University of Technology
Building and Construction Eng. Dept.
FINAL EXAM FIRST ATTEMPT 2015-2016

Subject: Remote Sensing — Class: 3rd Year
Division: All Except Geomatics Division — Time : 3.0 Hrs.
Examiner: Remote Sensing & GIS Comm. — Date: 18/6/2016

Note: Answer FOUR Questions

Q1).

A. Consider a whiskbroom scanner at $\mathbf{5000\,m}$ height and with IFOV of $\mathbf{2\,mrad}$ and FOV is $\mathbf{2°}$. Calculate the diameter of the area observed on the ground for the following:

1. At-nadir viewing.
2. Off-nadir viewing in direction of flight and in the scan line respectively. **(16%)**

B. Answer the following: **(9%)**

1. List the different types of geometric distortions.
2. Distinguish between whiskbroom and pushbroom scanners.
3. In RADAR system, by sketch show the difference among depression angle, look angle, incidence angle and grazing angle for flat and inclined terrain?

Q2).

A. During a single-band classification, the computer came across two pixels with values of $\mathbf{65}$ and $\mathbf{100}$. Assume the user had defined Three classes with the following spectral statistics:

Class	Min	Max	Mean	Standard Deviation
1	25	125	95	10
2	20	100	50	5
3	90	110	98	1

Into which class would the pixel be placed during?

1. A minimum distance to means classification (Euclidean Spectral distance)?
2. A parallelepiped classification? **(10%)**

B. A vertical aerial photo has been taken over a flat terrain; it is required to be corrected geometrically by using ground control points (GCPs) with 1st and 3rd order polynomial model. Find the minimum number of GCPs that are required to perform this transformation. If the X-residual for one of GCPs is $\mathbf{-0.441}$ pixel and the Y-residual for the same point is $\mathbf{0.388}$ pixel; also find the RMS error for this point? **(9%)**

C. Answer the following: **(6%)**

1. List the main elements of remote sensing system?
2. What are the main factors affecting thermal target and its background?

Q3).

A. In planning aerial photos, the flight map indicates that the base position of $\mathbf{1500\,m}$ mountain will appear $\mathbf{75\,mm}$ from a flight line at the anticipated scale of photo. If the flight altitude is to be $\mathbf{6000\,m}$ above the datum. How far from the base position will the image of the mountain top occur, and how near the edge of a $\mathbf{228.6\,mm \times 228.6\,mm}$ photo will the image be? **(8%)**

B. For FLIR analysis, a thermal object with square pattern, its length is $\mathbf{3\,m}$, what should be its bar pattern for detection and recognition and its aspect ratio in both cases? **(8%)**

C. Answer the following items: **(9%)**

1. Define spatial filtering and list its different approaches.
2. Distinguish between vertical and oblique aerial photos.
3. Compare between Rayleigh and Mie scattering.

Q4).

A. An area with **20 *km*** wide and **30 *km*** long to be surveyed along **6** flight lines to picture an aerial photo with dimension **20 *cm* × 23 *cm***. Knowing that the longitudinal overlap is **60%** and the speed of the plane **322 *km/hr*** with photo scale **1/12000**. Find **1-** the time period between the two successive photos **2-** the amount of sidelap **3-** the number of photos for each flight line. **(9%)**

B. A laser Scanning system operates at speed **75 *m/s*** and wavelength of **1540 *nm***, with diameter of its lens is 4.807×10^{-4} m. If the flying altitude about **2500 *m***, and the scan angle **30°** compute: 1. the footprint area; and 2. the swath width. **(9%)**

C. Answer the following: **(6%)**

1. State why a particular object or feature may not have the same appearance (i.e. backscatter response) on all radar images. List of the factors (parameters) which might account for this.
2. Define the following: Pixels; Image rectification, Point processing.

Q5).

