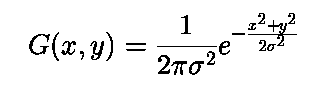
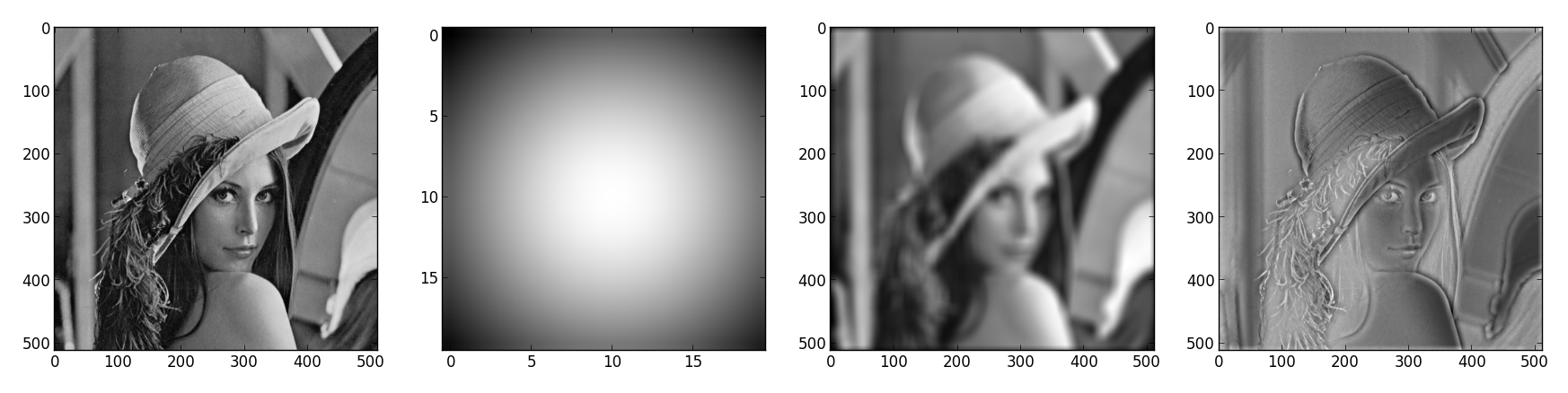
Complete the tasks using python and when submitting the answers include the code you wrote and word processed answers to the questions with relevant output images.

1. **Using the given equation for a 2D Gaussian filter, plot the output of a filter-convolved image with an appropriate sigma, σ, value [2]. What type of filter does a high sigma value produce [1]? Can you think of a way of extracting high frequency image components using only a low frequency filtered image [1]? Plot such an image and comment on it’s quality [1].**



*Hint: Use PIL.Image.open to import your image, and from scipy.signal use the convolve2d (with mode=’same’ ) for the convolution.*

*[2] Plotting the various blurred images (input image/ Gaussian filter/ Gaussian-blurred output/ edge-detected output)*



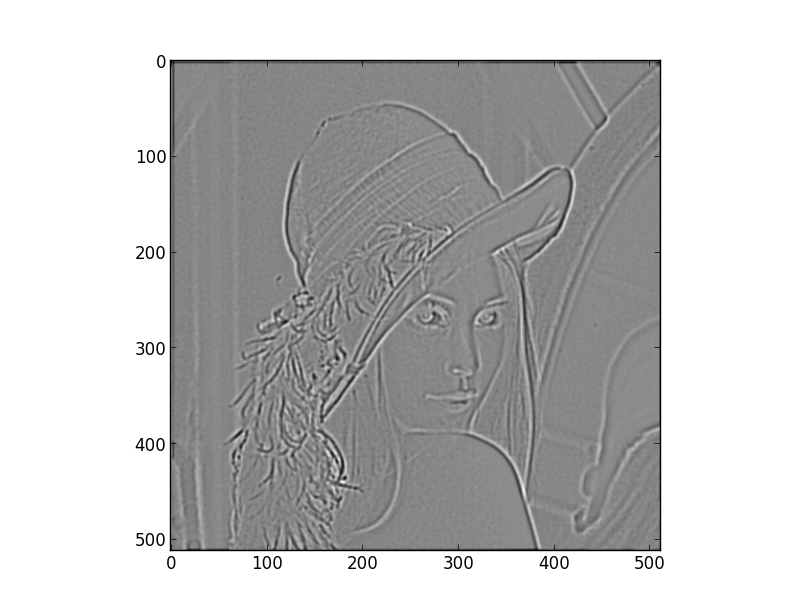
*[1] Low-pass filter.*

*[1] Subtract the low-pass filtered image from the original image.*

*[1] Roughly an edge-detected image plotted, low quality (far-right above plot).*

1. **Create a Difference of Gaussian (DOG) filter by applying two different sigma valued Gaussian filters to the original image and then subtracting the two outputs from each other [2]. Try to find optimum sigma values for edge detection [1]. Comment on the difference between this filter and the first [2].**

