Lab 5

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November 2022

1 Abstract

This paper covers two main topics:

- Normalized cross correlation;
- Harris corner detection;

In the first part we discuss about how the normalized cross correlation works, the main differences that it has with another template matching technique based on the color and how the size of the template impacts on the performance of the algorithm. In the second part we cover how the Harris corner detection technique works and some of its properties.

2 Introduction

This assignment focuses on ”normalized cross-correlation” and ”Harris corner detection”. In the first part the task is to apply the normalized cross-correlation to every frame using a template of a car, whose dimensions are chosen by us. This process allows us to detect the same car depicted in the template in every frame. The second part is about the detection of corners, using the Harris corner detection, in a given image.

3 Materials/Methods

The laboratory is carried out on MatLab. The core of the program is the main function, where the images are uploaded and functions are called. Five different functions are used in the program:

- normxcorr2e: this function applies the normalized cross-correlation and it requires an image and the template as input.
- boxing: we use this function to highlight the detected object in the original images using a red dot in the center and a box around it.

- derivatives: how the name suggests we use this function to compute the partial derivatives of the given image along the x and y axis.
- corner_detection: this function has the purpose of returning the "R map" and the "corner region" associated to the image.
- display_corner: prints a red dot on every corner detected.

4 Results

4.1 Normalized cross-correlation

The first thing we do is to choose the template for the object that we want to detect. The template for the dark car is shown in Figure 1.

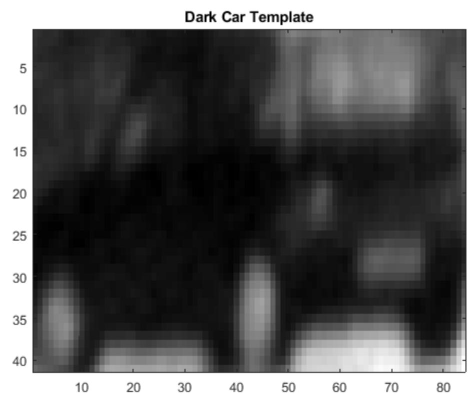


Figure 1: Dark Car Template

We use the template to compute the normalized cross-correlation to detect the car in every frame. We can see the result of this operation applied to the first frame in Figure 2.

The result of NCC operation displays a white dot on the object detected. This allows us to mark the same spot on the original image with a red dot and to put a box of the same size of the template centered in that point (see Figure 3).

In the last step we repeat everything we did so far, but using a smaller and a larger template. This two template are displayed below in Figure 4.

We can see the result of the NCC applying this two templates on the first frame in figure 5.

