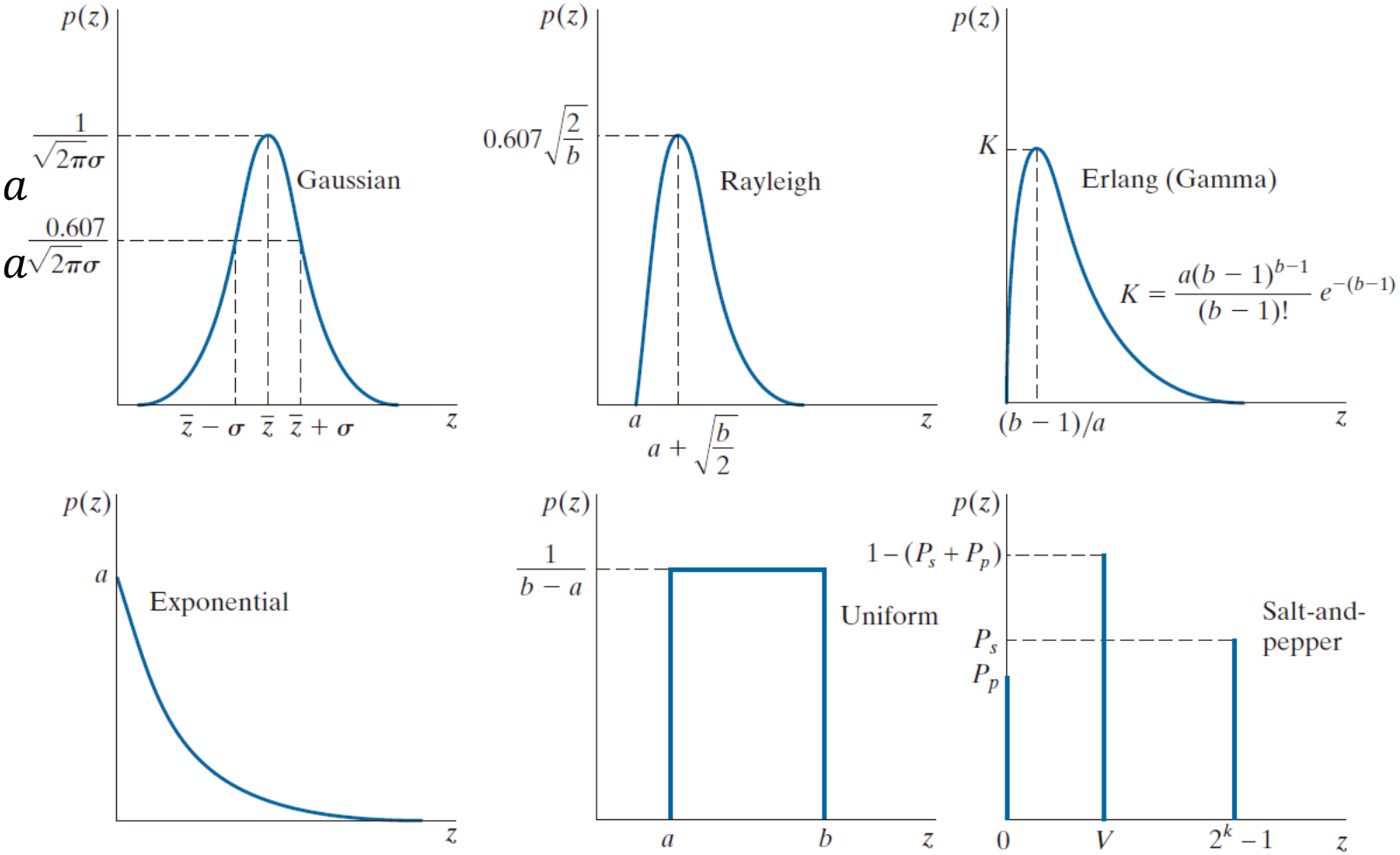
$$p(z)=\begin{cases}\dfrac{2}{b}(z-a)e^{-(z-a)^2/b} & z\geq a\\ 0 & z<a\end{cases}$$

