Δ05 - Computer Vision 2018-2019
Assignment 4 – Keypoint Descriptors
Due Date: Sunday, January 20th, 2019, 11.59pm

In this assignment we will implement a function:

[Desc, Loc] = descriptor(image,x,y,s,o)

which takes at its input an image, the locations of the keypoints in the respective scale and their orientation and outputs the descriptor and the locations of the keypoints that correspond to the descriptor. Our goal in this assignment is to implement the descriptor for each keypoint. **You cannot use any publicly available code and you cannot obtain the keypoints/descriptors from an implementation you found online.**

For every keypoint (x_c,y_c) we build the descriptor as follows:

1. We obtain a sub-image of size 12*s_i times 12*s_i centered at the keypoint. If the sub-image exceeds the boundaries of the original image just discard it and move to the next keypoint.
2. If N keypoints pass this condition the descriptor that has to be found has to be of size 128xN.
3. In the obtained image consider a 16x16 patch centered on the keypoint.
4. Decompose this patch into 4x4 tiles. Thus, there will be (16/4)*(16/4)=16 such tiles
5. Compute a Gaussian of hsize, the size of the sub-image and scale 3*s_i. Its size will have to be the same with the sub-image because we're going to use it as a weight for the histogram in the next steps.
6. For each such tile, we compute a histogram of its pixels' gradient orientations with 8 bins, each covering 45 degrees
    a. For every pixel in the tile compute the magnitude and use it as the respective weight for each pixel
    b. Compute the weighted histogram in the window using as weights the magnitude times (element-wise) the Gaussian of step 4.
    c. Perform a circular shift in the histogram so as the bin that contains the respective orientation o_i appears first. For example if the current o_i is 55^o then this means that the 2^{nd} bin should appear first then the third whereas the first will have moved at the end. (Make sure that you perform the shift properly and that you work with degrees from 0 to 360).
7. This gives 16 tiles * 8 histogram bins/tile = a 128-dimensional vector representing our a SIFT feature descriptor
8. Normalize this to unit length, for better illumination invariance

9. Threshold (trim) the values in this normalized vector to be no larger than 0.2
10. Then renormalize again to unit length
11. Return the descriptor for every keypoint along with its location

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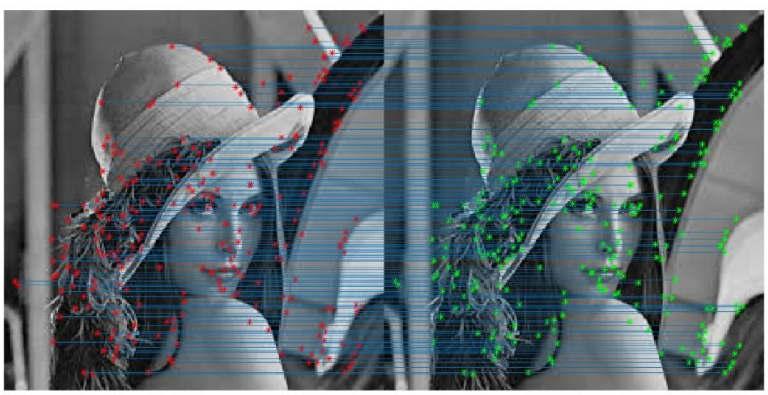
12. Having implemented this function the next thing that has to be done is given 2 images to compute their respective descriptors and compute the Euclidean distances between them. If the descriptor of the 1st image is $128xM_1$ and of the 2nd $128xM_2$ then the matrix that contains their distances should be M_1xM_2.
13. For every row in the above matrix compute the minimum (best matching SIFT feature) and the 2nd minimum value (2nd best). If the ratio of the closest distance to the 2nd closest distance is greater than a threshold then reject it as a false match, otherwise accept it. For the threshold, you may try values like 0.8, 0.85, and 0.9 and observe what keypoints are kept and their matching.
14. Only for the keypoints kept (you have to save their indices in both images) append the images one next to each other, plot the keypoints and the lines that connect them. (They have to start from the keypoint in the left image and go the respective in the right image. An example is shown below:



15. The images that you will use have 3 cases:
    a. At first, apply your algorithm to the same images so as to make sure that your code is working
    b. Then, apply the algorithm to a translated version of the first image
    c. Finally, apply the algorithm to a rotated version of the first image.
16. The images and their initial keypoints with the scale and orientations are provided as a text file.

- You should submit a report of what you did, containing sufficient details with images that support your findings. Include your code in the zip file you will submit.

- Please send your assignments to agiotis@cse.uoi.gr with the subject:
  - LastName_D05_Assignment_4
  - The name of your zip file should be LastName_D05_Assignment_4