江西理工大學 信息工程学院
JIANGXI UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF INFORMATION ENGINEERING

Digital Image Processing
数字图像处理

Lecture 012:
Noise Models

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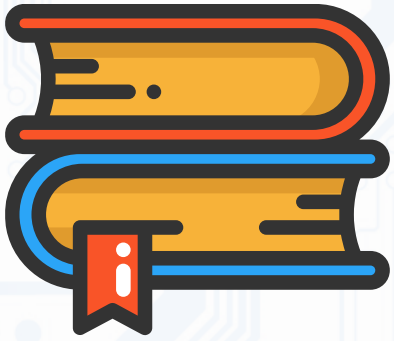


Digital Image Processing

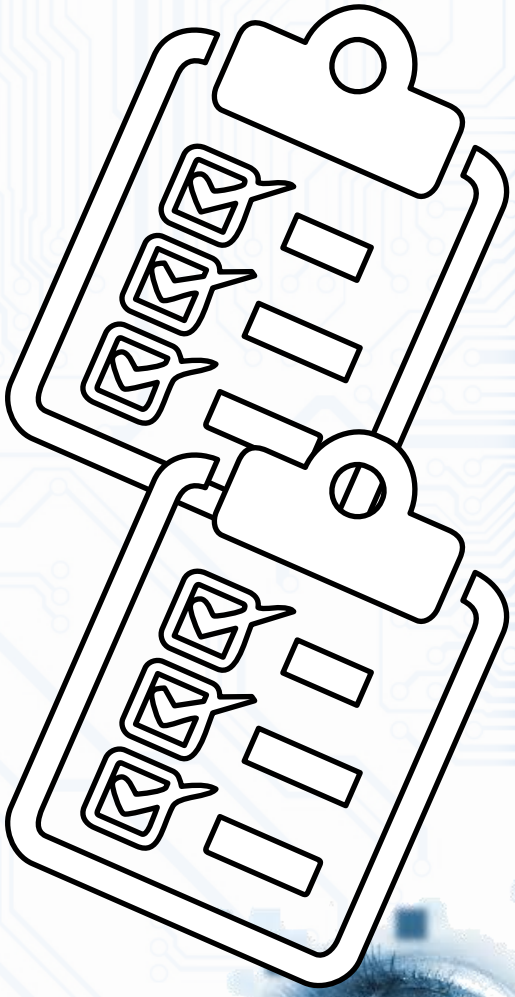
LECTURE 10: **Image enhancement**

Noise model and noise in image process

噪声模型与图像处理中的噪声

Agenda

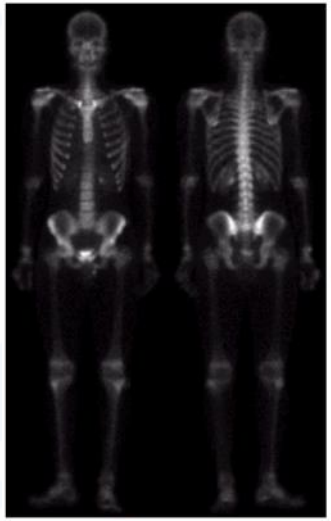
- **Image enhancement** 图像增强
  - Noise Models -噪声模型



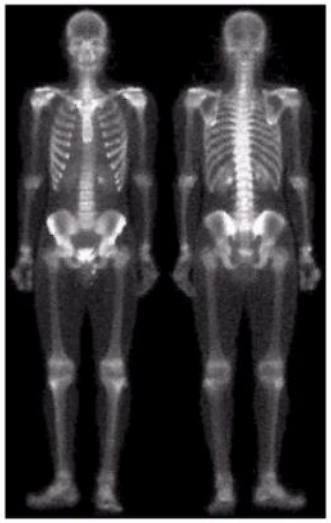
Review:
About Image Enhancement-Some Examples

original image

result of image enhancement



original image



result of image enhancement

About Image Enhancement

- Spatial domain VS frequency domain
- Spatial domain techniques:
  directly manipulate image pixels
- Frequency domain techniques

✓ Fourier transform or wavelet transform of an image

对图像增强
•空间域VS频率域
•空间领域技术:
直接操作图像像素
•频域技术
图像的傅里叶变换
或小波变换

What's noise in image

图像中的噪点是什么 Túxiàng zhōng de zàodiǎn shì shénme

- **Image noise** is random variation of brightness or color information in images, and is usually an aspect of electronic noise.
- It can be produced by the image sensor and circuitry of a scanner or digital camera.
- Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector.
- Image noise is an undesirable by-product of image capture that obscures the desired information.

图像噪声是图像中亮度或颜色信息的随机变化，通常是电子噪声的一个方面。它可以由扫描仪或数码相机的图像传感器和电路产生。 图像噪声也可能源自胶片颗粒和理想光子探测器不可避免的散粒噪声。
图像噪声是图像捕获的不良副产品，它掩盖了所需信息。

Noise in images:

- Images containing multiplicative noise have the characteristic that the brighter the area the noisier it.
- But mostly it is additive.
- We can model a noisy image as:

$$A(x,y) = H(x,y) + B(x,y)$$

Where,

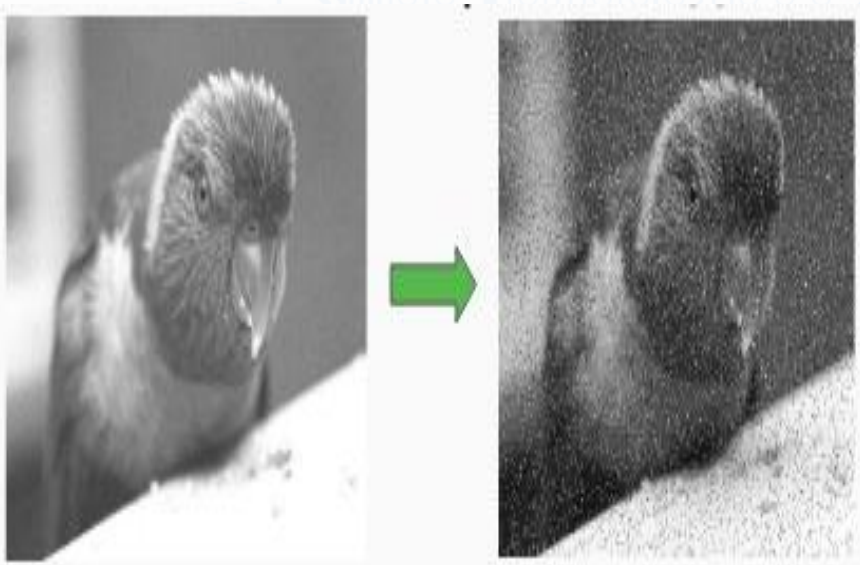
- *A(x,y)= function of noisy image,*
- *H(x,y)= function of image noise ,*
- *B(x,y)= function of original image.*

图像中的噪声:

- 包含乘数噪声的图像具有区域越亮、噪音越大的特点。
- 但主要是附加的。
- 我们可以将嘈杂的图像建模为:
- ***A(x,y) = H(x,y) + B(x,y)***

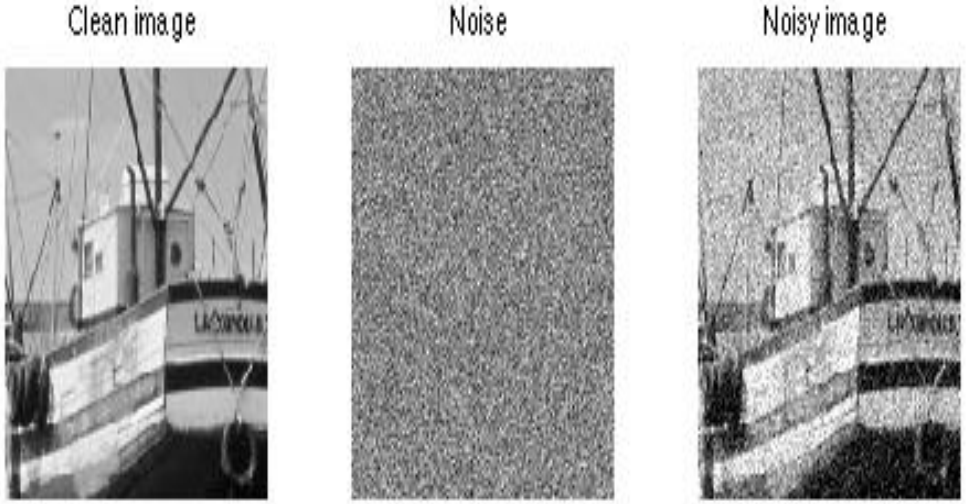
Where,

- *A(x,y)= 噪声图像函数,*
- *H(x,y)= 图像噪声函数,*
- *B(x,y)= 原始图像函数.*



Some noisy image

干净的图像 噪声 噪声图像



Some noisy image

Sources of Image noise:

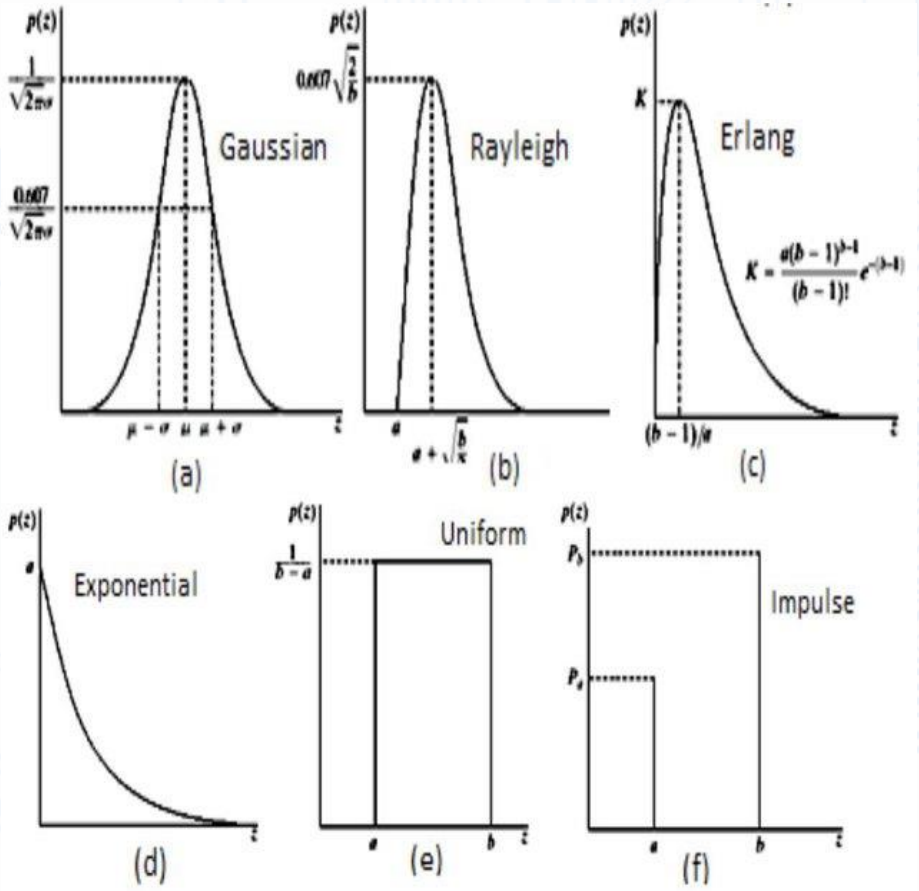
图像噪声来源：

- While image being sent electronically from one place to another.
- **Sensor heat** while clicking an image.
- With varying **ISO Factor** which varies with the capacity of camera to absorb light.

