

# Lecture 6-2 Histogram 2

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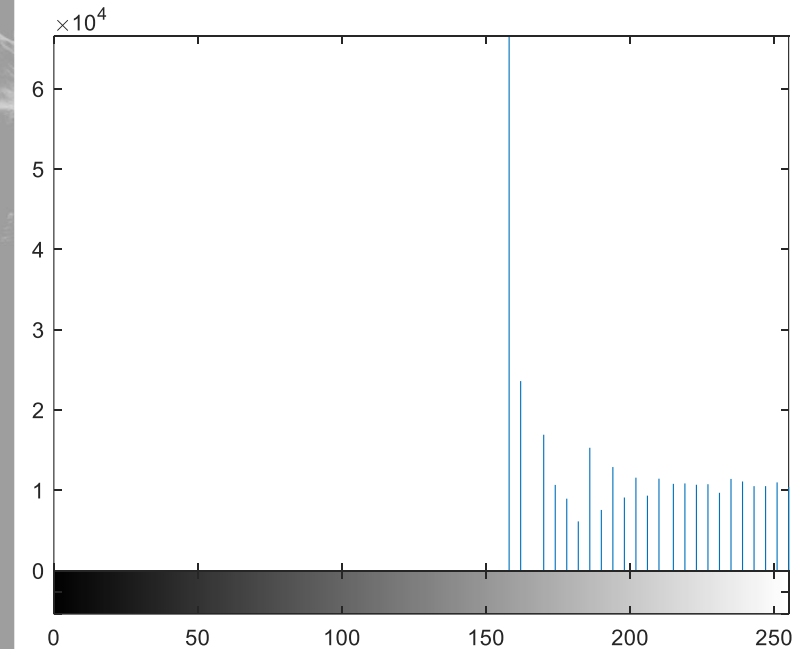
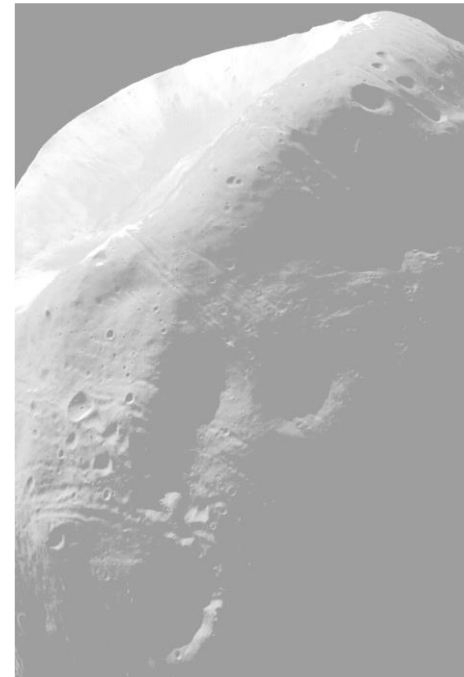
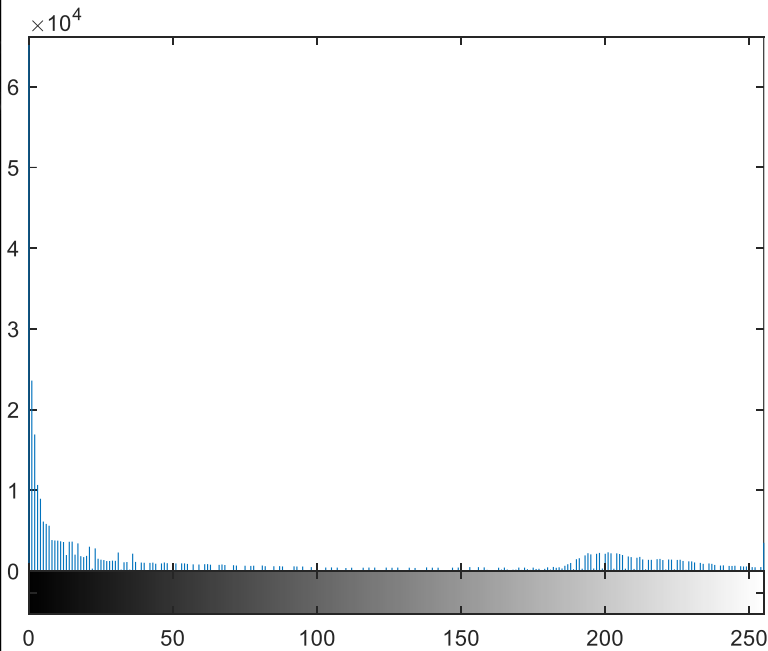
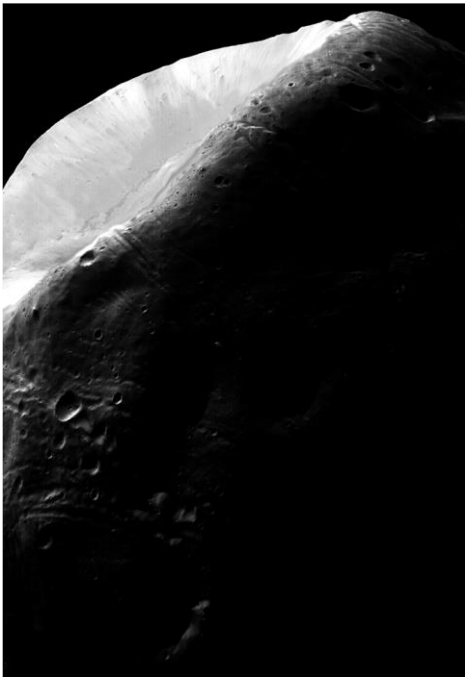
Course piazza link: [piazza.com/shanghaitech.edu.cn/spring2021/cs270spring2021](https://piazza.com/shanghaitech.edu.cn/spring2021/cs270spring2021)

