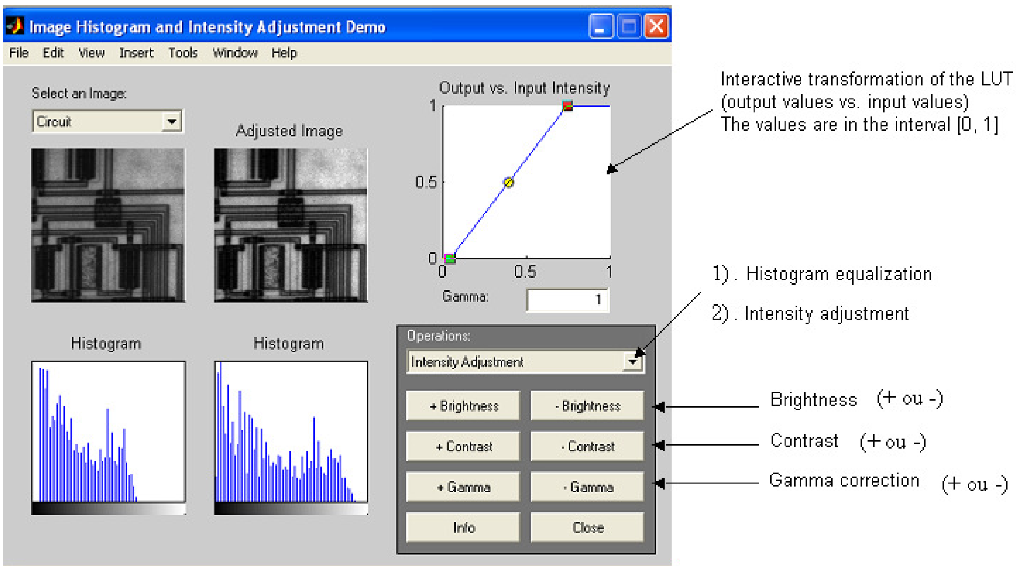
Exercise Chapter 2 – Histogram transformation

This exercise is mainly an observation exercise. You will use the demonstration ***imadjdemo*** (one of the Matlab image processing demonstrations) to see interactive image processing such as look-up table transformation, contrast adjustment, histogram equalization, etc.

Contrast Adjustment and Histogram

From the Matlab command window, you must type the command ***imadjdemo*** to launch the demonstration. The following window appears:



You can perform brightness and contrast adjustments, gamma correction and histogram equalization with the demonstration ***imadjdemo***. The corresponding LUT is plotted and you can visualize the effects directly on an image and its histogram.

Note : thanks to a LUT, you can change the display without changing the original data.

1 – Start by choosing the image "*Circuit*". Change the brightness. Interpret the results.

2 – Modify the contrast and gamma values. Interpret the results. Try to carry out these modifications on other images than the "*Circuit*" image and check your interpretations.

Histogram equalization

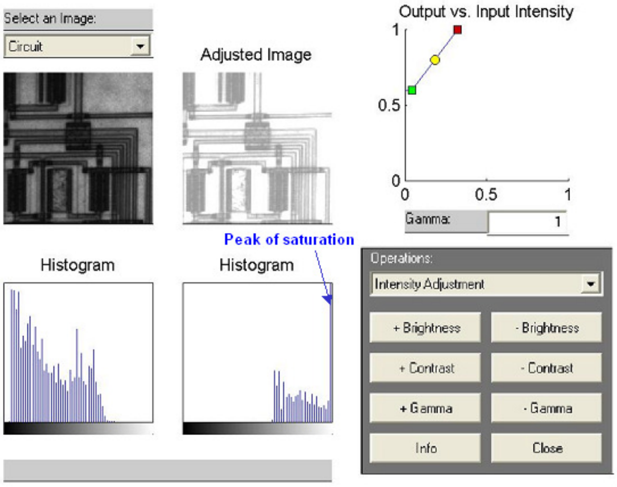
3 – By using the demonstration ***imadjdemo***, perform a histogram equalization. Visualize the effects on the image and its histogram.

4 – Use the Matlab help to display the description of the function ***histeq***. Load the grayscale image *CLOWN_LUMI* in your working folder then perform the histogram equalization with the function ***histeq***. Display and compare the images and the histograms before and after the histogram equalization.

