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

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Instructions

Duration T [minutes]: $60 \leq T \leq 110$

Answer all questions as concisely as possible.
You might find the following equations useful.

$$BV_{i,j,k} = \frac{1}{N}\sum_{i=1}^{N} BV_i \tag{1}$$

$$BV_{i,j,k} = \frac{1}{2}\left[BV_{i-1,j,k} + BV_{i+1,j,k}\right] \tag{2}$$

$$\mu_k = \frac{1}{n}\sum_{i=1}^{n} BV_{i,k} \tag{3}$$

$$var_k = \frac{1}{n}\sum_{i=1}^{n}\left(BV_{i,k} - \mu_k\right)^2 ; s_k = \sqrt{var_k} \tag{4}$$

$$\tag{5}$$

Question 1
An Overview of remote sensing, 12 marks

1. Illustrate using an example the significance of *in situ* measurements in remote sensing? **[4 marks]**

2. Explain briefly (*in point form*) the remote sensing process used by scientists when extracting information from a remotely sensed data. **[4 marks]**

3. Enumerate four advantages and four disadvantages of remote sensing. **[4 marks]**

Question 2
Remote sensing data collection, 12 marks

1. Name two ways through which digital imagery can be obtained **[1 mark]**:

2. Define the following terms **[2 marks]**:

   - A pixel
   - A Brightness number (BV)

3. How would a remote sensing analyst assign a BV to an hyper-spectral data set with i rows, j columns and k bands? **[1 mark]**

4. Digital remotely sensed data are transformed to useful information, possibly via the conversion of an analog electrical signal data recorded by the remote sensing sensor to a digital value.

   (a) What is the importance of the preprocessing stage in the data-to-information conversion process in remote sensing? **[1 mark]**

   (b) By giving examples, distinguish between multi-spectral and hyper-spectral remote sensing systems.**[1 mark]**

   (c) *Pushbroom* sensors are thought to yield accurate measurement of the reflected radiant flux from a specific portion of the terrain. Give two reasons for this? **[1 mark]**

(d) The Moderate Resolution Imaging Spectrometer- MODIS flown onboard NASA's Earth Observation System (EOS), *Terra* and *Aqua* provides long-term observations which are used to derive enhanced knowledge of global dynamics and processes occurring on the surface of the Earth and in the lower atmosphere.

- Complete Table 1 by filling in two examples each, of variables derived from MODIS data sets [**3 marks**]

Table 1: Global data sets derived from MODIS

Variable class	MODIS derived global variable
Land ecosystem	a:-
	b:-
Atmospheric	a:-
	b:-
Ocean variables	a:-
	b:-

- What is *spatial and radiometric* resolution? [**2 marks**]

Question 3
Digital Image Processing considerations 12 marks

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

- Name any three main features that an ideal remote sensing storage media should have. [**6 marks**]

- What are the attributes required of a good (remote scientist) digital image processing analyst? *state atleast two*[**2 marks**]

Question 4

Image quality assessment and statistical evaluation 12 marks

1. Name any two possible causes of low Signal-to-Noise ratio: S/N in the Brightens Values (BV) of a remotely sensed data? [**2 marks**]

2. How can a digital remote sensing analyst assess the quality and statistical characteristics of a remote sensed data? *any two ways*[**2 marks**]

3. The brightness values of a sample multi-spectral (*four channels: green, red, NIR and NIR*) dataset obtained over vegetated terrain are tabulated in Table 2:

Table 2: Brightness values obtained from green vegetation

Pixel	Band 1	Band 2	Band 3
(1,1)	130	67	180
(1,2)	165	45	215
(1,3)	100	35	135
(1,4)	135	50	200
(1,5)	145	65	205

Now use Table 2 to compute univariate statistics of the brightness values of the data set and:

(a) Fill Table 3: [**4 marks**]

(b) State which band has:

- Smallest standard deviation? [**1 marks**]
- Largest variance? [**1 marks**]

Table 3: Brightness values obtained from green vegetation

Band	1	2	3
Mean, μ_k	135.0		187.0
Std, s_k		16.27	
var_k	562.5	1007.5	
min_k	100		135.0
max_k		65	215.0
Range BV_r		40.00	

Univariate statistics do not provide information on the covariance of spectral measurements. Table 4 shows the correlation matrix derived from a sample multi-spectral data set.

Table 4: Correlation matrix derived the multi-spectral data set recorded from vegetated terrain

Band	1	2	3	4
1	-			
2	0.40	-		
3	0.90	0.50	-	
4	0.94	0.20	0.80	-

- What do the high correlation between bands 1, 3 and 4 signify? [**2 marks**]
- Which band provides unique information not found in the other bands? [**Bonus: 5 marks**]
- What is the proportion of total variation in the brightness values of band 4 that can be explained by a linear relationship with values of the random variation in band 1 ? [**Bonus: 6 marks**]

$-1 \leq r \leq r$

Question 5
Principles of electromagnetic radiation, (16 marks)

1. All objects with temperature, T>0 K emit electromagnetic energy. Table 1 is a record of temperature taken from a wet soil surface (i.e $\epsilon \approx 0.95$).