$$E(z)=\int_{-\infty}^{+\infty}zp(z)dz$$

$$D(z)=\int_{-\infty}^{+\infty}(z-\bar{z})^2p(z)dz$$

均值 $\bar{z}=a+\sqrt{\pi b/a}$

方差 $\sigma^2=\dfrac{b(4-\pi)}{4}$




a b c
d e f

**FIGURE 5.2** Some important probability density functions.

# 噪声概率密度函数—空间独立的噪声

$b$=1时

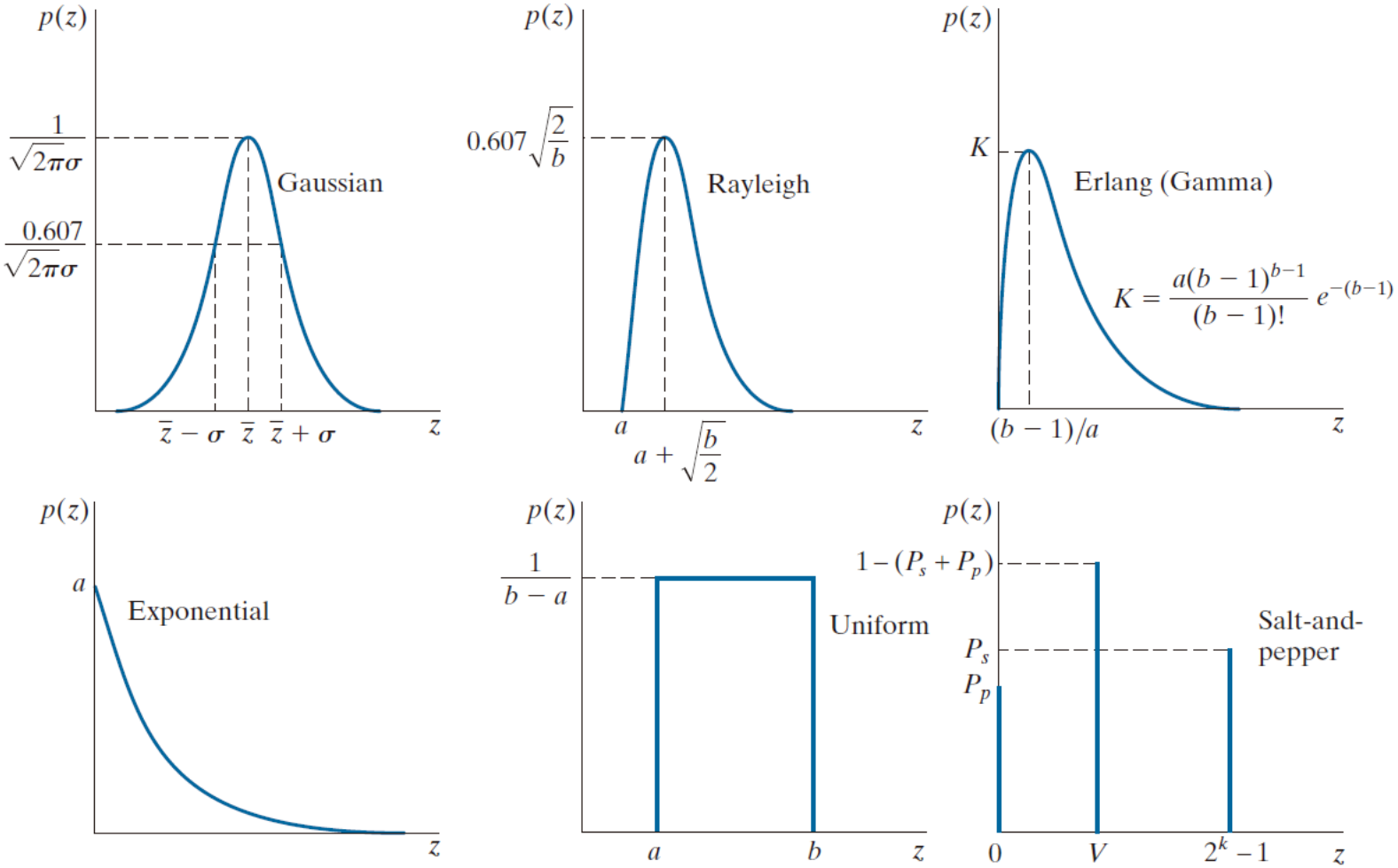
## Erlang (Gamma) Noise

$$p(z)=\begin{cases}\dfrac{a^b z^{b-1}}{(b-1)!}e^{-az} & z\geq a\\ 0 & z<a\end{cases}$$

