LEOWorks 3.0 Tutorial

EDUSPACE
## Contents

1. About LEOWorks 3.0 Tutorial .................................................................3
2. About Help ...............................................................................................4
3. Basic Operations ......................................................................................8
   3.1. Open and save an image .................................................................8
   3.2. Copy, cut and paste an image .......................................................12
   3.3. Printing an image .........................................................................13
   3.4. Inspecting an image ......................................................................16
   3.5. Rotate, Mirror, Shift, Crop and Invert ..........................................21
   3.6. Arithmetic ......................................................................................23
   3.7. Annotation .....................................................................................25
   3.8. Measuring distances ....................................................................27
   3.9. Transparent Overlay .....................................................................31
   3.10. Profile X and Profile Y .................................................................32
4. Colour Combinations ............................................................................34
   4.1. Working with colour images .........................................................34
   4.2. Improving an image ......................................................................38
   4.3. Improving a combined image ......................................................40
   4.4. Other image enhancing procedures .............................................42
   4.5. Using the LUT editor ....................................................................44
5. Classification .........................................................................................52
   5.1. Supervised Classification of an image ...........................................52
   5.2. Other classification methods .......................................................60
   5.3. Add a Legend (sometimes called a Key) to a classified image ........64
6. Tools .......................................................................................................67
   6.1. Special Combine ..........................................................................67
   6.2. Registration ..................................................................................69
   6.3. Computing NDVI .........................................................................76
   6.4. Animation ....................................................................................78
   6.5. Calibrate ......................................................................................80
   6.6. Edit Geotiff Header ......................................................................86
   6.7. Scatter Plot ..................................................................................88
7. GIS Module............................................................................................92
   7.1. GIS: Open a saved .shp file .......................................................92
   7.2. GIS: Add a new point theme ......................................................94
   7.3. GIS: Use shape files from other sources .....................................100
   7.4. GIS: Working with polygons ......................................................102
   7.5. GIS: Search ...............................................................................112
   7.6. GIS: Hot links ............................................................................117
   7.7. GIS: Buffer zone .........................................................................122
   7.8. GIS: GPS ..................................................................................125
8. About the Tutorial images and files ..................................................128
1. About LEOWorks 3.0 Tutorial

LEOWorks is a simple, yet powerful programme for inspection and analyzing satellite images.

This tutorial is aimed at the user who wants simple and easy access to satellite image processing.

LEOWorks has an extensive online Help section. Choose Help/Topics.

Data used
The Tutorial uses a Landsat image of part of the island, Romo situated in the southern part of Denmark.

When installing LEOWorks 3.0 the following files are present in the Data folder:

- Romo.tif
- Romo_Map.jpg
- METEOSAT images in the Animation folder
- Photos in the Photos folder
- GIS layers in the Themes folder
- GPS data in the GPS_Data folder
- Images for Special Combine in the Special_Combine_Data folder

Copyright notice:
LEOWorks is for educational purposes only.
LEOWorks can be downloaded from Eduspace and used only by registered schools.
2. About Help

Context based help can be found by clicking the Help button found in most of the windows generated by LEOWorks.

Choosing Help/Topics for accessing the extensive LEOWorks 3.0 help section.

The Help is found in Menu Description, How to ... and in the Glossary section.
Click the **Menu Description** button to access help for all menu lines.

Click the **Index** button to access the index of all help sections. Type the first characters for the word you are looking for.
Click the **Find** button to search the help section for a certain word.
1. Type the word(s) you want to find
   - ann

2. Select some matching words to narrow your search
   - Annotate
     - Annotation
     - annotations

3. Click a topic, then click Display
   - Annotate an image

1 Topics Found
All words, Begin, Auto, Pause

Display  Print...  Cancel
3. Basic Operations

3.1. Open and save an image

1) Open LEOWorks.
LEOWorks looks for image files in the directory LEOWorks/Data.

2) Open an image.
There are two ways to access the Open Dialog Box:

• select File/Open

• click the Open Button in the Tool bar

Using the normal Windows dialog box choose the file Romo.tif.
If a file contains more than 3 bands a window will appear so that bands can be selected. The Romol.tif is a GeoTiff file containing 7 bands/images.

The image used in this tutorial covers part of the island Romo in the SW part of Denmark.

Choose image1 and click OK.
The window **Image Preview** opens showing the image with high contrast. Click OK to accept the image.

If the user wants to open only a portion of the image click the **Crop** button. The window will expand to the right showing rulers used to crop the image. This function is very useful when working with large files.
Adjust the rulers and see the cropped image to the left.

The **Reset Crop** button will reset the rulers to cover the entire image. Click the OK button to accept the image.

LEOWorks will remember the crop parameters until the **Reset Crop** button is selected.

The **Resize** option is to reduce a large image. It will conserve the area covered but reduce the spatial resolution. Ticking Lock xy% will allow preserving the proportions of the image. With the X% or Y% the percentage of the reduction can be selected. Interpolation: for most images the default (next neighbourhood) is adequate, but for radar (SAR) images Block average is indicated, in order not to increase image noise.

3) Save an image.
There are two ways to access the **Save Image As...**

- select **File/Save As...**

- click the Save Button in the Tool bar. (Works when a change has been made on the image).

If you are saving a new file, LEOWorks will open the Save Image As Dialog Box.

Select the TIFF format because this is the only supported format that preserves geocoding information.
Using the normal Windows dialog box, choose a name for the file to be saved.
3.2. Copy, cut and paste an image

Cut and copy commands can be used to copy selections from LEOWorks to other applications and/or paste selections as new images.

1) Choose File/Open. Using the normal Windows dialog box select the Romo.tif file and select an image/band.

2) Choose the Selection Tool from the Tool bar.

In the Image window choose one of the tools and select the area to copy/cut.

3) Choose Edit/Cut (Copy) or click the Cut tool or the 'Copy Tools' option in the Tool bar.

4) LEOWorks will open a new dialog box:

Choose Copy Selection and Paste as New Image. The selection will now be placed in a new window. The geocoding is retained.

If the selection shall be pasted in another document e.g. a word processing document choose Copy Selection to the System clipboard.
3.3. Printing an image

1) Choose **File/Print Setup** to open the normal Windows Print selection window.

2) Choose **File/Print** or select the print button from the Tool bar.

In both cases you will get the **New Print Job** dialog window, where you can select the number of copies to print and click **OK**.

3) In the **Print Preview** window the user has control over the print result.
In the **Paper Position** field choose between **Portrait** and **Landscape**.

The **Fit to Page** option distorts the picture and fits it to the paper size. The **Normal Size** option restores the image to its original size.

When first displayed the preview image is scaled according to its size and the paper dimensions but preserving the aspect ratio.

Use the **Scale** field to select the scale of the printed image. Type a desired scale and see the result in the **Print Preview** window.

Use the **Title field** to type the title of the printed image. Use the **Font type** field to select a font.

The print preview is constructed by five elements:
- The image
- The North arrow
- The title
- The approximate scale bar
- The scale

Use the left mouse button to move the elements around. Click on the element and move the mouse up or down and inspect the result in the **Print Preview** window.

Use the right button in order to resize the elements. As regards the image see the result in the **Size X:** and **Y:** fields and the **Offset X:** and **Offset Y:** fields.

The North arrow, the Approximate Scale Bar and the Scale can be hidden by the user, ticking the corresponding field in the lower left section of the **Print Preview** window.
An example of a printed map modified by the user.

Click **Print** to print the image and Cancel to get rid of this window.
3.4. Inspecting an image

1) Choose **View/Image Information** or click the button in the tool bar of the image window.

The image size is displayed (300 x 290 pixels) and the pixel size is 30m x 30m. As the pixel is the basic component of an image, it is not possible to extract information about the surface imaged for a smaller extent than the pixel size.

Each pixel has one of several values that can be inspected and displayed using LEOWorks.

In addition to that, information on the projected coordinate system is displayed. This means that the image is geo-referenced so that it can be combined with other georeferenced data.

2) Choose **View/Cursor Position Value**.