A. At the site of Baghdad University, three buildings A, B and C located on flat terrain are being imaged by radar in the range direction. Buildings A and B are separated along the ground by a distance **200 *m***. While the distance between buildings A and C is **12 *m***. Satellite Altitude is **800 *km*** mounted SAR radar system has the following characteristics:

A wavelength of **23 *cm***, antenna length of **2 *m***, and a pulse length of **1 μ*sec***. If the three buildings were imaged in the far range with a depression angle of **30 *degrees*** and however, the same buildings were imaged in the near range with a depression angle of **60 *degrees***. Compute the following:

1. The ground-range resolution and the azimuth resolution for both cases.
2. Will these buildings be resolved in the far range and near range?
3. Compute of the swath width? **(16%)**

B. Answer the following items: **(9%)**

1. Show the difference between:
   1) TM and MSS.
   2) Laser ranging and laser profiling.
2. Define resampling method and its uses. Then list the common approaches used in resampling methods in geometric correction and explain one of them.

Useful Equations

$BV_{i,j,ratio} = \frac{BV_{i,j,k}}{BV_{i,j,l}}$; $BV_{out} = \left(\frac{BV_{in} - min_k}{max_k - min_k}\right) . quant_k$; $k_i = \sum_{i=0}^{quant_k} \frac{f(BV_i)}{n}$; $HFF_{5,out} = (2 \times BV_5) - LFF_{5,out}$;
$LFF_{5,out} = int\left[\frac{\sum_{i=1}^{9} c_i \times BV_i}{n}\right]$; $Sobel_{5,out} = \sqrt{X^2 + Y^2}$; $[X = (BV_3 + 2BV_6 + BV_9) - (BV_1 + 2BV_4 + BV_7)$;
$Y = (BV_1 + 2BV_2 + BV_3) - (BV_7 + 2BV_8 + BV_9)]$; $x = a_o + a_1 X + a_2 Y$; $y = b_o + b_1 X + b_2 Y$;
$A = S.E.(1 - V\%)$; $B = S.E.(1 - U\%)$; $< P_r \geq P_t \left[\frac{G^2.\lambda^2}{(4\pi)^3.R^4}\right].\sigma_0$; $h \leq \frac{\lambda}{25 \sin\gamma}$; $h \geq \frac{\lambda}{4.4 \sin\gamma}$;
$h = \frac{\lambda}{8 \sin\gamma}$; $\delta_R = \frac{c.\tau}{2.\cos\gamma}$; $\delta_{AT} = \frac{\lambda}{D_{AT}}.\frac{c.\tau.\cos\gamma}{2}$; $\varepsilon = \frac{M_R}{M_B} = \frac{T_{rad}^4}{T_{kin}^4}$; GCP's No. $= \frac{((t+1)(t+2))}{2}$; $d = \frac{v.t}{m} = \frac{v\,t\,f}{H}$;
$h = \frac{dH}{r}$; $X_A = \left(\frac{H - h_A}{f}\right).x_a$; $Y_A = \left(\frac{H - h_A}{f}\right).y_a$; $C_f = \frac{H}{C_i}$; $R^3 = GMT^2/4p^2$; $E = h \times c/\lambda$; $h = 6.6 * 10^{-34}$ J.s;
$c = 3*10^8$ m/s; $RMS\ error = \sqrt{XR_i^2 + YR_i^2}$; $W = \sigma\varepsilon T^4$; $\lambda_{max} = \frac{2897 mm°K}{Trad°K}$; $D = H \times IFOV$;
$H' = H / Cos(Fov/2)$; $K_{hat} = [N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} x_{i+} x_{+i}] / [(N^2 - \sum_{i=1}^{r} x_{i+} x_{i+1})]$; $D = \sqrt{\sum_{i=1}^{n} (d_i - e_i)^2}$;

$\omega = 2.44\frac{\lambda}{D}$; $d = \omega \times R$; $SW = 2H \tan\left(\frac{\theta}{2}\right)$; $\cos\phi_L = \frac{H}{R}$; $W_g = \frac{R_f - R_n}{\cos\psi}$; $R_\rho = \frac{\ln\left(\frac{1}{K_\rho} \quad \frac{\Delta T \sqrt{\varepsilon/7}}{MRT_\circ}\right)}{\beta_{atm.} + \frac{\gamma}{S}\beta_{sys.}}$

...GOOD LUCK...