$$E(z)=\int_{-\infty}^{+\infty} zp(z)dz$$

$$D(z)=\int_{-\infty}^{+\infty}(z-\bar{z})^2 p(z)dz$$

$$\bar{z}=\frac{b}{a}\qquad \sigma^2=\frac{b}{a^2}$$




a b c
d e f

**FIGURE 5.2** Some important probability density functions.

# 噪声概率密度函数—空间独立的噪声

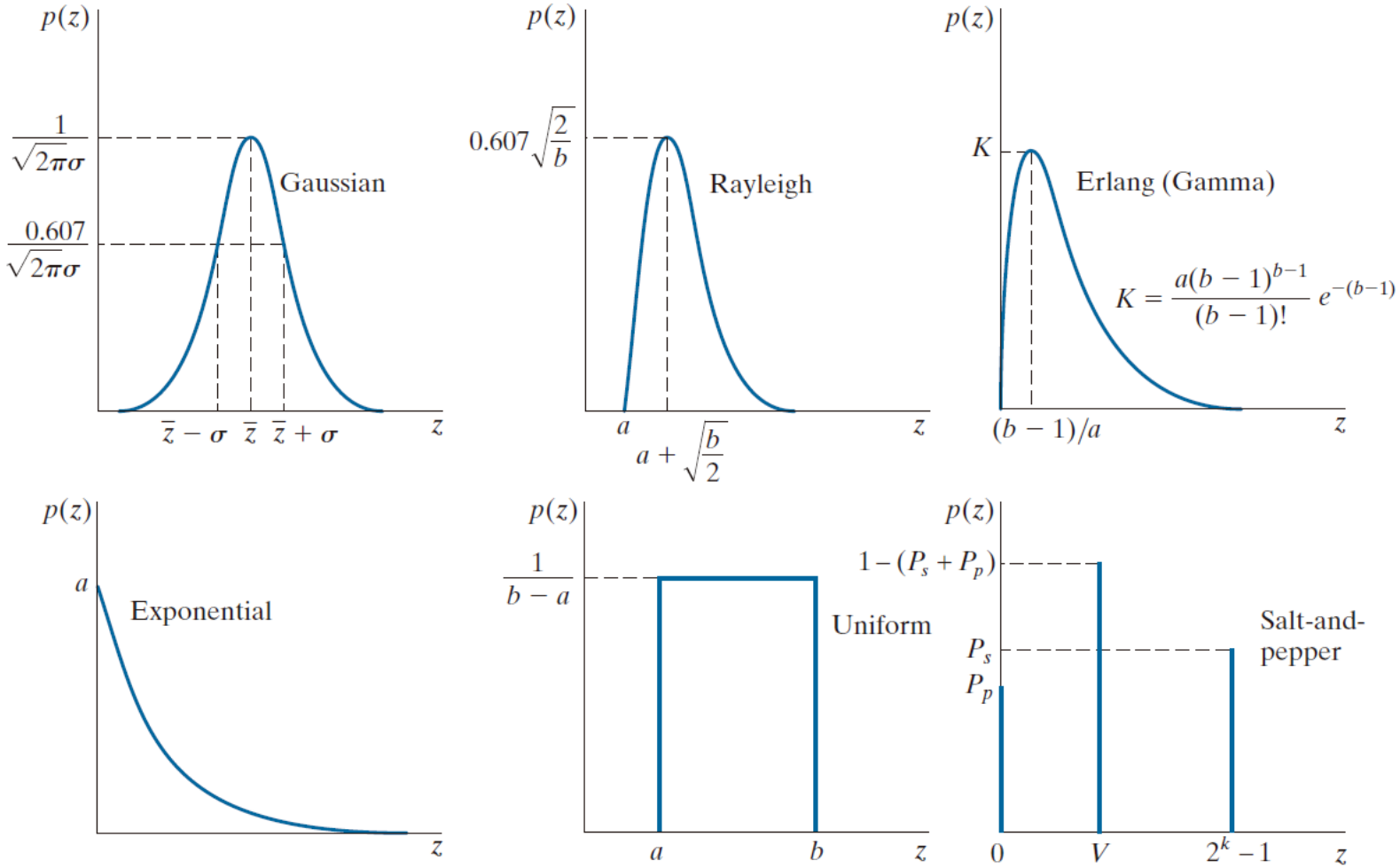
## 指数噪声

$$p(z)=\begin{cases} ae^{-az} & z\geq 0 \\ 0 & z<0 \end{cases}$$

$$E(z)=\int_{-\infty}^{+\infty} zp(z)dz$$

