

UNIVERSITY OF TWENTE.



Training Course
Remote Sensing – Basic Theory & Image Processing Methods
19 – 23 September 2011

Remote Sensing Platforms

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FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION





Course: Remote Sensing – Basic Theory & Image Processing Methods - 19 - 23 September 2011

Caucasus Environmental NGO Network



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Overview

- Introduction Digital Image Classification
- Image and feature space
- Image classification process - 5 steps
 - Supervised versus unsupervised
 - Object oriented analysis
- Questions



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Digital Image classification

The operator instructs the computer to perform an “interpretation” according to certain conditions.

Digital image classification is based on the different spectral characteristics of the Earth’s surface:

- Plants - crops
- Soil
- Rocks
- Human elements
 - (roads, houses etc.)
- Water – suspended materials

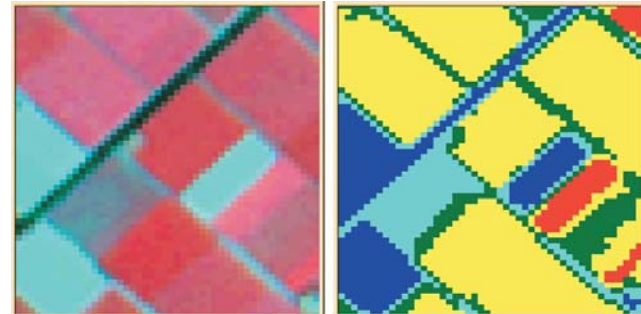


Image & feature space

Image space: Spatial arrangement in the image of the measurements of the EM spectrum

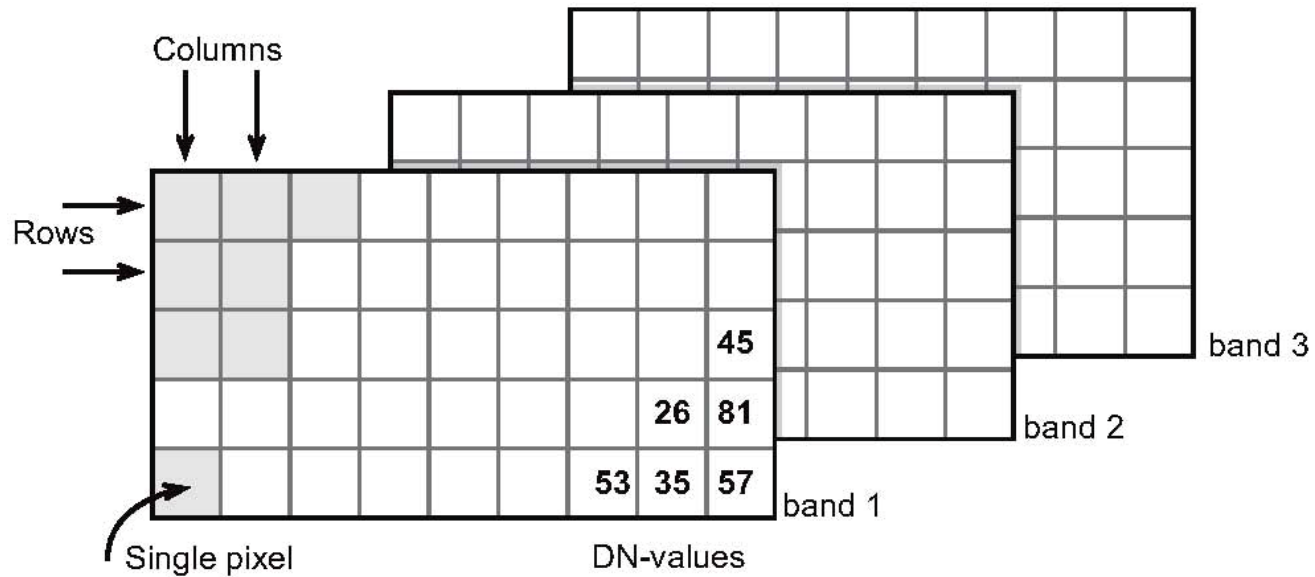


Image & feature space

Scatterplot of two bands of a digital image.

Intensity at a point related
to the number of cells at
that point.

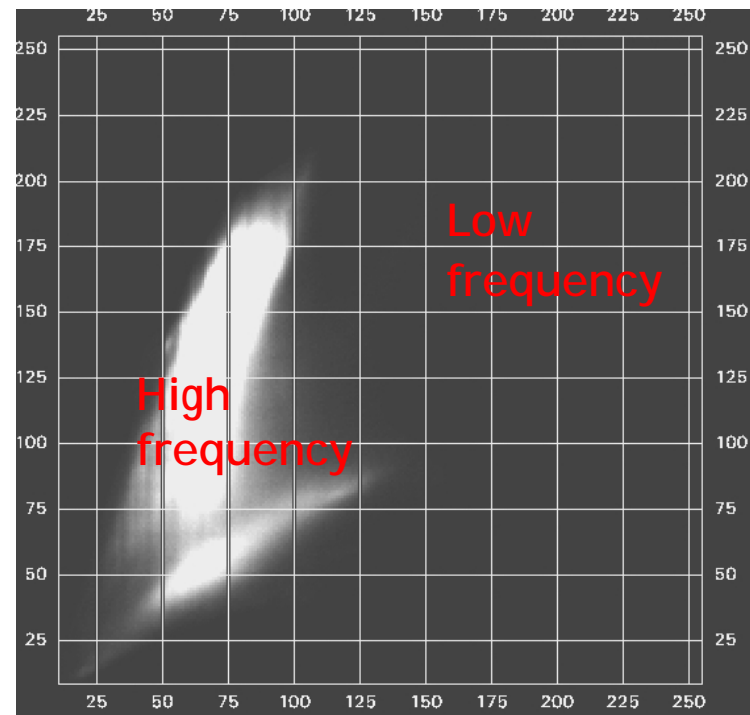
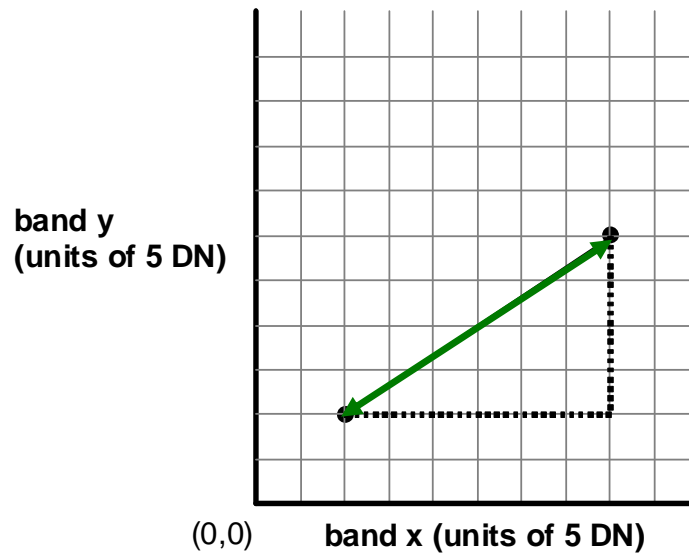


