Practicals on Land Use/Cover & Change Detection

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Exercise

Land cover mapping with very high spatial resolution data using a multi-stage classification approach

Exercise rational

In land cover map nomenclatures, classes usually define landscape units (e.g. Forest, Agriculture, Urban areas – see Fig 1). Nevertheless, the pixel of an IKONOS image, due to its small size (PAN: 1 m; MS: 4 m), does not represent landscape units. On the contrary, it identifies components of those units, which can be designated by surface elements (e.g. water, non-vegetated area, eucalyptus tree crown, cork tree crow, shadow – see Fig 2). Due to this constraint, development of land cover maps (landscape units maps) with these images cannot make use of simple per-pixel classifications.

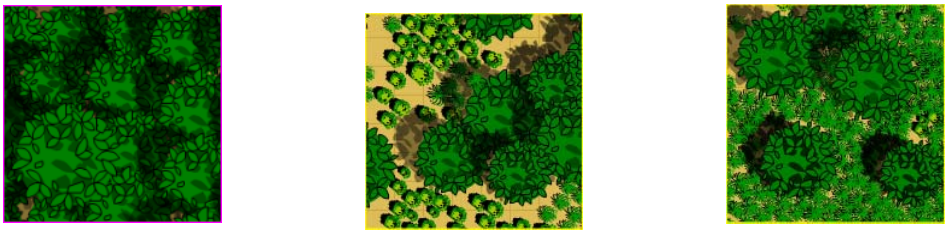


Fig 1. Landscape units representing forest areas.

Fig 2. IKONOS pixels representing surface elements: a) tree crown; b) shadow; c) herbaceous; d) bare soil.

In this exercise we apply a methodology developed in the Remote Sensing Unit of the Portuguese Geographic Institute (IGP) to produce a Landscape Units Map (LUP) with an IKONOS image. In brief, the methodology (Fig 3) consists in image classification at the pixel level, producing a Surface Elements Map (SEM). The IKONOS image is also segmented to derive a Map of Objects (MO), i.e. landscape units. Then the MO is overlaid on the SEM. A set of rules is then created to assign a landscape unit to each object. These rules take into account the abundance and spatial arrangement of the classified pixels inside each object. In the last step the set of rules are applied to the product SEM+Objects in order to derive the final mapping product, i.e. the LUM.

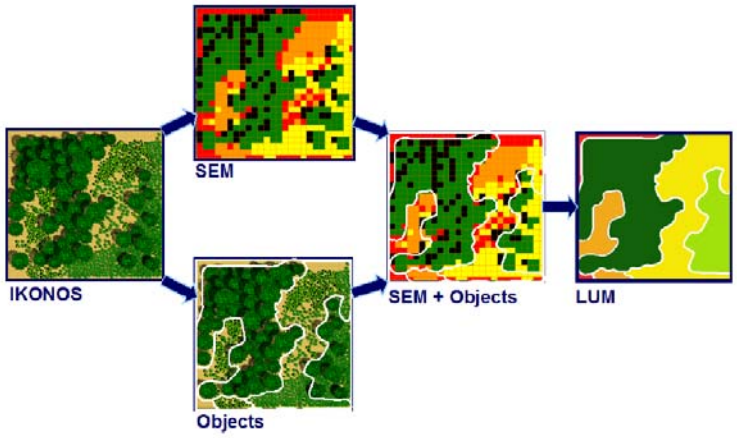


Fig 3. Methodological approach.

In the particular case of this exercise, the surface elements to be considered in the SEM are described in Table 1.

Table 1. SEM nomenclature

Code	Class name
1	Deep water
2	Shallow water
3	Bare soil
4	Eucalyptus crown
5	Shadow
6	Herbaceous vegetation
7	Cork tree crown
8	Pine tree crown
9	Sparse herbaceous vegetation

The land cover classes of the LUM are described in Table 2.

Table 2. LUM nomenclature

Code	Class name	Description
1	Urban / Bare soil	Areas with < 10% trees and with > 70% of bare soil
2	Sparse vegetation	Areas with < 10% trees and with 30% - 70% of bare soil
3	Cropland	Areas with < 10% trees and with > 70% of herbaceous vegetation
4	Other natural vegetation	Areas with < 10% trees and that are not Urban / Bare soil, Sparse vegetation and Cropland
5	Broadleaf forest	Areas with >30% trees in which >70% are of the broadleaf type
6	Needleaf forest	Areas with >30% trees in which >70% are of the needleleaf type
7	Mixed forest	Areas with >30% trees in which both broadleaf and needleleaf types are between 30% - 70%
8	Agro-forestry	Areas with 10% - 30% trees and with > 50% of herbaceous vegetation
9	Transitional-woodland forest	Areas with 10% - 30% trees and with < 50% of herbaceous vegetation
10	Water	Areas that are in their major part constituted by water

If you are not familiar with ArcGIS and/or image processing tools within ArcGIS please consult the tutorials we prepared for you during the resolution of the exercise:

Tutorial on Basics for image visualization and processing (Tutorial-for-image-processing-in-ArcGIS.doc)

Tutorial on supervised classification within ArcGIS (Tutorial-on-supervised-classification-in-ArcGIS.doc).

