## 2 – Point processing

- <u>Image histogram</u>: open image **Oxford.tif** and type **h** (= *Analyze>Histogram*). Make sure you understand the meaning of the displayed parameters: Count, Mean, StDev, etc.
- Click on the buttons List, Log (logarithmic histogram) and Live (make a selection on the image and move it around; the histogram changes correspondingly).
- <u>Brightness & contrast adjustment</u>: Open image **Venice_lc.tif** and then type **SHIFT + c** (= *Image>Adjust>Brightness/Contrast*).
- Adjust brightness or contrast automatically (Auto button); reset the image to its original view.
- Only the displayed intensities are changed, not the pixel values (check this with **h**); in order to change the pixel values, you should click on the Apply button.
- Adjustment works by displaying all intensity values lower than *min* as *0* (= black) and all intensity values higher than *max* as *Max intensity* (= white). Values between *min* and *max* are linearly mapped into values between *0* and *Max intensity*. In our case, auto adjustment mapping function is the following one: *89 … 168 → 0 … 255*.
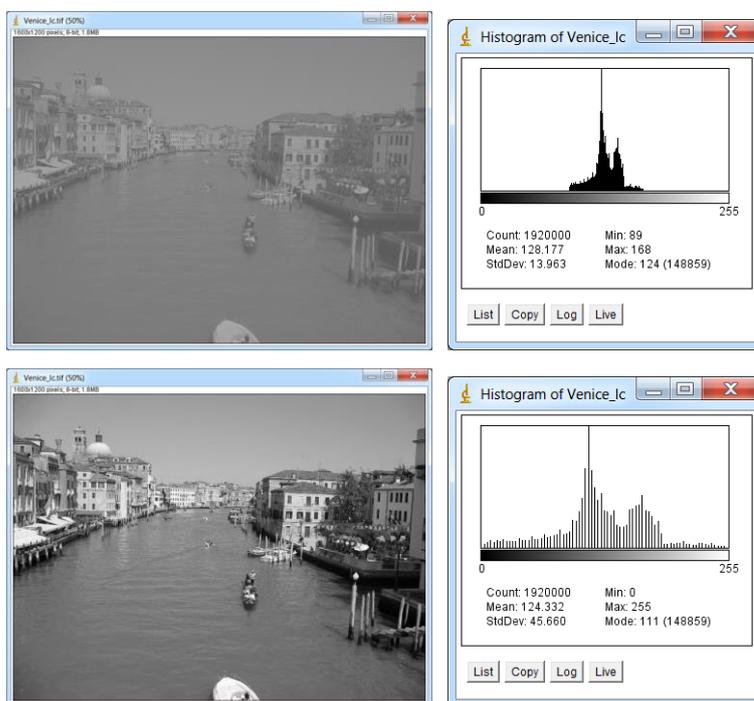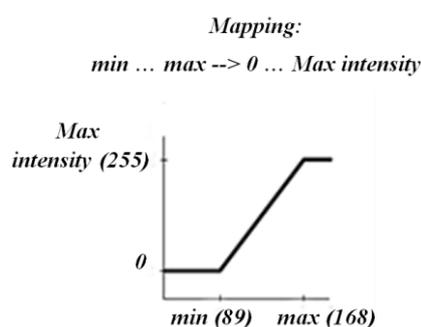


- For a non-linear input→output values mapping you can use e.g. Gamma function (*Process>Math>Gamma*): $V_{out} = V_{in}^{\gamma}$
- Experiment with shifting brightness or contrast sliders left or right; what is happening?
- The brightness adjustment simply adds or subtracts a constant value to every pixel leading to a histogram shift (left or right), but the distribution itself remains unchanged. Verify this with **h**.
    - Minimum/Maximum/Brightness adjustment of individual channels in an RGB color image: use *Image>Adjust>Color Balance* on **Flowers.tif** image.
- The contrast adjustment squeezes or expands the image histogram, i.e. changes the distribution of pixel values (= intensities). Verify again with **h**.
- <u>Contrast enhancement</u>: use image **Venice_lc.tif** again and select *Process>Enhance Contrast*.
- This dialog has several options:

o   Neither 'Normalize' nor 'Equalize histogram' is selected: the display is adjusted in a way, that the given number of pixels becomes saturated; the intensity values in the image are NOT changed.
   o   Option 'Normalize' is selected: a contrast stretching (normalization) is done. The result is very similar to that obtained with automatic brightness/contrast adjustment (see above); the intensity values are now changed.
   o   Option 'Equalize histogram' is selected: histogram equalization is performed; the other input in the dialog ('Normalize') is ignored.
- Local equalization: install the CLAHE plugin (http://rsbweb.nih.gov/ij/plugins/clahe/index.html) and test the operator on **boats.gif** (*File>Open Samples*) image.
- Arithmetic operations: these can be performed via *Process>Math* for adding (subtracting, multiplying, etc.) a constant to each image pixel or *Process>Image Calculator* for adding (subtracting, multiplying, etc.) two images. Use the latter command for detecting differences between the images **SchoolObjects.tif** and **SchoolObjects_2.tif** by subtracting the first one from the second one.
- Intensity thresholding: Open image **Blobs.tif**. To define a global threshold value, type **SHIFT + t** (= *Image>Adjust>Threshold*), choose one of the available algorithms and click on Apply. Thresholded image is now in a form suitable for ***Particle analysis*** (see https://sites.google.com/site/obdelavadigitalnihslik/primeri-uporabe/analiza-delcev)
- To see how severe is the effect of a particular thresholding method (i.e. the threshold value choice) on an (astronomical) image, select *Plugins<Examples<Macros<AutoThresholdingDemo*. These algorithms are accessible via *Image<Adjust<AutoThreshold*.
   o   Global thresholding is not always possible (check with **h** (=*Analyze>Histogram*)) – see the figure below!

Histogram = discrete frequency distribution, i.e. distribution of intensity values



Suitable for global thresholding          Adaptive thresholding needed
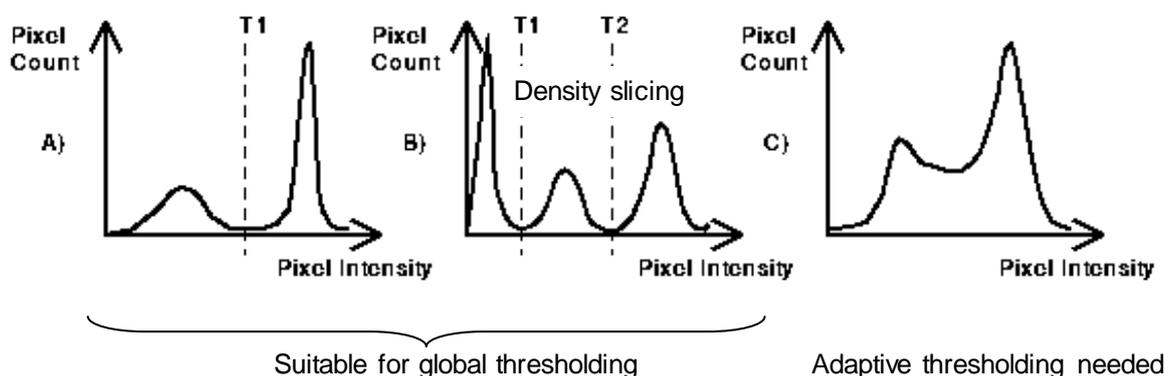
o   Using **Oxford.tif** image, try various adaptive (local) thresholding algorithms: *Image <Adjust<Auto Threshold* (Web: http://fiji.sc/wiki/index.php/Auto_Local_Threshold)
   o   Note that here the thresholding operation is performed examining a (small) window around a particular pixel, e.g. 7x7 region, rather than the whole image.