Гистограмма изображения

Гистограммой с уровнями яркости в диапазоне $[0, L-1]$ называется дискретная функция $h(r_k) = n_k$, где r_k – *k*-ый уровень яркости, n_k - число пикселов яркости r_k.

Нормализованная гистограмма

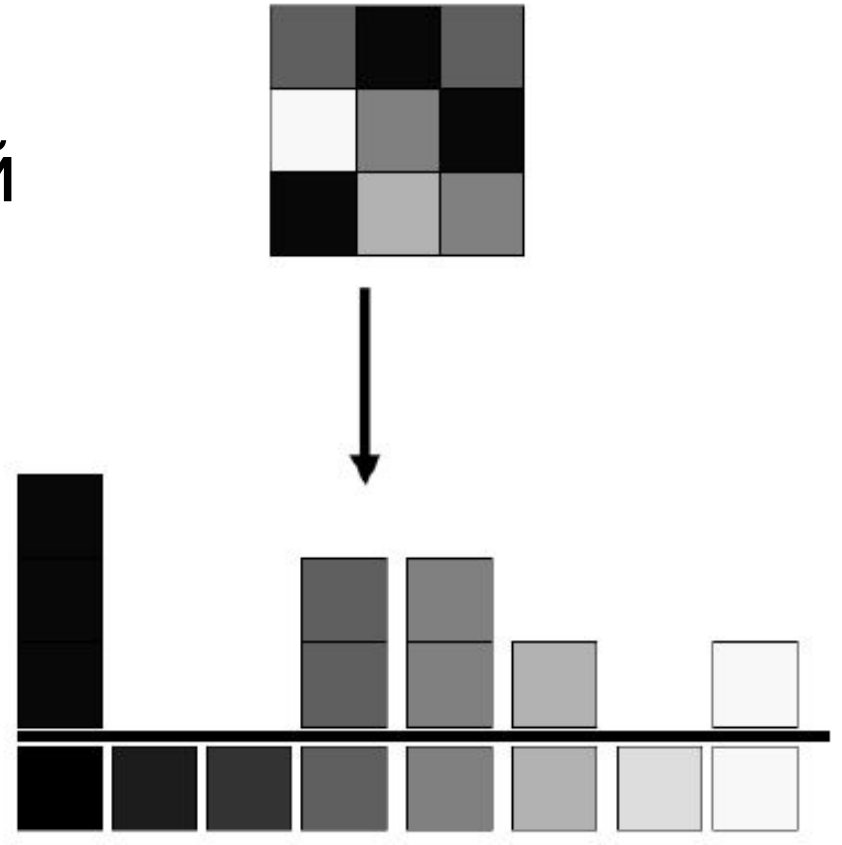
$$p(r_k) = \frac{n_k}{n}, \quad k = 0,1,\square \ ,L-1.$$

$$\sum_{k=0}^{L-1} p(r_k) = 1.$$

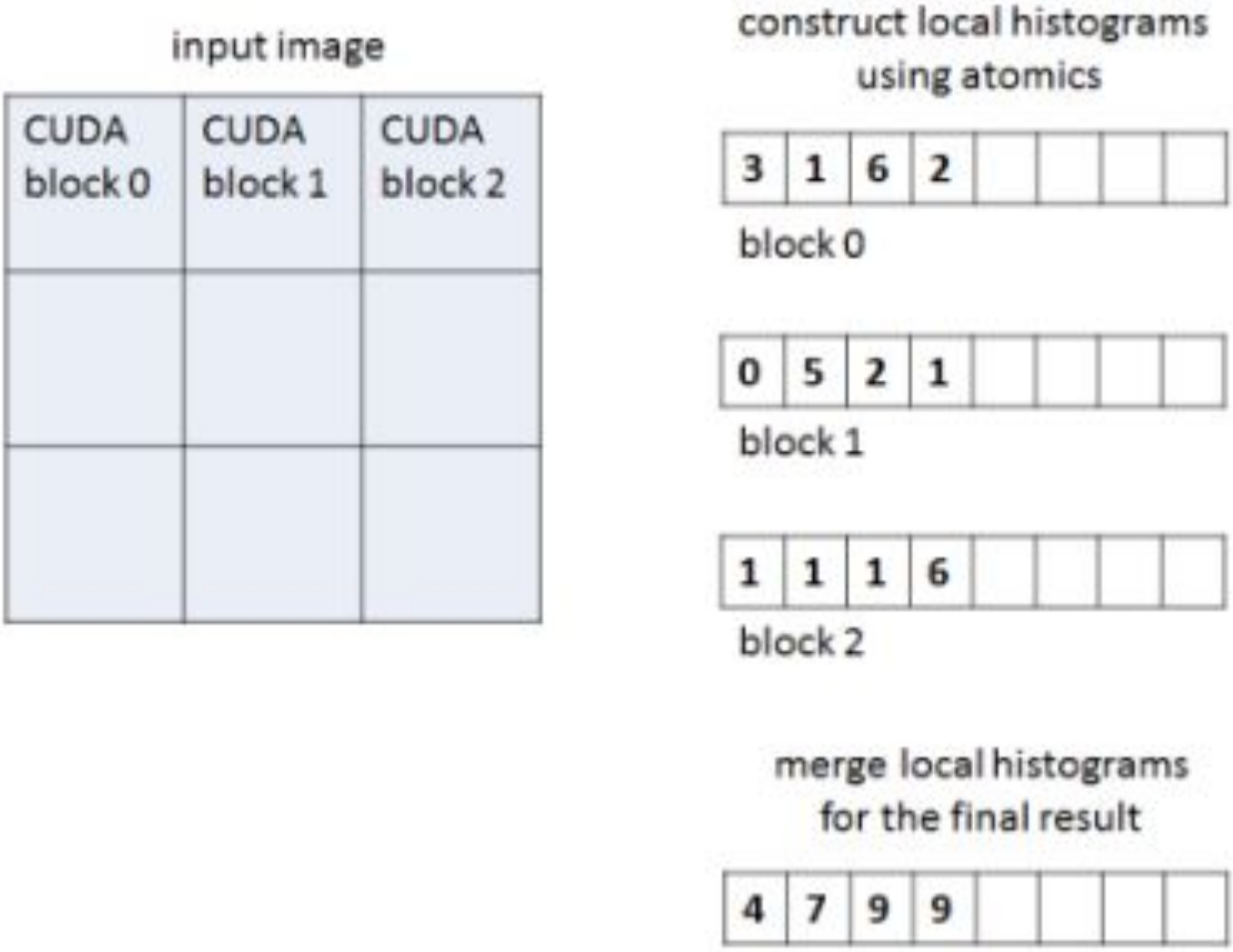
Гистограмма изображения

```
initialize h(i) = 0 for all i
for each pixel (i,j)
  h(pixel(i,j)) ++;
```

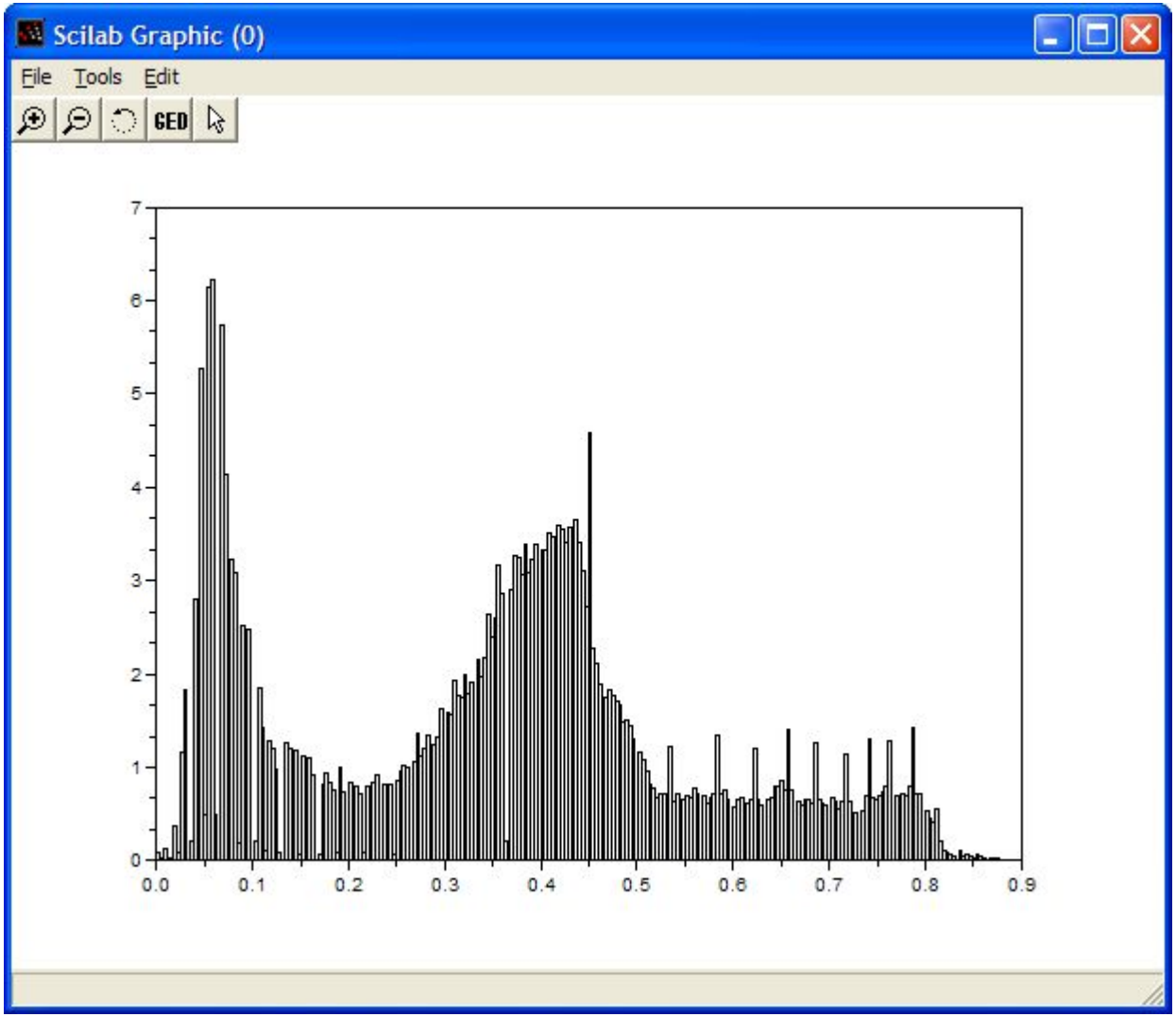
распределение яркостей
заранее неизвестно



