Concept of Accuracy Assessments

Paper Code: Digital Image Processing (GIS 04)

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PG Diploma in RS & GIS

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Today we will learn about…

- ✓ Understand the principle of accuracy assessment.
- ✓ Learn about different sources of errored while Classifying an image.
- ✓ What are the various methods through we can quantitatively asses whether the image has been accurately classified or there are some miss classified pixels.

MAP

ACCURACY ASSESSMENT

- As we know the hard classification techniques such as supervised and unsupervised classification techniques.

- Through these techniques once we have classified, it is important that we calculate accuracy of the classification of the images.

Now question is come why we need the accuracy assessment

- We need a accuracy assessment because once we have classify a image we need to be sure that whether pixel we have classify into a particular classes or not.

- Because it is not practical to test every pixel in the classification image, a representative sample of reference points in the image with known class values is used

Now what is the meaning of actually being present-

- Suppose we have an image and we want to classify into a waterbody the classification automatically classified that was waterbody but if you go for the ground truth at regional place may be the GPS location does not show as a clear water it might be water logged area so this implies we actually classify as water might have being a water logged so this amount to miss classification of the pixels.

Now question is that why this is occurring

- Because the reflectance we have capturing for water it does not justify a differentiate between being a waterbody or waterlogged area.

- So we need an accuracy assessment to understand that the water area is different form the waterlogged area and need to reclassify those pixels.

- So before we reclassify we always sure our self we need to have an accuracy assessment.

IS NEEDED WHEN WE
WANT TO COMPARE

* A MAP AND THE REALITY
* TWO DIFFERENT MAPS

What is accuracy assessment:

- It is a agreement between classification image and reference data.

- the reference data is the one which is assumed to be standard data or we assumed that it represent a reality.

What could be the treated as a reference data or sources of reference data

- Reference data may be GPS data points where we located or the GPS points or aerial photographs or some of the satellite data which have a very fine resolution.

- So suppose you classify a image using a Landsat 8 data it has a course spatial resolution of 30m. It can be have a reference data from suppose a data which have a 1m spatial resolution or even finer spatial resolution may be through aerial photographs.

Sources of errors

- ✓ Now we need to understand before we make a accuracy assessment the data which we collected as a reference data has to be also correctly or accurately identify.

- ✓ If you have a classify image of December month and you collect the reference data in April month there would be a difference and accuracy assessment could be low. Because for example in December there was a wheat crop plot in April or may the wheat crop is already harvested and it is no more a wheat plot, it might be a fallow land which might not be a available to use even for the next season

- ✓ So if you measure the accuracy assessment of this classified image of December month data and reference data of April you would be less accuracy assessment.

- ✓ So you need to understand that even the accuracy assessment has to be clearly define and need to know what was the timing of the reference data a collection and you have to have a satellite data also for the same time and period.

How can an errors occur

An errors can occurs if you have minimum mappable of sample point which do not represent the whole region.

What do I mean by that

suppose the classified image you have 5 classes on which you classify this image but actually when you go for the reference data collection you missed out one of the classes.

So when you do accuracy assessment you will not class which you have identified or classified is actually present in the field site or not.

This would be result an actually very low accuracy for the 5^{th} class even, through and overall accuracy might be high so you need to know the region where you have to the accuracy assessment that wherever the data have been properly collected or not.

Now how do you know whether the collection or how many observation points you need from one of the sites it usually considered that you should have minimum of 50 observation for a particular land use or land cover sites.

How can you determine or actually a bigger region you have a lot of sources or you can have even more points.

Field Sampling Design

Now what is the equation we can use to calculate how many number of sample we basically need.

It is a very basic equations which is

$$N = \frac{Z^2 (p)(q)}{E^2}$$

binomial probability theory:

Where,
N = number of sample you need

Z = Standard Deviation of the number of sample
(from the standard normal deviate of 1.96 for the 95% two-sided confidence level).

P = what is the expected percent accuracy

(Suppose you will never got an 100% accuracy so what will be the accuracy, it is a experimental things it will never 100% how much do expected. It may be 85% or 95% you can chose any one number between these two either 85% or 95%)

q = 1-p or **100 –** ***p*****, and**

E^2 = your allowable error

Sample Size

Sample size *N* to be used to assess the accuracy of a land-use classification map for the binomial probability theory:

$$N = \frac{Z^2(p)(q)}{E^2}$$

P – expected percent accuracy,

q = 100 – *p*,

E – allowable error,

Z = 2 (from the standard normal deviate of 1.96 for the 95% two-sided confidence level).

