SFU SIMON FRASER UNIVERSITY
THINKING OF THE WORLD

Course: Introduction to Remote Sensing
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Instructor: Anders Knudby, aknudby@sfu.ca
TA: Marco Jorge, mjorge@sfu.ca

Lab 6

Goal 1: Learn how to do Supervised Classification in ENVI

Goal 2: Experience how careful (or careless) selection of training areas influences the product

Terminology:

Regions of Interest (ROI): Regions of Interest is ENVI's term for polygons that you can draw on an image, and use for a variety of purposes. In this lab we will use ROIs as training sites for our classification.

Training sites: Training sites are areas that are outline using ROIs, and are used to calculate statistics that describe the properties of a class. Because ENVI uses ROIs to outline training sites, the two terms can often be used interchangeably (although ROI can also be used for other things than training sites!).

Classes: Classes (in this context) are categorical units that individual pixels are assigned to by a classifier, on the basis of the pixels' band values. Classes typically represent surface types, like "water", "forest", "desert" etc.

Important note: Next time we will look at how to assess the accuracy of classifications. It is therefore important that you save the work you have done in this lab, so you can work on it again in the next lab! Before you leave the lab, make sure you have the original data, your ROIs, your classification results and all other files saved in a place where you can access them again.

1) For this lab we will use the Landsat ETM+ data from Jasper Ridge Biological Preserve in California. Open the data set as a "Fast" file, (File – Open As – Landsat – Fast), selecting the file that ends in "hrf.fst".

2) Open three different displays:

   a) A true-colour composite

   b) A (7,5,4) false-colour composite

   c) A (4,3,7) false-colour composite

3) Some band combinations are more useful than others for specific surface types, so it is typically nice to have more than one display open at a time.

Q1: Provide screen shots of all three composite. 5 marks

4) The first step in a supervised classification is to decide what you want to map. Important considerations include the following:

   a) Define classes that together cover all the surface types that exist in the image, so nothing is left out. The ideal is to create a classification that is **complete** (covers all surface types) and uses classes that are **mutually exclusive**, for example

      i) Two classes called "Deciduous trees" and "Coniferous trees" are ok.

      ii) Two classes called "Deciduous trees" and "Forest" are not ok, because some areas will be both!

   b) Define **classes that can be distinguished with the bands you have available**. The more experience you have with classification, the easier it is to do this.

   c) However, the most important consideration is to define classes that are useful for your purpose, in the sense that you need the map that comes out of the classification to give you the information you need. In this lab we will create a general-purpose land cover map so we have no specific purpose. But, for example, if you are a forest company trying to find out where to log, you should have classes like "ready to log" and "not ready to log", even if such classes might be very difficult to map!

d) For the practical purpose of this exercise, you also need to consider the fact that you must be able to identify your classes without any direct on-the-ground information. Usually you would have some photos with GPS coordinates that would help you identify the land cover for some pixels in the image.

5) Look at all three displays, and try different kinds of contrast enhancement options, to get a good sense of the area. IT can be helpful to link the three displays and zoom in to compare different areas.

Q2: Based on a visual interpretation of the image, list the classes you want to use for your classification. For the purpose of this lab, list 5 classes. There's no right or wrong answer here, but choosing appropriate classes will make it easier for you to complete the rest of the lab! 5 marks

6) Now that you have a list of the classes you want to map, you need to define areas in the image where you are confident these classes are found (training areas). These areas are used to extract statistics about what values the classes typically have in each band.

7) To define these areas, you can either import some shape files from ArcGIS, or you can create your own. Unfortunately you can't do this in ENVI 5.0, so we need to use ENVI Classic to do it. Start ENVI Classic through All Programs – GIS_RS – ENVI 5.0 – 32-bit – ENVI Classic (32-bit). You'll notice that the design of ENVI Classis is quite different from ENVI 5.0. Initially nothing but a toolbar is opened in the top left corner of your screen.

8) Open the data in ENVI Classic (File – Open External File – Landsat – Fast). Just to assure yourself that the data have opened, you can create a true-colour composite by doing the following:

   a) Click on the radio button called "RGB Color"

   b) Click **once** where it says "Meta (Band 3) (0.6614)" (this first click selects the band that will be displayed in red)

   c) Click **once** where it says "Meta (Band 2) (0.5610)" (this second click selects the band that will be displayed in green)

   d) Click **once** where it says "Meta (Band 1) (0.4787)" (this third click selects the band that will be displayed in blue)

e) Click where it says “Load RGB”

