University of Technology
Building and Construction Eng. Dept.
FINAL EXAM FIRST ATTEMPT– 2013/2014

Subject: Remote Sensing & GIS — Class: 3^{rd} Year
Division: All Engineering Divisions — Time : 3 Hrs.
Examiner: Remote Sensing & GIS Comm. — Date:05.06.2014

Note: Answer FOUR Questions Only

Q1.

A. An aerial photo was taken with camera focal length 152 mm, format dimension (23×23) cm^2, longitudinal overlap 60%, the distance between successive flight lines 2100 m and the average terrain of the pictured area was 600 m above mean sea level. A railway line (AB) with length 10.16 cm was appeared in this photo with x-coordinates for the two ends of the photo ($x_a= +50.01\,mm$; $x_b= -52.6\,mm$). In the same time this railway was appeared with a length of 2.54 cm in a map with scale 1/50000. Find: **(17%)**

1. The average altitude of the plane from mean sea level.
2. The ground coordinates for the two ends of the railway.
3. The length of the appeared railway in the pictured scene.
4. The base line (B) and the lateral overlap (sidelap) (V).

B. Distinguish between the following items: **(8%)**

1. Vertical and oblique aerial photos.
2. Active and passive remote sensing system.

Q2.

A. An satellite image with 8 gray levels and the following information:

Gray level	0	1	2	3	4	5	6	7
Frequency (No. of Pixels)	10	8	9	2	14	1	5	2

Apply Histogram Equalization Technique to enhance this image. Plot the histogram before and after enhancement process. **(15%)**

B. Define **<u>Five Only</u>** of the following terms: **(10%)**
LiDAR, Black Body, Atmospheric windows, Remote sensing, Relief displacement, Ground control points (GCPs), Instantaneous Field of View (IFOV)

Q3.

A. For geometric correction of Multi spectral Scanner (MSS) images, a total number of 3 GCPs were used to perform 1^{st} order polynomial model. If the image coordinates (x, y) and grounds coordinates (X, Y) measured in pixels of GCPs with their polynomial coefficients ($a_0, a_1, a_2, b_0, b_1, b_2$) are listed in tables below. Find: **(17%)**

1. X-residual, Y-residual and
2. RMS error for each point.
3. The total RMS error.

GCP No.	x (pixel)	y (pixel)	X (pixel)	Y (pixel)
1	247.25	141.25	531.50	395.12
2	272.75	85.25	562.75	323.62
3	428.75	64.75	521.38	359.25

a_0	4991.917	b_0	-1489.042
a_1	-6.537	b_1	1.875
a_2	-3.214	b_2	1.603

B. Answer the following items: (8%)

1. What advantages do sensors carried on board satellites have over those carried on aircraft? Are there any disadvantages that you can think of?
2. How would thermal imagery be useful in an urban environment? Then list the main advantages and disadvantages of thermal imaging system.

Q4.

A. A 1:24,000 aerial photo that falls within this subscene was acquired. Starting with a field visit during the same growing season, the crops in many individual farms located in the photo were identified, of which about twelve points (12) were selected as training sites. Most were either corn or soybeans; others were mainly barley and wheat. A Maximum Likelihood supervised classification was then run. With the class identities in the photo as the standard, the number of pixels correctly assigned to each class and those misassigned to other classes were arranged in the confusion matrix (Error matrix) used to produce the summary information shown in the following table:

		Ground Data / Reference Data			
		Corn	Soybeans	Forest	Other
Map Data / Classified Data (Landsat Classes)	Corn	25	5	10	3
	Soybeans	2	50	6	5
	Forest	3	4	60	5
	Other	2	2	2	100

(17%)

1. Compute the overall accuracy?
2. Compute the Producers' and user' accuracy?
3. Compute of K_{hat} Coefficient?

B. Answer the following items: **(8%)**

1. If you wanted to detect heat from a fire, which portion of EM spectrum would you use? Why?
2. Compare a 2-bit image with an 8-bit image. List the different types of resolution.

