Answers to questions in
Lab 2: Edge detection & Hough transform

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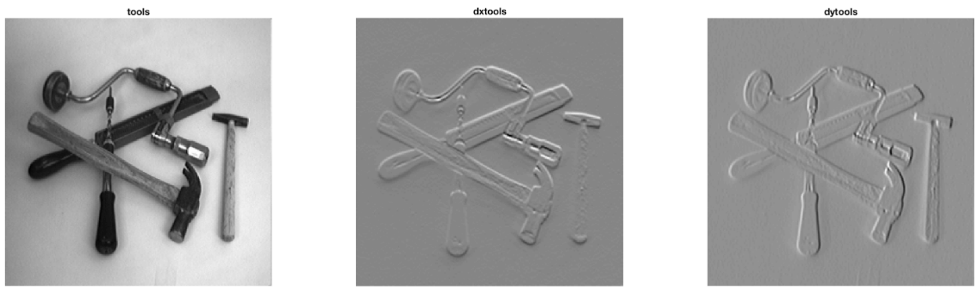
Instructions: Complete the lab according to the instructions in the notes and respond to the questions stated below. Keep the answers short and focus on what is essential. Illustrate with figures only when explicitly requested.

Good luck!

Question 1: What do you expect the results to look like and why? Compare the size of dxtools with the size of tools. Why are these sizes different?

Answers:

We expect to acquire two *edge map* images (that is images whose principal features are edges). They contain information related to the horizontal and vertical components respectively, of the gradient magnitude (intensity) of the original image. We anticipate observing differences in intensity values in the locations where there are variations between the objects and/or the background of the image. Whereas, the zero-response gradient areas represent the constant intensity image areas.
More specifically, the dxtools image gives stronger response for the vertical edges, since the orientation of x-axis is across the vertical axis. Thus, the edge detector focuses only on the vertical variations. Similarly, the dytools image illustrates the horizontal variations of the magnitude.
Comparing the size between the images dxtools and tools, we see that dxtools is smaller. This is reasonable since we convolve the image with the filter mask 3x3 while setting the shape equal to ‘valid’. Thus the edges of the image will be trimmed by 2 in each direction. This is due to the definition of the kernel i.e. we should have valid pixels around the center of the kernel.



Question 2: Is it easy to find a threshold that results in thin edges? Explain why or why not!

Answers:
In general, it is not easy to find a proper threshold that results in thin edges. This depends on factors such as the volume of noise and blurring of the image. In general, when we handle edges exported from high scales, the thresholding which will produce thick edges (due to the smoothing effects) could result vanishing of thin edges. On the other hand, when dealing with noisy images, the process of thinning the edges will have the drawback of loosing connectivity.Thus, there is a trade-off between producing thin edges and maintain the wanted edges and their connectivity.

Question 3: Does smoothing the image help to find edges?

Answers:

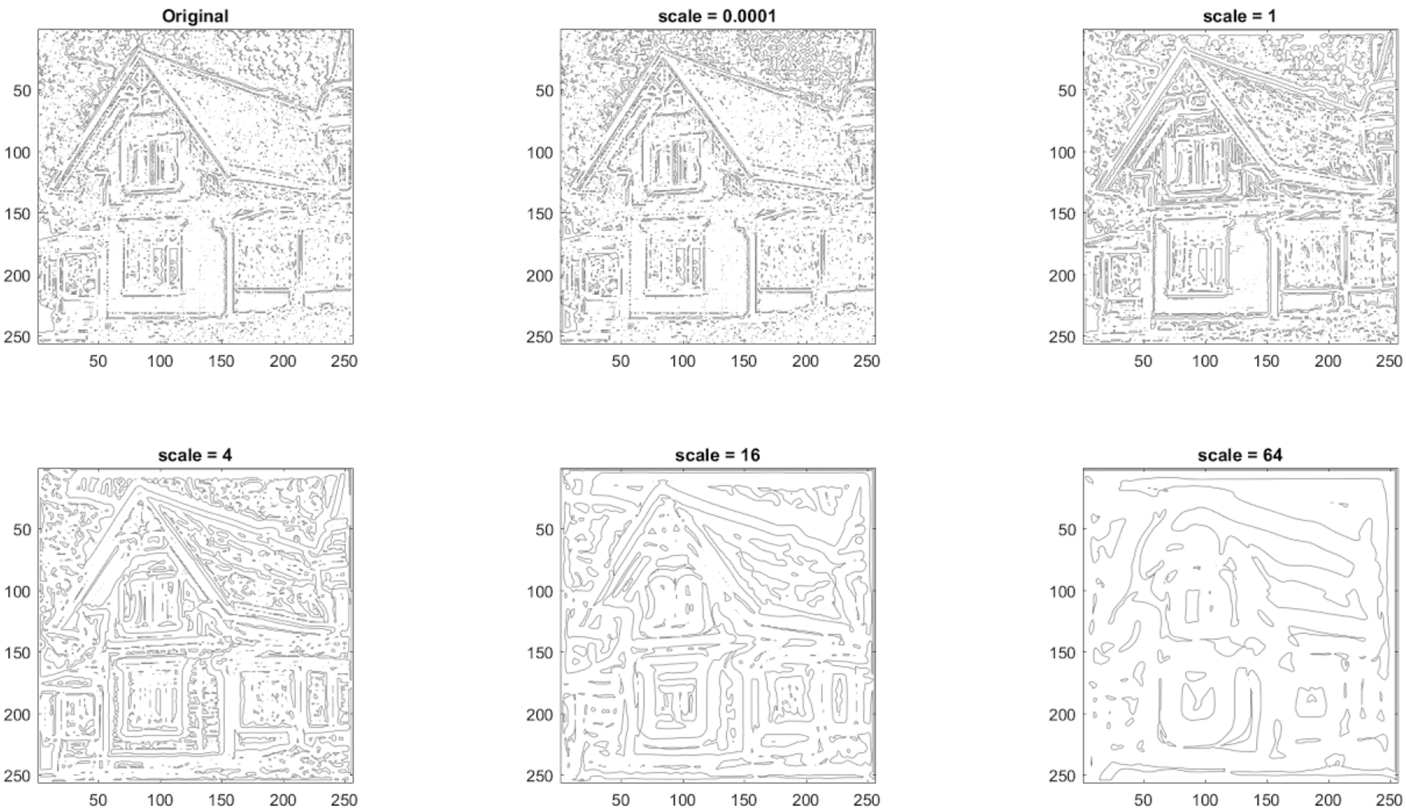
In general yes, as it subtracts the fine details and noise from the image (see LPF) as long as the smoothing is sensible (sensible in the sense of keeping the edge distortion to a minimum

extent). This way, we compute the principal edges without having the irrelevant details to interfere the results i.e. fine details and noise.
Note that a combination of smoothing with thresholding would result in even better results as this addition would act as a selector but, we should be careful as when smoothing is harder to set a proper threshold value.

Question 4*: What can you observe? Provide explanation based on the generated images.
Question 5*: Assemble the results of the experiment above into an illustrative collage with the subplot command. Which are your observations and conclusions?
* Note that we combined Questions 4 and 5 as they are asking the same thing.

Answers:
As we can see in the figure below, the edge detection in different scales would give different results. In detail, in small scales, the fine details are still present and the noise suppression is not high enough which leads to big set of non-principal edges i.e. false positives (note that due to error propagation, the higher the order of the gradient, the higher the noise). On the other hand, in big scales, we will have noise suppression and cut off of the false positives, but the extreme smoothing will result distortion of the principal edges both in extent and shape. Therefore, we conclude that, a scale of magnitude 3-5 will result the best results considering the noise and fine details to edge distortion ratio. Finally, we suggest that, a thresholding -in sensible extent to prevent connectivity- would provide better results as it would collect more primal edges.