Sample Size

For a sample for which the expected accuracy is 85% at an allowable error of 5% (i.e., it is 95% accurate), the number of points necessary for reliable results is:

$$N = \frac{2^2(85)(15)}{5^2} = \text{a minimum of } 203 \text{ points.}$$

Sample Size

With expected map accuracies of 85% and an acceptable error of 10%, the sample size for a map would be 51:

$$N = \frac{2^2(85)(15)}{10^2} = 51 \text{ points}$$

$$N = \frac{Z^2(p)(q)}{E^2}$$

P – expected percent accuracy,

q = 100 – *p*,

E – allowable error,

Z = 2 (from the standard normal deviate of 1.96 for the 95% two-sided confidence level).

Sample Design

There are basically five common sampling designs used to collect ground reference test data for assessing the accuracy of a remote sensing-derived thematic map:

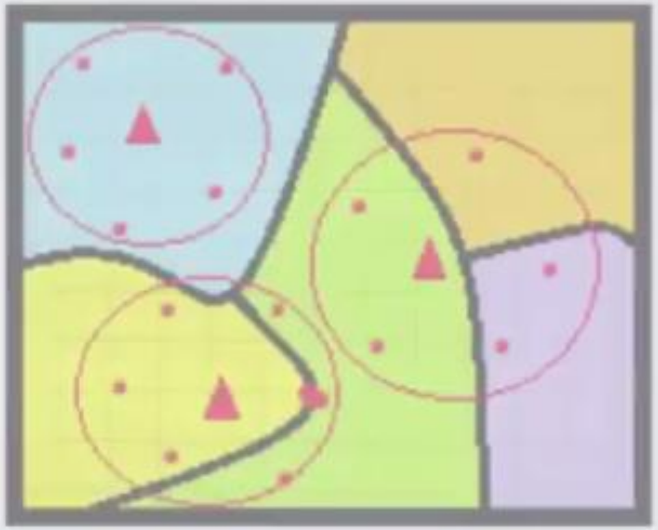
1. random sampling,
2. systematic sampling or Regular Grid,
3. stratified random sampling,
4. stratified systematic unaligned sampling, and
5. cluster sampling.

Simple random

Systematic

Stratified random

Systematic non-aligned



Cluster

Commonly Used Methods of Generating Reference Points

- *Random*: no rules are used; created using a completely random process
- *Stratified random*: points are generated proportionate to the distribution of classes in the image
- *Equalized random*: each class has an equal number of random points

Commonly Used Methods of Generating Reference Points

- ✓ The latter two are the most widely used to make sure each class has some points
- ✓ With a “stratified random” sample, a minimum number of reference points in each class is usually specified (i.e., 30)
- ✓ For example, a 3 class image (80% forest, 10% urban, 10% water) & 30 reference points:
  - ❖ completely random: 30 forest, 0 urban, 1 water
  - ❖ stratified random: 24 forest, 3 urban, 3 water
  - ❖ equalized random: 10 forest, 10 urban, 10 water

Primary data capture

- ❖Surveying
  - ✓ Uses expensive field equipment and crews
  - ✓ Most accurate method for large scale, small areas
- ❖GPS
- ❖Collection of satellites used to fix locations on Earth's surface
- ✓Field Spectrometer
- ✓High resolution imagery

TOTAL STATION

DGPS

GPS “HANDHELDS”

geographic coordinates

text

photos

video

audio

Bluetooth, WiFi

FIELD SPECTROMETER

***In Situ* Data Collection**

a. Spectroradiometer measurement. b. Global positioning system (GPS) measurement.

