Computer Vision: Lab Session n.5
NCC-based segmentation

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1 Introduction

The aim of this fifth lab is to detect an object through the NCC segmentation.

We have been given six different frames to work with, below we report the grayscale images obtained with MATLAB function *rgb2gray()*:

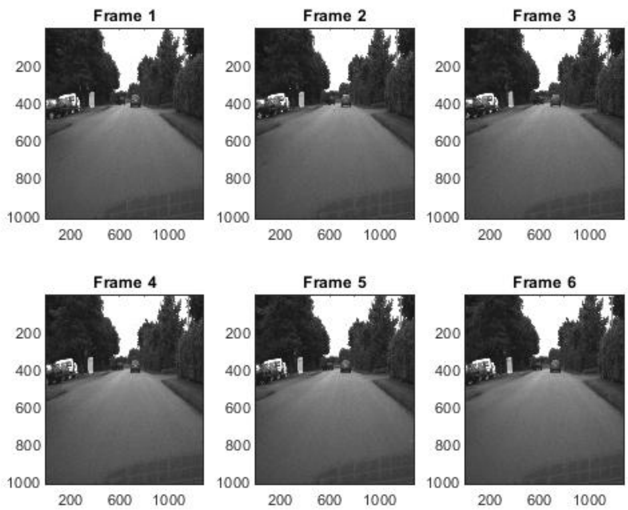

Figure 1: Grayscale images

From the first frame we select a template of size 130x130 pixels relative to the red car that we will use in the images for the recognition.

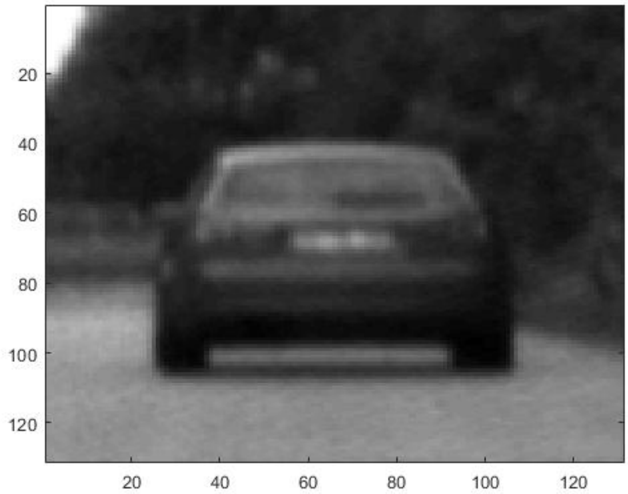

Figure 2: Template from frame 1

2 Normalized Cross Correlation

Template Matching is a high-level computer vision technique that identifies the parts on an image that match a predefined template. Advanced template matching algorithms allow to find occurrences of the template regardless of their orientation and local brightness. Template Matching techniques are flexible and relatively straightforward to use, which makes them one of the most popular methods of object localization. Their applicability is limited mostly by the available computational power, as identification of big and complex templates can be time-consuming.

Normalized cross-correlation is an enhanced version of the classic cross-correlation method that introduces two improvements over the original one:

- The results are invariant to the global brightness changes, i.e. consistent brightening or darkening of either image has no effect on the result (this is accomplished by subtracting the mean image brightness from each pixel value).
- The final correlation value is scaled to [-1, 1] range, so that NCC of two identical images equals 1.0, while NCC of an image and its negation equals -1.0

Let N_1 and N_2 be two square image patches of size $W * W$

$$\phi_{NCC}(N_1, N_2) = -\sum_{k,l=-\frac{W}{2}}^{\frac{W}{2}} \frac{(N_1(k,l) - \mu_1)(N_2(k,l) - \mu_2)}{W^2 \sigma_1 \sigma_2} \tag{1}$$

with:

$$\mu_i = \frac{1}{W} \sum_{k,l=1}^{W} N_i(k,l) \tag{2}$$

$$\sigma_i = \sqrt{\frac{1}{W} \sum_{k,l=1}^{W} (N_i(k,l) - \mu_i)^2} \tag{3}$$

with $i = 1, 2$.

To perform the normalized cross correlation, in order to find the template in the six images, we implemented the function *ncc*(). This function uses MATLAB function *normxcorr*2() to compute the NCC between the template and the gray image given in input. The resulting matrix contains correlation coefficients and its values may range from -1.0 to 1.0. Then we found the peak in the cross-correlation (in the images marked with a *) and we constructed a rectangle around it. Below we report the images obtained between the first frame and the template.

