

# A linear time implementation of k-means for multilevel thresholding of grayscale images



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# Outline

1. Thresholding
2. Otsu's method
3. K-means for thresholding
4. Equivalence of Otsu's method and K-means
5. Our method
6. Conclusions

# Thresholding

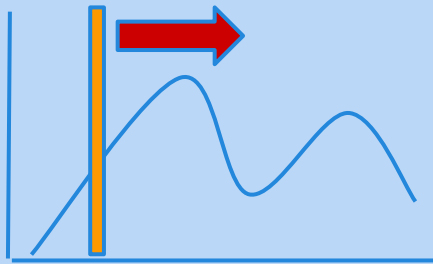
Thresholding is the simplest segmentation technique.



$$im2 = (im1 > threshold) * 255$$

# Otsu's method

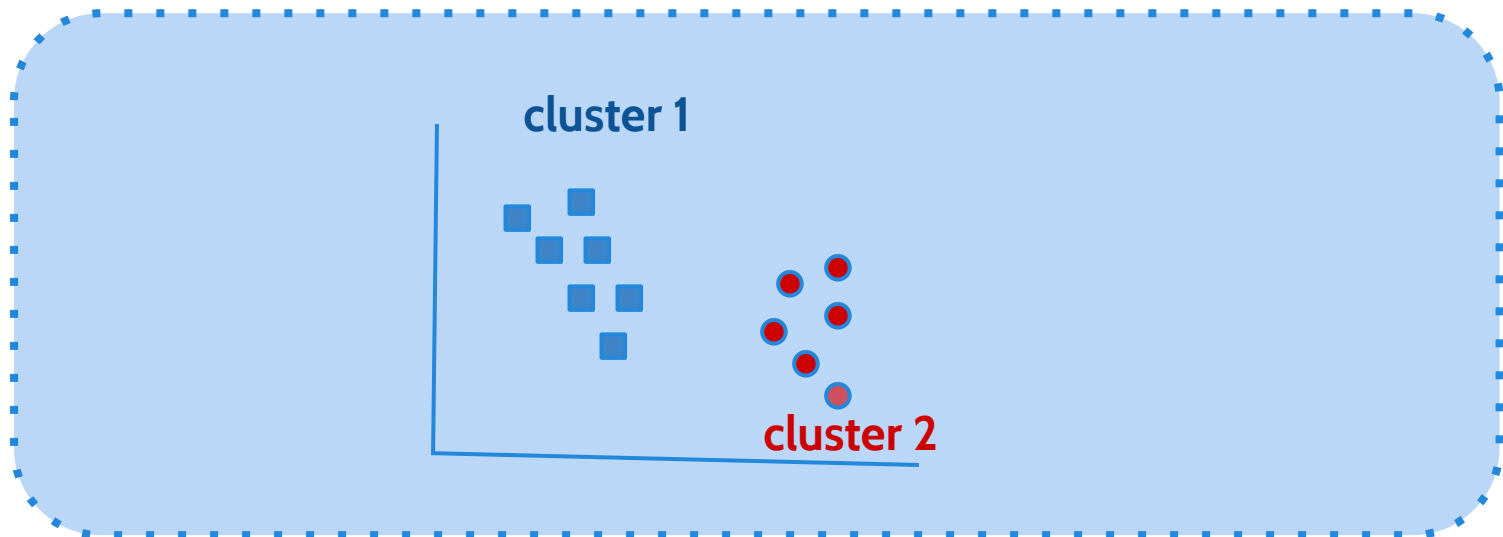
- Determines a threshold automatically.
- Moving threshold and variance calculation in each iteration for the bilevel case.



256 iterations of  
variance  
computation for  
the bilevel case

# K-means

- Distance based algorithm for clustering (or grouping).
- K clusters imply K-1 thresholds.



# Equivalence of Otsu's method and K-means

- K-means is equivalent to Otsu's method in optimization objectives.
- K-means is guaranteed to converge.
- However, k-means can converge to local minima.

# K-means on histogram (I)

- Histograms summarize a grayscale image with no spatial information.

**SPATIAL** information is not used for thresholding!

# K-means on histogram (II)

A bin in the histogram represents a lot of pixels in the image.



