DIGITAL IMAGE PROCESSING SIMULATOR DIPS

User Manual

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DIPS

BACKGROUND AND PURPOSE

I have been teaching remote sensing and GIS for quite a few years. Over this period I felt that quite a few concepts in digital image processing and remote sensing are very difficult to communicate to a new class using static mediums such as transparency sheets and PowerPoint presentations. For example, how do you explain to a class, how a digital convolution filter works without animatedly moving your hands to show the movement of the filter kernel to the next column or row! Or for that matter, how do you tell a class how the RGB guns on a monitor recreate colour for a multispectral satellite image without using your three fingers each representing a colour gun!

The usual cycle for remote sensing teaching is something like -- teach the concept in the class ---- show it on the image processing system. This cycle, I feel has a major learning gap. The image processing system does not give you an 'under the hood' view of what is happening. The smallest image that most teachers use to teach is 512 by 512 pixels and it is practically impossible to see what is happening to each of those 262144 pixels as they pass under the watchful scrutiny of a box classifier.

The learning gap is also visible from the student's side. The plight of a student who has been nuked by a Professors lecture where he has unburdened all those concepts can only be experienced as a student. After a lecture, the student has books or image processing exercises to follow up concepts taught in the class, which he/she might not have correctly imbibed in the first place. In short, the transition from the class to the image processing system may be too quick.

DIPS is essentially a Digital Image Processing learning tool that tries to bridge this learning gap between the class to the image processing system. It has been designed in a way that it can be shared between the student and the teacher. On one hand, it can be used by the teacher to explain difficult to understand fundamental image processing concepts during a lecture, while on the other, it can be used by the student to follow up concepts explained in the class at leisure. DIPS has a standard collection of exercises for most options which can be tried out by the student. In addition to these standard exercises, the teacher can design new exercises and ask the students to replicate and solve them using DIPS.

Some design criteria that I put before myself while writing this software are as follows:

a) It should be small in size to permit easy transmission.
b) It should offer under-the-hood explanations of all concepts.
c) It should provide interactivity to users to explore a concept by permitting them to change things and see the effect of these changes.

d) It should cover a core body of image processing concepts.
e) The software interface should be intuitive and easy to understand.
f) It should have learning pointers through exercises or highlights.

I have tried my best to stick to these design criteria while writing this software. It is in pursuance of one of these criteria that I have designed this simple help system using a text file rather than a standard windows .hlp file.

GETTING STARTED

To get familiar with his software quickly, the user can solve the exercises in each module. These exercises have been designed in a manner to give the user a 'walk-through' of all-important features. THE EXERCISES OF EACH MODULE ARE THE REAL HELP. If you need to know more about an option while working on an exercise, you can then consult the help on that topic. Once you are through with these exercises which are quite explanatory, you will be able to get a good feel of the software. You can then design your own exercises or experiment with the options.

The user is also requested to see 'ICON CONVENTIONS' option, which is at the top of the help topics list.

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DIPS RGB VIEWER

1.0 SUMMARY

The RGB Viewer permits a user to understand the re-creation (or rendering) of colour on a multispectral image. It has also been designed to convey band assignment to the red, blue and green guns and the colour composites that these assignments create. It permits the user to assign different pixel values to each gun and see the effect these values have on the resulting colour of the pixel being displayed. This module has been designed to help the teacher communicate multispectral image reconstruction using raw satellite data. It should also help the student play around with various combinations such that he/she is familiar and comfortable with the idea of colour on remotely sensed digital images. The display of this module is confined to just 1 pixel of an image which is shown enlarged. The Pixel animator then carries the idea of colour reconstruction as demonstrated by this module to recreate a sample three-band image.

The Pixel Animator (described in more details in another section) and the Fahsi'sTraingle are two companion learning resources to this module.

1.1 MODULE STARTUP

When the RGB Viewer module is invoked, it displays the Red, Green and Blue Guns and a band selector box under each gun. Before the RGB Viewer can display colour in the box titled 'Enlarged Image Pixel Colour', the user needs to assign a band to each gun. The intensity with which a gun illuminates a pixel can be set using the slider bars on respective guns. At startup, the gun slider controls are disabled but become available once the band assignment is complete.

This module has a menu bar, which has a resources option. Clicking the Resources menu option gives the user access to the Fahsi's triangle and Pixel Animator options.

1.2 ASSIGNING BANDS TO GUNS

Each gun has a band selector box that offers a choice of 4 bands that can be possibly assigned to a gun. The user can select a particular band to be displayed by a particular gun. Once the user has chosen a band for each gun, the gun sliders are enabled and the user can set intensity values for each gun.

As the purpose of the module is to illustrate colour reconstruction in multispectral images, the software prevents the user to set the same band to two different guns. Band assignments for each gun should therefore be distinct.

