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

Subject: Remote Sensing
Branch: Geomatic Eng.
Examiner: Prof. Dr. Abd Razzak T. Zibbon
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Class: 3rd Year
Time : 3 Hrs.
Date:

**Notes:** 1. Answer Four Questions. 2. Please return question sheets with answers.

**Q1. A.** 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 order polynomial model. If a total number of 3 GCPs were used to perform this order of polynomial model for geometric correction of satellite image with spatial resolution 0.6m. Where, the X residual and Y residual measured in pixels for the GCPs are shown in the table below. Find:

1. The RMS error for each GCP. **(15%)**
2. The total RMS error.

| GCP No. | X | Y |
|---|---|---|
| 1 | -0.441 | 0.388 |
| 2 | 0.451 | -0.406 |
| 3 | 0.436 | -0.503 |

**B.** List the advantages and disadvantages of thermal imaging systems. **(10%)**

**Q2. A.** .A surface has an average roughness of 10 cm. If the surface is imaged by a radar system operating at a wavelength of 23 cm with a depression angle of 45 degrees, would it be classed as a radar – smooth or a radar – rough surface? **(17%)**

**B.** List factors that influence emissivity of an object? **(8%)**

**Q3. A.** Apply the direction filter; East – West component Kernel to the 7*7 digital image. **(15%)**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| Raw data | | | | | | |

| | | |
|---|---|---|
| -1 | -2 | -1 |
| 2 | 4 | 2 |
| -1 | -2 | -1 |
| East – West component Kernel | | |

**B.** GPR has been used to detect pipes. Find the depth of pipes that detected at 46 ns in dry sand (Er = 4 ) ?.**(10%)**

**Continued**

**Q4.** An Iso-data unsupervised classification was used to classify QuickBird Image. The selection of a proper and efficient sample design to collect valid reference data, is one of the most challenging and important components of any accuracy assessment, was implemented. The reference data and classified data were arranged in the confusion matrix (Error matrix) which used to produce the summary information shown in the following table. **(25%)**

| Classification | Reference Data | | | |
|---|---|---|---|---|
| Classified Data | Grass | Wheat | Deciduous | Conifer |
| Grass | 65 | 4 | 22 | 24 |
| Wheat | 6 | 81 | 5 | 8 |
| Deciduous | 0 | 11 | 85 | 19 |
| Conifer | 4 | 7 | 3 | 90 |

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

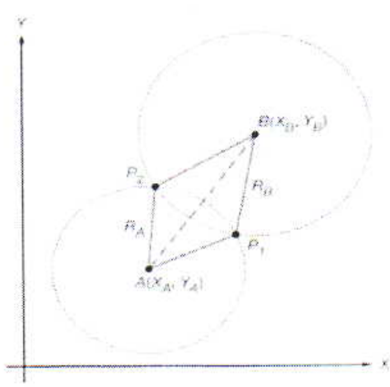
**Q5.A.** A multispectral image required to be classified according to minimum distance to mean classifier. Three traing set were collected for BAND 1 & BAND 2 as shown in following tables: **(15%)**

| Training set 1 (ClassA) | Brightness values |
|---|---|
| Band 1 | 135 , 138, 140 |
| Band 2 | 119, 122, 130 |
| Training set 2 (Class B) | Brightness values |
| Band1 | 84, 90, 88 |
| Band 2 | 99,100,110 |
| Training set3 (Class C) | Brightness value s |
| Band1 | 39, 44,60 |
| Band 2 | 36, 33, 30 |

| Pixel 1 | Brightness value |
|---|---|
| Band 1 | 100 |
| Band 2 | 142 |
| Pixel 2 | Brightness value |
| Band 1 | 55 |
| Band 2 | 118 |

1. Calculate Mean vector for each Training set
2. Find for which class should a Pixel 1 be assigned?
3. Find for which class should a Pixel 2 be assigned?

**B.** For the figure below, assume the following data (in meters) are available: $XA$=2851.28, $YA$=299.40, $RA$ =2000.00, $XB$=3898.72, $YB$=2870.15, $RB$=1500.00. Compute the X and Y coordinates of point P. **(10%)**