All the results produced in the exercise must be saved in the following directory:

C:\....\LCLU\Ex1\Results

Exercise data

Working directory:	C:\....\LCLU\Ex1
Input data:	C:\....\LCLU\Ex1\Data
Auxillary data:	C:\....\LCLU\Auxillary_data
Output data:	C:\....\LCLU\Ex1\Results
Project name:	Exercise1.mxd

Input data in Exercise1

	Description	Data format	MMU / Resolution	Date	Comments
Pt03	Stack of ortho-rectified IKONOS multi-spectral bands	Raster	4 m	06/04/2004	Band1 – blue Band2 – green Band3 – red Band4 – InfraRed
Pt03Pan	Stack of ortho-rectified IKONOS Pan-sharp bands	Raster	1 m	06/04/2004	Band1 – blue Band2 – green Band3 – red Band4 – InfraRed
CAOPv3	Portuguese official administrative limits	Shapefile (polygon)	-	2004	-
CLC2000	CORINE Land cover map for 2000	Shapefile (polygon)	25 ha	2000	CLC2000 (44 classes at level 3) - see CLC2000_nom.xls for nomenclature description
Quicklooks of aerial images	Quicklooks of aerial images. RGB with true and false color composites	Raster	50 cm	2004/2005/2006	There are quick-looks available for specific locations
Objects	Map of objects derived from Pt03 image segmentation	Shapefile (polygon	-	-	-
Objects	Map of objects derived from Pt03 image segmentation	Raster	4 m	-	-
Samples	Training samples for supervised image classification to derive the SEM (to be completed by the student)	Shapefile (polygon)	4 m	2004	9 types of surface elements
Samples_final	Training samples for supervised image classification to derive the SEM (complete file)	Shapefile (polygon)	4 m	2004	9 types of surface elements
Rules	Text file containing a set of rules to derive the LUM	Text file (*.aml)	-	-	

Starting the exercise

Open the ArcGIS – ArcMap module  . Once you do that, open the project Exercise1.mxd. In this project all data layers are already loaded by the correct order to do this exercise.

1.1. Production of the Surface Elements Map

Input data: Pt03 image (Esri grid)

Training Samples data: samples.shp

Method: supervised classification using maximum likelihood algorithm

1.1.1. Training stage

The main goal here is to collect the samples that will be used to train the classification algorithm. A sample (i.e. training area) can be a single pixel or a set of contiguous pixels.

What type of sample (i.e. a single pixel or a set of contiguous pixels) do you think it is more appropriated here? Why?

_____
_____
_____
_____
_____

For sample selection it is more appropriate to use the IKONOS PAN-sharp image. We also propose to use aerial images with 4 channels and 50 cm spatial resolution.

We already collected almost all samples for this exercise. However, we want you to get acquainted with sample selection in IKONOS imagery. The samples are in the file samples.shp. Activate ☑ samples and image layers and browse through some samples in order to have a feeling of the reflectance of each type of surface element.

In your opinion what can be the main reason for defining 2 different water classes (deep and shallow water)?

_____
_____
_____
_____
_____

The urban and bare ground were grouped in the same class? Why?

_____
_____
_____
_____
_____

Please, look for 8 missing labels in the samples file attribute table (coded as 999) and complete them (see the "Specific sample visualization" section of the Tutorial-on-supervised-classification-in-ArcGIS.doc). To do so, visualise these samples and use the Pt03Pan image and the available quick-looks of aerial images of 50cm resolution (click on the samples with the hyperlink tool ) and assign a surface element to each sample.

Compare now the samples.shp you just completed with our final selection of samples (samples_final.shp). Please complete the column "Surface element – Your decision" in the following table.

Sample ID (ID)	Surface element – your decision	Surface element – our decision
12		
13		
104		
151		
254		
614		
630		
713		

What are the most difficult surface elements to identify in the data sources we made available to you? How could you reduce the uncertainty in sample labelling?

_____
_____
_____
_____

1.1.2. Image classification

Classify the Pt03 image using the maximum likelihood algorithm. For the algorithm training use the samples_final.shp file. If you do not know how to classify images in ArcGIS please consult sections 4 and 7 of the Tutorial-on-supervised-classification-in-ArcGIS.doc.

Note that the output signatures file should be named as "sigSEM".

Note that the output land cover classification must be named as "SEM".

1.2. Production of the Landscape Units Map

Input data: SEM and objects

Method: develop and apply a set of rules to assign a landscape unit to each object.

1.2.1. Overlap the Objects Map on your classified image.

Activate ☑ the Object Map layer and the IKONOS image layer.

Do you think the objects capture well the landscape units in this study area? If not, explain how you could improve the Map of Objects?