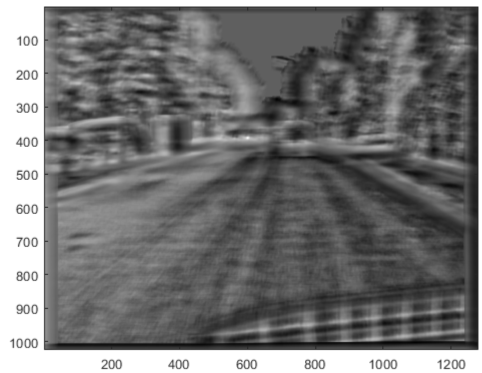


Figure 2: Dark Car NCC

(a) Frame 1

(b) Frame 2

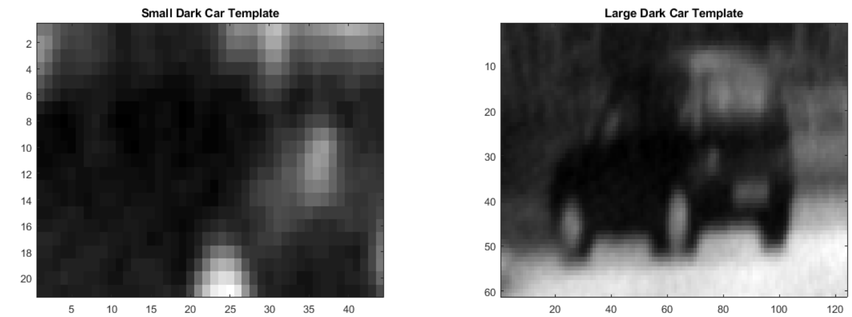
(c) Frame 3

(d) Frame 4

(e) Frame 5

(f) Frame 6

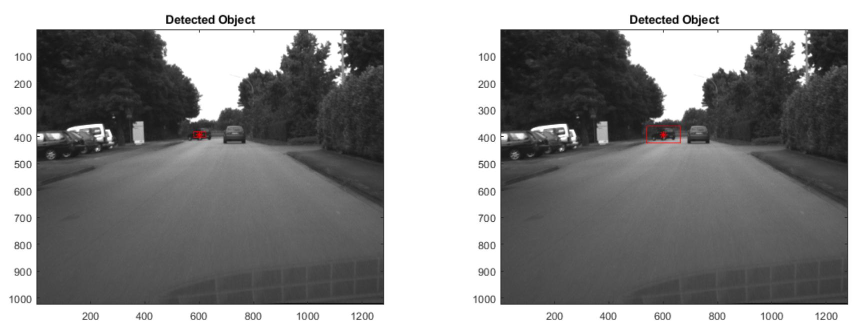
Figure 3: Result of boxing process



(a) Smaller Template

(b) Larger Template

Figure 4: Different Templates



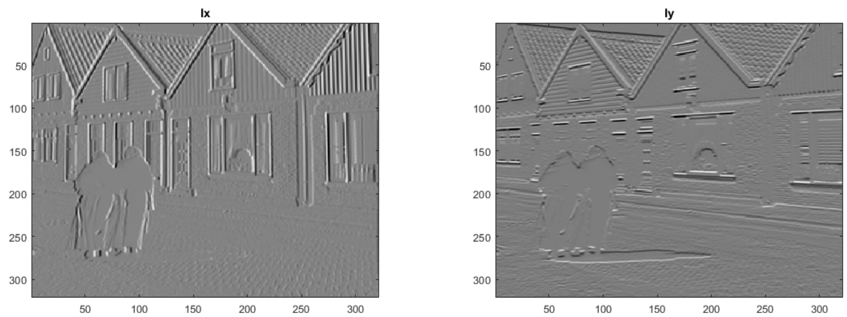
(a) Smaller Box

(b) Larger Box

Figure 5: Different Detection

4.2 Harris corner detection

The second part of the assignment has the purpose of using the Harris corner detection method to detect the corners in the given image. Firstly we calculate the partial derivatives along x and y axis of the image (Figure 6).

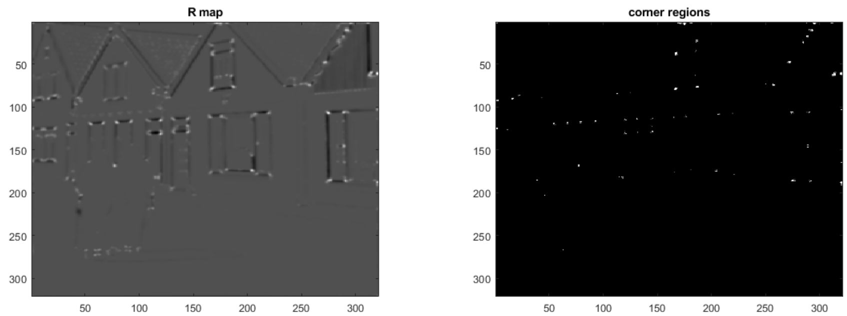


(a) X axis

(b) Y axis

Figure 6: Partial Derivatives

Secondly operating with this derivatives we are able to obtain the R map that we use to create the corner region (Figure 7).



(a) R Map (b) Corner Region

Figure 7

The last step is to highlight the corners detected by the corner region and display them on the original image as we can see in Figure 8.

Figure 8: Detected Corners

5 Conclusions

5.1 Normalized cross-correlation

Normalized cross-correlation is a type of "template matching". Template matching is a technique that allow us to detect a specific object by finding the highest correspondence in an image using a template that contains the object itself.

In Lab 4 the template matching technique was based on the color, instead, in Lab 5 the correlation score is higher only when darker parts of the template overlap darker parts of the image, and brighter parts of the template overlap brighter parts of the image. The NCC also counteracts a fine intensity change so it is very precise. The NCC technique is more robust than the one based on color that we used in Lab 4. For instance it can handle better variation in light intensity. The NCC works by subtracting the mean of the patch intensities and dividing by the standard deviation.

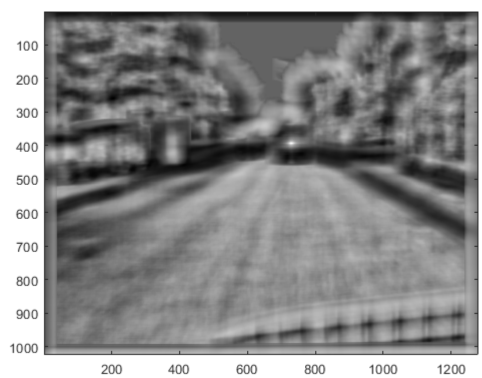


Figure 9: Another Example of NCC: Red Car NCC

The last task concerning normalized cross correlation was to use templates of different size to detect the dark car. As said earlier in the results section we used a larger and a smaller template than the one used so far. The different size of the template implies different accuracy, but also impacts the computational time that is required. The computational complexity is equal to the product of the size of the image and the size of the template, so the bigger the template the more time is required to compute the operation. The accuracy of the matching depends on the size of the object we want to detect. We need to choose the template accordingly to the object we are looking for.

5.2 Harris corner detection

Corners are points in the image. Their property is that if we take a small window around any corner and we shift the window there should be a large change in intensity. We used the Harris corner detection method. Using the partial derivatives and a Gaussian filter (Figure 10) we calculated the second moment matrix (M matrix).

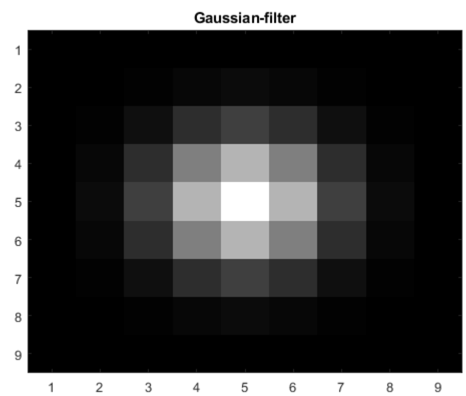


Figure 10: Gaussian filter

Knowing the M matrix we can calculate the cornerness by taking its determinant and subtracting the trace squared multiplied by a factor. To obtain the corner region we then only take the values of the cornerness above a certain threshold. The Harris corner detection is not scale invariant because if we zoom in the picture and repeat the process a point that was a corner could become part of a flat region.