$512 \times 512 = 262144$  pixels

**That means a faster  
thresholding!**

0.1	0.1	0.2	0.1	...	0.1	0.1
0	1	2	3	...	254	255

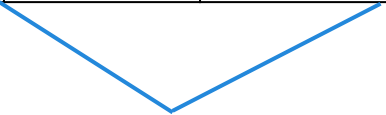
262144 pixels summed up in 256 bins



# K-means

Histograms are indexed by intensity levels

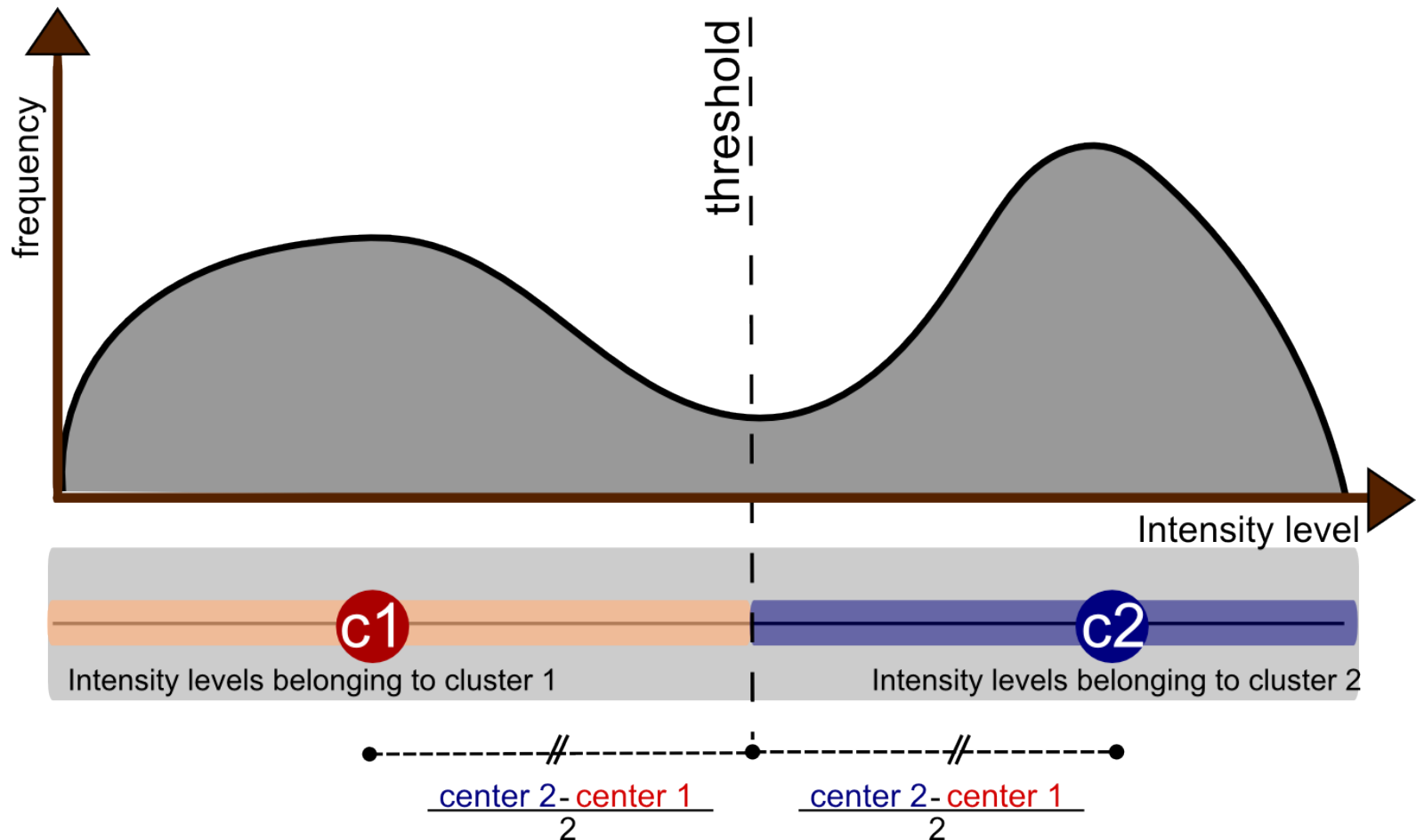
Frequency	0.1	0.1	0.2	0.1	...	0.1	0.1
INDEX	0	1	2	3	...	254	255



The distance of color is  $3 - 1 = 2$

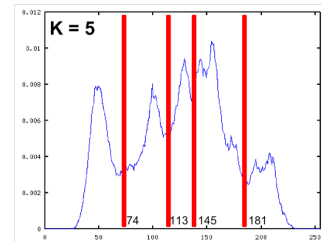
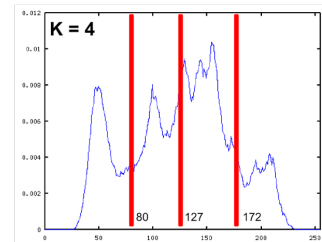
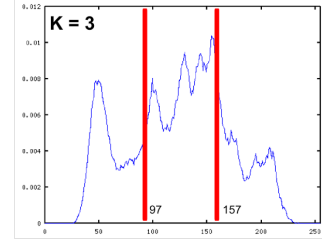
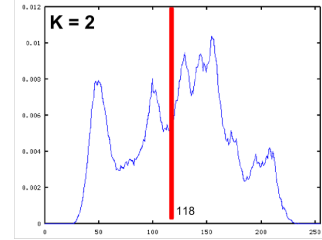
gray distances are a simple “rest” between indexes