نسخة الانترنيت

الحلول النموذجية لمادة التحسس النائي
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Typical Answers:

Q1).

A.

1. $D = H \times IFOV$

$D = 5000 \times 2/1000 = 10\,m$

2. $H' = H/\cos(Fov/2)$

$$H' = \frac{5000}{\cos 1} = 5001\,m$$

In direction of flight

$$D = H' \times IFOV \Rightarrow D = 5001 * \frac{2}{1000} = 10.002\,m$$

In scan line

$$D = H\,sec^2\left(\frac{Fov}{2}\right) \times IFOV \Rightarrow D = 5000\,Sec^2\,1 \times 2/1000 = 10.007\,m$$

B.

1. **List the different types of geometric distortions.**

Answer

The geometric distortions may be divided into two classes:

1. Systematic distortion: those that can be corrected using data from platform ephemeris and knowledge of internal sensor distortion.

2. Nonsystematic distortion: those that cannot be corrected with acceptable accuracy without a sufficient number of ground control points, which are used to establish a relationship between the ground and image.

Systematic distortions

The systematic distortions of the image can be classified as:

1- Scan Skew 2- Mirror-Scan Velocity Variance 3- Panoramic Distortion 4-Platform Velocity 5- Earth Rotation 6- Perspective distortion.

Nonsystematic distortions

The nonsystematic distortions of the image can be classified as:

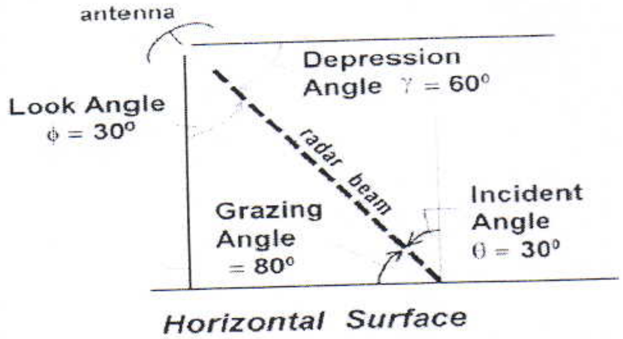
1- Altitude 2- Attitude

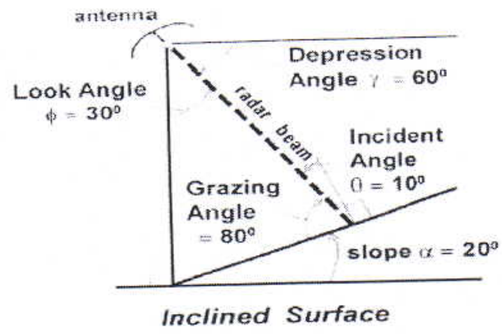
2. **Distinguish between whiskbroom and pushbroom scanners.**

A **whiskbroom scanner** also referred to as across-track scanners (e.g. on LANDSAT). It uses rotating mirrors to scan the landscape. The rotating mirrors redirect the reflected light to a point where a single or just a few sensor detectors are grouped together. Whiskbroom scanners with their moving mirrors tend to be large and complex to build. An advantage of whiskbroom scanners is that they have fewer sensor detectors to keep calibrated as compared to other types of sensors.

pushbroom scanner: Another type of scanner, which does not use rotating mirrors, is the **pushbroom scanner** also referred to as an along-track scanner (e.g. on SPOT). The sensor detectors in a pushbroom scanner are lined up in a row called a linear array. Pushbroom scanners are lighter, smaller and less complex because of fewer moving parts than whiskbroom scanners. Also they have better radiometric and spatial resolution. A major disadvantage of pushbroom scanners is the calibration required for a large number of detectors that make up the sensor system.

3. **In RADAR system, by sketch show the difference among depression angle, look angle, incidence angle and grazing angle for flat and inclined terrain?**





Q2).