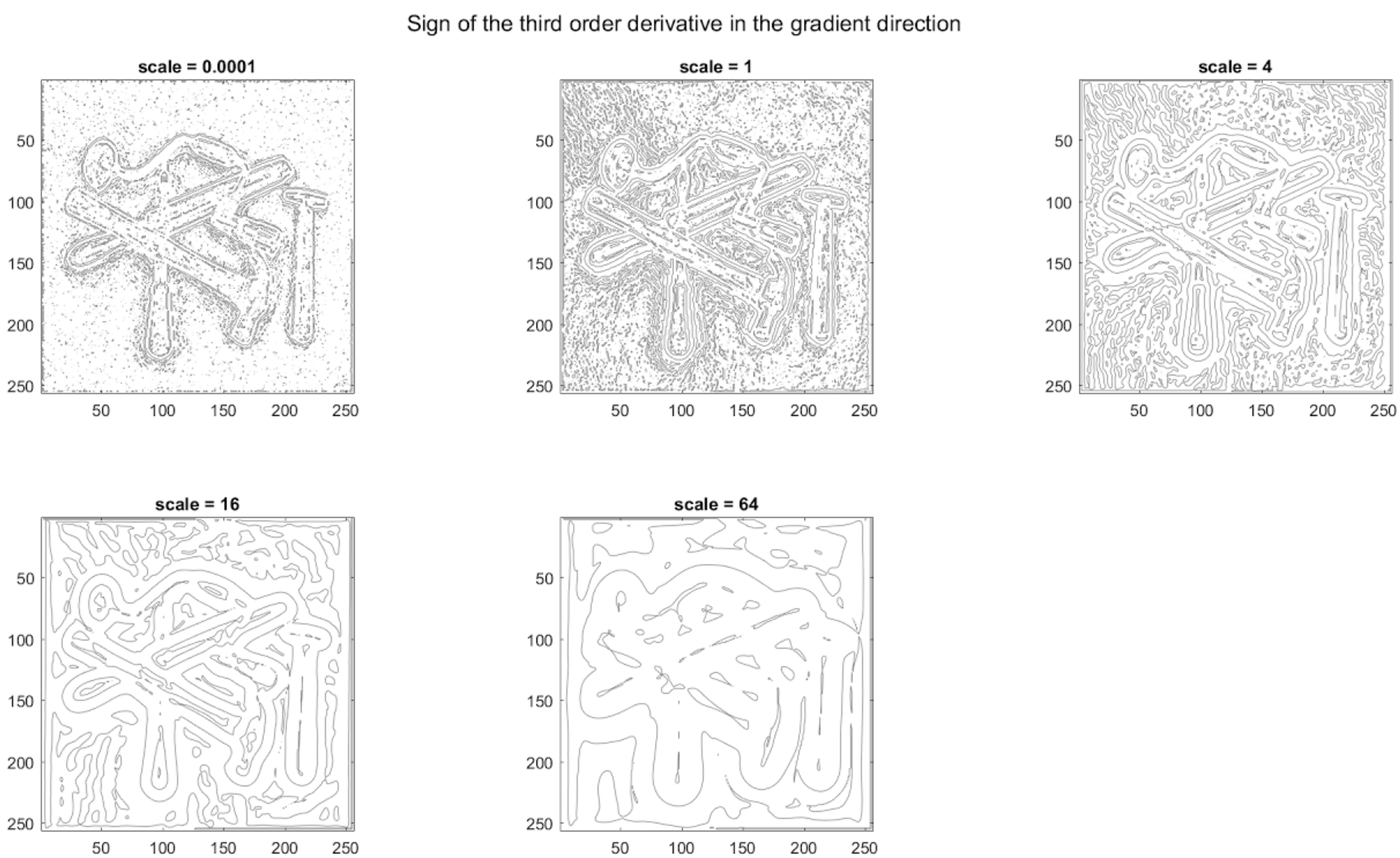
Zero crossings of the second order derivative



Question 6: How can you use the response from Lvv to detect edges, and how can you improve the result by using Lvvv?

Answers:

Let image’s DN values (intensity) represented by a function f at the edge area. Then, the first order derivative will give information about the slope changes in intensity. Correspondingly, the curvety of f will change at the zero-crossings of the second derivative e.g. fxx. Therefore, the use of the second derivative will give the edges in an image. Furthermore, in order to make sure that this is indeed a local maxima, we need to incorporate information about the derivative of that. That is the reason which we demand the negativity of the third derivative in the zero crossing of the second.



Question 7: Present your best results obtained with extractedge for house and tools.

Answers:

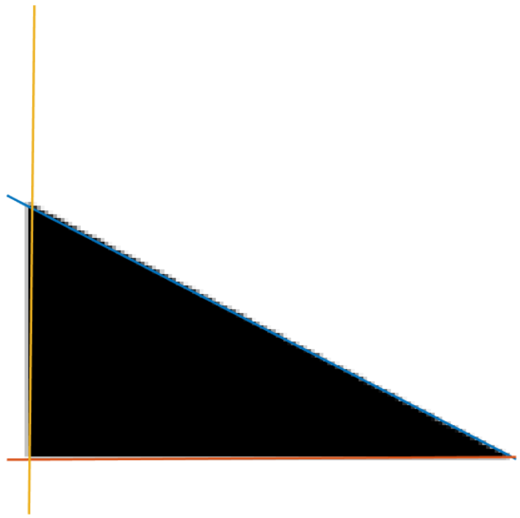
Question 8: Identify the correspondences between the strongest peaks in the accumulator and line segments in the output image. Doing so convince yourself that the implementation is correct. Summarize the results of in one or more figures.