# Outline

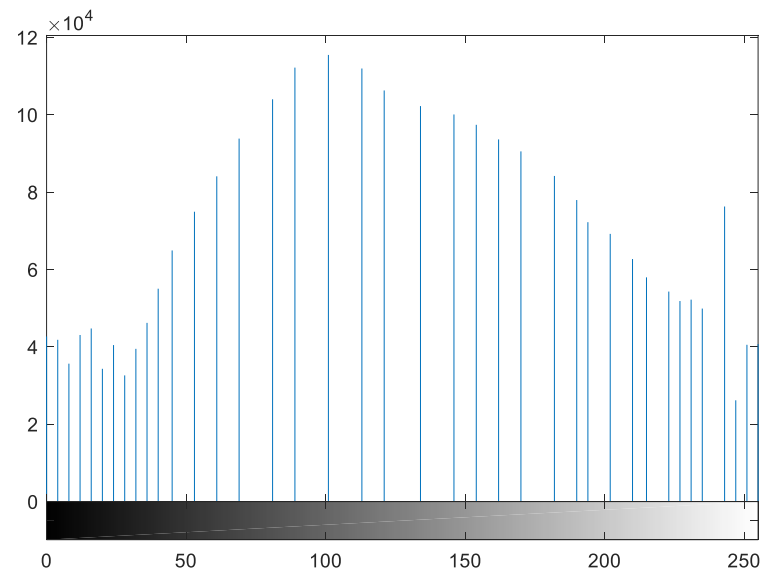
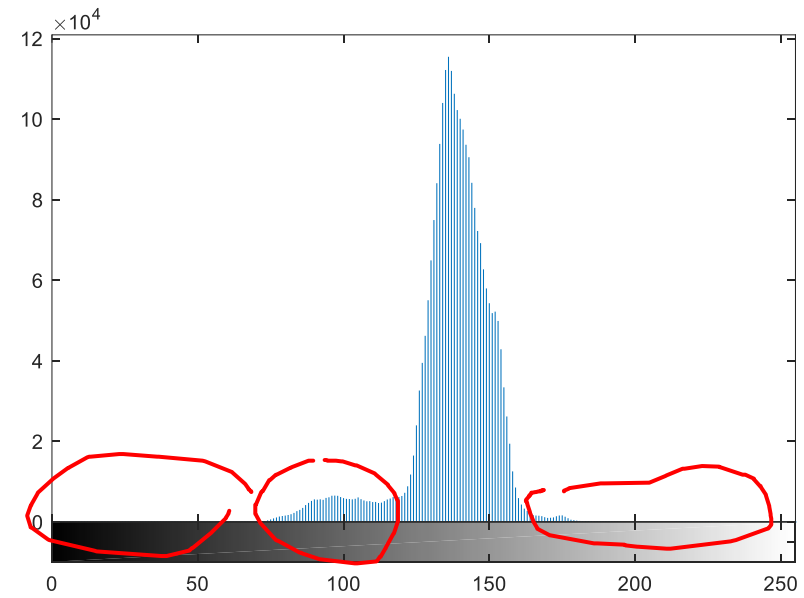
- Adaptive Histogram Equalization (AHE)
- Contrast Limited Adaptive Histogram Equalization (CLAHE)

