National University of Computer and Emerging Sciences, Lahore Campus

	Course:	Digital Image Processing	Course Code:	EE402
	Program:	BS(Computer Science)	Semester:	Spring 2018
	Duration:	60 Minutes	Total Marks:	100
	Paper Date:		Weight	15%
	Section:	ALL	Page(s):	6
	Exam:	Midterm-I		

Your Name: ________________________

Your Roll No : _________________

Instructions:

1: Please show all your work.

2: Please use the space provided for each problem. You can use extra sheet for rough work.

3: A list of formulas and relationships you might find useful are given on the last page.

4: In case of an ambiguity, you can make reasonable assumptions after stating them clearly.

Good luck!

- Problem 1:(30 points)

(a):

Apply filter $\begin{bmatrix} 0 & 1 & 0 \\ 1 & 2 & 1 \\ 0 & 1 & 0 \end{bmatrix}$ on $\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ assuming free boundary conditions.

(b):

Two Fourier Transforms $F_1(u, v)$ and $F_2(u, v)$ are exactly equal everywhere except at one frequency. How can we find that one frequency, using only images $F_1(u, v)$ and $F_2(u, v)$, given nothing else.

- Problem 2 (30 points)

(a): Let S1={Set of all 1s} in $\begin{bmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$. Find a pair of 1s that is NOT neighbors of each other in an 8-point neighborhood system and:

(i) With free boundary conditions
(ii) With toroidal boundary conditions

(b): We have an image $f(x, y)$ with a histogram $p_f(f)$. The image is to be transformed using the transformation $g(x, y) = 3f(x, y)$. How is $p_g(g)$ related to $p_f(f)$?

- Problem 3 (40 points)

(a)

(i) Design a 3x3 filter that performs the following:

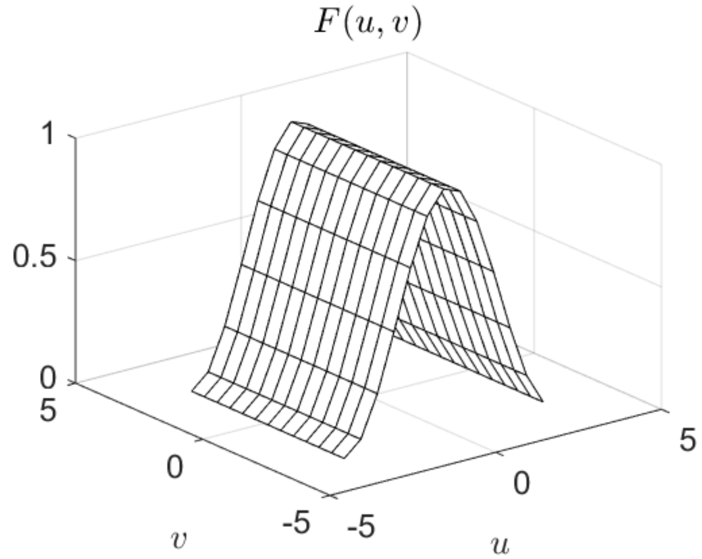
$$y_i = x_i - \mu_l$$

where

$$\mu_l = \sum_{j \in \partial i} x_j$$

i.e subtracts the local average of neighboring pixels from the current pixel.

(ii) The Fourier Transform of a filter is shown in figure below. What will this filter do to horizontal edges, vertical edges and flat regions?



(b): A real image has the property that it is equal to its complex conjugate i.e $f(x,y) = f^*(x,y)$. Prove that the magnitude of Fourier Transform of a real image $f(x,y)$ is symmetric, i.e

Given $f(x,y)$ is real, you have to prove $|F(u,v)| = |F(-u,-v)|$

Useful Fourier Properties And Other Relations

Property	Space Domain Function	CSFT
Linearity	$af(x,y)+bg(x,y)$	$aF(u,v)+bG(u,v)$
Conjugation	$f^*(x,y)$	$F^*(-u,-v)$
Scaling	$f(ax,by)$	$\frac{1}{\lvert ab \rvert}F(u/a,v/b)$
Shifting	$f(x-x_0,y-y_0)$	$e^{-j2\pi(ux_0+vy_0)}F(u,v)$
Modulation	$e^{j2\pi(u_0x+v_0y)}f(x,y)$	$F(u-u_0,v-v_0)$
Convolution	$f(x,y)*g(x,y)$	$F(u,v)G(u,v)$
Multiplication	$f(x,y)g(x,y)$	$F(u,v)*G(u,v)$
Duality	$F(x,y)$	$f(-u,-v)$

From basic probability theory

$$p_f(f) \qquad \xrightarrow{f} \boxed{T(f)} \xrightarrow{g} \qquad p_g(g) = \left[p_f(f)\frac{df}{dg} \right]_{f=T^{-1}(g)}$$

8-point neighborhood

$$\begin{array}{ccc} \circ & \circ & \circ \\ \circ & \times & \circ \\ \circ & \circ & \circ \end{array}$$