1.3 SETTING PIXEL INTENSITY VALUES FOR RGB GUNS

Once the band assignment is complete, the user can move the sliders on each gun by grabbing the slider by the mouse and moving it up or down. The intensity value is shown in the blue, green and red display boxes on top of each gun. The intensity values can also be set by clicking on the up arrow button (near min) or the down arrow button (near max). Moving a slider upwards decreases values while moving it down increases them. The range of display is between 0 (Min) and 255 (Max) in conformance with 8 bit digital data.

1.4 SEEING THE RESULTANT COLOUR

Once display intensities have been set on each gun, the user can press the 'Show' button on the bottom of the screen to see the resultant colour of the pixel. The user can move sliders any number of times to set different intensities on each gun and press the 'Show' button to see the resultant effect on the colour of the pixel.

As the show button is pressed and the colour on the pixel is rendered, a label highlighting the composite being generated is displayed. The composite nomenclature used in DIPS is as follows:

   a) True Colour Composite : Blue Band assigned to Blue Gun
                                      Green Band Assigned to Green Gun
                                       Red Band Assigned to Red Gun

   b) False Colour Composite : Green Band Assigned to Blue Gun
                                       Red Band Assigned to Green Gun
                                     IR Band Assigned to Red Gun

   c) Pseudo Color Composite :   Any band assigned to any gun other than the
                                         above two cases.

1.5 SETTING GUNS BY TYPING INTENSITY VALUES

The 'Play Pixel Values' box permits you to type in intensity values between 0 and 255 for each gun. After the values for each gun have been typed, the user can press the 'Play' button to see the effect.

1.6 RESOURCES MENU

The resources menu essentially displays the following two companion learning tool options.

1.6.1 Fahsi's Triangle

This option shows the Fahsi's triangle and provides brief explanations of additive and subtractive primary colours. This display is largely for the ready reference of the student and the teacher while creating different colour combinations in the RGB Viewer.

1.6.2 Pixel Animator

The pixel animator shows colour reconstruction on a sample three band image. It also illustrates the application of Linear Contrast stretching. The pixel animator is described in detail in the Pixel animator section.

1.7 HELP AND EXERCISES

The user can seek help on this module by clicking on the help button (lower left book with question mark). Learning pointers and exercises on this topic can be seen by clicking on the 'exercise icon' (distraught guy with a magnifying glass - lower left corner).

1.8 QUITTING

You can quit the module by pressing the 'Quit' Button or by clicking on the window cancel button.

PIXEL ANIMATOR

2.0 SUMMARY

The DIPS pixel animator provides the user to see colour reconstruction from Digital Data on a multispectral image. The pixel animator displays a 4 by 3 pixel wide 3 band image data set. Each band of the data set is assigned to a colour gun and the 12-pixel wide image is recreated using the digital data of individual bands. The pixel animator also illustrates step-by-step calculation for applying linear contrast enhancement.

2.1 MODULE START-UP

When the pixel animator is invoked, it displays 12 pixel digital data in 3 bands. By default, the first band is assigned to the red gun, the second to the green gun and the third to the blue gun. The screen also displays a linear stretch checkbox, which can be used to apply a linear contrast stretch to the image.

2.2 CREATING A COMPOSITE

To create a composite the user needs to press the 'Create Composite' button. Once the button is clicked, the 3 band data is examined from the top left pixel to the bottom right pixel, one pixel at a time. The pixels under consideration (from each band), are highlighted by coloured circles on the respective images and their values are displayed as labels in the three guns. Display is halted after rendering a pixel such that the user can see the effects of colour reconstitution in the display box. To proceed the next pixel the user can press OK till all pixels have been displayed and the composite complete. After all the pixels have been rendered, the user can press the 'Refresh' button to repeat the process.

Once the pixels have been rendered, the 'Image Swap' icon buttons are enabled on top of the Band 2 Image. The use of these buttons is described in section 3.4 below.

2.3 APPLYING LINEAR CONTRAST STRETCH

This option demonstrates the application and calculation details of linear contrast stretching. To apply linear contrast stretch to the rendered image, the user can check the 'Apply Linear Stretch' checkbox. Pressing the 'Create Composite' button with this option on shows calculation details for applying the linear contrast stretch. Calculations are shown in a step-by-step mode inside the stretch calculator box. The values used for stretching are also displayed for each gun in re-routed label boxes.

2.4 SWAPPING IMAGE BANDS

It is instructive to see how the colour of the image changes if the band assignment to guns is altered. DIPS permits such band swapping that allows a user to assign any band to any gun. The left and right arrow buttons placed on top of the Band2 image can be used to change the default assignment of the bands to guns. Click on the left arrow button to move Band 2 to Band 1 position and vice versa. The right arrow key can be used to swap band 2 and band three. This way, any band data can be assigned to any gun and the user can see the effect that this swap has on the colour of the resultant image.