# Key problem of HE

$$s = T(r) = (L - 1) \int_0^r p_r(w) dw = (L - 1) \sum_{j=0}^k p_r(r_j) = (L - 1) \sum_{j=0}^k \frac{n_j}{MN} = \frac{L - 1}{MN} \sum_{j=0}^k n_j$$



# Key problem of HE



# Naïve Adaptive Histogram Equalization

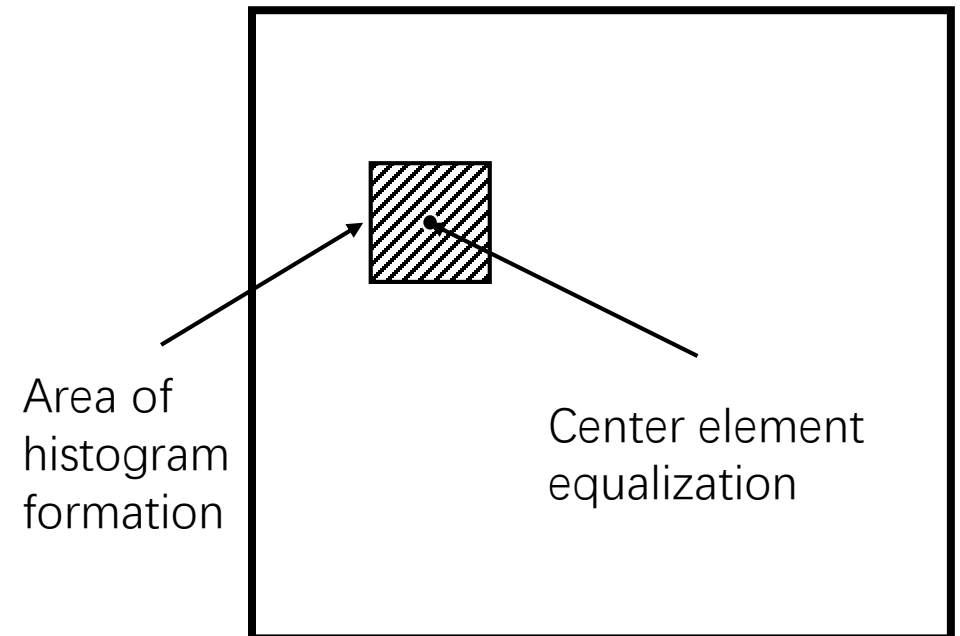
➤ Traverse every pixel with a  $W * W$  patch, process histogram equalization within each patch and update the center pixel.

➤ Advantage: better uniform distributed histogram.