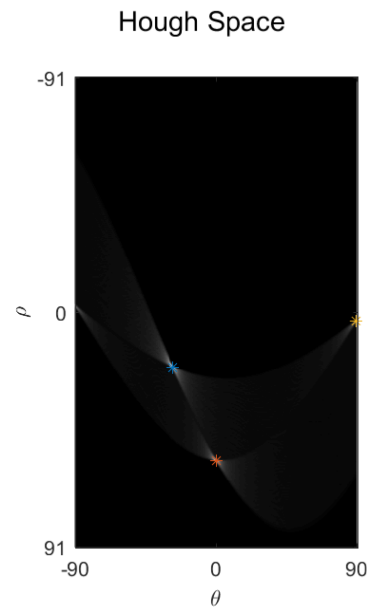
Answers:

For the simple triangle we used the following parameters

scale	Threshold	nrho	ntheta	nlines	Bin smoothing	Acc incr. function
0.5	40	500	300	3	0.1	f(x)

The results are showed below

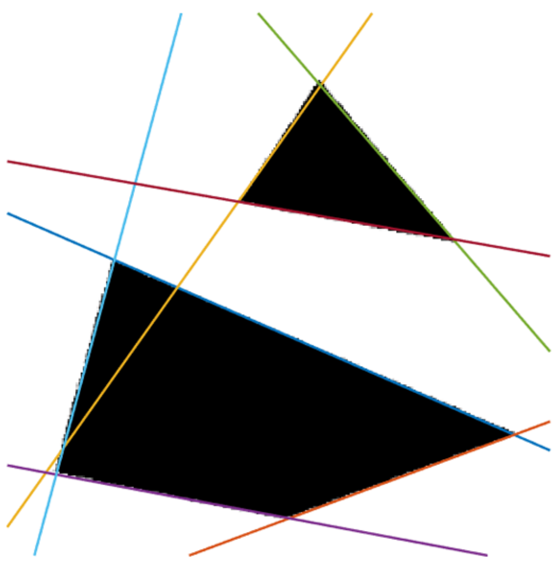


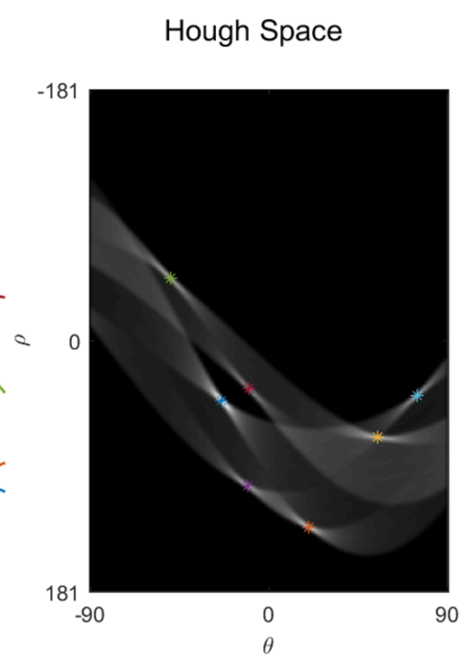


For the triangle and the polygon we used the following parameters

scale	Threshold	nrho	ntheta	nlines	Bin smoothing	Acc incr. function
0.5	60	700	500	7	0.7	f(x^2)

The results are showed below





Question 9: How do the results and computational time depend on the number of cells in the accumulator?

Answers:

Computational time increases with respect to the resolution of the accumulator matrix. That is the bigger the number of rhos and thetas, the higher the complexity, as the double looping increases proportional to the increment of cells. Although we lack in computational cost, high resolution increases the accuracy of line approximation, especially in complex structures where high accuracy in the distance and the orientation of the edgel is in need. Note though, that the high resolution could lead to several responses for the same line due to the existence of multiple neighbor local maxima.

Question 10: How do you propose to do this? Try out a function that you would suggest and see if it improves the results. Does it?

Answers:

When we increment the accumulator by one we make the assumption of all edgels being of equal strength. This is not always appropriate though, since different edgels are stronger than the others -stronger, in the sense of more sudden change in the DN value-. This information is incorporated in the gradient magnitude. Thus, we should let the “strongest” edgels to increment the accumulator according to its magnitude strength. This could be done by choosing a definite monotonically increasing function and upgrade the accumulator according to that. By experimenting, we found out that, in some cases we get better results (especially in cases where the primal lines are distinct in the image) but in cases where there are lines with strong magnitude response alongside lines with small response (but still distinctable) the extracted lines saturated along the first ones. Another detail that could influence the problem, is the slope of the monotonically increasing function. That is, if the slope is big enough it will give sudden changes in the accumulator, vanishing the edgels with medium responses, and this results to return either a saturation around the most extreme line or, saturation around a strong pick which could be due to noise. Combining all the above, and considering the exponential energy drop when capturing an image we infer that the function which fulfills all the above is the logarithmic.