Homework 2

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Introduction to Signal and Image Processing

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Note: Many information are also present in comments or debug info in the code. For many functions the *verbose* option can be set to True/False to display informations.

1 Linear Filtering - [7 Points]

1.3: *create a boxfilter of size 11 and convolve this filter with your image - show the result.*

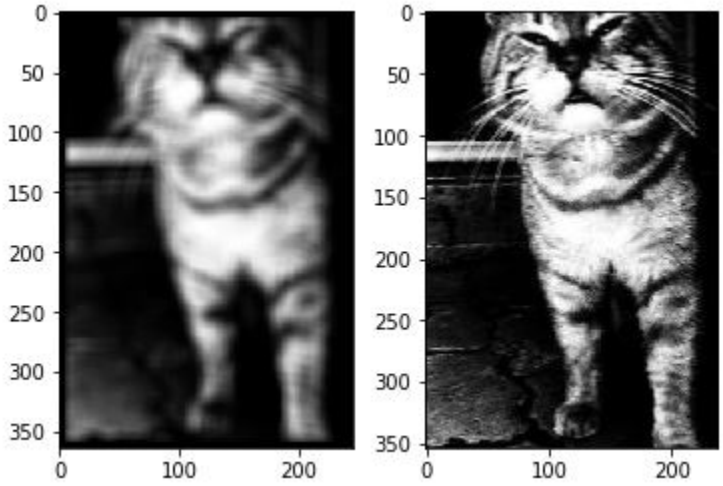

Figure 1: Box filter (left) - linear filter [1,0,1] (right)

1.5: *2D gaussian filter*

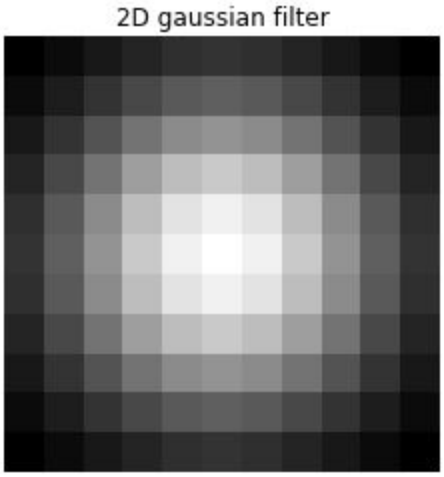

Figure 2: 2D gaussian filter of size 11x11

1.7: *Convolution with a 2D Gaussian filter is not the most efficient way to perform Gaussian convolution with an image. In a few sentences, explain how this could be implemented more efficiently and why this would be faster.*

We can convolve each row with a 1d filter and do it again for each row. For a 3x3 box filter, we can see that we can get rid of the corner value's calculation at each step. The bigger the filter, the more we gain memory space and reduce the number of operations needed.

1.8: *Kernel size vs. computation time between 1D and 2D Gaussian Filter*

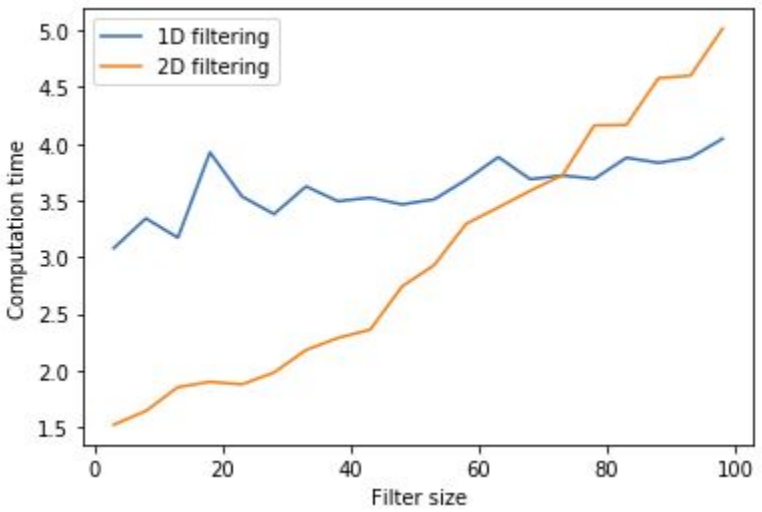

Figure 3: Computation time between 1D and 2D Gaussian filters of different size.