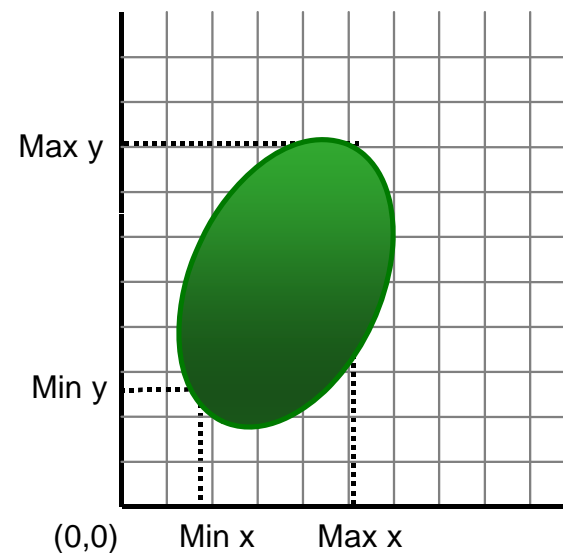


Image & feature space

Distances and clusters in feature space.



Euclidian distance



Cluster



Image & feature space

Euclidian Distance in feature space calculated by
Pythagoras - values in DN

(Euclidian) Distance between
(10,10) and (40,30) is the
square root of:
 $(40 - 10)^2 + (30 - 10)^2$

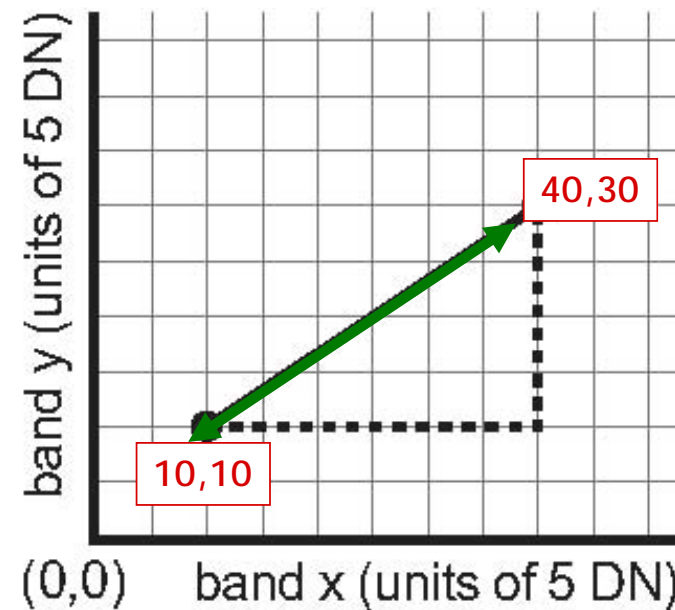


Image & feature space

Feature space: Graph showing the DN values of the *feature vectors*

(DN values per band of a certain pixel)

