CS 663 : Digital Image Processing

Assignment 1

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Question 2

a) **Task:** to find a binary mask for given image

Strategy:

1. To create a resultant image with all zero intensities
2. Update the intensities if the intensity in the original image is more than a particular value (here 12)
3. Convert the array to image

Observations:

1. Due to presence of noise in image, the mask does not have sharp boundary

b) **Task:** To make a function for linear contrast stretching

Strategy: to create a function which maps from [0,255] to [0,255] and has three linear segments. We considered the three segments as

Segment 1 - (0,0) to (70,10)

Segment 2 - (70,10) to (190,250)

Segment 3 - (190,250) to (255,255)

For colour images this was done for each colour channel

Observation : This function allows us to create a contrast in image where the pixel intensities are very close to each other and can't be distinguished easily.
This creation of contrast happens in the region where the slope of line is more than one, on the other hand, in the region of slope < 1 the contrast of image becomes worse.
The contrast stretching is not useful for the image 5 as most of its intensities lie in the region of 1st and third line segment i.e. they are either very large or very small

c)**Task:** To create a function to do the histogram equalization on given image
Strategy:

1. Counting the number of occurrence of every pixel intensity
2. Finding the CDF of every probability intensity and equating it to the b
3. Multiplying b by 255 to get pixel intensities from 0 to 255 as initially b was from 0 to 1 (here b is the corresponding intensity to pixel intensities of original)
4. Creating the resultant image from b

Observations : histogram equalization gives better contrast than linear contrast stretching for all the images.
We applied the contrast stretching on every channel of color image
For image 5, we get better results than that of linear contrast stretching

d)**Task:** to create a function to do the histogram matching for an image w.r.t to given reference image
Strategy:

1. Similar to histogram equalization we find out the CDF for every pixel intensity
2. We try to find the nearest value of CDF for the second image
3. We replace the intensity of the pixel in the first image with the intensity corresponding to the closest value of its CDF from the reference image.
4. Same process is done for all the colour channels in colour images

Observations: we get the CDF of the original image very close to the CDF of the reference image. This function helps in manipulating the contrast of image as the user desires**.**

e) **Task:** Perform Contrast-Limited Adaptive Histogram Equalization (CLAHE) on give 4 input images. Also manually tune the window-size parameter and the clip-threshold parameter to appropriate values to achieve good contrast enhancement without introducing too much noise

Strategy: Used accelerated CLAHE algorithm for contrast enhancement.[1]
This is achieved by dividing the image into non-overlapping subsets of window size (smaller towards right and bottom borders) and calculating the CDFs for these windows. We can now bilinearly interpolate the equalized intensities for any pixel using neighboring windows' CDFs and the distances from the centers of those windows. This strategy avoids repeated computations and is significantly faster than the naive CLAHE algorithm.

For the 4 input images, the following things have been shown:

1. Comparison of the original image and contrast-enhanced image
2. Effect of increasing and decreasing window sizes on contrast enhancement
3. Effect of reducing threshold parameter on contrast enhancement

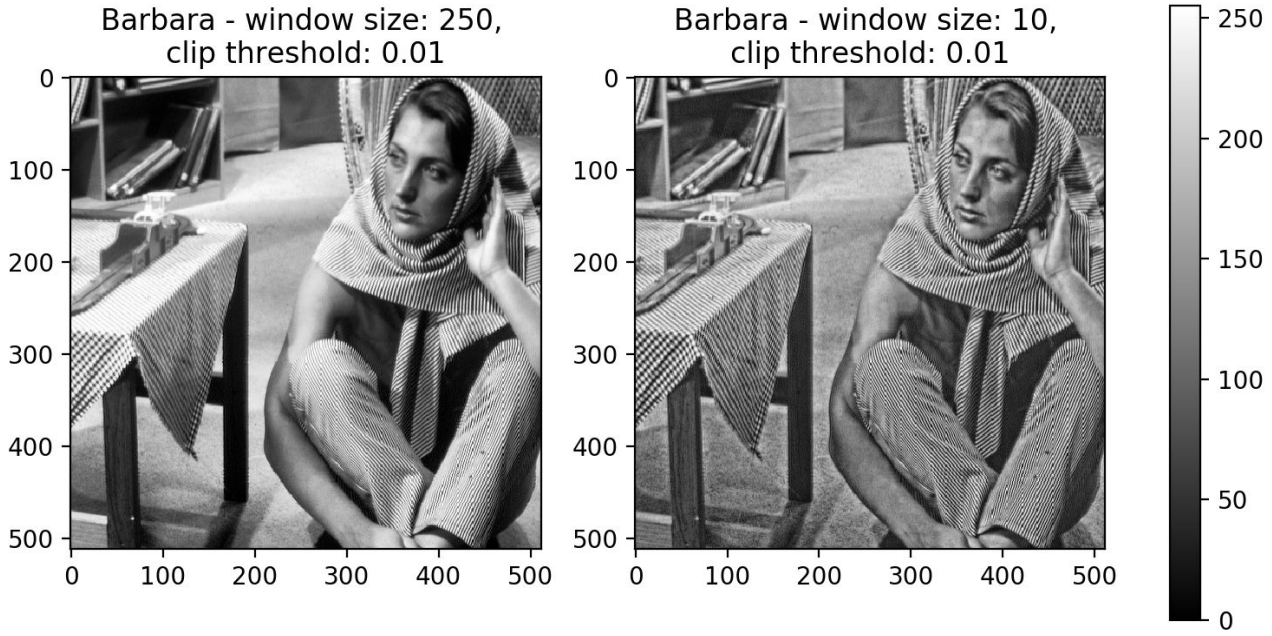
Observations:

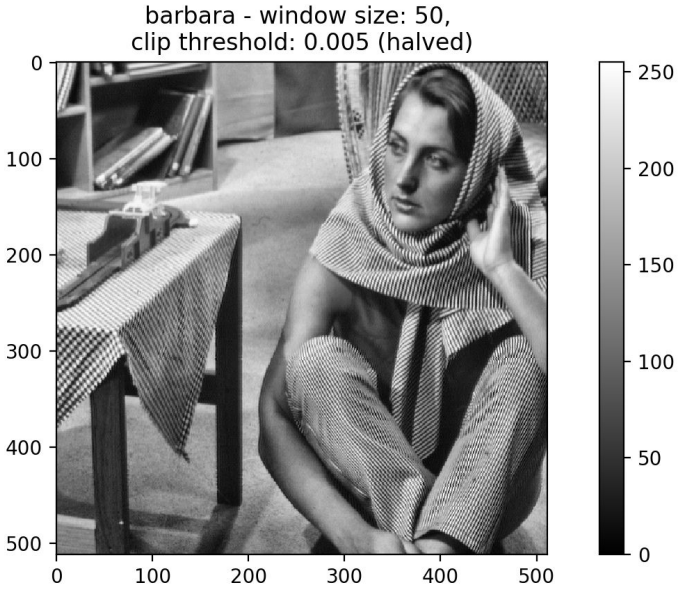
2. An increase in window size has shown to reduce local contrast enhancement but also reduces noise
3. A decrease in window size has shown to give stark local contrast but also introduces noise (which can be seen as a grainy and noisy image)
4. An increase in the clipping threshold has shown to increase noise in some cases due to increase in contrast amplification. So there appears to be a tradeoff here.

Small thresholds will give a more uniform clipped pdf and will reduce a mapping of a lot of pixels to the same intensity.

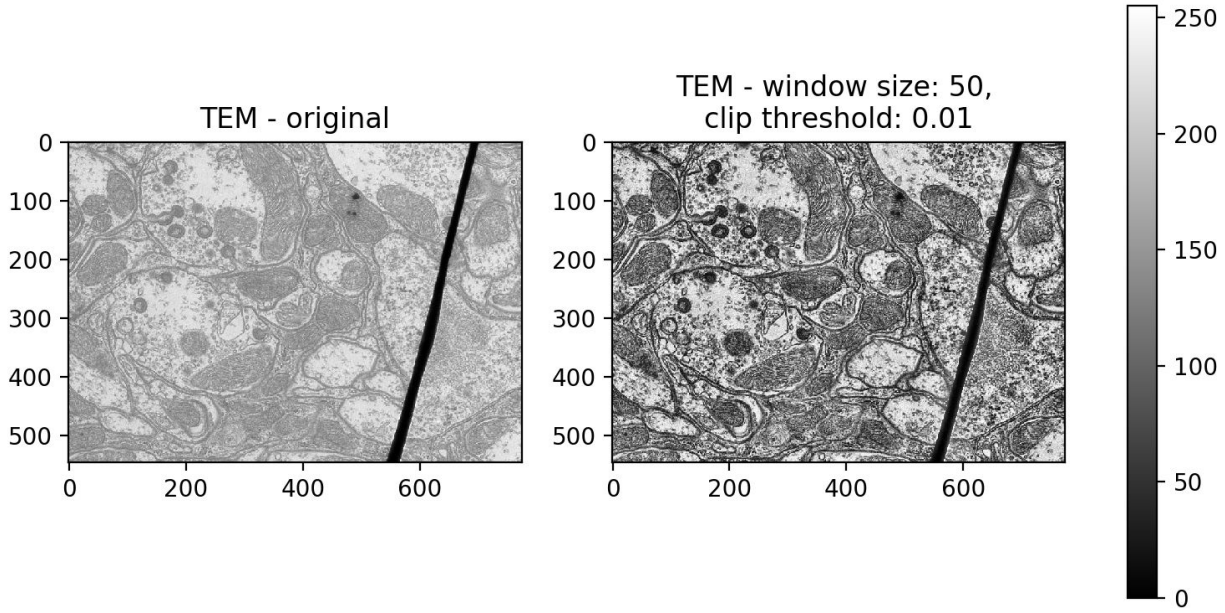
Output Images:

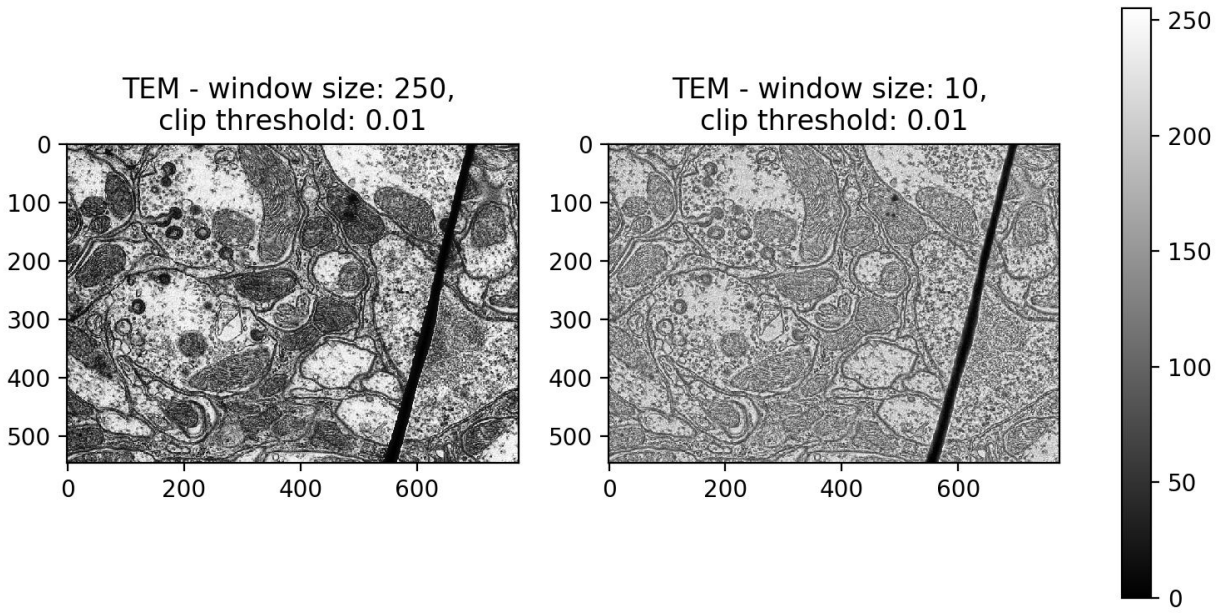
1. Input: `barbara.png`

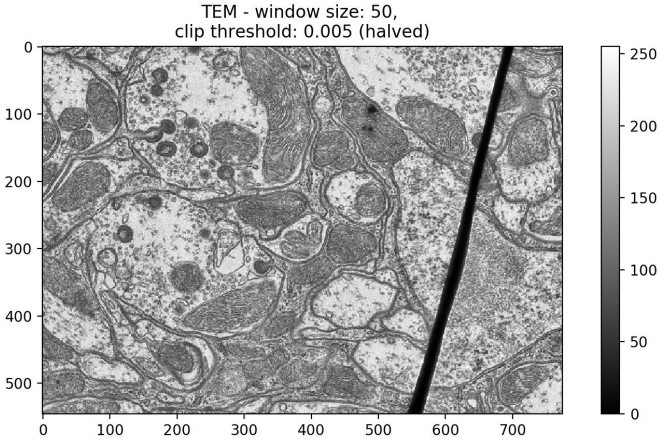

Barbara - window size: 250,
clip threshold: 0.01
Barbara - window size: 10,
clip threshold: 0.01
0
100
200
300
400
500
250
200
150
100
50
0


barbara - window size: 50,
clip threshold: 0.005 (halved)
0
100
200
300
400
500
250
200
150
100
50
0