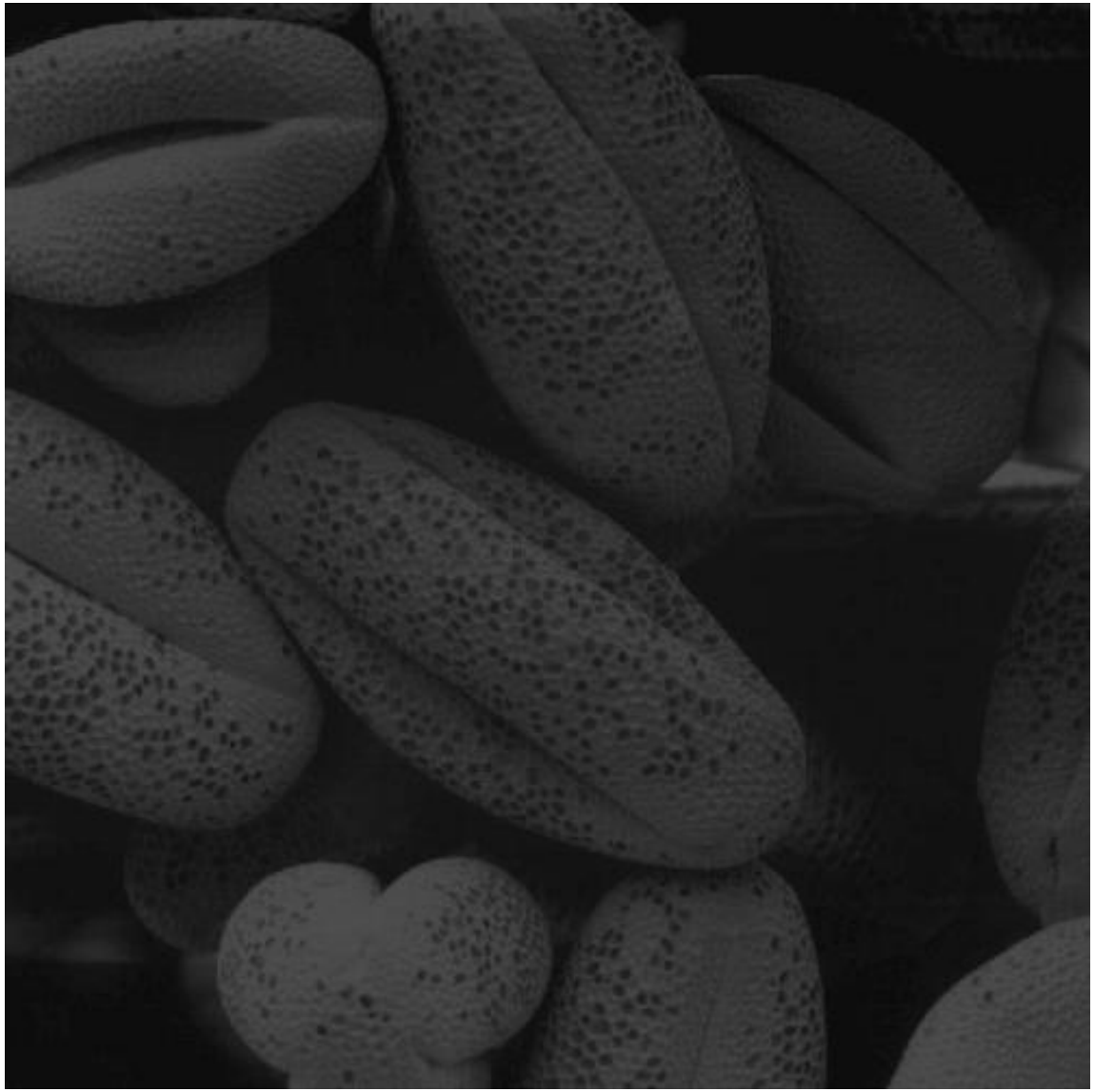
Гистограмма изображения



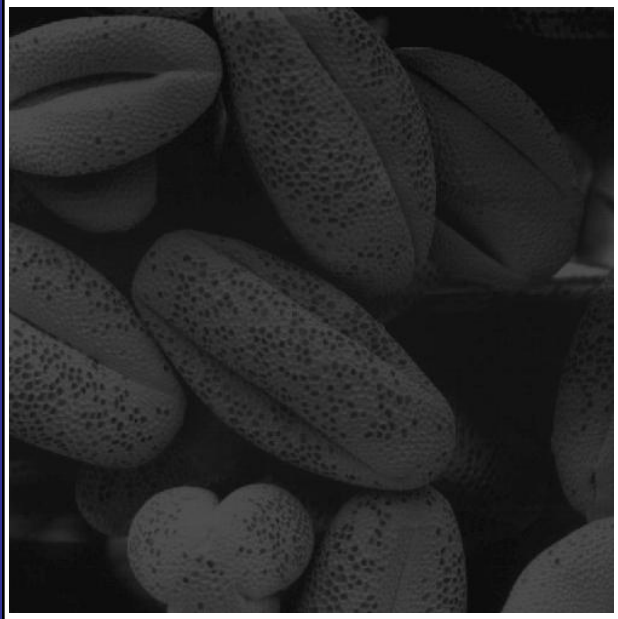
Примеры гистограмм

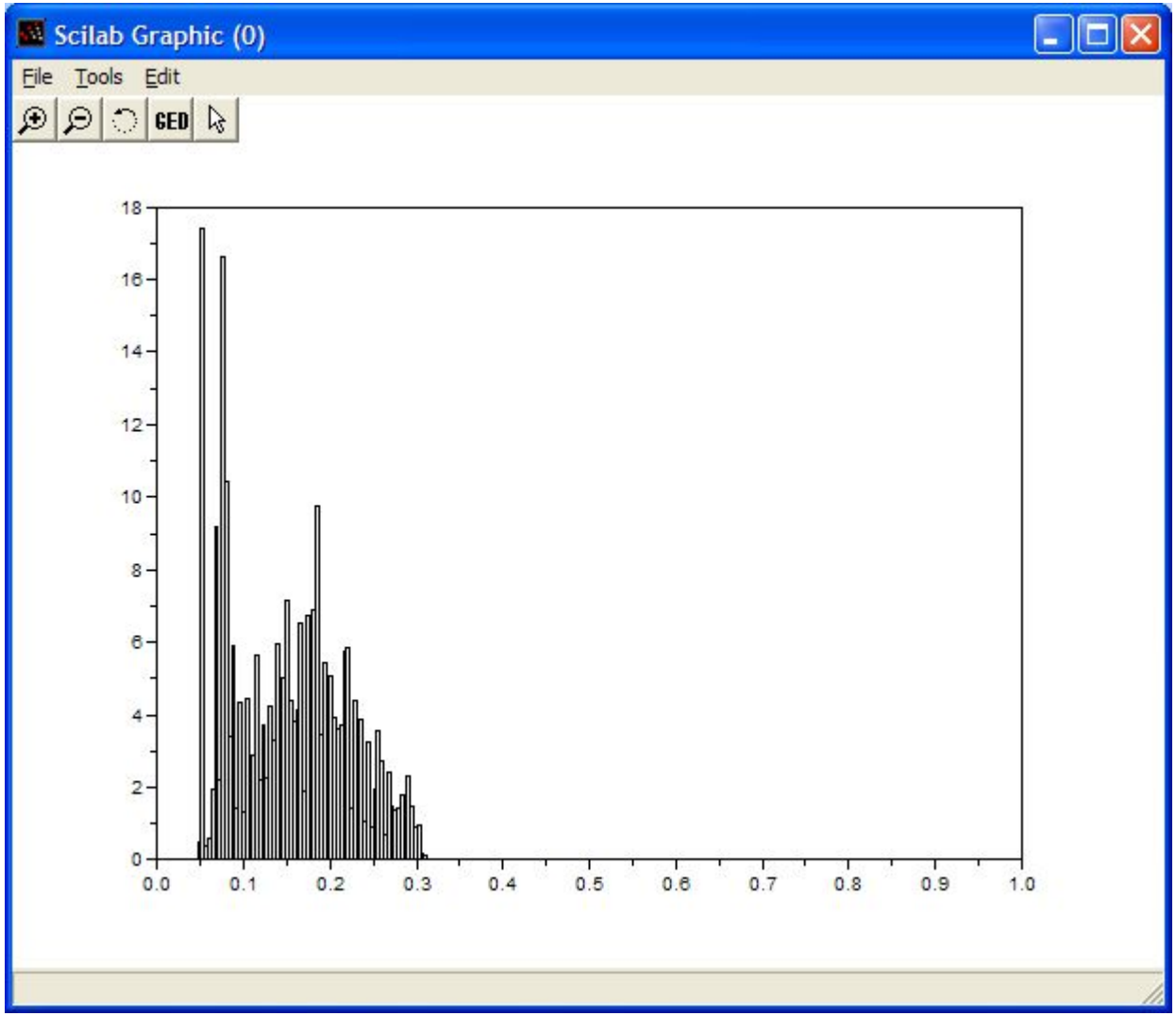


Примеры гистограмм



Примеры гистограмм

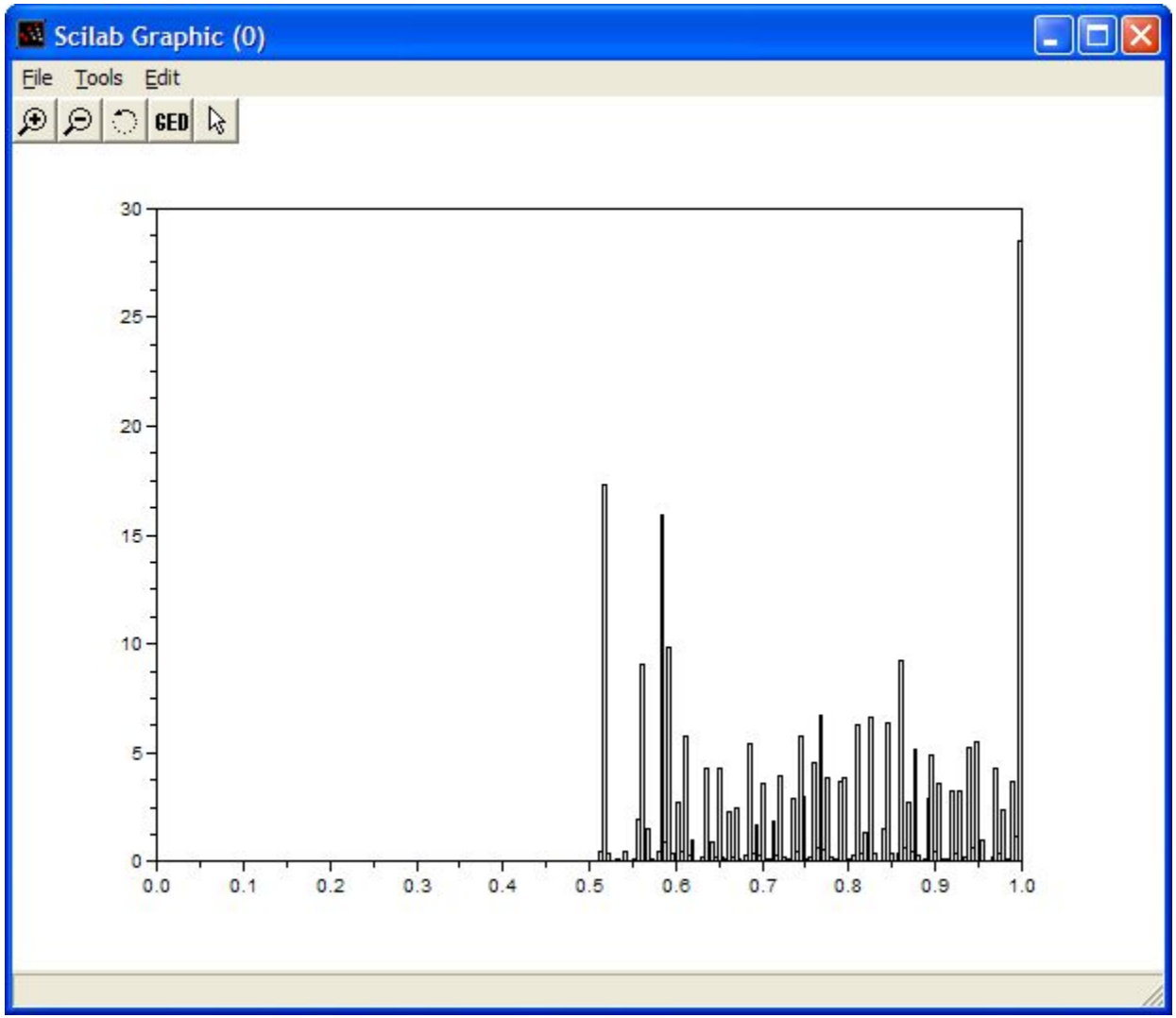




Images taken from Gonzalez & Woods, Digital Image Processing (2002)