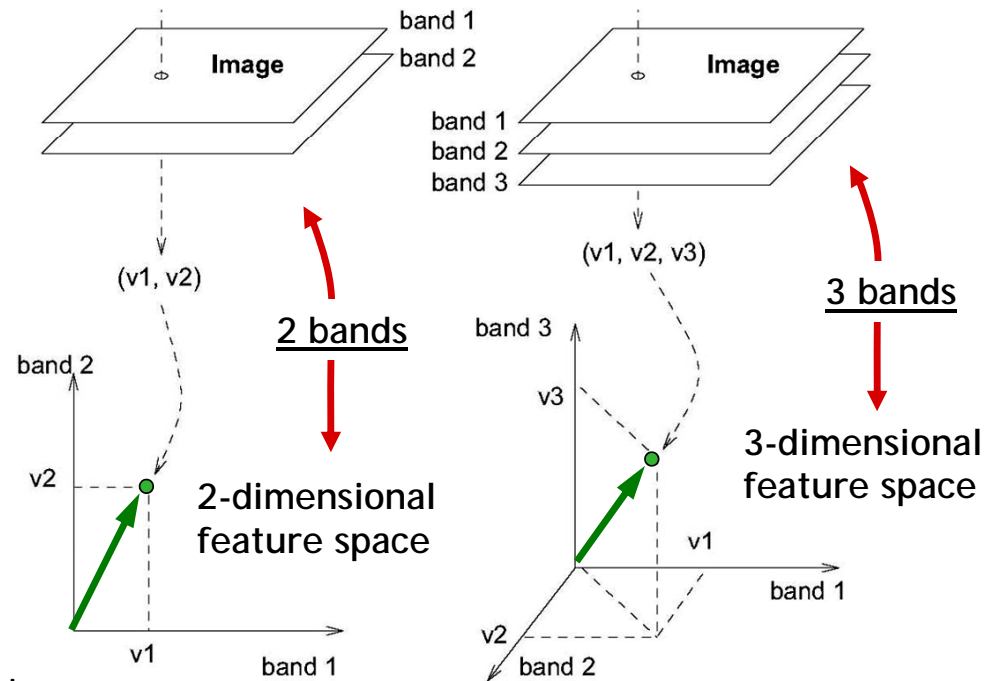




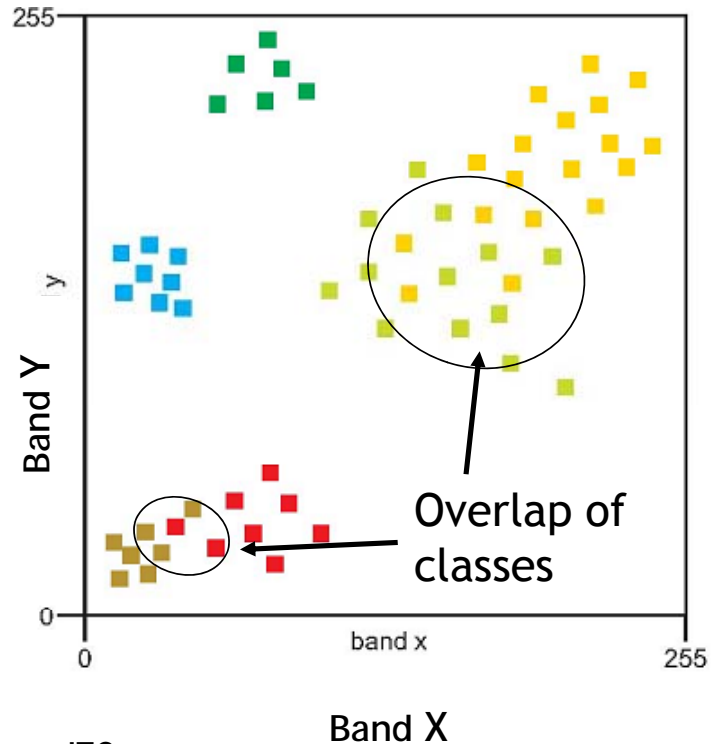
Image & feature space

Clustering of classes in a feature space – result of *training* process

Example:

six classes:

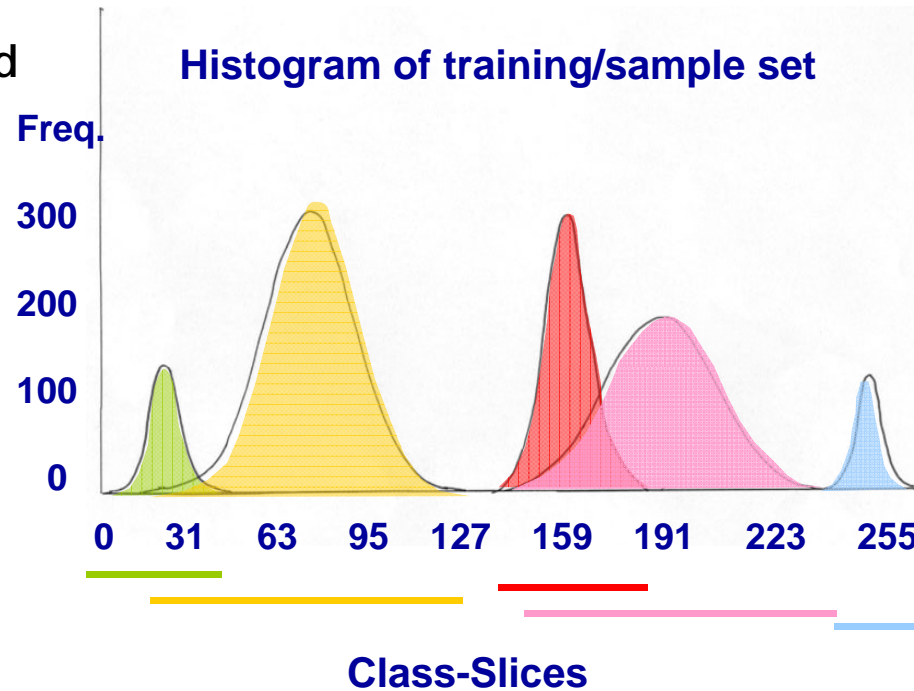
- grass
- water
- trees
- houses
- bare soil
- wheat



Training process

Example: one band

Ground-truth



Samples set of classes



Bakx

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Image classification process (1)

Five steps:

- A.** Selection and preparation of the RS image data
- B.** Definition of clusters in the feature space
- C.** Selection of the classification algorithm
- D.** Running of the actual classification
- E.** Validation of the result

