Practical – Image Enhancement: Contrast and Spatial Enhancement

Aims and Objectives
This practical aims to introduce you to a number of common image enhancement techniques.

Core Tasks for this session

1. Understand the image histogram
2. Undertake contrast enhancement on an image using linear stretches and image histogram equalisation
3. Spatially enhance an image using convolution filtering

At the end of the practical you should have some understanding of the processes and issues associated with image enhancement and be able to carry out a number of these techniques using ENVI.

Introduction
"The term enhancement is used to mean the alteration of the appearance of an image in such a way that the information contained in that image is more readily interpreted"
(Mather, 1999).

One type of image enhancement with which you are already familiar from the first practical is image *reduction* and *magnification*. This is a simple example but makes the point of how you can gather different information from the same image by simply zooming in and out of an image. In this practical we will introduce more advanced image enhancements. The basic idea is to use either global statistics (those from the entire image) or neighbourhood statistics (those from a smaller number of pixels) to modify or adjust each pixel's value.

INFORMATION BOX
There are 3 main types of image enhancement:

1. Contrast enhancement
Contrast enhancement is only intended to improve the *visual quality* of a displayed image. It is a process generally required for all images because satellite based sensors with global coverage need to image a wide range of scenes, from very low radiance (e.g. oceans, low solar elevation angles, high latitudes etc) to very high radiance (e.g. snow, sand, high solar elevation angles, high latitudes).
Any one scene will generally have a radiance range much less than the full range. When such a scene is imaged and converted to digital numbers (DNs), it uses less than the full quantization range (usually 0-255). When the image is displayed it will have low contrast, appearing quite dull, making visual interpretation difficult. Contrast stretching involves increasing the range (spreading or stretching) of data values to occupy the available image display range (usually 0-255). The result is displayed as an image with a greater level of contrast.

2. Spatial Enhancement
Spatial enhancement techniques modify the value of a given pixel based on the values of surrounding pixels.

3. Spectral Enhancement
Spectral enhancement techniques are mainly transforms that are used to aid in

interpreting image data.

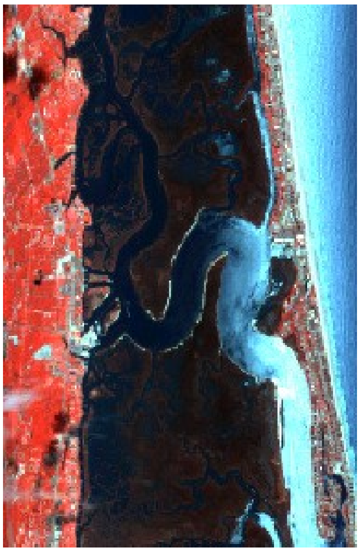
In this practical we will specifically concentrate on contrast and spatial enhancement techniques. We will not cover all the available enhancement methods, instead we will concentrate on the following:

1. *Contrast Enhancement*
   - Simple linear stretch
   - Linear stretch with saturation
   - Histogram equalisation

2. *Spatial enhancement*
   - High-pass convolution filter
   - Low-pass convolution filter

Locating Data For This Practical

Images used in this practical

File name	**murrells-inlet_cams_1997-08-02**	**Quick look (RGB = 4,3,2)**
Location	Murrells Inlet, SC	
Sensor	Calibrated Airborne Multispectral Scanner (CAMS)	
Spatial	3 × 3 m	
Temporal	August 2, 1997	
Spectral	Band 1 = Blue (.45-.52) Band 2 = Green (.52-.60) Band 3 = Red (.60-.63) Band 4 = Red (.63-.69) Band 5 = NIR (.69-.76) Band 6 = NIR (.76-.90) Band 7 = NIR (1.55-1.75) Band 8 = SWIR (2.08-2.35) Band 9 = Thermal (10.5-12	

