For this project three approaches for Content Based Image Retrieval (CBIR) where implemented. The first approach is based on the comparison of color histograms, the second solution uses spectral histogram to do the comparison, of images and the third approach uses SIFT features to compare images.

1 Description

In this section the three methods used for CBIR are described.

1.1 Color histogram

In this method we used the color (intensity filter) histogram to compare images. The following steps summarizes the method:

1. **Image pyramidization.** The images sizes where reduced to half their size in order to speed up the algorithm. The method used to compute the pyramids is *Gaussian pyramid*, the first step of the Gaussian pyramid algorithm is to blur the image using a Gaussian filter, and then scale down the image by creating one pixel from the average color of four pixels.

2. **Compute histograms.** The number of bins used for this method is 256, for each color band.

3. **Compute histogram distances.** The distance between each pair of image histograms were computed using histogram intersection:

$$dist(hist_a, hist_b) = \sum_{i=1}^{256} \min(hist_a(i), hist_b(i)) \tag{1}$$

4. **Images similarity**. The distance between the histograms of the images was used as the *similarity* parameter.

1.2 Spectral histogram

This method uses spectral histograms for CBIR. The proposed steps for this method are the following:

1. **Image pyramidization.** The images sizes where reduced to half their size in order to speed up the algorithm. The method used to

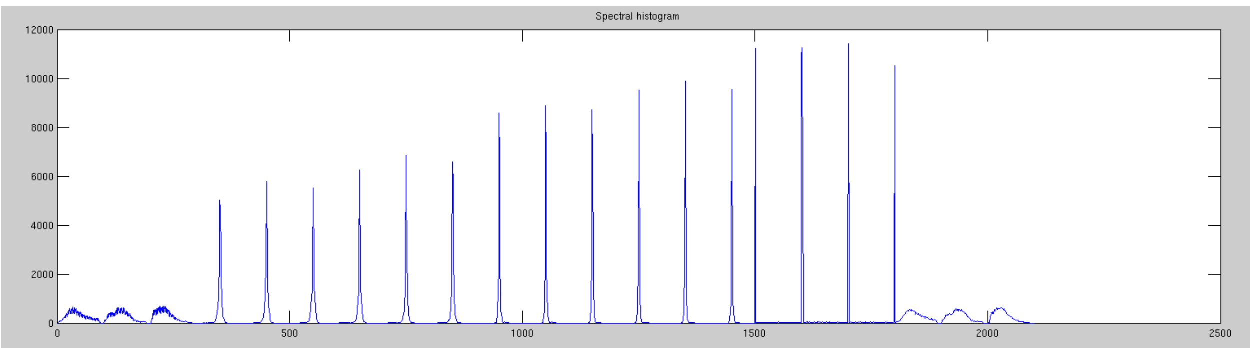
compute the pyramids is *Gaussian pyramid*, the first step of the Gaussian pyramid algorithm is to blur the image using a Gaussian filter, and then scale down the image by creating one pixel from the average color of four pixels.

2. **Filter images**. Six filters plus the intensity filter are applied to each of the images. The filters used and their corresponding masks are:

$$
\begin{aligned}
\frac{\partial I}{\partial x} &= [0 \ \ -1 \ 1] \\
\frac{\partial I}{\partial y} &= [0 \ \ -1 \ 1]^T \\
\frac{\partial I}{\partial x \partial x} &= [-1 \ 2 \ \ -1] \\
\frac{\partial I}{\partial y \partial y} &= [-1 \ 2 \ \ -1]^T \\
LoG(I(x,y)) &= (x^2 + y^2 - \sqrt{2\sigma^2})e^{-(x^2+y^2)/\sqrt{2\sigma^2}} \\
Gauss(I(x,y)) &= \frac{1}{2\pi\sigma^2} e^{\frac{-(x.^2+y.^2)}{2\sigma^2}}
\end{aligned}
\tag{2}
$$

For the Laplacian of Gaussian (LoG) and Gaussian filters the size of the filter used is 5 with a sigma value of 0.7.

3. **Compute spectral histograms.** The number of bins used for this method is 100, for each color band and for each filter. For all the filters the range goes from [0 256], even when the values of some of the filters may go from [-256 256]. Several options for the range of the histograms were tested, and the range of [0 256] gave the best results. The 100 bins are evenly splitted from [0 256]. Figure 3 shows an example of the spectral histograms.



4. **Compute histogram distances.** The distance between each pair of image histograms were computed using histogram intersection:

$$dist(hist_a, hist_b) = \sum_{i=1}^{100} \min(hist_a(i), hist_b(i)) \tag{3}$$

5. **Images similarity**. The distance between the histograms of the images was used as the *similarity* parameter.