Mathematical methods of signal and image processing
Winter semester 2021/2022
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Presence exercise sheet 1

Problem 1

Familiarize yourself with reading, displaying and writing of images. To this end, Python offers the following functions in the given libraries:

- `skimage.io.imread` - read an image (returns an array of integer values)
- `matplotlib.pyplot.imshow` - display an image, the gray values are normalized automatically
- `skimage.io.imsave` - write an image (Note: The behavior of `imshow` and `imsave` depends on whether the input image consists of integer or floating point values)

MATLAB offers comparable functionality with `imread` and `imwrite`. Python's `imshow` can be represented in MATLAB using either `imagesc` (display an image, gray value scaling can by specified optionally) or `imshow` (display an image, the gray values are normalized automatically).

Problem 2

Implement the intensity transformations T^{norm}, $T_\theta^{\text{threshold}}$, T_γ and $T^{\log}$ (cf. Definition 1.6) and study their behavior on the example images. Save the modified images in the PNG format and verify with GIMP that the images were correctly exported. Compare the effect of your implementation of T_γ with the gamma correction integrated in GIMP (in GIMP 2.8 available under Colors→Levels→Input-Levels - middle box).

To test $T^{\log}$ use the power spectrum of one of the example images. The power spectrum of an image `image` can be computed in MATLAB with `fftshift(abs(fft2(image)))`. It it helpful to subtract the mean value of the image from the image before computing its power spectrum. Python provides `fftshift` and `fft2` in `numpy.fft`.

Problem 3

Implement an algorithm that reduces the resolution of an image with $2^n \times 2^n$ pixels to $2^{n-1} \times 2^{n-1}$ pixels. To this end, the values of 2×2 pixels on the fine grid should be averaged to get the value for the corresponding pixel on the coarse grid. This corresponds to a special, discrete version of the sampling with a CCD sensor (cf. Remark 1.4).

Optional: Implement the algorithm without any for-loops.

Example images

`http://www.ece.rice.edu/~wakin/images/lenaTest3.jpg`
`http://www.engineering.uiowa.edu/~dip/homework/peppers.png`
`http://www.mathworks.com/matlabcentral/answers/uploaded_files/741/cameraman.jpg`