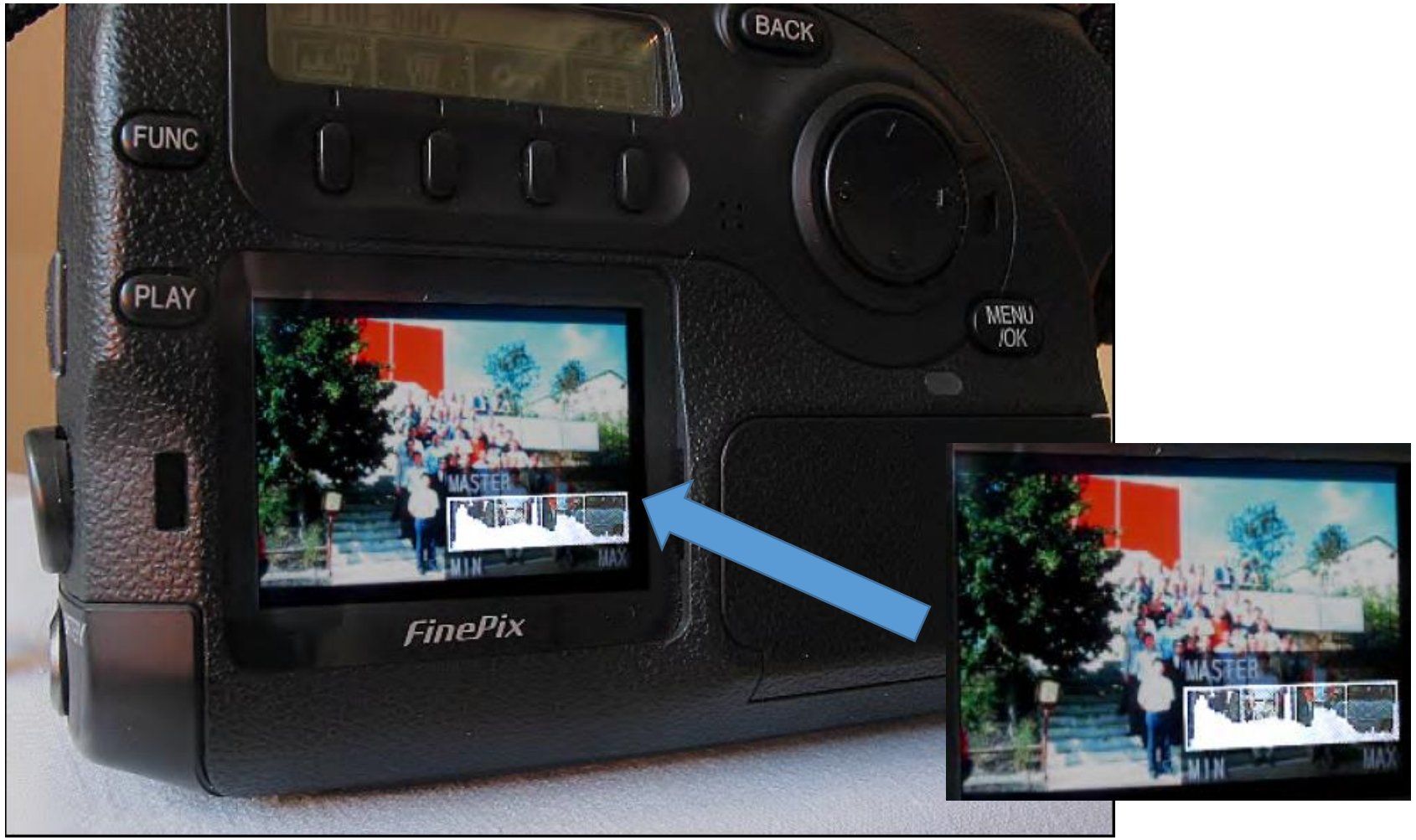
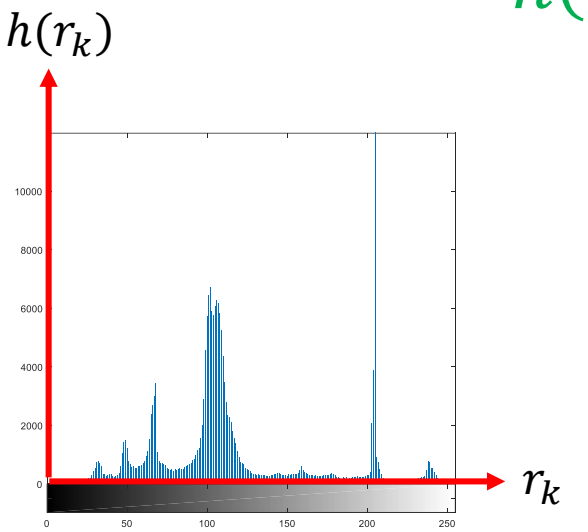
灰度直方图变换



灰度直方图（Gray Histogram）



$$h(r_k) = n_k$$

cardinality in a set

$$n_k = \underset{(x,y)}{card}\{I(x,y) = r_k\}$$ (灰度等于r_k的像素总数)

$$r_k = [0, K-1]$$ (图像灰度范围)

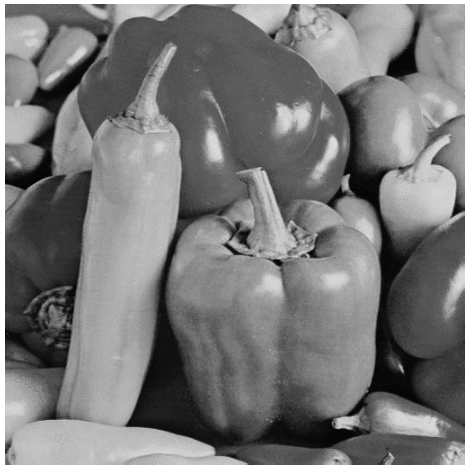
$$\sum_k h(r_k) = \sum_k n_k = n$$ (图像面积)