## Useful Equations

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

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

$$[X = (BV_3 + 2BV_6 + BV_9) - (BV_1 + 2BV_4 + BV_7)$$

$$;\ Y = (BV_1 + 2BV_2 + BV_3) - (BV_7 + 2BV_8 + BV_9)];\ x = a_0 + a_1 X + a_2 Y$$

$$;\ y = b_0 + b_1 X + b_2 Y;\ A = S.E.(1 - V\%)\ ;B = S.E.(1 - U\%);\ < P_r \geq P_t\left[\frac{G^2\lambda^2}{(4\pi)^3 R^4}\right].\sigma_0\ ;$$

$$h \leq \frac{\lambda}{25 \sin\gamma}\ ;\ h \geq \frac{\lambda}{4.4 \sin\gamma}\ ;\ h = \frac{\lambda}{8 \sin\gamma}\ ;\ \delta_R = \frac{c.\tau}{2.\cos\gamma}\ ;\delta_{AT} = \frac{\lambda}{D_{AT}}.\frac{c.\tau.\cos\gamma}{2};\ \varepsilon = \frac{M_R}{M_B} = \frac{T_{rad}^4}{T_{kin}^4};\ ;$$

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

$C_f = \frac{H}{C_i}$ ; $R^3 = GMT^2/4p^2$ ; $E = h \times c/\lambda$; h: $6.6 * 10^{-34}$ J.s c: $3*10^{8}$ m/s

$$R_\rho = \frac{\ln\left(\frac{1}{K_\rho}\ \frac{\Delta T\ \sqrt{\varepsilon/7}}{MRT_\circ}\right)}{\beta_{atm.} + \frac{\gamma}{S}\beta_{sys}}\ ;\quad K_{hat} = [N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} x_{i+}x_{+i}]/[(N^2 - \sum_{i=1}^{r} x_{i+}x_{i+1})];$$

$$RMS\ error = \sqrt{XR_i^2 + YR_i^2};\quad W = \sigma\varepsilon T^4\ ;\ \lambda_{max} = \frac{2897 mm^\circ K}{Trad^\circ K}$$

D = 5.9 t / SQRT of ER

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

$$< A = \cos^{-1}\left[\frac{(AB)^2 + (AP)^2 - (BP)^2}{2 \times AB \times AP}\right]$$

$$Az_{AP1} = Az_{AB} + < A$$
$$Az_{AP2} = Az_{AB} - < A$$

$$X_{P1} = X_A + AP_1 \sin(Az_{AP1})\quad ,\ Y_{P1} = Y_A + AP_1 \cos(Az_{AP1})$$
$$X_{P2} = X_A + AP_2 \sin(Az_{AP2})\quad ,Y_{P2} = Y_A + AP_2 \cos(Az_{AP2})$$

Stefan- Boltzman constant is $5.67*10^{-12}$ W. $cm^{-12}$

**...GOOD LUCK...**

Answer

Q1.A

1) The RMS error for GCP1

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

$$RMS\ error = \sqrt{XR_1^2 + YR_1^2}$$

$$RMS\ error = \sqrt{(-0.441)^2 + (0.388)^2}$$

$$= \sqrt{0.1944 + 0.1505}$$

$$= 0.5872\ pixel$$

The RMS error for GCP2

$$RMS\ error = \sqrt{XR_2^2 + YR_2^2}$$

$$RMS\ error = \sqrt{(0.451)^2 + (-0.406)^2}$$

$$= \sqrt{0.2034 + 0.1648}$$

$$= 0.6067\ pixel$$

The RMS error for GCP3

$$RMS\ error = \sqrt{XR_3^2 + YR_3^2}$$

$$RMS\ error = \sqrt{(0.436)^2 + (-0.503)^2}$$

$$= \sqrt{0.1900 + 0.2530}$$

$$= 0.6655\ pixel$$

2) The total RMS error

$$R_x = \sqrt{\frac{1}{n}\sum_{i=1}^{n} XR_i^2}$$

$$R_x = \sqrt{\frac{1}{3}\left[(-0.441)^2 + (0.451)^2 + (0.436)^2\right]}$$

$$R_x = \sqrt{\frac{1}{3}\,[0.1944 + 0.2034 + 0.1900]}$$

$$= \sqrt{\frac{1}{3}\,[0.5878]}$$

$$= 0.4426\ pixel$$

$$R_y = \sqrt{\frac{1}{n}\sum_{i=1}^{n} {YR_i}^2}$$

$$R_y = \sqrt{\frac{1}{3}\,[(0.388)^2 + (-0.406)^2 + (-0.503)^2]}$$

$$R_y = \sqrt{\frac{1}{3}\,[0.1505 + 0.1648 + 0.2530]}$$

$$= \sqrt{\frac{1}{3}\,[0.5683]}$$

$$= 0.4352\ pixel$$

$$T = \sqrt{{R_x}^2 + {R_y}^2}$$

$$T = \sqrt{(0.4426)^2 + (0.4352)^2}$$

$$= \sqrt{0.3852}$$

$$= 0.6206\ pixel$$

Q1.B

*The advantages of thermal imaging systems are:*

1) They are passive: i.e. no revealing radiation is emitted by the system.
2) They operate day and night, i.e. they do not dependent on sun or start illumination.

