Project 2: Pyramids & SIFT Features

Report

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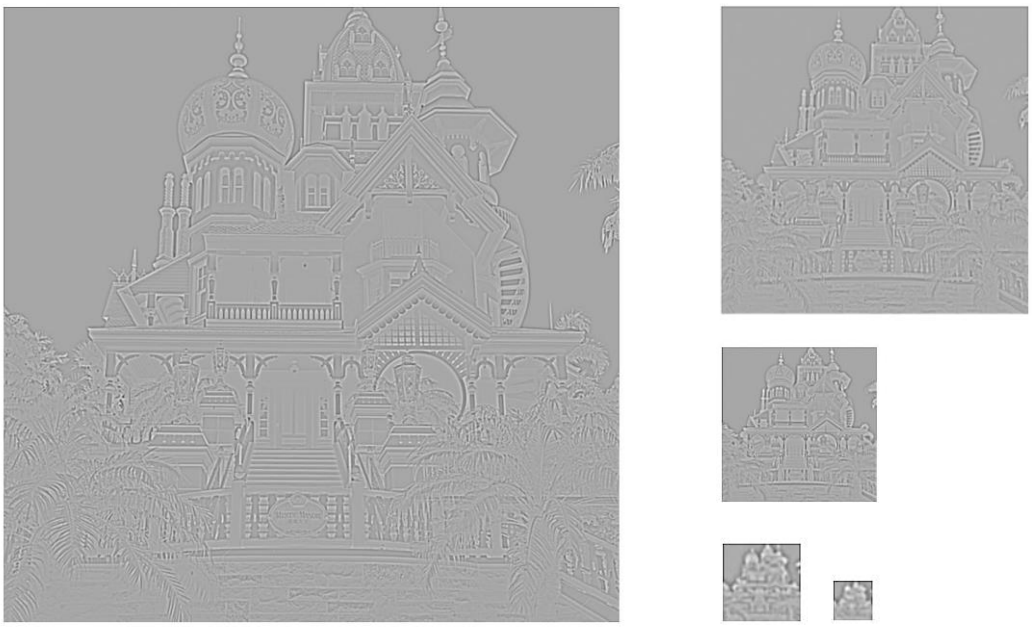
Question 1 – Gaussian Pyramid (7 levels)

Question 2 – Laplacian Pyramid (6 levels)



Important Remark:
In the following parts, the analyses are all done uniquely in the gray channel. i.e. the "value" of a point in the image is always in magnitude from ZERO to ONE.

Question 3 – SIFT Keypoints

Goal is to find local Max & Min in 3*3 grids of the current level and among the below and above levels.

In function *Q3_findkp(above, cur, below, sigma, threshold)*, we take the 3 levels, current level's *Sigma* and a threshold for parameters, looping across these 3 level to find the extrema in current level. We assure that the keypoints have at least some *minIntensity* and ALL of their neighbors have an absolute difference greater than *threshold* than the keypoints' values (i.e. the minimum absolute difference between the keypoint and its neighbors are greater than the *threshold* value).

Note that here, from Lecture 9 slides 28, the indexes of above, current and below level are L-1, L and L+1 respectively. Hence, we treat the upper level with smaller *Sigma* and the lower level with larger *Sigma*.

Also note that the greater the radius of the circle, the greater the *Sigma*.

And for the border case of keypoint level 5, theoretically we should make comparisons among DoG level 4,5 and 6. But since we got only Laplacian pyramid from level 0-5 (6 in total), we here assume the DoG level 6 is approximately *im6*.

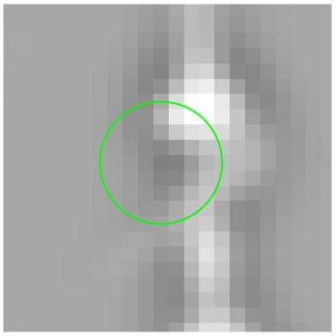
Here, we give an example to show the SIFT keypoints with some thresholds:

Question 4 – SIFT gradient

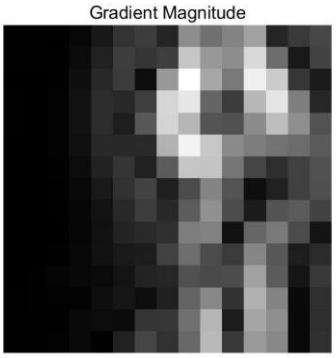
Here, I use the window of size 15*15 for computation and I choose the Gaussian *Sigma* equal 1.5 for the weighted gradient magnitude.

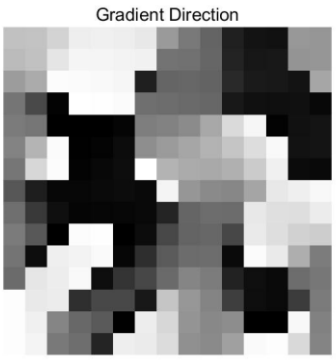
The following is some copies I made to show the keypoint, which I selected for illustration, both in the original image and in its Laplacian graph of its own DoG level (i.e. with a *Sigma* = 4, Green circles in the previous question).

