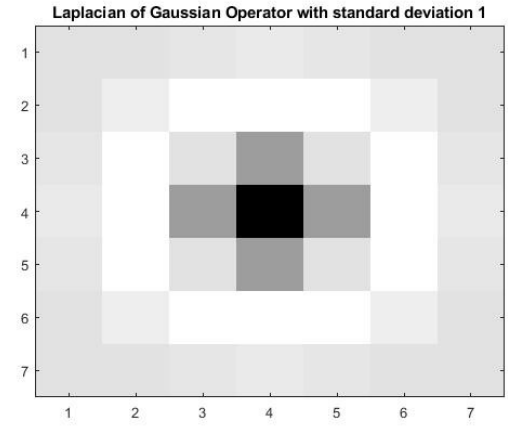
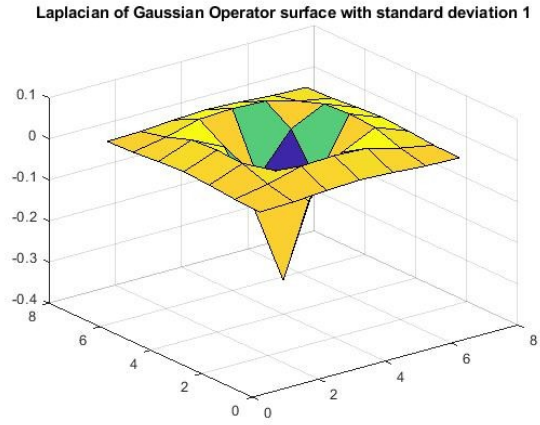
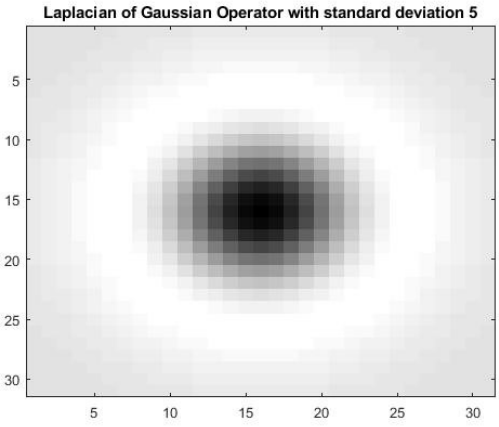
Edge Detection

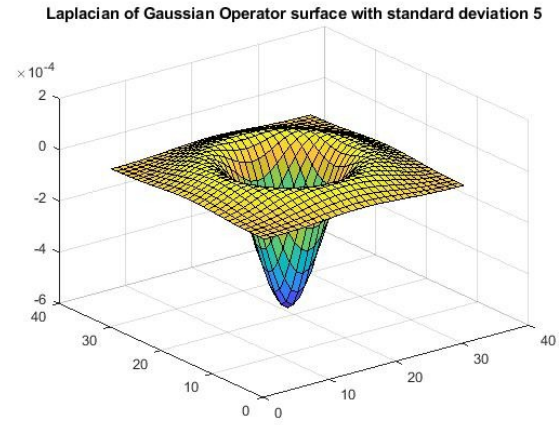
The aim of this lab session is to create a special filter (Laplacian of a Gaussian) and use it to evidence the edges (that are changes of intesities of pixels). Finally, we implement a function to effectly detect those edges.

Laplacian of a Gaussian (LoG.m)









Instead of convolute the image with the gaussian and then derive the result twice, it is better to convolute directly the image with the second derivative (i.e laplacian) of the Gaussian. So we can use directly the laplacian of gaussian formula:

$$LoG(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right]e^{-\frac{x^2+y^2}{2\sigma^2}}$$

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LoG.m function takes in input the standard deviation (sigma), computes the appropriate spatial resolution (~3*sigma) and return the LoG filter ready to be convoluted with the image.

Edge Evidentiation ( )

Once we have LoG, we convolute the image with it in order to have the input for the next step. This evidentiation is need to see well the borders, because it emphazizes the changes of intensities between near pixels.

With big standard deviation of the Gaussian the image will be less nitid and the little edge will not be visible because each pixel is convoluited with more neighbours, so we lost more details (that is a thing we may want if we are finding only ‘big’ edges).

