ECE/OPTI 533 Digital Image Processing **Spring Semester, 2003**
Mid-Term Exam 2 Solution
May 6, 2003

Exam: Open-Notes, books, no partial credit

Because there is no partial credit, *it is especially important* that you clearly define, specify or describe everything that you do.

1. (10%,10%,10%) Given the following noisy image segment g(m,n):

		m =			
		1	2	3	4
	4	123	114	188	173
n =	3	120	126	193	199
	2	135	127	197	201
	1	182	179	189	193

The global image noise variance is 100, and the noise is additive to and independent of the noiseless image f(m,n). Calculate the adaptive Wiener filter output at pixel (2,2) using a 3x3 pixel neighborhood and uniform box filters.

The adaptive WF output at pixel (m,n) is (notes17,p387):

$$\hat{f}(m,n) = LP(m,n) + \left[\frac{\sigma_f^2(m,n)}{\sigma_f^2(m,n) + \sigma_v^2}\right] HP(m,n)$$

Using a 3x3 uniform box filter,

LP(2,2) = 160.89
HP(2,2) = 127 - 160.89 = -33.89

$\sigma_f^2(2,2) + \sigma_v^2 = 1075.86$ (956.3 if variance calculated with N instead of N-1)

therefore, $\sigma_f^2(2,2) = 975.86$ and $\frac{\sigma_f^2(2,2)}{\sigma_f^2(2,2) + \sigma_v^2} = 0.907$ and $\hat{f}(2,2) = 130.15$ (130.55)

Note that, because this 3x3 region overlaps a high contrast feature and therefore has relatively high SNR, the change due to the WF is small.

2. (5%, 5%) Given the following 1-D image:

173 160 156 171 167 189 185 194 173 164 188 173 181

Calculate the other 2 levels in the resolution pyramid using the 1-D Burt kernel,