Exercise solution: Histogram Transformation

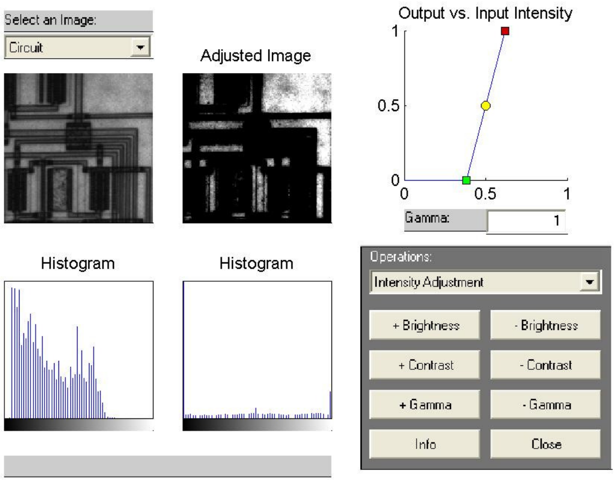
You will observe how an image is modified when you change some parameters such as the brightness, the contrast, and the gamma correction. The Matlab demonstration ***imadjdemo*** allows you to change these parameters interactively. You can then visualize the differences between the original image and the processed image. The demonstration displays also the image histogram and the LUT, you can thus interpret how the processed image is obtained.

1 – Here is the image *Circuit* before and after changing the brightness:



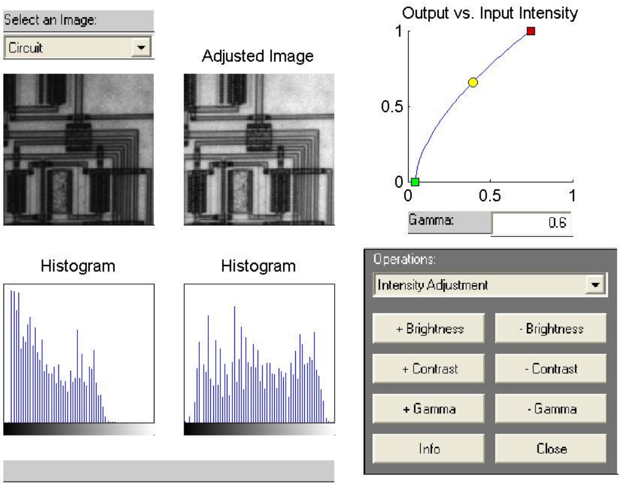
By increasing the brightness value, the LUT is modified so that the pixels which had low intensities have now a much more significant intensity. The pixels which have medium and strong intensity values are set to the maximal output level: 1 (saturation). The stronger the brightness value is, the more there are pixels with a low intensity which are set to 1. You can thus visualize on the histogram (after transformation) a strong number of pixels around the strong intensity values and a peak of population at level 1 due to saturation. The image thus appears “whitened”. By decreasing the brightness value, the image is “darkened" (inverse phenomena).

2 – By changing the contrast, we visualize the following result:



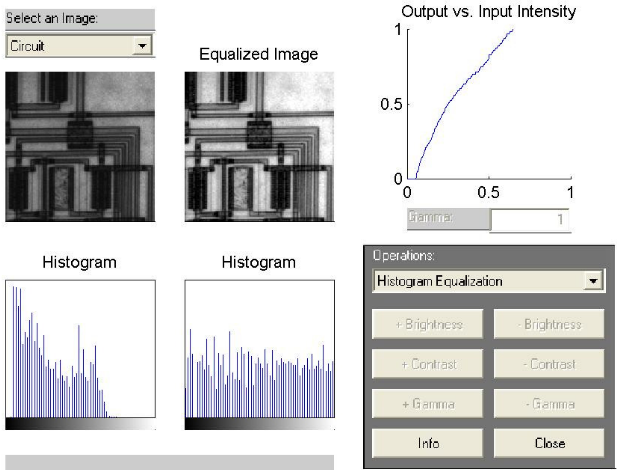
By increasing the contrast value, the LUT is modified so that the input pixels which have low intensity values are set to the minimal output level: 0 (saturation). The input pixels which have strong intensity values are conversely set to 1. For the non-saturated pixels, the gray levels are linearly scaled on the full range [0, 1]. The histogram is stretched and it has two peaks of population: one peak of pixels set to 0 corresponding to the saturation of the pixels which have a low intensity and one peak of pixels set to 1 corresponding to the saturation of the pixels which have a strong intensity. However the dynamic is linearly fully used for the other gray levels. The contrast is thus enhanced after stretching (for non-saturated areas).