*The main disadvantage.*

1) Is the need for reasonably good visibility conditions due to scattering in fog and rain.
2) The interpretation of picture takes a trained person because emitted thermal radiation , and not the ordinary reflected solar radiation, is used to produce the picture.

Q2.A

Using equation for radar – smooth

$$H \le \frac{\lambda}{25\ \sin\gamma}$$

$$H \le \frac{23\ cm}{25\ \sin 45^\circ} \quad ;\ \sin 45^\circ = 0.707$$

$$H \le \frac{23\ cm}{17.677}$$

$$H \le 1.3\ cm \qquad radar - smooth\ surface$$

Using equation for radar – rough

$$H \ge \frac{\lambda}{4.4\ \sin\gamma}$$

$$H \ge \frac{23\ cm}{4.4\ \sin 45^\circ}$$

$$H \ge \frac{23\ cm}{3.11}$$

$$H \ge 7.4\ cm \qquad radar - rough\ surface$$

Thus the surface is radar – smooth if H is less than 1.3 cm, and the surface is radar – rough if H is greater than 7.4 cm. Because the surface roughness is 10 cm it would appear bright on the radar image and be classed as a radar – rough surface.

But for this system for roughness values between 1.3 cm and 7.4 cm an intermediate grey tone would be assigned. It can be seen from above equations that by. investigating the same surface using different wavelengths and depression angles, the signatures obtained may allow its roughness to be determined quite accurately.

Q2.B

1. Color -darker colored objects are usually better absorbers and emitters (i.e. they have a higher emissivity) than lighter colored objects which tend to reflect more of the incident energy.
2. Surface roughness-the greater the surface roughness of an object relative to the size of the incident wavelength. the greater the surface area of the object and potential for absorption and re-emission of energy.
3. Moisture content-the more moisture an object contains. the greater its ability to absorb energy and become a good emitter. Wet soil particles have a high emissivity similar to water.
4. Compaction-the degree of soil compaction can effect emissivity.
5. Field-of-view-the emissivity of a single leaf measured with a very high resolution thermal radiometer will have a different emissivity than an entire tree crown viewed using a coarse spatial resolution radiometer.
6. Wavelength-the emissivity of an object is generally considered to be wavelength dependent. For example. while the emissivity of an object is often considered to be constant throughout the (8 -14 μm) region. its emissivity in the (3 -5 μm) region may be different.
7. Viewing angle-the emissivity of an object can vary with sensor viewing angle

Q3.A

$$R_2, C_2 = -1(1) + (-2)(1) + (-1)(1) + 2(1) + 4(1) + 2(1) + (-1)(1) + (-2)(1) + (-1)(1) = 0$$

$$R_2, C_3 = -1(1) + (-2)(1) + (-1)(2) + (2)(1) + 4(1) + 2(2) + (-1)(1) + (-2)(1) + (-1)(2) = 0$$

$$R_2, C_4 = -1(1) + (-2)(2) + (-1)(1) + (2)(1) + 4(2) + 2(1) + (-1)(1) + (-2)(2) + (-1)(1) = 0$$

$$R_2, C_5 = -1(2) + (-2)(1) + (-1)(1) + (2)(2) + 4(1) + 2(1) + (-1)(2) + (-2)(1) + (-1)(1) = 0$$

And so on. continue the rest elements of window

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Output image

Q3.B

Answer:

D = (5.9 x 46) / sqrt (4)

D = 135.7 in

Therefore the object is about 11 ft underground

Q4.

| Classification | Reference Data | | | | |
|---|---|---|---|---|---|
| Classified Data | Grass | Wheat | Deciduous ag | Conifer | Row |
| Grass | 65 | 4 | 22 | 24 | 115 |
| Wheat | 6 | 81 | 5 | 8 | 100 |
| Deciduous | 0 | 11 | 85 | 19 | 115 |
| Conifer | 4 | 7 | 3 | 90 | 104 |
| Coloum total | 75 | 103 | 115 | 141 | 434 |

