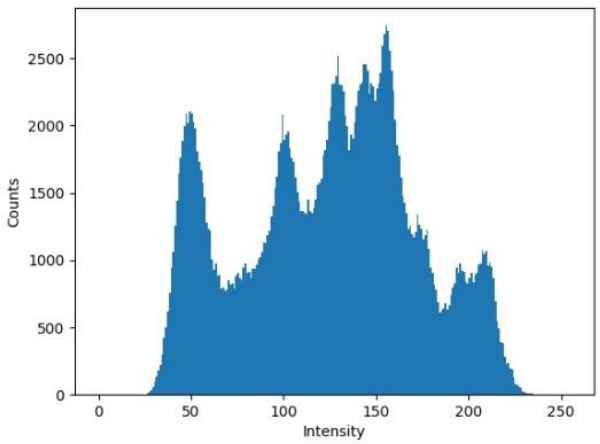
`Language: Python3.8.3`

`Modules: OpenCV(cv2), numPy, matplotlib.pyplot`

(a) Generate a binary image (threshold at 128):

Algorithm: Traversing all the pixel. If its intensity is higher than or equal to 128, then raise it to 255 (brightest); otherwise, reduce it to 0 (darkest).

(b) Generate a histogram:



Algorithm: Accumulating the pixels with the same intensity and draw it by the module *matplotlib.pyplot.bar*

(c) Find the connected components with centroid and bounding box.

In my method, I divide this problem to four steps:

Step.1

We need to turn lena.bmp into binary image. Just take the result of problem (a), let the intensity 255 be ‘1’ and 0 be ‘0’.

Step.2

In this homework, I adopt an algorithm which is similar to **flooding algorithm** with **4-connected** because I think the algorithms taught in class are not such intuitive and a little complicated. This method traverses all the pixels, if it hasn't been labeled, then we put a barrel of "water" (label) on it and it will flood to 4 directions of its neighbors. If the neighbor has been labeled, the flood stops there; otherwise, we label the neighbor and continue the flood. We use a queue to maintain whom is the next one to be labeled and another list to record if the scale of this flood is over 500 pixels. This algorithm takes **O(RC)** time. (for size of image is RxC.) Each pixel just needs to check status, check neighbor status and labeled, so I think it is still a good way just like the algorithms taught in the lecture but easier to realize.

Step.3

After finishing labeling, we traverse the image again for measuring the boundary and centroid of each component. By the way, I also color a demo image to make sure if the algorithm worked.

Step.4

Finally, draw the boundary boxes and centroids by *cv2.rectangle and cv2.circle*.

Bonus(?)

These problems are found in the last page of slide:

- 舉兩種 connected component labeling ，以及他們的傳播方向、次數與其特色。
  1. Iterative Algorithm:
     - 方向: 先**由上往下，由左往右**，再以相反方向再做一次
     - 次數: 基於圖形的圈數等因素，次數可能會多於一次
     - 特色: 由於要做到不再發生變化的平衡點才能停，因此時間複雜度很不穩定；但因撰寫容易，適合處理尺寸較小的圖片。
  2. Classical Algorithm:
     - 方向: 由上往下，由左往右
     - 次數: 兩次，第一次做粗略的標籤和建立等價表，第二次再將相連的區塊合併。
     - 特色: 只需遍歷兩次，因此時間複雜度穩定；但需要建立等價表，在做較大尺寸的圖片時會耗費較大的記憶體。

- Signature segmentation 可以有什麼切法，舉兩種。
  1. Vertical and horizontal projections
  2. Diagonal projections

- 舉出兩種你所知道的 thresholding 演算法
  1. Otsu’s threshold
  2. Kullback-Leibler divergence threshold