Exercises for
Introduction to Pattern Recognition (IntroPR)
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Image Enhancement, Edge Detection, Interpolation

Exercise 15 The Laplacian operator is defined as

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \tag{1}$$

Show that it is invariant to rotations. Thus, show that

$$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = \frac{\partial^2 f}{\partial x'^2} + \frac{\partial^2 f}{\partial y'^2} \ , \tag{2}$$

where (x, y) are unrotated, and (x', y') are rotated coordinates of the same object.

The relationship between (x, y) and (x', y') can be expressed as

$$x = x' \cos\theta - y' \sin\theta \tag{3}$$

$$y = x' \sin\theta + y' \cos\theta \tag{4}$$

Exercise 16 **Programming Task:**

One popular image enhancement method is combining an image with its Laplacian-filtered image. Test this approach on the image `moon.jpg` from our website.

- Create a Laplacian filtered version of the image using the filter mask

  $[1, 1, 1; 1, -8, 1; 1, 1, 1]$
- Calculate the enhanced version of the image:

  $$g(x, y) = f(x, y) - \nabla^2 f(x, y) \tag{5}$$
- Try using other edge-detecting methods to achieve similar results.

Exercise 17 **Programming Task:**

One important preprocessing step is the normalization of images. Here, the normalization with respect to illumination will be covered. In the zipped folder `Histoimages.zip`, you can find a selection of histological images which are inhomogeneously illuminated, with decreasing brightness towards the edges. One strategy to correct for this illumination bias is to create an artificial background image containing the bias field, and substracting or dividing the original image by the artifical background image. Try the effectiveness of this strategy using a gaussian filter to create the artificial background image. How do you choose the kernel size and standard deviation of the filter? Do you encounter any problems? Please read also the file `Readme.txt` in the zip-file.

Exercise 18 **Programming Task:**

Rotate the image `object.png` 260° around its center using bilinear interpolation:

(a) Iterate in steps of one degree and re-interpolate the result of the previous iteration.

(b) Use one interpolation step, and rotate the image by 260°.

(c) Use your favorite high pass convolution kernel to extract the edges from the two rotated images. How does its output differ when applied on both rotation variants?