$$D(z)=\int_{-\infty}^{+\infty} (z-\bar{z})^2 p(z)dz$$

$$\bar{z}=\frac{1}{a} \qquad \sigma^2=\frac{1}{a^2}$$




a b c
d e f

**FIGURE 5.2** Some important probability density functions.

# 噪声概率密度函数—空间独立的噪声

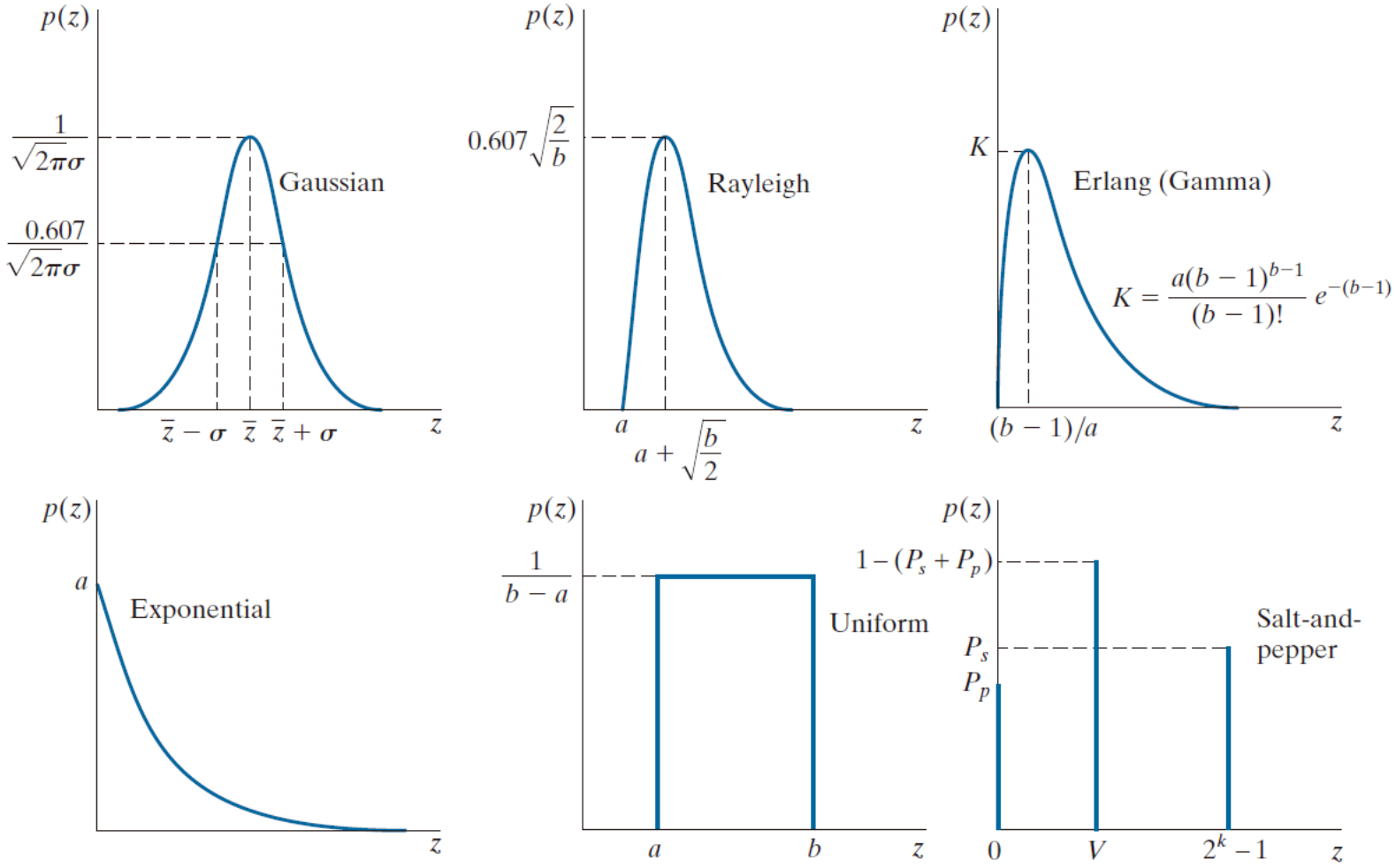
## 均匀噪声

$$p(z)=\begin{cases}1/(b-a) & \text{若} a\le z\le b\\ 0 & \text{其他}\end{cases}$$

$$E(z)=\int_{-\infty}^{+\infty} zp(z)dz$$

$$D(z)=\int_{-\infty}^{+\infty}(z-\bar{z})^2p(z)dz$$