图像从一个地方以电子方式发送到另一个地方。
单击图像时传感器加热。
ISO 因子各不相同，与相机吸收光线的能力不同。

Noise model 噪声模型

- Noise model are:
  - *Gaussian Noise:*
  - *Rayleigh Noise:*
  - *Erlang (gamma) Noise:*
  - *Exponential Noise:*
  - *Uniform Noise:*
  - *Impulse (salt & pepper) Noise*



噪声模型是:
高斯噪声:
瑞利噪声:
Erlang(γ)噪声:
指数噪声:
平均的噪声:脉冲(盐和胡椒)噪声

Gaussian Noise

- Gaussian Noise is a statistical noise having a probability density function equal to normal distribution, also known as Gaussian Distribution.
- Random Gaussian function is added to Image function to generate this noise.
- It is also called as electronic noise because it arises in amplifiers or detectors.
- ***Source:*** ***thermal vibration of atoms and discrete nature of radiation of warm objects.***

-高斯噪声是概率密度函数等于正态分布的统计噪声，也称为高斯分布。

- 随机高斯函数被添加到图像函数以生成此噪声。

- 它也被称为电子噪声，因为它出现在放大器或检测器中。

- **-来源：原子的热振动和温暖物体辐射的离散性质。**

Noise Models_ Gaussian Noise:

噪声模型 Zàoshēng móxíng

高斯噪声 Gāosī zàoshēng

- **Gaussian Noise:** The Probability Density Function (PDF) of Gaussian noise is

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

- where z represents gray level, μ is the mean of average value of z, and s is its standard deviation.
- The standard deviation squared, s^2, is called the variance of z.
- Mathematically easily traceable in both spatial and frequency domains.

Noise Models_ Gaussian Noise:

噪声模型 Zàoshēng móxíng

高斯噪声 Gāosī zàoshēng

- **高斯噪音:高斯噪音的概率密度函数（PDF）是**

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

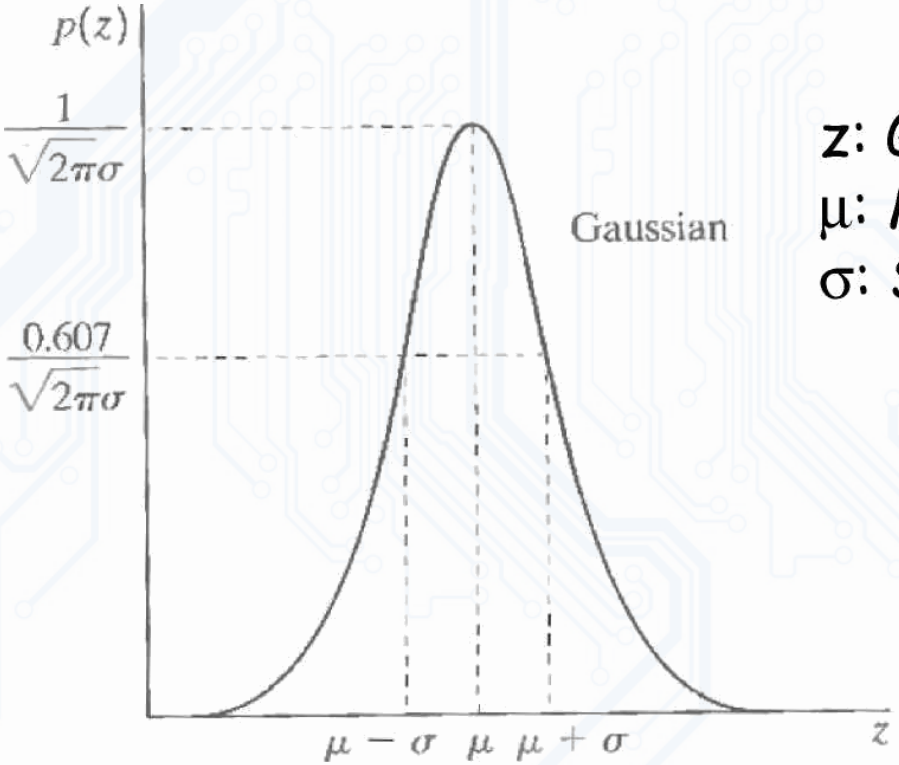
- z 表示灰色水平，μ表示 z 的平均值，s 表示其标准偏差。
- 标准偏差方形 s2 称为 z 的方差。
- 在空间和频率域中，数学上很容易追踪。
-

Noise Models :Gaussian Noise

噪声模型：高斯噪声

- The distribution of Gaussian noise is shown in the following figure.

高斯噪声的分布如下图所示。



z: Gray level value
μ: Mean
σ: Standard deviation

Noise Models :Gaussian Noise

噪声模型：高斯噪声

(a) Input original image

(b) Gaussian noise image $\sigma = 20$

Noise Models: Rayleigh Noise

噪声模型：瑞利噪声

- **Rayleigh Noise:** The Probability Density Function (PDF) of Rayleigh noise is

