Visual Perception Lab 1 - Harris Corner Detector

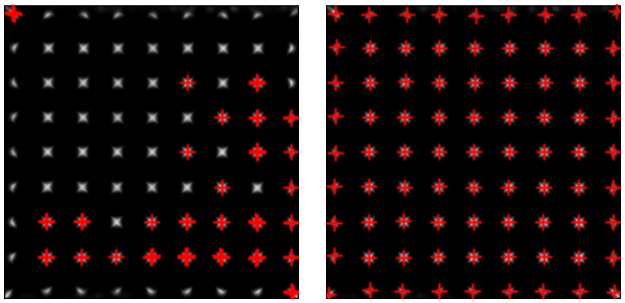
Songyou Peng
psy920710@gmail.com

I. INTRODUCTION

In this report, we will not mention the algorithm step of Harris corner detector or the answers of the questions that the professor asked during the lab. Instead, we will briefly talk about some implementation details, including our way of non-maximal suppression and sub-pixel accuracy. Besides, we found out a proper pre-processed gaussian smooth filter is very important for the final result. Some examples will be used to illustrate all the aspects mentioned before.

II. NON-MAXIMAL SUPPRESSION

After acquiring matrix E (or R), where every element corresponds to the lower eigenvalue of M matrix, we sort all the pixels of E in descent order based on the pixel values. There are 81 intersections in chessboard image. However, if we just keep the 81 pixels with highest values, the image would be like in Fig. 1(a), where many high values crowd in only several intersections.



(a) (b)

Fig. 1. Illustration for the apply of non-maximal suppression

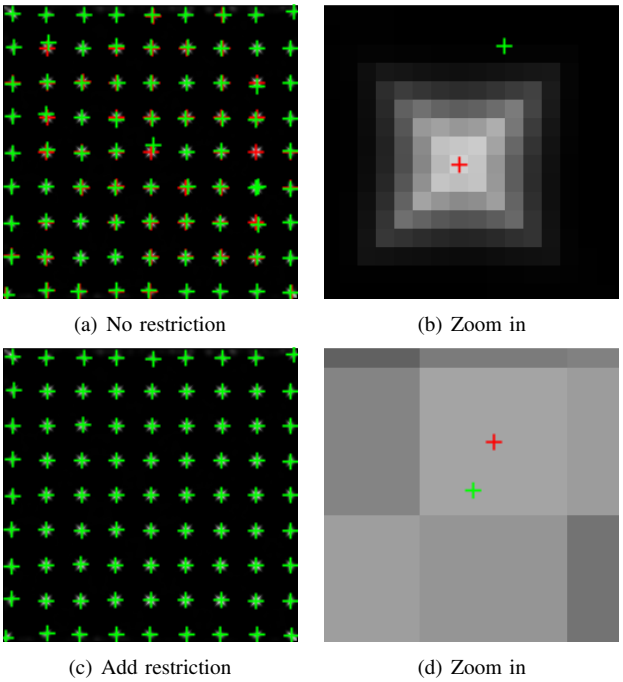
In order to solve the problem, we introduce non-maximal suppression. Our algorithm is as follow: First we start from the pixel with highest values in the image, and set all the values within a 11×11 window in E to 0. And then we check all the neighbors in the window of the pixels according to the descent order of pixel values. If the current pixel has not been set to zero, which means it is not within the window of a higher value pixel, we keep the value of the pixel, otherwise we just skip to the next pixel. The result is shown in Fig. 1(b).

III. SUB-PIXEL ACCURACY

In order to have more accurate corner results, we use the formulation below to fit a paraboloid:

$$ax^2 + bxy + cy^2 + dx + ey + f = I$$

We use a 3×3 neighborhood of corner points to get all the parameters by using least mean square method. As for some details of implementation, first of all, we will not consider sub-pixel accuracy if a or b is smaller than zero because the quadratic form will only have a minimum in this case [1]. Besides, as mentioned in [2], there is no minimum or maximum when $4ac - b^2 < 0$ as it is a hyperbolic paraboloid. Even if having these constraints, there are some maximum points far away from the original point because of the shape of a paraboloid, so we decide to eliminate any points which are 0.5 pixels away from the original points. The results are shown in Fig. 2



(a) No restriction (b) Zoom in

(c) Add restriction (d) Zoom in

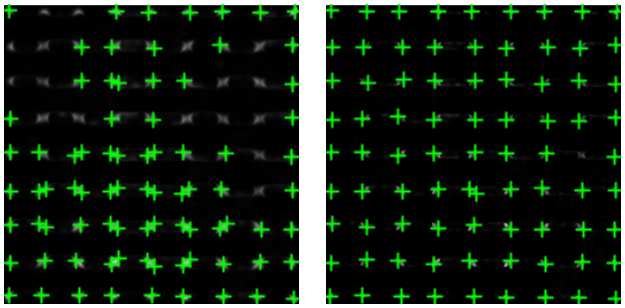
Fig. 2. Illustration for the restrictions of sub-pixel accuracy. Red crosses are before sub-pixel accuracy, Green ones are after sub-pixel accuracy

IV. ANALYSIS OF APPLYING GAUSSIAN FILTER

Another thing that we also notice is, if different size of pre-processed Gaussian filters are applied to the derivative of images, different situation may happens. We will use two examples to illustrate this idea.

First, if we apply a 9×9 Gaussian filter to `chessboard03` (Fig. 3(a)), the result is really bad compared to the result filtered by a 3×3 one (Fig. 3(b)). As we analyse the `chessboard03` image, we may notice that different blocks are relatively similar to each other, so the derivatives around the intersections in the image are

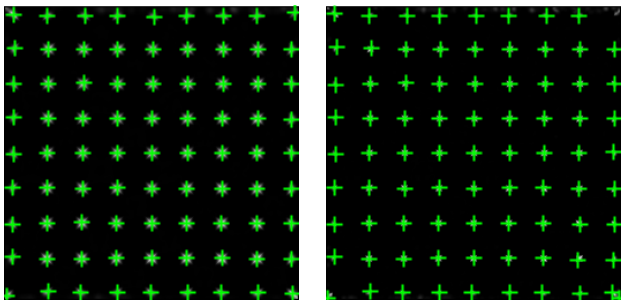
not very significant. If we apply a large size smooth filter, the derivatives are likely to become small and the detection result is not accurate.



(a) 9×9 (b) 3×3

Fig. 3. Result of `chessboard03` filtered by different size of Gaussian filters

In contrast, as for other chessboards (`04, 05, 06`), whose different blocks are quite different, the large size smooth filter can lead to better results. The reason is, the boundaries of these 3 chessboards more or less have some noises, whose derivatives are also large, so some wrong corners may be detected if we only apply 3×3 Gaussian filters (top-right and bottom-left corner points in Fig. 4(b)).



(a) 9×9 (b) 3×3

Fig. 4. Result of `chessboard04` filtered by different size of Gaussian filters

Based on our discussions, choosing proper gaussian filters is also essential to the final result.

V. Conclusions

In this lab, we implement Harris corner detector as well as non-maximal suppression scheme. Also, for the sake of getting accurate results, we can apply sub-pixel accuracy and pay attention to the choice of Gaussian filters.

References

[1] Border, Kim C. "More than You Wanted to Know about Quadratic Forms." More than You Wanted to Know about Quadratic Forms. Accessed March 3, 2016. `http://people.hss.caltech.edu/~kcb/Notes/QuadraticForms.pdf`.

[2] Wikipedia, The Free Encyclopedia, s.v. "Quadratic function" (accessed March 2, 2016), `https://en.wikipedia.org/wiki/Quadratic_function#Maximum_and_minimum_points`