ECE 5273
Test 2

Friday, May 10, 2024
10:30 AM - 12:30 PM

Spring 2024 Name:____________________

Dr. Havlicek Student Num:____________________

Directions: This is an open notes test. You may use a clean copy of the course notes as published on the course web site and a calculator. Other materials are not allowed. You have 120 minutes to complete the test. All work must be your own.

SHOW ALL OF YOUR WORK for maximum partial credit!

GOOD LUCK!

SCORE:

1. (20) ________

2. (20) ________

3. (20) ________

4. (20) ________

5. (20) ________

TOTAL (100):

____

On my honor, I affirm that I have neither given nor received inappropriate aid in the completion of this test.

Name:____________________ Date:____________________

POSTING OF FINAL GRADES

It is the policy of the University of Oklahoma that grades will not be posted by student name, social security number, or student number.

Therefore, final grades for this class will be posted on the course web site using CODE NAMES, but only AT YOUR REQUEST.

Indicate your preference by marking ONE of the boxes below. If you request that your grade be posted, you MUST provide a CODE NAME. Your code name must NOT include any part of your real name, your student number, or you social security number.

☐ Do NOT post my final grade.

☐ DO post my final grade.

Code Name: ______________________________

1. **20 pts**. True or False. Mark *True* only if the statement is **always** true.

TRUE FALSE

______ ______ (a) **2 pts**. When the spectra of the noise and the image are overlapping, the window of a *linear* denoising filter must be designed very carefully in order to ensure that *all* of the noise is removed.

______ ______ (b) **2 pts**. Laplacian noise is characterized by heavy tails – meaning a higher probability of very large or very small noise samples (outliers) compared to Gaussian noise.

______ ______ (c) **2 pts**. When the window is $\mathbf{B} = \text{SQUARE}(9)$, the 3×3 square window, the coefficient vector for a trimmed mean OS filter $\text{TM}_3[\mathbf{J}, \mathbf{B}]$ is given by $\mathbf{A}^T = [0, 0, 0, \frac{1}{3}, \frac{1}{3}, \frac{1}{3}, 0, 0, 0]$.

______ ______ (d) **2 pts**. The bilateral filter is based on a product of two kernels (weighting functions): one that weights neighbors based on spatial distance and one that weights neighbors based on luminance similarity.

______ ______ (e) **2 pts**. Baseline JPEG achieves lossless compression by quantizing the DCT coefficients of each 8×8 block of pixels.

______ ______ (f) **2 pts**. Baseline JPEG achieves lossy compression by Huffman coding the quantized DCT coefficients after they have been placed in a 1D array using the zig-zag order and run-length coded.

______ ______ (g) **2 pts**. The main reason for using normalized cross-correlation in gray scale template matching algorithms is that the normalized cross-correlation is not affected by scaling and rotation.

______ ______ (h) **2 pts**. The Laplacian-of-Gaussian (LoG) and Canny edge detectors are both based on finding zero crossings in the approximated second derivative of the image.

______ ______ (i) **2 pts**. One of the main features of Canny's Edge Detector is that it computes a second derivative in the direction normal to the edge.

______ ______ (j) **2 pts**. The technical term *pixel* is actually a contraction of "pixie elephant," referring to a species of tiny winged elephants found primarily in Sub-Saharan Africa.

2. **20 pts**. The 512×512 image $\mathbf{I}$ shown at left below has 8-bit pixels in the range $0 \le I(m,n) \le 255$. This image is transmitted through a communication channel where it is corrupted by IID additive white Gaussian noise with standard deviation $\sigma_N = 16$. The received image $\mathbf{J}$ is shown at right below.

