Lab1 Report

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3. Smoothing Masks

3.1 Box masks

3.1.1: In your report include a print out of the figure with four subplots that you have just created. Briefly describe and explain the results you have obtained.

- Result

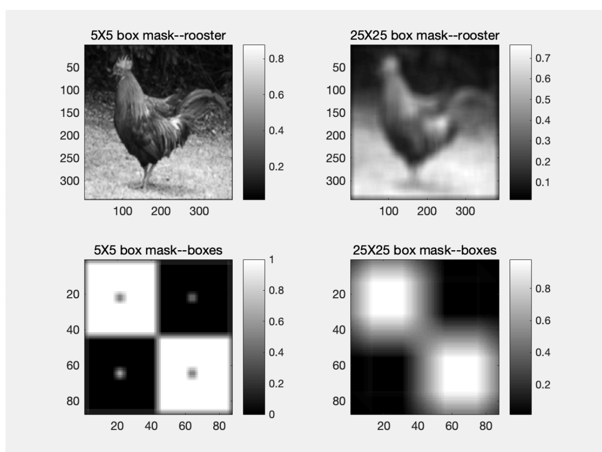

Figure 1: Convolved images.

- Description: Box mask can smooth an image by removing high spatial frequencies and only leaving low ones, it blurs the image. The larger the box mask is, the more blurred the image will get.

3.2 Gaussian masks

3.2.1: In your report include a print out of the figure with four subplots that you have created using Gaussian masks. Briefly describe and explain the results you have obtained, and compare these results with those obtained using the box masks.

- Result

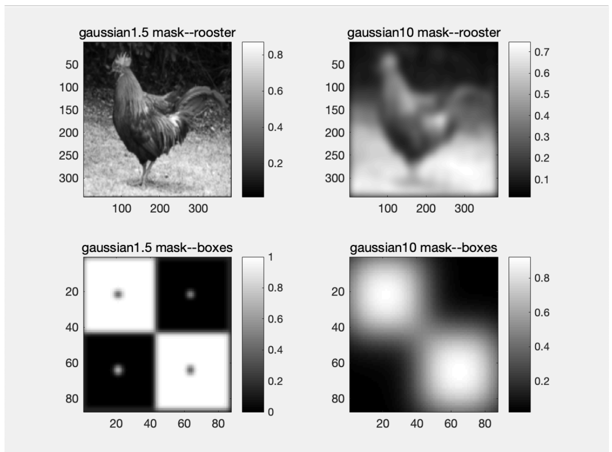

Figure 2: Convolved images.

- Description: Gaussian mask is also a smoothing mask, it can effectively remove those spatial frequencies whose wavelengths are smaller than the standard deviation of the Gaussian mask (σ). So the image will get more blurred if there is a larger σ (corresponds to shorter wavelength). As σ gose larger, the size of the mask should increase as well, I set the mask width to 7σ to ensure it can represent the Gaussian accurately. Comparing Figure 2 with Figure 1, we can tell that they both have blurred images, but it can be noticed that the edges of those images in Figure 1, especially the boxes image, are sharper than those of the same images in Figure 2. It is because that box mask has sharp edges while Gaussian mask falls off gently at the edges. Gaussian mask is a weighted smoothing mask, it gives more weight to nearby pixels.

4. Difference Masks

4.1 Difference Masks (1-D)

4.1.1: Plot the results in your report. Briefly describe and explain the results you have obtained.

- Result

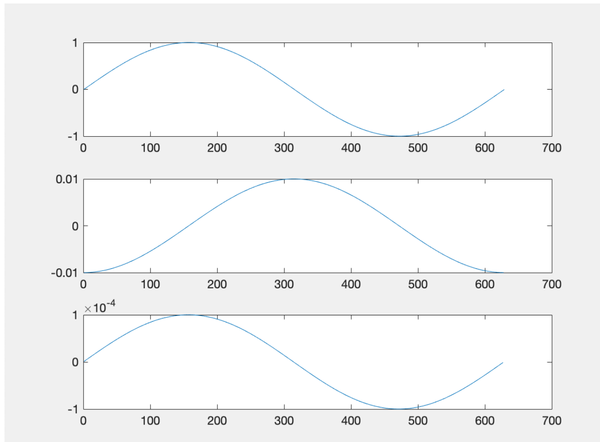

Figure 3: 1-D signal effects.