A)

1. <u>A minimum distance to means classification (Euclidean Spectral distance)</u>

<u>For pixel 1 (= 65)</u>

Training set 1 (Class 1)

$$D = \sqrt{\sum_{i=1}^{n} (d_i - e_i)^2}$$

$D = \sqrt{(65-95)^2} = \sqrt{(-30)^2} = \sqrt{900} = 30$

Training set 1 (Class 2)

$D = \sqrt{(65-50)^2} = \sqrt{(15)^2} = \sqrt{225} = \mathbf{15}$

Training set 1 (Class 1)

$D = \sqrt{(65-98)^2} = \sqrt{(-33)^2} = \sqrt{1089} = 30$

Therefore; Pixel 1 (= 65) is assigned to Class 2.

<u>For pixel 1 (= 100)</u>

Training set 1 (Class 1)

$$D = \sqrt{\sum_{i=1}^{n} (d_i - e_i)^2}$$

$D = \sqrt{(100-95)^2} = \sqrt{(5)^2} = \sqrt{25} = 5$

Training set 1 (Class 2)

$D = \sqrt{(100-50)^2} = \sqrt{(50)^2} = \sqrt{2500} = 50$

Training set 1 (Class 1)

$D = \sqrt{(100-98)^2} = \sqrt{(2)^2} = \sqrt{4} = \mathbf{2}$

Therefore; Pixel 2 (= 100) is assigned to Class 3.

2. A parallelepiped classification

<u>For pixel 1 (= 65)</u>

It can be assigned to Classes 1 & 2 only.

<u>For pixel 1 (= 100)</u>

It can be assigned to Classes 1, 2 & 3.

B)

<u>1) For 1st order</u>

$$Minimum\ number\ of\ GCPs = \frac{(t+1)(t+2)}{2}$$
$$= \frac{(1+1)(1+2)}{2} = \frac{2*3}{2} = \frac{6}{2} = 3\ points$$

<u>For 3rd order</u>

$$Minimum\ number\ of\ GCPs = \frac{(t+1)(t+2)}{2}$$
$$= \frac{(3+1)(3+2)}{2} = \frac{4*5}{2} = \frac{20}{2} = 10\ points$$

2) The RMS error for GCP

RMS

RMS

RMS

$$RMS\ error = \sqrt{0.1944 + 0.1505} = 0.5872\ pixel$$

C)

1. List the main elements of remote sensing system.

Energy Source or Illumination 2. Radiation and the Atmosphere (B) 3. Interaction with the Target (C) 4. Recording of Energy by the Sensor (D) 5. Transmission, Reception, and Processing (E) 6. Interpretation and Analysis (F) 7. Application (G) the final element of the remote sensing process is achieved

2. What are the main factors affecting thermal target and its background?

1) **Temperature**, the temperature of man-made targets is often higher than the temperature of most of background .Therefore the radiation from the target is often higher than the radiation from the background. Both man-made and natural objects have rather high emissivity in the part of the spectrum concerned. By paint, the targets can be given similar emissivity as the background.

2) **Size,** the size of target can sometimes be advantageous for detection. If the target itself is small and hot or if it contains small and hot spots these can easily be detected by special filtering techniques.

Q3).

A) Solution:

$$d = \frac{rh}{H-h} = \frac{75mm \times 1500m}{(6000-1500)m} = 25\ mm$$

The distance from edge of photo to image is:

$$114.3 - 75 - 25 = 14.3\ mm$$

B)Solution:

<u>For detection</u>

$$\gamma = 1\ pair$$

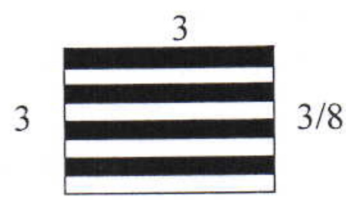
$$\varepsilon = \frac{3}{3/2} = \frac{6}{3} = \frac{2}{1}$$