归化直方图(normalized histogram) : $$p(r_k) = \frac{h(r_k)}{n} = \frac{n_k}{n}$$

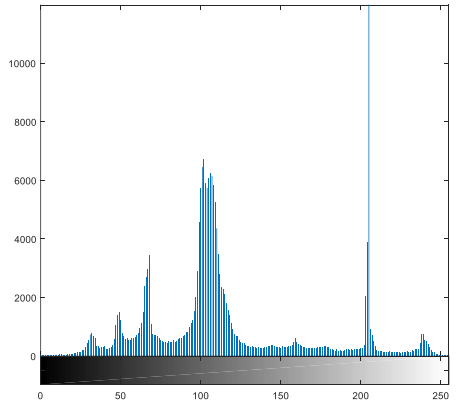
$$0 \le p(r_k) \le 1$$

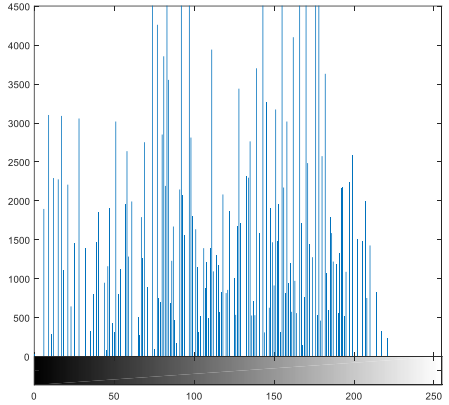
$$\sum_k p(r_k) = 1$$

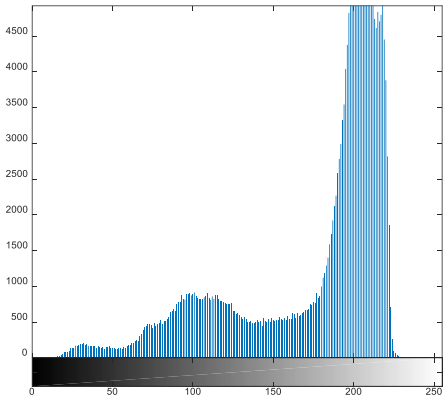
理解灰度直方图

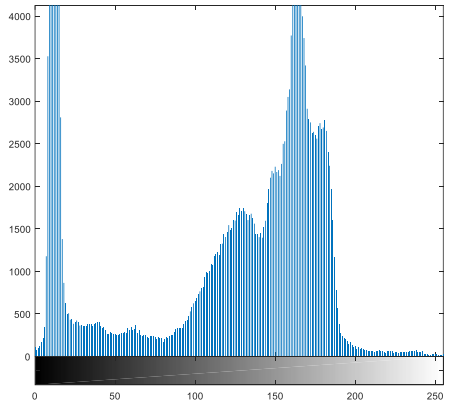



F16
U.S.AIR FORCE

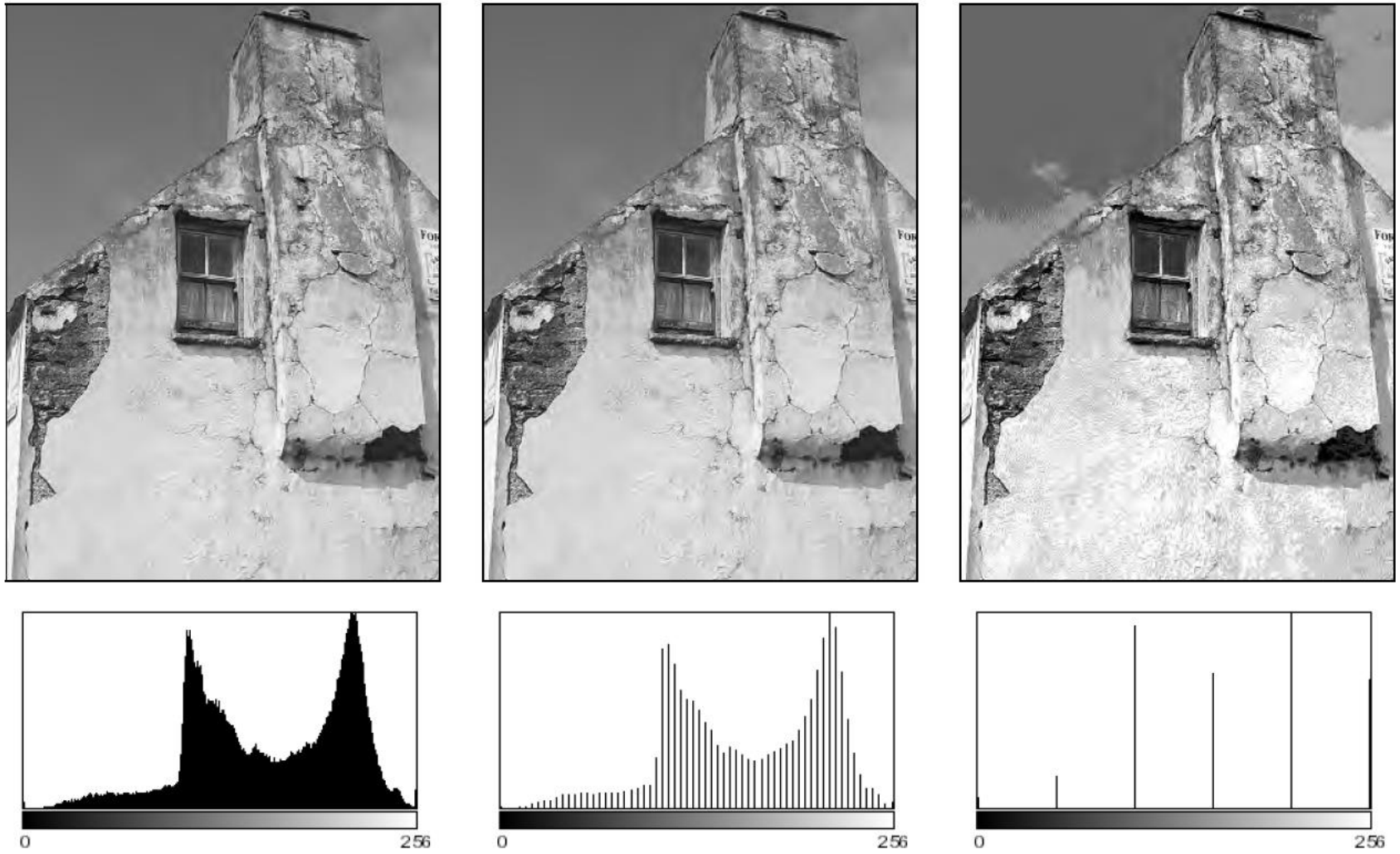

10000
8000