Q5

A. Two buildings on flat terrain are separated in the range direction by a distance along the ground by 20 m. Knowing that the radar system flying with altitude (800km) has the following characteristics: a wavelength of 23cm, antenna length along track (D_{AT}) is 2m with antenna length cross track (D_R) is 1.25 m, and pulse length (duration) of 0.1 μsec. If the buildings were imaged in the near range with a depression angle of 30° and however, the same buildings were imaged in the near range with a depression angle of 60° and the grazing angle is 47.45°.
Find the following: **(17%)**

1. The ground – range resolution
2. The azimuth resolution for both cases.
3. Will these buildings be resolved in the far range and near range?
4. The swath width for radar scanning.

B. Answer the following items: **(8%)**

1. The difference between *Synthetic Aperture Radar* (SAR) and *Real Aperture Radar* (RAR).
2. Solar radiation is scattered by atmosphere. Identify and explain the types of scattering process that occur.

Useful Equations:

$BV_{i,j,ratio} = \frac{BV_{i,j,k}}{BV_{i,j,l}}$; $BV_{out} = \left(\frac{BV_{in} - min_k}{max_k - min_k}\right).quant_k$; $k_i = \sum_{i=0}^{quant_k} \frac{f(BV_i)}{n}$;

$HFF_{5,out} = (2 \times BV_5) - LFF_{5,out}$; $LFF_{5,out} = int\left[\frac{\sum_{i=1}^{9} c_i \times BV_i}{n}\right]$; $Sobel_{5,out} = \sqrt{X^2 + Y^2}$;

$[X = (BV_3 + 2BV_6 + BV_9) - (BV_1 + 2BV_4 + BV_7)$; $Y = (BV_1 + 2BV_2 + BV_3) - (BV_7 + 2BV_8 + BV_9)]$;

$x = a_o + a_1X + a_2Y$; $y = b_o + b_1X + b_2Y$; $A = S.E.(1 - V\%)$;$B = S.E.(1 - U\%)$; $< P_r \geq P_t\left[\frac{G^2\lambda^2}{(4\pi)^3.R^4}\right].\sigma_0$; $h \leq \frac{\lambda}{25\sin\gamma}$; $h \geq \frac{\lambda}{4.4\sin\gamma}$; $h = \frac{\lambda}{8\sin\gamma}$; $\delta_R = \frac{c.\tau}{2.\cos\gamma}$; $\delta_{AT} = \frac{\lambda}{D_{AT}}.\frac{c.\tau.\cos\gamma}{2}$; $\varepsilon = \frac{M_R}{M_B} = \frac{T_{rad}^4}{T_{kin}^4}$;

; GCP's No. $= \frac{((t+1)(t+2))}{2}$; $d = \frac{v.t}{m} = \frac{v\,t\,f}{H}$; $h = \frac{dH}{r}$; $X_A = \left(\frac{H - h_A}{f}\right).x_a$; $Y_A = \left(\frac{H - h_A}{f}\right).y_a$; $C_f = \frac{H}{C_i}$;

$R^3 = GMT^2/4p^2$; ; $K_{hat} = [N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} x_{i+}\, x_{+i}]/[(N^2 - \sum_{i=1}^{r} x_{i+}\, x_{i+1})]$;

$RMS\ error = \sqrt{XR_i^2 + YR_i^2}$; $W = \sigma\varepsilon T^4$; $\lambda_{max} = \frac{2897 mm°K}{T_{rad}°K}$; $W_g = \frac{R_f - R_n}{\cos\psi}$

...GOOD LUCK...

Typical Answers of Set 1 -2013-2014

Q1 A- An aerial photo was taken with camera focal length 152 mm, format dimension (23×23) cm^2, longitudinal overlap 60%, the distance between successive flight lines 2100 m and the average terrain of the pictured area was 600 m above mean sea level. A railway line (AB) with length 10.16 cm was appeared in this photo with x-coordinates for the two ends of the photo ($x_a = +50.01\ mm$; $x_b = -52.6\ mm$). In the same time this railway was appeared with a length of 2.54 cm in a map with scale 1/50000. Find:

1- The average altitude of the plane from mean sea level.
2- The ground coordinates for the two ends of the railway.
3- The length of the appeared railway in the pictured scene.
4- The base line (B) and the lateral overlap (sidelap)(V).

