

# CS512 Assignment 3

## Report

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### 1. Problem Statement

In this assignment, I implemented the Harris Corner Detection based on Python and OpenCV.

### 2. Proposed Solution and Implementation Details

#### Harris Corner Detection

1. Compute x and y derivatives of image

$$I_x = G_\sigma^x * I \quad I_y = G_\sigma^y * I$$

2. Compute products of derivatives at every pixel

$$I_{x2} = I_x I_x \quad I_{y2} = I_y I_y \quad I_{xy} = I_x I_y$$

3. Compute the sums of the products of derivatives at each pixel

$$S_{x2} = G_{\sigma'} * I_{x2} \quad S_{y2} = G_{\sigma'} * I_{y2} \quad S_{xy} = G_{\sigma'} * I_{xy}$$

4. Define at each pixel (x,y) the matrix

$$H(x, y) = \begin{bmatrix} S_{x2}(x, y) & S_{xy}(x, y) \\ S_{xy}(x, y) & S_{y2}(x, y) \end{bmatrix}$$

5. Compute the response of the detector at each pixel

$$R = \text{Det}(H) - k(\text{Trace}(H))^2$$

6. Threshold on value of R. Compute non-max suppression

#### Corner Localization

Find the centroids of the corners found by harris detection, then use

$$P = C^{-1}V$$

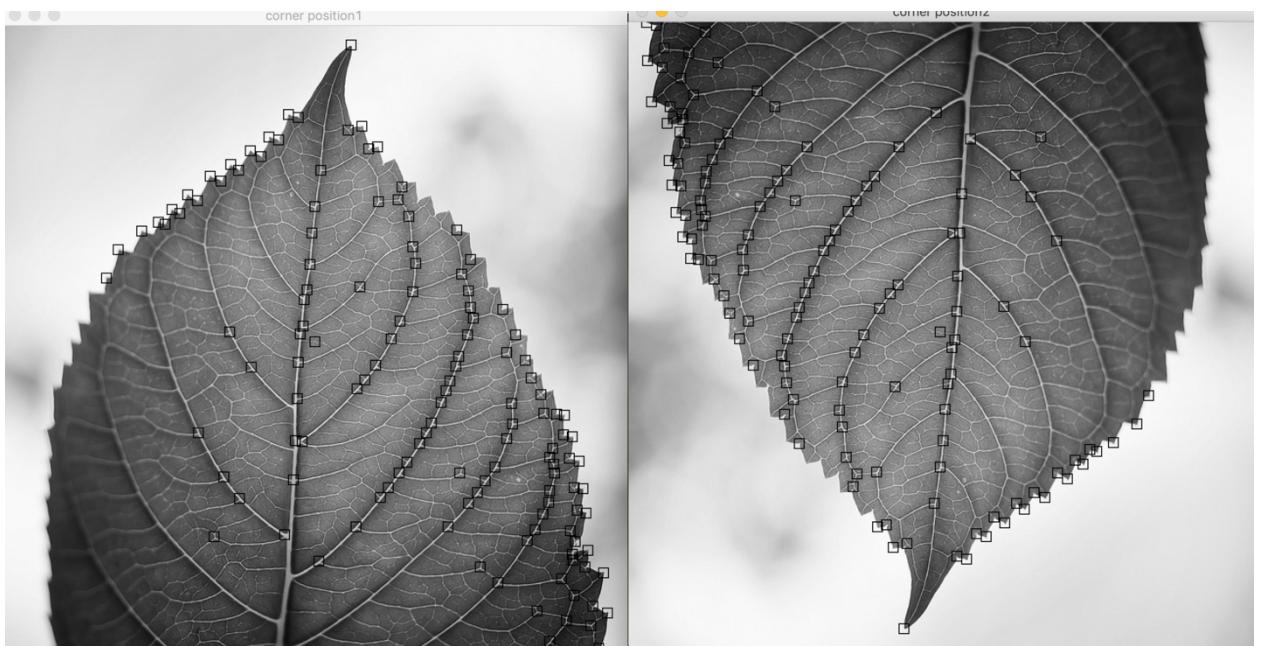
$$\text{, where } C = \sum_{i=1}^n (\nabla I_{xi}(\nabla I_{xi})^T)^{-1} \quad V = (\nabla I_{xi}(\nabla I_{xi})^T)x_i$$

to find a better location for each corner.