➤ Disadvantage: high complexity

$O(W * W + L)$  within each patch

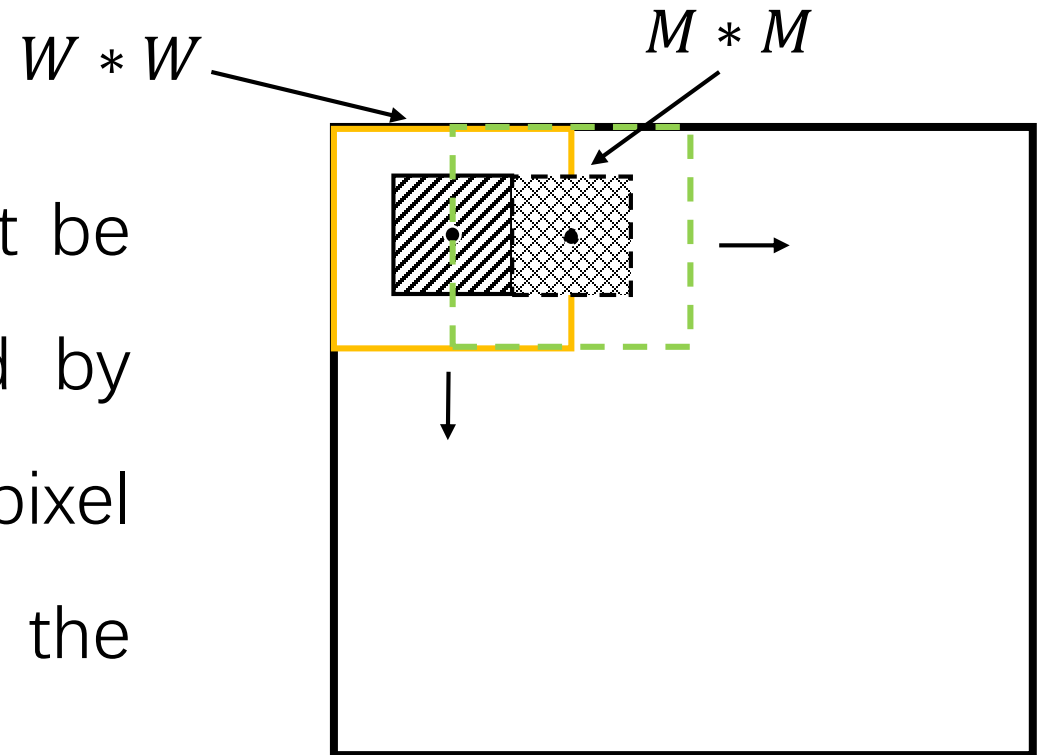
$O(M * N * (W * W + L))$  for whole image