Solution:

1)

$$photo\ scale = \frac{dis.on\ photo}{dis.on\ map} \times map\ scale$$

$$photo\ scale = \frac{10.16\ cm}{2.54\ cm} \times \frac{1}{50000} = \frac{1}{12500}$$

$$Scale = \frac{C}{Hav.-h_{av.}}$$

$$\frac{1}{12500} = \frac{0.152\ m}{Hav.-600\ m}$$

$Hav. = 2500\ m$ The average altitude of the plane from mean sea level

2)

$$X_A = xa\left(\frac{Hav.-h_{av.}}{C}\right) = +50.01\left(\frac{2500-600}{152}\right) = +625.125\ m$$

$$X_B = x_b\left(\frac{Hav.-h_{av.}}{C}\right) = -52.6\left(\frac{2500-600}{152}\right) = -657.5\ m$$

3) To solve railway line (AB length), either use photo scale or map scale

$$Photo\ Scale = \frac{ab}{AB}$$

$$\frac{1}{12500} = \frac{10.16}{AB}$$

$$AB = 1270\ m$$

$$Map\ Scale = \frac{ab}{AB}$$

$$\frac{1}{50000} = \frac{2.54}{AB} \qquad AB = 1270\ m$$

4)

B = S×E (1−U %)

B = 0.23× 12500 (1− 0.6) = 1150 m the base line length

A=S×E (1−V %)

2100= 0.23× 12500(1−V %)

2100= 2875− 2875V%

2875 V%= 775

V%= 0.269≈ 27% Lateral Overlap (Sidelap)

B. Distinguish between the following items:

1. **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. 3.5(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 obliques is much larger than that of vertical photographs. The main application of oblique photographs is in reconnaissance.

2. **Active and passive remote sensing system.**

   A *passive* **Remote Sensing system** records the energy naturally radiated or reflected from an object

An *active* **Remote Sensing system** supplies its own source of energy, which is directed at the object in order to measure the returned energy. Flash photography is active Remote Sensing in contrast to available light photography, which is passive. Another common form of active Remote Sensing is radar, which provides its own source of Electromagnetic energy in the microwave region. Airborne laser scanning is a relatively new form of active Remote Sensing, operating the in the visible and Near Infra Red wavelength bands.

Q2.

A. An satellite image with 8 gray levels and the following information:

Gray level	0	1	2	3	4	5	6	7
Frequency (No. of Pixels)	10	8	9	2	14	1	5	2

Apply Histogram Equalization Technique to enhance this image. Plot the histogram before and after enhancement process.

Gray level	Frequency No. of pixels $f(BV_i)$	Probability	Cumulative frequency Transformation	Σ Σ Σ	Histogram Equalization value (Round)
0	10	10/51 = 0.196	0.196	1.372	1
1	8	0.157	0.353	2.471	3
2	9	0.176	0.529	3.703	4
3	2	0.039	0.568	3.976	4
4	14	0.275	0.843	5.901	6
5	1	0.020	0.863	6.041	6
6	5	0.098	0.961	6.727	7
7	2	0.039	1.0	7	7

B. Define **Five** of the following terms:
LiDAR, Black Body, Atmospheric windows, Remote sensing, Relief displacement, Ground control points (GCPs), Instantaneous Field of View (IFOV)

LiDAR: The acronym "laser" stands for **(Light Amplification by Stimulated Emission of Radiation).** A laser is a device which generates a stream of high energy particles (photons) within an extremely narrow range of wavelengths. Lasers produce a coherent light source designed for a specific purpose, which could be anything from a CD or DVD player to an industrial cutting tool, a surgical instrument, a surveying instrument, or a LiDAR mapping system. A laser light source forms the basis for a LiDAR system. The term "LiDAR" is an acronym for "**l**ight **d**etection **a**nd **r**anging." The wavelength chosen for most airborne topographic mapping lasers is 1064 nanometers, which is in the near-infrared band of the electromagnetic spectrum. Two sources of light are said to be **Coherent** if the waves emitted from them have the same frequency and are 'phase-linked'; that is, they have a zero or constant phase difference.