瑞利噪声：
瑞利噪声的概率密度函数 (PDF) 是

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

- where z represents gray level and the mean and variance are given by

其中z表示灰度，均值和方差由

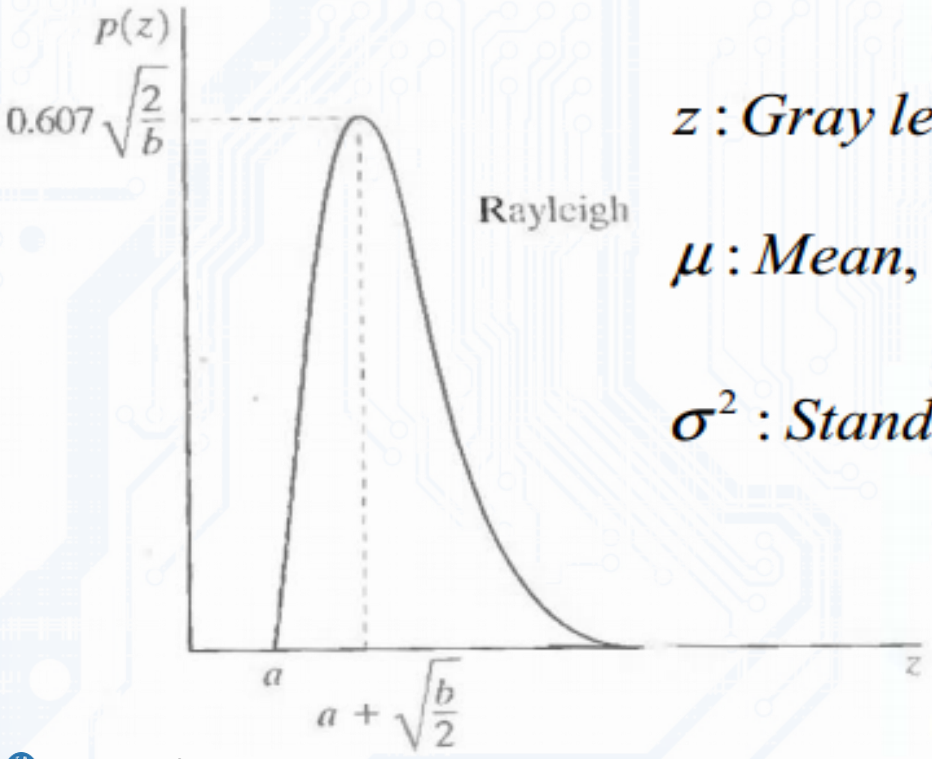
$$\mu=a+\sqrt{\frac{\pi b}{4}}$$

$$\sigma^2=\frac{b(4-\pi)}{4}$$

Noise Models:Rayleigh Noise

- The distribution of Rayleigh noise is shown in the following figure.

瑞利噪声的分布如下图所示。



z : *Gray level value*

μ : *Mean*, $a+\sqrt{\frac{\pi b}{4}}$

σ^2 : *Standard deviation*, $\frac{b(4-\pi)}{4}$

Noise Models:

Gaussian Noise /Rayleigh Noise

噪声模型：高斯噪声/瑞利噪声

Gaussian noise

Rayleigh noise

Poisson Noise: 泊松噪声： Pō sōng zàoshēng:

- The appearance of this noise is seen due to the statistical nature of electromagnetic waves such as x-rays, visible lights and gamma rays.
- The x-ray and gamma ray sources emitted number of photons per unit time.
- These rays are injected in patient's body from its source, in medical x rays and gamma rays imaging systems.
- These sources are having random fluctuation of photons.
- Result gathered image has spatial and temporal randomness.
- This noise is also called as quantum (photon) noise or shot noise.

- 由于电磁波（如 X 射线、可见光和伽马射线）的统计特性，可以看到这种噪声的出现。
- X 射线和伽马射线源每单位时间发射的光子数。
- 这些射线从其来源，在医疗 X 射线和伽马射线成像系统中注入患者体内。
- 这些源具有光子的随机波动。
- 结果采集的图像具有空间和时间的随机性。
- 这种噪声也称为量子（光子）噪声或散粒噪声。

Noise Models: Erlang (gamma) Noise

Erlang (gamma) 噪声：

- **Erlang (gamma) Noise:** The Probability Density Function (PDF) of Eralng (gamma) noise is

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

Eralng (gamma) 噪声的概率密度函数 (PDF) 是

- where z represents gray level and the mean and variance are given by

其中z表示灰度，均值和方差由

$$\mu=\frac{b}{a}$$

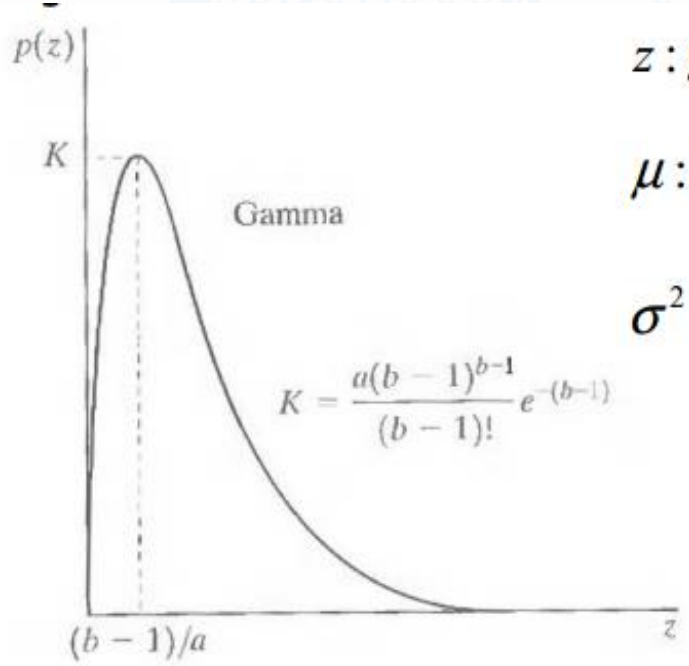
$$\sigma^2=\frac{b}{a^2}$$

Noise Models: Erlang (gamma) Noise

噪声模型：Erlang (gamma) 噪声 Zàoshēng móxíng:Erlang (gamma) zàoshēng

- The distribution of Erlang (gamma) noise is shown in the following figure.

Erlang (gamma)噪声的分布如下图所示。



$$K = \frac{a(b-1)^{b-1}}{(b-1)!}e^{-(b-1)}$$

z : *gray level value*

μ : *Mean*, $\frac{b}{a}$

σ^2 : *Standard deviation*, $\frac{b}{a^2}$

标准差

Noise Models: Erlang (gamma) Noise

噪声模型：Erlang (gamma) 噪声 Zàoshēng móxíng:Erlang (gamma) zàoshēng

Gamma noise

Exponential noise

Noise Models: Exponential Noise

噪声模型：指数噪声Zàoshēng móxíng: Zhǐshù zàoshēng

- **Exponential Noise:** The Probability Density Function (PDF) of exponential noise is

指数噪声：指数噪声的概率密度函数 (PDF) 是

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

This is Erlang with b=1.