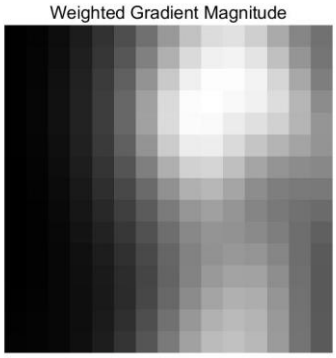




And here are the graphs that I computed to illustrate the gradient (15*15):

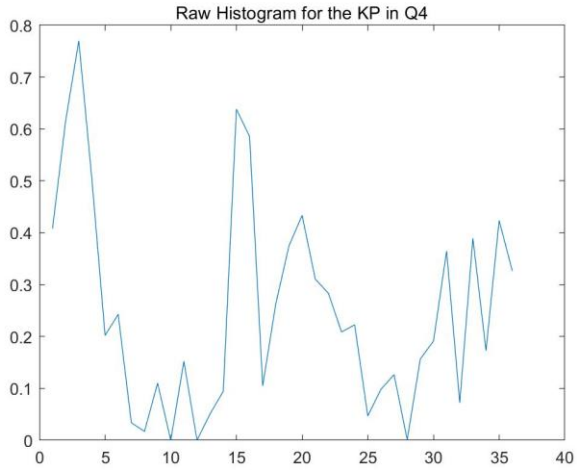




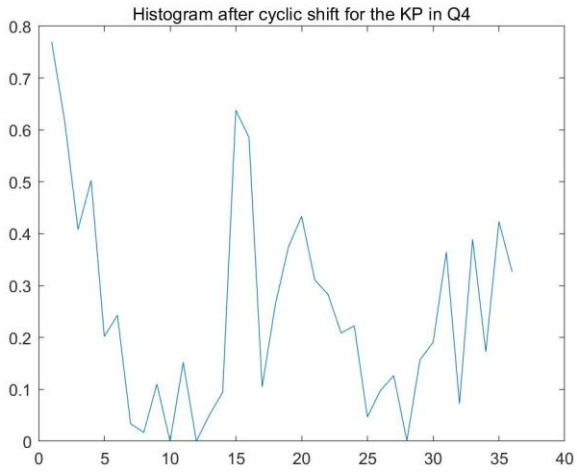


Question 5 – SIFT feature vectors

For the order of magnitude of data, please recall the previous remark.



The following is the histogram after *findpeak* & CCW cyclic shift:



Question 6 – SIFT feature vectors

Original Image

Center at (450,650); Scaling at 1.5;
Rotation of 60deg CW

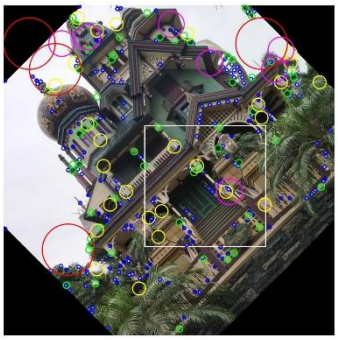
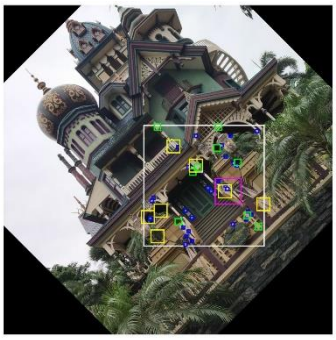
Center at (500,500); Scaling at 1.2;
Rotation of 45deg CCW

Center at (500,450); Scaling at 0.8;
Rotation of 45deg CCW

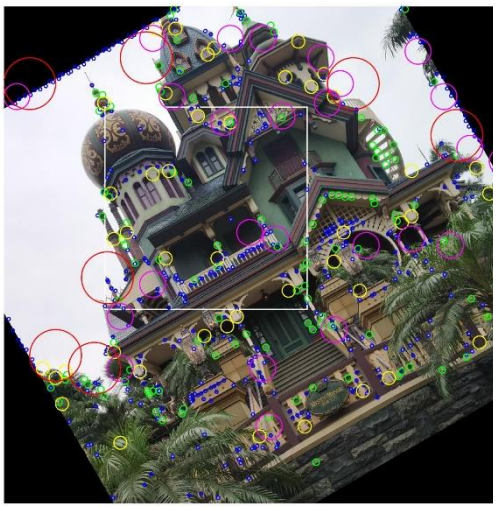
Here we have three examples of the transformed images. The rotation center is showed in magenta in each image.
Note the all of these images are zoomed in/out in equal proportion to fit the size of page.

Question 7 – Compare Histogram

Here, goal is to select SIFT keypoint which maximizes the Bhattacharya coefficient, in other words, minimizing the Bhattacharya distance.
We took the Bhattacharya distance less than 0.04 in both cases to select the points which match the points **almost perfectly** in the original picture. (Run Q7_im1 & Q7_im2)

In this case, we get almost all feature points perfectly matching. Some points may also possibly have a Bhattacharya distance extremely small with a keypoint in different level in original picture.




Here, we still get almost all feature points perfectly matching. Some points in level with color magenta are eliminated.
In conclusion, we get a decent SIFT detector.

Question 8 – Discussion

For an arbitrary SIFT keypoint, we may need to choose some appropriate Euclidean distance to classify several nearby SIFT keypoints in our “Neighbor Candidates”, even if these neighbor points may have undesired Bhattacharya distance. Than we do other comparisons with the original graph, if some of these points may located almost along the lines, or the directions of each “isolated” and “matching” keypoint, we may also vote for them to be the keypoints that we want.