

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

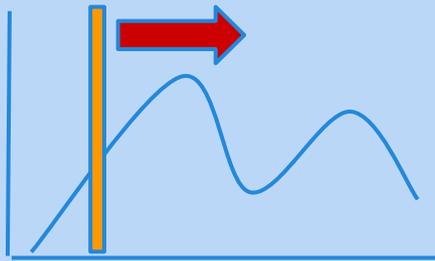
Thresholding is the simplest segmentation technique.



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

Otsu's method

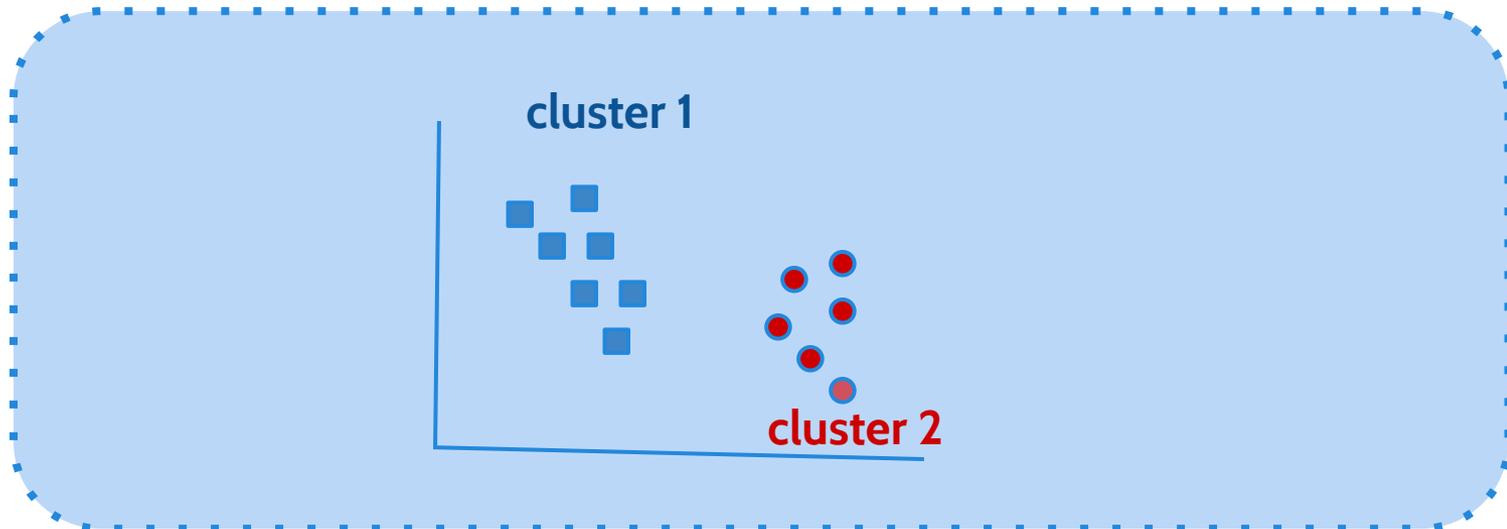
- Determines a threshold automatically.
- Moving threshold and variance calculation in each iteration for the bilevel case.



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.

ORIGINAL



$512 \times 512 = 262144$ 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

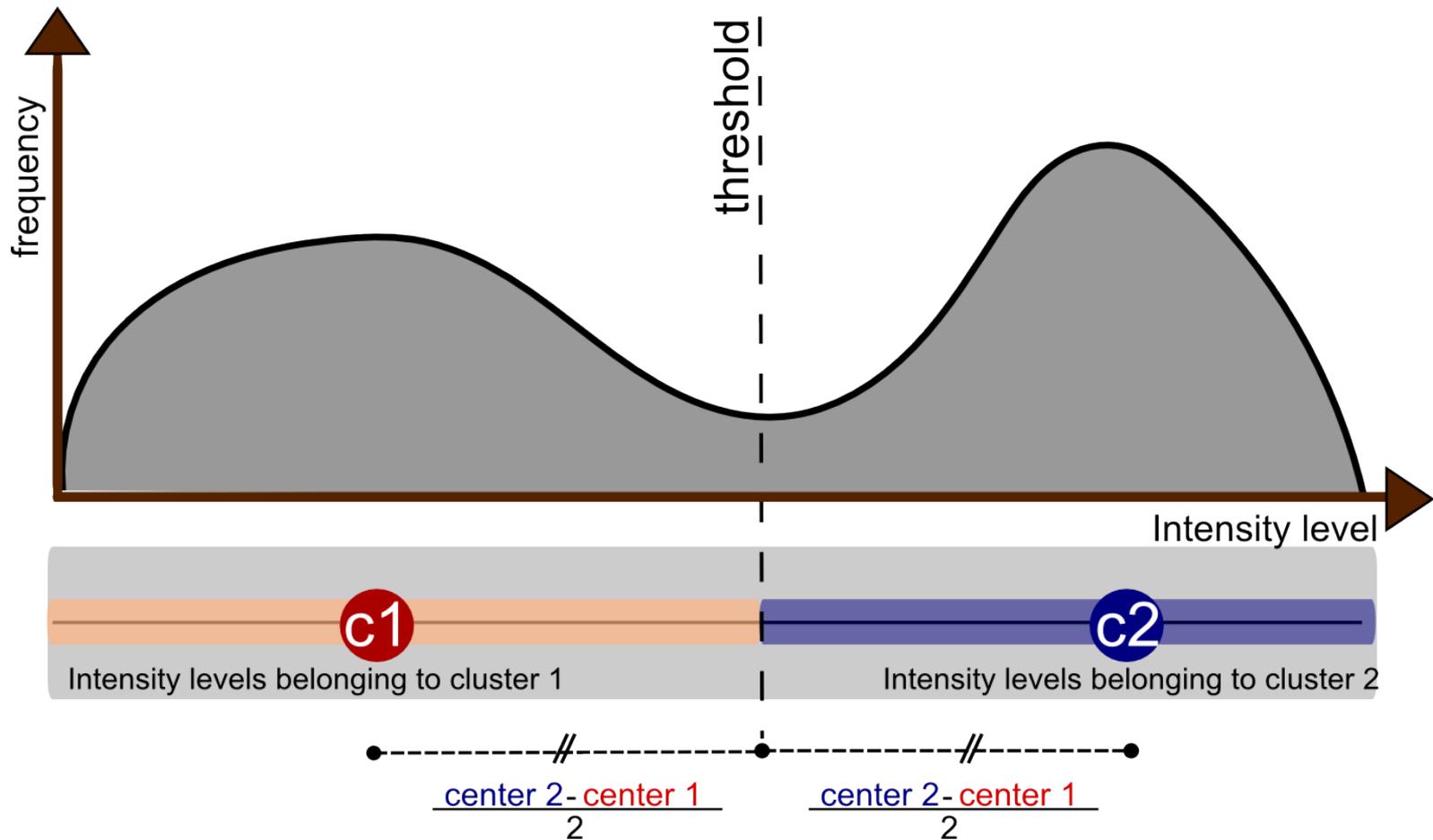
Histograms are indexed by intensity levels