<u>For recognition</u>

$$\gamma = 4\ pairs$$

$$\varepsilon = \frac{3}{3/8} = \frac{24}{3} = \frac{8}{1}$$

Detection



Recognition

C) Answer

1) **Define spatial filtering and list its different approaches.**

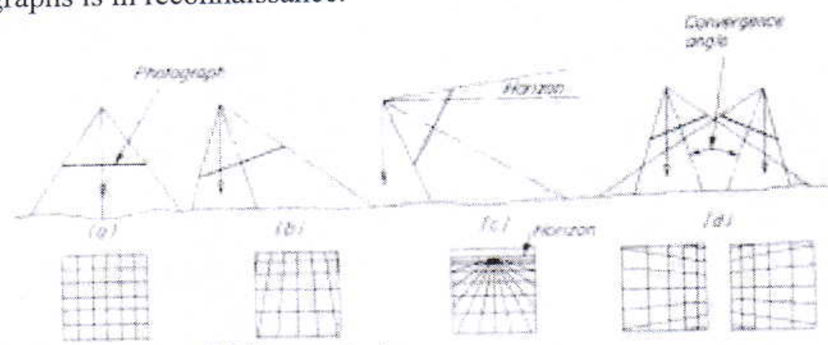
A characteristic of remotely sensed image is a parameter called spatial frequency; defined as the number of changes in brightness value per unit distance for any particular part of an image. If there are very few changes in brightness value over a given area in an image, this is commonly referred to as a low-frequency area. Conversely, if the brightness values change dramatically over short distance, this is an area of high-frequency detail. Spatial convolution filtering based primarily on the use of convolution masks.

- **Spatial Filtering approaches**
  1. Low frequency Spatial Filtering: Median filtering; Min-Max filtering
  2. High frequency Spatial Filtering
  3. Edge Enhancement:
     Linear: Directional 1st Difference; 2D Compass gradient; Laplacian
     Non-Linear: Kirch; Roberts; Sobel

2) **Distinguish between vertical and oblique aerial photos.**

Vertical photograph: A photograph with the camera axis perfectly vertical (identical to plumb line through exposure center). Such photographs hardly exist in reality (True). **Near vertical photograph** A photograph with the camera axis nearly vertical. The deviation from the vertical is called tilt which is usually less than two to three degrees.

Oblique photograph: A photograph with the camera axis intentially tilted between the vertical and horizontal. A **high oblique photograph**, depicted in Fig.(c) is tilted so much that the horizon is visible on the photograph. A **low oblique** does not show the horizon (Fig.). The total area photographed with oblique is much larger than that of vertical photographs. The main application of oblique photographs is in reconnaissance.



3) **Compare between Rayleigh and Mie scattering.**

Rayleigh scattering occurs when particles are very small compared to the wavelength of the radiation. These could be particles such as small specks of dust or nitrogen and oxygen molecules. Rayleigh scattering causes shorter wavelengths of energy to be scattered much more than longer wavelengths. Rayleigh scattering is the dominant scattering mechanism in the upper atmosphere. The fact that the sky appears "blue" during the day is because of this phenomenon. As sunlight passes through the atmosphere, the shorter wavelengths (i.e. blue) of the visible spectrum are scattered more than the other (longer) visible wavelengths. At sunrise and sunset the light has to travel farther through the atmosphere than at midday and the scattering of the shorter wavelengths is more complete; this leaves a greater proportion of the longer wavelengths to penetrate the atmosphere (thus the sky is "painted" in red).

Mie scattering occurs when the particles are just about the same size as the wavelength of the radiation. Dust, pollen, smoke and water vapour are common causes of Mie scattering which tends to affect longer wavelengths than those affected by Rayleigh scattering. Mie scattering occurs mostly in the lower portions of the atmosphere where larger particles are more abundant, and dominates when cloud conditions are overcast.