# Our method

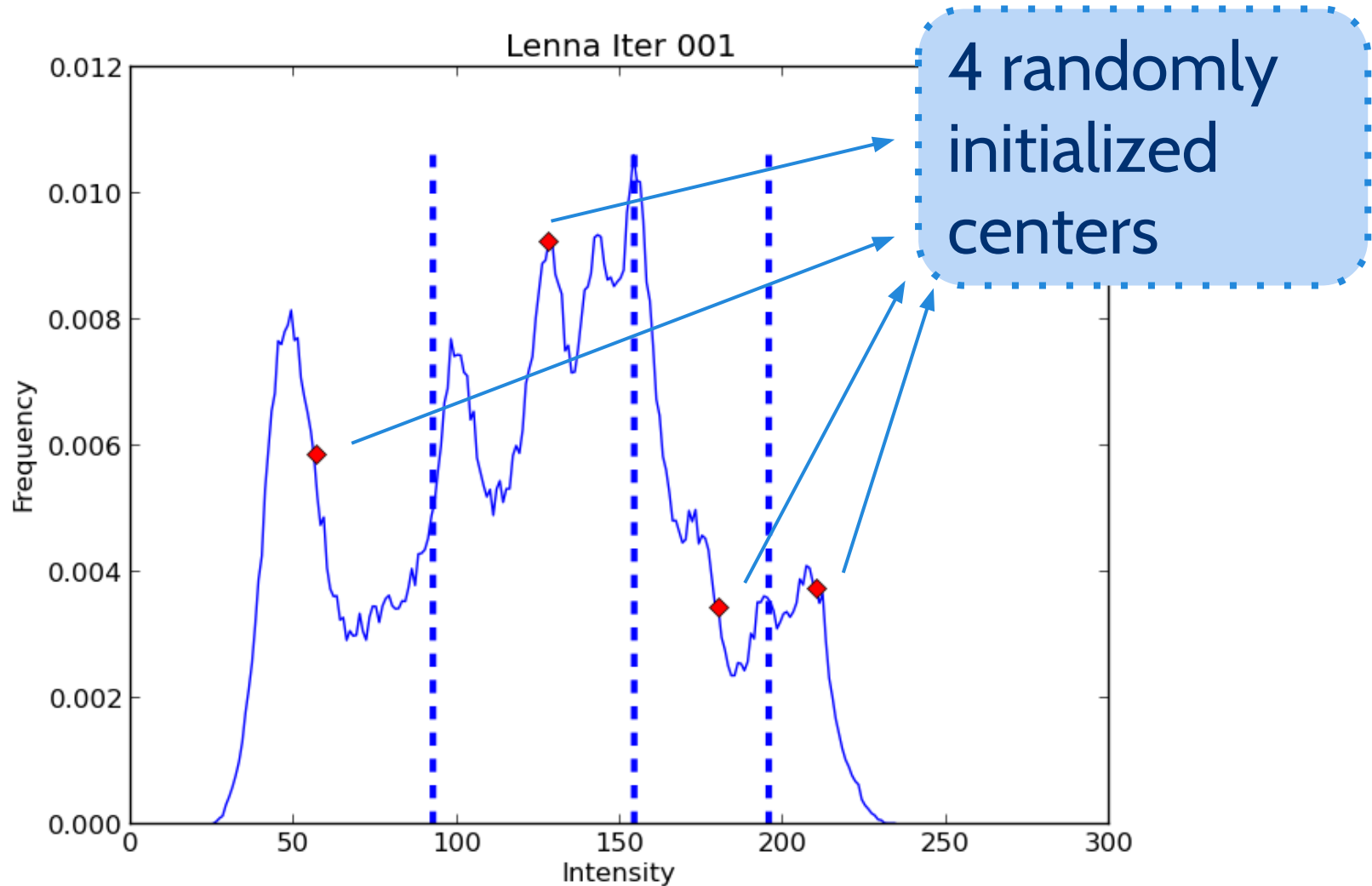


# Our method (II)