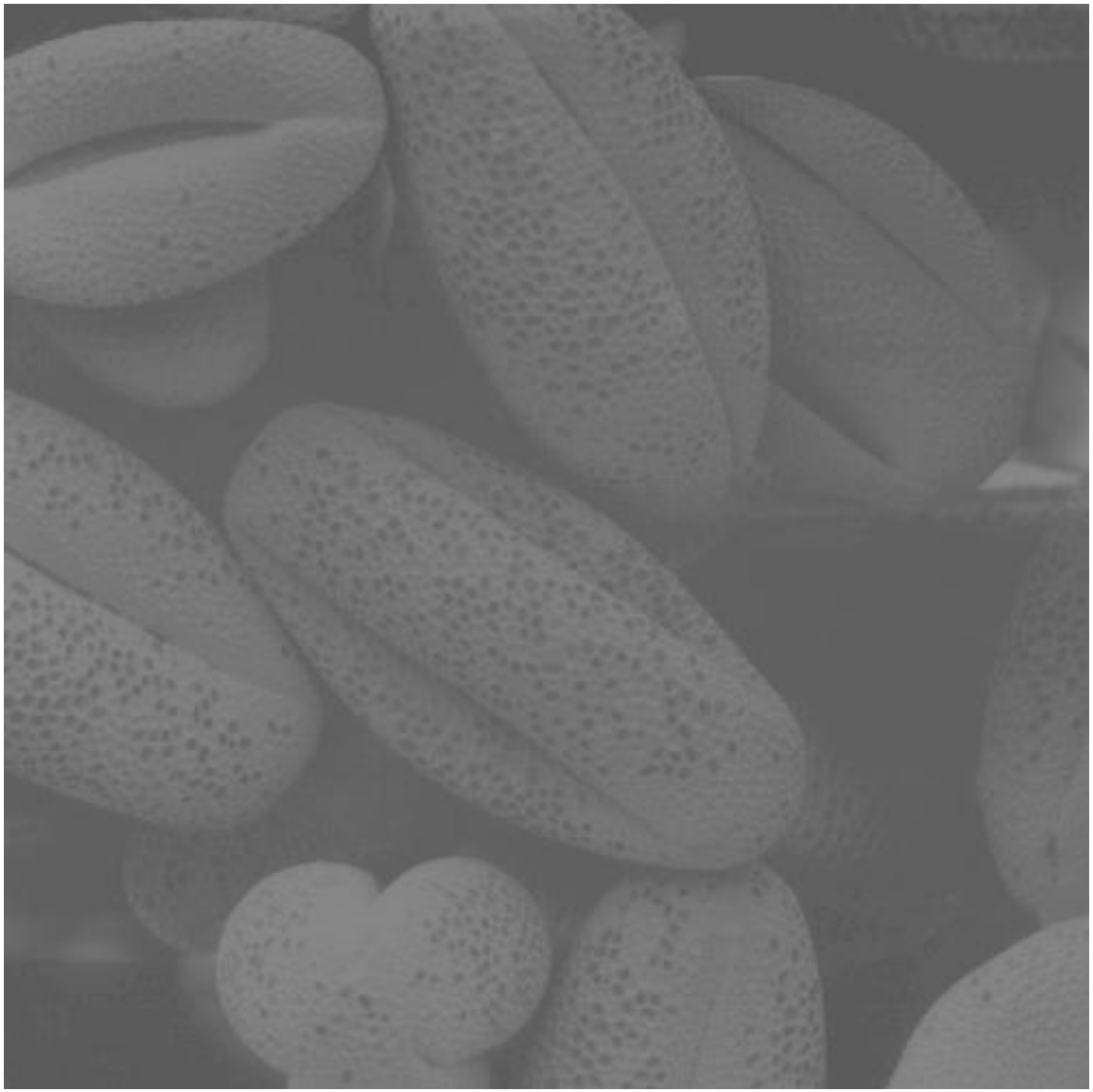
Примеры гистограмм

Примеры гистограмм

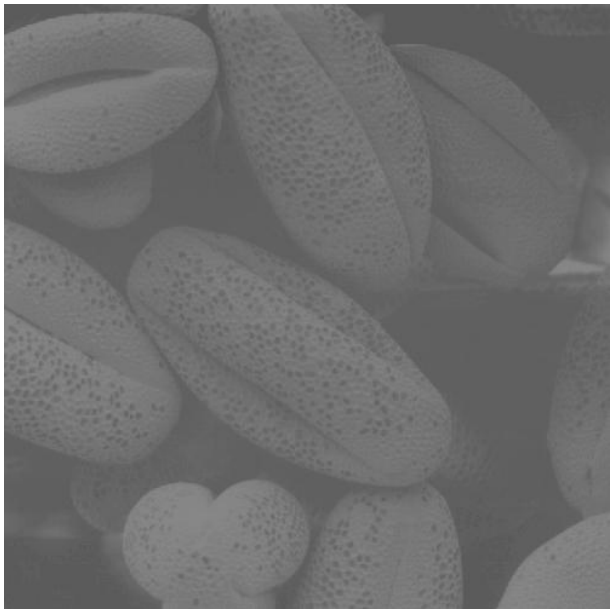


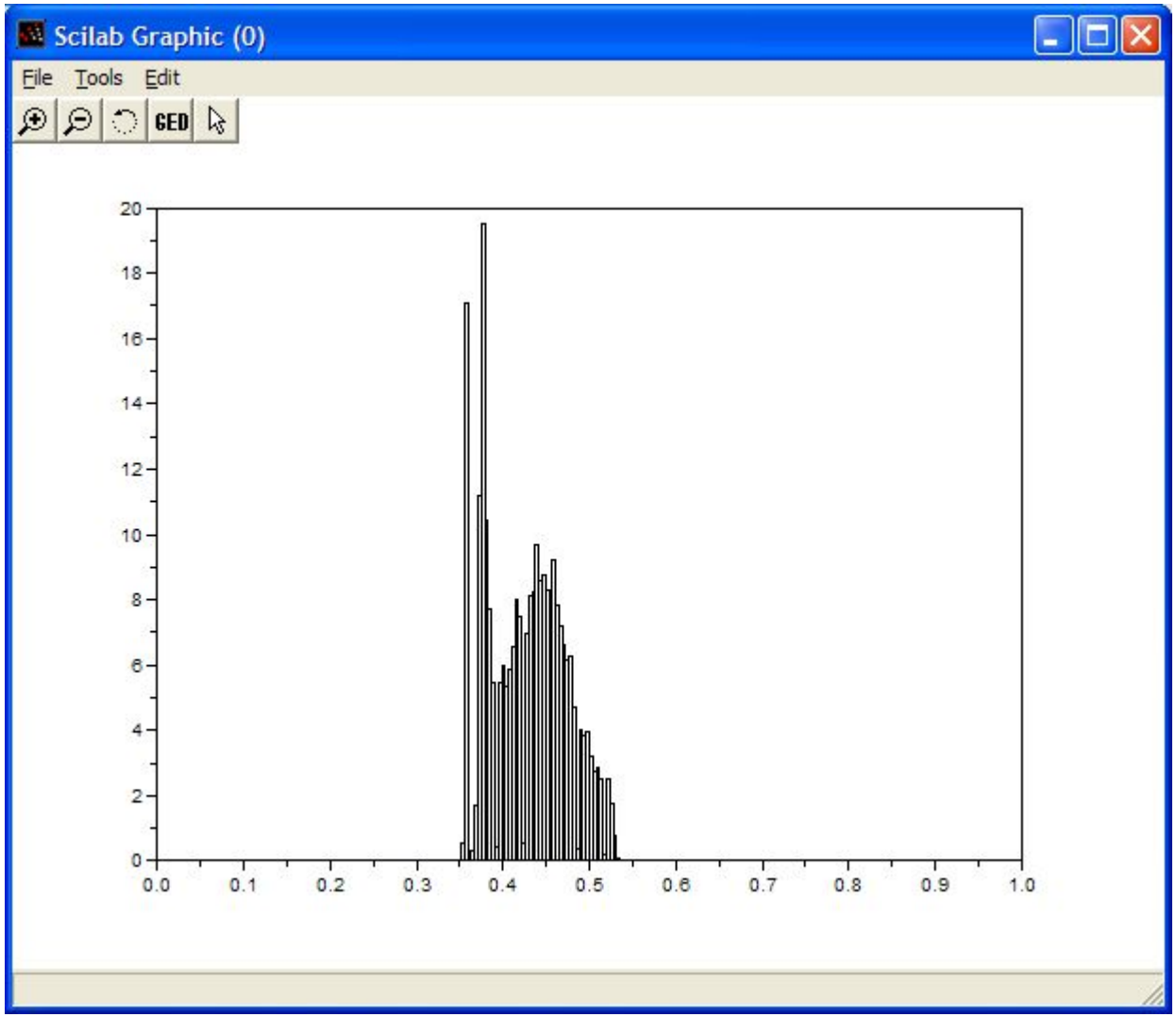
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Примеры гистограмм



Примеры гистограмм

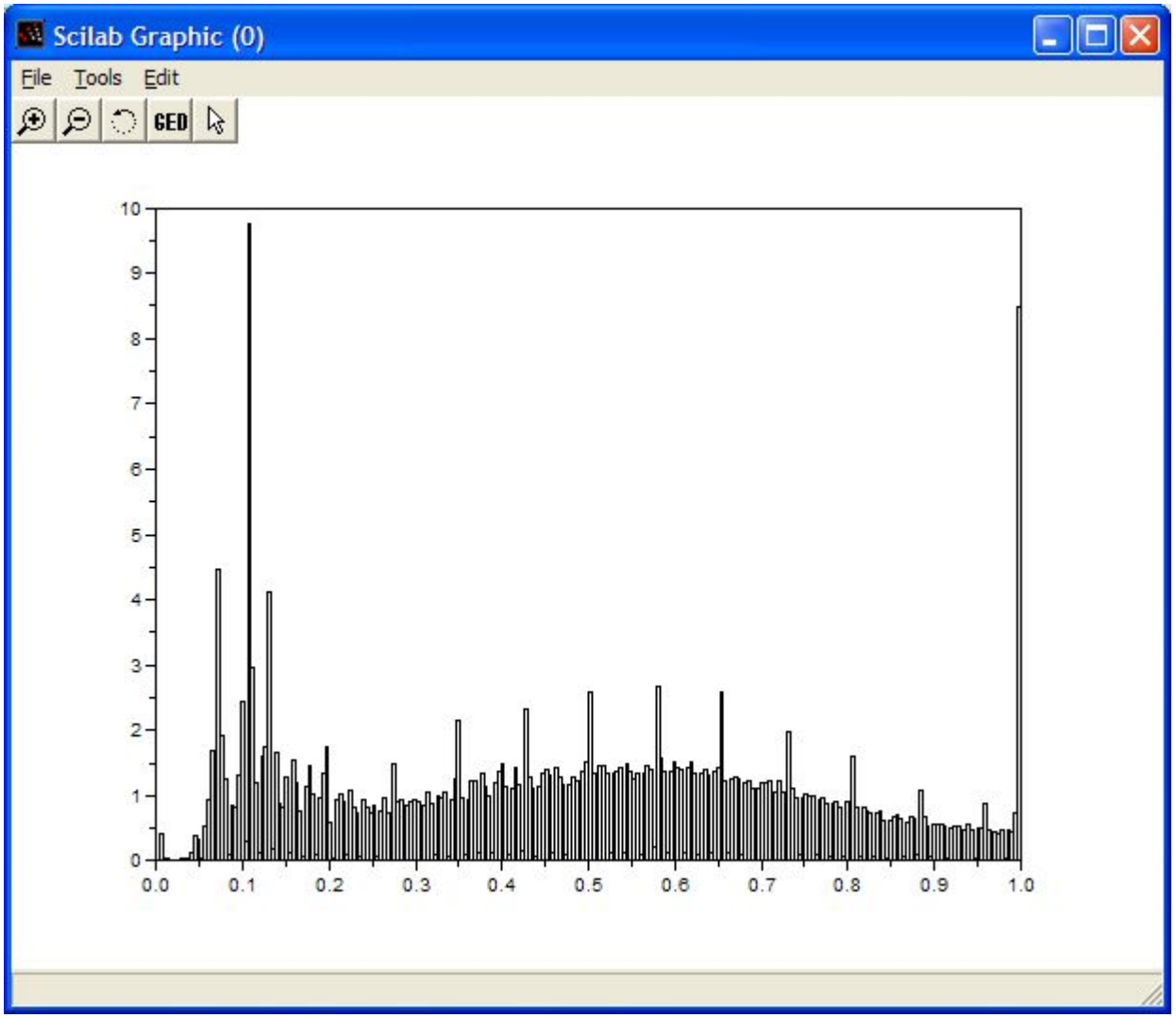




Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Примеры гистограмм