- where z represents gray level and the mean and variance are given by

其中z表示灰度，均值和方差由

$$\mu=\frac{1}{a}$$

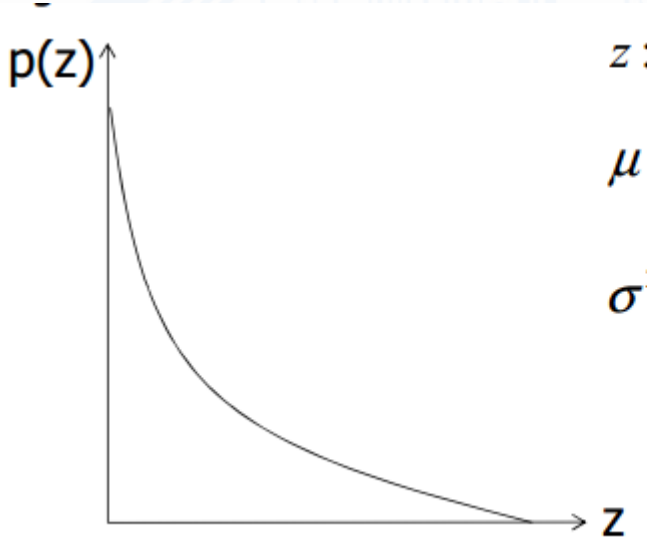
$$\sigma^2=\frac{1}{a^2}$$

Noise Models: Exponential Noise

噪声模型：指数噪声Zàoshēng móxíng: Zhǐshù zàoshēng

- The distribution of exponential noise is shown in the following figure.

指数噪声的分布如下图所示。



z : *gray level value*

μ : *Mean,* $\frac{1}{a}$

σ^2 : *Standard deviation,* $\frac{1}{a^2}$

标准差

Noise Models: Uniform Noise:

均匀噪声:均匀噪声的概率密度函数为

- **Uniform Noise:** The Probability Density Function (PDF) of uniform noise is

$$p(z)=\begin{cases}\dfrac{1}{b-a}, & a\le z\le b\\ 0, & otherwise\end{cases}$$

- where z represents gray level and the mean and variance are give

$$\mu=\frac{a+b}{2}$$

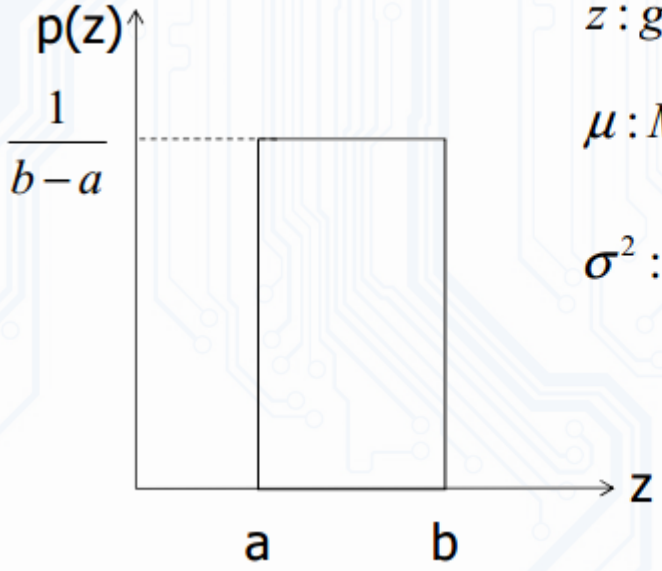
$$\sigma^2=\frac{(b-a)^2}{12}$$

Noise Models: Uniform Noise:

噪声模型： 均匀噪声：Zàoshēng móxíng: Jūnyún zàoshēng:

- The distribution of uniform noise is shown in the following figure.

均匀噪声的分布如下图所示。



z : *gray level value*

μ : *Mean*, $\frac{a+b}{2}$

σ^2 : *Standard deviation*, $\frac{(b-a)^2}{12}$

Noise Models: Impulse (salt & pepper) Noise

- Impulse Function: In the discrete world impulse function on a vale of 1 at a single location and In continuous world impulse function is an idealised function having unit area.

脉冲函数：在单个位置的1 vale上的离散世界脉冲函数中，连续世界脉冲函数是具有单位区域的理想化函数。

Types of Impulse Noise:

脉冲噪声的类型： Màichōng zàoshēng de lèixíng:

- There are three types of impulse noises. Salt Noise, Pepper Noise, Salt and Pepper Noise.

盐噪声:

  - **Salt Noise:** Salt noise is added to an image by addition of random bright (with 255 pixel value) all over the image.

胡椒噪声

  - **Pepper Noise:** Salt noise is added to an image by addition of random dark (with 0 pixel value) all over the image.

椒盐噪声:

  - **Salt and Pepper Noise:** Salt and Pepper noise is added to an image by addition of both random bright (with 255 pixel value) and random dark (with 0 pixel value) all over the image.This model is also known as data drop noise because statistically it drop the original data values
  - ***Source: Malfunctioning of camera's sensor cell.***

Types of Impulse Noise:

脉冲噪声的类型： Màichōng zàoshēng de lèixíng:

- 脉冲噪声有三种类型。盐噪音，胡椒噪音，盐和胡椒噪音.
  - **盐噪声:**盐噪声通过在图像上添加随机亮度（255 像素值）添加到图像中。
  - **胡椒噪声:**盐噪声通过在图像上添加随机暗（0 像素值）添加到图像中。
  - **盐和胡椒噪声:** 盐和胡椒噪音通过在图像上添加随机明亮（255 像素值）和随机暗（0 像素值）添加到图像中。此模型也称为数据掉落噪声，因为从统计学上讲，它会降低原始数据值
  - ***资料来源:相机传感器单元故障.***