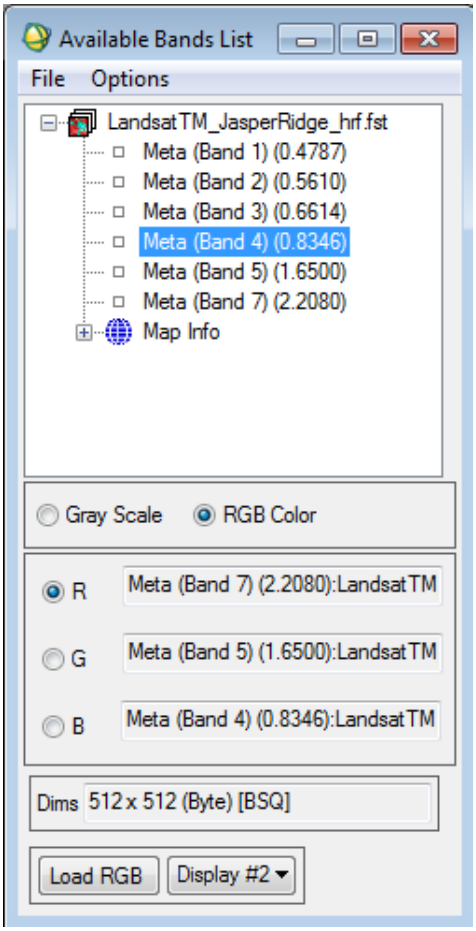
9) Three windows should open now (again, quite different from ENVI 5.0).

a) The top is called the “Image” window, where each pixel in the image is displayed using one of your screen’s pixels.

b) The bottom left is called the “Scroll” window, which is zoomed out far enough that the entire image is shown in it.

c) The bottom right is called the “Zoom” window, and the level of zoom is shown in the top window frame (default is 4x).

10) You can move the focus of the Image window but dragging the red square in the Scroll window, and you can move the focus of the Zoom window but dragging the red square in the Image window.

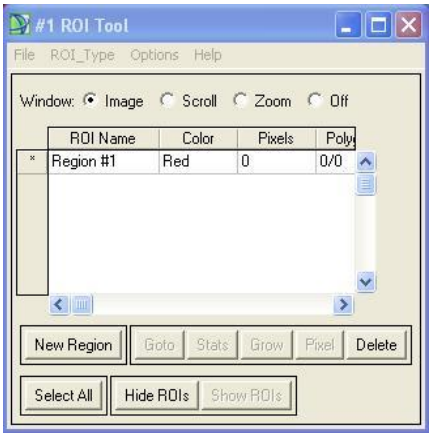


11) You can create the false-colour composites from ENVI 5.0 again if you want, but to make sure you place each of them in a new set of three windows, you need to select “New Display” before you click “Load RGB”. If you want to create the 7,5,4 false-colour composite, your “Available Bands List” window should look like this before you click “Load RGB”:

12) When you’re ready, in the “Image” window of the true-colour composite, go to “Overlay – Regions of Interest...”. That brings up the “ROI Tool”.

a) **You need to be careful with the ROI tool, it's easy to make a mistake when using it!**

b) On the blue top part of the window, you get information about which display the ROI tool is related to. A display is the set of three windows that open when you show an image. In the example below, it is related to display #1 (which is probably your true-colour composite). This means that you can draw ROIs by clicking on display #1, not the others.

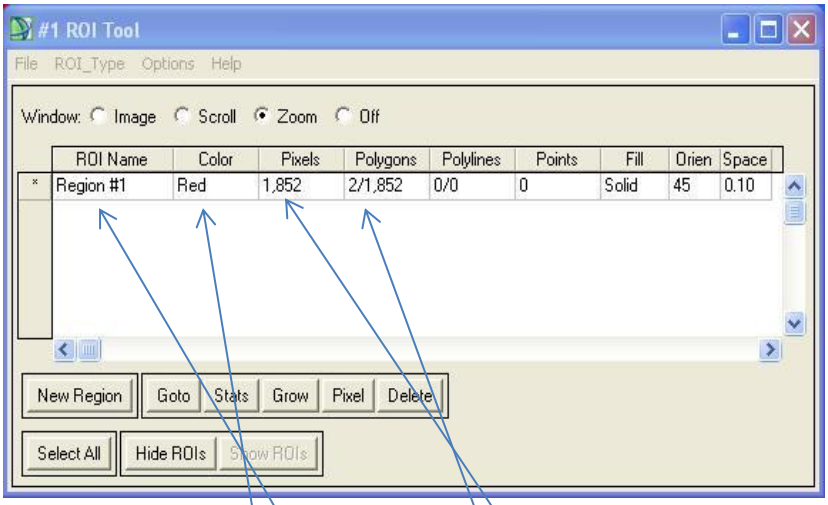


c) Now look at the part where it says “Window:”, and then there's a radio button that can be set to either “Image”, “Scroll”, “Zoom” or “Off”. In the example above it is set to “Image”. This means that when you click in the “Image” part of the display, you'll start building a polygon, but if you click in the “Scroll” part or the “Zoom” part of the display you won't.