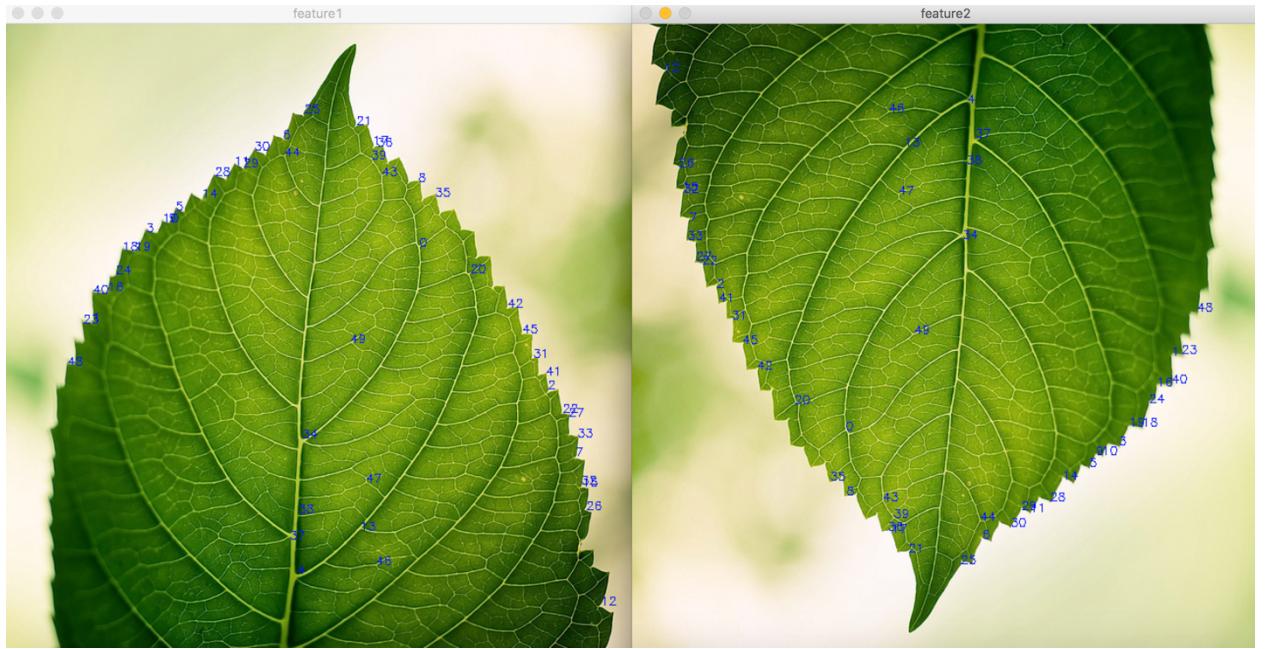
### Feature Matching

Use cv2.ORB function to compute feature vectors and match each corner point with each other. Note: I only numbered the first 50 corner points in the two images because points of interest are too many to number them all, otherwise it's very hard-recognizable.

## 3. Results and Discussion



This is the screenshot of corners detected by Harris algorithm and localization.



This is the screenshot of each corner with numbers on it.

Note: I only numbered 50 corners, otherwise the whole image would be very messy and hard to recognize.

#### Discussion:



After changing the threshold value from 10 to 20, the Harris Corner Detection finds less corner points than the previous attempt.

## 4. References

1. HarrisCorner <https://github.com/hughesj919/HarrisCorner/blob/master/Corners.py>
2. Harris Corner Detection [https://docs.opencv.org/3.0-beta/doc/py\\_tutorials/py\\_feature2d/py\\_features\\_harris/py\\_features\\_harris.html](https://docs.opencv.org/3.0-beta/doc/py_tutorials/py_feature2d/py_features_harris/py_features_harris.html)
3. Feature Matching [https://docs.opencv.org/3.0-beta/doc/py\\_tutorials/py\\_feature2d/py\\_matcher/py\\_matcher.html](https://docs.opencv.org/3.0-beta/doc/py_tutorials/py_feature2d/py_matcher/py_matcher.html)