KOGW-PM-KNP: Edge detection Questions - Gaussian filtering

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Retinal ganglion cells and neurons in the LGN respond preferentially to dark or light spots of a particular size and neurons in V1 respond preferentially to stimuli of a certain orientation and spatial frequency. Being selective to these stimulus attributes the neurons act as filters that pass some information and not other to the next level of visual information processing. This exercise will illustrate some of the transformations that are applied to the input image by neurons or filters that are selective for different features.

Work through the Python code provided and answer any following questions.

Task 1. Gaussian filtering of an image

This is the equation for a 2D Gaussian, plot the output of a filter-convolved image with an appropriate σ value.

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

1. What happens to the image?

2. Are these low or high-pass type filters? Describe the effect of changing σ.

3. Can you think of a way of extracting high frequency components from an image using only a low frequency filtered image? Plot such an image and comment on its quality

Task 2. Difference of Gaussian filtering of an image

A Difference of Gaussian (DOG) filter is made by applying two different σ valued Gaussian filters to the original image. These two blurred images are then subtracted from each other. In this way, the σ values of the filters can be used to specify which frequency values are extracted.

1. Read through the code. Try changing the N and σ values. What type of filter is the DOG?

2. Try to find optimum σ and N values for detecting edges in an image. Remember the two Gaussians must have different σ values

3. Comment on differences between this filter and the first.

Task 3. Hybrid Images

Using the Gaussian filter from task 1, extract low spatial frequency information from the image of Albert Einstein provided and add this to the high spatial frequency information of the Marilyn Monroe.

Experiment with two different sigma value Gaussian filters, until up close the combined image looks like Monroe but from afar like Einstein.

What does this say about the way our visual system detects images?

Task 4. Phase and Fourier Transforms

Another way to extract image information is via the Fourier transform. Read through the code which splits the Einstein and Monroe images into their magnitude and phase components, using the Fourier transform.

Recombine the components for each image using the reconstruction equation for one image below:

$$Recontruction = [A(ft1) * cos(\phi(ft2))] + [A(ft1) * sin(\phi(ft2))]i$$

where A is amplitude and ϕ is phase.

Note: i is imaginary and is denoted by "0j" in python.

What do you notice about the output? What does this suggest about what Fourier information our visual system relies upon?