Black Body: A black body is a physical abstraction, for no material has an absolute absorptivity, and no material radiates the full amount of energy as defined in the equation above.
For real materials a property called *emissivity*, e, has been defined, as e=Fr/Fb, where
Fr is radiant flux from a real material. For a black body e=1, but for all real materials
e<1. Emissivity is wavelength dependent, which means that the emissivity of a material is different when, is measured at different wavelengths of radiant energy

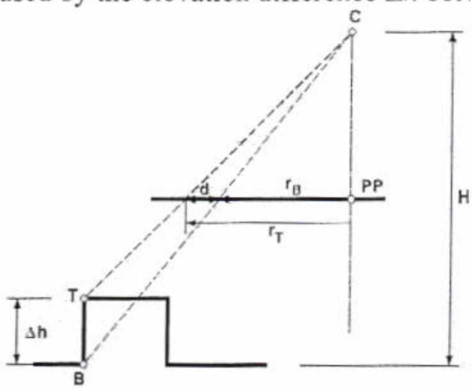
Atmospheric Windows: Those areas of the spectrum which are not severely influenced by atmospheric absorption and thus, are useful to remote sensors, are called atmospheric windows.

Remote sensing

The Definition of **Remote Sensing** In the broadest sense, the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study; e.g., the utilization at a distance (as from aircraft, spacecraft, or ship) of any device and its attendant display for gathering information pertinent to the environment, such as measurements of force fields, electromagnetic radiation, or acoustic energy. The technique employs such devices as the camera, lasers, and radio frequency receivers, radar systems, sonar, seismographs, gravimeters, magnetometers, and scintillation counters.

Relief displacement

The effect of relief does not only cause a change in the scale but can also be considered as a component of image displacement. Figure below illustrates this concept. Suppose point *T* is on top of a building and point *B* at the bottom. On a map, both points have identical *X, Y* coordinates; however, on the photograph they are imaged at different positions, namely in $T\_$ and $B\_$. The distance *d* between the two photo points is called *relief displacement* because it is caused by the elevation difference Δh between *T* and *B*.



Relief displacement

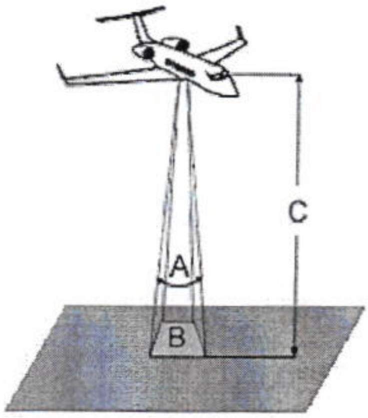
Ground control points (GCPs)

A ground control point (GCP) is a location on the surface of the Earth (e.g., a road intersection) that can be identified on the imagery and located accurately on a map. Each GCP has two coordinates system, first the coordinates of input image denoted by (X, Y) given in pixel unit, second the coordinates of map denoted by (E, N) given in meter unit. The (GCPs) data can be gathered from a wide variety of sources, including map, aerial photograph, field survey, and Global Positioning System (GPS).

Instantaneous Field of View (IFOV)

The IFOV is the angular cone of visibility of the sensor (A) and determines the area on the Earth's surface which is "seen" from a given altitude at one particular moment in time (B). The size of the area viewed is determined by multiplying the IFOV by the distance from the ground to the sensor (C). This area on the ground is called the **resolution cell** and determines a sensor's maximum spatial resolution. For a homogeneous feature to be detected, its size generally has to be equal to or larger than the resolution cell. If the feature is smaller than this, it may not be detectable as the average brightness of all features in that resolution cell will be recorded.

However, smaller features may sometimes be detectable if their reflectance dominates within a particular resolution cell allowing sub-pixel or resolution cell detection. $IFOV(A) \times C = B$



Q3. A. For geometric correction of Multi spectral Scanner (MSS) images, a total number of 3 GCPs were used to perform 1st order polynomial model. If the image coordinates (x, y) and grounds coordinates (X, Y) measured in pixels of GCPs with their polynomial coefficients ($a_0, a_1, a_2, b_0, b_1, b_2$) are listed in tables below. Find:

4. X-residual, Y-residual and

5. RMS error for each point.

6. The total RMS error.

GCP No.	x (pixel)	y (pixel)	X (pixel)	Y (pixel)
1	247.25	141.25	531.50	395.12
2	272.75	85.25	562.75	323.62
3	428.75	64.75	521.38	359.25

a_0	4991.917	b_0	-1489.042
a_1	-6.537	b_1	1.875
a_2	-3.214	b_2	1.603

Solution:

1) X residual = x retransformed – x input ; $XR = x_r - x_i$

Y residual = y retransformed – y input ; $YR = y_r - y_i$

For GCP 1:

$\boldsymbol{x_r = a_o + a_1X + a_2Y}$

$x_r = 4991.917 + (-6.537 * 531.50) + (-3.214 * 395.12);\ x_r = 247.58\ pixel$

$XR_1 = 247.58 - 247.25; XR_1 = 0.33\ pixel$

$y_r = b_o + b_1X + b_2Y$

$y_r = -1489.042 + (1.875 * 531.50) + (1.603 * 395.12); y_r = 140.89\ pixel$

$YR_1 = 140.89 - 141.25; YR_1 = -0.36\ pixel$

The RMS error for GCP1:

$$RMS\ error = \sqrt{XR_i^{\ 2} + YR_i^{\ 2}}$$

$$RMS\ error = \sqrt{XR_1^{\ 2} + YR_1^{\ 2}}; RMS\ error = \sqrt{(0.33)^2 + (-0.36)^2};\ \ RMS\ error = 0.48\ pixel$$

For GCP 2:

$x_r = 4991.917 + (-6.537 * 562.75) + (-3.214 * 323.62); x_r = 273.10\ pixel$

$XR_2 = 273.10 - 272.75; XR_2 = 0.35\ pixel$

$y_r = -1489.042 + (1.875 * 562.75) + (1.603 * 323.62); y_r = 84.87\ pixel$

$YR_2 = 84.87 - 85.25;\ YR_2 = -0.38\ pixel$

$$RMS\ error = \sqrt{XR_2^{\ 2} + YR_2^{\ 2}};\ RMS\ error = \sqrt{(0.35)^2 + (-0.38)^2}; RMS\ error = 0.51\ pixel$$

For GCP 3:

$x_r = 4991.917 + (-6.537 * 521.38) + (-3.214 * 359.25);\ x_r = 429.02\ pixel$

$XR_3 = 429.02 - 428.75; XR_3 = 0.27\ pixel$

$y_r = -1489.042 + (1.875 * 521.38) + (1.603 * 359.25); y_r = 64.42\ pixel$

$YR_3 = 64.42 - 64.75; YR_3 = -0.33\ pixel$

$$RMS\ error = \sqrt{XR_3^{\ 2} + YR_3^{\ 2}}; \boldsymbol{RMS\ error = \sqrt{(0.27)^2 + (-0.33)^2}; RMS\ error = 0.42\ pixel}$$

2) The total RMS error

$$R_x = \sqrt{\tfrac{1}{n}\textstyle\sum_{i=1}^{n} XR_i^{\ 2}};\ R_x = \sqrt{\tfrac{1}{3}\left[(0.33)^2 + (0.35)^2 + (0.27)^2\right]};\ R_x = \sqrt{\tfrac{1}{3}\left[0.1089 + 0.1225 + 0.0729\right]}$$

$$= \sqrt{\frac{1}{3}\left[0.3043\right]}\ = 0.3184\ pixel$$

$$R_y = \sqrt{\tfrac{1}{n}\textstyle\sum_{i=1}^{n} YR_i^{\ 2}};\ R_y = \sqrt{\tfrac{1}{3}\left[(-0.36)^2 + (-0.38)^2 + (-0.33)^2\right]}; R_y = \sqrt{\tfrac{1}{3}\left[0.1296 + 0.1444 + 0.1089\right]}$$

$$= \sqrt{\tfrac{1}{3}\left[0.3829\right]}\ = 0.3572\ pixel$$

$$T = \sqrt{R_x^{\ 2} + R_y^{\ 2}};\ T = \sqrt{(0.3184)^2 + (0.3572)^2};\ = \sqrt{0.2289}\ = 0.4785\ pixel$$

B. Answer the following items:

1. What advantages do sensors carried on board satellites have over those carried on aircraft? Are there any disadvantages that you can think of?