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 $3-1 = 2$

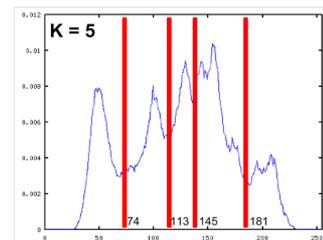
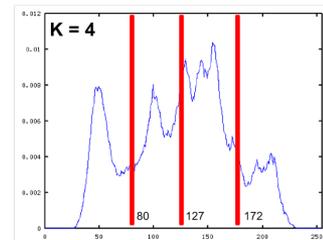
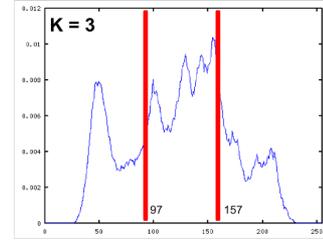
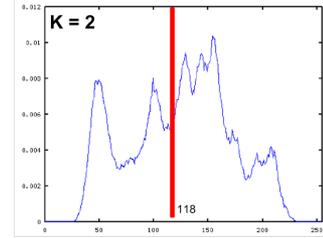
gray distances are a simple “rest” between indexes

Our method

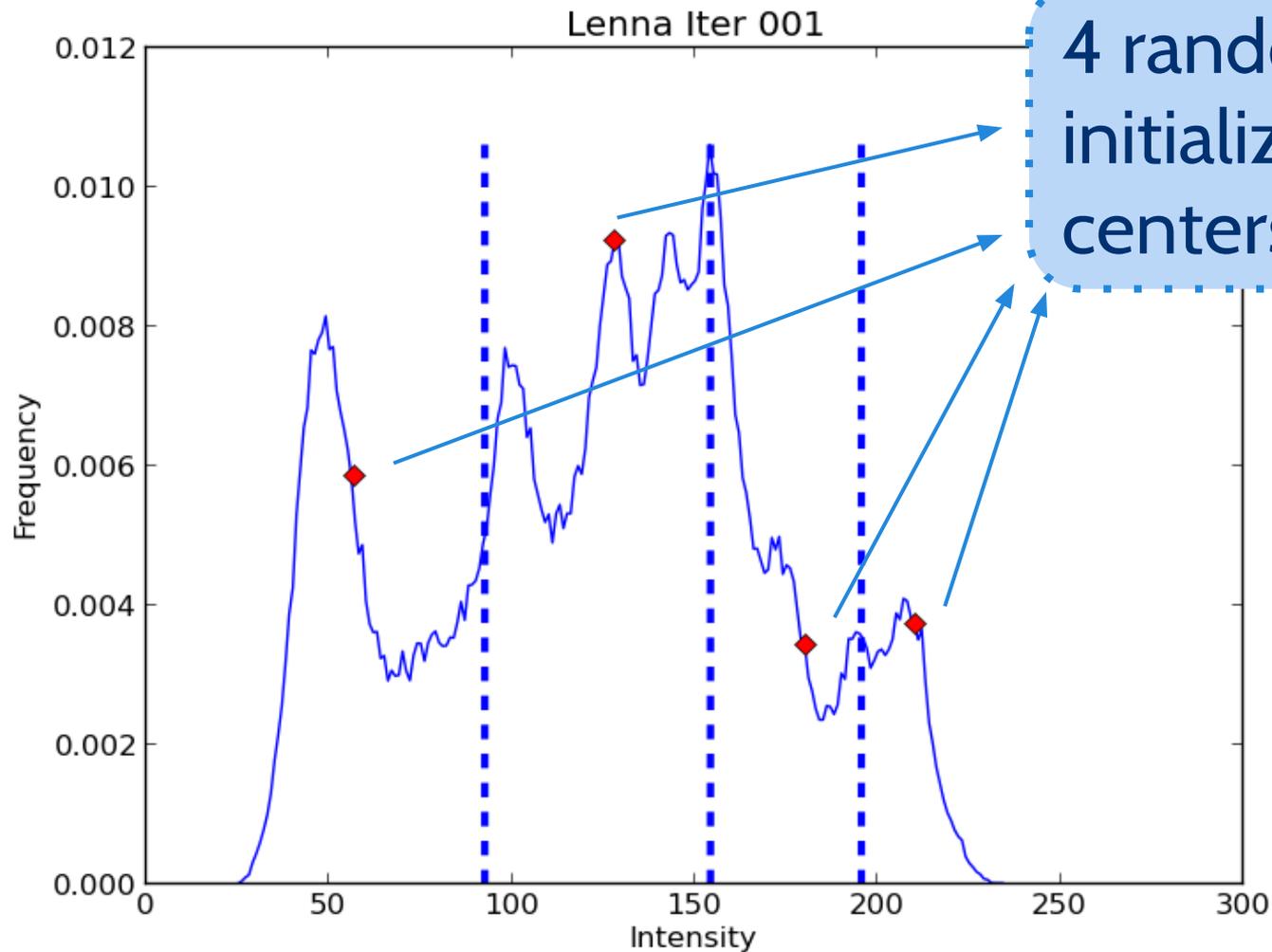


Our method (II)

ORIGINAL

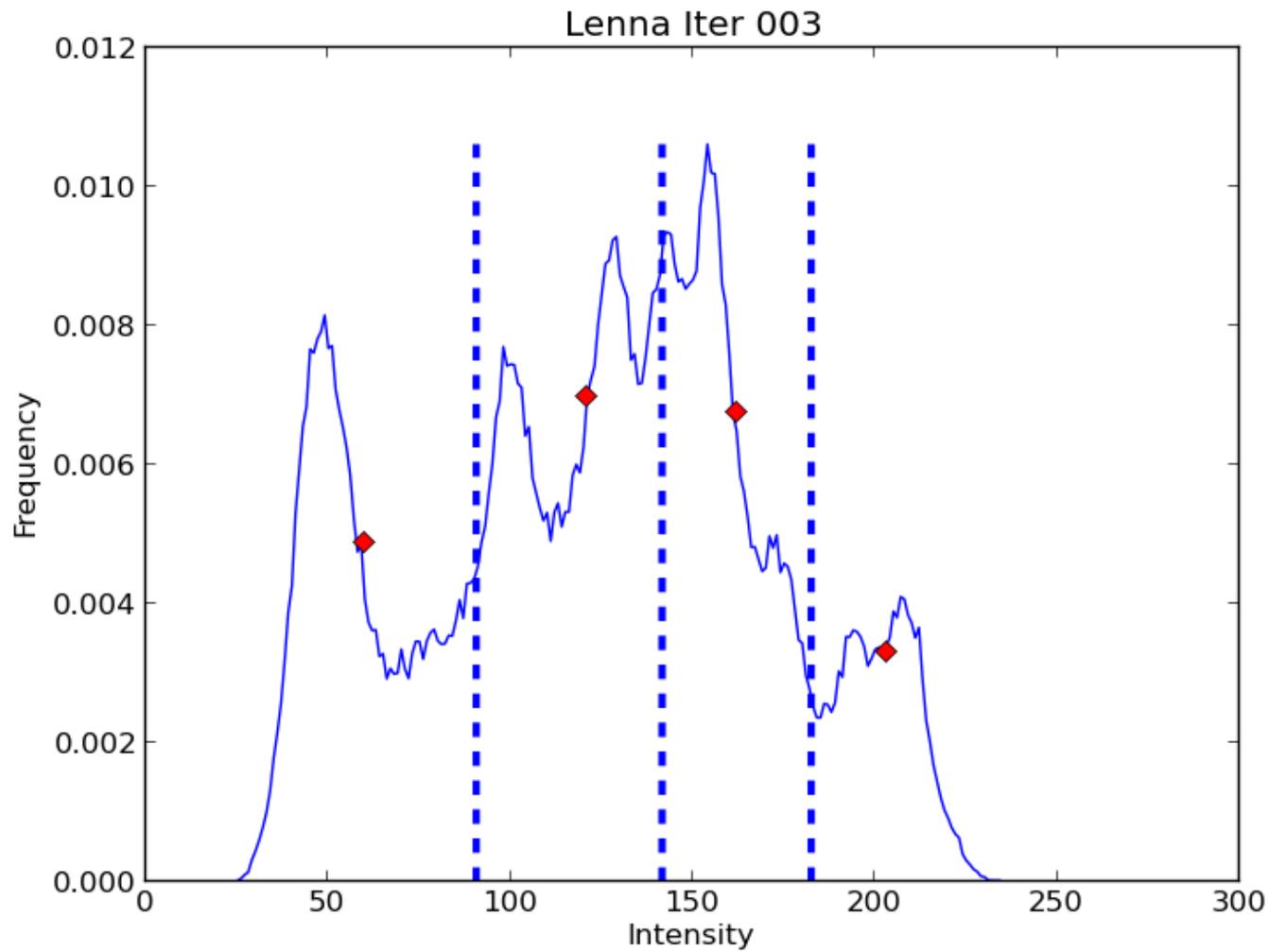


Lena (Iter 001)