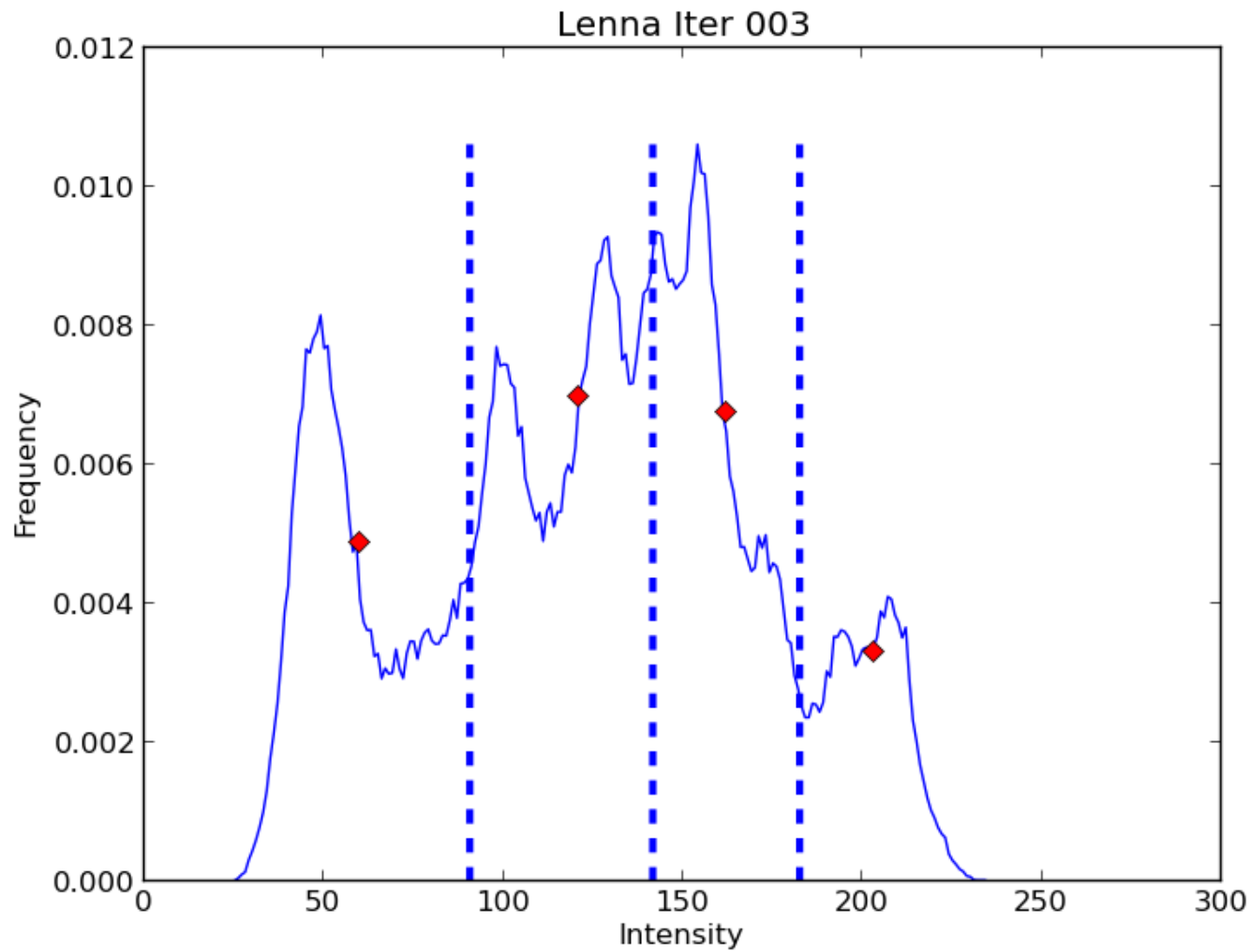
ORIGINAL



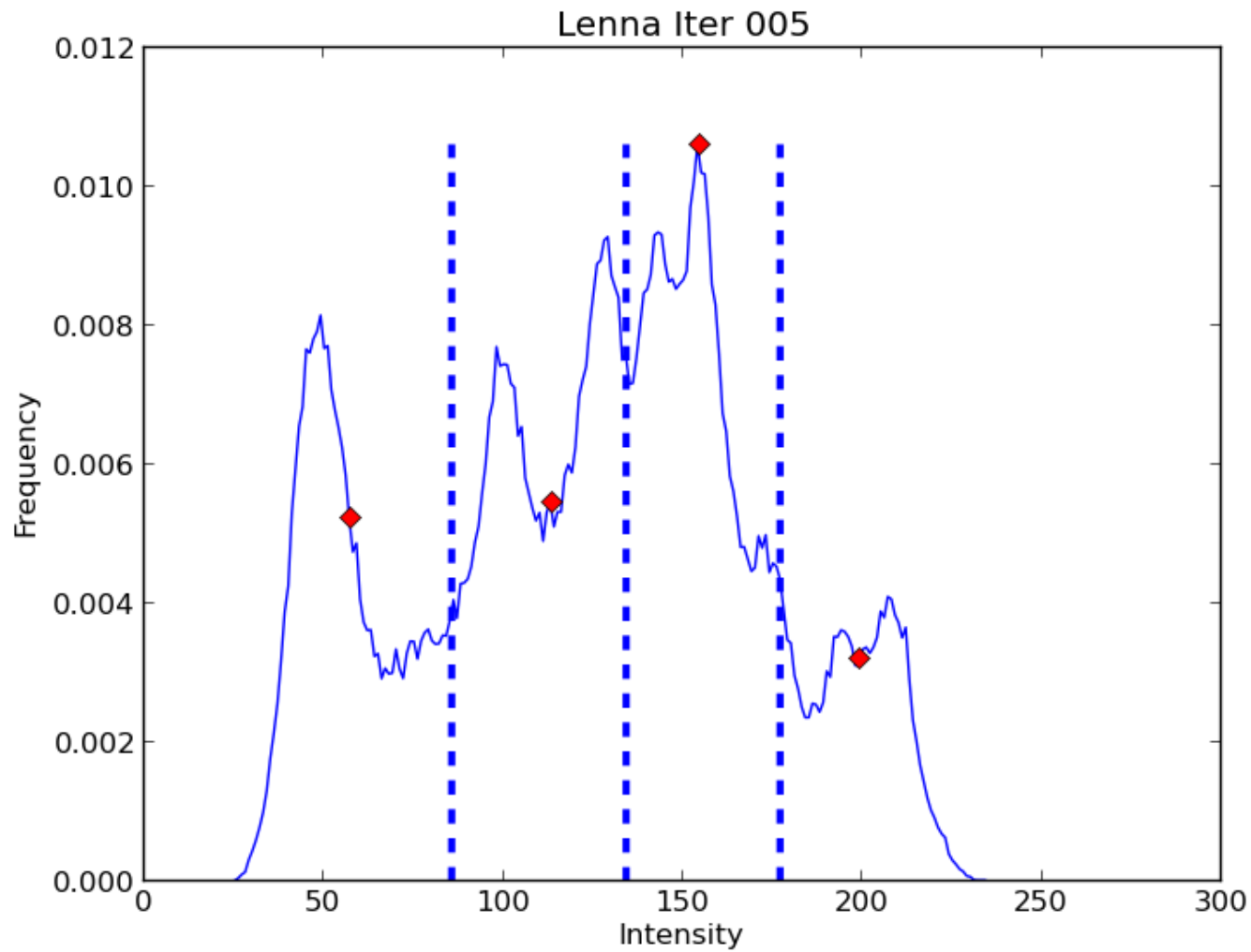
# Lena (Iter 001)