$$\bar{z}=\frac{a+b}{2}\qquad \sigma^2=\frac{(b-a)^2}{12}$$




a b c
d e f

**FIGURE 5.2** Some important probability density functions.

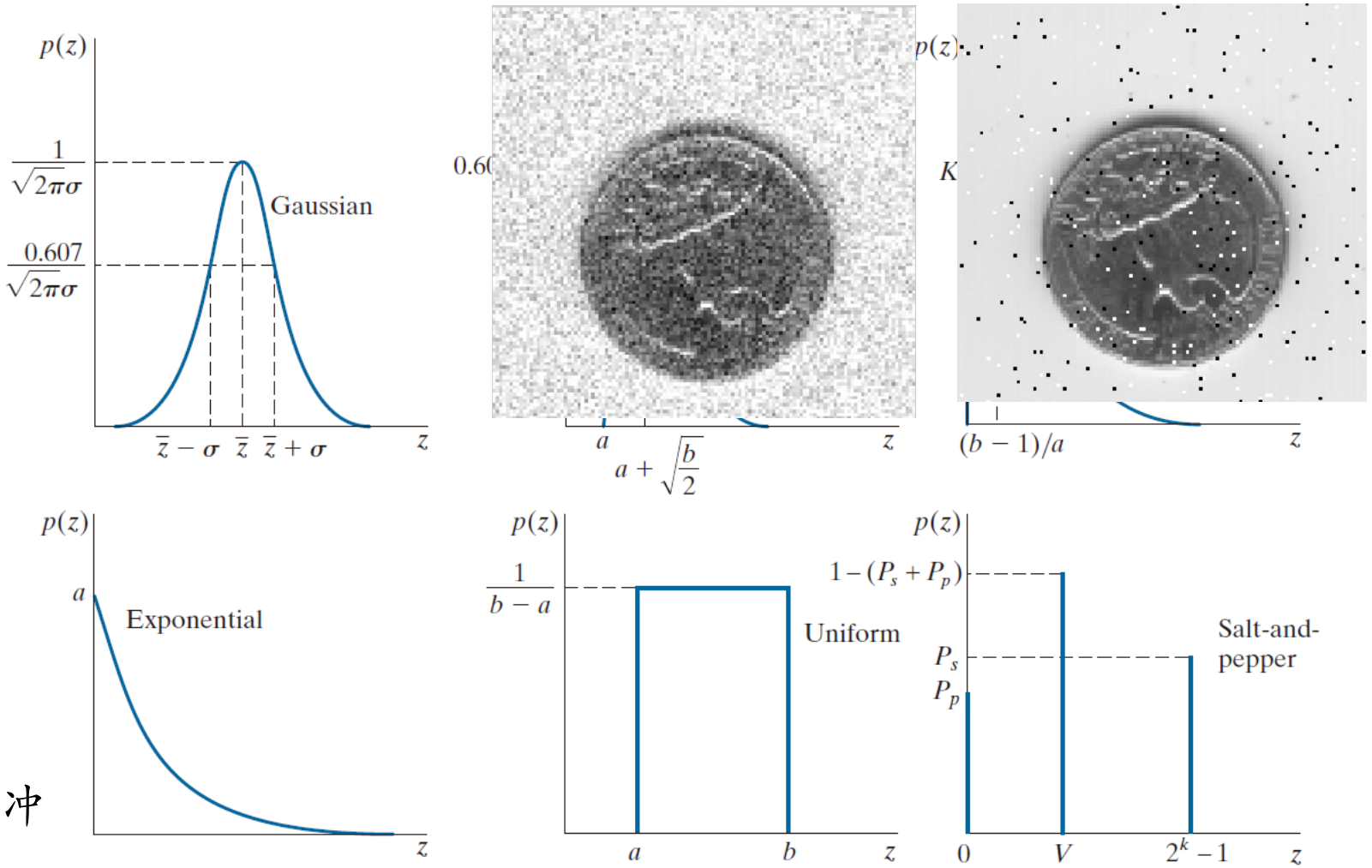
# 噪声概率密度函数—空间独立的噪声

## 脉冲（椒盐）噪声

$$p(z)=\begin{cases}P_s & \text{for } z=2^k-1\\ P_p & \text{for } z=0\\ 1-(P_s+P_p) & \text{for } z=V\end{cases}$$

the range of possible intensity values for that image is [0, $2^k$- 1] (e.g.,[0,255] for an 8-bit image).