d) Just to get comfortable with how it works, try clicking around a bit. To make a polygon, click along what you want to be the polygon's borders. To finish the polygon, right-click once to link your end point with the first point, and right-click again to store the polygon. You should now see a red polygon on your image.

e) Try making another polygon using the “Zoom” window. First you need to move the radio button in the ROI tool to “Zoom”, and then you click around in the “Zoom” window to make the polygon, like before.

f) Now look at the ROI Tool window. You'll probably need to drag the right edge of the window to make it wider, in order to see all the information. It should look something like the figure below.



g) The name of your ROI is “Region #1”. You can double-click in the box to change the name if you want to.

h) The colour of your ROI is Red, and you have 2 polygons that define “Region #1”.

i) In the example above, those 2 polygons together have 1852 pixels in them.

j) You can ignore the rest of the information in the window.

13) Now it's time to create your training classes. It's easiest to create one class at a time.

a) The first thing you need to do is to delete any ROIs that you have already created. If you've followed the instructions above you should have only one ROI. To delete it, highlight the ROI by clicking anywhere in the row, and click the “Delete ROI” button.

b) We'll start with creating a water class, assuming you have at least one of those. If you didn’t select “water” as one of your classes for Q2, you should probably go back and change the class structure to include a water class.

c) Draw a polygon that contains less than 500 pixels, and that covers nothing but water. The exact number isn't important, but it's a good idea to keep the individual polygons fairly small, especially for the water class because there isn't so much water in the image.

   i) I normally find it easiest to use the “Zoom” window because drawing these polygons requires some precision. But you can also use the “Image” or “Scroll” windows.

   ii) Move to a different part of the image that also has water, and draw another polygon. Repeat this process until you have at least 500 pixels in the ROI.

   iii) Be very careful not to include pixels that are not water. If you create a polygon that contains non-water, there is no easy way to delete it again.

d) When you are done creating water polygons, name the ROI appropriately (e.g. “water”), and select an appropriate colour (e.g. blue). You select a colour by right-clicking where it says “Red” and then selecting an alternative colour. When you right click in the pop up, select “Colors 1-20” to find blue and other basic colors.

14) Assuming you chose to draw the polygons in the true-colour display, when you're done the “Image” display window of your true-colour composite should look something like the one shown below.

15) Now click “New Region” in the “ROI Tool” window. You get a new row in the window. This should be again be called “Region #1”, and again be given the colour Red. You use this new region to create a new class, repeating the process from above.

    a) Notice the little star left of where it says “Region #1”. That means you are right now working on “Region #1”. If you wanted to create an additional water polygon, all you need to do is click on the water row to select it, and start drawing polygons. But you don't want to do that now....

16) Decide which of your classes you want to create training sites for now, and start drawing polygons that cover this class. When you are done, rename the ROI, and give it an appropriate colour.

17) Continue with this process for all your classes. Make sure each class has at least 4 different polygons and at least 500 pixels in it. These are not general rules of thumb, they are just useful for this lab.

> **Saving ROIs:** At any time, you can save the ROIs you have created so far. In the ROI Tool window, click “File – Save ROIs...”. In the new window, click on “Select All Items”, choose an appropriate filename, and click “OK”. It is highly recommended to do this regularly.
>
> **Exporting ROIs:** Using the File – Save ROIs menu, you can also export ROIs to EVF (ENVI Vector File) and SHP (shapefile) formats.

18) When you are done creating all your training sites, **make sure to save the ROIs**.

Q3: Include a screenshot of the ROI Tool window with all training sites completed (minimum 4 polygons for each class, minimum total of 500 pixels) 10 marks.

