University of Pretoria
Department of Geography, Geoinformatics and Meteorology
GMA 320: Remote Sensing Semester Test
Total score: 70

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Instructions

Duration T : 90 [minutes]
Answer all questions.

Formulae

$$R = \left[\frac{R_{max} - R_{min}}{255} \times DN\right] + R_{min}$$

$$R = \beta \times DN + \epsilon$$

$$T = \frac{K_2}{ln\left[\frac{K_1}{R} + 1\right]}$$

$$R = \frac{\{R_{max} - R_{min}\}\{DN - DN_{min}\}}{\{DN_{max} - DN_{min}\}} + R_{min}$$

$$\text{eigenvalue}[\%] = \frac{\text{eigenvalue}}{\sum_{PC} \text{eigenvalue}}$$

Table 1: ETM+ Spectral Radiance Range [$Wm^{-2}ster^{-1}\mu m^{-1}$] before and after July 1, 2000

	Before	July	2000		After	July	2000
Low	Gain	High	Gain	Low	Gain	High	Gain
R_{min}	R_{max}	R_{min}	R_{max}	R_{min}	R_{max}	R_{min}	R_{max}
0.0	17.04	3.2	12.65	0.0	17.04	3.2	12.65

Table 2: ETM+ Thermal constants constant value units

Constant	**value**	**unit**
K_1	666.09	[$Wm^{-2}ster^{-1}\mu m^{-1}$]
K_2	1282.71	[°K]

Question 1
A review of fundamentals of remote sensing [17 marks]

1. Explain briefly the following concepts as used in remote sensing [**4 marks**]
   - Geometric correction [1 marks]
   - A pixel [1 marks]
   - Spectral signature [2 marks]
2. What is being sensed by remote sensing instruments? [**1 mark**]
3. What is radiometric resolution? What effect does radiometric resolution have on remote sensing (i.e., how does changing radiometric resolutions affect image interpretation)? [**4 marks**]
4. Name three examples of common application of remote sensing. [**3 marks**]
5. Name the five main stages of *the remote sensing process.* [**5 marks**]

Question 2
Remote sensing data collection, (10 marks)

1. List two advantages and two disadvantages of digital image analysis. [**4 mark**]:

2. What are the three basic steps of digital image analysis? List one procedure which is commonly used from each step.[**6 mark**]:

Question 3
Digital Image Processing considerations [7 marks]

1. Enumerate any four important Digital Image Processing (DIP) system considerations. [**4 marks**]

2. Name any three main features that an ideal remote sensing storage media should have. [**3 marks**]

Question 4
Image quality assessment, statistical evaluation[15 marks]

1. Table 1 shows the correlation matrix derived from a sample multispectral data set.

Band	**1**	**2**	**3**	**4**
1	-	0.42	0.52	0.66
2		-	0.51	0.25
3			-	0.97
4				-

   (a) What do the high correlation between bands 3 and 4 signify? [**2 marks**]

(b) Which band provides unique information not found in the other bands? [**3 marks**]

(c) What is the proportion of total variation in the brightness values of band 1 that can be explained by a linear relationship with values of the random variation in band 4? [**2 marks**]

2. You are provided with the following sample covariance matrix and corresponding eigen values(see Table 3) from image analysis.

Table 3: **Covariance matrix and eigen values for bands 1 → 6**

	1	2	3	4	5	6	Eigen value
1	1423.44	1285.58	1324.69	1455.73	2010.68	1349.20	9782.80
2	1285.58	1175.56	1225.84	1317.50	1843.92	1249.63	336.86
3	1324.69	1225.84	1342.04	1300.68	1962.05	1386.25	130.32
4	1455.73	1317.50	1300.68	1712.95	2113.74	1340.94	29.21
5	2010.68	1843.92	1962.05	2113.74	3113.93	2124.28	12.47
6	1349.20	1249.63	1386.24	1340.94	2124.28	1526.88	3.13

(a) Calculate the sum of variance. [**3 marks**]

(b) Calculate the proportion of the total information content explained by each principal component. [**3 marks**]

(c) What percentage of the total information content is explained by the 1st three principal components? [**2 marks**]

Question 5
Error sources and error correction[18 marks]

1. Explain two ways through which the remote sensing sensor contributes radiometric noise. [**4 mark**]:

2. Identify and describe two sources of geometric distortions commonly found in remote sensing imagery? [**4 mark**]:

3. Explain the two steps involved in generating a geometrically corrected image.[**4 mark**]:

4. You are provided with spectral radiances (minimum (R_{min}) and maximum (R_{max})for each band at maximum (DN_{min}) and minimum (DN_{max}) digital numbers respectively of a thermal band of landsat 7 imagery acquired before and after July 2000 and in Table and the pre-launch calibration constants in Table . Determine the effective at-satellite temperature in [° K] for a pixel with DN value of 136 for an landsat 7 high gain band acquired in February 2002 given that the gain (β) and bias (ϵ) are 0.037040[$\mathrm{Wm^{-2}ster^{-1}}\mu\mathrm{m^{-1}}$] and 3.16 [$\mathrm{Wm^{-2}ster^{-1}}\mu\mathrm{m^{-1}}$] respectively. [**6 marks**]

Question 6
Radiometric and geometric enhancement techniques [10 marks]

1. Differentiate between spatial and spectral enhancement techniques. [**2 marks**]

2. What is the difference between convolution and correlation as used in digital image analysis? [**2 marks**]

3. You are provided with the following image subset (I) and mask K. Determine the output pixel value at the location $\{i, j\} = \{2, 3\}$ after convolution and correlation. [**6 marks**]

$$\mathbf{I} = \begin{bmatrix} 45 & 24 & 34 & 28 & 55 \\ 23 & 51 & 47 & 31 & 36 \\ 44 & 46 & 53 & 40 & 52 \\ 40 & 52 & 39 & 61 & 53 \end{bmatrix}$$

$$\mathbf{K} = \begin{bmatrix} 109 & 128 & 131 \\ 123 & 11 & 142 \\ 144 & 140 & 153 \end{bmatrix}$$