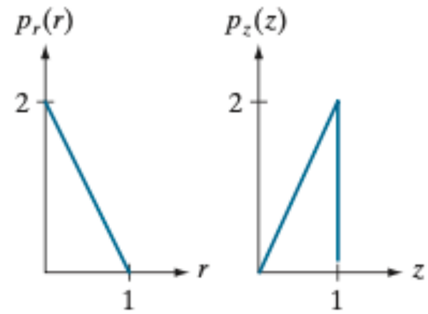
Assignment 2
CSC 8260 – Advanced Image Processing
Due Date: February 7^{th}, 2023, 11:59 pm

Q1. An image with intensities in the range [0,1] has the PDF, $p_r(r)$, shown in the following figure. It is desired to transform the intensity levels of this image so that they will have the specified $p_z(z)$ shown in the figure. Assume continuous quantities, and find the transformation (expressed in terms of r and z) that will accomplish this.



Q2. Bit plane extraction is a technique that is used to compress an image. These compression techniques are often categorized as lossy or lossless, which category does bit-plane extraction fall into?

0	1	8	6
2	2	1	1
1	15	14	12
3	6	7	10

a. Submit code showing all possible bit planes of above 4 bit image
b. If you believe bit plane slicing is lossless, convert all possible bit planes back to original 4 bit image.
c. If you believe bit plane slicing is lossy, can 1st-order extrapolation or 2D bilinear interpolation recover the original image?

Q3. What effect would setting to zero the lower-order bit planes have on an Image's histogram? What would be the histogram's effect if we set the higher-order bit planes to zero instead?

Q4. Answer the following

a. If V = $[1\ 2\ 1]^T$ and $W^T = [2\ 1\ 1\ 3]$ is the kernel formed by VW^T separable.
b. The following kernel is separable. Find the W_1 and W2 such that w = $W_1 \star$ W2

1	3	1
2	6	2

c. The following kernel is separable. Find W_1 and W_2 such that w = $W_1 \star W_2$

2	1	1	3
4	2	2	6
2	1	1	3

Q5. An image is filtered four times using a Gaussian kernel of size 3×3 with a standard deviation of 1.0. Because of the associative property of convolution, we know that equivalent results can be obtained using a single Gaussian kernel formed by convolving the individual kernels.

a. Is the resulting filter Gaussian? Explain.
b. What is its standard deviation?
c. What is its size?

Q6. You saw in Fig. 3.46 that the Laplacian with a −8 in the center yields sharper results than the one with a −4 in the center. Explain the reason why.

Q7. Are any of the following highpass (sharpening) kernels separable? For those that are, find vectors **v** and **w** such that $\mathbf{v}\mathbf{w}^T$ equals the kernel(s).

a. The Laplacian kernels in Figs. 3.45(a) and (b).
b. The Roberts cross-gradient kernels shown in Figs. 3.50(b) and (c).
c. The Sobel kernels in Figs. 3.50(d) and (e).

Q8. Submit code that performs 2D convolution of the image testpattern.tif. Use zero padding for the image and a 3x3 size kernel.

Q.9. Submit code that performs lowpass filter using Gaussian Kernel on testpattern.tif image.

a. Select the kernel such that the large letter "a" is barely readable.
b. Submit code that performs lowpass filter using Gaussian Kernel, such that when the image is thresholded, the filtered image only contains large square on top right.

Q.10 An image is filtered with three Gaussian lowpass kernels of sizes 3×3, 5×5, and 7×7, and standard deviations 1.5, 2, and 4, respectively. A composite filter, w, is formed as the convolution of these three filters.

a. Is the resulting filter Gaussian? Explain.
b. What is its standard deviation?
c. What is its size?

Bonus Questions

Q1. Intensity level slicing in images allows a specific range of intensities while blocking the rest of them, transforming images to near monochrome. Submit code and outputting images for the below questions

a. Your task is to display the PDF of the Washington.tif image and perform intensity-level slicing.

b. Perform intensity level slicing on the above image and display the new PDF that you have selected.
c. What detail does this transformation inform?

Hint : Intensity level slicing for the above image has two benefits. Enhancing low intensity informs one certain details and enhancing higher intensity informs other things.

Q2. Do the following

a. Show that the Gaussian kernel, $G(s, t)$, in Eq. (3-45) is separable. (*Hint:* Read the first paragraph in the discussion of separable fil- ter kernels in Section 3.4.)
b. Because G is separable and circularly symmetric, it can be expressed in the form $G = \mathbf{v}\mathbf{v}^T$. Assume that the kernel form in Eq. (3-46) is used, and that the function is sampled to yield an $m \times m$ kernel. What is $\mathbf{v}$ in this case?

Q3. Do the following:

a. Show that the magnitude of the gradient given in Eq. (3-58) is an isotropic operation (see the statement of Problem 3.39).
b. Show that the isotropic property is lost in general if the gradient is computed using Eq. (3-59).

NOTE :

1. Answers are to be submitted as PDF
2. Any code submissions are to be sent as separate files