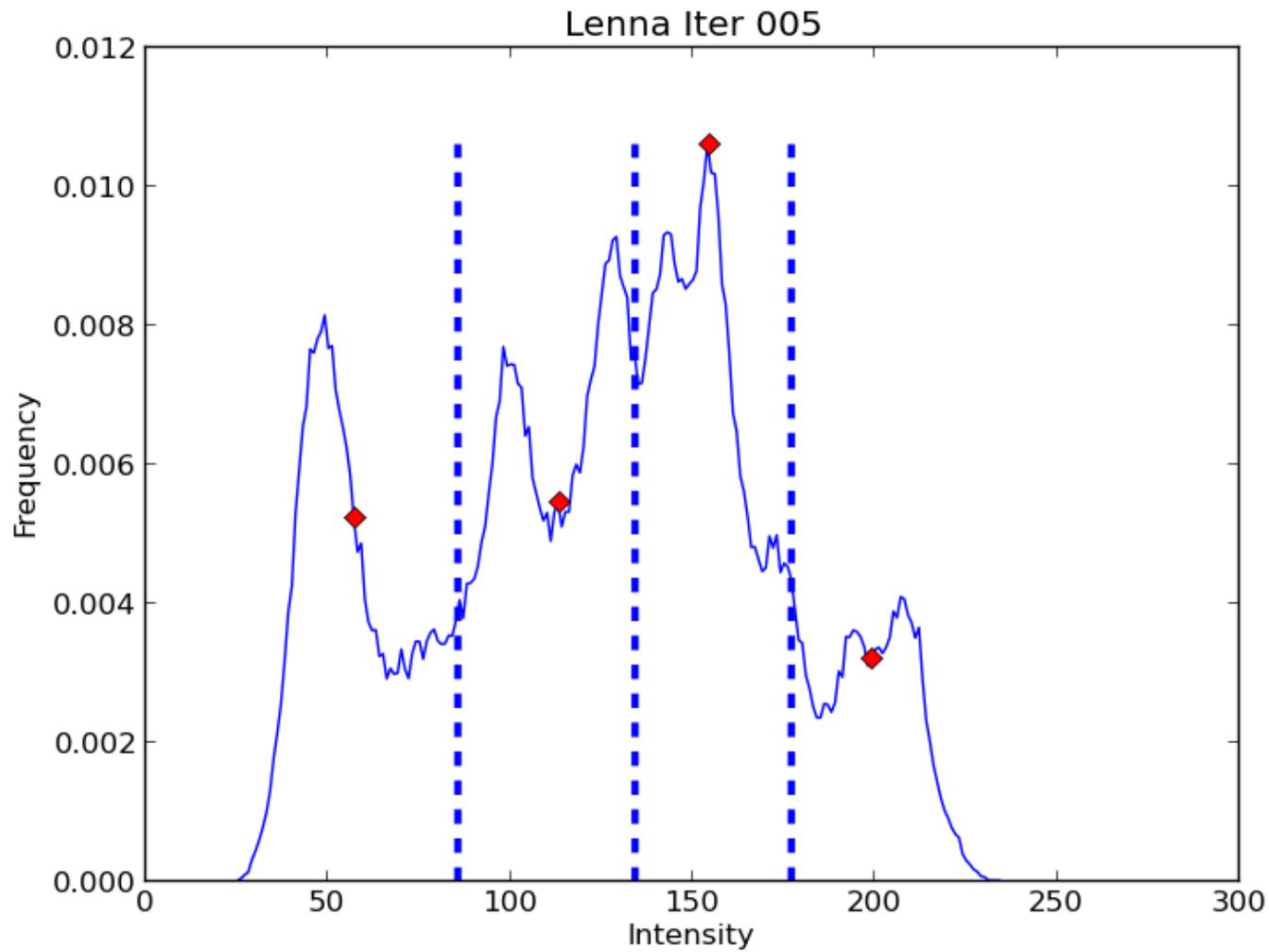


4 randomly
initialized
centers

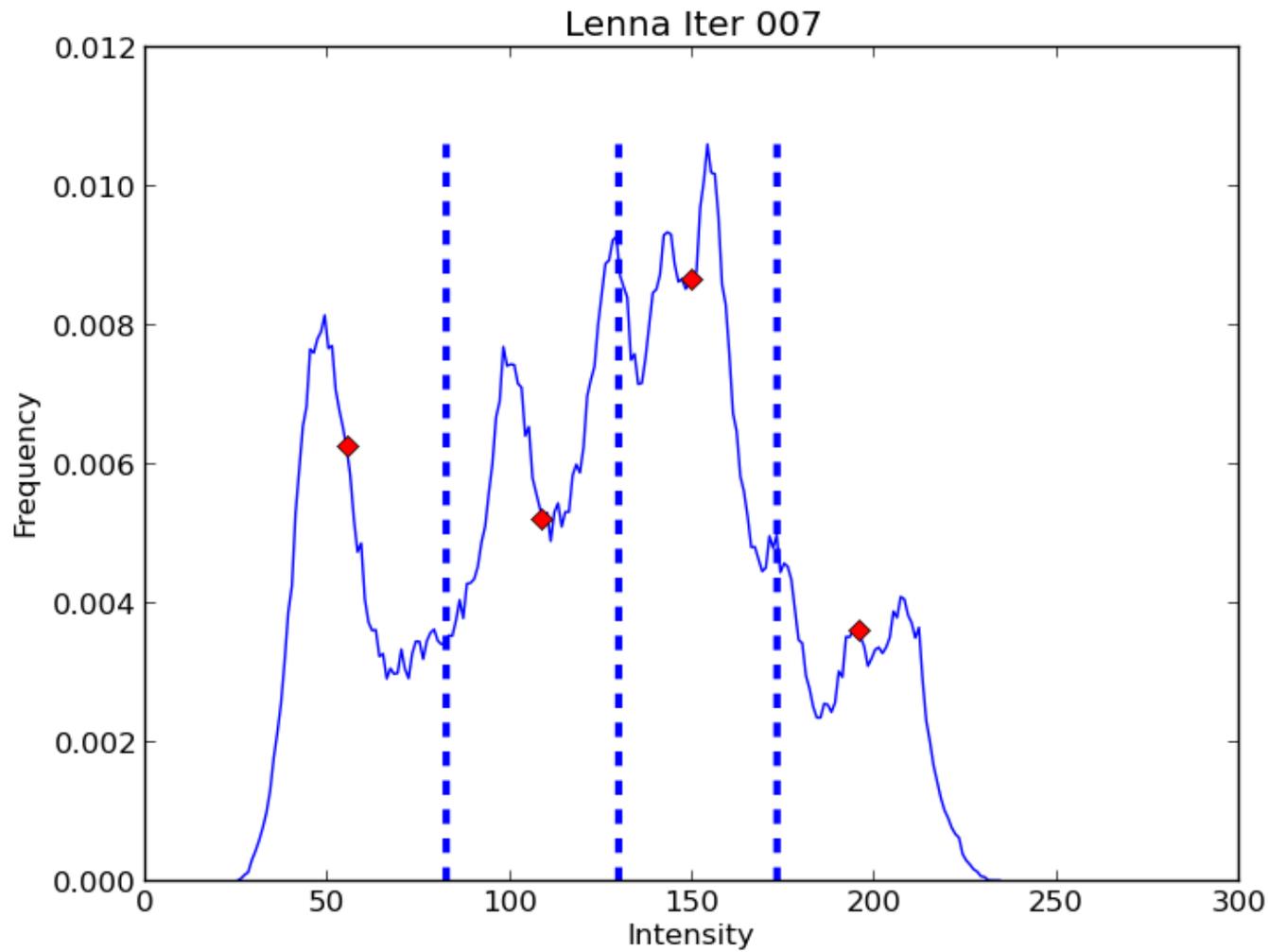