I

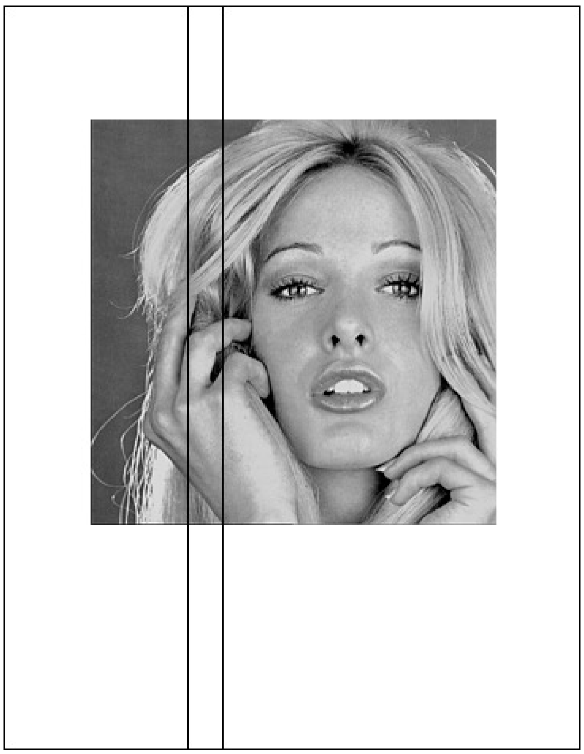
J

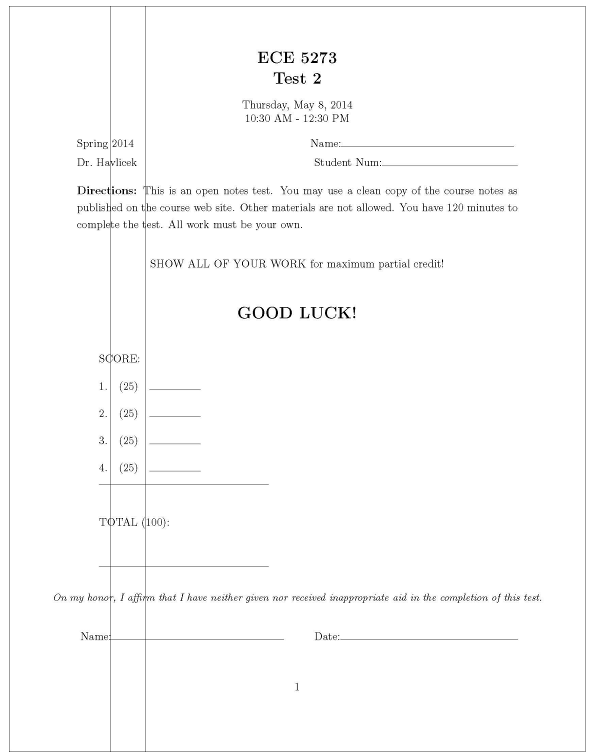
The following two filters are applied to perform denoising:

- A 512×512 Gaussian low-pass filter with space constant $\sigma = 2.50$, implemented as described on pages 5.64-5.65 of the course notes,
- A bilateral filter with Gaussian weighting functions having $\sigma_G = 8.0$ and $\sigma_H = 35.5$.

Identify and label the two filtered images shown below:

3. **20 pts**. The ECE department photocopier has developed a problem. There are vertical black lines on all of the copies. The lines are always one pixel wide and are always separated by at least 64 columns. Because it is a hardware problem, these same vertical black lines show up when the photocopier is used to make scans as well. Two examples are given below:




ECE 5273
Test 2

Thursday, May 8, 2014
10:30 AM - 12:30 PM

Spring 2014 Name:__________
Dr. Havlicek Student Num:__________

Directions: This is an open notes test. You may use a clean copy of the course notes as published on the course web site. Other materials are not allowed. You have 120 minutes to complete the test. All work must be your own.

SHOW ALL OF YOUR WORK for maximum partial credit!

GOOD LUCK!

SCORE:

1. (25) ______
2. (25) ______
3. (25) ______
4. (25) ______

TOTAL (100):

On my honor, I affirm that I have neither given nor received inappropriate aid in the completion of this test.

Name:__________ Date:__________

1

Unfortunately, it will be at least three weeks before a technician can come out to repair the problem. In the meantime, here is the plan: instead of copying, everybody will use the photocopier to scan instead. A nonlinear digital gray scale filter will then be applied to remove the vertical black lines from the scanned images, which can then be printed.