*Hint: Larger sigma values require larger Gaussian kernels.*

*[2] Produce a DOG filter and plot the output*

*[1] Optimum filter sizes have low sigma values e.g. 1 & 2. Must be different, low values.*

*Any 2 from below:*

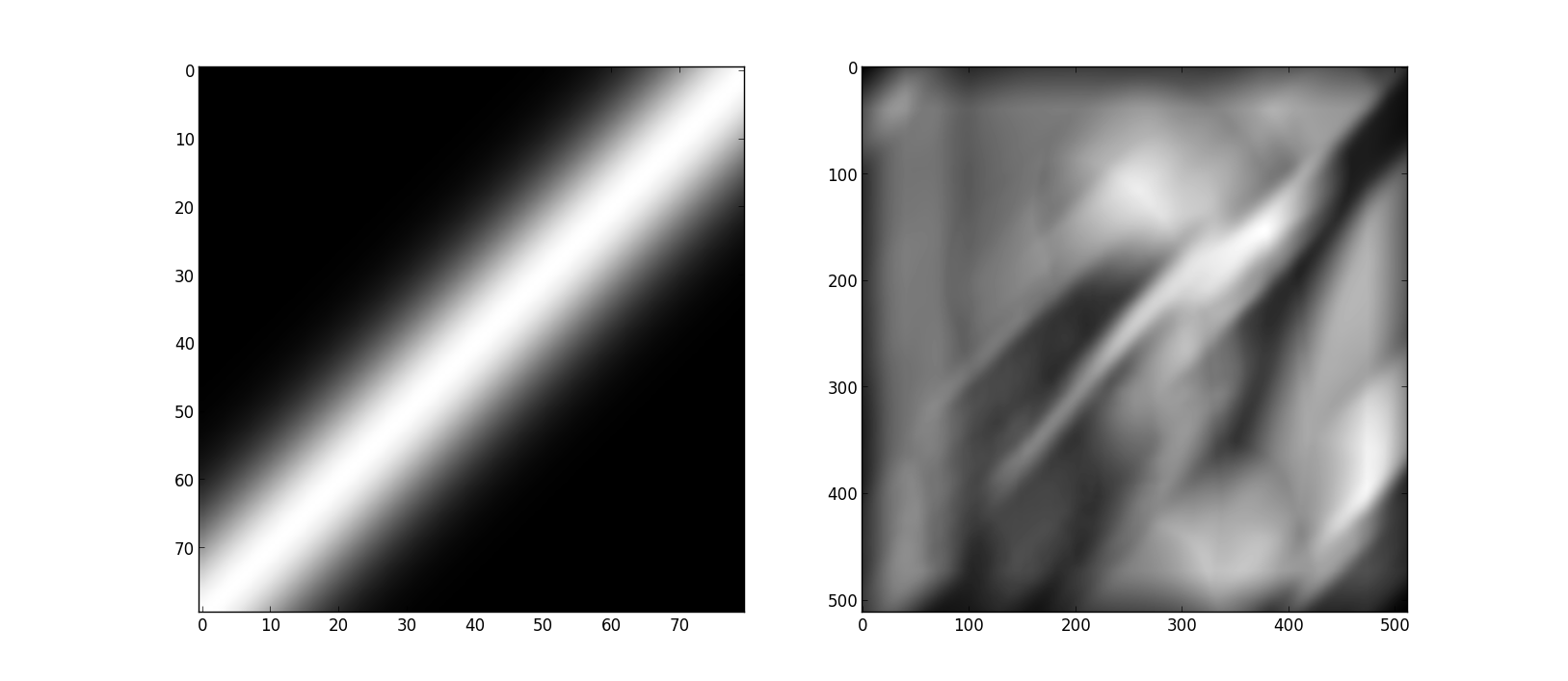
*[1] Higher quality filter*

*[1] Less image noise*

*[1] More easily controlled*

1. **Oriented Difference of Gaussian (ODOG) filters can be created by using the below equation. Where [a, b] is a directional vector of x and y respectively for defining the direction of the filter. Plot a range of differently oriented difference of Gaussian-blurred images filters[3].**

[3] Images of Oriented Gaussian filters and their resulting blurred images.



1. **Take the derivative of a Gaussian filter with it's scaling and normalization constants set to zero [1], as below. Plot these filters and convolve these differentiated Gaussians with an input image[1]. The using two different sigma values created a difference of derivative Gaussian filter [1].**

[1]

[1] Gaussian derivative blurred image and filter plotted.

1. **Multi-scale spatial filtering models have been applied to common visual illusion images to see if they could replicate differences in observed lightness e.g. White's illusion. Describe the model, mentioning what kind of filters they use [4]? Does this model indicate early or late stage visual processing as being responsible for whites illusion[1]?**

[1] Oriented Difference of (Differentiated) Gaussian filters across different spatial scales

[1] Filters are convolved with a image of white's illusion.

[1] The outputs are summed and normalized to create an output image (percept).

[1] The result produces the observed lightness observed in the illusion.

[1] Early stage visual processing.

**Maximum marks 20/20**

Email your answers to marianne.maertens@tu-berlin.de by **DATE**