State University of New York at Buffalo

CSE 473/573 Fall 2016 Homework Set #3

Assignment Date: Wednesday October 19, 2016; Due: ***Wednesday October 26, 2016 at 3:00PM***

Name: _____ Student Number: _____

Problem (1) **(Sampling Theorem and Nyquist Criterion)** 20%

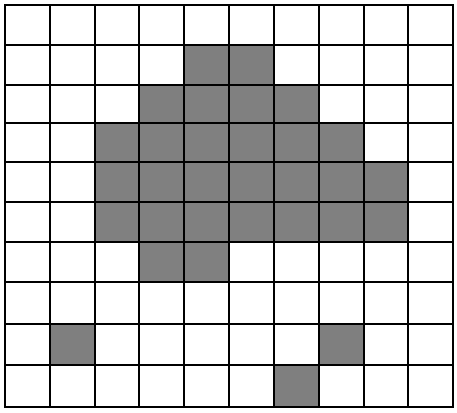
(a) Determine the highest frequency components of the following $sinc$ signals:
   (1) $sinc\ (500\pi t)$
   (2) $sinc\ (500\pi t)\ sinc\ (1000\pi t)$
   (3) $sinc^2\ (1000\pi t)$

(b) Determine the Nyquist sampling rate and the Nyquist sampling interval for the above three signals

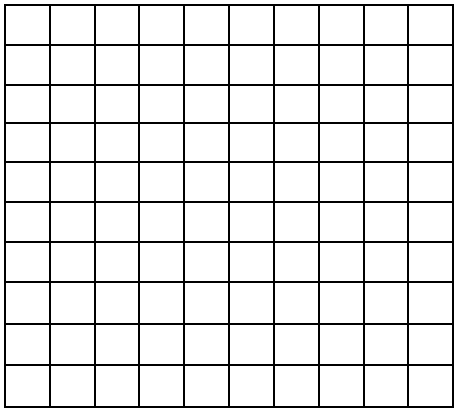
(c) Based on the results obtained in (b), explain how the sampling rate would usually change for a product of two $sinc$ signals.

Problem (2) **(Image Filtering with 2D Convolution)** 40%

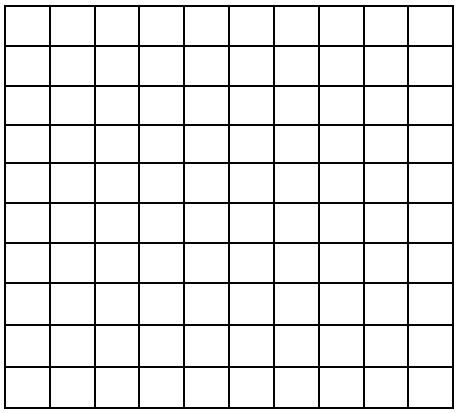
Consider a 10×10 image as shown below in which the object pixels are shaded gray (pixel value = 1) and background pixels are white (pixel value =0).



(a) Perform a low pass filtering with a 3×3 convolutional kernel as: $h = \frac{1}{5}\begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix}$ to the above image and label all pixels in the following with filtering results (may be fractional).

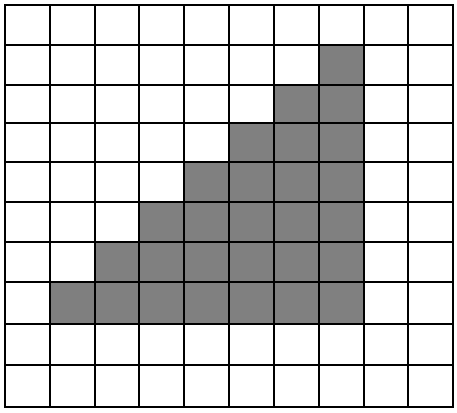


(b) Apply a threshold of 0.5 to the results of the low pass filtering shown above. That is, if the result at a pixel (i, j) is > 0.5, assign $f(i, j) = 1$; otherwise, assign $f(i, j) = 0$. Compare the thresholding results with original image and comment on the comparison.

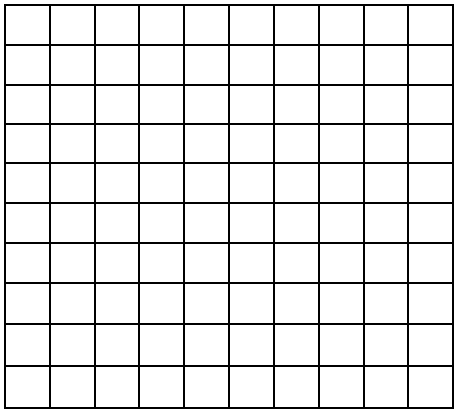


Problem (3) **(Edge Detection with Laplace Operator)** 40%

Consider a 10×10 image as shown below in which the object pixels are shaded gray (pixel value = 1) and background pixels are white (pixel value =0).



(a) Apply the Laplace Operator, $h = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$ to the above image and label all pixels in the following with the results from Laplace Operator application.



(b) The Laplace operator can be used for the detection of zero-crossings in a digital image while the zero-crossing is defined between two pixels with opposite (positive and negative) pixel values. Identify and mark the zero crossings (the **edge** between two pixels) from the above results of Laplace Operator. Is the Laplace operation result different from the visual inspection?