The **Cursor Position/Value** window will display.
Try moving the cursor inside the image and inspect the position values in the **Cursor Position/Value** window.

The Pixel value is always shown at the bottom left corner of the image window.

3) **Use the zoom tool.**

To activate the zoom tool, choose Zoom from the View Menu or click the button in the Tool bar. The Zoom menu will appear at the top of the image window.

To zoom in, click once the button, then click the area to be zoomed in the image. If the window does not refresh move very gently one of the sliders. The magnification increase by one level each time you click the image, and the image centres where the mouse was clicked. If zoom is applied many times the individual pixels will become visible.

To zoom out, click once the button, then click the image. The magnification decrease by one level with each click.

To return to the standard view, click the button, then click the image.

3) **Use the histogram tool.**

To open the image histogram window, choose **View/Histogram** or click the button on the Tool bar.
A histogram is a special type of graph used to display image statistics. In its most common form, the number (usually 256) of grey levels, called bins, is plotted along the horizontal axis and the number of pixels in each 'bin' is plotted along the vertical axis. A histogram can help you decide what changes might enhance the appearance of the image.

The first and second columns below the histogram window also show useful information about the data. When the cursor is over the histogram, the third column displays information about the current bin (the bin vertically under the cursor position).
By clicking on the histogram and then dragging the mouse, more information about a range of bins can be obtained. When the image contains 3 channels (e.g., an RGB image), the currently-selected channel can be changed using the drop list above the histogram.

Various choices can be found in the Options and Properties menus. It is possible to copy and print the histogram, to shift between linear and logarithmic scale and to change the line style and symbol size.

4) Choose **View/Image Values** to open a window with the matrix of all pixel values.
With reference to the displayed image, the pixel values can be inspected. The options allow the user to edit single or blocks of values of the matrix or replace them by an average.
3.5. Rotate, Mirror, Shift, Crop and Invert

It is possible to many basic manipulations of images.

1) Open Romo(image4)

**Rotate**
2) Select **Image/Rotate…**

![Rotate Window]

The **Rotate** window allows you to rotate the image Right or Left 90, 180 or 270 degrees. In addition to this it is possible to type a value in the **Free** field.

To restore the original image select **Enhance/Original Image**.

**Mirror**
3) Select **Image/Mirror/Horizontally**.
The image will mirrored along the horizontal line.

Try Select **Image/Mirror/Vertically**.

**Shift**
4) Select **Image/Shift**.

![Shift Window]

In the **Shift** window select Left – Right or Up – Down and the amount of pixels for the operation.
**Crop**
5) Select **Image/Crop**.

Using the sliders in the **Crop** window to determine the size of the cropped image.

This option is especially useful if you want to extract a large part of a very big image. For extracting small parts of an image the **Edit** option in the main menu can also be used.

**Invert**
6) Select **Image/Invert**
Use this option if you want to invert the image. The result is in fact a shift of the gray scale from black to white to a gray scale from white to black.
3.6. Arithmetic

The arithmetic toolbox allows many arithmetic combinations of two images.

1) Open Romo(image3) and Romo(image4).

2) Select the images to combine in the droplist boxes.

The colour data from the two images is combined on a pixel by pixel basis according to the arithmetic operation chosen.

The arithmetic operations is summarized in the table:

<table>
<thead>
<tr>
<th>Operations</th>
<th>New Image is:</th>
</tr>
</thead>
</table>

- **Add**
- **Subtract**
- **Multiply**
- **AND**
- **OR**
- **XOR**
- **Minimum**
- **Maximum**
- **Average**
- **Difference**
- **NDVI**
- **Gray**
- **All channels**

OK Cancel Help
<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add</td>
<td>Image 1 + Image 2</td>
</tr>
<tr>
<td>Subtract</td>
<td>Image 1 - Image 2</td>
</tr>
<tr>
<td>Multiply</td>
<td>Image 1 * Image 2</td>
</tr>
<tr>
<td>AND</td>
<td>Image 1 AND Image 2 (Binary AND)</td>
</tr>
<tr>
<td>OR</td>
<td>Image 1 OR Image 2 (Binary OR)</td>
</tr>
<tr>
<td>XOR</td>
<td>Image 1 XOR Image 2 (Binary XOR)</td>
</tr>
<tr>
<td>Minimum</td>
<td>Minimum of (Image 1, Image 2)</td>
</tr>
<tr>
<td>Maximum</td>
<td>Maximum of (Image 1, Image 2)</td>
</tr>
<tr>
<td>Average</td>
<td>(Image 1 + Image 2)/2</td>
</tr>
<tr>
<td>Difference</td>
<td>Absolute Value of (Image 1 - Image 2)</td>
</tr>
</tbody>
</table>

If colour images are used, select from the Channel panel the colour to combine. Select the “All channels” check box to use all the colour channels in both images. This will produce a 3-channels image.

Select a specific channel for each image to produce a greyscale image.

Select the **Help** section in the **Arithmetic** window to learn more about the possibilities of the **Arithmetic Tool**.
### 3.7. Annotation

The annotation tool can be used to annotate an image. It is possible to draw lines and rectangles as well as text on an image.

1) Open an image.

2) Chose Image/Annotation from the menu line.

Select **Objects/Text** in the **Annotation Tool for image**…. window.

Type a text in the **Text** field. **Font type**, **Font size** and **Font alignment** can be selected in the three fields. The colour for the text can be chosen by clicking in the **Colour** field.

Click in the image to place the text. The attributes of the text can be changed.

Click in the **Select/Edit** radio button to enable the text to be moved around in the image. Click on the text in the image and drag it to a new position.

To delete a text select **Selected/Delete** in the **Annotation Tool for image**…. window.

Select **Line**, **Rectangle** and **Filled rectangle** can be selected from the **Objects** menu.
Example of an annotated image.

The annotated image can be saved including the annotated objects.

The **Manage Layer** button on the image window can be used to switch on and off the image layers.
3.8. Measuring distances

1) Choose File/Open. Using the normal Windows dialog box select Romo.tif and open image1.

This image is geocoded and, therefore, contains information about pixel size.

2) Choose View/Image Information to inspect the pixel size of the image.

The Pixel Size in this Landsat image is 30 metres × 30 metres.

If this information is missing it is only possible to measure distances in the pixel units (i.e. numbers of pixels).

3) Choose Image/Measure tool.

In the Measurement tool window, select Units/Metres.

Click on the image at the required starting point, then click at the ending point and the distance between the points appears in the Measurement tool window.
Click again in a different position and the distance for the second segment appears and so on. A right mouse-click will end the measurement.

4) The Measurement tool window shows the measurements of the distances for the selected segments. The area is calculated for the polygon by connecting the first and last point selected.
5) Choose **Units/Metres** to see the results in metres. If the images are not geocoded, then the results will not display properly. First of all, you will need to define the pixel size (see point 2 above).

6) Choose **File/Save measures** to save the measurements. The saved data can be opened in a word processor or a spreadsheet if you want to work with the data.

7) In case the image is not geocoded but the pixel size is well known, this tool can be
used for all types of images. Just open **Image/Pixel size** and insert the pixel size (remember pixel is derived from: picture element).
3.9. Transparent Overlay

This function creates an image in which you can see through the foreground image (colour) to the background Image (always greyscale) to the extent defined by the opacity of the foreground image. The operator forms a blend of two input images of the same size.

1) Open a combined image e.g. Romo342 and a single channel image e.g. Romo(image4).

2) select Image/Transparent Overlay.

![Select Images](image)

Select Romo(image4) as the Background Image and Romo_432 as the Foreground Image.

Use the slider to input a value for the Opacity and click OK.

The feature allows only greyscale images (1 channel) as background and 3 channel images as foreground.

Try to use Romo(image6) the thermal channel as the Background. The result is better if Interactive Stretching has been used to enhance the image.
3.10. Profile X and Profile Y

It is possible to draw a horizontal X profile. This can be useful in the process of analyzing an image.

1) Open Romo(image4). Choose Image/Profile X.