Noise Models: Impulse (salt & pepper) Noise

脉冲（盐和胡椒）噪声

- **Impulse (salt & pepper) Noise:** The Probability Density Function (PDF) of impulse (salt & pepper) noise is

脉冲(盐和胡椒)噪声的概率密度函数为

$$p(z)=\begin{cases} P_a & for\ z=a \\ P_b & for\ z=b \\ 0, & otherwise \end{cases}$$

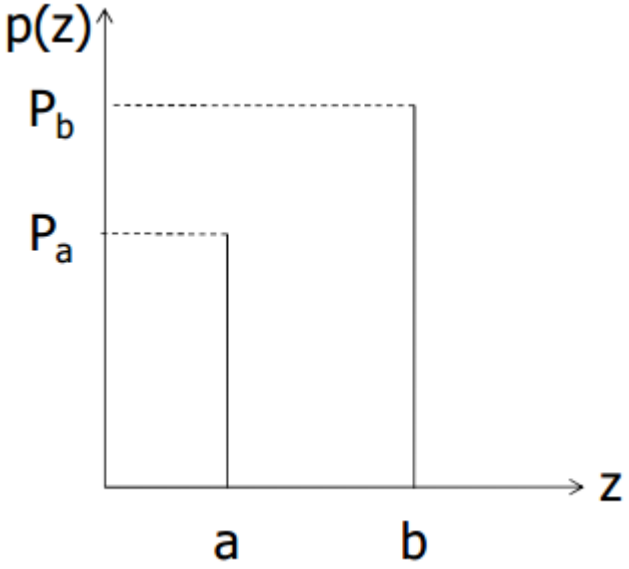
- where z represents gray level.

Noise Models: Impulse (salt & pepper) Noise

噪声模型：脉冲（盐和胡椒）噪声

- The distribution of impulse (salt & pepper) noise is shown in the following figure.

脉冲(盐和胡椒)噪声的分布如下图所示。



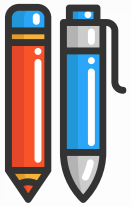
Noise Models: Impulse (salt & pepper) Noise

噪声模型：脉冲（盐和胡椒）噪声

Uniform noise

Impulse noise

salt & pepper



Speckle Noise

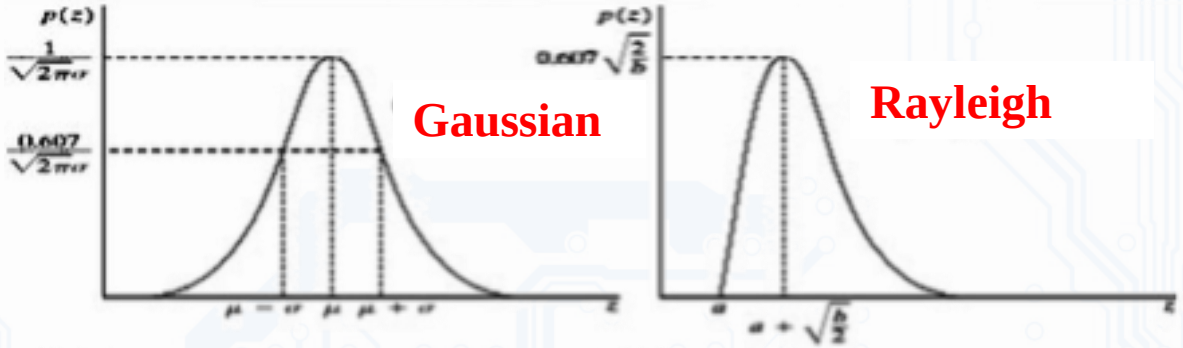
散斑噪声 Sàn bān zàoshēng

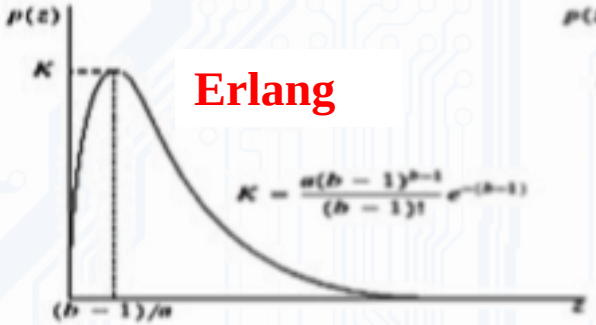
- A fundamental problem in optical and digital holography is the presence of speckle noise in the image reconstruction process.
- Speckle is a granular noise that inherently exists in an image and degrades its quality.
- Speckle noise can be generated by multiplying random pixel values with different pixels of an image.

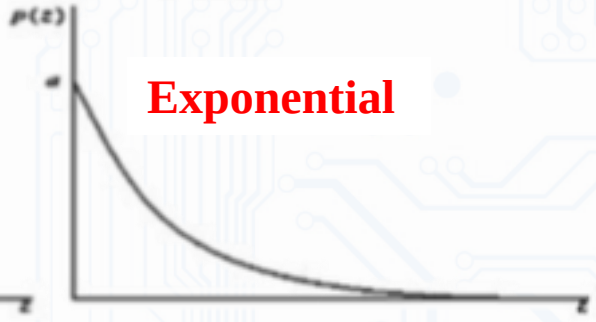
- 光学和数字全息术中的一个基本问题是图像重建过程中存在斑点噪声。
- - 散斑是图像中固有的颗粒状噪声，会降低其质量。
- - 散斑噪声可以通过将随机像素值与图像的不同像素相乘来产生。