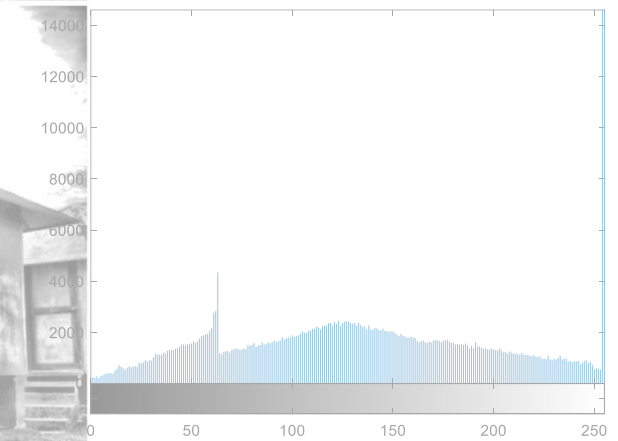
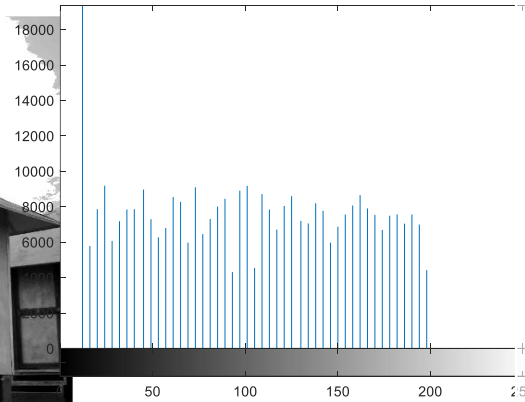
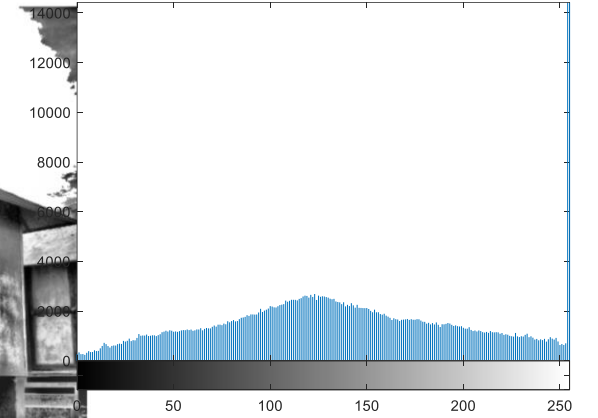
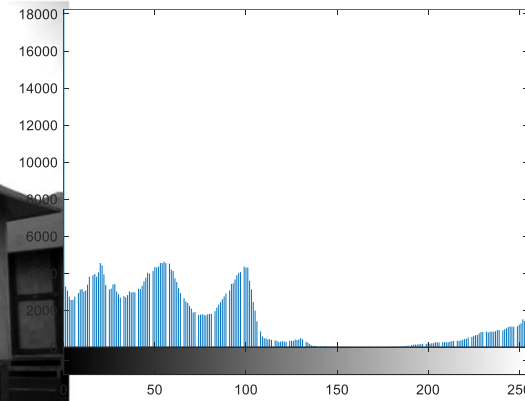
# Naïve Adaptive Histogram Equalization

➤ For faster processing AHE, it is proposed to update a center patch of size  $M * M$  instead of just the center pixel in each HE in each within the  $W * W$  patch HE.

➤ Pixels near the image boundary must be treated specially, This can be solved by extending the image by mirroring pixel lines and columns with respect to the image boundary.



# Effect of AHE



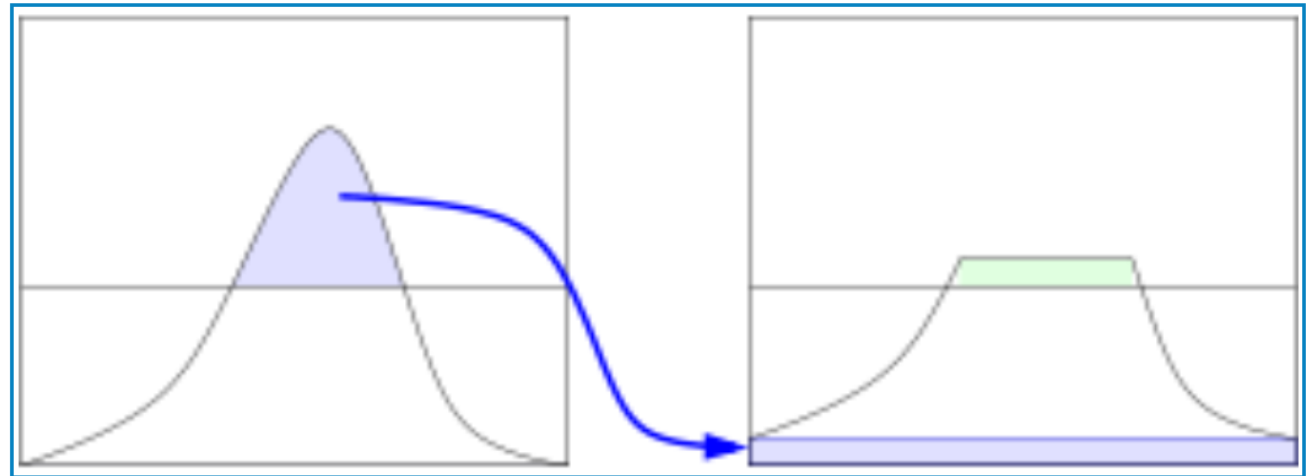
# Contrast Limited Adaptive Histogram Equalization (CLAHE)

- CLAHE differs from naïve AHE in its contrast limiting.
- CLAHE was developed to prevent the over amplification of noise that AHE can give rise to.
- This feature can also be applied to global histogram equalization, giving rise to contrast limited histogram equalization.