Types of Comparison

Thermology of accuracy

- ✓ Overall Accuracy
- ✓ Omission Errors
- ✓ Commission Errors
- ✓ Kappa Coefficient

} Error Matrix

Accuracy Assignment Formula

$$\text{Overall Accuracy} = \frac{Total\ Number\ of\ Correctly\ Classification\ Pixels\ (Diagonal)}{Total\ Number\ of\ Refence\ Pixel} \times 100$$

$$\text{Users Accuracy} = \frac{Total\ Number\ of\ Correctly\ Classification\ Pixels\ in\ Each\ Category}{Total\ Number\ of\ Refence\ Pixel\ in\ that\ category\ (The\ Row\ Total)} \times 100$$

$$\text{Producer Accuracy} = \frac{Total\ Number\ of\ Correctly\ Classification\ Pixels\ in\ Each\ Category}{Total\ Number\ of\ Refence\ Pixel\ in\ that\ category\ (The\ Column\ Total)} \times 100$$

$$\text{Kappa Coefficient (T)} = \frac{(TS \times TCS) - \sum(Column\ Total \times Row\ Total)}{TS^2 - \sum(Column\ Total \times Row\ Total)} \times 100$$

Error Matrix

- ✓ A tabular result of the comparison of the pixels in a classified image to known reference information
- ✓ Rows and columns of the matrix contain pixel counts
- ✓ Permits the calculation of the overall accuracy of the classification, as well as the accuracy of each class

Assessment of Classification Accuracy

- Most common form of expressing classification accuracy is the error matrix (confusion matrix or contingency table)

TABLE 7.3 Error Matrix Resulting from Classifying Training Set Pixels

Classification Data	Training Set Data (Known Cover Types)[a]						
	W	S	F	U	C	H	Row Total
W	480	0	5	0	0	0	485
S	0	52	0	20	0	0	72
F	0	0	313	40	0	0	353
U	0	16	0	126	0	0	142
C	0	0	0	38	342	79	459
H	0	0	38	24	60	359	481
Column total	480	68	356	248	402	438	1992

- Error matrices compare, on a class-by-class basis, the relationship between known reference data (ground truth) and the corresponding results of the classification procedure.

Error Matrix Table

Row Side

Column Side

Classified Data

Reference Data or True Data

Class	URBAN	VEGETATION
URBAN		
VEGETATION		

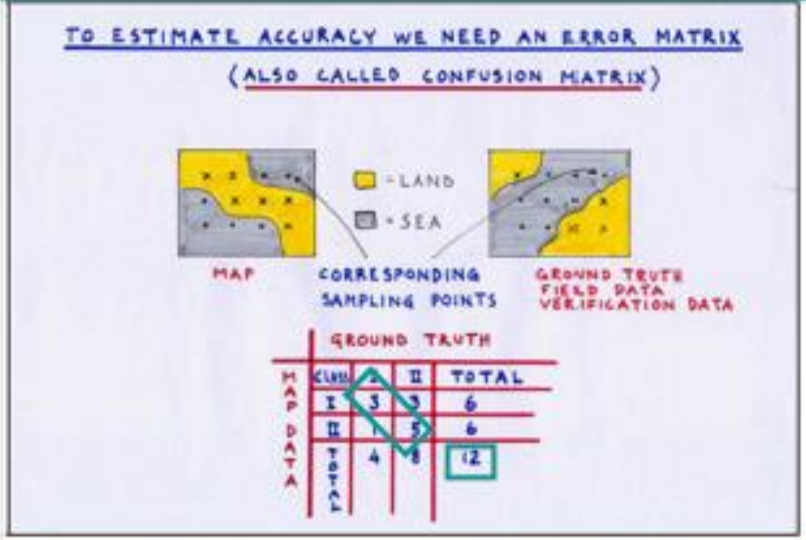
Overall Accuracy

- ✓ Overall accuracy is how many pixel in each of this classes where correctly classified based on your reference data,
- ✓ So it kind of gives you a data where you know your classification accuracy these much of data and these much of miss classify data.
- ✓ How ever it is does not tell you which class is miss classified or either all of the classes was miss classified.
- ✓ So it is a very summarized values, it is also quantitative thing but along over all accuracy is not sophisticate for the assessment of your classified image.
- ✓ For a example how do you do this…..
- ✓ Suppose you need to create an error matrix or confusion matrix or commonly known as contingency table .
- ✓ What do you do …. Suppose you have a two class ….

Overall and Individual Class Accuracy

- Overall / Total Accuracy
  - Computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels
- Individual Class Accuracy
  - Calculated by dividing the number of correctly classified pixels in each category by either the total number of pixels in the corresponding column; Producer's accuracy, or row; User's accuracy.