By changing the gamma value, we visualize the following result:



The factor gamma represents the non-linearity of the light intensity reproduction. A cathode ray tube is naturally non linear: light intensity reproduced on screen is a non linear function of input tension. Gamma correction can be considered as a process which allows us to compensate these effects to obtain a faithful reproduction of the light intensity. Gamma effects are represented by functions $f(x)=x^{\gamma}$, where x is the input luminance value and γ is a real value in the range [2; 2.5] in the case of television applications. We must thus build a LUT: $g(x)=x^{1/\gamma}$ to compensate the gamma effects. The pixels which have low intensities in the original image are then set to stronger intensity values and the dynamic is increased. The details located in the dark areas are detected more easily than in the original image: the contrast is enhanced for these dark areas.

3 – Here is the result after having performed the histogram equalization:

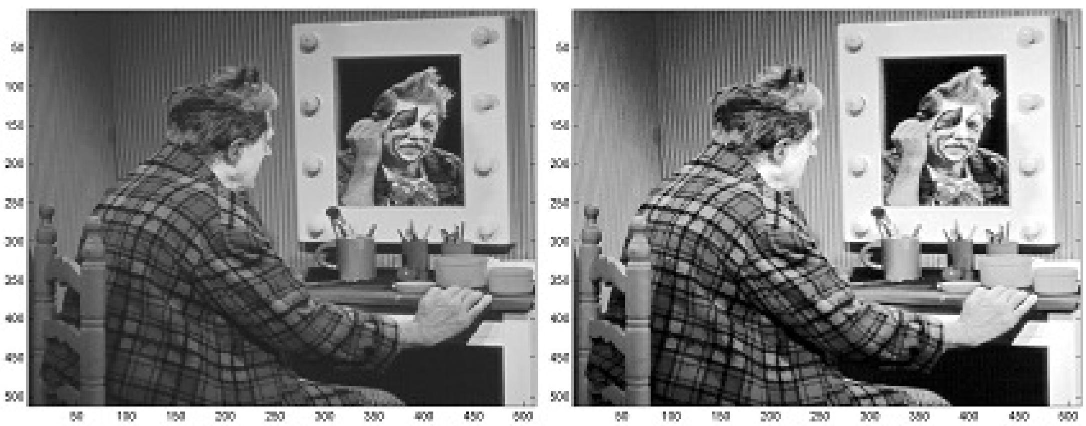


The histogram is almost uniformly stretched on the full range of the gray levels: each gray level is represented in the image by a constant number of pixels. The contrast of the processed image is also enhanced (histogram stretching).

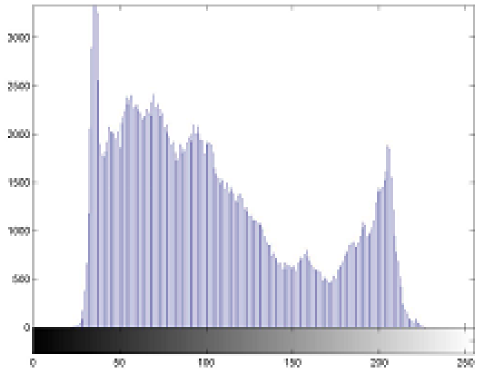
4 – We want to perform the histogram equalization on any image and without using the demonstration ***imadjdemo***. After having loaded the grayscale image *CLOWN_LUMI* in your work file, type the following commands to perform a histogram equalization and to display the results:

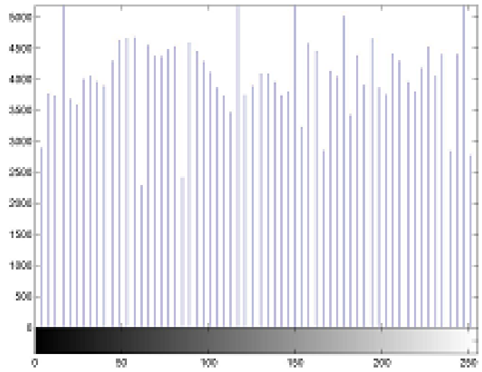
```
% a LUT to visualize an achromatic image in gray levels
r=0:1/255:1; g=r; b=r;
% Histogram equalization
I=imread('CLOWN_LUMI.BMP') ;
image(I)
colormap([r' g' b'])
figure
imhist(I);
J=histeq(I);
figure
image(J)
colormap([r' g' b'])
figure
imhist(J)
```

Here are the obtained images before and after histogram equalization:



The contrast is definitely more enhanced on the right hand image which is obtained after the histogram equalization.
Here are the histograms before (on the left) and after (on the right) performing an equalization:





The histogram on the right is almost uniform and a re-scaling is performed (range = [0, 255]).