- Description: The first image shows a sine fuction in a interval of 0 to 2π ($y = \sin x, 0 < x < 2\sigma$). Convolve it with [-1, 1] to get the second figure, according to the trend, it is a cosine fuction ($y = -a \cos x, 0 < x < 2\sigma$), then this convolution can be seen as a first derivative of the first figure ($-\partial/\partial x$). Similarily, the last figure can be seen as the second derivative of the first figure ($-\partial^2/\partial x^2$). The range of y changes because the step length of x is 0.01. First and second derivative show the gradient of values, then those differencing masks can highlight loctions with intensity changes in an image.

4.2 Difference Masks (2-D)

4.2.1: In your report include the resulting images and note any difference in the two images that result from these two convolutions.

- Result

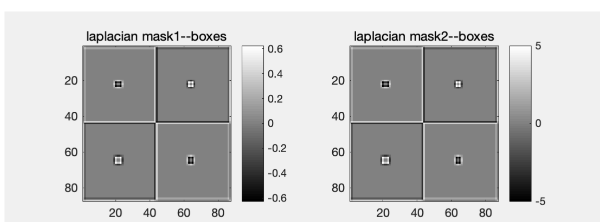

Figure 4: Convolved images.

- Description: The range of value changes because value of the first Laplacian mask is 8 times larger than the one of the second mask. Every value of the second image is approxmately 8 times larger than the vaule at corresponding loction of the first image.

4.3 Other Difference masks

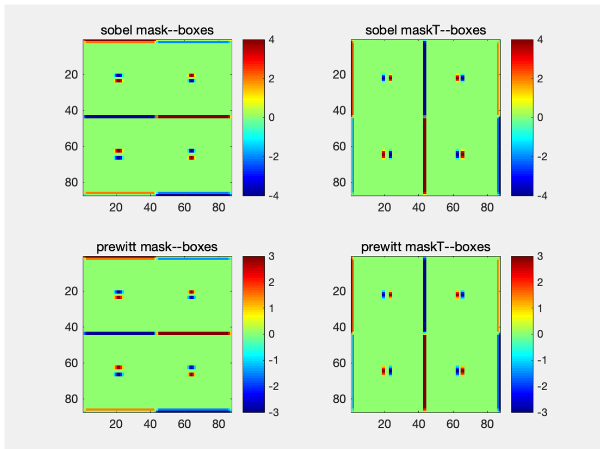

Figure 5: Convolved images.

5. Edge Detection

5.1 Gaussian derivative masks

5.1.1: In your report include a print out of the figure with four subplots that you have created. What is the value of the convolved image at the locations of large intensity discontinueties (i.e. at edges)?

- Description: I calculate the gradients of these two images in horizontal and vertical directions and find out the value of these convolved images at the loctions of large intensity discontinuities are -0.0478 and -0.0479 respectively.
- Result

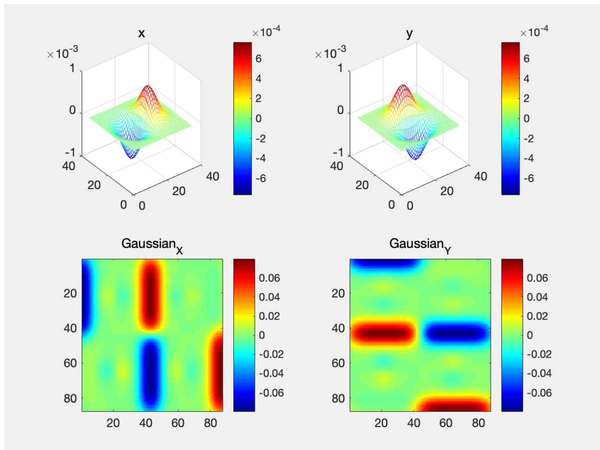

Figure 6: 2-D Gaussian masks and convolved images.

5.1.2: In your report include a print out of the second figure with four subplots that you have created. What is the value of the convolved image at the locations of large intensity discontinueties (i.e. at edges)?