Q4). Answer:

A)

1) $B = S.E\,(1 - U\%) = 0.23 \times 12000\,(1 - 0.6) = 1104\,m$

$$\Delta T = \frac{B}{G_s} = \frac{1104}{\frac{322 \times 1000}{3600}} = 12.34\,sec \approx 12\,sec$$

2) $A = \frac{W}{R}$

$$A = \frac{20000}{6} = 3333.3\,m$$

$A = S.E\,(1 - V\%)$

$3333.3 = 0.2 \times 12000\,(1 - V\%)$

$V\% = 38.9 \qquad the\ sidelap$

3) $N = \frac{L}{B} + 2$

- $N = \frac{30000}{1104} + 2 = 27.17 + 2 \approx 28 + 2 = 30\ photos\ for\ each\ flight\ line$

B)

1.

$$\omega = 2.44\frac{\lambda}{D} = 2.44\frac{1540 \times 10^{-9}}{4.807 \times 10^{-4}} = 7.817\ mrad = 0.007817\ rad$$

$$Diameter\ of\ footprint\ d = \omega \times R = 0.007817 \times 2500m = 19.5425\ m$$

$$A = \frac{\pi d^2}{4} = \frac{3.14 \times 19.5425^2}{4} = 299.95 = 300\ m^2$$

2. $SW = 2H\ tan\left(\frac{\theta}{2}\right) = 2 \times 2500\ tan\left(\frac{30}{2}\right) = 5000 \times 0.2679 = 1339.74\ m$

C)

1. State why a particular object or feature may not have the same appearance (i.e. backscatter response) on all radar images. List of the factors (parameters) which might account for this.

The backscatter response, and thus the appearance of an object or feature on a radar image, is dependent on several things.

The parameters of the radar system include:

1. Different radar wavelengths or frequencies; 2. Using different polarizations; 3. Variations in viewing geometry, including look/incidence angle,

   While the parameters of the object system include:

2. Dielectric constant of the body 2. Electrical resistivity; 3. Changes in the moisture; 4. Surface geometry; 5. Roughness; 6. Lithology.

2. Define the following: Pixels; Zooming; Point processing

1. **Pixels:** Most remote sensing images are composed of a matrix of picture elements, or **pixels**, which are the smallest units of an image. Image pixels are normally square and represent a certain area on an image.
2. **Zooming** Image magnification techniques allow the analyst to zoom in and view very site-specific pixel characteristics. Integer Image Magnification. To magnify a digital image by an integer factor m2, each pixel in the original image is usually replaced by an m x m block of pixels, all with the same brightness value as the original input pixel.
3. **Point processing operation** modifies the brightness values of each pixel in an image dataset independent of the characteristics of neighboring pixels.

Q5). Answer:

A.

1)

Note: For Flat terrain only Look angle =Incidence angle and

$\gamma = 90^o$- *look angle* ; or *look angle* $= 90^o - \gamma$

The same results will be obtained either using depression angle or look angle (=incidence angle for flat terrain)

$\delta_R = R_g = \frac{(c\tau)}{2\cos\gamma}$; $\delta_R = R_g = \frac{c\tau}{2\sin\phi_l}$;

$\delta_{AT} = R_a = \frac{\lambda}{L_a} \cdot \frac{(c\tau\cos\gamma)}{2}$

In the far range:

You can use either γ or ϕ_l

$\gamma = 90^o$ - *look angle* $=90^o - 60^o = 30^o$

$\delta_R = R_g = \frac{(c\tau)}{2\cos\gamma} = \frac{3\times10^8 \times 1\times 10^{-6}}{2cos30} = \frac{3\times10^2}{2\times0.866} = \frac{300}{1.732} = 173.205\ m$

Thus A and B can be resolved

$\delta_{AT} = R_a = \frac{\lambda}{L_a} \cdot \frac{(c\tau \cos\gamma)}{2} = \frac{0.23m}{2m} \times \frac{3\times10^8 \times 1\times 10^{-6} \cos 30}{2} = \frac{59.754}{4} = 14.9\ m$

Thus A and C cannot be resolved

In the near range:

You can use either γ or ϕ_l

$\gamma = 90^o$ - *look angle* $= 90^o - 30^o = 60^o$

$\delta_R = R_g = \frac{(c\tau)}{2\cos\gamma} = \frac{3\times10^8 \times 1\times 10^{-6}}{2cos60} = \frac{3\times10^2}{2\times0.5} = \frac{300}{1.0} = 300\ m$