In the Romo[image4] window a horizontal line can be moved up and down by the movements of the mouse.
In the **X Profile for image** .... a profile is shown with the pixel values as the vertical component.

It is possible to show both an X Profile and a Y Profile at the same time.
4. Colour Combinations

4.1. Working with colour images

1) A colour image stores its colour information in channels. The information contained in the channels depends on the colour model being used to define the image.

With LEOWorks you have four choices for combining or splitting channels:
- RGB (Red - Green - Blue)
- HLS (Hue - Lightness - Saturation)
- HSV (Hue - Saturation - Value)
- IHS (Intensity - Hue - Saturation).

In this tutorial we only use the RGB model.

2) Combining three channels into a colour image.
Open image 2, 3 and 4 from the file Romo.tif.

3) Choose Image/Combine from...(Red Green Blue)
Select the images for each of the three bands and click OK.

The combined image
4) Choose **View/Histogram**.
Inspect the distribution of the pixels in the three channels chosen from the drop-down list.

In all three histograms, two features can be identified, a tall one in the low pixel
values and a smaller one with higher pixel values. Note the different shapes of the distribution patterns in the three channels. This corresponds to two major features in the image. Can you suggest what these features could be?

5) Save the combined image.

Close all image windows.

6) **Splitting a combined image into three channels.**

When you split a colour image into separate channels, LEOWorks creates individual greyscale images that you can edit and see the results from in the combined (colour) image.

7) Open the combined image saved under 5)

8) Choose **Image/split to.../(Red Green Blue)**. Each new image is named after its corresponding channel: File name [Red Channel].

<table>
<thead>
<tr>
<th>Landsat TM bands:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Band</strong></td>
<td><strong>Spectral definition</strong></td>
</tr>
<tr>
<td>Band 1</td>
<td>Blue-green</td>
</tr>
<tr>
<td>Band 2</td>
<td>Green</td>
</tr>
<tr>
<td>Band 3</td>
<td>Red</td>
</tr>
<tr>
<td>Band 4</td>
<td>Near infrared</td>
</tr>
<tr>
<td>Band 5</td>
<td>Mid infrared</td>
</tr>
<tr>
<td>Band 6</td>
<td>Far(thermal)infrared</td>
</tr>
<tr>
<td>Band 7</td>
<td>Mid infrared</td>
</tr>
</tbody>
</table>

9) **True colour image**
The colour image constructed above is a false colour image.

Try to construct a combined true colour image using bands 1, 2 and 3 by selecting image3 for the red band, image2 for the green band and image1 for the blue band.
The combined image needs to be improved using the technique described in the Improving a combined image section.

A true colour image is the best "natural" colour representation of a Landsat image.

10) **False colour image**
Try to construct a combined false colour image using different band combinations. The band combination 4, 5 and 7 used above is a one example of such an image.

A false colour image is often an impressive version of the Landsat image. The colours are dissimilar to the ones found in the real world but they are often good for distinguishing between different picture elements / surface types such as sand, sea, forest and built-up areas etc.

For an optimal display of different types of vegetation the combination band4 (red), band5 (green) and band3 (blue) is recommended.
4.2. Improving an image

1) Choose **File/Open**. Using the normal Windows dialog box select the file Romo.tif.

2) Select Romo1 from the **Open** Window.

3) Choose **Enhance/Interactive Stretching**.

Interactive stretching allows control of the image histogram using a selection of bins. Drag the cyan and magenta vertical lines and the output histogram will be stretched with the image immediately updated with the results.

Note that the process is quite slow for large images. It is possible to select or deselect Live Update in the **Interactive Stretching for ....** window.

The image has now been linear stretched from the lowest pixel value of 63 to the highest pixel value of 154.
4) Try other ways of Stretching this image using the Interactive Stretching process.

5) Use Interactive Stretching on the other five bands/images from the Romo.tif file. Notice how the different features are enhanced using Interactive Stretching.

6) Choose **Enhance/Original Image** to restore the original data.

7) Choose **Enhance/Histogram Equalization**.
The Histogram Equalization enhancement uses non-linear stretching methods which take into account the input image's pixel distribution.

8) Choose **View/Histogram** to inspect the histogram of the stretched image.
4.3. Improving a combined image

1) Open image2, image3 and image4 from the file Romo.tif.

2) Combine the three images into a RGB image.

3) Stretch the individual channels and see the result in the combined image.

4) Bring Romo(image4).tif to the front and make it the active window.

5) Interactive stretch this image using pixel values from 12 to 140 and watch the changes in the red channel in the combined image.

Click on the Apply button.

6) Perform the same operations on the Romo(image2).tif using pixel values from 23 to 83 and Romo(image3).tif using pixel values from 20 to 110.
Save the stretched image as a TIFF file using the name Romo432. You will need it in the next parts of the tutorial.

7) Try the procedure with other combinations of images from the Romo.tif using other ranges of pixel values.

Notice how the different features in images are enhanced.

8) You can also interactively stretch an already combined image by splitting the image into Red Green Blue.
4.4. Other image enhancing procedures

LEOWorks includes many tools for enhancing images.

Interactive Stretching is very useful.

However, in this chapter, other enhancing methods will be shown.


2) Choose Enhance/Histogram Equalization.
This function produces a non-linear stretching of the image.

3) Choose Enhance/Filter/Interactive Sharpening to sharpen the image.

This filter allows sharpening an image by means of a three steps approach. First it uses a smoothing filter with a customizable window size (between 3 and 11). The second step makes use of the sharp coefficient by multiplying the original data with \((1 + \text{SharpCoefficient}/100)\) then rescaling in the 0-255 interval. In the final step the smoothed image is subtracted from the sharpened one.
Try different values using the slider in the Interactive Sharpening for … window.

4) Try the other filters to see their results. Use the LEOWorks Help function to read about the many different types of filters.

Notice that you can easily restore the original image by clicking the button.
4.5. Using the LUT editor

LUT is an acronym for "Look Up Table". It is a conversion table that attributes a new value higher or lower in the range from 0 to 255 to a pixel's original or input value to enhance its appearance and provide more detail in the image.

All input pixel values are transformed into new values resulting in an image with more contrast (or a changed appearance in another way). Often this effect is achieved by attributing a range of input values, e.g. 0 to 20 to just one output value e.g. 0, then input 21 to 40 to output value 20 and so on. In this way the existing possible 255 input values for an image are reduced to just 13, as the output image will only contain the values 0, 20, 40, 60, etc. But many other types of output are possible.

The statistical distribution of values in the histogram will determine how a LUT is manipulated to produce a well-contrasted image, e.g. using band/image5 of the Romo image.

<table>
<thead>
<tr>
<th>Input value-range, (hypothetical)</th>
<th>Output value solution</th>
<th>Input value-range, (image5)</th>
<th>Output value solution for image5</th>
</tr>
</thead>
<tbody>
<tr>
<td>00-20</td>
<td>0</td>
<td>00-50</td>
<td>0</td>
</tr>
<tr>
<td>21-40</td>
<td>20</td>
<td>51-55</td>
<td>20</td>
</tr>
<tr>
<td>41-60</td>
<td>40</td>
<td>56-60</td>
<td>40</td>
</tr>
<tr>
<td>61-80</td>
<td>60</td>
<td>61-65</td>
<td>60</td>
</tr>
<tr>
<td>81-100</td>
<td>80</td>
<td>66-70</td>
<td>80</td>
</tr>
<tr>
<td>101-120</td>
<td>100</td>
<td>71-75</td>
<td>100</td>
</tr>
<tr>
<td>121-140</td>
<td>120</td>
<td>76-80</td>
<td>120</td>
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<tr>
<td>141-160</td>
<td>140</td>
<td>81-85</td>
<td>140</td>
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<tr>
<td>161-180</td>
<td>160</td>
<td>86-90</td>
<td>160</td>
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<tr>
<td>181-200</td>
<td>180</td>
<td>91-95</td>
<td>180</td>
</tr>
<tr>
<td>201-220</td>
<td>200</td>
<td>96-100</td>
<td>200</td>
</tr>
<tr>
<td>221-240</td>
<td>220</td>
<td>101-105</td>
<td>220</td>
</tr>
<tr>
<td>241-255</td>
<td>240</td>
<td>106-255</td>
<td>255</td>
</tr>
</tbody>
</table>

But many other things can be done with a LUT, for instance, splitting an image into just back and white values. By filling the LUT with zeros for say values 0 to 101 and
with value 255 for all input values between 101 to 255, the image will contain only two values, either zeros or 255s. In an image containing land and sea areas this could mean that all water-covered areas will appear black and all land will appear bright. Of course we have to inspect the image first to find out the threshold value that separates land from sea, in one of the bands. Produce such an image for band 4, 5 or 7 (near and mid-infrared bands) of the Romo image!