- Result

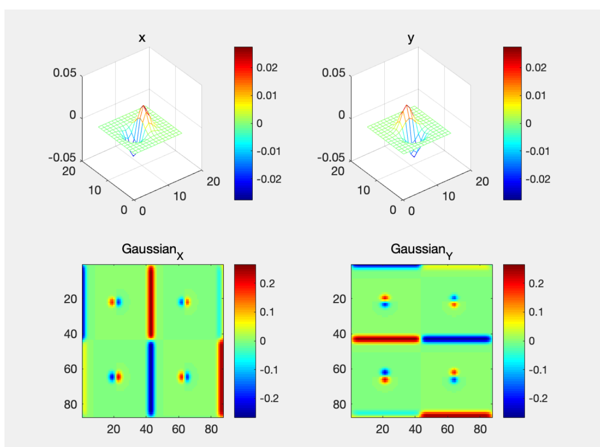

Figure 7: 2-D Gaussian masks and convolved images.

- Description: I calculate the gradients of these two images in horizontal and vertical directions and find out the value of these convolved images at the loctions of large intensity discontinuities are $1.0408 \times e^{-17}$ and $3.4694 \times e^{-18}$ respectively.

5.1.3: In your report include a figure with both these images as two subplots.

- Result

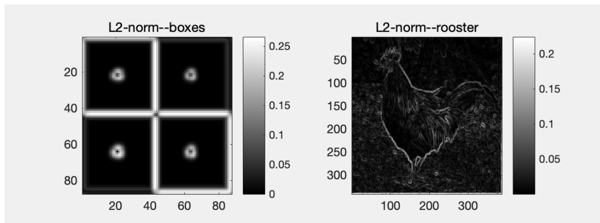

Figure 8: Convolved images.

5.2 Laplacian of Gaussian (LoG) mask

5.2.1: In your report include a print out of the figure with four subplots that you have created. What is the value of the convolved image at the locations of large intensity discontinueties (i.e. at edges)? What is the value of the convolved image near to image locations of large intensity discontinuities (i.e. near edges)?

- Result

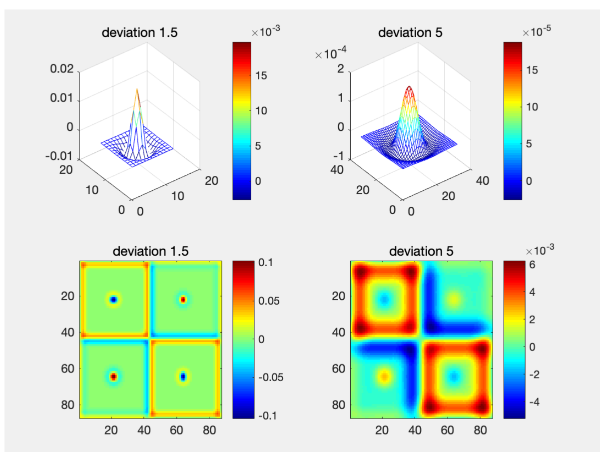

Figure 9: 2-D Gaussian masks and convolved images.

- Description: I calculate the gradients of these two images in horizontal and vertical directions and find out the value of these convolved images at the loctions of large intensity discontinuities are 0.0641 and 0.0023 respectively. And the values of the pixels near the edges in these two images are 0.0114 and 0.0009 respectively.

5.2.2: What effect does changing the standard deviation of the Gaussian used to create the Laplacian of Gaussian mask have on the result?

- Result

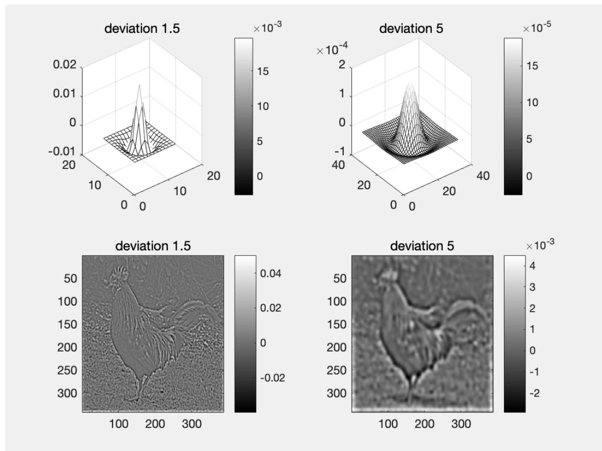

Figure 10: 2-D Gaussian masks and convolved images.