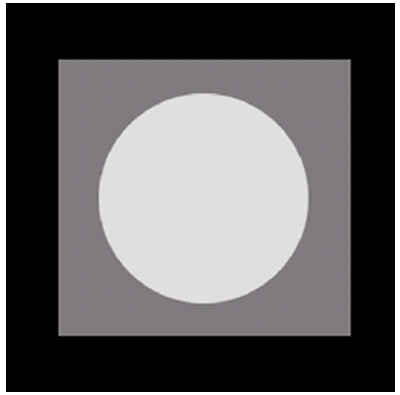
若$P_a$或$P_b$为零，则脉冲称为单级脉冲

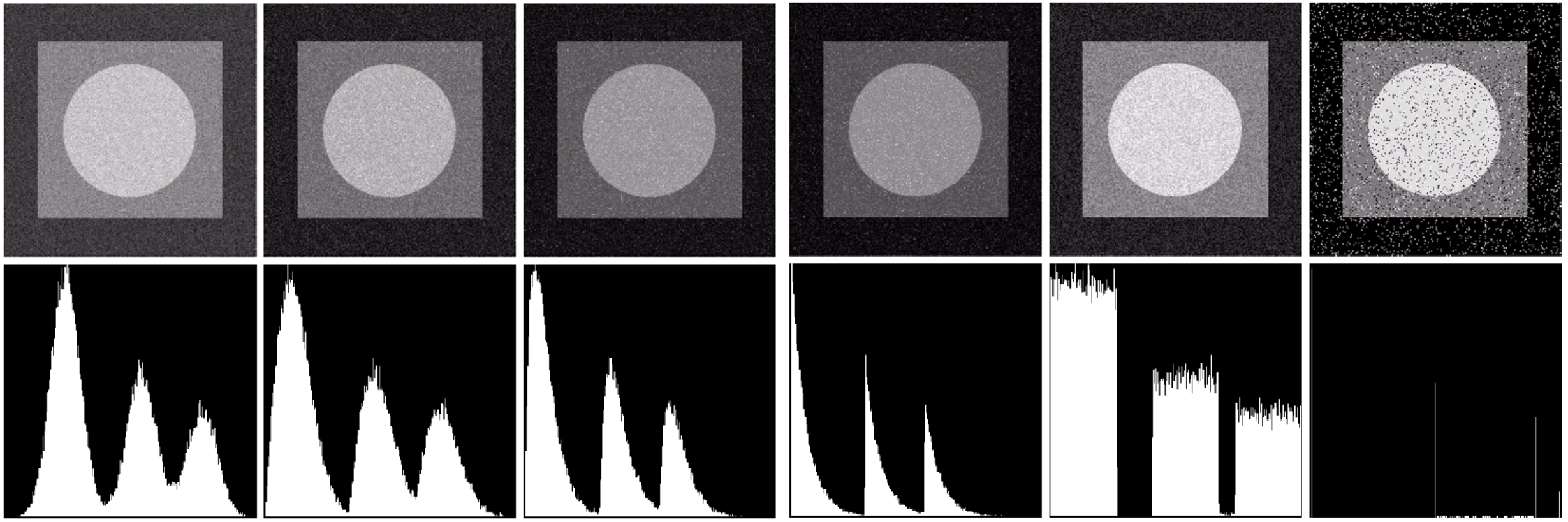



a b c
d e f

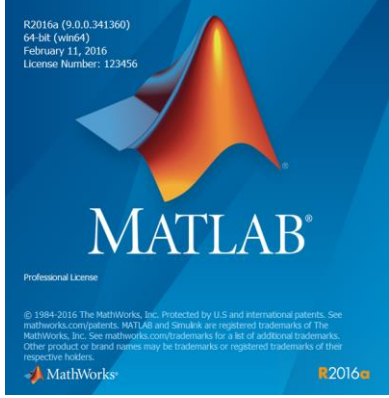
**FIGURE 5.2** Some important probability density functions.