Edge Detection (edgeDetection.m)

With the convoluited image, we detect the edges with this function.
To do this, we find the zero crossing of the image obtained at the previous step. This because a zero crossing in the second derivative means a change of intensity in the real image.
We need a threshold to say if a zero crossing is taken into account for the edge detection. When the threshold is exceeded (see the two different methods below), the edge point is detected (it is a “big jump” between two pixel passing through zero), so we put a 1 in the edgePoint matrix (which is initialized with all zero)

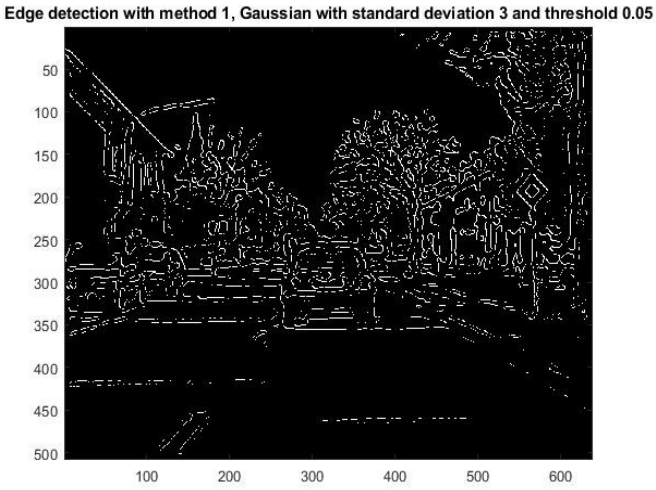
The detection is done comparing two near pixels: first the ones near horizzontaly and then the ones near vertically. There are four types of zero crossing:

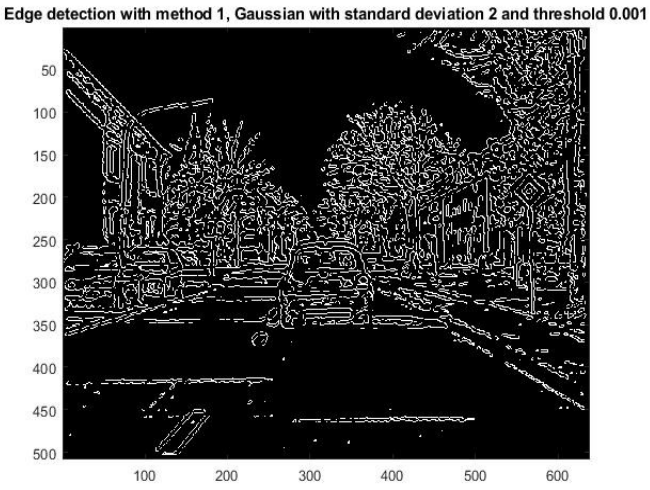
1. Transition + - : when the curve is positive before the zero value and negative after the zero value
2. Transition - + : when the curve is negative before the zero value and positive after the zero value
3. Transition + 0 - : as 1, but passing through real 0 value
4. Transition – 0 + : as 2, but passing through real 0 value

Note that we don't consider the 3 and 4 transition because matrix will pratically never have exactly zero value.

We use two methods for the evaluation:

1. See if the intensity of the actual pixel is greater than the threshold and the intensity of the near one is less than -threshold (transition + -) or the opposite (for the transition - +)