1) Overall accuracy = (65+81+85+90)/434 = 321/ 434 = 74 %

2) Producers accuracy

Grass = 65/75 = 87%

Wheat = 81/103= 79%

Deciduous = 85/115= 74%

Conifer = 90/ 141= 64 %

Users accuracy

Grass = 65/ 115 = 57%

Wheat =81/100= 81%

Deciduous= 85/ 115= 74 %

Conifer= 90/104= 87%

3) Compute of $K_{hat}$ coefficient

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

N=434

$$\sum_{i=1}^{r} x_{ii} = (65 + 81 + 85 + 90) = 321$$

$$\sum_{i=1}^{r} x_{i+} x_{+i} = (115 * 75) + (100 * 103) + (115 * 115) + (104 * 141) = 46814$$

$$K_{hat} = {(434 * 321) - 46814} \Big/ {[(434^2 - 46814)]} = 65\ \%$$

$K_{hat} > 75\ \%$ *Strong agreement(accuracy)between classification map and the ground refrence information*

$75\% > K_{hat} > 40\ \%$

*fair to good agreement(accuracy)between classification map and the ground refrence information*

$K_{hat} < 40\ \%$

*Poor agreement(accuracy)between classification map and the ground refrence information*

Q5..A

Training set 1

Mean vector band1 : (135 + 138+ 140)/3= 137.6

Band2=123.6

Training set2

Band1 = 87.3

Band2= 103

Training set3

Band1 =47

Band2 = 33

Euclidean Spectral distance for pixel 1 with Training set 1

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

= squrt ( 100-137.6)$^2$ +( 142-123.6)$^2$ =41.8

Euclidean Spectral distance for pixel 1 with Training set2

=41

Euclidean Spectral distance for pixel 1 with Training set3

=121.2

Therefore Pixel 1 is assigned to class B

FOR PIXEL 2 with training set 1

(55,118)

D=82.7

With traning set 2

D=35.6

with traning set 3

D= 85

Therefore pixel 2 assigned to class B also

Q5.B

The length and azimuth of $AB$ are

$$tan\ bearing\ AB = \frac{3898.72 - 2851.28}{2870.15 - 299.40}$$

$$berAB = 22.16820773° = 22^o\ 10^{'}\ 05.6^{''}$$

$$dist\ AB = \sqrt{(3898.72 - 2851.28)^2 + (2870.15 - 299.40)^2} = 2775.948\ m$$

And $A$ is

$$A = \cos^{-1}\left[\frac{(2775.948)^2 + (2000.00)^2 - (1500.00)^2}{2 \times 2775.948 \times 2000.00}\right]$$

$$A = \cos^{-1}(0.851590816) = 31.61488075° = = 31^o\ 36^{'}\ 53.6^{''}$$

The possible solutions for $P$ are

$$X_{P1} = 2851.28 + 2000.00\sin(22^o\ 10^{'}\ 05.6^{''} + 31^o\ 36^{'}\ 53.6^{''})$$

$$X_{P1} = 2851.28 + 2000.00\sin(53^o\ 46^{'}\ 58.12^{''})$$

$$X_{P1} = 2851.28 + 2000.00\sin(53.783^o)$$

$$= 2851.28 + 2000.00\ \times 0.80678504$$

$$X_{P1} = 2851.28 + 1613.570081 = 4464.85\ m$$

$$Y_{P1} = 299.40 + 2000.00\cos(22^o\ 10^{'}\ 05.6^{''} + 31^o\ 36^{'}\ 53.6^{''})$$

$$Y_{P1} = 299.40 + 2000.00\cos(53^o\ 46^{'}\ 58.12^{''})$$

$$Y_{P1} = 299.40 + 2000.00\cos(53.783^o)$$

$$= 299.40 + 2000.00\ \times 0.590845071$$

$$Y_{P1} = 299.40 + 1181.690143 = 1481.09\ m$$

Or

$$X_{P2} = 2851.28 + 2000.00\sin(22^o\ 10^{'}05.6^{''} - 31^o\ 36^{'}\ 53.6^{''})$$

$$X_{P2} = 2851.28 + 2000.00\sin(-9^o\ 26^{'}\ 48.0^{''})$$

$$X_{P2} = 2851.28 + 2000.00\sin(-9.446666666^{o})$$

$$X_{P2} = 2851.28 + 2000.00 \times (-0.164129458) = 2851.28 - 328.2589163$$

$$X_{P2} = 2523.021\ m$$

$$Y_{P2} = 299.40 + 2000.00\cos\left(22^{o}\ 10'\ 05.6'' - 31^{o}\ 36'\ 53.6''\right)$$

$$Y_{P2} = 299.40 + 2000.00\cos\left(-9^{o}\ 26'\ 48.0''\right)$$

$$Y_{P2} = 299.40 + 2000.00\cos(-9.446666666^{o})$$

$$X_{P2} = 299.40 + 2000.00 \times (-0.986438807) = 2851.28 - 1972.877615$$

$$X_{P2} = 2772.28\ m$$