Each pixel's value as displayed on a computer screen is composed of three colours, a red value, a green value and a blue value. If all 3 values are the same, a grey colour will display on the screen for that pixel. If we change just one value of the three, e.g. increase the red one; the picture elements (pixels) will appear reddish. That is why there are 3 LUTs. In LEOWorks, only one LUT, also known as a Colourmap, is explicitly shown. It consists of 255 squares. Look at it by opening an image and converting the image to a LUT.

1) Open Romo and select band/image5. Convert the image to an image with a LUT by choosing Image/Convert to .../Image with LUT.

A greyscale is now attached to the lower right corner of the Image window.

![Greyscale](image.png)

Double click on the greyscale to open the LUT Editor window. The LUT Editor window presents several tools for manipulation of the LUT.
Select **View/Histogram** for Romo image5. The histogram shows a distribution of pixel values with three distinctive maxima.
Using the LUT editor it is possible to colour the image based on the histogram. The three maxima can be described using the **Histogram for ....** window

- 0 – 39
- 40 – 119
- 120 – 185

Using the LUT editor we will colour the range 0-39 blue, the range 40-119 green and the range 120 – 185 yellow.

In the Range fields type 0 and 39 respectively – remember to hit return in each of the fields. Select a blue colour using the colour sliders and click **Apply**.
Now select green for the range 40-119 and yellow for the range 120 – 185.
The coloured image with the chosen LUT will look like this:
The three classes correspond to water, sand and vegetation covered land.

Alternatively a range can be selected by clicking in the first **Range field** and then in the colour map and next in the second **Range field** and then in the colour map.

3) To open, save and restore to original use the **Open LUT**, **Save LUT** and **Restore Original** buttons.

Save the modified LUT above under the name of Romo3 by clicking **Save LUT**.

Restore the original LUT by clicking **Restore Original**.

Open the saved LUT by clicking **Open LUT**.

4) Use the sliders for changing the **Brightness** and the **Contrast** of the image.
5. Classification

5.1. Supervised Classification of an image

Classification of a satellite image involves assigning all the pixels in an image to specific classes. These classes need to be predefined or created as part of the classification process, which requires former knowledge of the area or information about the different features and pixel colours in the image.

Classified images are thematic maps which show the distribution of selected classes.

Information on classification methods can be found in the View Graph section of Eduspace.

In order to produce a supervised classification, training fields on the image for major features such as water, forest etc. need to be identified in the image, which is easier with an image that has been contrast-stretched.

1) **Open** all images in the Romo file excluding Romo6.

2) Construct a combined colour image e.g. a combination such as:

![Combine RGB](image)

Remember to stretch the images using **Interactive Stretching**. Save the image under the name Romo_457.

2) Select the Training Fields option via either:
The top menu - **Classification/Supervised/Select Training Fields** or from the tool bar by using the **tf** button.
During selection of Training Fields (TF), it is not necessary to have all images open on screen. The TFs can be saved at any time and opened in a different window containing another image of the same area, for instance when it might be easier to use known / accurate training fields.

3) Select the Polygon Tool \[\text{polygon tool}\] from the menu bar and draw a polygon over part of the area on the image that you have identified as a sandy beach.

All you need to do is to click where you want each of the polygon corners to be set. To close the polygon, double-click or right click.

The Training Field Information window will open automatically.

Edit the Class name by typing Sand in the **Class Name** field and press enter.
Repeat the process by selecting training fields over the following features:
• Sea
• Arable land
• Forest
• Meadow
• Heath
• Tidal flat

While defining TF it can be useful to zoom in using the button. After zooming click the button to continue the process of defining TFs.

The Romo457 image with chosen Training Fields.
The **TF Information** window containing information of the selected TFs.

4) Save the selected training fields using the button in the menu bar of the window containing the image with the selected TFs.

5) Classify the scene using the Maximum Likelihood method
Choose **Multivariate Analyses/Supervised Classification/Maximum Likelihood**.

8) In the **Select Images** window that will appear, select the channels to be part of the classification process.
In this example we will use:
- Romo(image1)
- Romo(image2)
- Romo(image3)
- Romo(image4)
- Romo(image5)
- Romo(image7)
In order to get an accurate result, it is necessary to use original unstretched images like the ones chosen here!

In the Set Threshold window select 0 which means that all pixels in the image will be represented by one of the classes.

9) After the operation is finished, a new Classified Image window will be displayed showing the result of the classification.
The selected classes are shown on the image using different colours.

The Class Statistics window contains a table showing the statistics of the classes in number of pixels and as a percentage.

9) Select Multivariate Analyses/Post classification filter/3x3. This filter can be useful if the goal is to present a simplified classified image where “noise” is filtered away.
10) Use the LUT editor to select colours of your own choice for the eight classes.

12) Select Multivariate Analyses/Supervised Classification/Inspect TF Statistics.
In the Select Images window that will appear, select the channel for which to compute the statistics. Select Romo image7 and click OK.

13) In the Channel Statistics on Training Fields window, you can inspect
the training field statistics.

14) For image7, analyze the range of pixel values for the different classes. We will use a histogram of the same image to show the range of different classes. Therefore you will need a print of the histogram.

Draw boxes on the histogram representing the seven classes. For the Training Field Dry sand the distribution of values range from a minimum value of 93 to a maximum value of 117.

Overlapping boxes indicate that the training fields are not well differentiated. This means that pixel values represented in more than one class will not be classified.

To overcome this, carefully select more training fields to help allocate pixel values to individual classes.

Notice that it is possible to have more than one training field for each class. Actually this is strongly recommended.
5.2. Other classification methods

The aim of classification of a satellite image is to assign pixels to one out of two or more classes, which may be predefined or created as part of the classification process.

**Unsupervised Classification**

Unsupervised classification can be used to cluster pixels in a data set based on statistics only, without any user-defined training classes. Selecting this option allows classifying an image using the ISODATA algorithm. Isodata unsupervised classification calculates class means evenly distributed in the data space and then iteratively clusters the remaining pixels using minimum distance techniques. Each iteration recalculates means and reclassifies pixels with respect to the new means. All pixels are classified to the nearest class.

1) Open image1,2,3,4,5,7 from the file Romo.tif

2) Choose Multivariate Analysis/Unsupervised Classification

3) In the Unsupervised Classification window the channels used in the classification can be selected. Here all the channels have been selected.

Select the number of classes in the classification. Here 7 classes have been selected.

Select the number of iterations used in the calculation. The higher the number, the more accurate the classification. Here 20 iterations have been selected.

4) The classified image is shown in a new window.
5) The different classes are shown with their own colour.

The **Class Statistics** window contains a table showing the statistics of the classes in number of pixels and as a percentage.

The resulting classes are somewhat artificial and based purely on statistics but can at the same time be real. Often they can be attributed to real land cover features such as crops, roads, settlements, tidal flats etc. The user has determine this and insert appropriate class names in a legend (also known as a key).

**Principal components analysis**
Principal components analysis is a complex statistical calculation based on the channels of a scene to provide scientists with somehow better visual information than the original band-combinations can produce. The resulting principal components images express collectively exactly the same information as the original images but in a more value-added way.