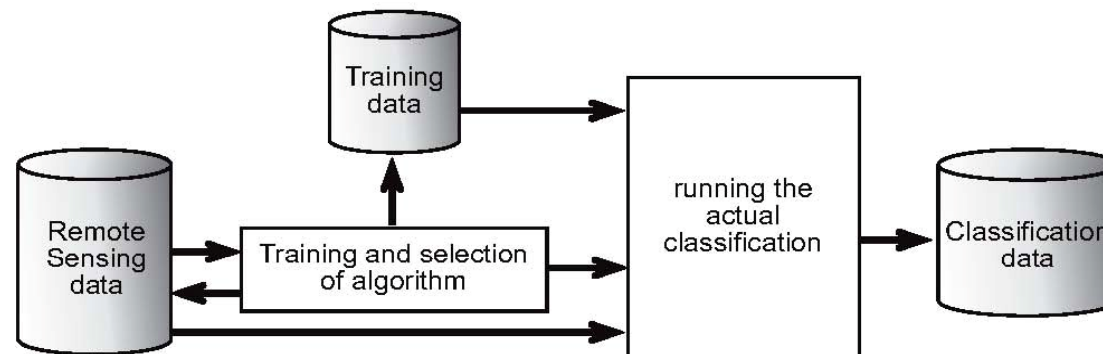
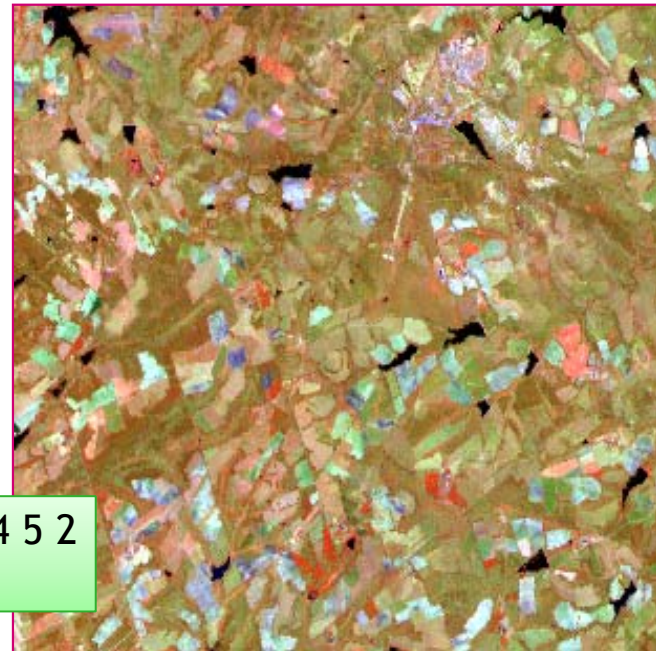


Image classification process (2)

A. Selection and preparation of the image data

Depending on:

- *Cover types* to be classified
- Selection of most appropriate
 - sensor (spatial & spectral res.)
- Best date(s) of acquisition
 - (season !)
- Band combination / correlation



Landsat TM - R G B : 4 5 2
Karoi, Zimbabwe

Image classification process (3)

B. Definition of clusters in the feature space

Supervised classification:

Operator defines clusters during training process.
Knowledge of the area needed.

Collection of sample sets during *Fieldwork* !!

Unsupervised classification:

Clustering being **done by computer** based on for instance:

- Number of user defines clusters, etc.
- '*minimum distance to cluster centroid*' decision rule



Image classification process (4)

B. Definition of clusters in the feature space

Unsupervised classification

Clustering being done by computer, based on for instance:

- Number of user defined clusters, threshold, cluster distance etc.
- *'minimum distance to cluster centroid'* decision rule

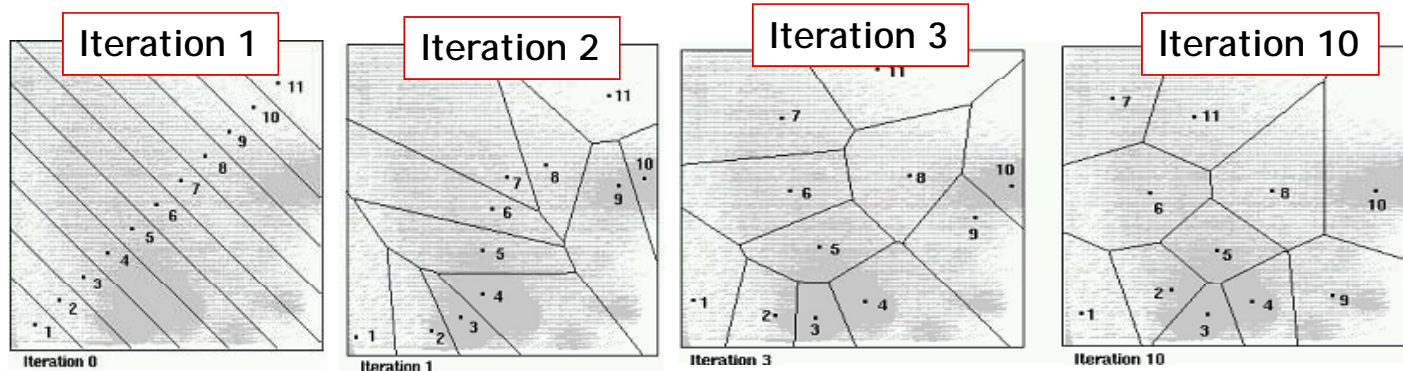
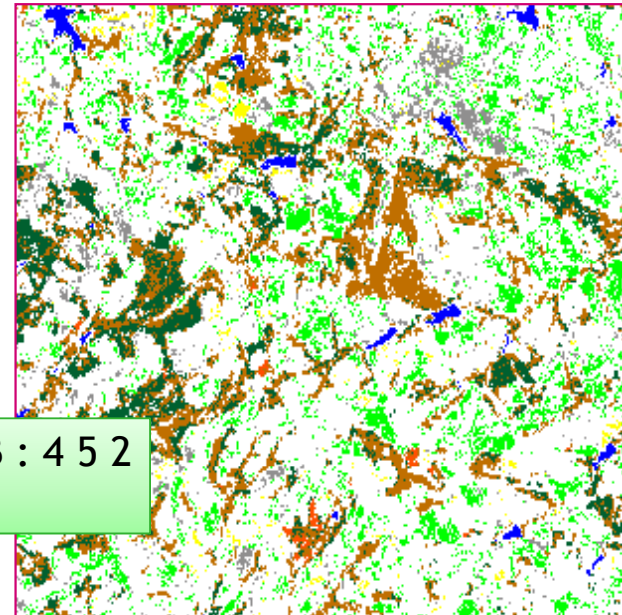


Image classification process (5)

C. Selection of the classification algorithm ...1

Types of algorithms:

- ***Box classifier*** (very simple)
- ***Minimum Distance to Mean***
- ***Maximum Likelihood***