Because of your excellent performance in ECE 5273, you have been asked to design the filter. Carefully explain which filtering operation you recommend, which window or structuring element, and the reasons for your choices.

Work Space for Problem 3. . .

4. **20 pts**. Pixels in the 6×6 image **I** shown below take values in the range $\{0, 1, 2, \ldots, 99\}$. The image is sent through a communication channel where it is corrupted by additive noise. The received image **J** is also shown below.

I =

11	**11**	**12**	**12**	**13**	**13**
11	**12**	**12**	**13**	**13**	**13**
12	**12**	**13**	**13**	**13**	**14**
12	**13**	**13**	**13**	**14**	**14**
13	**13**	**13**	**14**	**14**	**14**
13	**13**	**13**	**14**	**14**	**14**

J =

11	**11**	**33**	**12**	**13**	**13**
11	**12**	**0**	**13**	**13**	**13**
12	**12**	**99**	**13**	**13**	**14**
12	**13**	**13**	**89**	**14**	**14**
13	**13**	**13**	**45**	**14**	**14**
13	**13**	**13**	**1**	**14**	**14**

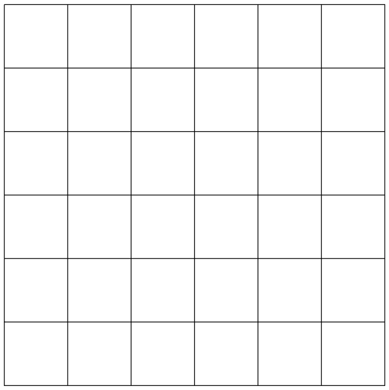
Design a nonlinear filter to restore the received image by attenuating the noise. Handle edge effects by replication. Explain your solution. Show the restored image **K** below and compute the ISNR. There is workspace on the following two pages.

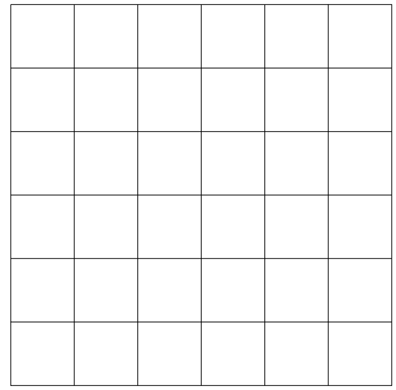
Show the restored image here:

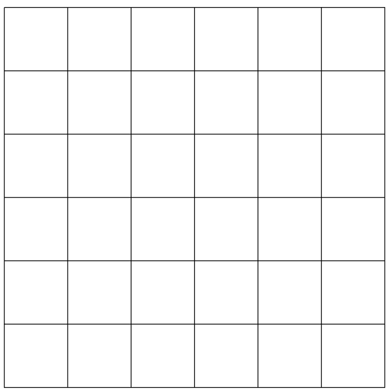
K =

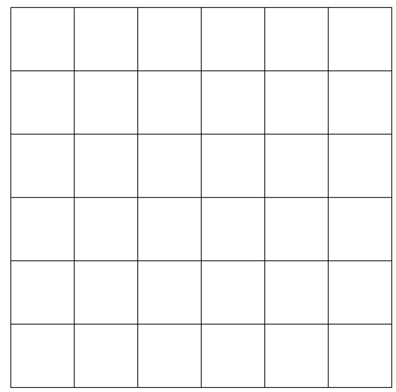
ISNR=

More Workspace for Problem 4…









More Workspace for Problem 4...

5. **20 pts.** Gray scale digital images **I** with 3 bits per pixel and gray levels in the range $\{0, 1, \ldots, 7\}$ are modeled as coming from an information source with the following source symbol probabilities (normalized histogram):

k	0	1	2	3	4	5	6	7
$p_{\mathbf{I}}(k)$	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{7}{8}$	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{1}{64}$

(a) **12 pts**. Design a Huffman code to encode these images.

Problem 5 cont…

(b) **4 pts**. Find the expected BPP (bits per pixel) and CR (compression ratio) for the coded images $C(\mathbf{I})$.

(c) **4 pts**. Does your code achieve the theoretical lower bound on BPP for the coded images? Explain why or why not.