Примеры гистограмм



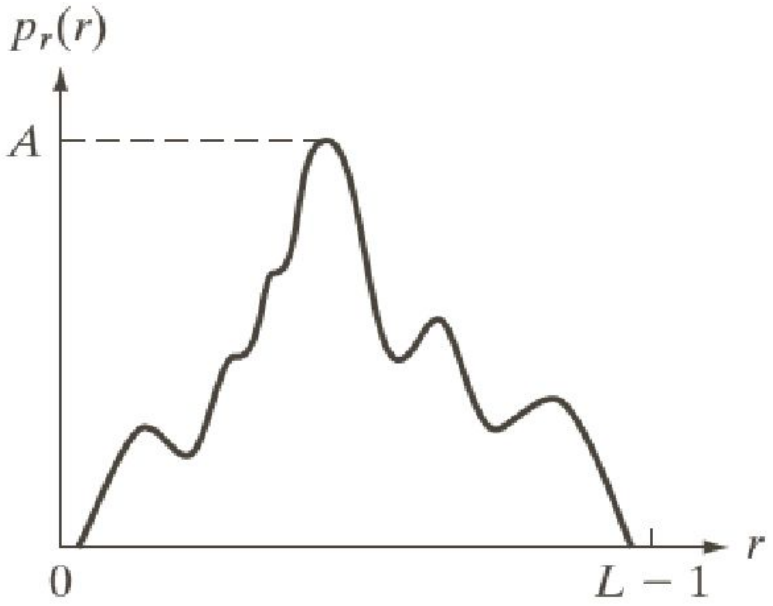
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

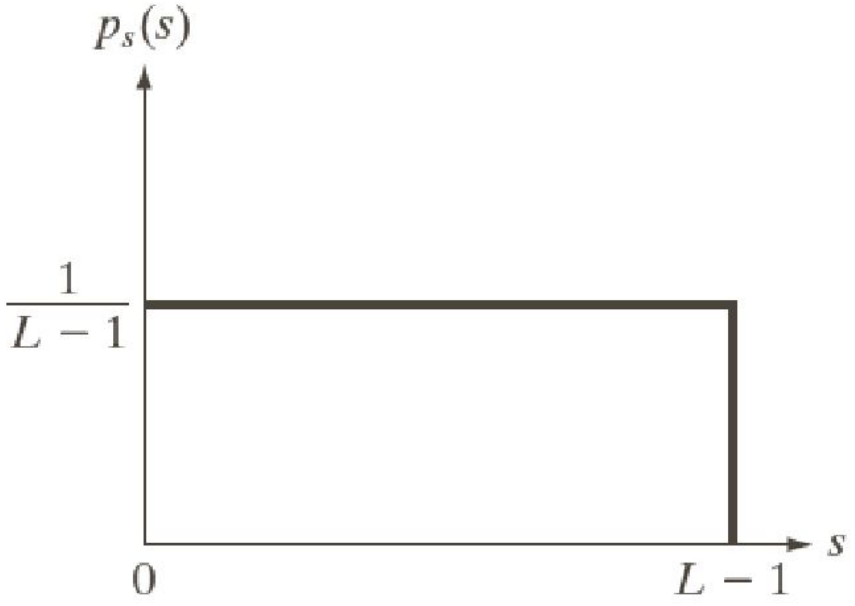
Contrast Stretching

We can fix images that have poor contrast by applying a pretty simple contrast specification

The interesting part is how do we decide on this transformation function?