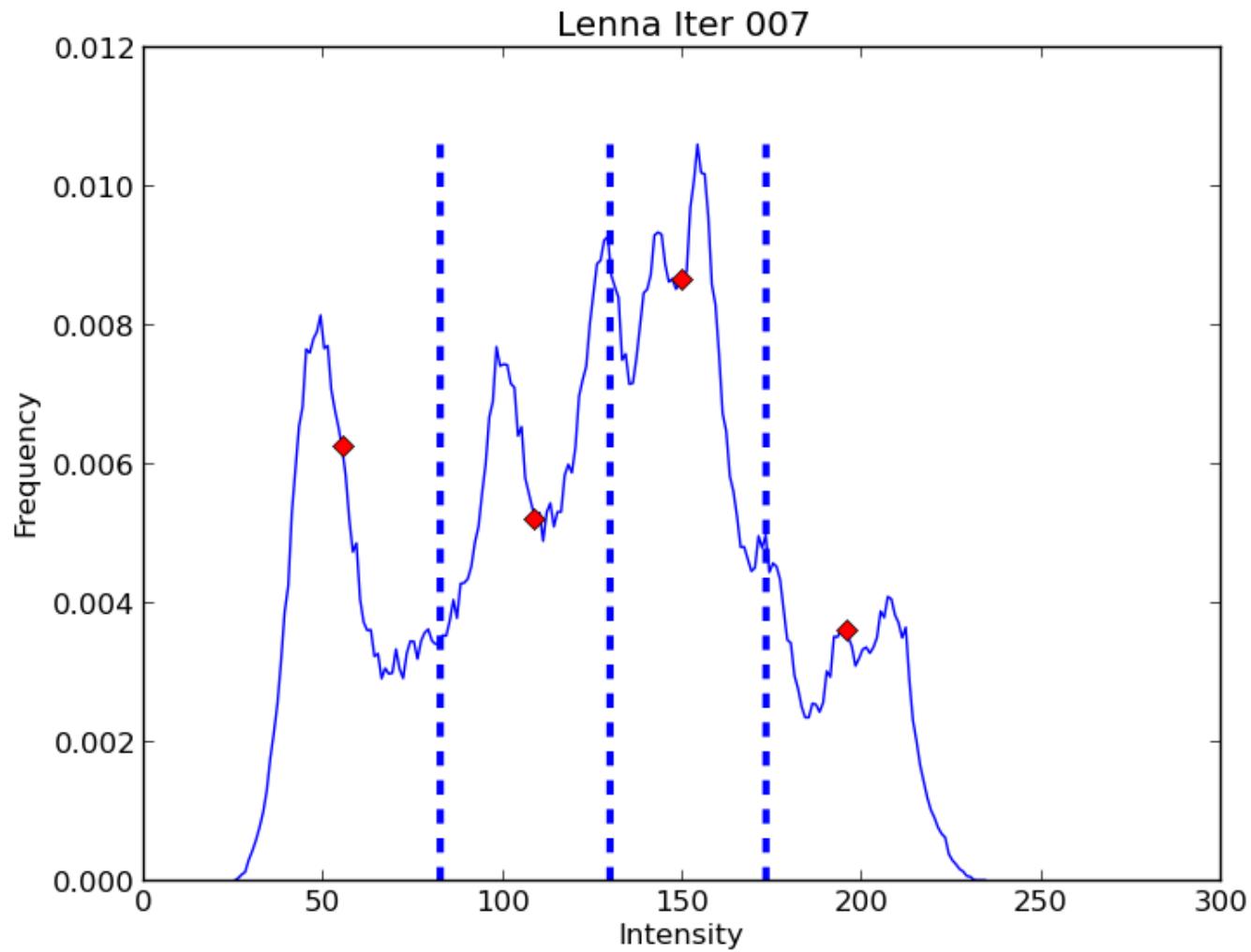
# Lena (Iter 003)



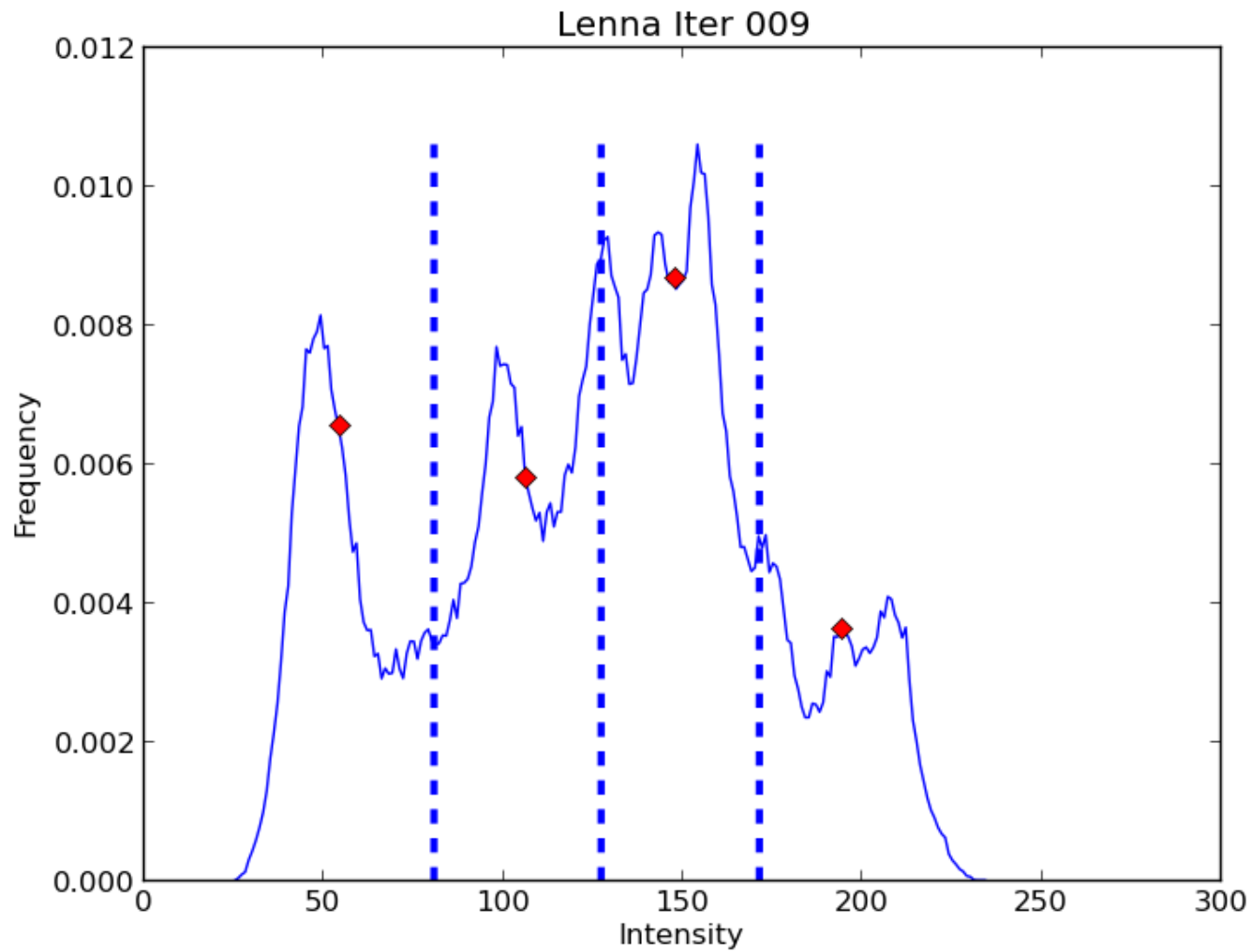
# Lena (Iter 005)