The first component (artificial new channel) contains as much of the total information as can be put into one variable, the second contains as much as possible of the rest of the information, the third as much as possible of the "new" data and so on.
An RGB image can be combined from the first three principal component images. The resulting image shows greater detail that could not be seen in RGB images combined from original images.

10) In the Principal Components Analysis window select all the channels and click OK.

11) The resulting Principal Component images are numbered from 1 to the number of original channels; here it is 6.

12) Choose Image/Combine from.../(Red Green Blue) for combining three images into an RGB image.

Select three Principal Component images: 1, 2 and 3.

The resulting image shows many features not apparent in the single original channels and in RGB combined images based on the original channels. Try different colour combinations.
Use the Interactive Stretching to extract all the features in the image.
5.3. Add a Legend (sometimes called a Key) to a classified image

Classified image with legend.
1) To learn this procedure, you will need a classified image such as the one produced on the preceding pages Supervised Classification of Scene or Other classification methods.

2) Choose Image/Add Legend.
The Legend Customize window gives the opportunity to change the title of the classes and the class colour.

Select a class (item). In the Current item field type in a new title and hit return.

To change the colour of the class click in the button. The Item: Select Colour window allows you to change the colour of the class using the colour sliders. Click OK to accept the new colour which will the replace the original both on the map and the legend.
The legend can be shown on the classified image by selecting **Show on Map** in the **Legend Customize** window.

The position of the legend can be controlled by the **X Translation** and the **Y Translation** sliders.
6. Tools

6.1. Special Combine

The Landsat 7 system gives a panchromatic image Band 8 with a higher spatial resolution of 15 metres than the 30 metres for the other bands.

To utilise this LEOWorks can construct a colour image using band 8 to sharpen a normal multispectral image.

In this example we will use Landsat images showing the volcano Vesuvius. Other images can be downloaded from the Eduspace Image Data Bank.

Open the images:
- LS7_196_22_15052000_B02
- LS7_196_22_15052000_B03
- LS7_196_22_15052000_B04
- LS7_196_22_15052000_B08

Choose **Tools/Special Combine**. To construct a false colour image select the bands as shown in the **Combine special** window and click **OK**.

The resulting sharpened image is shown in the **Special Combined Image** window.

Try to make a normal combined image for comparison choosing **Image/Combine from.../Red Green Blue**.

To enhance the contrast select **Enhance/Interactive Stretching**.

A comparison between the two combined images shows clearly the difference in
spatial resolution.

The crater of Vesuvius with 30 metres “normal” resolution to the left and the special combined image to the right with the 15 metres resolution from the panchromatic band 8.
6.2. Registration

The goal of image registration is to be able to navigate with the cursor on a satellite image and to locate each point with respect to:

- another image we know well – **Image to Image**
- a map and its coordinate system and thematic content – **Image to Map**

Why do we want to register or - in more technical terms – to geocode a digital image?

The main reason is to find the position of features or objects such as agricultural fields, houses, ships, oil spills, icebergs, etc. and read from the position of the cursor their location in coordinates (line and column, latitude and longitude in degrees or easting and northing in meter).

When we compare a satellite image with other images or with the map or with field observations we need to recognize common features. In order to locate our position or the position of a feature in nature, we require an accurate map, a large-scale map, or we need a GPS. This is a small satellite receiver that indicates the position of the holder at any time and in any place (with the sky visible) on Earth. With such indications we can directly point to such a position on a registered or geocoded digital image. Even if the image is of low spatial resolution we would know were we are, or where a specific feature is.

Geocoded data is essential to generate a satellite map. Such a map can be used on an excursion or on an expedition into a badly mapped area. Or such data can be used for updating a thematic map e.g. in the classroom.

**How can we register an image?**

Let us talk first about **registering an image onto another**. In this case we have a Master image e.g. a scanned part of a map and we have a Slave Image. In principle we read the coordinates (line and column numbers) of some conspicuous points in the Master Image and look them up in the Slave image. Then we ask the program to perform the transformation of the full image content. After this process both images can be superimposed e.g. by using the Transparent Overlay in the “Image” tools (see Main Menu).

**Image to Image registration**

The aim is to georeference a Landsat image from the island of Romo to a scanned map of the same part of the island.

In general term this is what we want to do:

Open and display the image you want to use as reference, your **Master Image**.

Open and display the image you want to superimpose or register to the Master Image. This is the **Slave image**.
1) **Open RomoMap** and a Landsat image from Romo - here a False Colour image **Romo432**.

2) Choose **Tools/Registration/Image to Image**. The window **Select Images for registration** will open.

![Select Images for registration](image)

It contains two identical columns named **Master Image** and **Slave Image** with all the file names of images that are actually displayed on your screen. Click on the file name to select your Master Image, e.g. the scanned map **RomoMap** (left column) and on the image you want as the Slave image in the right column, e.g. a satellite image **Romo432**.

Click **OK**.

3) The **GCPs collection** windows opens. GCPs stands for ground control points. This is to define and collect the common points.

![GCPs Collection](image)

First move the images next to each other and place the GCPs Collection
window to the side. Now look for common features in both images, you need at least 5 or 6 in order to have a good registration and they must be well distributed over the image.

For better pointing you can operate the zoom function – use it! But after you have zoomed and roamed the image immediately make a right-click on the mouse to be sure that the fine Cross Hair is again visible.

If you are sure of the first pair of points then place the cursor (with the cross hair) in the Master Image accurately in that position and press left click on the mouse.

The Master X and Y in the GCPs Collection window are filled (the Slave section is also filled with a default value).

Now go over the Slave image with the cursor and point it on the equivalent position and Left Click the mouse – the Slave X and Y is filled.

Click the Add Point button - the first pair of reference points is entered. You can look at it by clicking on Show List.

4) Continue in this way for another 5 or 6 points (4 are the absolute minimum). Remember that you can replace a specific pair of points on both images until you are happy; only after clicking Add Point they become definite – and a fine cross will appear there on both images.

Be sure to save GCP collection from time to time by selecting Options/Save GCP as Ascii from the GCPs Collection window.

If you are not satisfied with a point on the List you have to delete it there and start pointing again.

5) Before you decide to go ahead with the transformation of the Slave image better check the List and look at the last 3 columns showing the pre-computed
This error is given as RMS (Root Means Square) as shown in the GCP Collection window.

If in one or more cases a point has an error of greater than 2.0000 then delete that point(s) and try again with the same (erroneous entry?) or look for an additional one.

6) Next and final step is the warping of the image: Click Option in the GCPs Collection/Warp Image window menu and the registered image will appear in a moment in a new window. This New Image can be saved e.g. as a .tif file.

If the Master Image is geocoded tif (geotif) then also the Slave Image will become a geotif file. Save it accordingly as a .tif.

You can save the GCPs as a file, using again the Option button and then choose Save GCPs as ASCII.

Do not forget to name the file correctly and also add the extension txt. Later this file can be retrieved and improved, if necessary, but of course only applied to the same Master and Slave images (or images of the same relative sizes).

Image to map registration

The procedure to geocode an image with respect to a map coordinate system is rather similar, only that you have to deal shortly with map projections etc. and also read correctly the coordinates of a map. Especially the latter is often not that trivial. So better avoid frustrations and read coordinates at least twice.

7) Open the image you would like to register to a map. Eventually contrast-stretch the image to have good interpretation possibilities.

8) Choose Tools/Registration/Image to Map in the Main Menu.

Select the image to be geocoded in the Select Image window and click OK.

9) In the window Select the Transformation Method you have the choice between entering the coordinates as Geographic, that mean Latitude and Longitude in degrees or as UTM in meters, depending the map you use.
For large-scale maps (scale 50,000, 25,000 or better) UTM or in general kilometre-coordinates as Easting and Northing are commonly used, since most such maps include solid lines for each kilometre. Smaller scale maps (1:100,000, 1:1Mio or higher) are usually based on Latitude and Longitude but may also contain a kilometre-grid.

Under ‘Others’ a much larger choice of map projections is presented. Just in case you are a map-specialist!

