Intro to Image Understanding (CSC420)

Assignment 1

Posted: Jan 23, 2021 **Submission Deadline : Jan 31, 11.59pm, 2021**

Instructions for submission: Please write a document (pdf or doc) with your solutions (include pictures where needed). Include your code inside the document. Please submit through MarkUs. You are expected to work on the assignment **individually**.

Max points: 15

1. (a) **[2 points]** Write your own function for computing convolution of the 2D (grayscale) image and a 2D filter. The function should accept a 2D image and a 2D filter (you can assume it's a square matrix with odd height and width), and return the resulting matrix obtained by convolving the input image with the given filter. Make the output matrix be the same size as the input image. Be careful to correctly deal with the border of the image – the easiest way to do this is to "zero-pad" the image prior to convolution.
   (b) **[2 points]** Now assume that the filter is separable. Write a function that 1) verifies that the input filter is separable, 2) write a faster convolution function leveraging the fact that the filter is separable.
   (c) **[1 point]** What is the number of operations required for performing 2D convolution? What is the number of operations required for performing convolution with a separable filter?

2. (a) **[2 points]** You convolve an image I with a filter $f_1 = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$, then take the output and convolve it with another filter $f_2 = \begin{pmatrix} e & f \\ g & h \end{pmatrix}$. Is it possible to get the same final result by just performing one convolution? If so, what is the filter to do this? Please write down the mathematical justification. No need to write code.
   (b) **[1 point]** Write your own function that creates a Laplacian of Gaussians (LoG) filter with σ as an input parameter.
   (c) **[1 point]** Convolve the attached waldo.png with a (2D) Gaussian filter with $\sigma = 1$ and visualize the result (display the result of the convolution). You can use built-in functions for convolution. Include the visualized result in the assignment's document.
   (d) **[2 points]** Is a vertical derivative, $\frac{\partial G(x,y)}{\partial y}$, of a Gaussian filter G a separable filter? Analyze both the isotropic and anisotropic case. Explain your answer. Is a Laplacian of Gaussians (LoG) a separable filter? No need to write code.

3. (a) **[1 point]** Compute magnitude of gradients for the attached images waldo.png and template.png. Write your own function to do this. You can use the built-in convolution function.

   (b) **[1 point]** Write a function that localizes the template (template.png) in the image waldo.png based on the magnitude of gradients. Visualize the result and include it in the assignment's document.

4. (a) **[2 points]** Implement the Canny edge detector yourself. You do not need to do hysteresis thresholding. However, do perform non-maxima suppression. Please visualize your results on waldo.png.