# Lena (Iter 007)

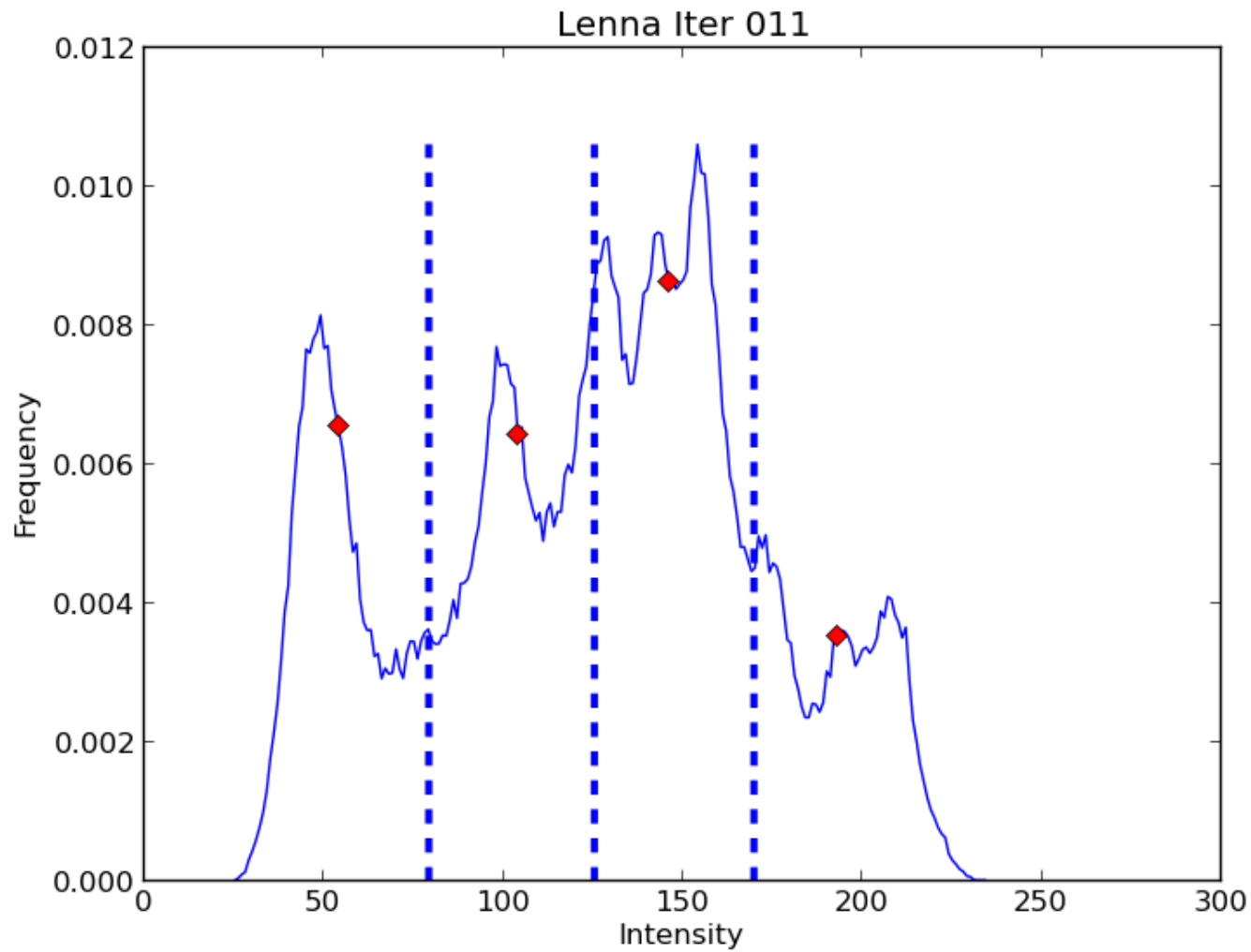


# Lena (Iter 009)

