Computer Vision 1: Assignment 4
(Due date: 29.01.2021)

Submission instructions:

- For each programming task, submit a `.py` source code file. Do not need to include any images or data files you used.
- For each pen & paper task, submit a `.pdf` file. Type your solution in LaTeX, Word, or another text editor of your choice and convert it to PDF – **do not submit photographs or scans of handwritten solutions!**
- In all files, include at the top names of all students in the group
- Choose exactly one person in your group that submits your solution via Moodle, it will count for the entire group.

Task 1: SIFT (pen & paper)

Explain why $r = \frac{\alpha}{\beta} > 0$, with α, β being the eigenvalues of the Hessian matrix at a keypoint. Using this result, prove that when $r > 0$, the function $f(r) = \frac{(r+1)^2}{r}$ has a minimum at $r = 1$.

Task 2: ORB Feature Detectors (programming)

ORB is a fast and efficient alternative to SIFT. Download and read the image `Elbphilharmonie.jpg` on Moodle.

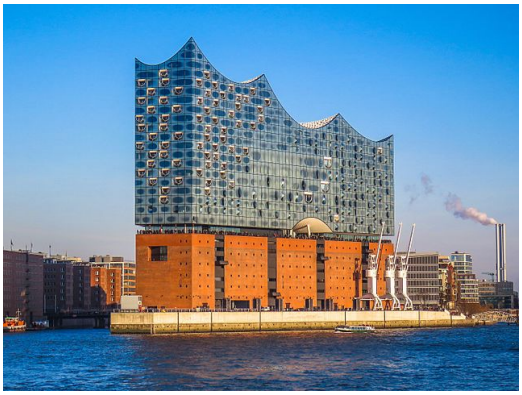

Figure 1: Hamburg Elbphilharmonie. Image source: Wikipedia

- Convert the image to grayscale image `im`.
- Using `skimage.transform.AffineTransform`, obtain a transformed image `im2` with the following parameters: shrink the dimensions by half, 20 degree counter-clockwise rotation, 300 pixels to the right and 300 pixels to the bottom translation.
- Visualize the images `im, im2`.
- Using `skimage.feature.ORB`, extract 100 ORB key points and descriptors of the two images above. Visualize the matching results.

  Note: Follow the example at `http://scikit-image.org/docs/dev/auto_examples/features_detection/plot_orb.html`.

Task 3: SIFT (pen & paper)

Consider Figure 2, which shows a normalized orientation histogram for a SIFT keypoint after weighting[1].

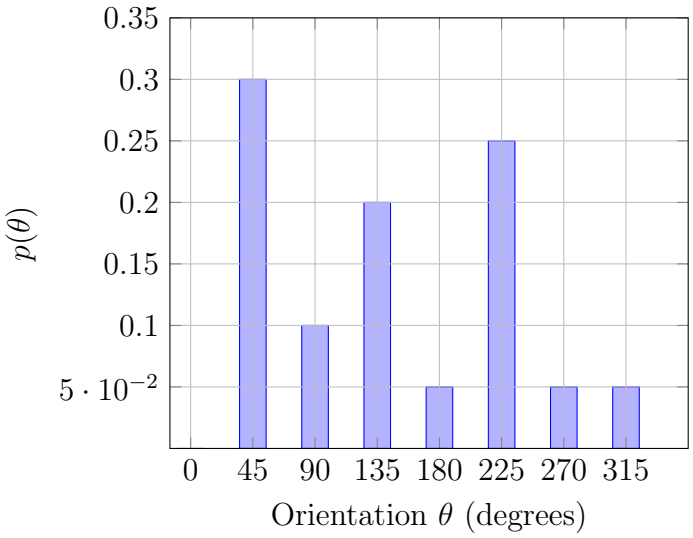

Figure 2: A normalized orientation histogram of a SIFT keypoint.

(a) What is the dominant local direction of the keypoint?

(b) How many new keypoints will be created, and why? What are their orientations?

[1]For simplicity, we consider an 8-bin orientation histogram. In the original SIFT algorithm, 36 bins are used.