19) We’ll take a closer look at some statistics before we run a classification based on these polygons.

    a) In the ROI tool, click “Options – Compute ROI Separability...”.

    b) Select the input file (there should only be one option), and click “OK”.

c) In the new window, click “Select All Items” to compute the separability of all classes, and click “OK”.

d) ENVI now calculates some statistics for each ROI, based on the band values in the 6 Landsat bands we have available, and opens a new window with an “ROI Separability Report”. The purpose is to see whether we can expect a classifier to be able to distinguish the different classes, or whether some of them overlap substantially in band values for all or most bands.

e) The one statistic is called the “Jeffries-Matusita distance”, the other “Transformed Divergence”. The calculations for both are quite complex, but the interpretation is simple: Values close to 2.0 indicate perfect separability, values close to 0.0 indicate no separability at all. In practice, though, a separability value of less than 1.6 using either statistic problematic – it means that the classes are quite similar and will most likely be confused for each other in the classification process.

f) For a quick look at whether you have any classes that are not well separated, take a look at the list near the bottom of the report, called “Pair Separation (least to most)”. It lists the worst pairs of ROIs at the top – those that have the worst separability.

Q4: Include a screenshot of the ROI Separability Report. You may need to make the window bigger so all of the information is captured in the screenshot. Less than full marks will be given if the separability between any classes is less than 1.8 for either score. (If you have this problem, and you want full marks, go back, recreate polygons for the problematic classes, and try again). 15 marks

20) Now we'll take a quick look at some of the classes that are easy/hard to separate.

a) In the “Image” window of the display you used for the ROI Tool, click “Tools – 2D Scatter Plots”.

b) A new window opens up, where you need to choose a band to put on the x axis of the scatter plot, and a band to put on the y axis. Select band 3 for the x axis (the left hand side of the new window), and select band 4 for the y axis (the right hand side of the new window). Click “OK”. A new window opens, called “Scatter Plot”.

c) In the new window, click “File – Import ROIs”.

d) Another new window opens up. Click “Select All Items”, and click “OK”.

e) Some colour should appear on your scatter plot. The colours correspond to the colours you have chosen for your ROIs.

f) Find the two classes that are easiest to separate (the ones at the very bottom of the “Pair Separation” part of your ROI Separability Report). They should be located in very different parts of the scatter plot.

g) Find the two classes that are hardest to separate (the ones at the very bottom of the “Pair Separation” part of your ROI Separability Report). They are probably located right next to each other, maybe even overlapping a bit.

h) You can change the bands that are used for the two axes, by clicking “Options – Change Bands” in the Scatter Plot window. After you have changed bands, you will need to re-import the ROIs.

i) If it's a bit hard to see the different colours, you can change the colours in the ROI Tool. Again, you will have to re-import the ROIs to update the colours in the Scatter Plot.

Q5: Create a scatter plot that illustrates both the best and the worst separability. In other words, create a scatter plot that shows how the two classes that have the lowest separability are next to each other or overlap a bit, and also shows how the two classes that have the highest separability are far away from each other. You may need to change bands and/or colour to make a scatter plot that shows this clearly. Include the scatter plot with your assignment, and write a few sentences that explain what it shows. 20 marks.

21) Ok, now we’ve looked very closely at the ROIs, the surface types they cover, and what values those surface types typically have in the different Landsat bands. Now it’s time to run the classification.

22) ENVI Classic has most of the functionality of ENVI 5.0, but as you can probably tell by now it is NOT user friendly. So now that we have created our polygons and saved them in an ROI file. So to run the classification based on the polygons you have created, we will not return to ENVI 5.0.

23) To import the ROIs in ENVI 5.0:

a) Go to File – New – Vector Layer.

b) In the window that opens, make sure the LandsatTM_JasperRidge_hrf.fst image is selected (it should be the only one), click the "Open File" button, and find the .roi file you saved in ENVI Classic.

c) Change the Layer Name to something meaningful, like "Training areas", and click OK to import the ROIs. Although the ROI are not displayed as they were in ENVI Classic, they are now associated with the Landsat image.

24) To run a Minimum Distance Classification:

a) Use the Classification – Supervised Classification – Minimum Distance Classification tool.

b) Select the image as input file and click "OK". Now you are taken to a new window where you need to set some parameters for the classifier:

i) In the box called "Select Classes from Regions" select all classes from your ROI (click the "Select All Items" button).

ii) In the box called "Set Max stdev from Mean", select "None". This option allows you to leave some pixels as unclassified if they are too far from any class centre, compared to the spread (standard deviation) in each class.

iii) In the box called "Set Max Distance Error", select "None". This option allows you to leave some pixels unclassified if they are too far from any class centre in absolute terms.

iv) Select a proper filename for the results file (e.g. "MinimumDistanceResult").

v) In the box called "Output Rule Images", select "Yes", output to file, and select an appropriate filename (e.g. "MinimumDistanceRules").

vi) Click "OK" to run the classifier.

vii) ENVI now applies the Minimum Distance Classifier to each pixel in the image, based on statistics calculated from the training sites (ROIs) you have made. Two new files should be automatically loaded into ENVI, one with the classification result, and one with the rules images.