Lena (Iter 003)



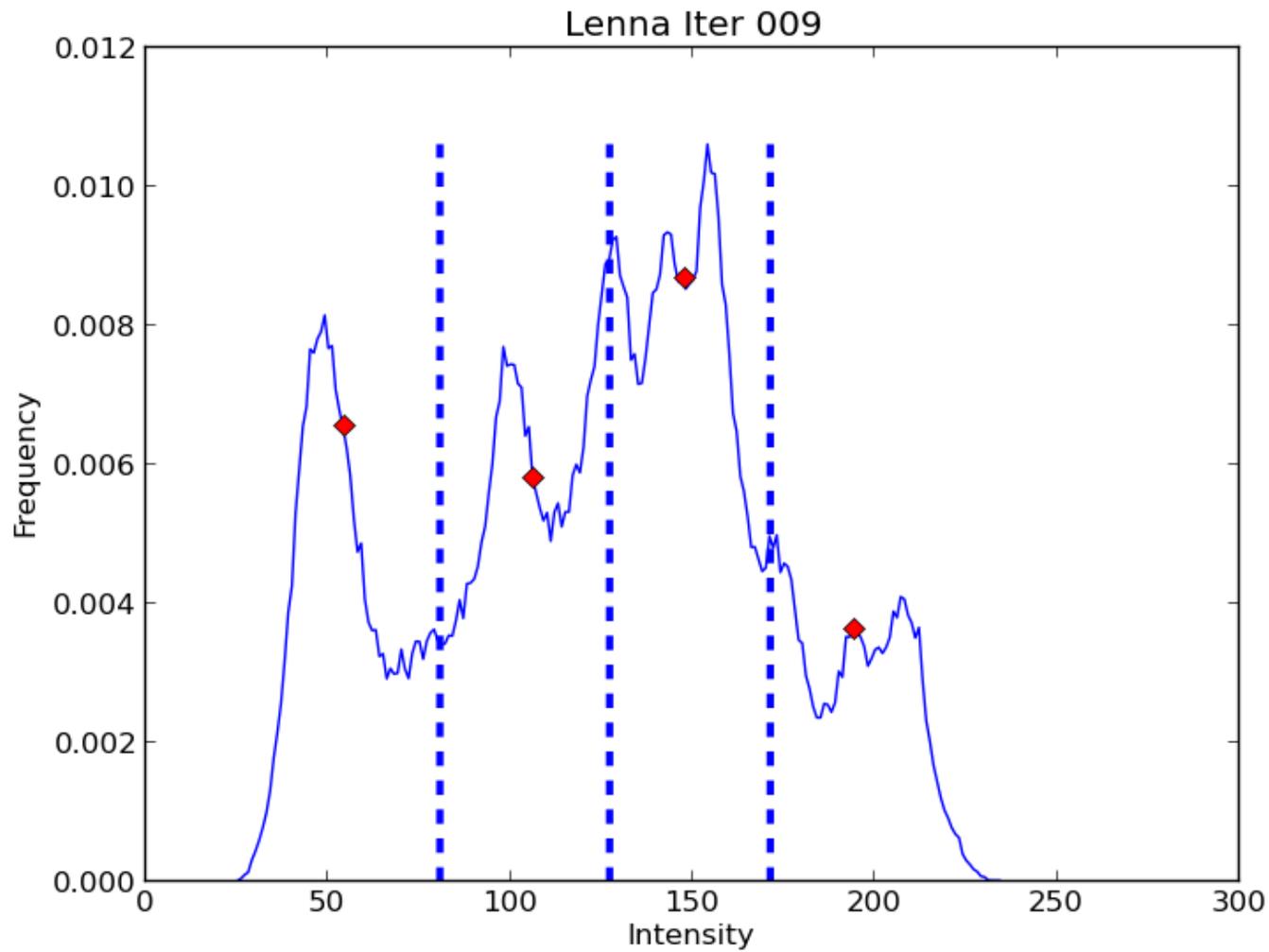
Lena (Iter 005)