- Description: As we can see from these two convolved images, convolving with the mask of smaller deviation enhances edges, but it makes the image more noisy as well. The one convolved with the mask of larger deviation gets more blurred but less noisy.

5.3.1: In your report include a print out of the three images that you have created in this section. Include colorbars for each image.

- Result

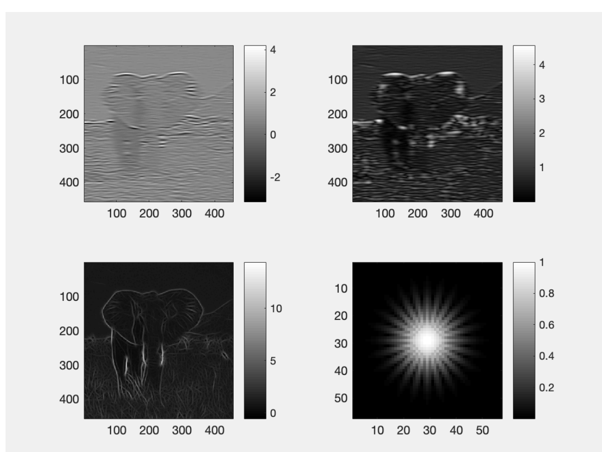

Figure 11: 2-D Gaussian masks and convolved images.

- Description: The third image shows the maximum response of the elephant image convolved with Gabor masks across orientations and the last image shows the maximum response of Gabor masks across orientations. Sorry that I am comfused with the descripotion of the last question, so I just include both images in my report.

6. Redundancy in Natural Images

6.1 Measuring Redundancy

6.1.1: Plot a graph of shift vs correlation coefficient for both the rooster and the woods image. Include in your report a print out of this figure. Briefly describle and explain the results you have obtained.

- Result

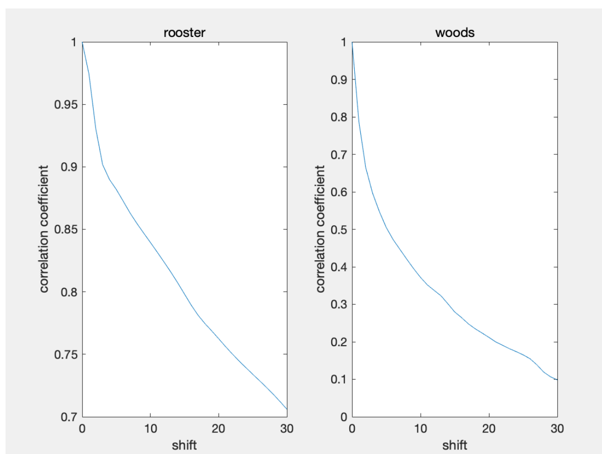

Figure 12: Shift vs correlation coefficient for the rooster and the woods image.

- Description: The correlation coefficient goes down gradually as the part shifts more pixels for both images. It indicates that the further the two part of a same image from each other, the more uncorrelated they will be.

6.2.1: Plot graphs of shift vs correlation coefficient for both the rooster and the woods image after convolution with both the DoG masks. Include in your report a print out of this figure. Briefly explain why the results for the two DoG masks differ, also explain why the current results differ from those in the previous section.

- Result

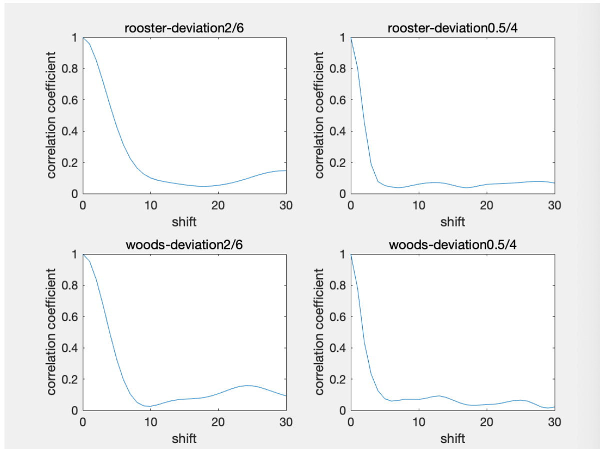

Figure 13: Shift vs correlation coefficient for the rooster and the woods image.