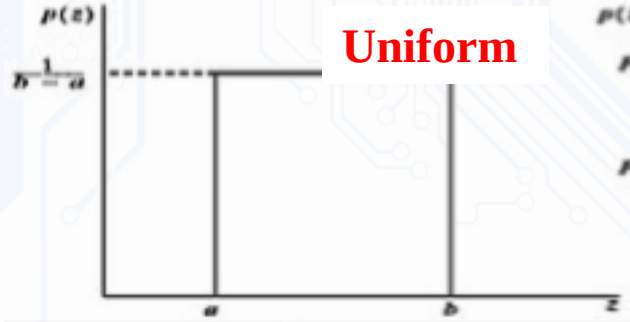
Noise model

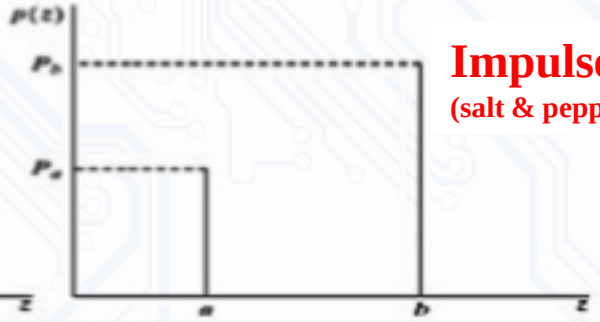
噪声模型 Zàoshēng móxíng







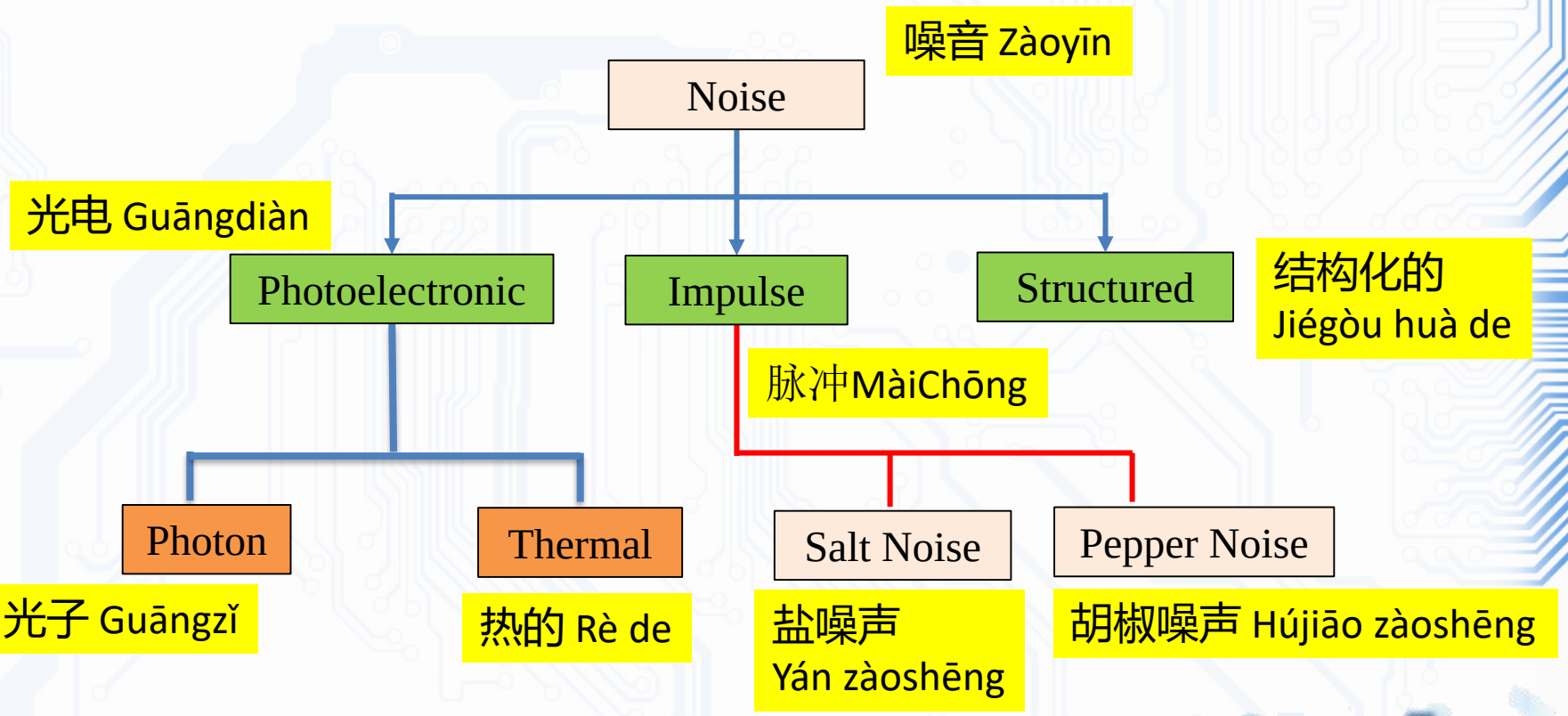




Souce: Lawrence Rabiner

Types of Image noise:

图像噪声的类型：



Reference

- Images taken from Gonzalez & Woods, Digital Image Processing (2002)
- Introduction to MATLAB, *Kadin Tseng,Boston University, Scientific Computing and Visualization*
- https://medium.com/image-vision/noise-in-digital-image-processing-55357c9fab71

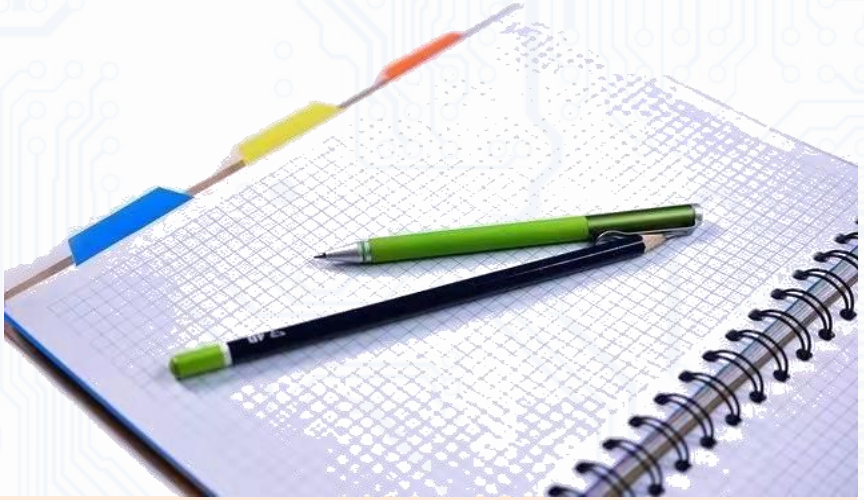
Notice

@dip学生：亲爱的学生，关于你的时期：你应该在matlab中使用代码来在图像处理中找到一个主题，并通过演示文稿中的ppt，但我应该在此之前批准主题。 所有学生都被邀请确定您的主题并在10月30日之前将其发送给我。请注意，这次不会扩大。 该计划是这样，学生将在可能的课程中讨论他们的主题和显示代码，学生可以用中文说话。学生演讲时间将于11月开始，每个学生都有10分钟的会话时间

