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Exercise Sheet 11
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Exercises in Tracking & Detection

Exercise 1 Template Matching

In the lecture you have learned multiple approaches towards robust template matching. In this exercise, you are asked to implement matching based on different scores.

a) Given template T and image I, we define the intensity-based scores for position x, y as

$$SSD(x, y, I)_T = \sum_{(i,j)\in T} (T(i, j) - I(x + i, y + j))^2 \tag{1}$$

$$NCC(x, y, I)_T = \frac{\sum_{(i,j)\in T} T(i, j) \cdot I(x + i, y + j)}{\sqrt{\sum_{(i,j)\in T} T(i, j)^2} \cdot \sqrt{\sum_{(i,j)\in T} I(x + i, y + j)^2}} \tag{2}$$

Implement and run both matching scores on an image and template (a small patch of the image) of your choice and output the response space. You are also asked to employ a pyramid scheme to increase the matching speed, i.e. using subsampled versions and taking the best responses into the next pyramid stage. Run your implementation both on a grayscale and colored version of your image (by scoring each channel on its own and averaging). Compare runtimes and matching fidelity between scores and with/without employing pyramids.

b) We now take a closer look at edge-based template matching. In contrast to intensity-based matching, we solely rely on edge information which is inherently stable towards illumination changes and requires no costly normalization. We will loosely follow the first steps in the paper of Hinterstoisser et al., 'Gradient Response Maps for Real-Time Detection of Texture-Less Objects'. To this end, we find strong gradients of our color image by computing them channel-wise and selecting the ones having highest magnitudes:

$$G(x, y) = \underset{C\in\{R,G,B\}}{\operatorname{argmax}} \left|\left|\frac{\partial C}{\partial x \partial y}\right|\right|. \tag{3}$$

Threshold the gradient image with a small value τ and then extract gradient orientations:

$$O(x, y) = \begin{cases} ori(G(x, y)) & , \text{ if } G(x, y) > \tau \\ \perp & , \text{ else} \end{cases}. \tag{4}$$

Matching now is the normalized sum of absolute cosines of the angle differences:

$$EM(x, y, O_I)_{O_T} = \frac{1}{\#(O_T(i, j) \neq \perp)} \sum_{(i,j)\in O_T} |\cos(O_T(i, j) - O_I(x + i, y + j))|. \tag{5}$$

Make sure that the matching takes only those orientations into account that are really present (i.e. not $\perp$). Evaluate like with the exercise above (pyramid,grayscale/color,runtimes).