Answer

Sensors on board satellites generally can "see" a much larger area of the Earth's surface than would be possible from a sensor onboard an aircraft. Also, because they are continually orbiting the Earth, it is relatively easy to collect imagery on a systematic and repetitive basis in order to monitor changes over time. The geometry of orbiting satellites with respect to the Earth can be calculated quite accurately and facilitates correction of remote sensing images to their proper geographic orientation and position. However, aircraft sensors can collect data at any time and over any portion of the Earth's surface (as long as conditions allow it) while satellite sensors are restricted to collecting data over only those areas and during specific times dictated by their particular orbits. It is also much more difficult to fix a sensor in space if a problem or malfunction develops!

2. Explain why data from the Landsat TM sensor might be considered more useful than data from the original MSS sensor. Hint: Think about their spatial, spectral, and radiometric resolutions.

Answer

There are several reasons why TM data may be considered more useful than MSS data. 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.

(Remember, 6 bits = 2^6 = 64, and 8 bits = 2^8 = 256 - therefore, 256/64 = 4). However, this does not mean that TM data are "better" than MSS data.

Indeed, 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.

Q4). A. A 1:24,000 aerial photo that falls within this subscene was acquired from the EPA. Starting with a field visit during the same growing season, the crops in many individual farms located in the photo were identified, of which about 12 were selected as training sites. Most were either corn or soybeans; others were mainly barley and wheat. A Maximum Likelihood supervised classification was then run. With the class identities in the photo as the standard, the number of pixels correctly assigned to each class and those misassigned to other classes were arranged in the confusion matrix (Error matrix) used to produce the summary information shown in the following table.

		Landsat Classes			
		Corn	Soybeans	Forest	Other
Photo /Ground Classes	Corn	25	5	10	3
	Soybeans	2	50	6	5
	Forest	3	4	60	5
	Other	2	2	2	100

1. Compute the overall accuracy?
2. Compute the Producers' and user' accuracy?
3. Compute of K_{hat} Coefficient?

Answer:

		Landsat Classes				Total Row
		Corn	Soybeans	Forest	Other	
Photo /Ground Classes	Corn	25	5	10	3	43
	Soybeans	2	50	6	5	63
	Forest	3	4	60	5	72
	Other	2	2	2	100	106
Total Column		32	61	78	113	284

1. **Overall Landsat classification Accuracy**=(25+50+60+100)/ 284=235/ 284= 83%
2. **Producers' Accuracy**
   Corn= 25/32= 78%
   Soybeans= 50/61= 82%
   Forest= 60/78= 77%
   Other=100/113= 88.5%

   Producers' Accuracy
   Corn=25/43= 58%
   Soybeans=50/63=79%
   Forest=60/72=83%
   Other=100/106=94%
3. **Compute of K_{hat} Coefficient**

$K_{hat}=[N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} x_{i+}\, x_{+i}]/[(N^2 - \sum_{i=1}^{r} x_{i+}\, x_{i+1})]$

N=284

$\sum_{i=1}^{r} x_{ii}$ =(25+50+60+100)=235

$$\sum_{i=1}^{r} x_{i+}\, x_{i+1} = (43 \times 32) + (63 \times 61) + (72 \times 78) + (106 \times 113) = 22813$$

$K_{hat}=[(284 \times 235) - 22813]/[(284^2 \ - 22813)] = \frac{43927}{57843} = 0.7594 \approx 76\ \%$

K_{hat}> 75% Strong agreement (accuracy) between classification map and the ground reference information

75% >K_{hat}> 40% Fair to good agreement (accuracy) between classification map and the ground reference information

K_{hat}< 40% Poor agreement (accuracy) between classification map and the ground reference information

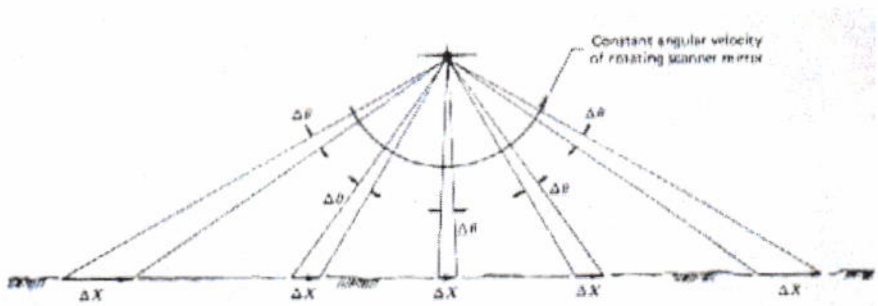
As K_{hat}> 75% , So Strong agreement (accuracy) between classification map and the ground reference information