Overall / Total accuracy



(3 + 5) / 12 = 67%

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	F	0	0	313	40	0	0	353
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	C	0	0	0	38	342	79	459
	H	0	0	38	24	60	359	481
	Column total	480	68	356	248	402	438	1992

Producer's Accuracy
W = 480/480 = 100%
S = 052/068 = 76%
F = 313/356 = 88%
U = 126/248 = 51%
C = 342/402 = 85%
H = 359/438 = 82%

User's Accuracy
W = 480/485 = 99%
S = 052/072 = 72%
F = 313/353 = 87%
U = 126/142 = 89%
C = 342/459 = 74%
H = 359/481 = 75%

Overall accuracy = (480 + 52 + 313 + 126 + 342 + 359)/1992 = 84%

[a]W, water; S, sand; F, forest; U, urban; C, corn; H, hay.

Overall Accuracy

Classified Data

Reference Data

Class	URBAN	VEGETATION	
URBAN	10	10	20
VEGETATION	5	15	20
	15	25	40

Overall Accuracy

$$\text{Overall Accuracy} = \frac{10+15}{40} * 100$$

$$= \frac{25}{40} = 62$$

Classification of Errors

Omission Errors

Commission Errors

Omission Error:

Omission error is tell you how many pixels where not correctly identify

Classified Data

Reference Data

Class	URBAN	VEGETATION	
URBAN	10	10	20
VEGETATION	5	15	20
	15	25	40

Mis class pixels

Urban Misclass Pixels = $\frac{5}{15}$ **=33%**

- ✓ In hear 5 pixel in true data where actually in urban but in the classified data, it come under vegetation class.
- ✓ So these pixel are actually misclassified error.
- ✓ Hear true pixel urban is 15 and 5 where misclassified.
- ✓ So 5/15 is hear omission error.
- ✓ It is also give you producer accuracy, which is

1 - 5/15

Producer's Accuracy

- Producers Accuracy (Omission Errors)
  - Results from dividing the number of correctly classified pixels in each category (on the major diagonal) by the number of reference pixels "known" to be of that category (the column total)
  - This value represents how well reference pixels of the ground cover type are classified

Commission Error:

Reference Data

Classified Data

Class	URBAN	VEGETATION	
URBAN	10	10	20
VEGETATION	5	15	20
	15	25	40

Commission error $= \frac{10}{20} * 100$

$= 50\ \%$

✓ It is also give you User Accuracy, which is

1 - 10/20

User’s Accuracy

- Users Accuracy (Commission Error)
  - computed by dividing the number of correctly classified pixels in each category by the total number of pixels that were classified in that category (the row total)
  - Represents the probability that a pixel classified into a given category actually represents that category on the ground.

Error Matrix Table

Reference Data

Map Data	F	W	U	row total
F	28	14	15	57
W	1	15	5	21
U	1	1	20	22
column total	30	30	40	100

Land Cover Categories

F = Forest

W = Water

U = Urban

OVERALL ACCURACY = 63/100 = 63%

PRODUCER'S ACCURACY

F = 28/30 = 93%
W = 15/30 = 50%
U = 20/40 = 50%

USER'S ACCURACY

F = 28/57 = 49%
W = 15/21 = 71%
U = 20/22 = 91%

Overall Accuracy

Reference Data

Classified Data

	Water Body	Built Up Area	Vegetation	Total (User)
Water Body	6	1	0	7
Built Up Area	1	5	0	6
Vegetation	0	1	6	7
Total (Producer)	7	7	6	20

$$\text{Overall Accuracy} = \frac{Total\ Number\ of\ Correctly\ Classification\ Pixels\ (\ Diagonal)}{Total\ Number\ of\ Reference\ Pixel} \times 100$$

$$\text{Overall Accuracy} = \frac{17}{20} \times 100$$

= 85 %

Producer Accuracy

Reference Data

Classified Data

	Water Body	Built Up Area	Vegetation	Total (User)
Water Body	6	1	0	7
Built Up Area	1	5	0	6
Vegetation	0	1	6	7
Total (Producer)	7	7	6	20

$$\text{Producer Accuracy} = \frac{Total\ Number\ of\ Correctly\ Classification\ Pixels\ in\ Each\ Category}{Total\ Number\ of\ Refereance\ Pixel\ in\ that\ category\ (The\ Column\ Total)} \times 100$$