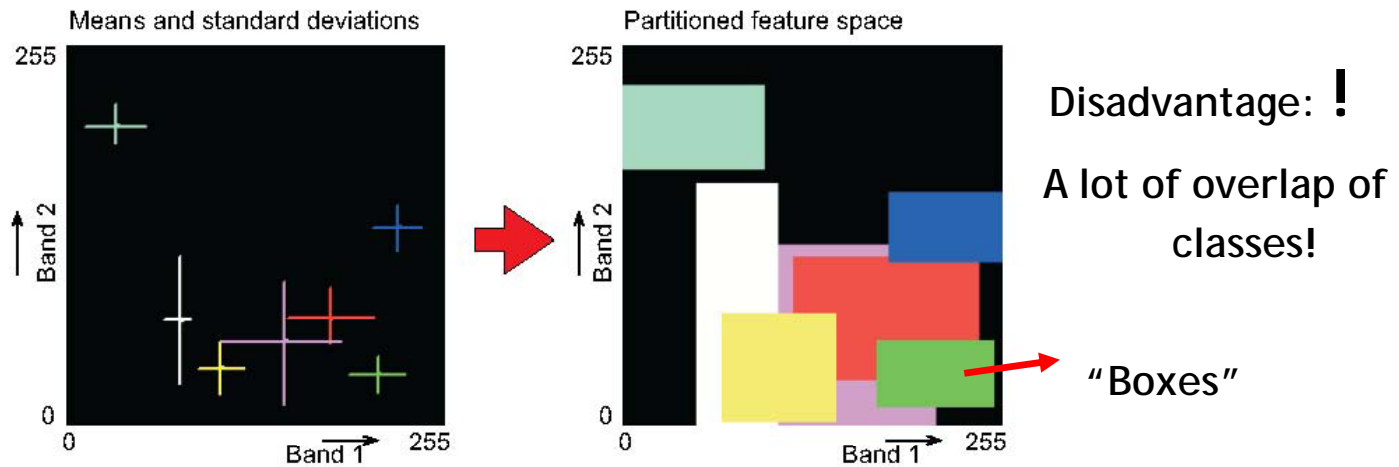
Landsat TM - R G B : 4 5 2
Karoi, Zimbabwe

Image classification process (6)

C. Selection of the classification algorithm ...2

Box classifier (or parallelepiped classification)

Only upper and lower class limits defined.



Disadvantage: !
 A lot of overlap of classes!

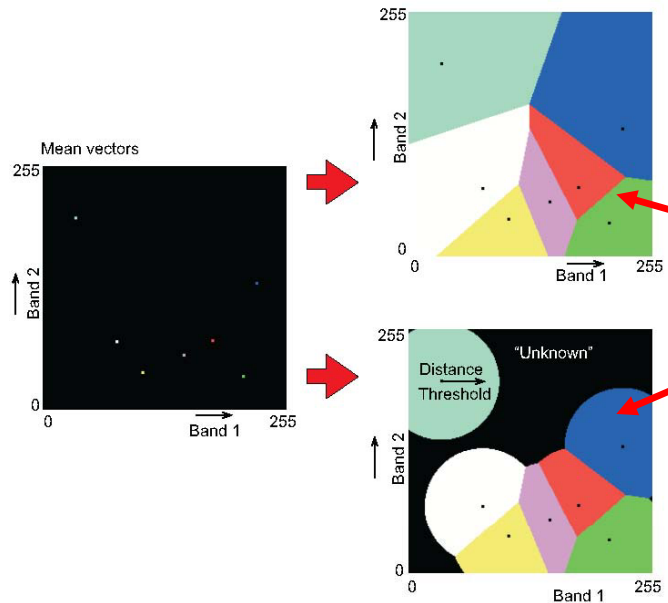
"Boxes"

Feature space partitioning — Box classifier

Image classification process (7)

C. Selection of the classification algorithm ...3

Minimum Distance to Mean classifier (MDM)



Euclidian distances from pixels to cluster centres calculated

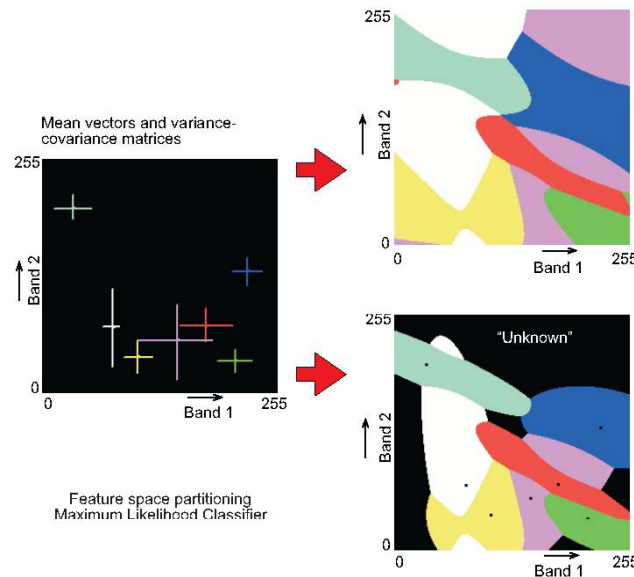
Disadvantage: Pixels at large distance from cluster centre wrongly classified.

Solution: definition of threshold distance (circle)

Image classification process (8)

C. Selection of the classification algorithm ...4

Maximum Likelihood classifier (ML)



Considers not only the centre, but also shape, size and orientation of the clusters.

Calculation of statistical distance based on the mean values and covariance matrix of the clusters.

