Remote Sensing for Earth Observation: Practical 5 - Supervised Classification

Aims and Objectives
The purpose of this practical session is to classify the land cover types of Hong Kong Harbour using supervised classification

Core Tasks for this session

1. Training Site Development
2. Supervised Classification
3. Comparison of supervised and unsupervised classification approaches
4. Interpretation of the error matrix

Locating the Data for this Practical

Files for this practical we will use the same data as in practical 4 i.e. Hong Kong Harbour

Image Classification

In practical 2 you drew spectral response patterns for 3 types of land cover: urban forest and water. Hopefully, you recognised that the spectral response patterns of each of these cover types was unique. Land covers, then, may be identified and differentiated from each other by their unique spectral response patterns.

The methods for image classification fall into two categories: supervised and unsupervised classification. With supervised classification, the analyst develops the spectral responses of known categories, such as urban, forest, water (training site development) and then the software assigns each pixel in the image to the cover type to which its spectral response is most similar.

TASK 1: Training Site Development

A. Defining Training Areas

1. You will create five training classes for use in the supervised classification. These classes and colours are the same as those created in your unsupervised classification namely:

    1. Thick vegetation - Green
    2. Sparse vegetation (grass) - Sienna
    3. Urban - Yellow
    4. Bare concrete/soil - Cyan
    5. Water - Blue

2. Open ENVI Classic: ENVI 5.x >Tools> ENVI Classic (64bit)

3. Display *a true and/or false colour composite* of the Hong Kong image. Use these composites, along with higher resolution images available in Google Earth (Install Google Earth in your computer if you don’t have it and zoom to Hong Kong), to help you to decide on training sites for each of your land cover types.

4. Remember you can use the zoom and scroll windows to focus in more closely on your image if you need to.

B. Signature Extraction - Digitising Polygons

For each training class you will define a Region of interest (ROI) of the specified colour.

N/B: Read all instructions before you begin digitising

To start digitising polygons you must open the ***Region of Interest Tool*** window:

1. From the main image menu select **Overlay > Region of Interest**

   You will use the ROI (Region of Interest) tool to gather spectral signatures for training sites.

   The ***ROI Tool*** dialog window will allow you to digitize polygons on the image, in addition to editing and saving them. There are several choices across the top of the dialog box that let you digitize features from the ***Image, Scroll,*** or ***Zoom*** display windows. Depending on where you want to do the digitizing (i.e. what image window you want to digitize in), you can choose any one of these options.

2. To start digitizing, go to the location on the image where you want to draw a polygon. Click the left mouse button. Move the cursor to the next position along the boundary and click again...and so on – you should now see a boundary line beginning to form.

3. Continue digitising until just before you have finished the boundary and then click the right mouse button to close the polygon, and to fill the polygon click on the ***right button*** again.

Inside the dialogue box, the name, colour, and number of pixels of each polygon are displayed in spreadsheet format.

4. If you want to **add another polygon to an existing region**, highlight the region (an * will appear to the left of the name), and digitize additional areas anywhere in the image. You will notice that the number of pixels column becomes larger when you add additional polygons.

   Consider the disadvantages and advantages of a single large training site per class (or ROI) versus many medium sized training sites.

5. To edit the name of a region of interest, click on the ***ROI Name*** (e.g. Region #1), change its name, and make sure to hit return. To edit the colour of the polygon right click on the **colour** cell.

6. To create a new **ROI** click on ***New Region***, and repeat the above steps.

If you make a mistake, you can:

1. Delete **an entire ROI** by highlighting the ROI and pressing the "Delete" button in the ROI dialogue box.
2. Delete **individual polygons within a single ROI** by toggling though the polygons by clicking on the **"Goto"** button in the ROI dialogue box. When the relevant polygon is highlighted select **"Delete Part".**

NOTE: There are two things that are recommended when making your supervised classification ROIs. First, it is important that you label each ROI immediately after you create it. Second, you can have more than one ROI per class. Since each ROI, in effect, becomes a class, this can be useful for the classifier to account for the subtle variations in the same land cover classes, such as the differences within a forest based on stand dynamics and canopy structure.

C. How unique are my classes/ROIs?
You can examine the statistics of any (one or more) class(es) by selecting that class/ROI and clicking the **'Stats'** button.

You can also compute a measure of separability between the ROIs that you have defined, using the selection: **Options/Compute ROI Separability…**. This outputs Divergence metrics between the classes you have defined. These values range between 0 and 2.0. As a guide to interpretation, values greater than 1.9 indicate good separability of classes.

If class separability is less than this, you might consider splitting the classes for the classification and **recombining them post-classification** (e.g. have two classes: forest1 and forest2) using the same procedure as outline in Practical 4, Task 2.