1. Waterbody $= \frac{6}{7} \times 100 =$ **86%**

2. Built Up Area $= \frac{5}{7} \times 100 =$ **71%**

3. Vegetation $= \frac{6}{6} \times 100 =$ **100%**

User Accuracy

Reference Data

Classified Data

	Water Body	Built Up Area	Vegetation	Total (User)
Water Body	6	1	0	7
Built Up Area	1	5	0	6
Vegetation	0	1	6	7
Total (Producer)	7	7	6	20

$$\text{Users Accuracy} = \frac{Total\ Number\ of\ Correctly\ Classification\ Pixels\ in\ Each\ Category}{Total\ Number\ of\ Refereance\ Pixel\ in\ that\ category\ (The\ Row\ Total)} \times 100$$

1. Waterbody $= \frac{6}{7} \times 100 = \mathbf{86\%}$

2. Built Up Area $= \frac{5}{6} \times 100 = \mathbf{83\%}$

3. Vegetation $= \frac{6}{7} \times 100 = \mathbf{86\%}$

Kappa Coefficient

Reference Data

Classified Data

	Water Body	Built Up Area	Vegetation	Total (User)
Water Body	6	1	0	7
Built Up Area	1	5	0	6
Vegetation	0	1	6	7
Total (Producer)	7	7	6	20

$$\text{Kappa Coefficient (T)} = \frac{(TS \times TCS) - \sum(Column\ Total \times Row\ Total)}{TS^2 - \sum(Column\ Total \times Row\ Total)} \times 100$$

Where, TS = Total Number of Sample

TCS = Total Corrected Sample (Diagonal Values)

$$\text{Kappa Coefficient (T)} = \frac{(20 \times 17) - \{(7 \times 7)+(6 \times 7)+(7 \times 6)\}}{400 - \{(7 \times 7)+(6 \times 7)+(7 \times 6)\}} \times 100$$

=78%

Kappa Coefficient, K

Kappa Estimation

THIS CAN BE DONE BY CALCULATION OF THE COEFFICIENT OF AGREEMENT, KAPPA (κ)

$$-1 \leq \kappa \leq 1$$

- -1 = NO AGREEMENT
- 0 = RANDOM AGREEMENT
- 1 = PERFECT AGREEMENT

KAPPA CAN BE ESTIMATED ACCORDING TO

$$\hat{\kappa} = \frac{Nd - q}{N^2 - q}$$

WHERE

- N = TOTAL NUMBER OF POINTS
- d = SUM OF CORRECTLY MAPPED POINTS
- q = SUM OF THE PRODUCTS BETWEEN B AND C FOR EACH CLASS

$$\hat{k} = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \cdot x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \cdot x_{+i})}$$

Reference Data

Classified Data

	Water Body	Built Up Area	Vegetation	Total (User)
Water Body	6	1	0	7
Built Up Area	1	5	0	6
Vegetation	0	1	6	7
Total (Producer)	7	7	6	20

Classified data		Reference data					
		Residential	Commercial	Waterlogged	Vegetation	Water	Row Total
	Residential	70	5	0	13	0	88
	Commercial	3	55	0	0	0	58
	Waterlogged	0	0	99	0	0	99
	Vegetation	0	0	4	37		41
	Water	0	0	0	0	121	121
	Column Total	73	60	103	50	121	407

Kappa Coefficient, K

$$\hat{k} = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \cdot x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \cdot x_{+i})}$$

Limitation of Accuracy Assessment

Limitation of Accuracy Assessment

- ✓ Proper Sample Design
- ✓ Source data and Reference data Timing should be same.
- ✓ Proper Geo Rectification
- ✓ Error free GPS Location
- ✓ Reference data resolution should not be finer in compare to Classify data resolution
- ✓ Proper identification of Boundary Edge of two or more classes.

Accuracy assessment "best practices"

- ✓ 30-50 reference points per class is ideal
- ✓ Reference points should be derived from imagery or data acquired at or near the same time as the classified image
- ✓ If no other option is available, use the original image to visually evaluate the reference points (effective for generalized classification schemes)