

Computer Vision 1: Homework 3

Deadline 15.11. 12:15

Important: Submit your programming solutions through Moodle. The deadline for submitting your work is always on Thursday, at 12.15, the week after handing out the homework. For other, non-programming homework, bring your solution with you to the exercise class. For each homework problem, one student will be chosen at random to present their solution.

Programming tasks.

Note: please use `skimage` for filtering and `matplotlib` for displaying images.

- Read the following image as a `numpy` array. This is the same `sample.jpg` image we had last week.



Figure 1: A sample image (id=345434) from the MSCOCO dataset

- Add `salt` and `pepper` noise to the image. Display this noise image.
- Smooth the image using a) median filter b) box filter c) Gaussian filter with $\sigma = 1$. The filter size for median and box filters is 9×9 . Display these 3 smoothed images.
- Instead of using `skimage.filters`, implement the median and box filterings using for-loop. Verify that the results are the same.
- Apply DoG filter on the image with $\sigma_1 = 2, \sigma_2 = 5$. Display the result.
- Approximate the DoG filter above using DoB (Difference of Boxes) with the box sizes are 19 and 43. Display the result.

Other tasks.

1. Given an image $I = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ and a filter $K = \begin{bmatrix} 0 & 1 \\ 0 & 2 \end{bmatrix}$.

a Compute the convolution $I * K$ without any padding. The result should be a scalar.

- b Write down the procedure for computing the convolution $I * K$ in 3 steps: 1) flipping the filter 2) padding the image with zeros 3) cross-correlation. How many multiplications and additions are there in the computation? Explain your answer.
2. Knowing that $K = uv^T = \begin{bmatrix} 1 \\ 2 \end{bmatrix} \begin{bmatrix} 0 & 1 \end{bmatrix}$, compute the convolution $(I * u) * v$. How many multiplications and additions are there in the computation? Explain your answer.
3. Given a 2-dimensional filter matrix K , how to determine if K is separable? If $K = uv^T$ is separable, how to determine u, v ? Apply your answer to the 3×3 box filter and the Sobel filter.

Hint: matrix decomposition.

Note: the Sobel filter is $\begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix}$.

4. Calculate $\text{median}(A+B)$ and $\text{median}(A) + \text{median}(B)$ with two images A, B given below and the median filter size is 3×3 . Zeros are padded to the border. Are the results the same? Why/Why not? What does this prove?

$$A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 2 & 3 & 1 & 0 \\ 3 & 1 & 2 & 1 \end{bmatrix}$$

$$B = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 4 & 5 & 6 & 8 \\ 7 & 8 & 9 & 6 \end{bmatrix}$$