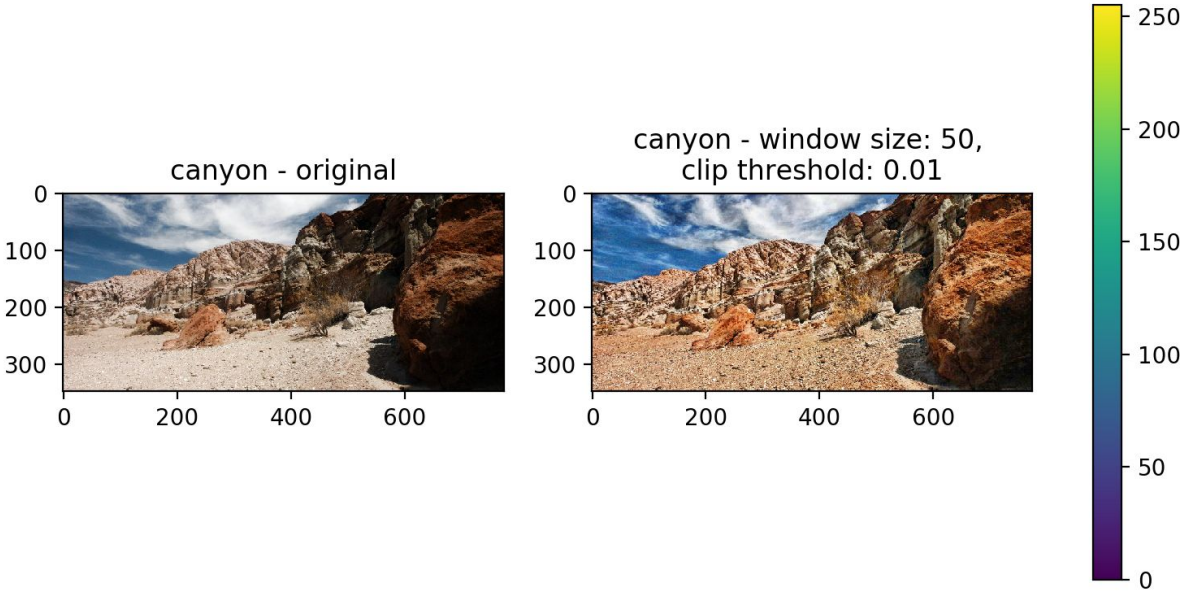
2. Input: `TEM.png`

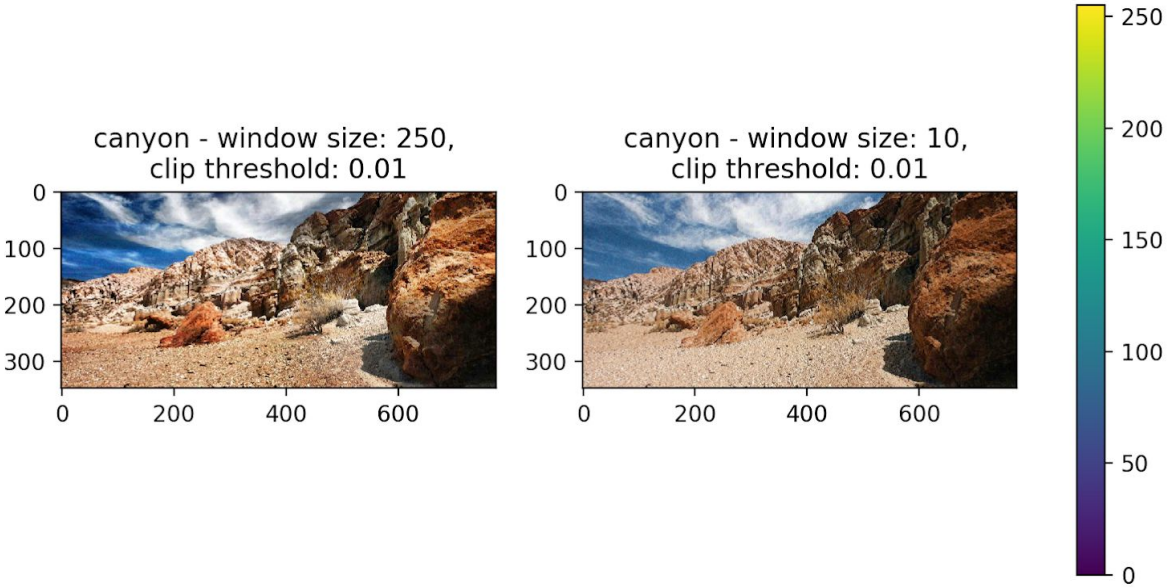


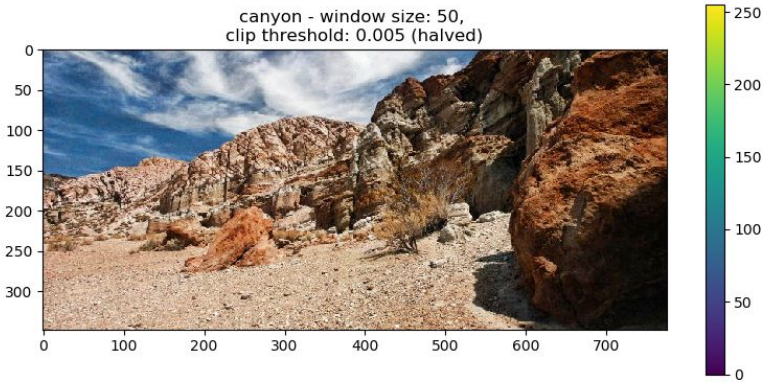