- Description: The correlation coefficient goes down and hits a very low point fast and then basically maintains this low value as the part shifts more pixels for those images. The DoG mask with smaller standard deviation (0.5-4) hits the point even faster than another one. It is because that the convolved image with the smaller DoG mask has sharper edges, the gradients nearby become larger, only a few pixels shifted can enhance the uncorrelation. Comparing with the original images, convolved with DoG mask performs edge detection, causing large intensity discontinuities in images. So the correlation coefficient of current results falls off dramatically within a few shifts rather than goes down gently of the previous results.

7. Colour Detection

7.1 Colour Oppoent Cells

7.1.1: In your report include a print out of the figure with four subplots that you have just created. Briefly describe and explain the results you have obtained.

- Description: Both images highlight the part whose colour matches the one of the on-channel and suppress the one matches the colour of off-channel. For example, the red area of the image has a high positive value while the green area has a low negative value. Cells at the locations where the colour matches the colour of on-channel respond stronger than where the colour does not match.

- Result

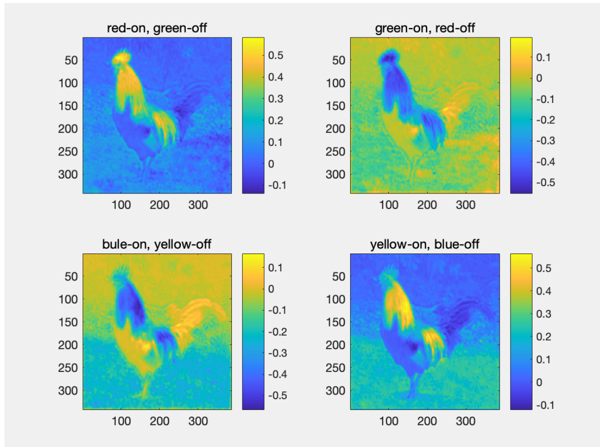

Figure 14: Centre-surround colour opponent cell combinations on the rooster image.

8. Multi-Scale Representations

8.1 Gaussian Image Pyramid

8.1.1: In your report include a print out of the figure with four subplots that you have created.

- Result

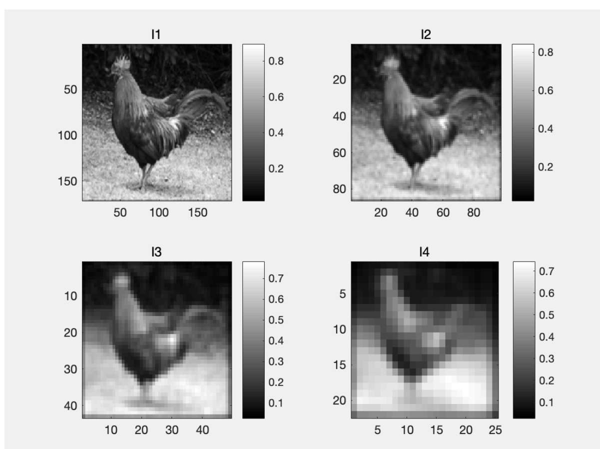

Figure 15: Gaussian image pyramid.

8.2.1: In your report include a print out of the figure with four subplots that you have just created. Comment briefly on this results in comparison to the results from section 5.2.

- Result

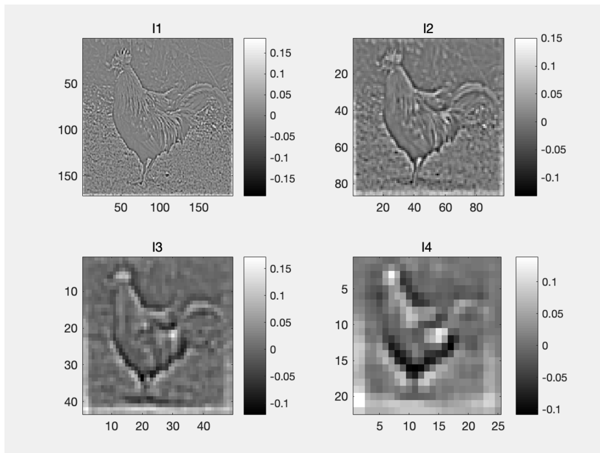

Figure 16: Centre-surround colour opponent cell combinations on the rooster image.

- Description: It indicates that both method can be used to perform edge detection because all the results I get locates the intensity discontinuities in images. And they all can be used on images of different scale as well.