Эквализация гистограммы





Эквализация гистограммы

$$p(r_k) = \frac{n_k}{n}, \quad k = 0,1,\square \ ,L-1.$$

Эквилизация (лиреанизация, растяжение) гистограммы

- r_k: исходная яркость
- s_k: получаемая яркость
- k: диапазон яркостей
- n_j: число точек яркости j
- n: общее число пикселей

$$\begin{aligned} s_k &= T(r_k) \\ &= \sum_{j=0}^{k} p(r_j) \\ &= \sum_{j=0}^{k} \frac{n_j}{n} \end{aligned}$$

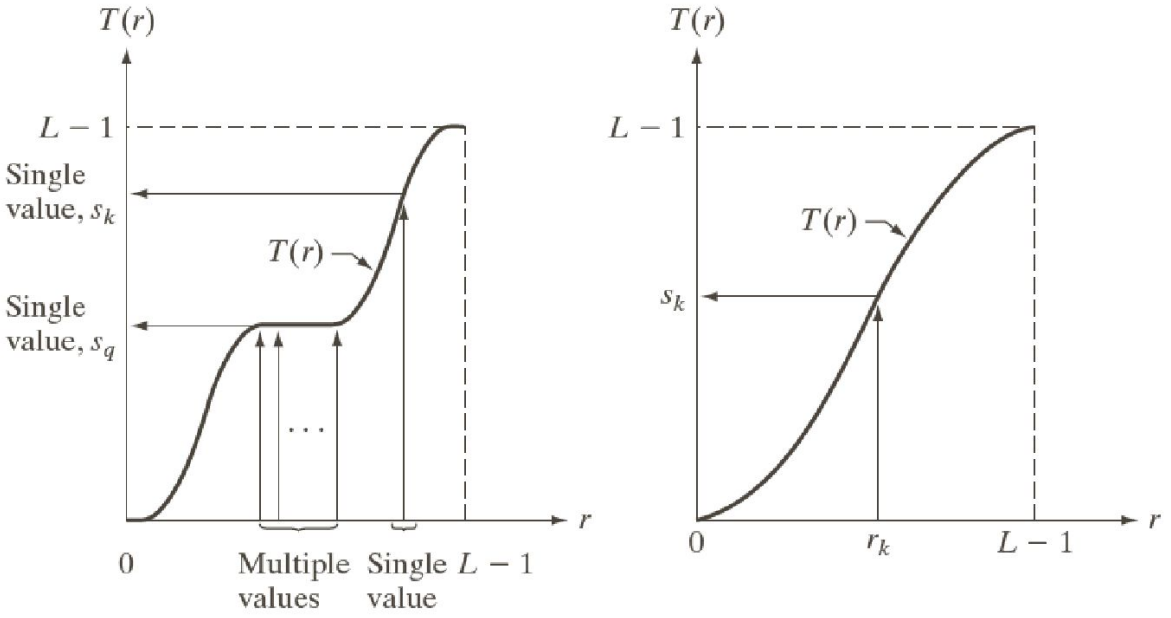
$$r_k = T^{-1}(s_k), \quad k = 0,1,\square \ ,L-1.$$

Функция эквализации

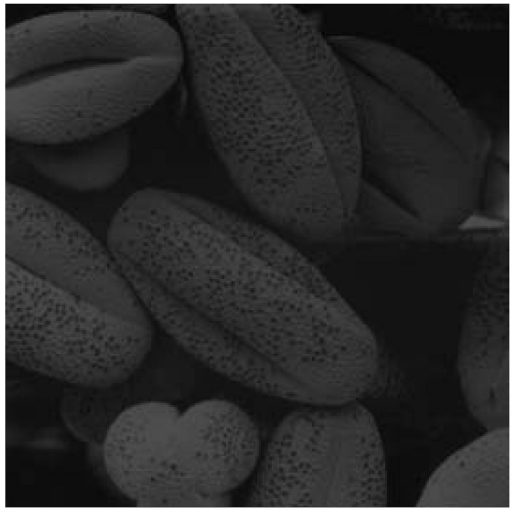
(а) $T(r_k)$ – монотонно возрастающая функция на отрезке $[0, L-1]$

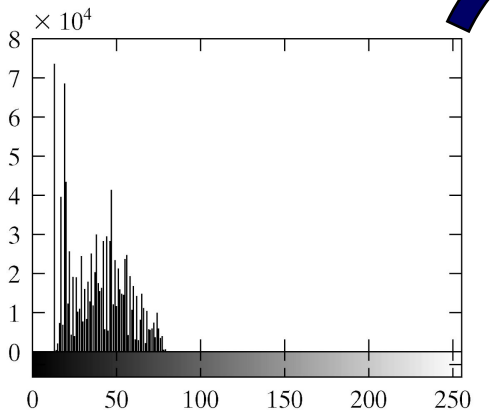
(а') $T(r_k)$ – строго монотонно возрастающая функция

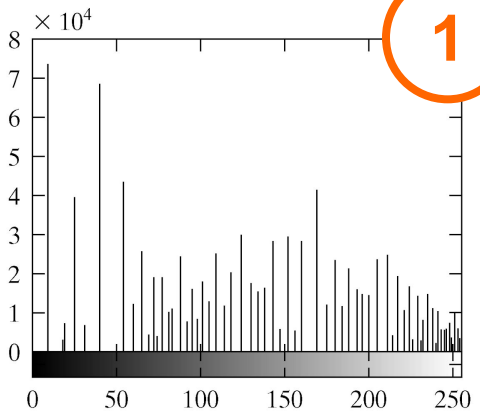
(б) $0 \le T(r_k) \le L-1$ на отрезке $[0, L-1]$