Let us choose Geographic and click OK. (For UTM see below)

10) In the Select the Transformation Method window you have to define the Datum Name. In principle both the map projection name and the datum should be written somewhere on the map you use. Read carefully all annotations on your map.

If you cannot find any and also the map-producer (could be a national institution) cannot be reached e.g. on the Web, or if the requested name is not included in our list, we recommend to choose ‘WGS 84’, which is a world standard.

Click OK

11) The Input Display Pixel Size window opens. If you are geocoding a satellite image then the satellite data vendor has included this information. Web sites for downloading images also provide format descriptions and there you can find the pixel size. The pixel size of Landsat TM is 30 metres, but there are satellite images with other pixel sizes. Consult the tables in the chapter Remote Sensing Principles/Resources Satellites.

But what to in all other cases?

In case you have a scanned map, it is very useful to include in the scanning also the scale-bar (in kilometre) or ideally the kilometre grid, if available.

In order to know the pixel size of your map you have to count the number of
pixels along 1 kilometre horizontally and also vertically. Use the Measure tool from Image in the Main Menu. Measure accurately 1 kilometre and note the distance in numbers of pixels. Do it several times horizontally and several times vertically. Take the mean of each series. Divide 1000 by the number of pixels and you have size in X (horizontally) and also in Y (vertically).

In case you have a satellite image of unknown pixel dimension, you may use the map for a controlled distance measurement (again horizontally and vertically with respect to the image – and NOT necessarily with respect to the map). Again a similar division has to be made.

Type in the horizontal pixel size in the X Pixel Size in meter(s) field and the vertical pixel size in the Y Pixel Size in meter(s) field in the Input Display Pixel Size window and click OK.

12) Now the GCPs Collection can start. Search for common points you find on the RomoMap map and on the Romo432 image. Be precise and check again and again whether the points correspond. Point and click with the cursor on the first ground control point. It appear in the window as Image X and Y (row and column). Disregard the default values in the Lat. and Lon. cells.

13) Repeat this procedure for another 3 to 10 points.

Read from your map the coordinates and type them in the corresponding cells as Latitude degrees minutes and seconds (if possible) and similarly for Longitude.

Click the N North button if the Latitude is North, and like-wise the E button if the Longitude is East.

Click Add Point.

13) Repeat this procedure for another 3 to 10 points.
In case you have your coordinates listed in degrees and decimals you can use the “toggle button” and get the “DD” option. Always overwrite some default values there. Perhaps you got hold of the four corner coordinates of your image. Perfect! Use them!

Remember to click Add Point after inserting the four values of a new point.

Check the list by choosing Show List after entering at least 4 points. Look at the last 3 columns, the pre-computed errors. If in one or more cases a point has an error of greater than 2.00 delete that point(s) and try again with the same (erroneous reading or entry?) or a different point. The value for RMS must be below 2.

14) Finally choose Options/Warp image to start the geometric correction module. The transformed image is displayed as New Image. You must save it as tif file in order to get the geocoding effective. Prove it using View/Cursor position value.

The warping is done as a first order, linear or affine transformation shown as the number 1 in the Degree field.

You can save the GCPs as a file. Click the Option button and choose Save GCPs as ASCII. Do not forget to name the file accordingly and also add the extension txt. Later this file can be retrieved Restore GCP from ASCII and improved if necessary but of course only applied to the same image.

15) If you geocode the image using UTM Easting and Northing kilometre coordinates, you have to define also the UTM zone. Look it up in an overview map.

UTM Grid Zones of the World (http://www.dmap.co.uk/utmworld.htm)

In the Select the Transformation Method you have to select the UTM zone. In the GCPs Collection the Map X (easting) and Map Y (northing) meters are requested.

The full length of the number (small and large counts) has to be read from the map and typed in. Especially the Northing number is rather high, it is the distance in meters to the Equator. For central Europe it is in the order of 4500000.
6.3. Computing NDVI

Scientists have found that many surfaces have distinctive spectral signatures that are apparent within certain wavelengths or channels. For instance, to distinguish between bare ground and vegetation a sensor should scan in the area between 0.6-0.7 micro-metres (red colour) and 0.7-0.9 micro-metres (near infrared). Vegetation will give a strong reflection between 0.7-0.9 micro-metres, whereas it will weakly reflect between 0.6-0.7 micro-metres.

The spectral signature of vegetation is quite characteristic so the distinction between it and bare ground is usually straightforward. The difference between radiation reflected in the visible wavelength red and near infrared can be used to determine more detail about the vegetation such as its photosynthesis and vegetated ground cover.

The Normalized Difference Vegetation Index (NDVI) is usually calculated as

\[
NDVI = \frac{\text{near infrared} - \text{red}}{\text{near infrared} + \text{red}}
\]

Selection of bands.
1) Choose Tools/Compute NDVI
Using the Romo images select image4 for Channel 1 (near infrared) and image3 for channel 2 (red) and click OK.

The computed NDVI image is shown with a default colour LUT.
The colours from yellow brown to green represent increasing NDVI index from 0 to 1.
6.4. Animation

An animation is used to display a series of images. The user can select the speed, direction or specific frames in each animation.

1) Choose **Tools/Image Animation** which brings up the **Select Files for Animation** window.

![Select Files for Animation](image)

Select the files for the animation from the normal Windows dialog box and click **Open**.
2) The top slider is used to control the speed of the animation. Moving it to the far right is one hundred percent, as fast as the animation can go.

The four bitmap buttons are reverse play, pause, forward play and cycle. Use them to select a direction or to pause the animation and view a specific frame.

The bottom slider is used to view single frames from the animation. The animation must be paused, in order to use the frame selection slider.
6.5. Calibrate

LEOWorks can calibrate a gray scale or LUT image for a given parameter (for instance temperature, pressure, etc.) if known values exist.

Here the Romo(image6) will be used. Landsat Band 6 is the thermal infrared part of the spectrum, 10.4 – 12.5 µm.

1) Open Romo(image6).

2) Choose Tools/Calibrate.

3) Draw a line around an area in the Romo(image6).
4) Click the Add button in the Calibrate image window.
Let us suppose we know that the temperature is 10 degrees for this area. Type 10 in the **Known value** field of the **Calibrate image** .... window and hit **return**.
Repeat the procedure for an area that is more bright. Type 15 in the **Known value** field of the **Calibrate image ....** window and hit **return**. You can delete the last value added with the **Delete last** button.

5) Now LEOWorks can calibrate the image based on the input. Hit the **Calibrate** button.
The **Calibrate graphic** window shows the relationship between the Pixel value and the calibrated value – here called Temperature.
5) Choose **View/Cursor Position/Value** to inspect the calibrated value for the pixels in the image.

The Measured column on the left will contain the values that are measured on the image while the right column contains the known values that will be used to calibrate the image. Select an area on the image and using the ‘Add’ button the corresponding average value will be added in the left column. You can delete the last value added with the ‘Delete last’ button, or reset all the values with the ‘Reset’ button, close the dialog window with ‘Close’ button or calibrate the image when all the values are edited using the ‘Calibrate’ button. Edit the Y axis label by using the Units feature.

More options are available in the menu.
6.6. Edit Geotiff Header

The GeoTiff image format stores the geo-referencing information in a special header of the image file. LEOWorks uses this information if it is present.

You are able to edit the GeoTiff header and modify the cell size (both x and y), the coordinates for left-upper corner and the projection.

1) Open an image file e.g. Romo(image4).

2) Choose Tools/Edit Geotiff Header.

![Image of Select Image window]

3) Select the image you want to work with and click OK.

4) In the Edit GeoTiff Header window it is possible to type in new values.
6.7. Scatter Plot

The Scatter Plot tool allows you to construct a scatter plot of two images in order to analyze the differences of the images.

1) Open Romo(image3) and Romo(image4).

5) Chose **Tools/Scatter Plot**.

Select Romo(image3) and Romo(image4) in the drop down lists for **Image #1** and **Image #2** and click **OK**.
The **Scatter Plot** window shows the scatter diagram for the two images chosen. The colour scale to the right shows the amount of pixels for a given pixel value for the images. Move the cursor around the **Scatter Plot** to analyze the distribution. E.g. a Romo(image3) level of 28 and a Romo(image4) level of 17 gives a count of 235 pixels as showed on the image. This is represented by a red colour.