B. Answer the following items:

1. If you wanted to detect heat from a fire, which portion of EM spectrum would you use? Why?

The thermal portion will be used to detected the heat and the factors effecting thermal imagery

1. Solar gain. During the daytime direct sunlight differentially heats objects according to their thermal characteristics. This can be an advantage in looking for specific differences in tonal signature from differing materials. However, there is the problem of shadowing by trees, buildings and other objects, which causes thermal shading, and orientation, which leads to differential heating, patterns on slopes.
2. Air temperature. The stability and variation in the temperature range throughout the expected survey period can have a significant bearing upon the interpretation. This is particularly important for examination of building heat loss where the maximum difference between internal and external temperature is required. For this application, the air temperature is required to below $+6^{\circ}C$.
3. Wind. Wind speeds are required to be below 15 knots and preferably around 5 knots. There are two reasons for this firstly, low wind speed reduces the amount of buffeting the aircraft receive; secondly, high winds result in strong wind shadows and differential cooling and an increase in the convective rather than radiative temperature loss.
4. Look angle. The scanner scans the ground perpendicular to the line of flight and as such only the area directly beneath the scanner is viewed vertically (see figure). Away from the nadir the scanner "Looks" at an angle to the ground surface, and for buildings a compressed view of walls is achieved.



Resulting variations in linear velocity of ground resolution element

مصادر تشوه المقياس المماسي .

5. Survey timing. The mission planning is an important factor in terms of type of results required. For example, the scanning of hot water from a power station must be completed during the period of power generation. Effects of tides and currents, for example also have to be taken into account.

2. Compare a 2-bit image with an 8-bit image. List the different types of resolution.

Two bit records an exponent of power 2 (e.g. 4 bit=2^4= 16 digital values); and 8-bits records 2^8 =256 digital values By comparing a 4-bit image with an 8-bit image, we can see that there is a large difference in the level of detail discernible depending on their radiometric resolutions. Thus, if a sensor used 8 bits to record the data, there would be 2^8=256 digital values available, ranging from 0 to 255. However, if only 4 bits were used, then only 24=16 values ranging from 0 to 15 would be available. Thus, the radiometric resolution would be much less.

1. Spatial resolution
2. Radiometric resolution
3. Spectral resolution
4. Temporal resolution

Q5

A. Two buildings on flat terrain are separated in the range direction by a distance along the ground by 20 m. Knowing that the radar system flying with altitude (800km) has the following characteristics: a wavelength of 23cm, antenna length along track (D_{AT}) is 2m with antenna length cross track (D_R) is 1.25 m, and pulse length (duration) of $0.1\ \mu sec$. If the buildings were imaged in the near range with a depression angle of $30°$ and however, the same buildings were imaged in the near range with a depression angle of $60°$. The Grazing angle is $47.45°$

Find the following

1. The ground – range resolution
2. The azimuth resolution for both cases.
3. Will these buildings be resolved in the far range and near range?
4. The swath width for radar scanning.

Solution:

<u>In the far range:</u>

$$The\ ground - range\ resolution\ \delta_R = R_{gr} = \frac{c.\tau}{2\cos\gamma}$$

$$\delta_R = R_{gr} = \frac{3 * 10^8\ m/sec\ *\ 0.1 * 10^{-6}\ sec}{2\cos 30°} = 17.32\ m$$

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

$$\delta_{AT} = R_a = \frac{0.23\ m}{2} \cdot \frac{3 * 10^8\ m/sec\ *\ 0.1 * 10^{-6}\ sec\ \cos 30°}{2}$$

$$\delta_{AT} = R_a = 1.494 \approx 1.5\ m$$

<u>In the near range:</u>

$$The\ ground - range\ resolution\ \delta_R = R_{gr} = \frac{c.\tau}{2\cos\gamma}$$

$$\delta_R = R_{gr} = \frac{3 * 10^8\ m/sec\ *\ 0.1 * 10^{-6}\ sec}{2\cos 60°} = 30.0\ m$$