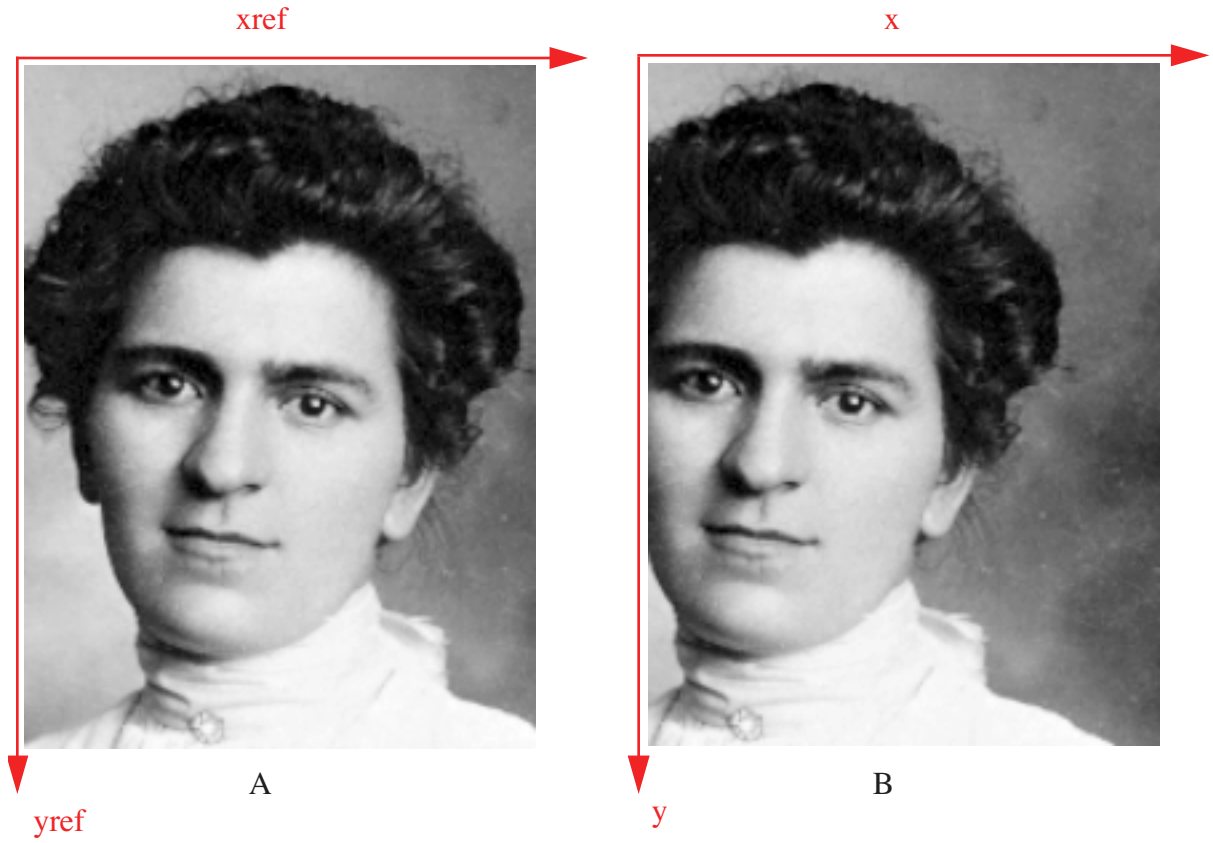
0.05 0.25 0.4 0.25 0.05

Average 5 pixel segments and downsample by 2 (no padding):

second level: 162.15 173.85 186.75 177.35 177.15
third level: 179.47

Various padding schemes OK, as long as weighting and downsampling are correct

3. You take two portraits of a woman, but accidentally move the digital camera between the two pictures (A and B below). The offset is 33 pixels in the x-direction (horizontal); there is no other distortion. Determine the two polynomials required to register image B to image A (reference). **Show your coordinate systems.** (20%)



$$x = a_{00} + a_{10}x_{ref} + a_{01}y_{ref} + \ldots$$
$$y = b_{00} + b_{10}x_{ref} + b_{01}y_{ref} + \ldots$$

The only distortion is a horizontal shift; therefore, all other coefficients are either zero or one, including higher-order terms

$$x = a_{00} + x_{ref}$$
$$y = y_{ref}$$

By inspection, $a_{00} = -33$ and $x = -33 + x_{ref}$
$y = y_{ref}$

4. Given the following DN values for a digital image:

		x = 1	2	3	4	5
	1	201	183	190	204	184
	2	186	156	167	170	145
y =	3	188	187	182	171	152
	4	192	200	189	185	202
	5	173	177	181	178	183

The image is resampled for geometric correction. What is the resampled pixel value at (x,y) = (2.4, 3.7), if bilinear resampling is used? **Note the coordinate sytem.** (10%)

From notes17, p330:
DN(2.4,3.7) = (0.4*182 + 0.6*187)*0.3 + (0.4*189 + 0.6*200)*0.7 = 192.42

5. Given the following 1-band image,

row \ col	1	2	3	4
1	201	232	211	204
2	186	166	167	170
3	188	187	182	171
4	192	200	223	209

Cluster the image into 2 clusters using the K-means iterative nearest-mean clustering algorithm, with seed mean values 188 (cluster a) and 210 (cluster b).

Calculate the cluster map after the first cluster assignment (10%) and
after the second cluster assignment (10%).

after first cluster assignment:

b	b	b	b
a	a	a	a
a	a	a	a
a	b	b	b

new cluster mean estimates:

mean a = 178.78
mean b = 211.43

after second cluster assignment:

b	b	b	b
a	a	a	a
a	a	a	a
a	b	b	b

No change.

Calculate the signature map after the second cluster assignment (10%).

211.43	211.43	211.43	211.43
178.78	178.78	178.78	178.78
178.78	178.78	178.78	178.78
178.78	211.43	211.43	211.43