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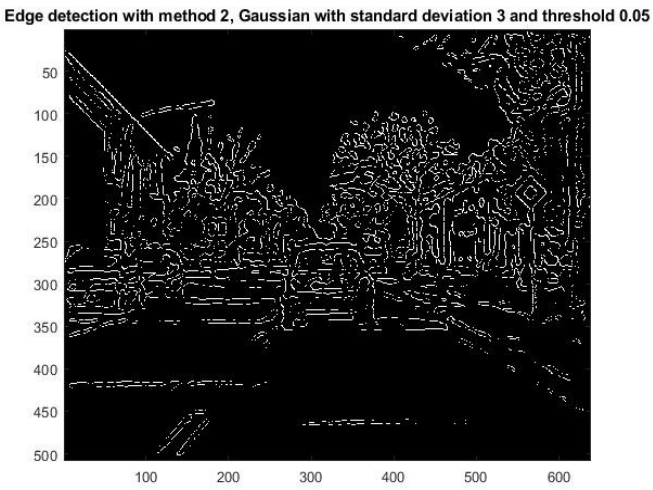
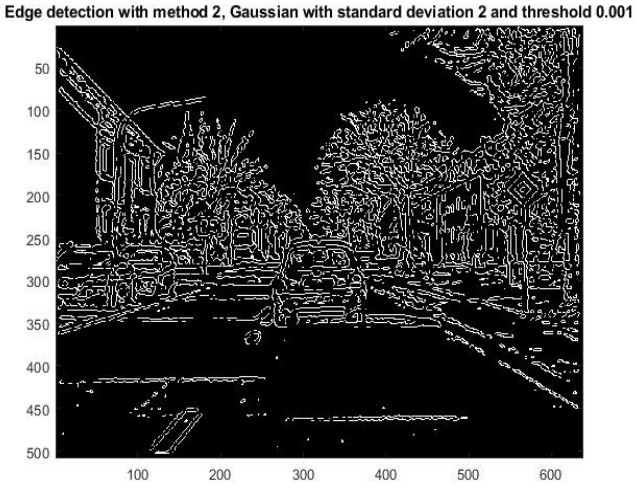
2. Firstly, we see if a zero crossing exists (product of intensities of two nearby pixel is negative). Then we make the sum of the absolute values of the two intensities. If it is greater than the threshold, an edge point is detected.





The parameters that make the edge detection good or bad are two: the standard deviation of the Gaussian (and the relative spatial resolution) and the choosen threshold. The choice of these parameters depends on the original image and on the kind of edge wanted (only ‘big’ ones or also the little ones). With big standard deviation the little detailed edge are lost.
The more the threshold is, the more two nearby pixel must have different intensities to be choosen as edge point.

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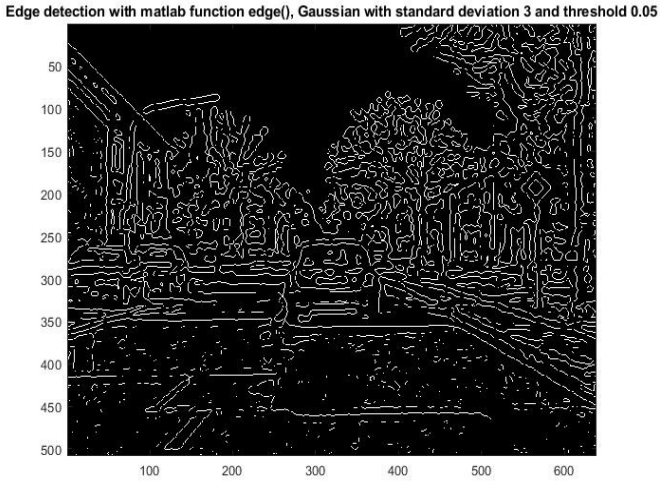
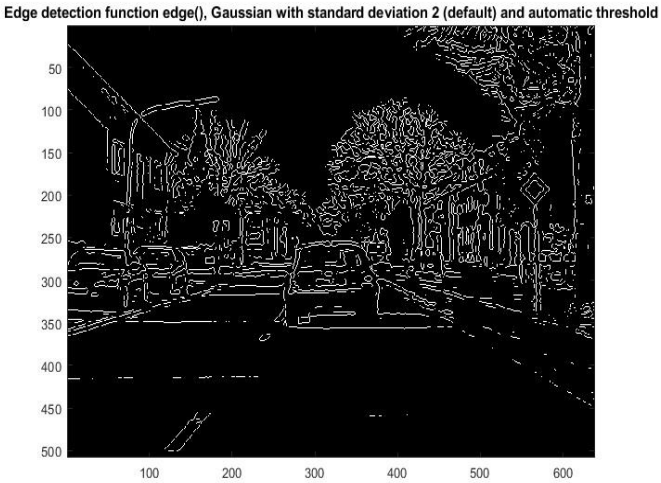
In matlab exists a function, edge(), which perform directly the edge detection with the wanted method. In this case it is ‘log’ method (that is laplacian of gaussian) with given standard deviation and given threshold.
If the standard deviation is not specified it is 2 by default, and if the threshold is not specified, it is calculated based on the real image.





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