6000
4000
2000
0
0
50
100
150
200
250


4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250

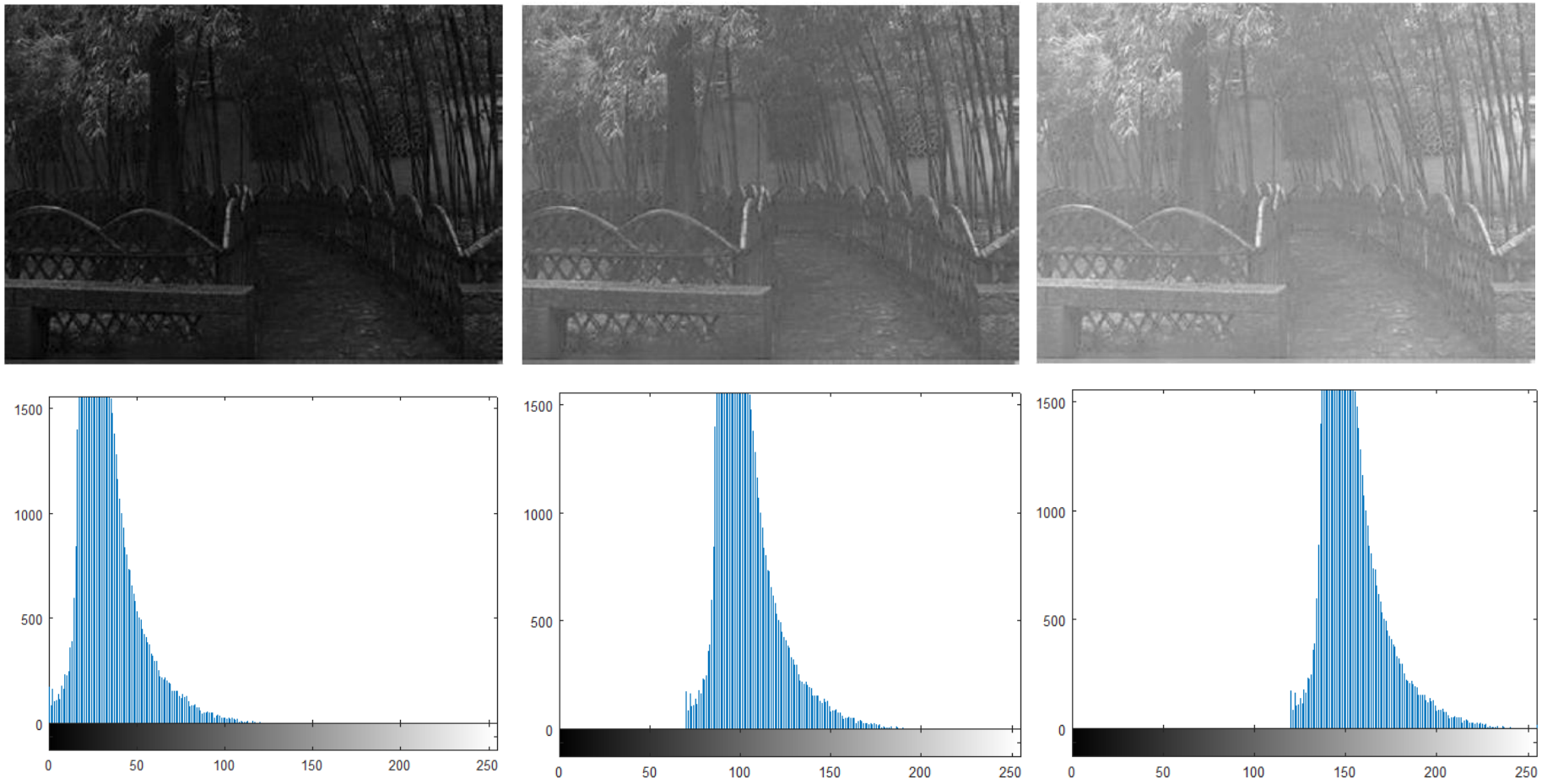

4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250


4000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250

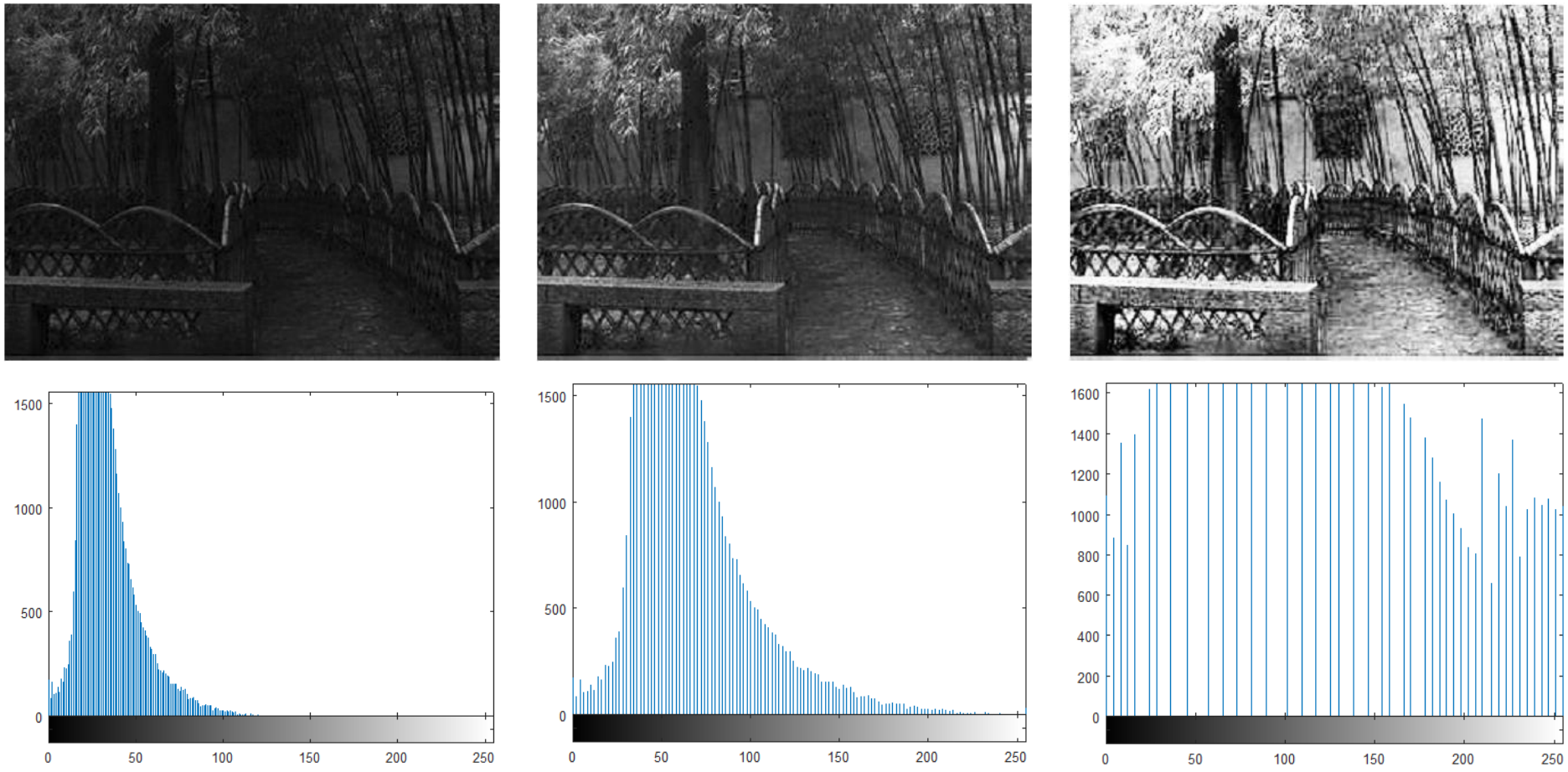
视觉特性：有效灰度级与视觉质量



视觉特性：灰度范围与视觉质量



视觉特性：灰度分布与视觉质量