Thus A and B cannot be resolved

$\delta_{AT} = R_a = \frac{\lambda}{L_a} \cdot \frac{(c\tau \cos\gamma)}{2} = \frac{0.23m}{2m} \times \frac{3\times10^8 \times 1\times 10^{-6} \cos 60}{2} = \frac{34.5}{4} = 8.625\ m$

Thus A and C can be resolved

2) In the far range:

A and B can be resolved and A and C cannot be resolved

In the near range:

A and B cannot be resolved; A and C can be resolved

3. Compute swath width

$$\psi = 60^\circ - 30^0 = \left(30^\circ/_2\right) + 30^0 = 45^\circ$$

ϕ look angle in the far range = $(90^\circ - 30^\circ) = 60^\circ$

$$\cos\ \phi_L = \frac{H}{R_f}$$

$$R_f = \frac{H}{\cos\ \phi_L} = \frac{800\ km}{\cos 60} = 1600\ km$$

ϕ look angle in the near range = $(90^\circ - 60^\circ) = 30^\circ$

$$R_n = \frac{H}{\cos\ \phi_L} = \frac{800\ km}{\cos 30} = 923.76\ km$$

$$W_g = \frac{R_f - R_n}{\cos\psi} = \frac{1600 - 923.76}{\cos 45^\circ} = 956.348\ km$$

B. Answer the following items:

1. **Show the difference between:**
   1) TM and MSS.
   2) Laser ranging and laser profiling.

1. TM and MSS

Although the areal coverage of a TM scene is virtually the same as a MSS scene, **TM** offers higher spatial, spectral, and radiometric resolution. The spatial resolution is 30 m compared to 80 m (except for the TM thermal channels, which are 120 m to 240 m). Thus, the level of spatial detail detectable in TM data is better. TM has more spectral channels which are narrower and better placed in the spectrum for certain applications, particularly vegetation discrimination. In addition, the increase from 6 bits to 8 bits for data recording represents a four-fold increase in the radiometric resolution of the data.

MSS data are still used to this day and provide an excellent data source for many applications. If the desired information cannot be extracted from MSS data, then perhaps the higher spatial, spectral, and radiometric resolution of TM data may be more useful.

2. Laser ranging and laser profiling

All laser methods are used to measure the distance to a high degree of accuracy.

In Laser ranging: the measurement of distance or range, which is always based on the precise measurement of time, can be carried out using one of the two main methods. The first of these involves the accurate measurement of the Time-Of-Flight TOF of a very short but intense pulse of laser radiation to travel from the laser ranger to the object and back being measured Thus, the laser ranging instrument measures the precise time interval that has elapsed between the pulse being emitted by the laser ranger and its return after reflection from a ground object In the second

(alternative) method, the laser transmits a continuous beam of laser radiation instead of a pulse.

Laser Profiling: The use of a reflectors laser ranger to measure the distances to a series of closely spaced points located adjacent to one another along a line on the terrain results in a two-dimensional (vertical) profile or vertical cross section of the ground showing the elevations of the ground along that line.

2. **Define resampling method and its uses. Then list the common approaches used in resampling methods in geometric correction and explain one of them.**

Resampling: It is used for geometric correction of the original distorted image, to determine the digital values to place in the new pixel locations of the corrected output image. The resampling process calculates the new pixel values from the original digital pixel values in the uncorrected image. There are three common methods for resampling: nearest neighbor, bilinear interpolation, and cubic convolution.

Resampling Methods:

1. Nearest Neighbor 2. Bilinear Interpolation 3. Cubic Convolution

Nearest Neighbor: This approach uses the digital value from the pixel in the original image which is nearest to the new pixel location in the corrected image. This is the simplest method and does not alter the original values, but may result in some pixel values being duplicated while others are lost. This method also tends to result in a disjointed or blocky image appearance, as shown in figure.