# 噪声图像及直方图



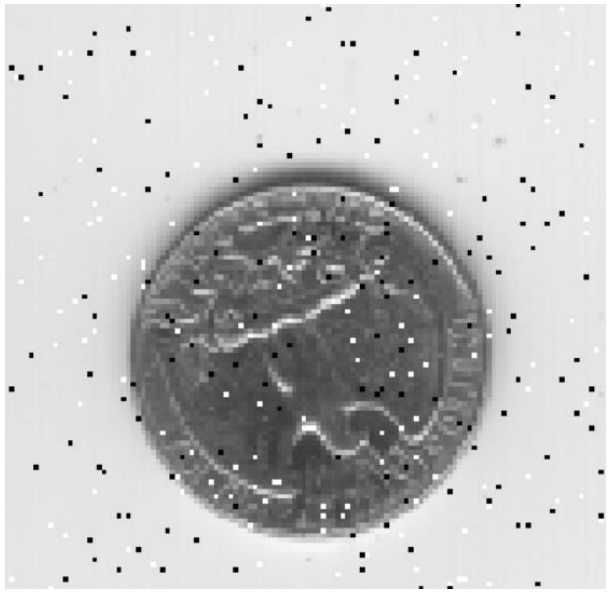


# MATLAB加入噪声

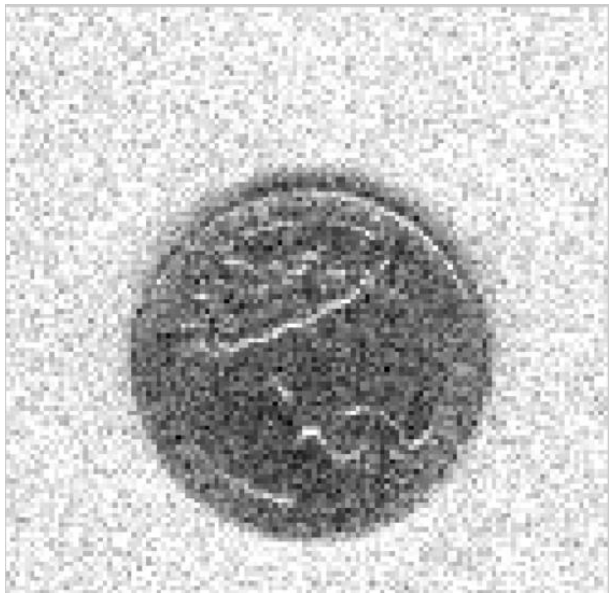



## 原始无噪图像

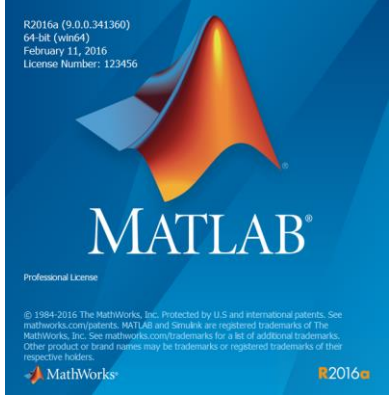
## 椒盐噪声



## 高斯噪声



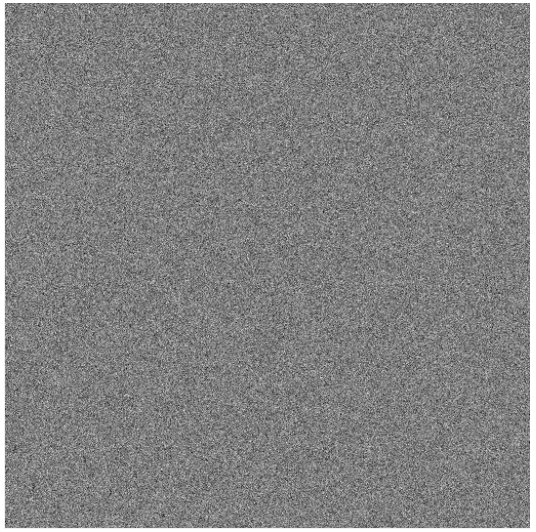
# MATLAB加入噪声




原始图像

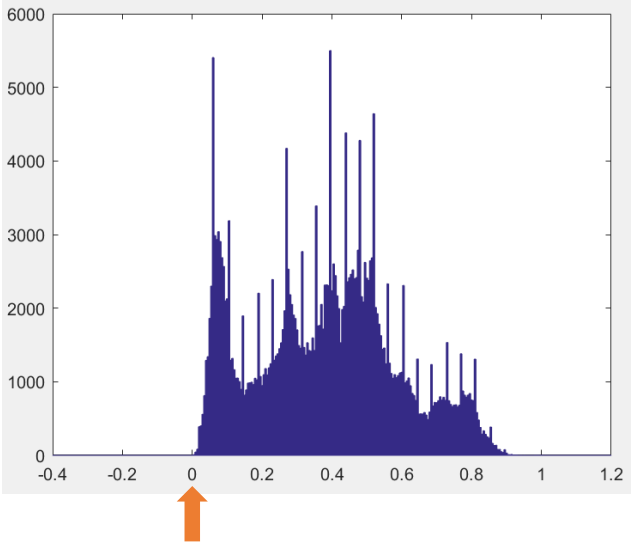
+

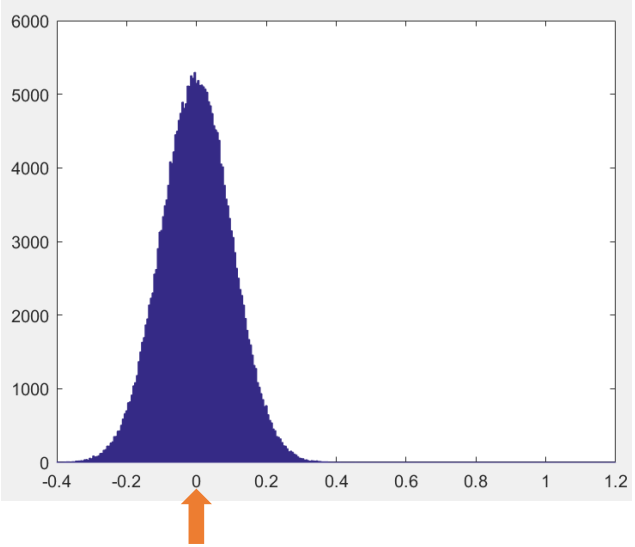
高斯噪声