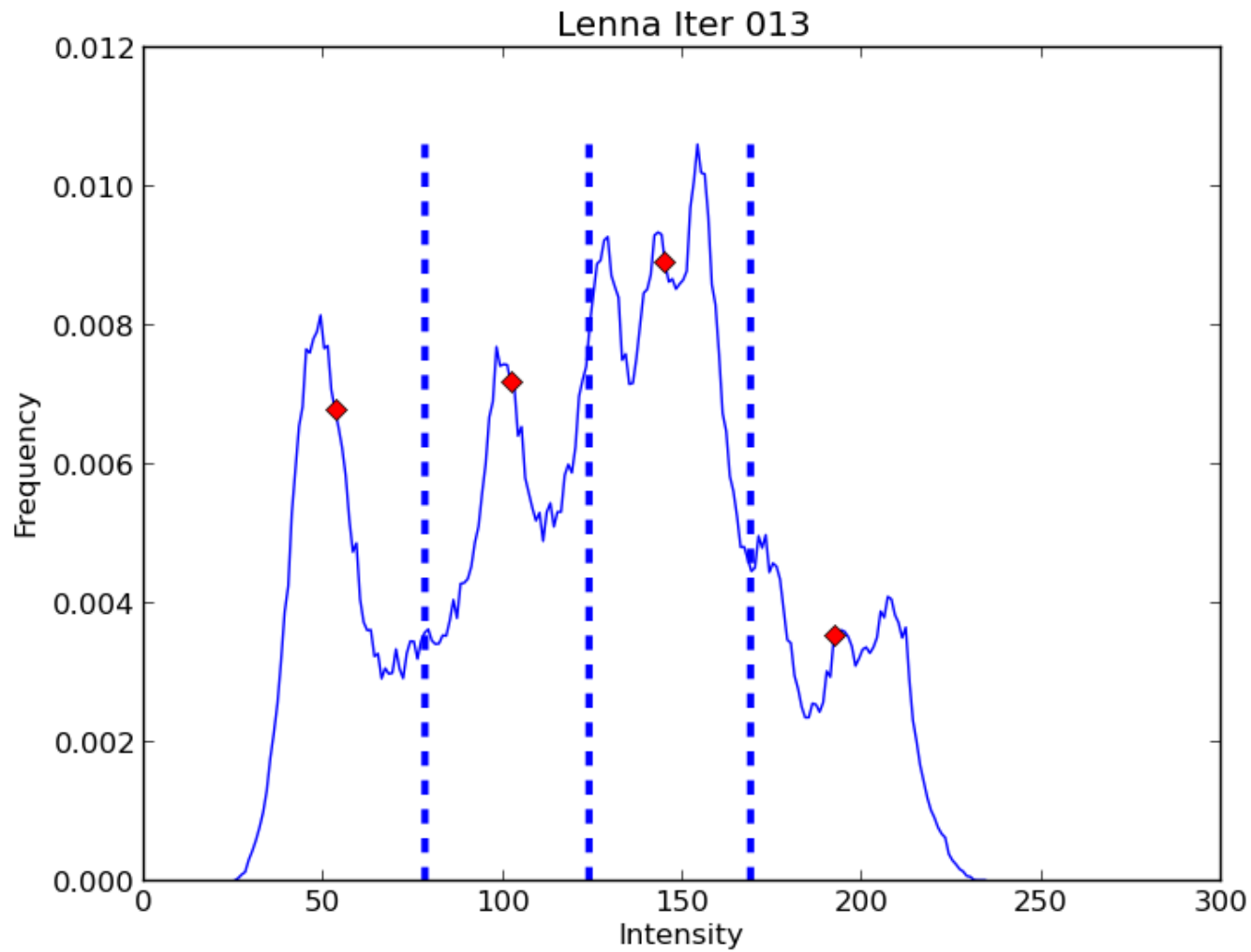




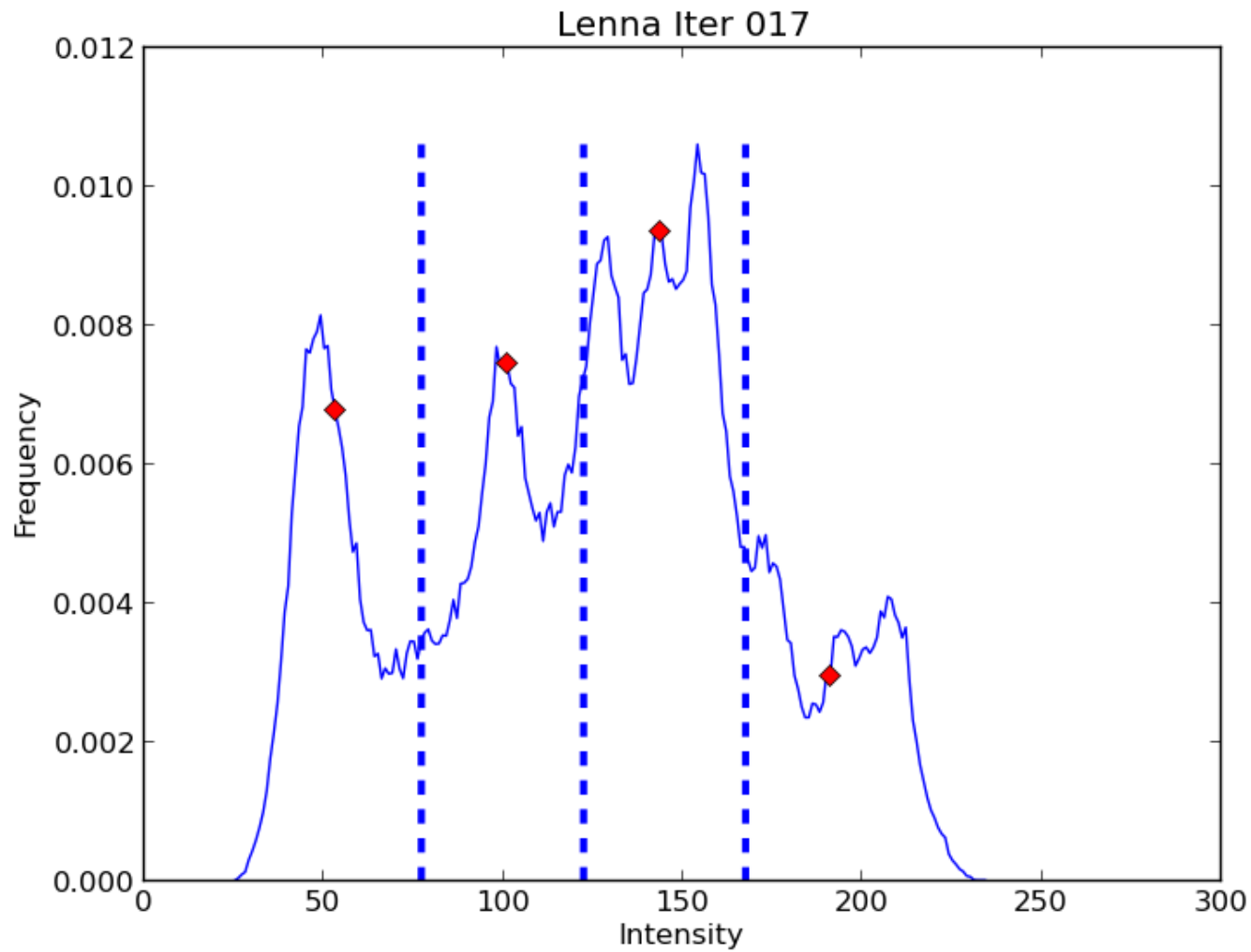
# Lena (Iter 011)