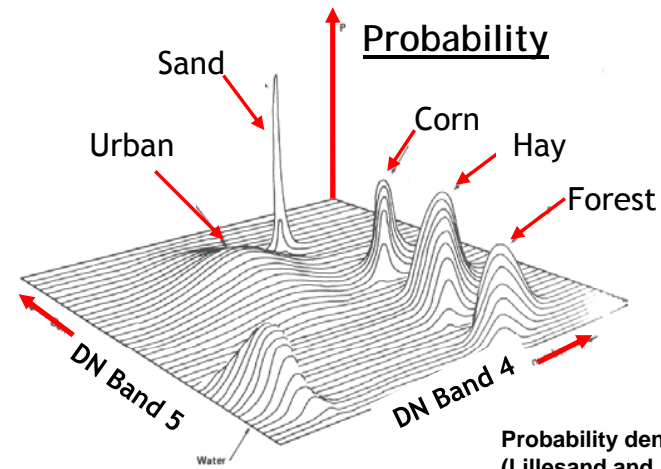
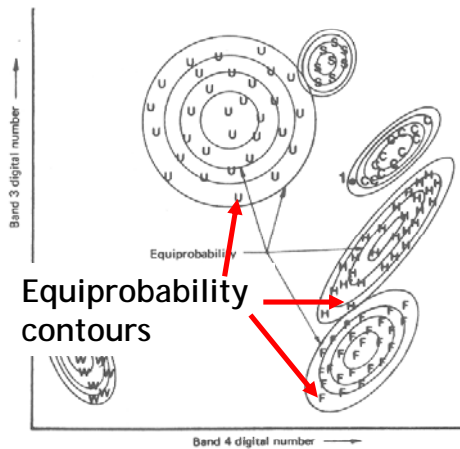
Statistical distance is probability value (equiprobability contours).

Image classification process (9)

C. Selection of the classification algorithm ...5

Maximum Likelihood classifier (ML)

Statistical distance based on equiprobability contours.



Probability density functions (Lillesand and Kiefer, 1987)

Image classification process (10)

C. Selection of the classification algorithm ...6

Maximum Likelihood classifier (ML)

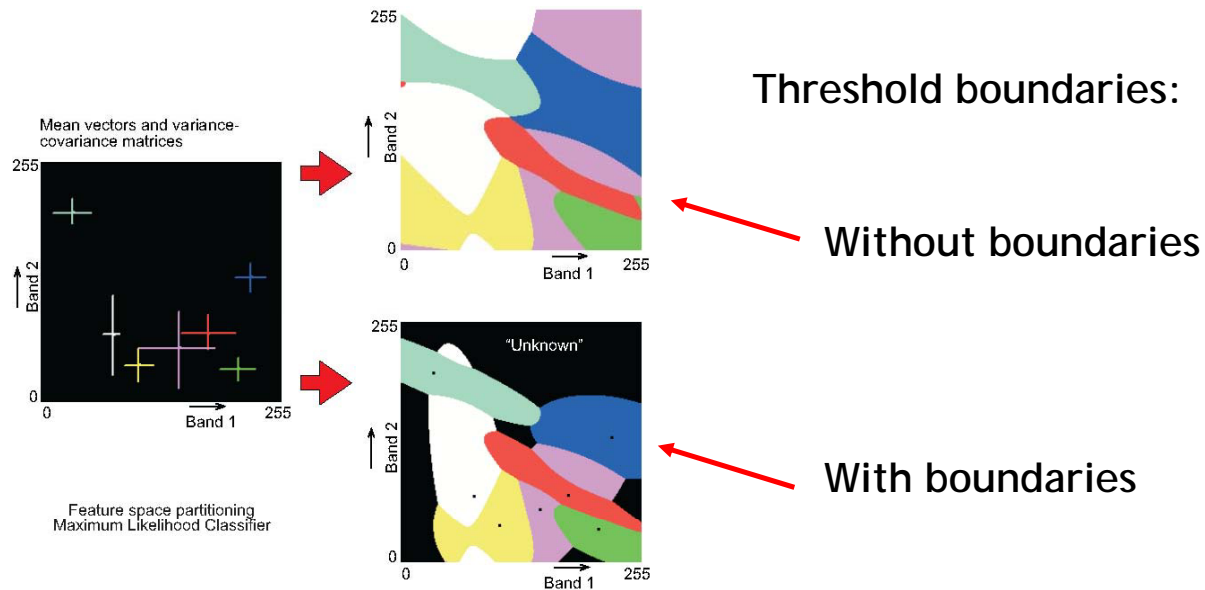


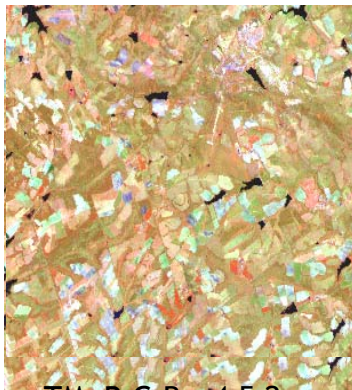


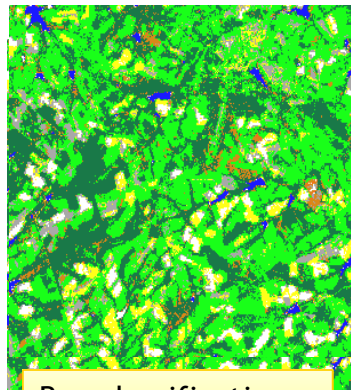
Image classification process (11)

D. Running of actual classification

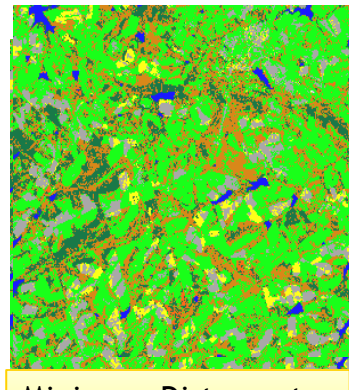
-  agriculture
-  eucalyptus
-  forest
-  grassland
-  marshland
-  settlement
-  water



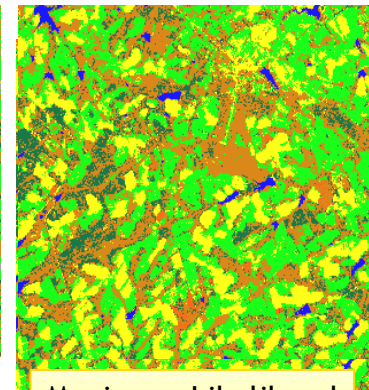
TM R G B : 4 5 2
Karoi, Zimbabwe



Box classification
Factor = 10



Minimum Distance to
Mean Threshold = 100



Maximum Likelihood
Threshold = 100

Image classification process (12)