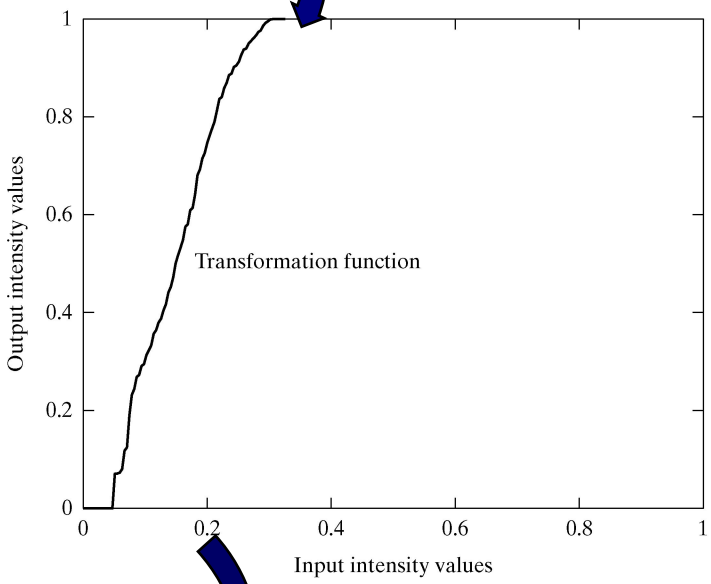
Пример эквализации





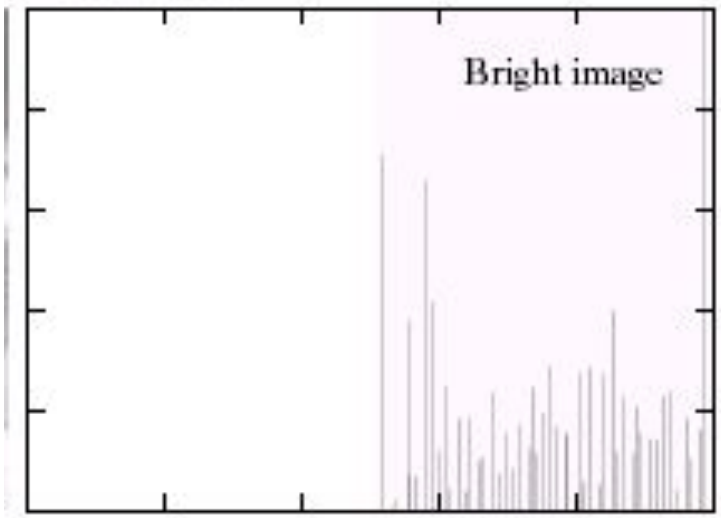


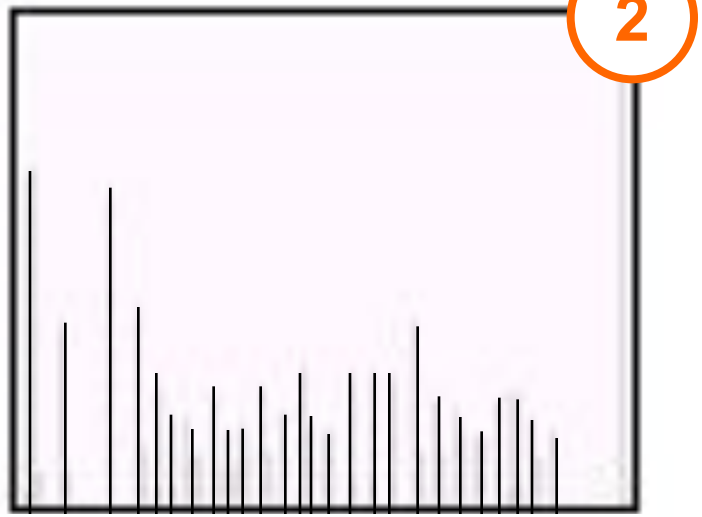
1



Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Пример эквализации

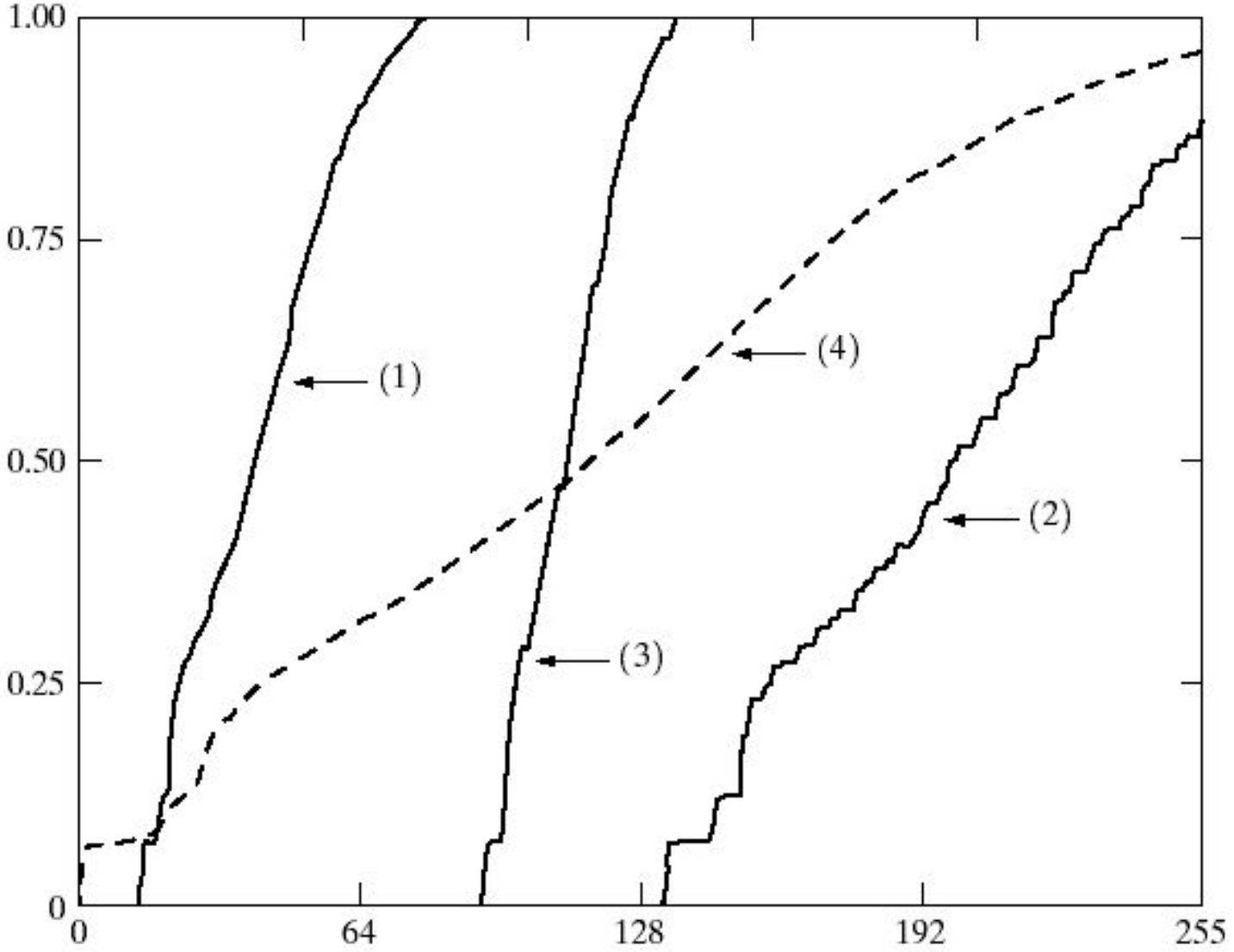




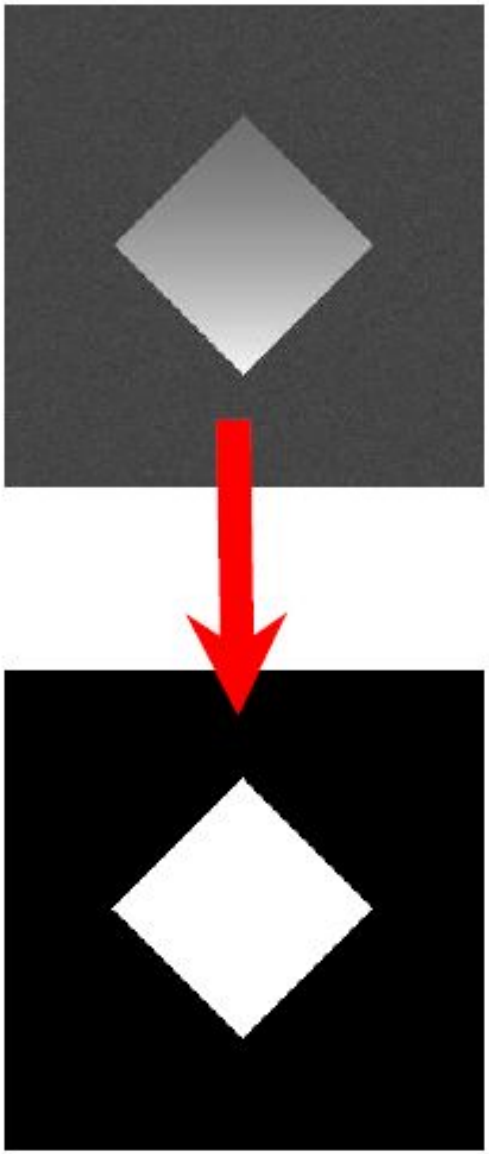
Пример эквализации

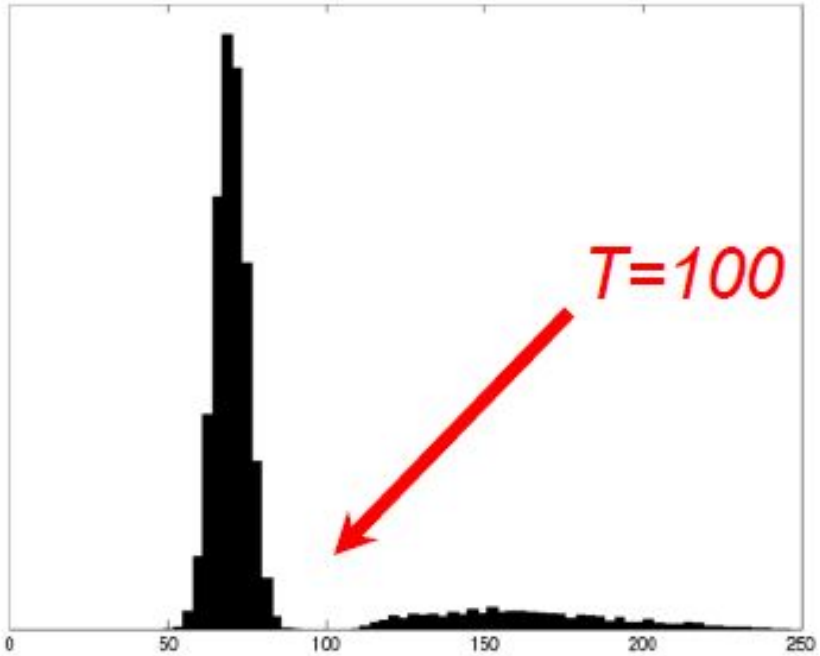
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Функции эквализации