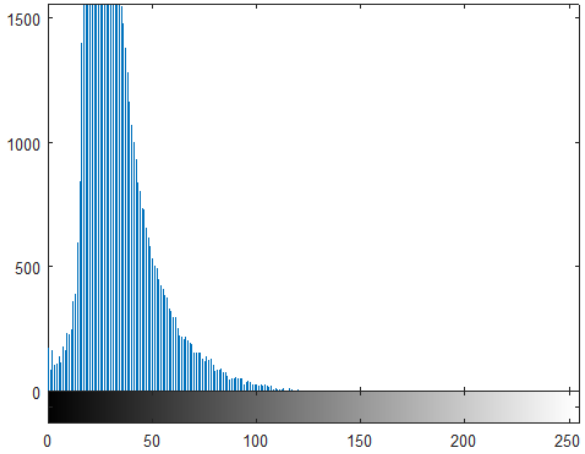
灰度映射
Gray Mapping

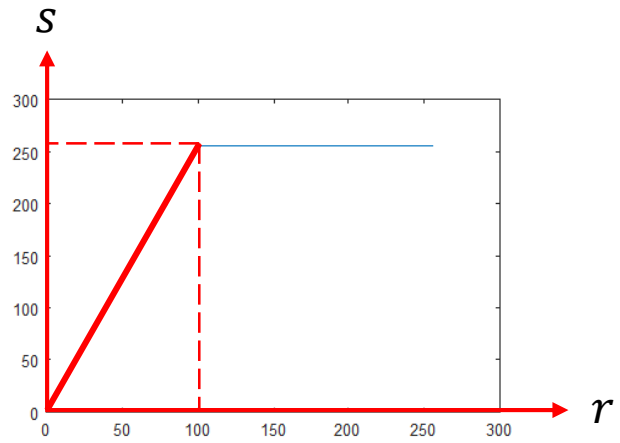
灰度分段线性映射

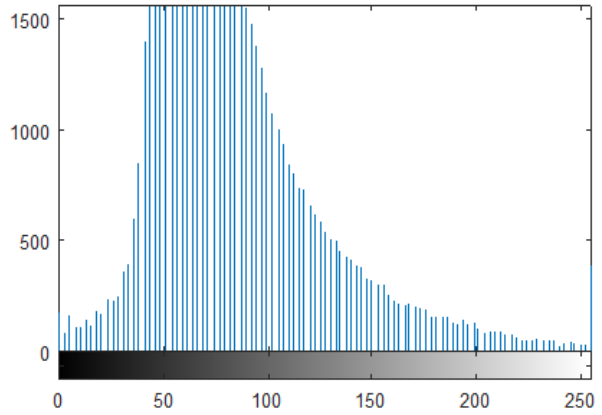
目标图像灰度s

原始图像灰度r

$$s = T(r)$$

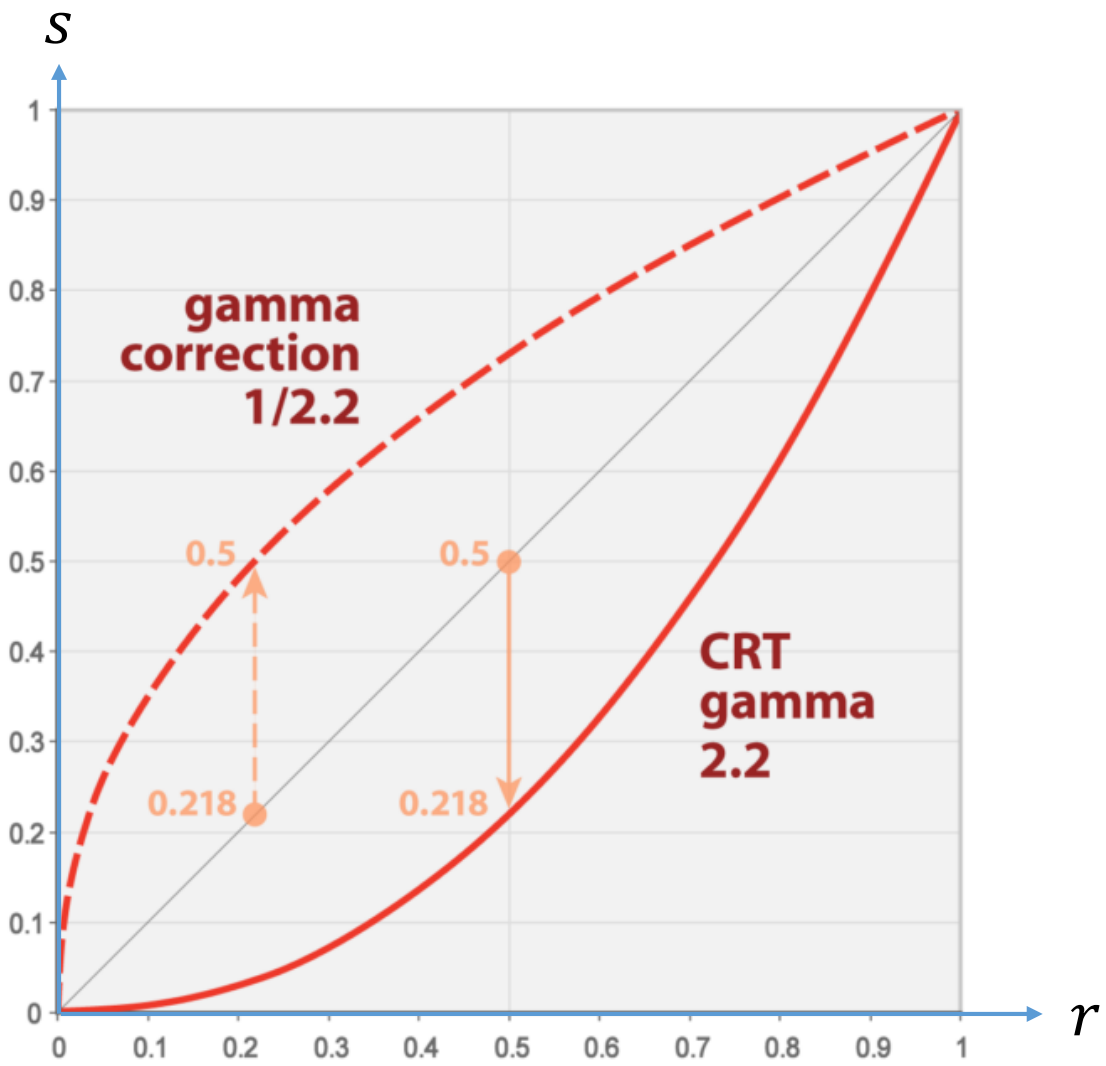


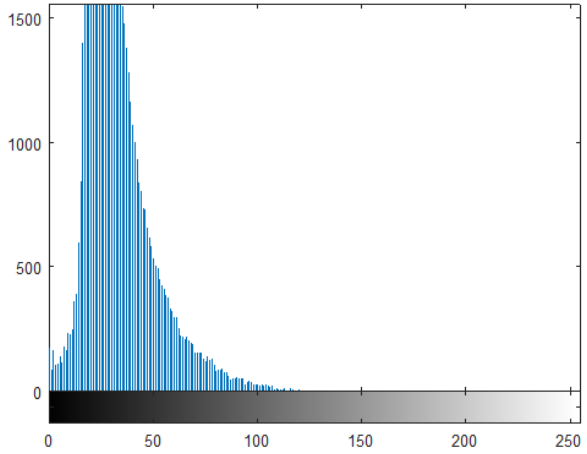




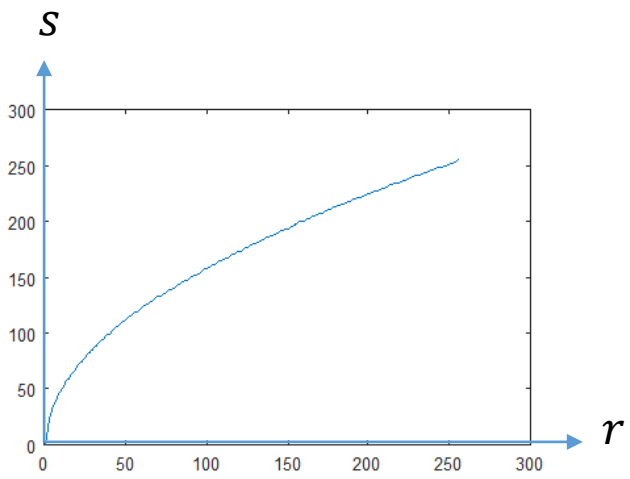
伽玛校正（Gamma Correction）

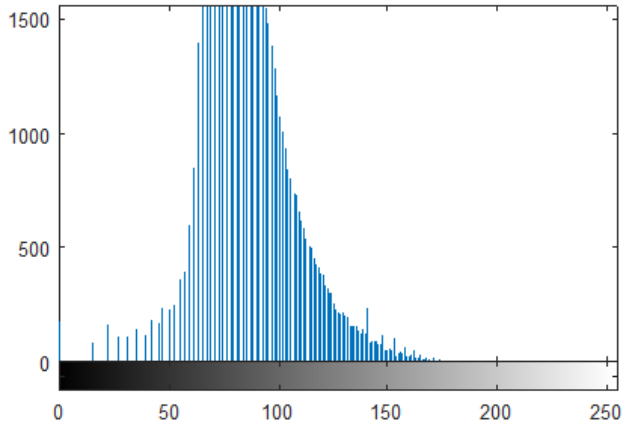
$$s = r^{\gamma}$$