7. Once you collect all of the polygons you are interested in, go to ***File > Save ROIs…***in the ***ROI Tool*** window. MAKE SURE YOU CLICK on ***Select All Items***. Click ***Choose***, and enter your personal directory and a file name. Don't forget to give an extension of *.roi to this file (such as “superclass.roi”).

TASK 2: Supervised Classification

Now that you have specified your training sites, you are ready to proceed with the supervised classification – classifying the image based on the spectral data contained within your training sites (i.e. ROIs). Each pixel in the study area has a value in each of the five bands of imagery. These values form a unique signature which can then be compared to each of the signature files you created. Each pixel is then assigned to the cover type that has the most similar signature. There are several different supervised techniques that may be used to evaluate how similar signatures are to each other. For this practical, we will be using the *Minimum Distance to Means* and *Maximum Likelihood* classifiers. You should re-read your lecture notes if you are unsure about how this classifiers work.

1. Under the **Classification** menu in the main ENVI toolbar, choose the **Supervised Classification** option.

2. Select **Minimum Distance** as the classification method

3. Specify **Hong_Kong_TM_1998-16-03** as the input file and click **OK**.

4. Make sure you select all of your ROIs in the **“select classes from regions.”** Set **"maximum standard deviation from mean"** and **"maximum distance error"** as **none**.

5. Click on the radio button **output results to file,** navigate to your home directory and enter a name for your image

6. Change “**output rule images?”** to **NO**

7. Select **OK** when everything is in place.

8. Open a new viewer and display the results

9. Now repeat the classification but this time using the maximum likelihood classifier.

10. Produce maps from the two classification approaches and compare the results- Are there any difference between the outputs from the two approaches?

TASK 3: Verifying the Accuracy of the Supervised Classification

Are you curious how well the classifiers classify your image?
A confusion matrix compares that relationship between known reference data and the corresponding results of the classification. ENVI can calculate a confusion matrix (contingency matrix) using either a ground truth image or using ground truth regions of interest (ROIs). In each case, an overall accuracy, producer and user accuracies, kappa coefficient, confusion matrix, and errors of commission and omission are reported.

Before you continue you must make sure that you have exactly the same classes mapped in each classified image. For example: If you decided to split your classes during supervised classification to help improve the classification and you have classes such as thick vegetation 1 and thick vegetation 2 then you need to combine these classes into a single thick vegetation class before you can continue with the accuracy assessment (see practical 4 to remind you how to combine classes)

Using Ground Truth Regions of Interest
I have provided you with a set of ground truth regions of interest to use in the production of a confusion matrix. These regions are not entirely accurate themselves as they were derived from an old paper matrix, although they will allow you to derive the required accuracy measurements.

1. Load the original Hong Kong TM image, and classified images (Unsupervised and both supervised (minimum distance and max likelihood) into 4 new displays

2. We will now open the ground truth ROIs, but first we must clear the ROI menus so as not to confuse the ground truth ROIs with those used as training data during the classification. Select **Basic Tools/ Region of Interest/Delete ROIs/ Select all/Ok** from the main ENVI menu bar.

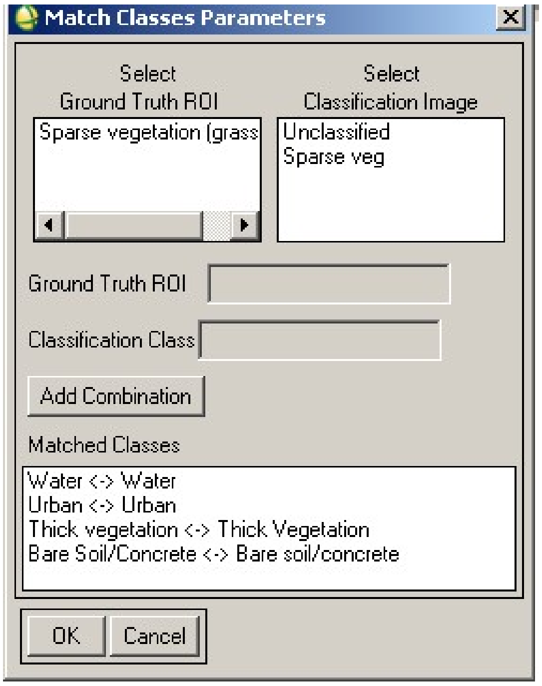
3. Now we will load the ground truth regions of interest. Select **Basic Tools/ Region of Interest/ restore saved ROI file**. Navigate to your home directory and select the **Gtruth.roi** file that you downloaded from blackboard and click OK.