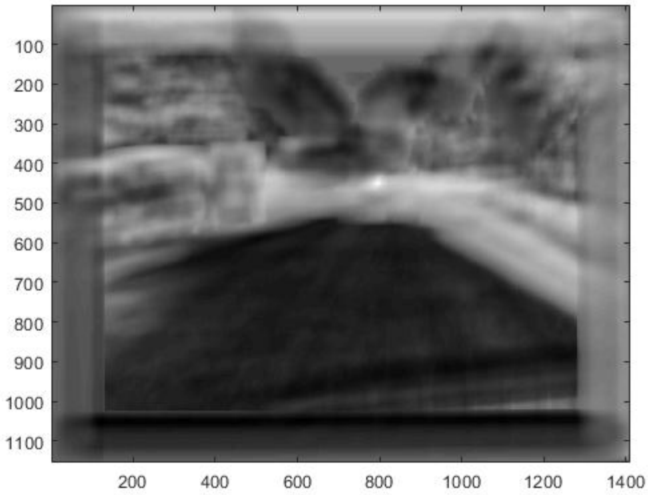

Figure 3: NCC

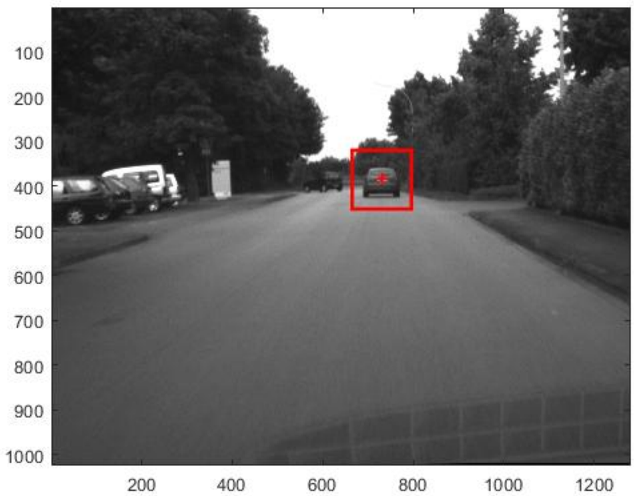

Figure 4: Template matching

3 Different sizes

To test the algorithm we created other two templates of different sizes. The first one is of size 110x110 pixels and the second of 90x90 pixels. Below we report the results obtained between the first frame and the three different size of templates.

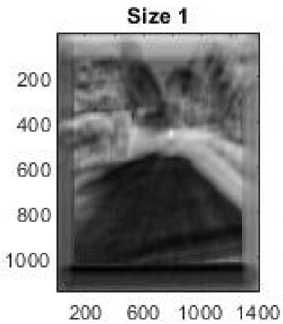

Figure 5: NCC

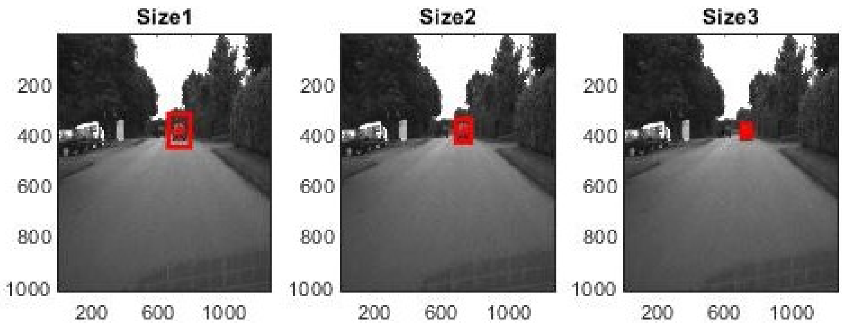

Figure 6: Template matching

Bigger templates require higher computational times because the cross-correlation is done with bigger matrix, but in theory, taking more pixel gives a more accurate result (here the differences is not noticed). The computational times are:

- 1.5938 s - first size (130x130)
- 1.0469 s - second size (110x110)
- 0.8125 s - third size (90x90)

4 Difference with Lab 4

Simply looking at the final results there are no particular differences between the work done in the fourth Lab and the latter but going into details in order to detect object this method is more efficient than the color-based one for several reasons:

- Now we can analyze an image without the dependency from the color;
- Now we can focus on a specific object or also on a single detail with more accuracy (in Lab 4 if we had another red object we would not have been able to distinguish one between them).