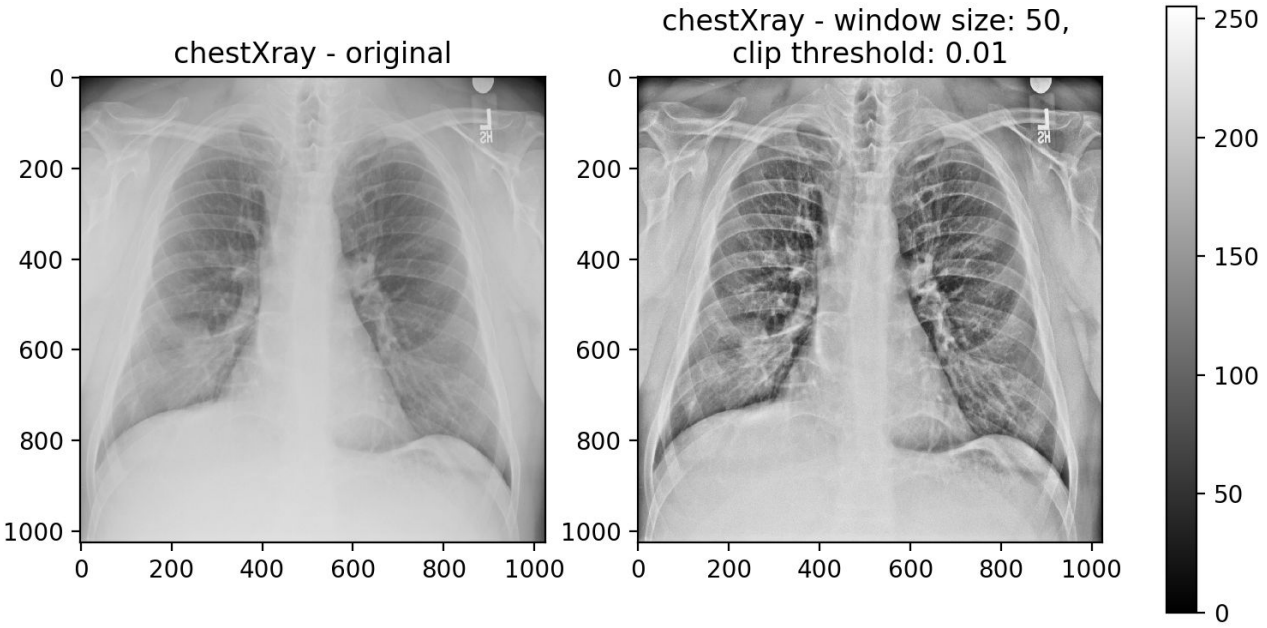
3. Input: `canyon.png`

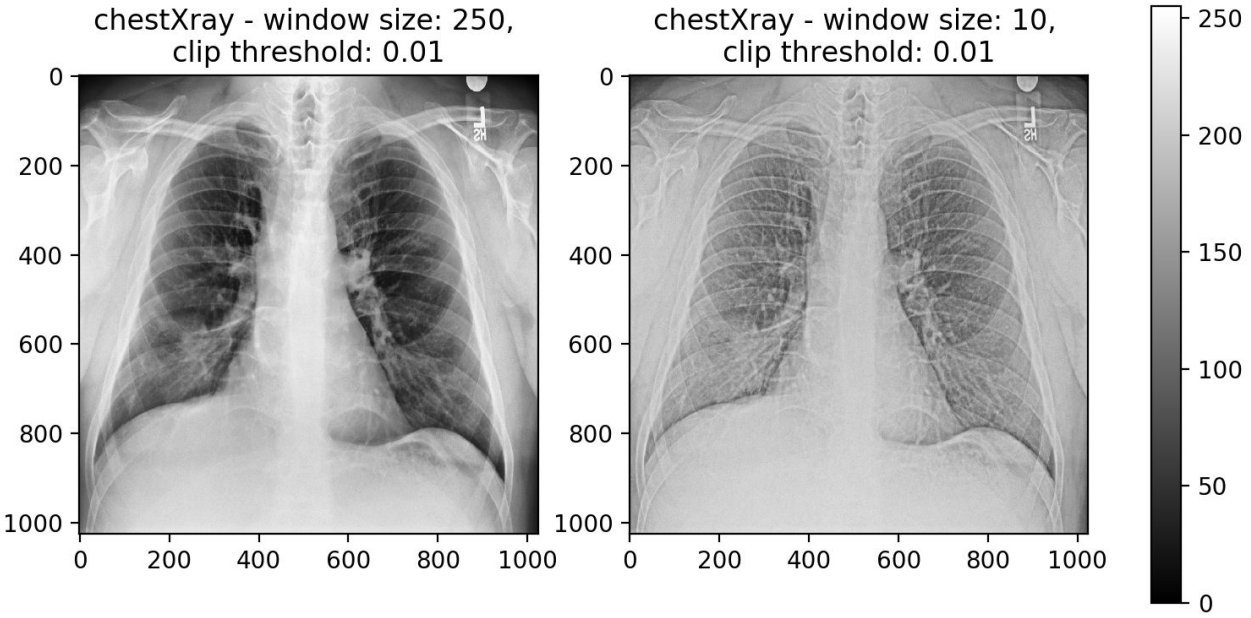


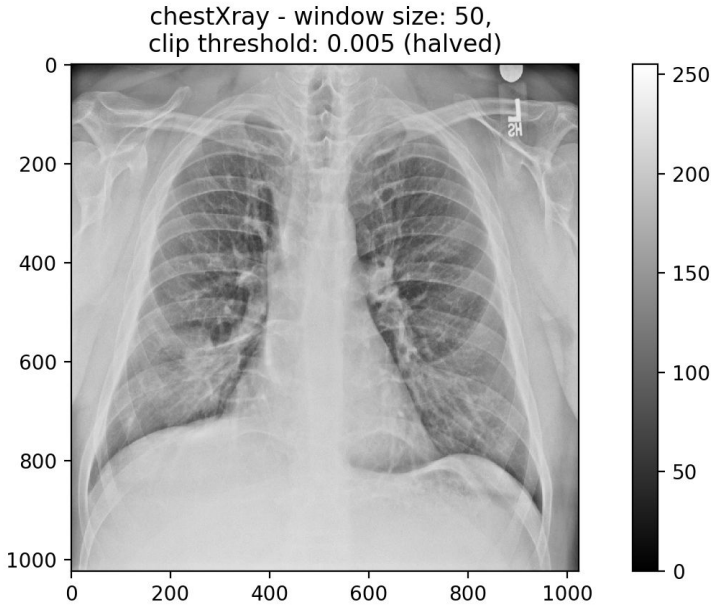




4. ChestXray.png







References:

[1] Pizer, Stephen M., et al. "Adaptive histogram equalization and its variations." Computer vision, graphics, and image processing 39.3 (1987): 355-368.