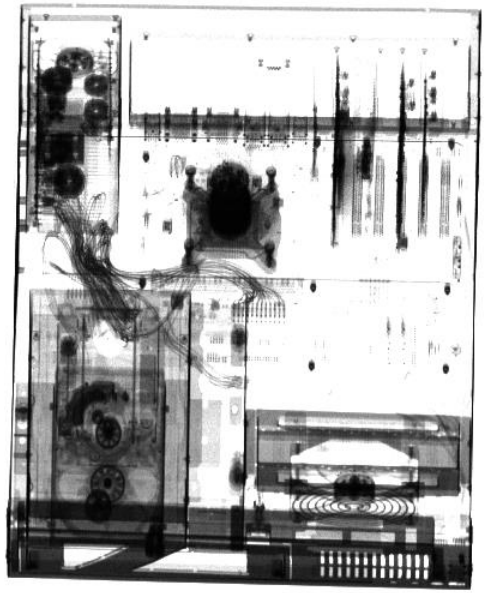


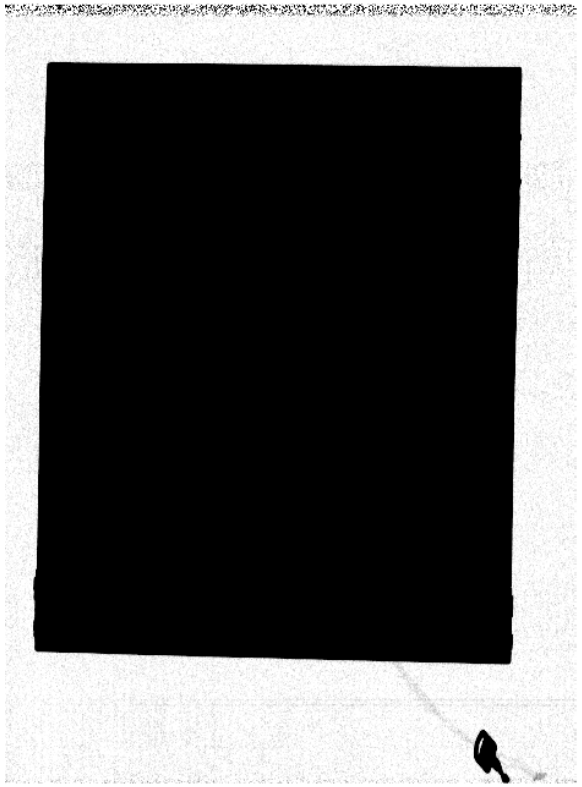

1500
1000
500
0
0
50
100
150
200
250

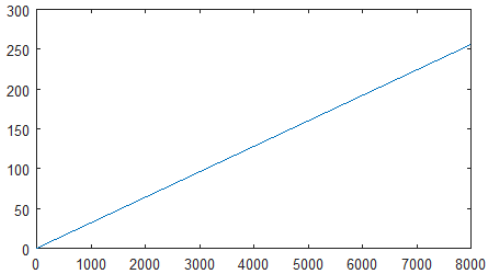
$$s = r^{0.5}$$

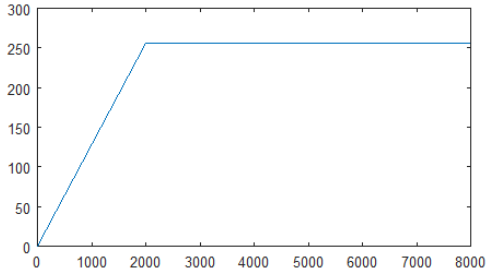

s
300
250
200
150
100
50
0
0
50
100
150
200
250
300
r

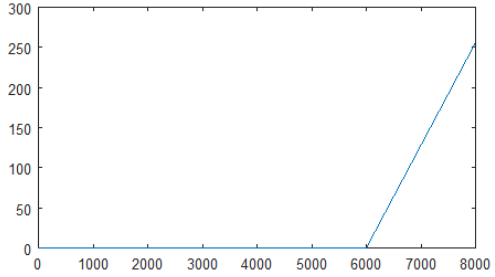

1500
1000
500
0
0
50
100
150
200
250