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

$$= \frac{0.23\ m}{2} \cdot \frac{3 * 10^8\ m/sec\ *\ 0.1 * 10^{-6}\ sec\ \cos 60°}{2}$$

$$\delta_{AT} = R_a = 0.8625\ m$$

Swath width for radar scanning $= W_g = \frac{R_f - R_n}{\cos\psi} = \frac{\lambda R}{D_R \sin\psi}$

$$R_f = \frac{800\ km}{\cos(90 - 30)} = 1600\ km$$

$$R_n = \frac{800\ km}{\cos(90 - 60)} = 923.76\ km$$

$$W_g = \frac{R_f - R_n}{\cos\psi} = \frac{1600 - 923.76}{\cos 47.45°} = 1000\ km$$

If the buildings were in the far range, the two buildings would be resolved. Whereas, in the near range the two buildings would not be resolved in ground – range resolution. But they are resolved in the azimuth resolution. Thus, the range resolution is better in the far range, and azimuth resolution is better in the near range.

B. Show the difference between the following items:

1. SAR and RAR

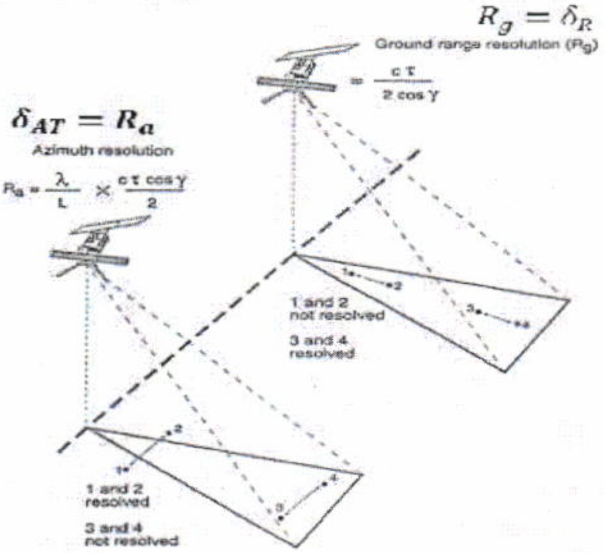
SLAR (Side-looking Airborne Radar)—uses an antenna which is fixed below an aircraft and pointed to the side to transmit and receive the radar signal.

SAR—uses a side-looking, fixed antenna to create a synthetic aperture. SAR sensors are mounted on satellites and the NASA Space Shuttle. The sensor transmits and receives as it is moving. The signals received over a time interval are combined to create the image. Both SLAR and SAR systems use side-looking geometry.

For the **RAR**, the cross-range spatial resolution (Azimuth resolution) is a direct function of radar wavelength (λ) and target range (R) and inverse function of antenna length along track (D_{AT}), see Figure.

$\delta_{AT}=\lambda.R/D_{AT}$

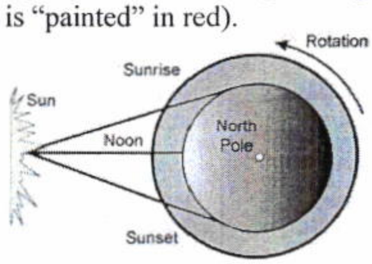
While; For the **SAR**, the cross-range spatial resolution (Azimuth resolution) is a direct function of antenna length along track (DAT), $\delta_{AT}=D_{AT}/2$, see Figure.



2. Solar radiation is scattered by atmosphere. Identify and explain the types of scattering process that occur.

Scattering occurs when particles or large gas molecules present in the atmosphere interact with and cause the electromagnetic radiation to be redirected from its original path. How much scattering takes place depends on several factors including the wavelength of the radiation, the abundance of particles or gases, and the distance the radiation travels through the atmosphere. There are three (3) types of scattering which take place.

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.

The final scattering mechanism of importance is called **nonselective scattering**. This occurs when the particles are much larger than the wavelength of the radiation. Water droplets and large dust particles can cause this type of scattering. Nonselective scattering gets its name from the fact that all wavelengths are scattered about equally. This type of scattering causes fog and clouds to appear white to our eyes because blue, green, and red light are all scattered in approximately equal quantities
(Blue+Green+Red light = white light).