Table 2: *Stefan-Boltzmann law*: T_{kin} - Kinetic temperature, T_{rad}- Radiant temperature and M-total radiant exitance

$T_{kin}[^\circ]$	15	18	21	25
$T_{rad}[K]$				
M $[Wm^{-2}]$				

You are required to:

- Complete Table 2 above [**5 marks**]
- If the average kinetic temperature of a vegetated portion ($\epsilon \approx 0.89$) of the terrain measured simultaneously was 28°. What could be the appropriate spectral resolution in order to discriminate the two surface types? Show all your calculations. [**6 marks**]

2. Though reflectance curves do not provide any information about transmittance and absorption of remote sensing target objects, they provide valuable information that forms the basis for surface description. Figure 1 shows spectral reflectance curves for two earth surface characteristics: Grass and water. Describe how a white-and-black image of the terrain could be obtained? [**5 marks**]

Question 5

Principles of electromagnetic radiation and Radiometric correction, 12 marks

1. The total radiance L_s, recorded by the a sensor onboard a remote sensing system cruising at an orbital and/or suborbital platform is given by:

$$L_s = L_T + L_P \quad [Wm^2sr^{-1}] \tag{6}$$

where L_T and L_P are the total amount of radiance exiting the target study area and path radiance respectively.

   (a) What constitutes the path radiance, L_p? [3 marks]

   (b) What is the role of *in situ* data in correcting for L_p component present in L_s [3 marks]

2. State any three types of radiometric biases that can be contributed by the remote sensing sensor system. [3 marks]

3. What will be the *net* effect of atmospheric scattering to the brightness values of the remotely sensed data set? [3 marks]

1. In situ remote sensing data can be collected : obtaining direct from the area or object
For example population at a given ~~car~~ area can be obtained by taking / counting number of people (2)
In remote sensing in situ data are used to calibrate the remote sensor and unbiased estimation for final result

2. - use knolwedge of remote sensing
- study the instruments used on ~~acquire~~ obtaining information
- Able to analysis, (2) processing the remote sensing data
- Able to utilize it the societies

3. Advantage
- Used in cartographic and mapping
- used in monitoring natural disaster eg Earthquake
- Used in Oceanic monitoring eg determine water temperature
- Used in atmospheric weathering
↑
- give daily climatic condition

3 1/2

Disadvantage
- Need knolwedge / idea before process the remote sensing data
- To operate remote sensing expensive / Cost / For example need to buy digital image processing machine
- It take time to record / imaging information

- Direct by digital remote sensor
  eg spot satellite
- By converting the analog (1 to - digital form (2)
  For example using linear array

2. A pixel - describe how size of object do you want to see size (ie larger or small)
   A Brightness number (BV)
   - Is a digital number corresponding to band number
     for example BV (1,3,4) Lt describe how much Images are bright (1

3. - Is assign in the matrix or array form -

4 (a) - Is about data correction (1)

(b) Multispectral remote sensing
- Is a sensor which called electromagnetic radiation (reflected, emitted; back scatter) in a multiple bands.
  eg Landsat

Hyperspectral (1
- Is a sensor which collect data to thousands bands
  eg spot sat

(c) Pushbroom
- It used for longtime of life (1)

a) • Land ecosystem - soil moisture ✓
- Vegetation ✓

• Atmospheric - Temperature ✓
- climate condition

• Ocean Variable
- Sea Temperature
- sea wind ✓

(3)

• Spatial resolution
- Is a type of resolution which describe how small object size and area covered do you want to see an object

• Radiometric resolution
- Is a type of resolution which describe how sensor is sensity to signal strength from (reflected, emitted ✓ radiation) energy
(ie how fine do you want to see)

(2)

Qn3 • Digital Image Process (DIP) Consideration
- The speed of central process Unit (CPU)
- The size of random accessing memory (RAM)
- The resolution of your monitor
- Input data size ✓

(4)

• Main features
- The speed of cpu and RAM size
- The Network availability
- The Operating system kind and version of Linux, Window

(2)

• Attributes good remote sensing [
- Knowledge in general about remote sensing
- Be familiar with DIP instrument

(2)

- Internal error caused by remote sensor instrument itself
- External error caused by environmental such as object (or) terrain where aquisition take place

2. - By using central tendency (mean, mode and median) (1)
- By using Multivariant (variance, standard covariance)

3. (a)

Band	1	2	3
Mean, Vic	135	52.4	187.0
Std, Sic	23.72	16.27	31.74
Vare	562.5	1007.5	100
Min ic	100	25x	135
Max ic	165	65	215
Range Bv-	65	40.	80

(b) Band 2 small standard deviation
Band 2 and 3 equal variance Lagest

(c) • High correlation mean more data/ infom on bands
• Band 4 with covanance Cov_{42} have low Covanance/ 0.20
• It has high Covariance compared to other bands

$L_S = L_T + L_P$

$L_P = L_S - L_T$

Is the difference between total radiance (L_S) and total amount of radiance existing (L_T) to the target

(b) – Is to check/estimate unbiased for final result as (3)

2. Radiometric biases
   - Scattering which differs with reflectance by direction is unpredictable
   - Absorption –
     Involve absorbed of radiant energy and converted to another form of energy
   - Reflectance –
     Involve amount of radiant energy reflected on a target / object

3. Net effect of atmospheric scattering
   It cause 3 problem
   - Rayleigh scattering (diameter of molecules is smaller than wavelength)
   - Mie scattering (diameter of molecules is equal to wavelength length)
   - Non selecting scattering – (diameter of molecules / particles greater than wavelength