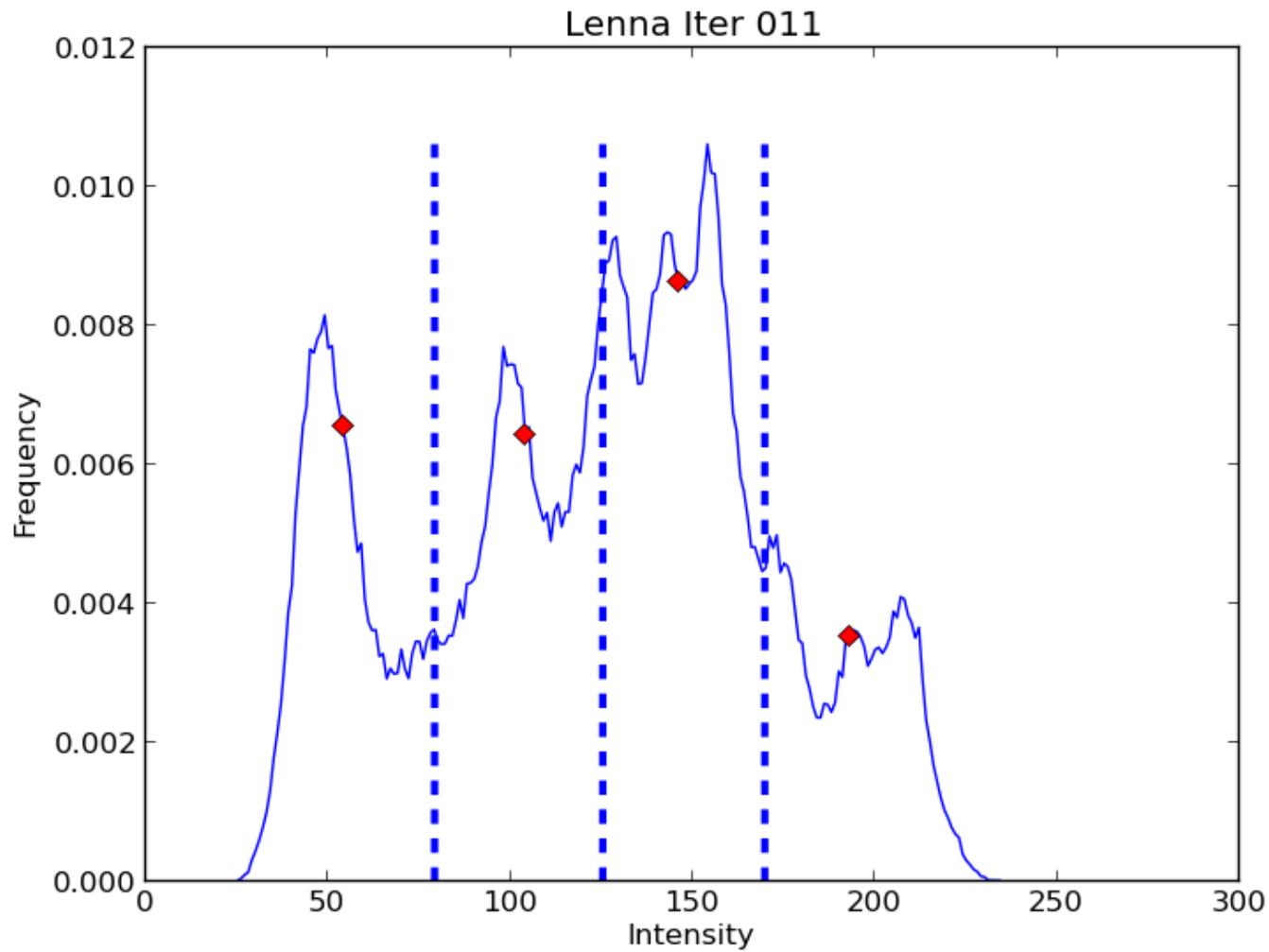
Lena (Iter 007)