Student Task : DIP

- Select and send your Project topic from the link and list and run it in matlab make the report about project

Send after 2 week



- **You have time to send your task before 9 am (bejing time) of lecture**
- **Send the file in PPT(power point format) to this email :**

drajm@ yahoo.com

- **Your file should have this format of name**

<Task number><student name><Student ID>.ppt

Student Task_3: DIP

- 请帮我翻译部分的朋友鼓掌
- Qǐng bāng wǒ fānyì bùfèn de péngyǒu gǔzhǎng

Solve the Question shared in mooc

解决mooc分享的问题

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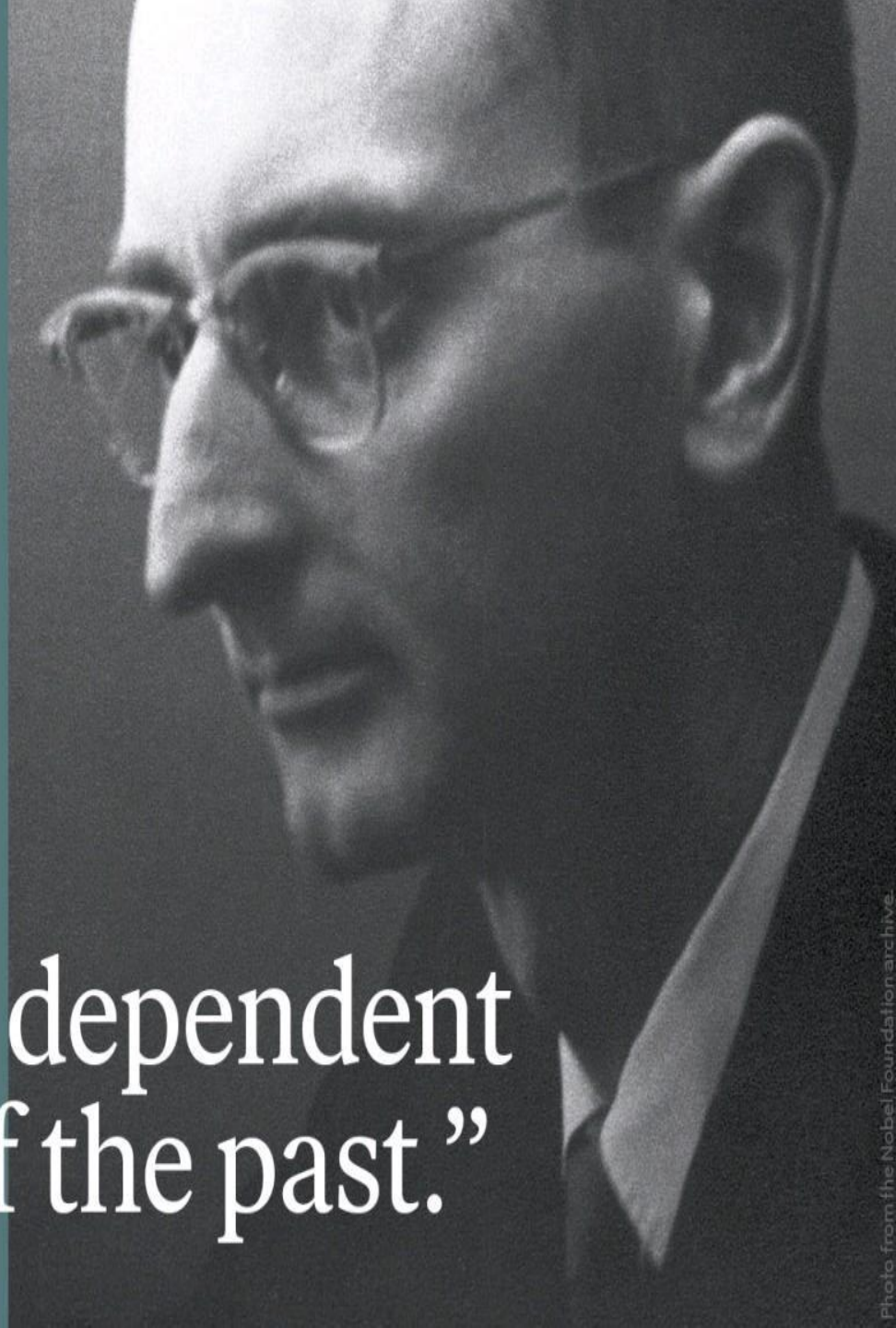
发送下一个讲座

江西理工大学
Jiangxi University of Science and Technology
信息工程学院
School of information engineering

Digital Image Processing

THANK YOU

OWEN CHAMBERLAIN
Nobel Prize in Physics 1959



"Each new idea is dependent upon the ideas of the past."

Photo from the Nobel Foundation archive.

Student Task_3: DIP

- 请帮我翻译部分的朋友鼓掌
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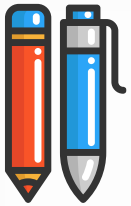

"BE HUMBLE. BE HUNGRY. AND ALWAYS BE THE HARDEST WORKER IN THE ROOM."