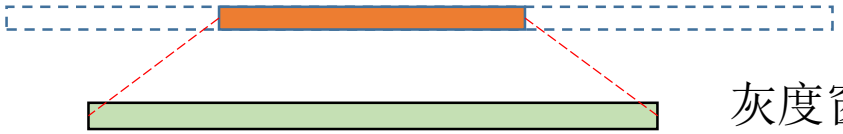












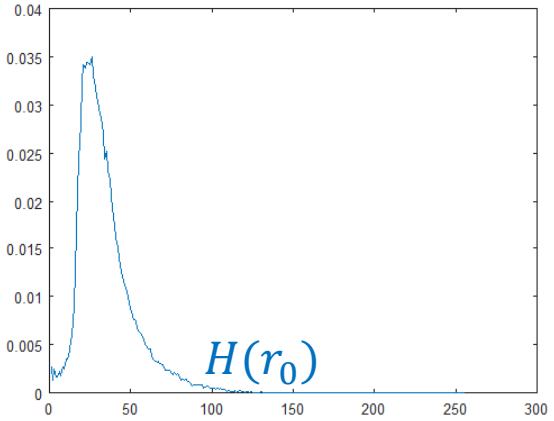
灰度窗调整（窗宽窗位调整）

累积直方图（Cumulative Histogram）

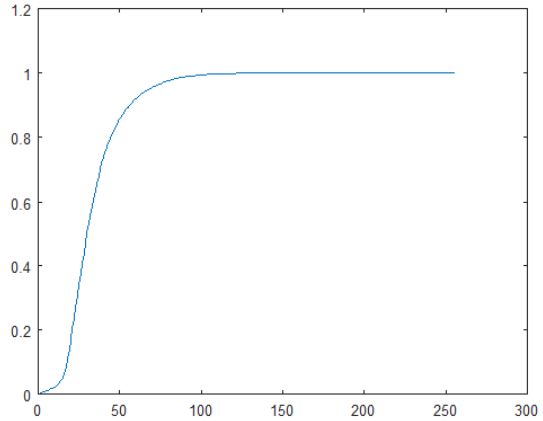
$$H(k) = \sum_{i=1}^{k} h(i)$$

$$H(k) = \begin{cases} h(1) & (k = 1) \\ H(k-1) + h(k) & otherwise \end{cases}$$

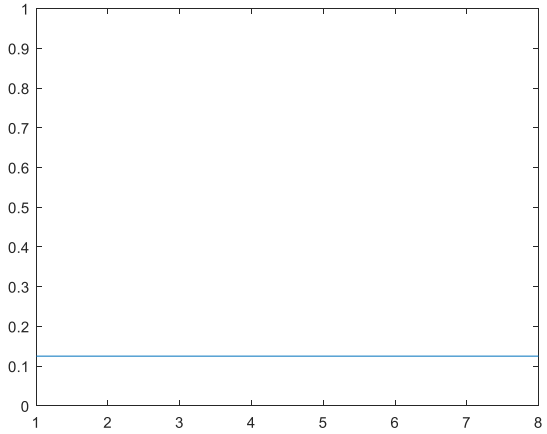
$h(k)$



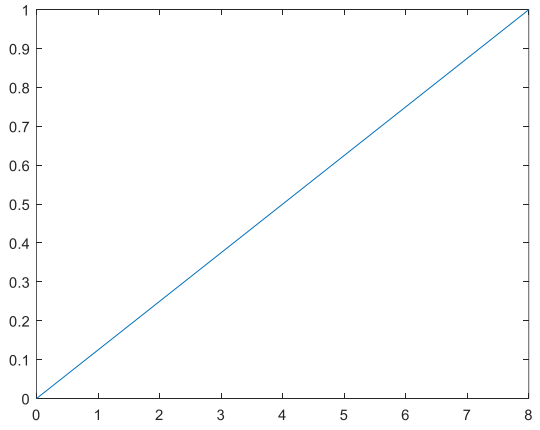