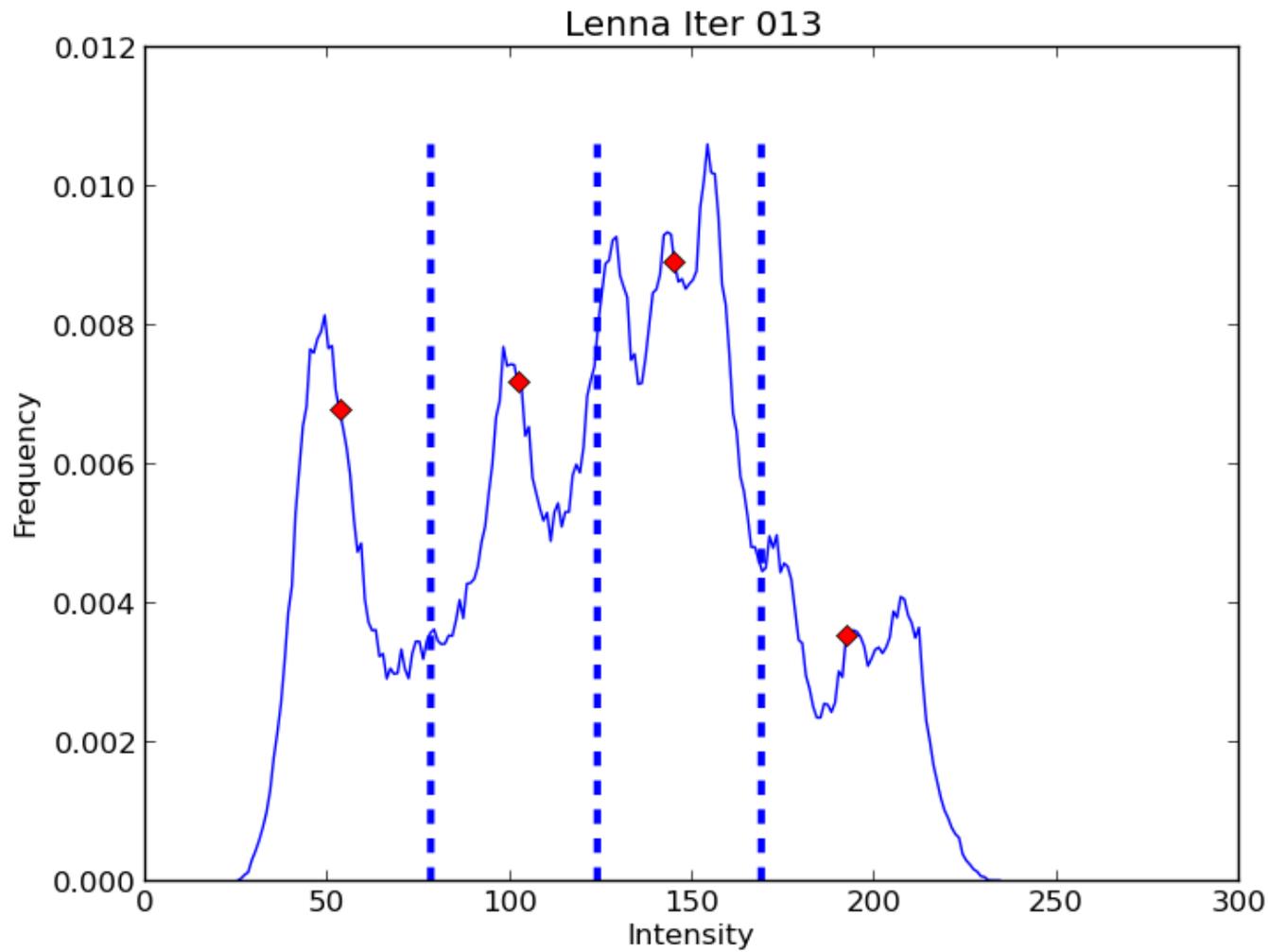
Lena (Iter 009)



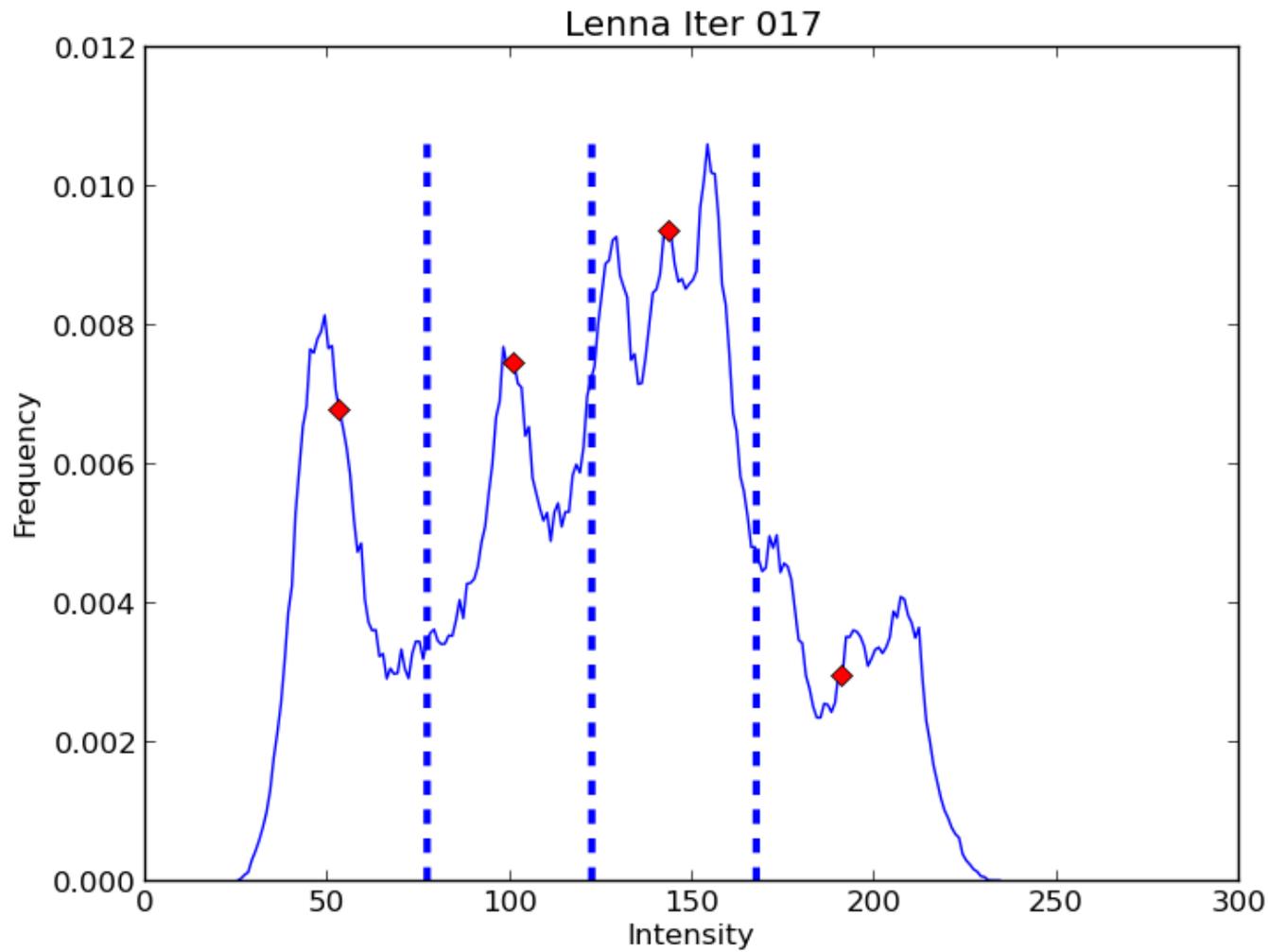
Lena (Iter 011)