2 Gradients and Edge Maps - [7 Points]

2.2: *Edge magnitude image of bird.jpg*

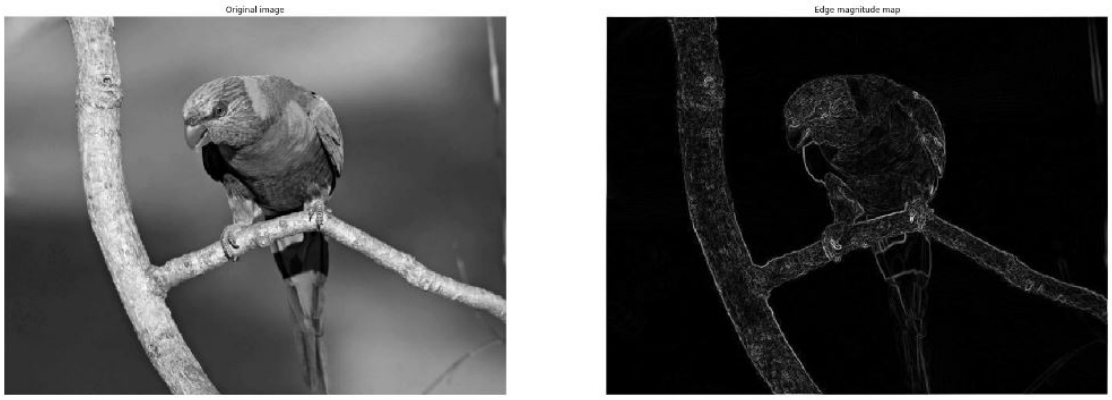

Figure 4: Gradient magnitude image.

2.3: *Edge images of particular direction*

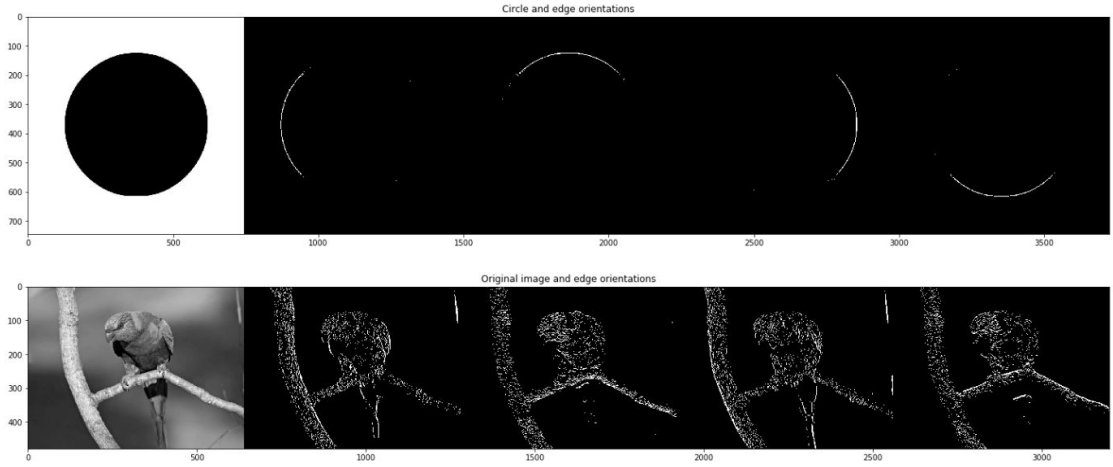

Figure 5: (Above) Edge maps of a circle for 4 different directions. (below) Edge maps of a nice pigeon on a branch during a fresh spring afternoon picture for 4 different directions

Note: the edges of the circle are very clear in comparison to the pigeon. With the circle, an edge coefficient threshold of 200 or above is largely enough. But to distinguish the bird and to see an orientation difference, a low threshold has to be used with the second picture. With 20 we can see a nice orientation difference on the tree but it adds noise on the first image.