Task1: The Image histogram

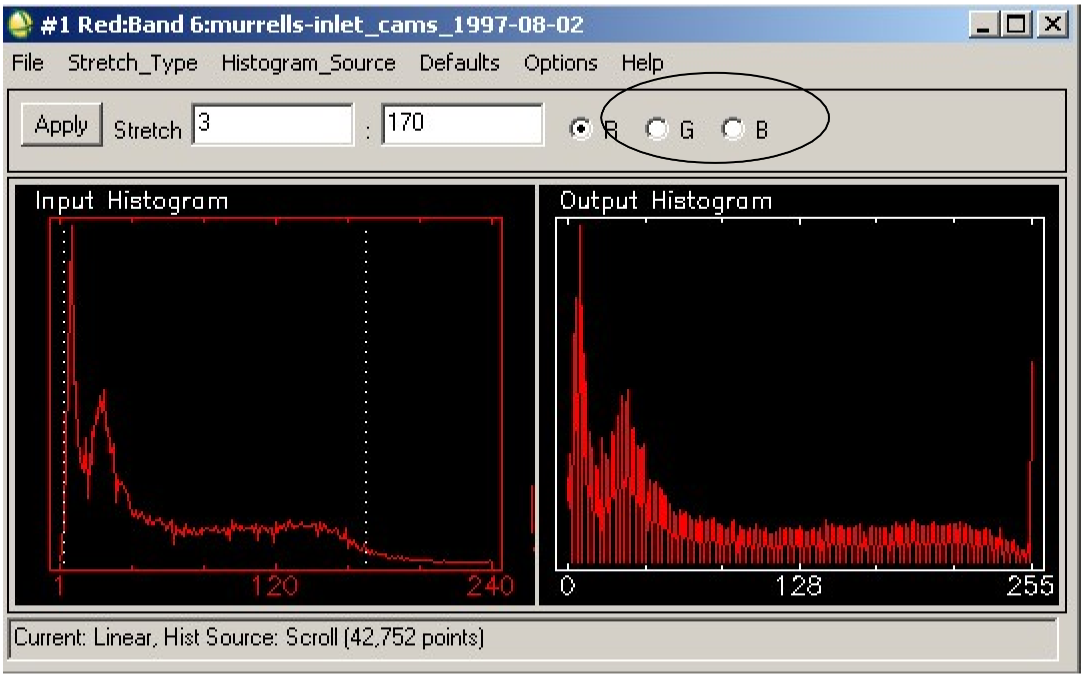
Before we apply a contrast stretch to our image, we must first view and understand the image histogram on which contrast stretches are based.

1. Load the Murrells Inlet image into a false colour display as RGB = 6,4,2

2. In the viewer tool bar select **Enhance/Interactive Stretching.**

3. Select **Histogram_Source/Scroll** to display the histogram using all pixels in the image

Two windows should appear as shown below



The input histogram shows the raw (un-stretched) data values for your band in question. The histogram shows the frequency of pixel DNs within the image. The output histogram is how the histogram looks following the application of a contrast stretching operation.

The text boxes above the plots show the minimum and maximum values which are used in the stretch i.e. in this case 3 and 170. These values are represented on the plots by two dotted vertical lines, which we will call *range bars* (minimum and maximum range bars).

The R G B radio buttons at the top right hand side allow you to toggle between the bands that you have assigned to R G B in your image i.e. bands 6, 4, 2. For example the above example shows the histogram for the band assigned to R which is band 6. To look at the histogram for bands 4 and 2 simple press the G and B radio buttons, respectively.

<u>Question1:</u>

Explain the shape of the NIR (band 6) input histogram based on your knowledge of the electromagnetic spectrum.

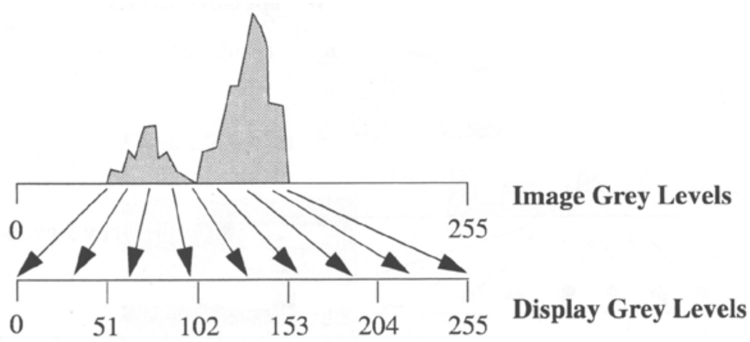
Hint: To see how the DN changes in the NIR for different land cover types select **Window / Cursor Location/Value** in the display window. A white crosshair displays in the Viewer and the Cursor Location/Value dialog opens which shows the Main Image display number, cursor position, screen value (RGB colour), and the **actual data value** of the pixel underneath the crosshair cursor. You can move the Inquire Cursor in the Viewer by dragging the white crosshair over the image

Task 2: Contrast stretching

We will now apply some stretches to the data.

A. Simple linear stretch

This is the simplest type of stretch, it uses the minimum and maximum data values as stretch endpoints. Basically, the endpoints of the data distribution are pulled to the endpoint of the palette and all the values in between are re-scaled accordingly.



B. Applying a Linear stretch

At the moment the input and output histograms for each band are different because ENVI automatically applies a 2% linear stretch to each image band.

First we will remove this default stretch to **look at the original output histogram.**

1. If not already loaded, load the Murrells inlet image and open the interactive stretching dialogue box using the steps outlined in task 1.

2. To remove the default stretch select **Default {Scroll} Linear 0-255.** The output histogram should now match the input histogram. You will notice that the contrast in the image has now decreased (this is the point of the stretch facility i.e. to improve visual display).

You will see that the wetlands are poorly defined in the original image. You can get better contrast in an image by applying a linear stretch. We will now experiment using interactive stretching (i.e. you are in control of the stretch parameters)

3. To apply a linear stretch move the ***Maximum and Minimum*** **range bars** to the left and right to find a level which best enhances the detail of the estuaries and wetlands within Murrell's inlet colour. To automatically apply the stretch to the image select **options/auto apply.** *Remember that you can alter the stretches in each of the RGB bands.*

Question2:

What were the stretch parameters (numerical values above the histograms) that you choose to enhance detail within the estuaries and wetlands of Murrell's Inlet and why did your chosen parameters improve the contrast in this particular region?