$H(k)$



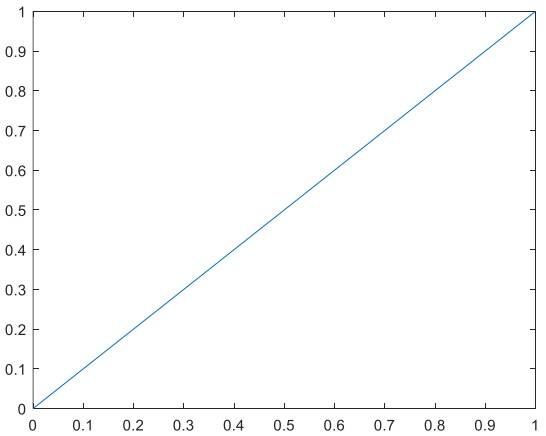
$h(k)$



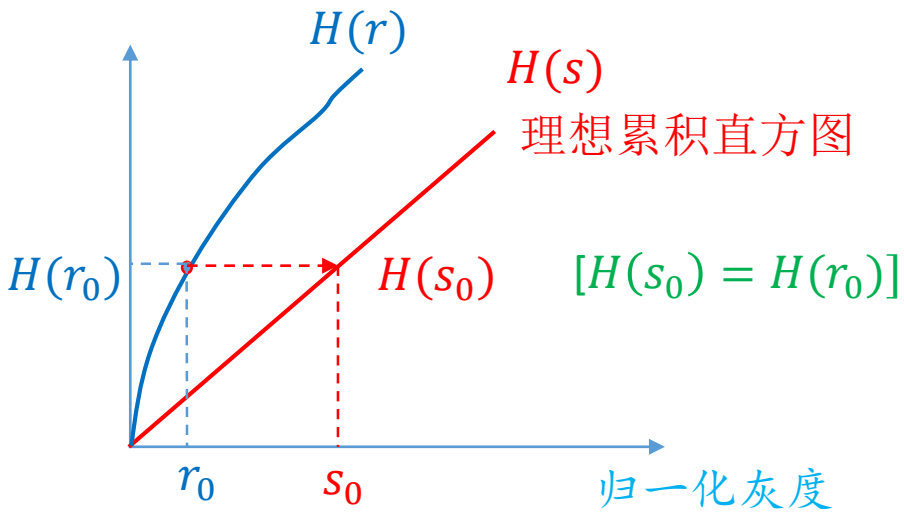
$H(k)$



$H(k)$

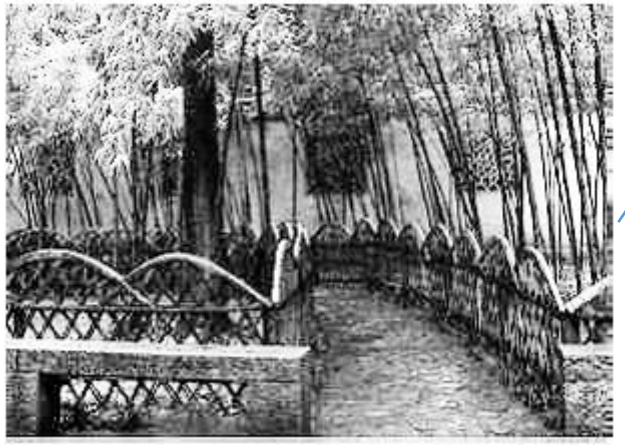


直方图均衡算法原理

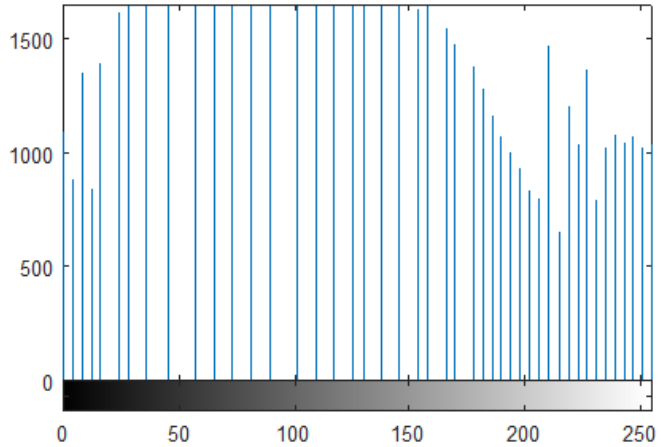


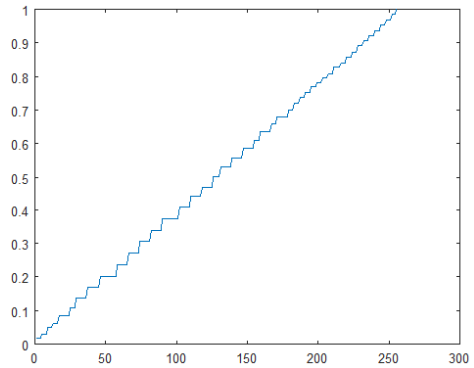
累积直方图（局部）

因为理想累积直方图$H(s) = s \rightarrow s = H(r)$



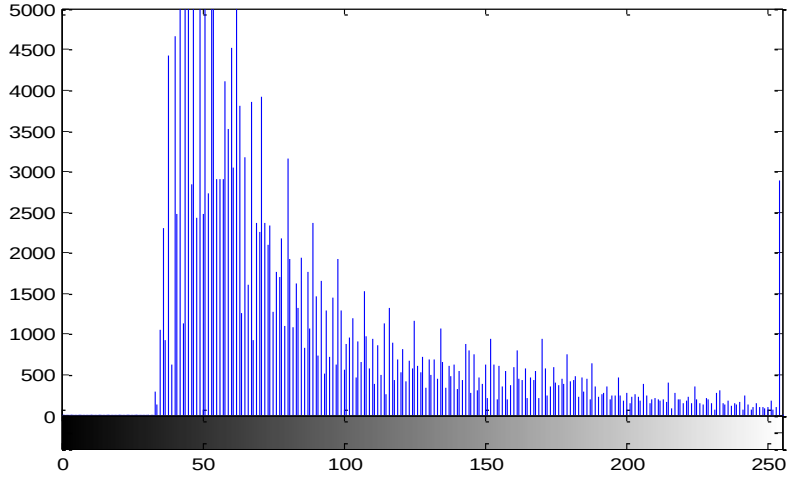
灰度直方图