If the ROIs appear in the TM image do nothing if not from the main ENVI menu select **Basic Tools/ Region of Interest/ Reconcile ROIs** and s**elect the six ROIs in the display**. Click **Select values from source/destination files** and select the Hong Kong TM file. Click **Ok** and then select the Hong Kong TM file again and click **OK** again. The ROIs should appear in the TM image in your display window.

4. We will now calculate the confusion matrix. From the main ENVI menu select **Classification/Post Classification/Confusion Matrix/Using Ground Truth ROIs**.

5. In the **Classification Input File dialog**, select your **unsupervised classification image.** The ROIs are automatically loaded into the **Match Classes Parameters dialog.**

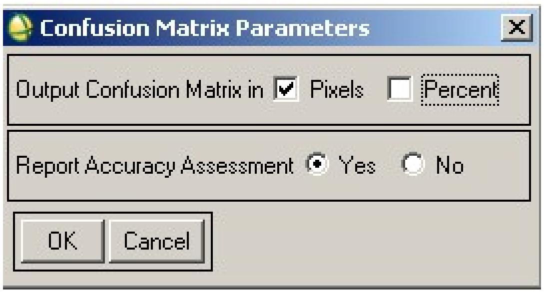
6. When the Match Classes Parameters dialog appears, match the ground truth ROIs with the classification result classes by clicking on the matching names in the two lists and clicking **Add Combination**. The class combinations are shown in a list at the bottom of the dialog. If the ground truth and classification classes have the same names, they are automatically matched. If not you will need to match them manually by sequentially clinking on the Ground truth ROI and matching it with the class name. Click **add combination** and repeat until all classes are matched.



7. After all of your class combinations are made, click **OK**. The Confusion Matrix Parameters dialog appears.

8. Next to the **Output Confusion Matrix in** label, select the **Pixels** check boxes.

9. Next to the Report Accuracy Assessment label, click the Yes toggle button and click **OK**.



10. To save the classification accuracy report S**elect file/ Save Text To ASCII in** the report window and navigate to your home directory and give it a useful file name. You can open this file in any text editor (including Word) or in Excel.

11. Repeat steps 4-10 above twice more but on each occasion select your supervised classification image (minimum distance to means or max likelihood) as the input image in step 5.

The output reports shows the **overall accuracy**, **kappa coefficient**, **confusion matrix**, **errors of commission** (extra pixels included in a class), **errors of omission** (pixels left out of a class), **producer accuracy**, and **user accuracy** for each class. Remember that producer accuracy is the probability that a pixel in the classification image is put into class X given the ground truth class is X. User Accuracy is the probability that the ground truth class is X given a pixel is put into class X in the classification image. The confusion matrix output shows how each of these accuracy assessments is calculated. See the following example for details.

Class Confusion Matrix

File

Confusion Matrix: D:\Practicals\class_unsup_merged_ii

Overall Accuracy = (3230/10498) 30.7678%
Kappa Coefficient = 0.1260

Ground Truth (Pixels)

Class	Water	Urban	Thick vegetat	Bare Soil/Con	Sparse vegeta
Unclassified	0	0	0	0	0
Water	50	0	0	0	1
Urban	666	995	282	63	78
Thick Vegetat	449	1165	1736	410	445
Bare soil/con	229	416	14	7	6
Sparse veg	969	963	681	431	442
Total	2363	3539	2713	911	972

Ground Truth (Pixels)

Class	Total
Unclassified	0
Water	51
Urban	2084
Thick Vegetat	4205
Bare soil/con	672
Sparse veg	3486
Total	10498

Ground Truth (Percent)

Class	Water	Urban	Thick vegetat	Bare Soil/Con	Sparse vegeta
Unclassified	0.00	0.00	0.00	0.00	0.00
Water	2.12	0.00	0.00	0.00	0.10
Urban	28.18	28.12	10.39	6.92	8.02
Thick Vegetat	19.00	32.92	63.99	45.01	45.78
Bare soil/con	9.69	11.75	0.52	0.77	0.62
Sparse veg	41.01	27.21	25.10	47.31	45.47
Total	100.00	100.00	100.00	100.00	100.00

Ground Truth (Percent)

Class	Total
Unclassified	0.00
Water	0.49
Urban	19.85
Thick Vegetat	40.06
Bare soil/con	6.40
Sparse veg	33.21
Total	100.00

Formative question: Use the confusion matrices to examine the accuracy of your two thematic maps (e.g. user's accuracy, producer's accuracy, overall accuracy kappa coefficient etc.). Which classes were most accurately classified and misclassified in each thematic map and why?