C. Applying Histogram Equalisation
Histogram Equalisation stretch is another form of contrast stretching.

Prepare: Remove all stretches by reloading the image into a new display (RGB=6, 4, 2)

1. Choose **Enhance/ Interactive Stretching**

2. Choose **Defaults / [Scroll] Equalisation**

Question3:
What happens to the output histogram when using histogram equalization and why? How does it affect this image?

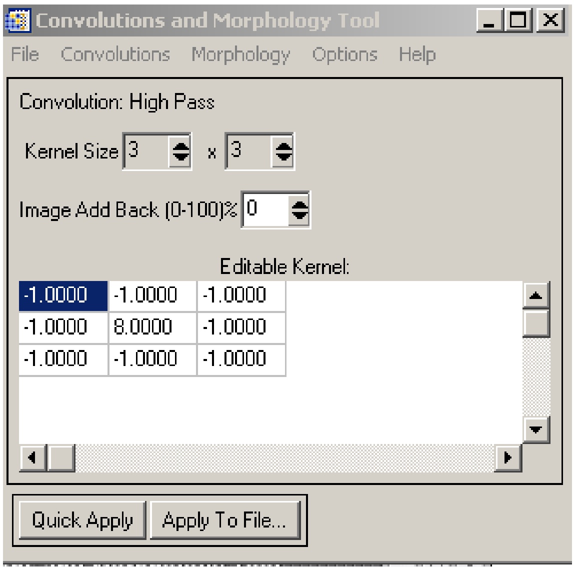
Other techniques
There are a range of other contrast enhancement techniques such as haze and noise reduction etc. and you can try them out in your own time if you wish.

Task 2: Spatial Enhancement – Spatial filtering

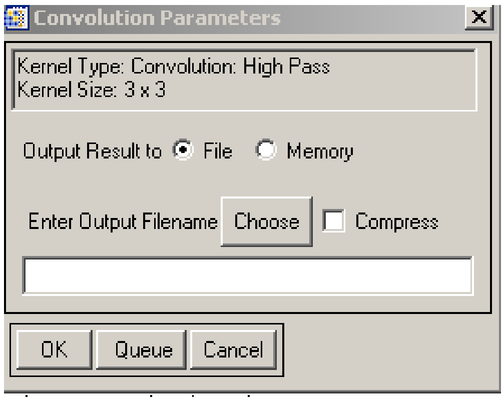
Spatial filters are used to either emphasize or de-emphasize abrupt changes in pixel DNs, thereby altering an image's textural appearance.

A. High pass filter
1. Load band 6 (NIR) of the Murrell Inlet image into a greyscale new display.

2. From the main tool bar select **Filter/Convolutions and Morphology.** The following window should appear.



3. To apply the filter, you can either select Quick Apply, which acts on the image in the current display by default or Apply to File. For this practical select **Apply To File** to save the results to a new file, select your **input** file. Rather than applying the filter to all bands (the default), to save time select the **spectral subset** button and then in the spectral subset window select the **NIR** band (band 6). Select **OK** and then **OK. You should then see the following window.**



4. Enter a name for you output file – i.e. something that tells you what the input is, the filter type is and the size. Make sure that you save it in your home filestore directory!

5. **From the available bands list, l**oad up the resulting image in a new display. To explore the results, link the displays (remember, **Tools/Link/Link Displays …**).

B. Low pass filter

6. Repeat the above procedure, but this time select Convolutions/low pass from the Convolutions window tool bar.

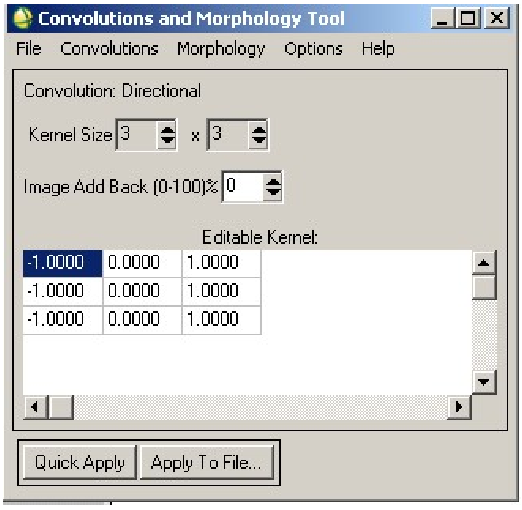
    Question4:

Describe your observations of these spatial filters. Your observations should cover area features (e.g. forests, wetlands, large/small buildings) and line features (e.g. road networks). How do these features change after filtering and why?

Hint: it may help you to display the image as a colour or false colour composite and link it with the low and high pass filter displays.

<u>Question5:</u>

Look at the filter shown below.



Using your knowledge of how spatial filters work, what effect would you expect the above filter to have on an image and why

<u>Question6:</u>
Discuss two potential real world applications of spatial filtering. Each application must relate to a different method of spatial filtering e.g. high pass, low pass, edge detection etc.