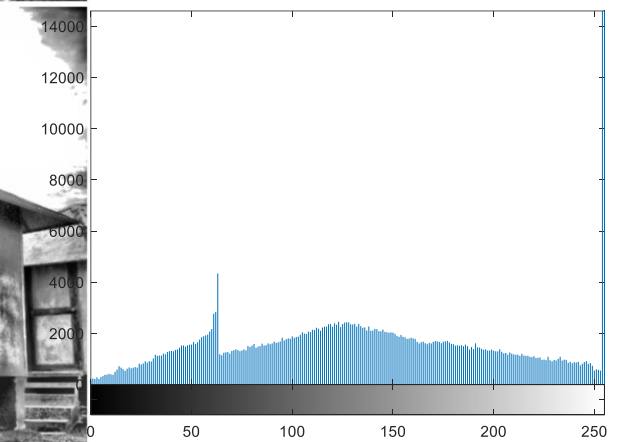
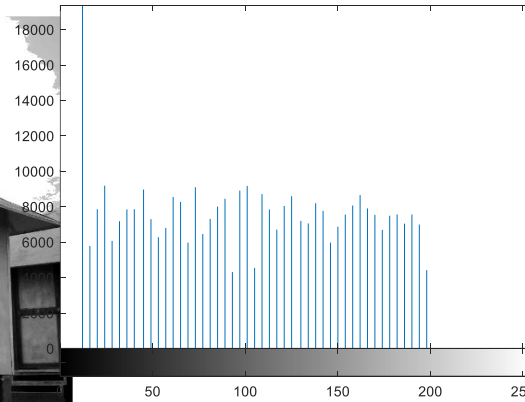
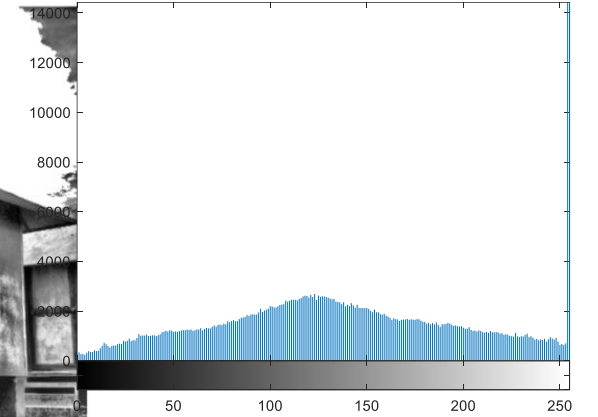
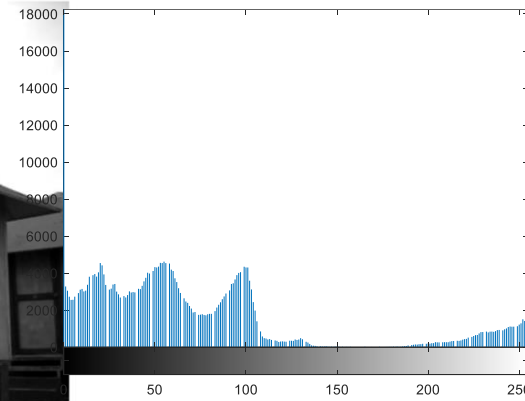


# CLAHE

- CLAHE limits the amplification by clipping the histogram at a predefined value before computing the CDF.
- This limits the slope of the CDF and therefore of the transformation function.
- The so-called clip limit depends on the normalization of the histogram and thereby on the size of the neighborhood region.



# Effect of CAHE



# Take home message

- Key idea: AHE&CLAHE was developed to prevent the over amplification of noise.