3) Select **View/3D surface** from the menu of the **Scatter Plot** window.
Click and drag to rotate the 3D surface. The image can be modified in many ways using the options in the View menu.
The 3D surface can be used to analyze the distribution and relationship between the two images as an addition to the normal histogram for each of the images.
7. GIS Module

7.1. GIS: Open a saved .shp file

1) Open an image from the Romo file. Here a combined image using band 4, 5 and 7 with histogram equalisation will be used.

![Image of image with RGB (202.96)--> (R:245, G:195, B:189)]

2) Click on the button in the toolbar.

Select File/Open Theme in the GIS Tool for image .... window.

Select the .shp file to open e.g. the My Points Theme and click Open. Select information on projection in the Transformation Method field in the Input Projection window. If no specific information is available select Unknown.

![Input Projection window]

LEOWorks can transform a .shp file in any of the listed projections in to the projection of the displayed image.
If the image is geocoded select **Map based** in the **Load Mode** field.

If the image is not geocoded and the .shp file as well select **Pixel Based** in the Load Mode field.

The Romo image is geocoded. Therefore select **Map Based** in the Load Mode field and click **OK**.

Be careful to have the same coordinate system for the image and the .shp file.
7.2. GIS: Add a new point theme

1) Open an image from the Romo file. Here a combined image using band 4, 5 and 7 where **Histogram Equalisation** have been applied.

2) Click on the `button in the toolbar. Note that the tool bar in the image window changes to show the contextual GIS buttons and the **GIS Tool for image…. Window** is opened.

3) To create a new theme click one of the `button or go to the menu
File/New theme.

Name the Theme and select Type of Theme Points and click OK. Notice that the new theme is displayed in the GIS Tool for image .... Window.

The next step is to add object (points) to the theme.

4) In the GIS Tool for image .... window select Edit/Start Edit.

Point and click in the image window to add points.
A right click will delete the last point. Select **Edit/Stop Edit** to stop adding points.

5) To add attributes to the points select **Edit/Theme Tools**.

Select **Tools/New Attribute** to create a new attribute.
Examples of attributes

- **Integer**: Number cars or persons - 1023
- **Floating points**: Temperature or density - 10.3
- **String**: Name of persons or regions - Charles

In the Theme Tool window it is possible to change the name of the theme, the symbol used, the colour and the thickness.

6) The Theme Properties window display the new attribute.

The IDs for the points is incremented by default.

To input values for the point select the cell with a double click, mark the previous values, delete, type the new value and click enter to finish.

7) Select **Tools/Information** to inspect the attribute for the theme.
To see the attribute value on a Point click in the left column in the **Theme Information window**.

The values for the selected point will be highlighted in the table to the right and on the image. The UTM-coordinates of the point are shown on the button of the **Theme Information** window.

Likewise if a point is selected in the image window the attribute will be highlighted in the **Theme Information window**.
8) To save the theme in the .shp file format close the Theme Information window, select File/Save Theme in the GIS Tool for image .... window. Rename the theme or use the default name and click Save.

The .shp format is compatible with most GIS software packages.
7.3. **GIS: Use shape files from other sources**

1) Assuming the user has an image opened in LEOWorks and want to import a shape file from another source and to display the theme on top of the image.

The image must be geocoded.

2) Click on the button in the toolbar.

Select **File/Open Theme** in the **GIS Tool for image ... Window**.

Select the .shp file to open and click **Open**.

There are three possibilities:

3) The shape file is geocoded and the user has information on the projection used.

Select information on projection in the **Transformation Method** field in the **Input Projection** window.

![Input Projection](image)

The should input all the information requested as shown in the example above and click OK.

LEOWorks is doing all the needed conversions from the projection coordinates of the .shp file to the projection coordinates of the image file.

4) The .shp file is geocoded but the user has no information on the projection used.

Select information on projection in the **Transformation Method** field in the **Input Projection** window.
Select Arbitrary as the Transformation Method along with the Map Based option and click OK.

LEOWorks is assuming that the shape file is in the projection format as the geocoded image.

5) The shape file is not geocoded.

Select information on projection in the Transformation Method field in the Input Projection window.

Select Arbitrary as the Transformation Method along with the Pixel Based option and click OK.
7.4. GIS: Working with polygons

1) Open an image from the Romo file. Here is shown a combined image using band 4,5 and 7 with histogram equalisation will be used.

This section will show how to digitize two simple polygons, to save them and to edit them.

2) Click on the button in the toolbar.

Note that the tool bar in the image window changes to show the contextual GIS buttons and the GIS Tool for image .... Window is opened.
3) To create a new theme click one of the button or go to the menu File/New theme.

Name the Theme and select Type of Theme Polygons and click OK. Notice that the new theme is displayed in the GIS Tool for image .... Window.

The next step is to add objects (polygons) to the theme.

4) In the GIS Tool for image .... Window select Edit/Start Edit.

Draw a simple polygon by pointing and clicking around the area you want to digitize.
Do a right click to stop the drawing of the polygon.

Draw another by pointing and clicking around new area.

5) To edit one or more polygons select Edit/Start Edit in the **GIS Tools for image**... window.

There are three ways of editing a polygon:

- Edit Vertex
- Move
- Insert Vertex
- Edit Vertex

Select **Edit/Edit Vertex** in the **GIS Tools for image**... window.
Left click on a vertex to select it.

Right click to delete the vertex.

Right to stop the process of editing the selected polygon.

Select **Edit/Stop Edit Vertex** in the **GIS Tools for image...** window to stop editing vertexes. Point and on the polygon to edit. The vertexes will be displayed.

7) Move

Select **Edit/Edit Vertex** in the **GIS Tools for image...** window.

Point and click to select the polygon to move.
Move the polygon to a new position and do a right click to place it in the new position.

Select **Edit/Stop Move** in the **GIS Tools for image...** window to stop moving polygons.

8) **Insert Vertex**

Select Edit/Insert Vertex in the **GIS Tools for image...** window.

Point and click to select the polygon to insert a vertex to.

Left click on the point where you want to insert a vertex.
Right click to stop inserting vertexes.

Select **Edit/Stop Insert Vertex** in the **GIS Tools for image**... window to stop insert vertexes.

If you want to edit the polygon with the new inserted vertex select **Edit/Edit Vertex** in the **GIS Tools for image**... window and use the procedure described above in 6).

Select **Edit/Stop Edit** in the **GIS Tool for image** .... Window to stop editing the polygon theme.

9) Working with Theme properties/appearance

Select **Edit/Properties** in the **GIS Tool for image** .... window to work with attributes for the current theme.
You can change Line Style, Thickness, Colour and name by choice.
Click **Apply** to preview the result of the changes.

Click **OK** to make the changes permanent.

10) Working with Theme properties/attributes

Select **New Attribute** in the **Theme Properties** window.
Type in a name for the attribute in the **Name** field.

Select Integer in the **Type** field and click OK.

The ID's for the points is incremented by default.

To input values for the point select the cell with a double click, mark the previous values, delete, type the new value and click enter to finish.

11) To select a polygon point and click in the polygon number field.
The selected polygon will be highlighted in the image window.

In this way the selected polygon can be identified and if needed removed by clicking the **Remove** button in the **Theme Properties** window.
7.5. GIS: Search

This option allows you to make a search through the elements of a theme. You can search after its value for a selected attribute.

You have to double click the attribute to select it and make the search possible. To begin another search you have to ‘Reset’ the precedent one.

You can use the ‘Save’ button to save the search results into a file.

1) Open an image from the Romo file. Here is shown a combined image using band 4, 5 and 7 with histogram equalisation will be used.

![Image](image1.png)

2) Click on the button in the toolbar.

Note that the tool bar in the image window changes to show the contextual GIS buttons and the GIS Tool for image .... Window is opened.
3) Choose File/Open Theme in the GIS Tool for image … window. Select the theme Romopoint and click OK.