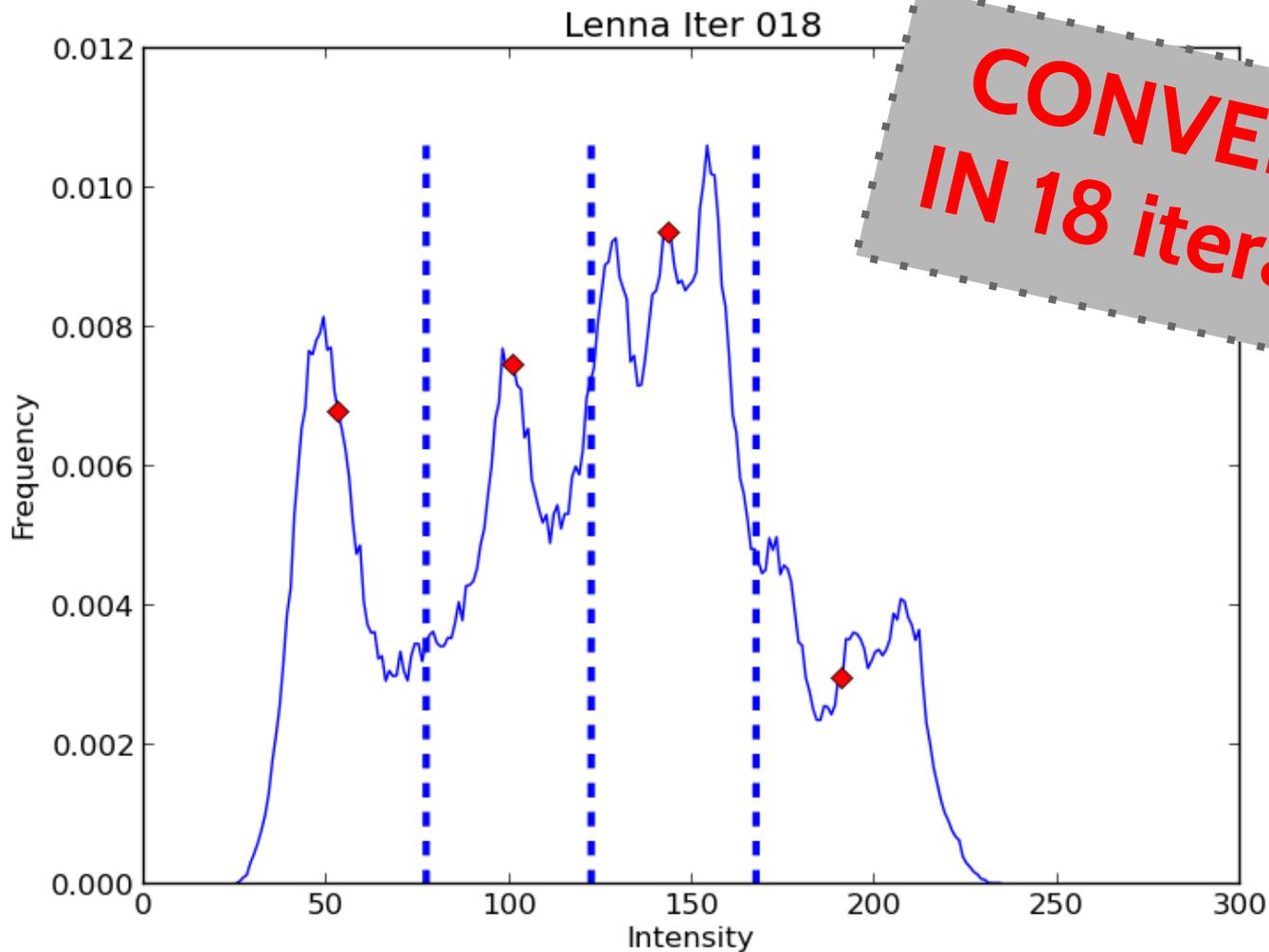
Lena (Iter 013)



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.