Выбор порога

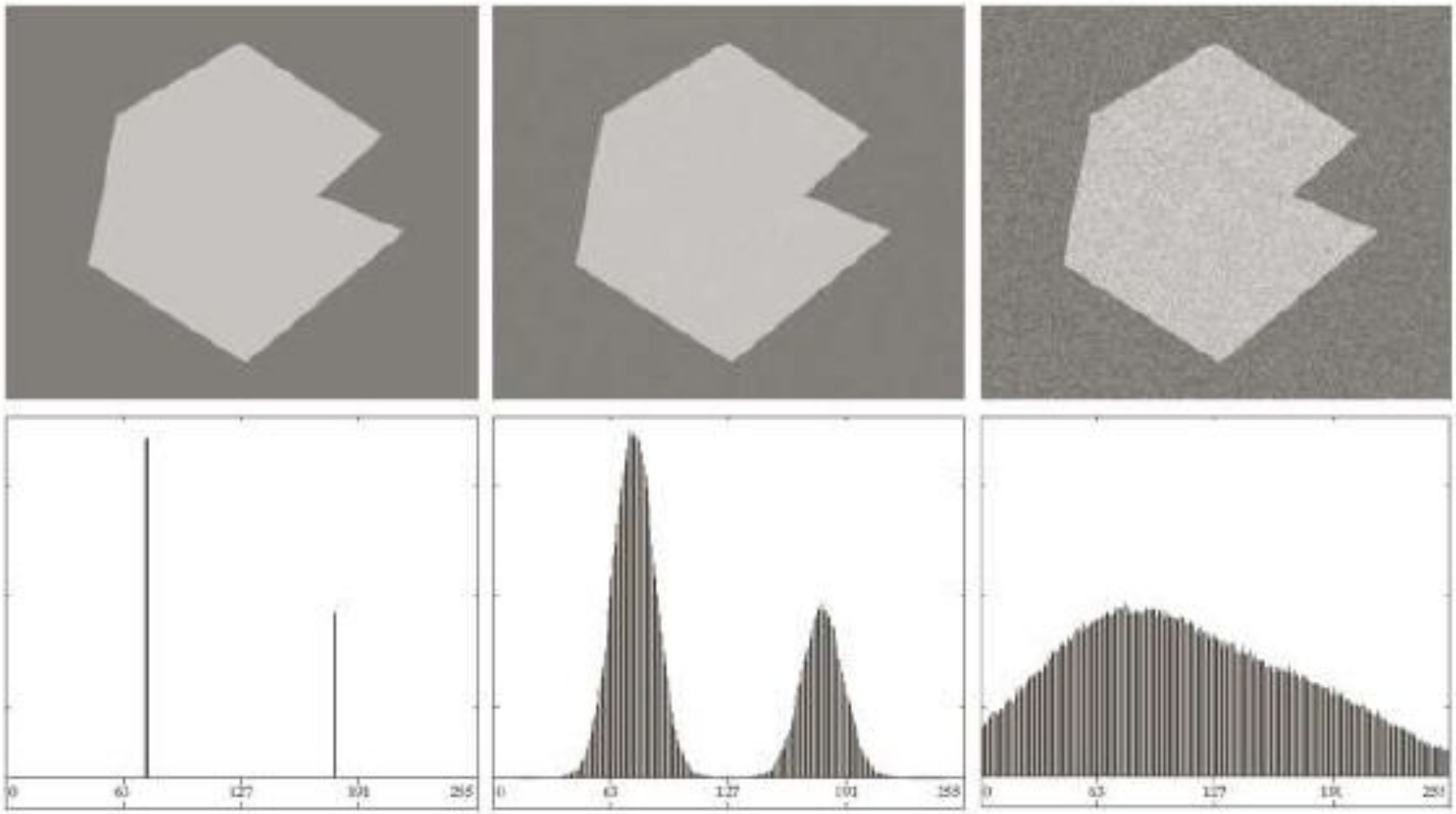




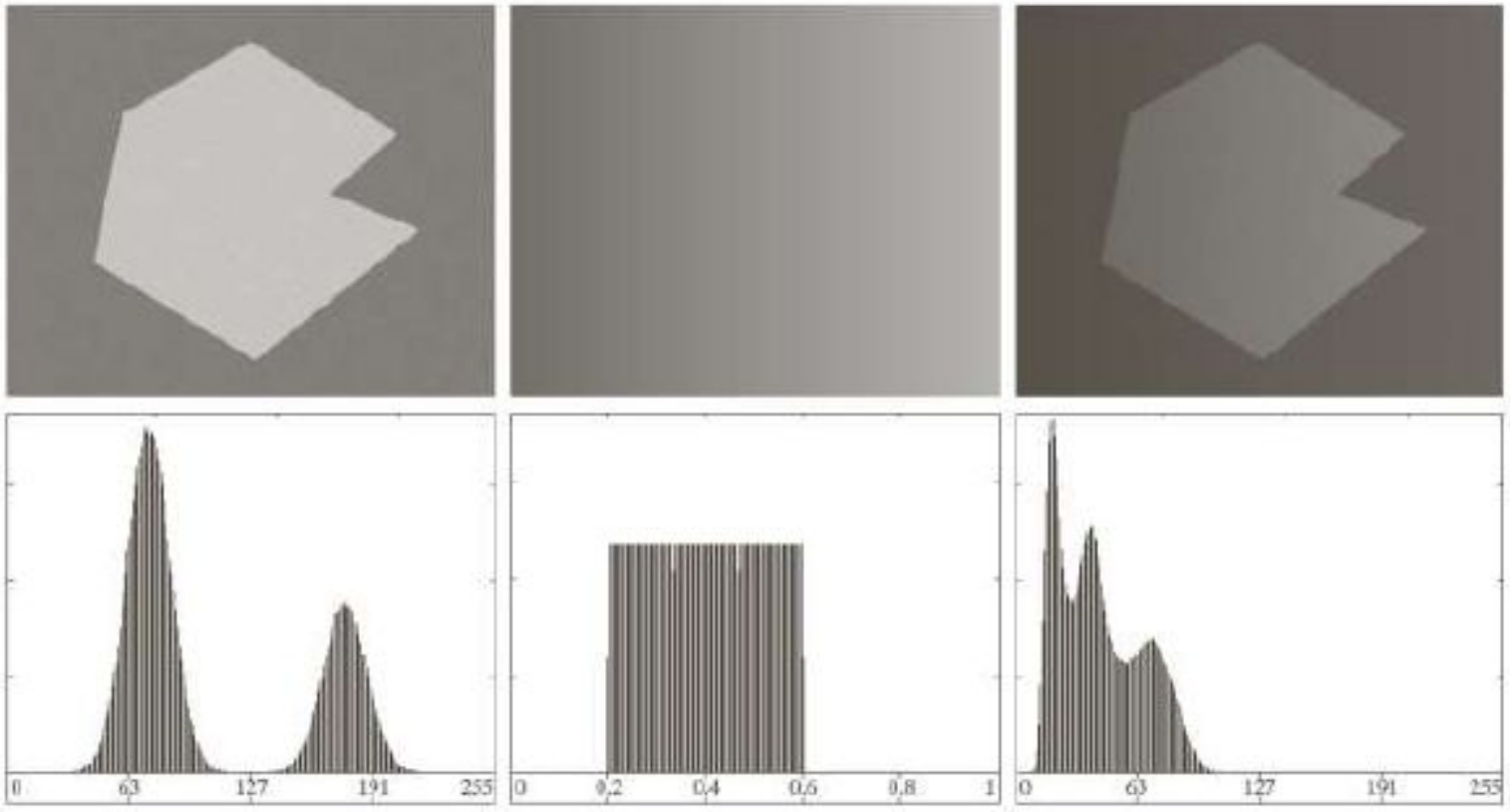
Histogram

$$g(x,y) = \begin{cases} 1 & if \quad f(x,y) > T \\ 0 & if \quad f(x,y) \leq T \end{cases}$$

Отображение шума на гистограмме



Отображение освещения на гистограмме



f x g = h

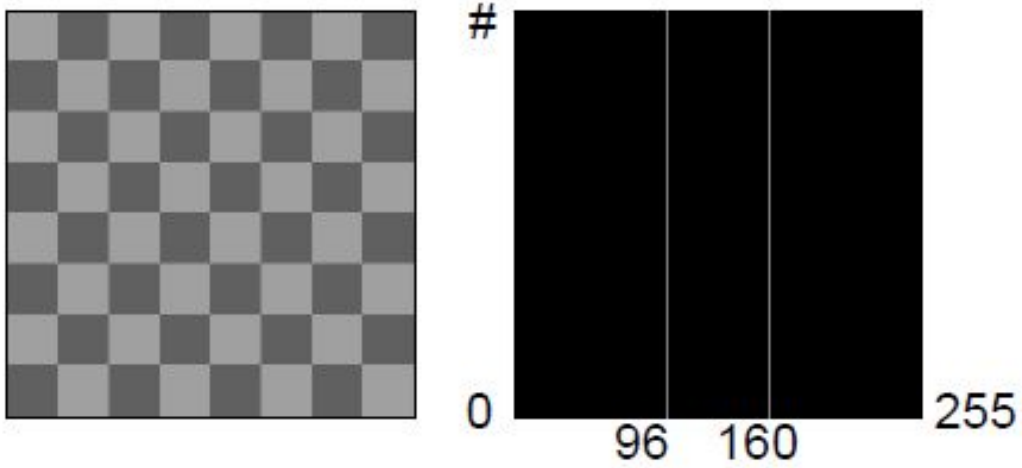
Original image

Illumination image

Final image

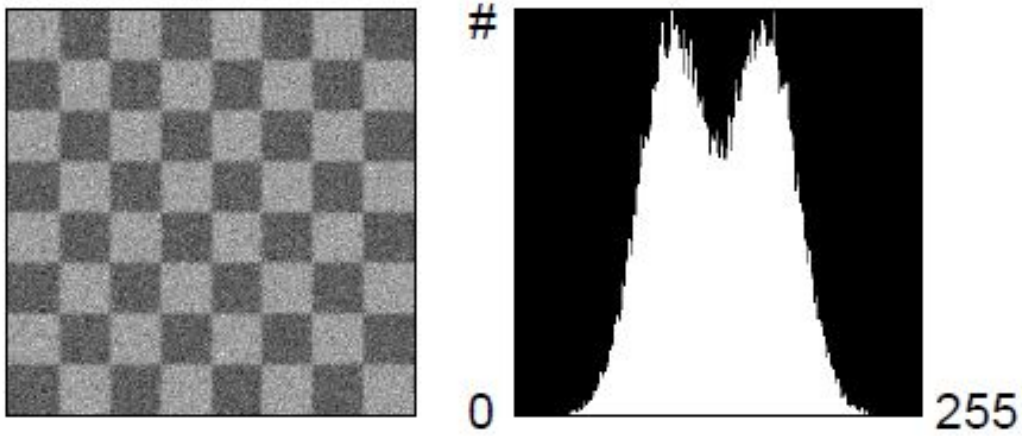
Histogram of Pixel Intensity Distribution

Histogram: Distribution of intensity values $p(v)$
(count #pixels for each intensity level)



Checkerboard with values 96 and 160.