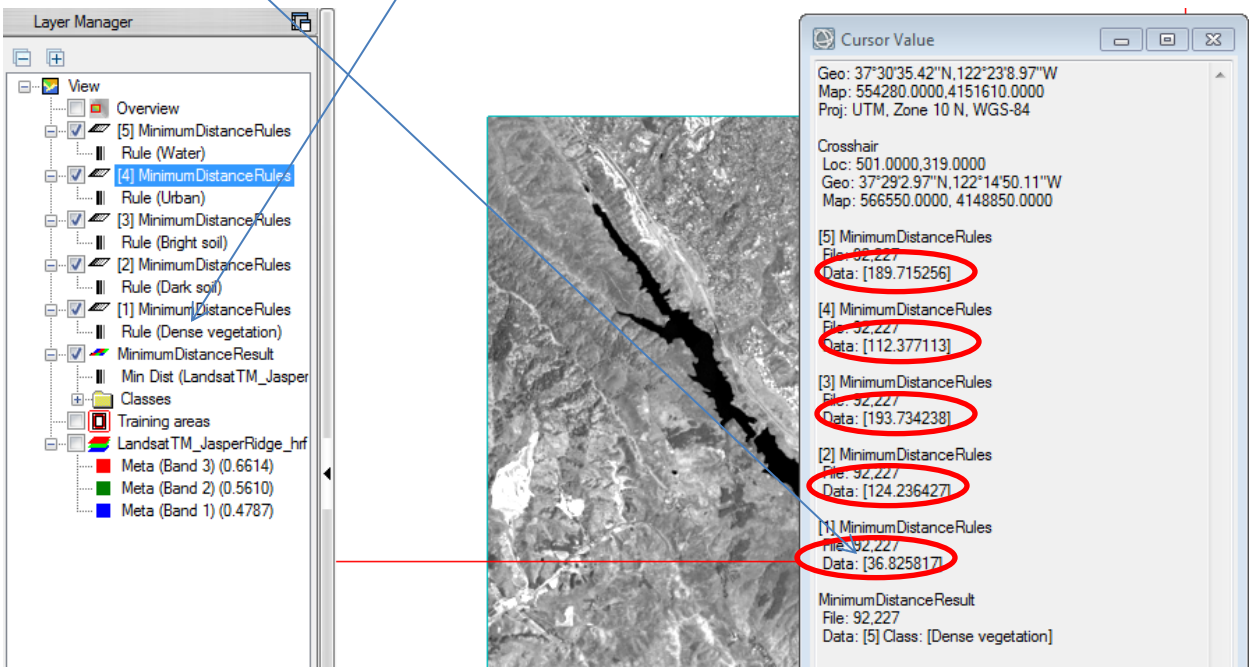
25) Display one of the Rules images. If you have a water class, display that one. The rule images for the Minimum Distance Classifier shows the "spectral distance" (calculated from band

values) for each pixel in the image to the (band value) centre of the given class (see lecture slides for details). Low values means that the pixel has very similar band values to the water class, and high values means that the pixel's band values are very different. Not surprisingly, we see that most of the water looks quite dark in the water rules image.

26) Display the other rules images, and the result image. **Make sure** you understand how each pixel was assigned to the class it was, in the result image. For a single pixel, use the Cursor Value or Crosshairs tools to check the value of each rule image for a single pixel, and the value of the result.

Q6: Provide a screenshot of the Cursor Value/ Crosshairs window showing the values of all rules images and the results image, as well as an explanation of what the rules values mean and how they have been used to determine the class of the pixel. I have provided an example here, and an example answer as well. 25 marks.

The values of all rules images are circled in red. The one with the smallest Data value is number 1, which is the "Dense vegetation" rules image. Because the "Dense vegetation" rules image has the lowest value of all the rules images, this particular pixel will be assigned to the "Dense vegetation" class in the result.



27) Now try running a Maximum Likelihood Classifier. The procedure is pretty much the same as the Minimum Distance Classifier (you need to select "None" in the "Set Probability Threshold" box).

Q7: Include screenshots of both the Minimum Distance and the Maximum Likelihood results images with your assignment. Include a small legend that describes what colour each of your classes has. 10 marks.

Q8: Describe at least two differences between the two images. 10 marks.

Q9: Which of the two results do you think is more correct. 0 marks.

Important note: Next time we will look at how to assess the accuracy of classifications, so it is important that you save the work you have done in this lab, so you can work on it again in the next lab! Before you leave the lab, make sure you have your ROI file and your classification results saved in a place where you can access them again.