4) Select Arbitrary in the Transformation Method field and Map Based in the Load mode field in the Input Projection window and click OK.

5) Select Tools/Search in the GIS Tool for image …. window and click OK.
6) In the **Search** window you can search for point element with a certain value or value range for an attribute of your choice.

Here a search is done for points with an altitude that equals 2 metres!

Double click on **Altitude** and the **Equal icon** and the value **2.00000**. The search parameter is shown in the field at the button of the **Search** window. Click **Search**.
7) The result of the search is shown in the **Search** window. There are 3 components that have an altitude of 3 metres.

8) Click on a point to show its location on the image.
9) The operators in the Search window allows the user to perform quit accurate searches on large datasets.

10) Click Result to save the components that met the search criteria. These components can then be opened and shown on the image.

11) The search function is quit powerful. It lets you build a detailed search based on search criteria such as:

    ALTITUDE<1.00 AND ALTITUDE>2.00

If you have created your own attributes it can used with them as well.
7.6. GIS: Hot links

It is possible to associate a mouse click on an element with an action such as to open a picture. An example is to create a hot link between a point and a photo taken at that particular locality.

1) Open Romo_457 or a single channel image such as Romo(image4).

2) Click on the button in the toolbar.

Note that the tool bar in the image window changes to show the contextual GIS buttons and the GIS Tool for image ... Window is opened.

3) Select File/Open Theme in the GIS Tool for image ... window. Open the .shp file romopoint in the Themes folder.

Select arbitrary in the Transformation Method field and Map Based in the Load Mode field in the Select the Transformation Method window and click OK.

4) Chose Edit/Theme Tools in the GIS Tool for image... window.

5) Chose Tools/New Attribute in the Theme Tools window.
6) Type **Link** in the **Name** field and select **String** in the **Type** field and click **OK**.

7) Click **OK** in the **Theme Tools** window.

8) Chose **Edit/Edit/Create Hot Link** in the **GIS Tool for image...** window.

9) Select **Link** in the **Edit/Create Hot Link** window and click **OK**.
10) Scroll to the attribute field **Link** in the **Theme Tools** window.

We will make a hot link to three photos for point number 1, 4 and 7.

Click in the Link field for Point #1 to open **Photo1** in the **Images** folder

The path to the photo is written by LEOWorks in the **Link** field in the **Theme Tools** window.
11) Repeat the process for the two other photos, Photo4 and Photo7 related to the points Point #4 and Point #7 respectively and click OK in the Theme Tools window.

12) In order to see the images select Tools/Hot Link in the GIS Tool for image… window.

13) Point and click on point #1 in the Romo_457 image to open Photo1 which is now related to this point.
14) To get information on the theme elements select **Tools/Information** in the **GIS Tool for image**... window.

15) Click on the Point-1 element in the **Theme Information** window and the point is highlighted in the image.
Click on a point in the image and the **Attribute Values** are shown in the **Theme Information** window.
7.7. GIS: Buffer zone

LEOWorks allows the user to draw a buffer zone around a point, line or polygon. Here it is shown how to draw a buffer zone of a distance of 500 metres around a point.

1) Open Romo_457 or a single channel image such as Romo(image4).

2) Click on the button in the toolbar.

Note that the toolbar in the image window changes to show the contextual GIS buttons and the GIS Tool for image … Window is opened.

3) Select File/Open Theme in the GIS Tool for image … window. Open the .shp file romopoint in the Themes folder.

Select arbitrary in the Transformation Method field and Map Based in the Load Mode field in the Select the Transformation Method window and click OK.

4) Choose Tools/Buffer Zone in the GIS Tool for image … window.

5) Select meter(s) and type 500 in the Draw Buffer at a distance field in the Create Buffer Zone window and click OK.
6) To change the properties of the buffer zone click in the colour button in the GIS Tool for image … window.

7) Select a colour of your choice and Thickness of the buffer line and click Apply.
The Romo image shows the buffer zone drawn at a distance of 500 metres from the points.

As shown in the **GIS Tool for image** window romopoint_Buffer is also a new theme. You can save it using **File/Save Theme**.

Draw also buffer zones around the line theme **Dyke** and the polygon theme **Car_Free**.
7.8. GIS: GPS

LEOWorks allows the user to read GPS Waypoints files. This means that you can import and show e.g. points of interest registered by a hand held GPS device.

First step is to transfer the GPS data to your computer. Consult your GPS device on how to do this.

Save the data on disk as a text file with the following format:

<table>
<thead>
<tr>
<th>Name</th>
<th>Lat</th>
<th>Long</th>
<th>Altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>55.15796316</td>
<td>8.55142741</td>
<td>3</td>
</tr>
<tr>
<td>23</td>
<td>55.17535225</td>
<td>8.55783999</td>
<td>3</td>
</tr>
<tr>
<td>26</td>
<td>55.15073519</td>
<td>8.53542401</td>
<td>2</td>
</tr>
<tr>
<td>27</td>
<td>55.15160012</td>
<td>8.53307465</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>55.145985</td>
<td>8.49770721</td>
<td>1</td>
</tr>
<tr>
<td>32</td>
<td>55.14551385</td>
<td>8.48655676</td>
<td>2</td>
</tr>
</tbody>
</table>

Note that the file should contain only the points without the header (Name, Lat, Long, Altitude).

1) Open Romo_457 or a single channel image such as Romo(image4).

2) Click on the button in the toolbar.

Note that the tool bar in the image window changes to show the contextual GIS buttons and the GIS Tool for image window is opened.

3) Choose Tools/GPS/Read GPS Waypoints file in the GIS Tool for image window.

4) Select the Romo_GPS file in the Data/GPS_Data folder and click Open.
5) Use the ASCII Template window to prepare your data. The Romo_GPS file has already the format that can read by LEOWorks so click Next.

6) Select Geographic (Lat/Long) in the Select the Transformation Method window.

7) Select WGS 84 for the Datum Name and Ellipsoid Name and click OK. Most GPS devices can be set to use WGS84.
The imported GPS points become visible on the image. In the GIS Tool for image window the new theme “Romo_GPS” appears. Click on it and then click File/Save Theme and save it in the directory Theme under this name or a name of your choice.

You may check the attributes of the theme by selecting Edit/Theme tool. Now you can add additional attributes e.g. a LINK attribute (see Hot Links).
8. About the Tutorial images and files

**Romo.tif**
The image used in the Tutorial is a Landsat TM from the Danish island Rømø situated on the west coast of Jutland.

**Image information:**
Sensor: LANDSAT TM
Acquisition date: 24 May 1992
Number of bands: 7
Spatial resolution: 30 metres
File format: GeoTIF

<table>
<thead>
<tr>
<th>Landsat TM bands:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Band</strong></td>
</tr>
<tr>
<td>Band 1</td>
</tr>
<tr>
<td>Band 2</td>
</tr>
<tr>
<td>Band 3</td>
</tr>
<tr>
<td>Band 4</td>
</tr>
<tr>
<td>Band 5</td>
</tr>
<tr>
<td>Band 6</td>
</tr>
<tr>
<td>Band 7</td>
</tr>
</tbody>
</table>

**Animation.zip:**
The images used show a low pressure system crossing Northern Europe.

**Image information:**
Sensor: METEOSAT
Acquisition date: 3 December 1999
Number of bands: 1 (Thermal infrared band)
File format: JPEG
Please use WINZIP to unpack the compressed file

**Vesuvius**
Landsat 7 image
LS7_189_32_02082000_B01.tif
LS7_189_32_02082000_B02.tif
LS7_189_32_02082000_B03.tif
LS7_189_32_02082000_B04.tif
LS7_189_32_02082000_B08.tif
Source: Eduspace Image Data Bank

**GPS_Data**
Data collected using a Garmin etrex Vista Cx

**Images**
Photos from Romo May 2006.

**Map**
Romomap.jpg
**Themes**
Point: Romopoint
Polyline: Dyke
Polygon: Car_Free (Car free zones on the beach)