_____
_____
_____
_____

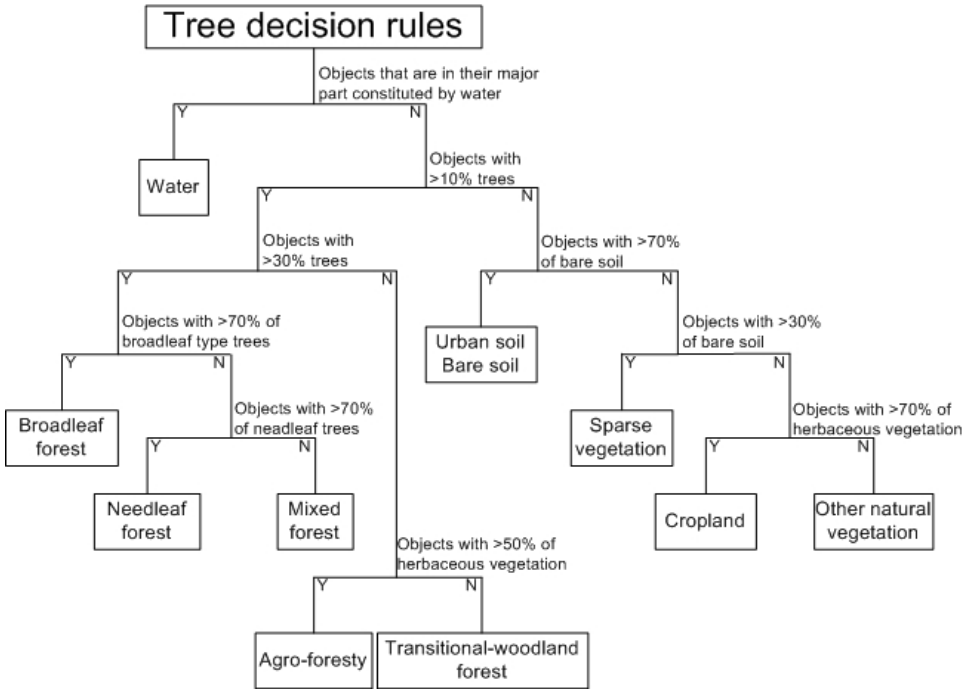
What are the landscape classes that most benefit from the approach defined in this exercise, i.e. a combination of a pixel based classification with an object-oriented classification?

_____
_____
_____
_____

1.2.2. Develop a rational for assigning a landscape unit to each object

This is a very important step of the methodology we are applying here to derive a map of landscape units. Here, you have to define the rules that assign a class of the nomenclature to each object. These rules are then implemented in an AML file, which will be run in order to produce the Map of Landscape Units.

For the definition of rules we can define a decision tree, where the inputs are the abundance of the surface elements within each object and the output are the classes of the Map of Landscape Units (MLU).



1.2.3. Implementing the rules in an AML file

To apply the rules to the SEM you have to generate an AML file, which has its own syntax. The AML to this exercise is the Rules.aml. Please consult the file that is in c:\....\LCLU\Ex1\results

To illustrate the AML syntax, let´s translate the rationale to identify a coniferous forest into AML syntax.

Coniferous forest: The trees proportion in an object must be greater than 30%, and the coniferous type proportion of those trees must be greater than 70%

In AML the above expression would be written as follows:

```
if ((sum(coniferous_proportion, broadleaf_proportion) > 30) and
((coniferous_proportion / broadleaf_proportion) * 100 >= 70))
Coniferous_forest = 1
else Coniferous_forest = 0
endif
```

1.2.4. Run the AML

Run the AML to your classified image at the pixel level (SEM) in order to create the Landscape Units Map (LUM).

To do so you must start the Arc module of ArcInfo workstation. Then apply the following expressions

```
Arc > &workspace c:\<workspace path> ex: &workspace
c:\....\lclu\Ex1\results
Arc > &r <name of aml file> ex: &r rules
```

Write “quit” until exit

A raster file named “LUM” was created in c:\....\LCLU\Ex1\results as a result of the above procedure.

1.3. Qualitative Evaluation of the Landscape Units Map

In the ArcGIS project exercise1.mxd, import the created LUM raster file and compare it visually with the input and pan-sharp image (use the available bookmarks in order to focus your analysis on specific predefined areas – see section 4 of the Tutorial-for-image-processing-in-ArcGIS.doc). Then, answer the following questions:

Bookmark 1: Is this object correctly classified in the LUM? If not, explain why?

_____
_____
_____

Bookmark 2: What is the problem in the central object of the area covered by this bookmark? Justify.

_____
_____
_____

Bookmark 3: Is this object correctly classified in the LUM? If not, explain why?

_____
_____
_____

Bookmark 4: Is this object correctly classified in the LUM? If not, explain why?

_____
_____
_____

The Landscape Unit Map has some errors. What are the most important ones?

_____
_____
_____
_____
_____

How cold you improve the quality of the Map of Landscape Units (MLU)

_____
_____
_____
_____
_____