E. Validation of the result ...1

- **Image classification should be checked and quantified afterwards**
- **Comparison of classification result with enough real world (field) samples:**
 - Random sampling
 - Stratified random sampling





Image classification process (13)

E. Validation of the result ...2

- Creation of error matrix (confusion matrix)
 - Overall accuracy: Proportion Correctly Classified (PCC)
 - Error of Commission: Incorrectly classified samples
 - Error of Omission: Sample points omitted in interpretation

| | | Reference classes | | | | Total | Error of Commission (%) | User Accuracy (%) |
|-------------------|----------------------------------|-------------------|----|----|----|-------|-------------------------|-------------------|
| | | A | B | C | D | | | |
| a | Classes in classification result | 35 | 14 | 11 | 1 | 61 | 43 | 57 |
| b | | 4 | 11 | 3 | 0 | 18 | 39 | 61 |
| c | | 12 | 9 | 38 | 4 | 63 | 40 | 60 |
| d | | 2 | 5 | 12 | 2 | 21 | 90 | 10 |
| Total | | 53 | 39 | 64 | 7 | 163 | | |
| Error of Omission | | 34 | 72 | 41 | 71 | | | |
| Producer Accuracy | | 66 | 28 | 59 | 29 | | | |



Image classification process (14)

E. Validation of the result ...3

- Creation of error matrix (confusion matrix)

Omitted
18 classes
of total 53

| | A | B | C | D | Total | Error of Com- mission (%) | User Accuracy (%) |
|-------------------|-------------------|----|----|----|-------|------------------------------|----------------------|
| | Reference classes | | | | | | |
| a | 35 | 14 | 11 | 1 | 61 | 43 | 57 |
| b | 4 | 11 | 3 | 0 | 18 | 39 | 61 |
| c | 12 | 9 | 38 | 4 | 63 | 40 | 60 |
| d | 2 | 5 | 12 | 2 | 21 | 90 | 10 |
| Total | 53 | 39 | 64 | 7 | 163 | | |
| Error of Omission | 34 | 72 | 41 | 71 | | | |
| Producer Accuracy | 66 | 28 | 59 | 29 | | | |

Class A : 53 samples in "real world" but 61 cases in classification
 in 35 classes agreement between classification and "real world"

Error or Omission: $53 - 35 = 18 / 53 * 100 = 34 \%$

Producer accuracy: $35 / 53 * 100 = 66\%$

Image classification process (15)

E. Validation of the result ...4

- Creation of error matrix (confusion matrix)

Incorrectly
Classified:
26 of refer.
classes

| | A | B | C | D | Total | Error of Com- mission (%) | User Accuracy (%) |
|-------------------|-------------------|----|----|----|-------|------------------------------|-------------------|
| | Reference classes | | | | | | |
| a | 35 | 14 | 11 | 1 | 61 | 43 | 57 |
| b | 4 | 11 | 3 | 0 | 18 | 39 | 61 |
| c | 12 | 9 | 38 | 4 | 63 | 40 | 60 |
| d | 2 | 5 | 12 | 2 | 21 | 90 | 10 |
| Total | 53 | 39 | 64 | 7 | 163 | | |
| Error of Omission | 34 | 72 | 41 | 71 | | | |
| Producer Accuracy | 66 | 28 | 59 | 29 | | | |

Class A : Error of commission : $61 - 35 = 26 / 61 * 100 = 43 \%$

User Accuracy : $35 / 61 * 100 = 57 \%$

Image classification process (16)

Some problems in image classification

1. Spectral classes basically land cover classes (except in arid areas)
2. Differences in time (season !!) between image acquisition and field data collection
3. Shadows
4. Mixed pixels (*mixels*)

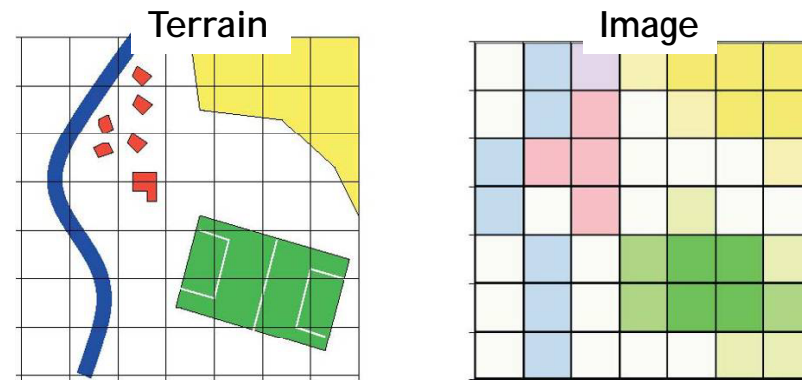




Image classification process (17)

Linking spectral classes with

- a. land cover &
- b. land use classes



| <i>Spectral Class</i> | <i>Land Cover Class</i> | <i>Land Use Class</i> |
|-----------------------|-------------------------|-----------------------|
| <i>water</i> | water | shrimp cultivation |
| <i>grass1</i> | grass | nature reserve |
| <i>grass2</i> | grass | nature reserve |
| <i>grass3</i> | grass | nature reserve |
| <i>bare soil</i> | bare soil | nature reserve |
| <i>trees1</i> | forest | nature reserve |
| <i>trees2</i> | forest | production forest |
| <i>trees3</i> | forest | city park |

DEM or other additional data can improve classification



Image classification process (12)