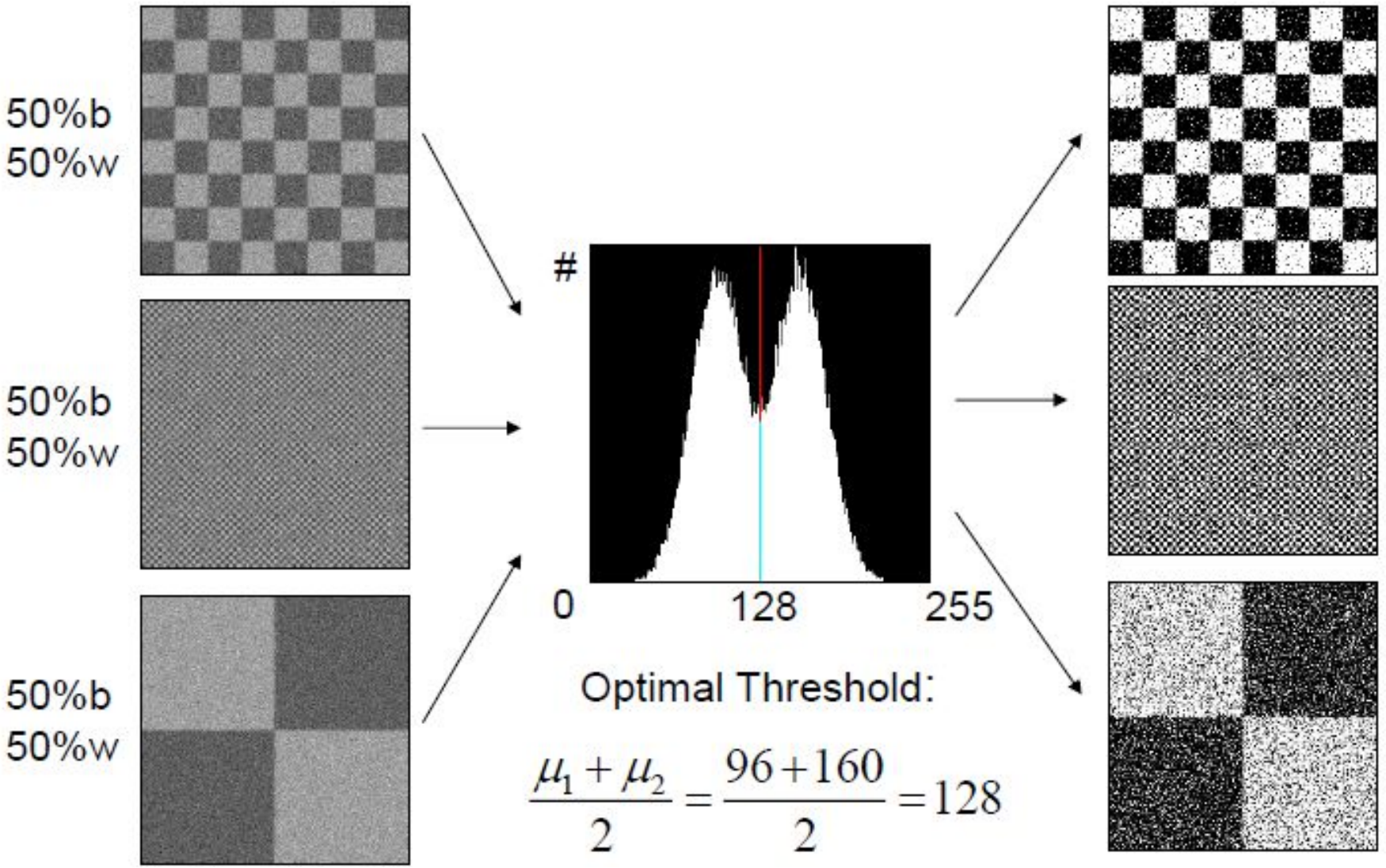
Histogram:
- horizontal: intensity
- vertical: # pixels



Checkerboard with additive Gaussian noise (sigma 20).

Regions: 50%b,50%w

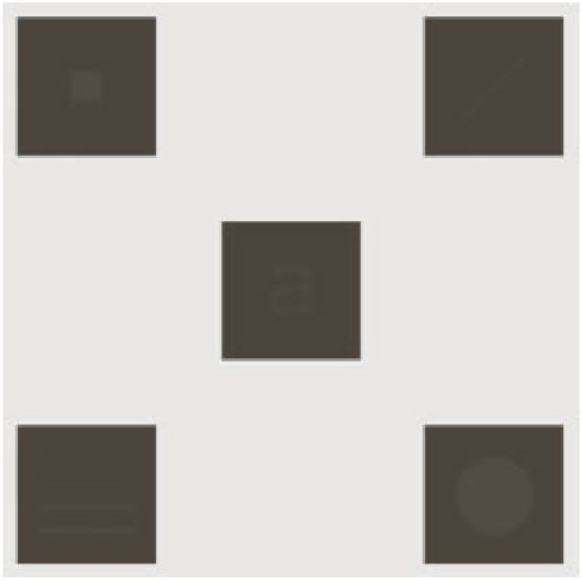
Classification by Thresholding

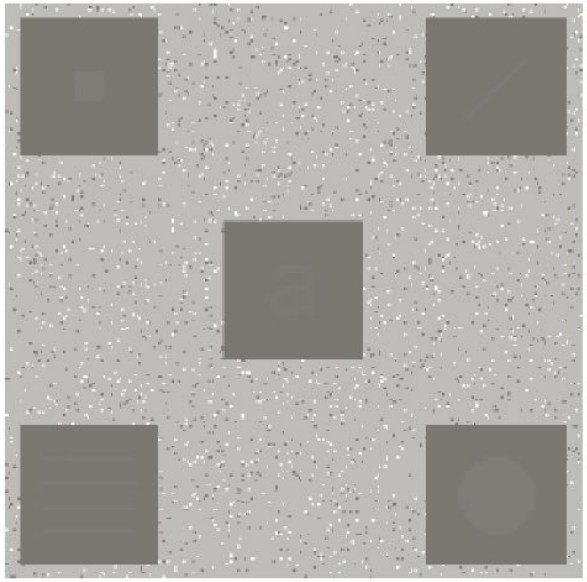


Optimal Threshold:

$$\frac{\mu_1 + \mu_2}{2} = \frac{96 + 160}{2} = 128$$

Локальная гистограммная обработка





Гистограммные статистики

$$\mu_n(r) = \sum_{i=0}^{L-1} (r_i - m)^n p(r_i)$$

$$m = \sum_{i=0}^{L-1} r_i p(r_i) \qquad \mu_2(r) = \sum_{i=0}^{L-1} (r_i - m)^2 p(r_i)$$

$$m = \frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y)$$

$$\sigma^2 = \frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} [f(x, y) - m]^2$$

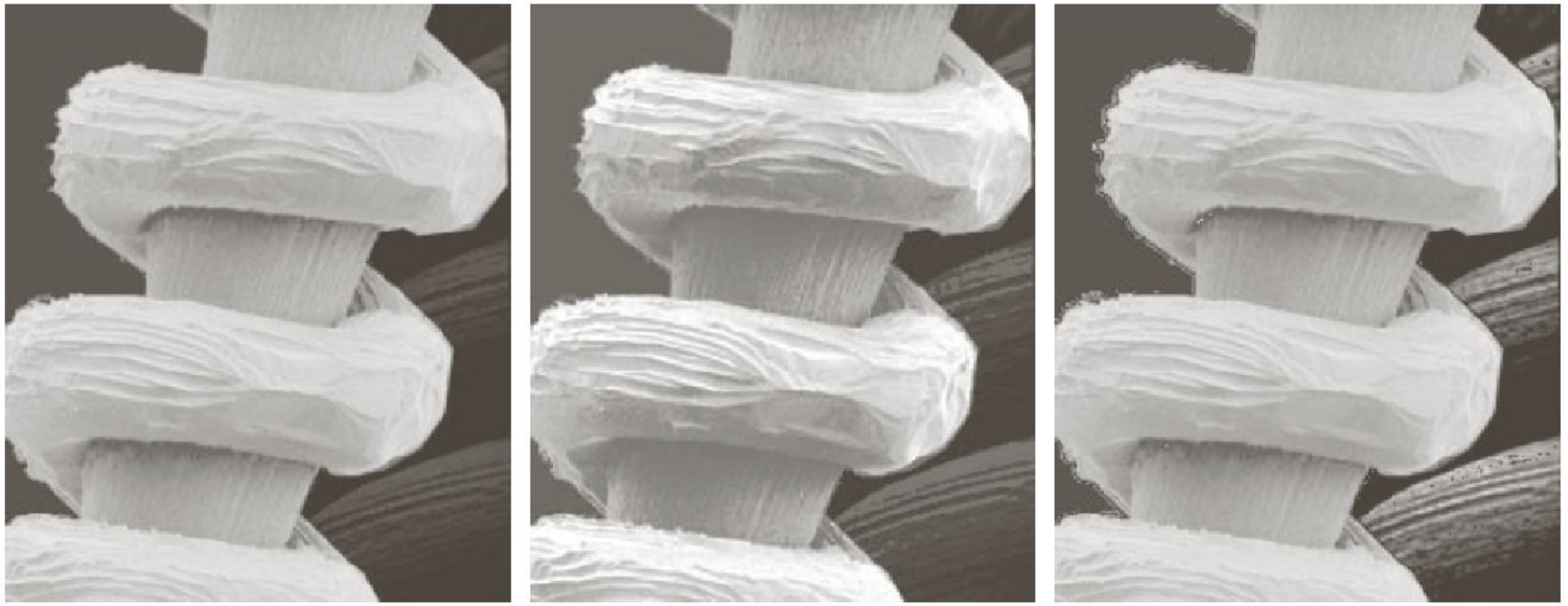
Локальные среднее и дисперсия

$$m_{S_{xy}} = \sum_{i=0}^{L-1} r_i p_{S_{xy}}(r_i)$$

$$\sigma^2_{S_{xy}} = \sum_{i=0}^{L-1} (r_i - m_{S_{xy}})^2 p_{S_{xy}}(r_i)$$

Еще пример локальной гистограммной обработки

$$g(x,y)=\begin{cases} E\cdot f(x,y) & \text{если } m_{S_{xy}} \le k_0 M_G \text{ и } k_1 D_G \le \sigma_{S_{xy}} \le k_2 D_G \\ f(x,y) & \text{в противном случае} \end{cases}$$



a b c

FIGURE 3.27 (a) SEM image of a tungsten filament magnified approximately 130×. (b) Result of global histogram equalization. (c) Image enhanced using local histogram