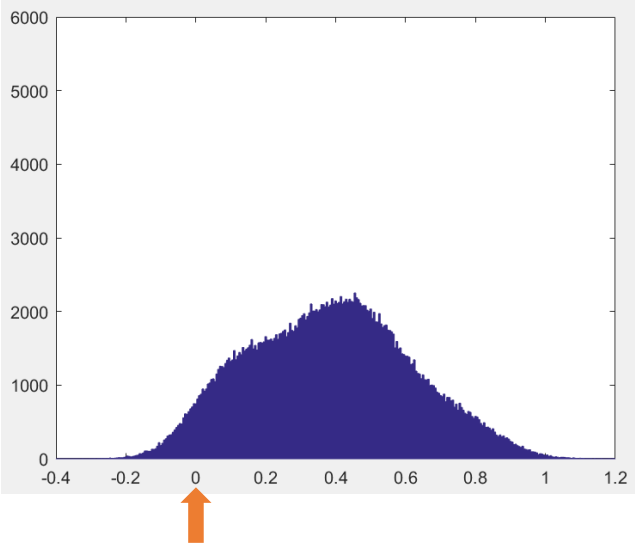


=

噪声图像



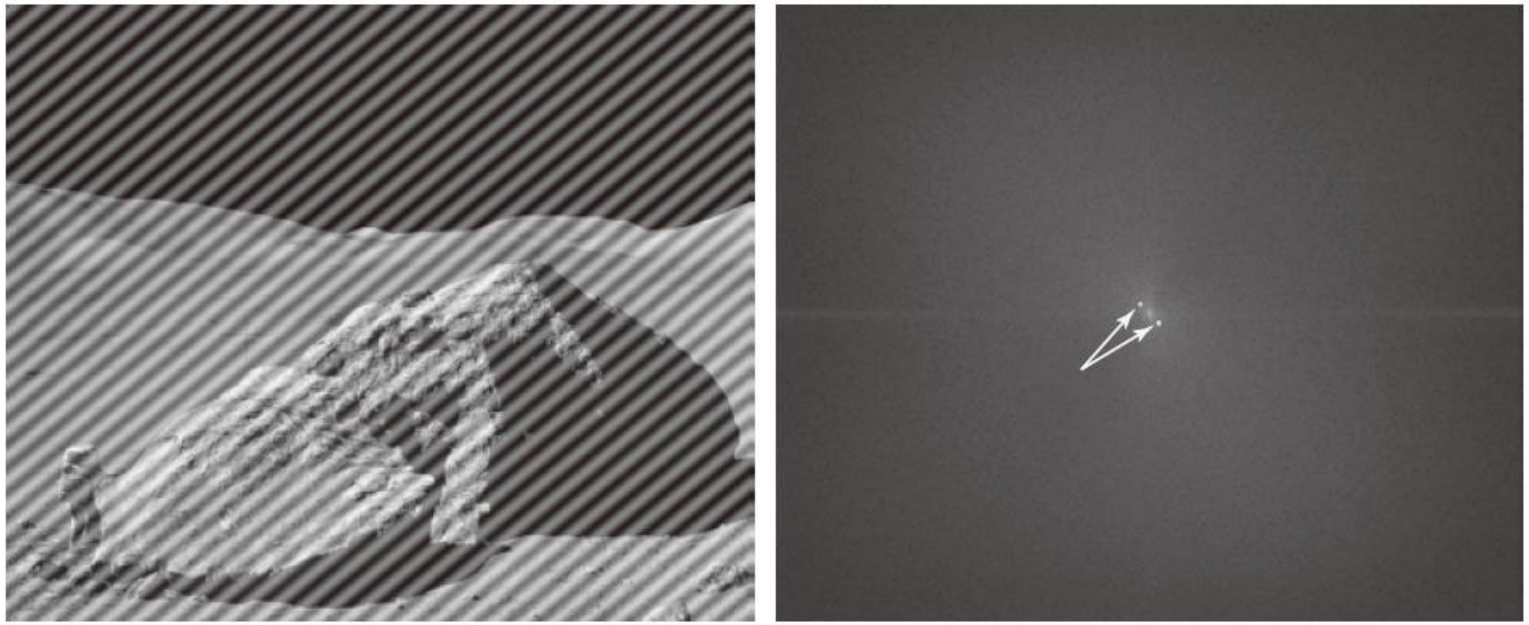
# 周期噪声

$$g(x,y) = f(x,y) \bigstar h(x,y) + \eta(x,y)$$

$$G(u,v) = F(u,v)H(u,v) + N(u,v)$$

a b

**FIGURE 5.5**
(a) Image corrupted by additive sinusoidal noise. (b) Spectrum showing two conjugate impulses caused by the sine wave. (Original image courtesy of NASA.)



**与空间位置有关**

**频率域滤波**