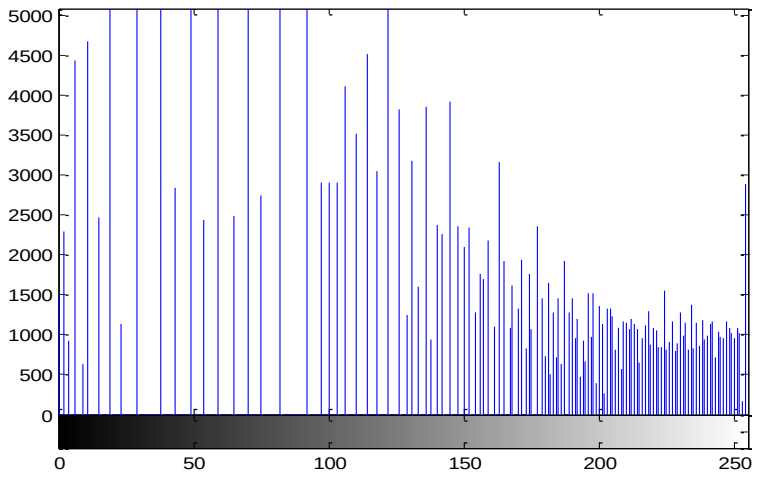




累积灰度直方图

灰度	0	1	2	3	4	5	6	7	[0,7]
k	1	2	3	4	5	6	7	8	[1,8]
h(k)	0.05	0.10	0.35	0.30	0.10	0.05	0.05	0.00	
H(k)	0.05	0.15	0.50	0.80	0.90	0.95	1.00	1.00	
s	0.05	0.15	0.50	0.80	0.90	0.95	1.00	1.00	
S	0.4	1.2	4.0	6.4	7.2	7.6	8.0	8.0	
	0	1	4	6	7	8	8	8	[1,8]
灰度	0	0	3	5	6	7	7	7	[0,7]


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250