Linking spectral classes with

- a. land cover &
- b. land use classes

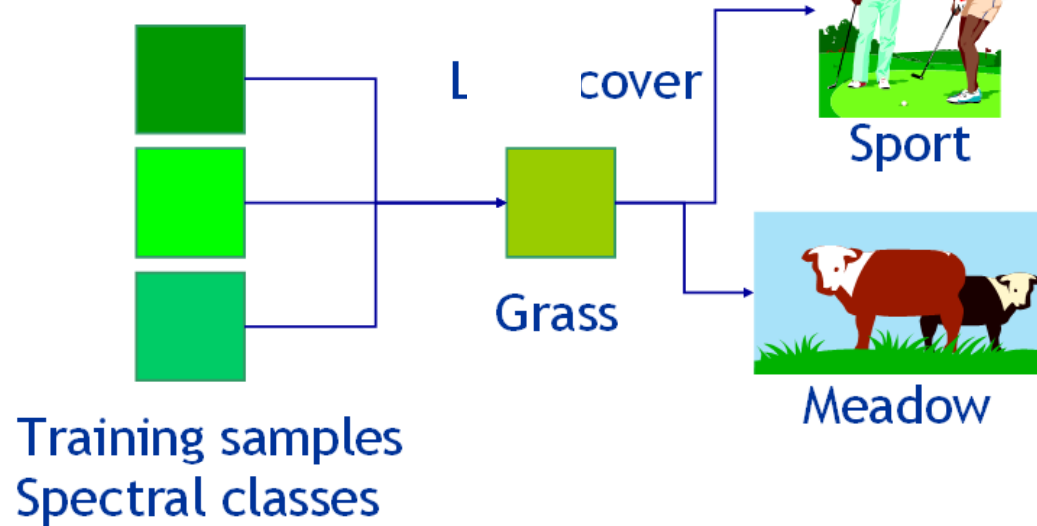


Image classification process

Object-oriented analysis (OAA)

- Object-oriented analysis also called segmentation-based analysis
- OAA breaks down an image into spectrally homogenous segments that correspond to fields, tree stands, buildings etc.
- Also based on footprints from GIS layers – object texture



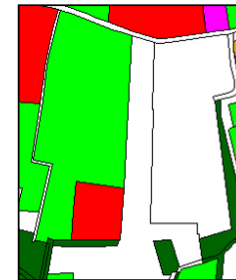
Image



Vector reference



Pixel based
classification



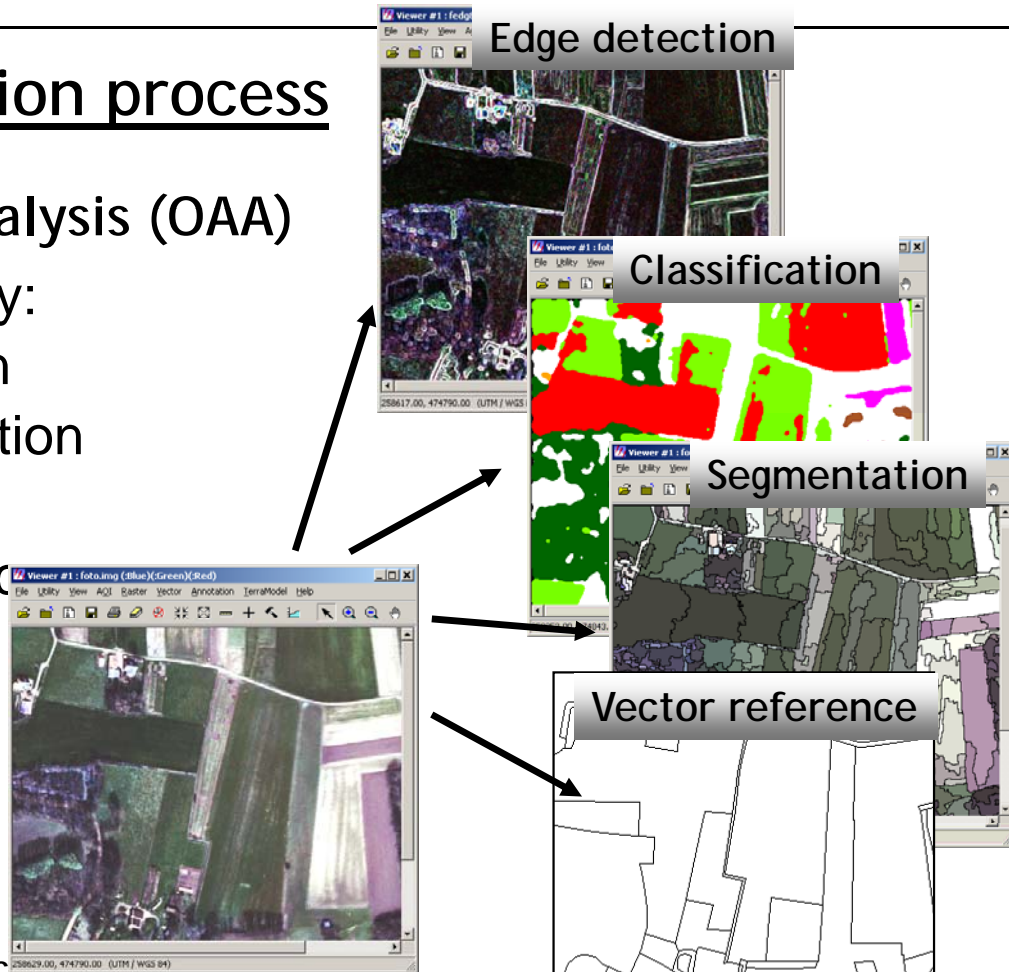
Result

Image classification process

Object-oriented analysis (OAA)

Obtain objects by:

- Edge detection
- Post-classification
- Segmentation
- Vector reference





Summary

- Digital image classification based on different characteristics of the earth surface
- *Image and feature space* being used for the classification
- Image classification process based on:
 - Selection and preparation of the image data
 - Definition of clusters in the feature space
 - Selection of the classification algorithm
 - Running of the actual classification
 - Validation of the result
- Problems may be caused by
 - Differences in time (season !!) between image acquisition and field data collection - Mixed pixels (*mixels*)
- OAA





Questions

