# 1- Implementation

1.1- Read the images

After adding the paths with the folders that contain the medical toolbox functions and the evaluation functions, images will be read and temporally stored to work with them.

This step was done with a modification of a function in the package ‘NIfTI\_20140122’.

1.2- Skull removal

The skull removal was done by the use of a binary mask and the logical multiplication operation. It allows a quick and effective removal. Several tries were done before the use of this mask without a good performance.

1.3- Getting the peaks and the valleys

The main idea was to look for the peaks of the histogram and segment each region with the lower limits given by the valley value between two valleys. In a first approach it was tried to make an automatic peaks and valleys detection for each slice, having different thresholds for different slices. After analyzing the results, and taking into account that the properties of the tissues shouldn’t change in terms of image features, algorithm was change in order to obtain the peaks and valleys over the whole volume histogram. These values where much more logical and changes of slices didn’t give any discontinuous step for the same region anymore.

1.3.1- 3D histogram

To get the 3D histogram all the slices where set together, and the number of beams was given as the same number of grey levels were wanted, in this case, 256.

1.3.2- Smoothing the histogram

As the histogram was given by bars and the purpose was to look for maxima and minima of the whole values, a line that smooth the data was created, redefining the data for the histogram. The unique parameter to smooth the line was the number of points to consider in each step of the smoothing. For our case, 5 points were giving good results.

1.3.3- Peaks and non-maximum suppression

Each tissue is going to be represented in the histogram by a different normal function. Each of the peaks in the histogram should represent a different region, but is necessary to remove the neighbors. The number of neighbors to remove is the parameter to use in this case, and they were practically the same for a neighborhood of an interval between 15 and 71.

1.3.4- Valleys and lower limits

If the normal distributions were perfectly located one after the other, the valley between two different maxima will indicate the value of the threshold to change. In this case the valley will give a good approximation, but the superposition of the distributions makes much more difficult the search of the limit for each region. The final values for these limits where set with a certain offset around the valleys. This value was calculated empirically.

1.4- Setting labels for each region

Once that limits for each tissue were found, each pixel of each slice received a label according to its intensity level. That allows a representation of the segmented image and a posterior comparison with the ground truth.

1.5- Slicing and morphological operations

To fill the possible wholes inside a region or to remove any noise is necessary to apply morphological operations. As these operations are quite difficult to perform over the volume, it was needed to apply them over the sliced image. A simple closing operation with a square as the structural element was used to get better results. The size of this structural element (number of neighbors to consider) and its shape are the only parameters to set at this step.

1.6- Analysis of the results

Several metrics were measured to understand how good the algorithm was. To analyze the images the ground truth should be given and the function ‘sevaluate’ will return Jaccard index, Dice coefficient, false positive ration and false negative ratio.