3 Harris Corner detection - [7 Points]

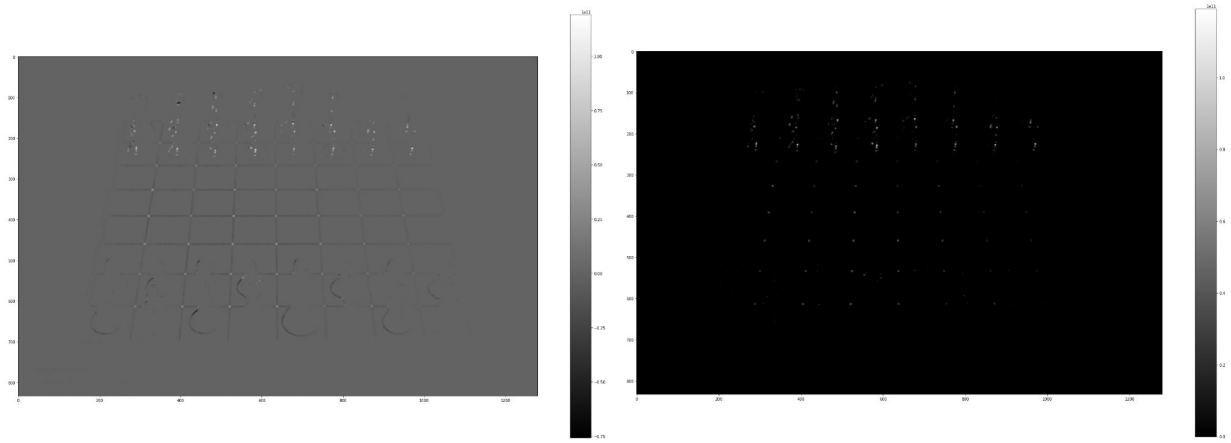

Figure 6: Picture before and after thresholding. Before the thresholding (threshold = 0.25^{10}), even if the corners are already visible, the borders are still visible as well.

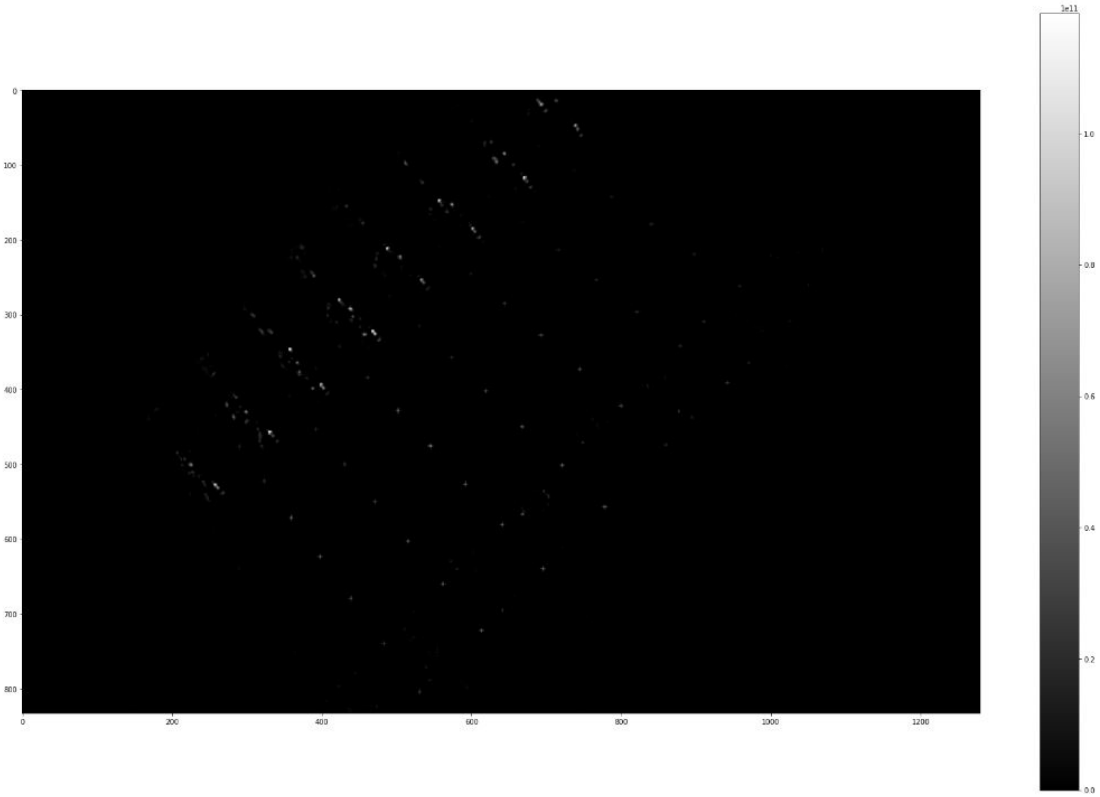

Figure 7: With the rotations the corners are still clearly visible.

Figure 8: Downscaled image, the corners are still clearly visible.

Question: Looking at the results, what can we say about the properties of Harris corners? What is maintained? What is it invariant to? Why?

The R response is invariant to image rotation but not to scaling (looking closely at a curve, it looks like a line but from far away it might look like a corner). For the rotation, if it were varying it would mean that corners in some direction wouldn't be detected which does not make sense. The derivative is available in every direction after the interpolation which means that all lines, and next all corners can be detected.