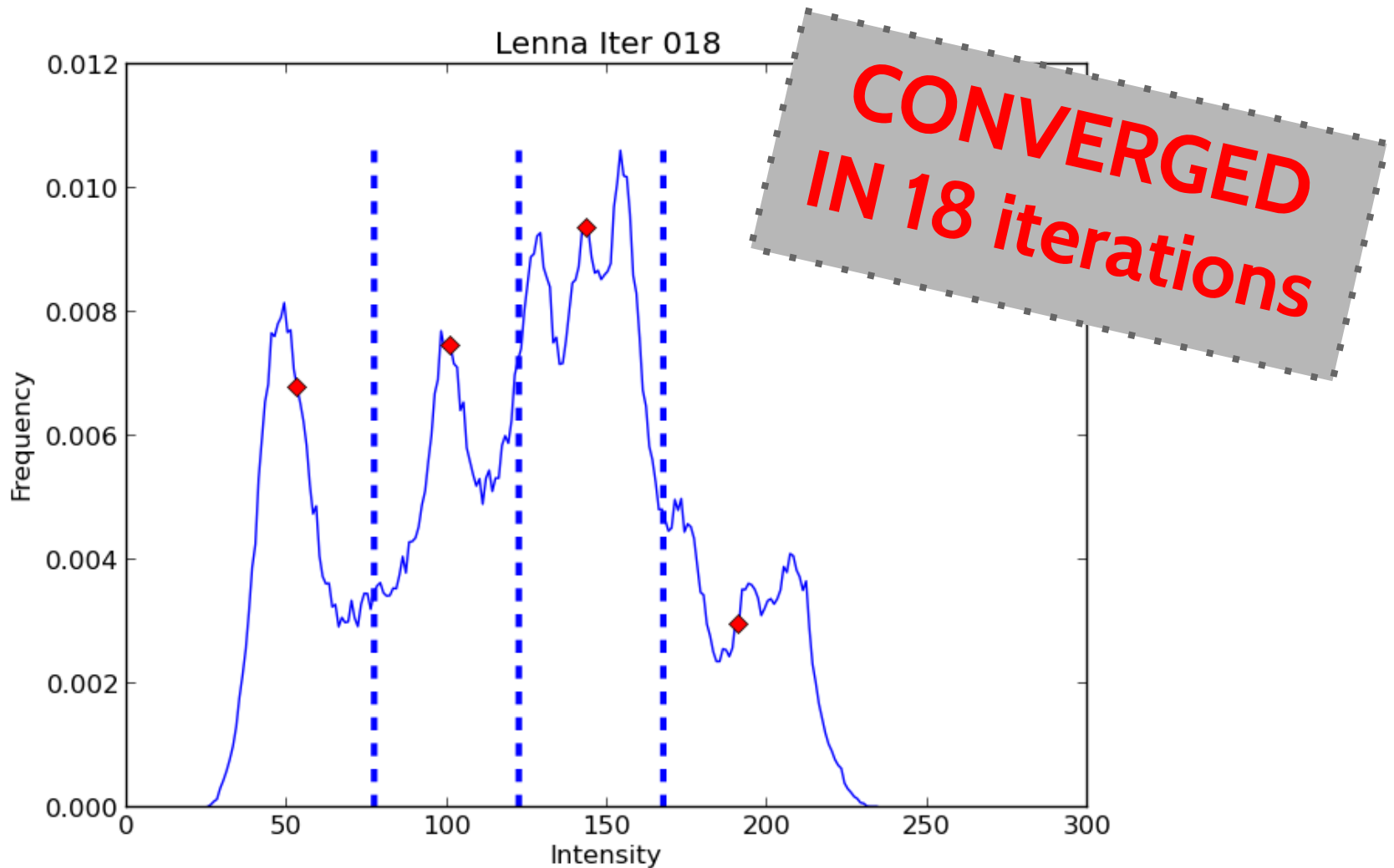
# Lena (Iter 013)



# Lena (Iter 017)



# Lena (Iter 018)



# Conclusions

- Equivalent to multilevel Otsu's method, but faster.

The code can be found on <http://bitbucket.org/palefo/kmeans>

**THANKS!**

Please, drop me an e-mail at  
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questions.