2.5 HELP AND EXERCISES

The user can seek help on this module by clicking on the help button (lower left book with question mark). Learning pointers and exercises on this topic can be seen by clicking on the 'exercise icon' (face with magnifying glass - lower left corner).

2.6 QUITTING

The user can quit the pixel animator using the quite button or window cancel button.

DIGITAL DATA READER

3.0 SUMMARY

The digital data reader read and displays, a small sample of raw digital data is stored in BSQ, BIL, BIP formats. It also demonstrates how reading a block of digital data in a wrong format can produce valid results with potentially problematic implications.

3.1 MODULE START-UP

When the data reader is invoked, a strip of data comprising of 27 pixel in 3 bands is shown on top of the screen. The imagery box shows a choice of formats in which data can be read. The 'rubber-pencil' button (rub and write), shown at the edge of the data set can be used to change the 27-pixel values in the raw data set. The 'Row/Col' change button (1/2) can be used to give an incorrect number of rows and columns to see effects of a faulty data reading operation (see exercise 3 for a simulated problem on this.) The '?' button explains the use of the 'Row/Col' button.

3.2 READING IMAGERY DATA

To read image data in a particular format (BSQ, BIL or BIP), choose the appropriate option from the 'image read' box. Data in the chosen format can be read in a 'fast read' mode, which does not stop to show the sequence of the data being read. It can also be read in a 'slow read' mode which shows pixel by pixel reading of data with marker highlights (red rectangle) on the pixel position being read. To move to the next pixel the user can press OK on the message box to see how data is being felt in respect bands. The user can click the refresh button and choose another option to see data being read in a different format.

Important: If the step by step message box (which halts after every pixel and display next) covers the image area or bothers you by its location, just move the application window (the entire data reader window) a bit towards the top left corner (i.e. move it upwards and leftwards). The message box will shift its position and should clear the image area.

3.3 CHANGING DATA VALUES

The user can change the data values of the 27 pixels in the data strip (green block with header and trailer). To do this, just press the 'rubber-pencil' icon on the right edge of the data block (under 'Trailer') and you will be prompted for a new data value for the first pixel. The default value is the current value of the pixel. If you wish to change that value, type in a new value. If you wish to leave the value unmodified, just press 'OK'. You can quit changing anytime by pressing 'Cancel'. Only values between 0 and 255 are accepted. Blank inputs will leave the pixel unchanged. Values being changed are highlighted by a red marker rectangle.

3.4 CHANGING ROWS AND COLUMNS

Click the 'Row/Col' Change button (Under Header on upper left) to give a different number of rows and columns to read data. This option has been provided to give the user an opportunity to see what can happen if the correct number of rows and columns is not specified at the time of reading data from the tape, bands having incorrect spectral information can be created. The '?' button explains this situation. See exercise 3 for more details.

3.5 HELP AND EXERCISES

The user can seek help on this module by clicking on the help button (lower left book with question mark). Learning pointers and exercises on this topic can be seen by clicking on the 'exercise icon' (face with magnifying glass - lower left corner).

3.6 QUITTING

The user can quit the data reader module by pressing the quit button (displaying a red cross) or the cancel button on the window.

NOISE EQUALIZER

4.0 SUMMARY

The Noise Equalizer module has been designed to generally illustrate the process of noise removal on digital images. Noise or spurious data may manifest itself in a number of different ways on a digital image. Mostly noise manifests on digital images due to detector problems or some such problem due to which ground reflectance is improperly recorded. This anomaly is either systematic like in the case of line dropouts which manifest as a string of 0's or random like salt and pepper noise where an odd pixel is either very bright (like 255) or very dark (like 0). Such values are exceptions and are unlikely to be produced by any feature on the ground. The DIPS noise remover graphically illustrates noise removal of line dropouts and salt and pepper noise through the process of averaging on a small 4 by 4 (16 pixels wide) sample image. Although this process cannot replace valid data, it improves the appearance of the image when little else can be done.

4.1 MODULE STARTUP

Invoking the Noise Remover module presents the user with the module form which shows on the left a defective image containing three lines of valid digital data and one line (row 3) full of 0's which were recorded as a result of detector problems at that time. The screen also shows a 'correct dropout' button that is used to correct the error. The right side of screen shows the corrected image. Calculations of correction are shown through appropriate image highlights. The refresh button is disabled on startup but once an image correction operation has been completed it is activated. The 'Show Salt and Pepper Noise' button in the right pane is used to simulate a random noise situation which is shown in Row 3.
The 'Change Data' button, which is located just below the 'Dropout Image' data view permits a user to change data in the input image. Just below the 'Drop out Image' data view, is an image view that shows the data as an image. Moving the mouse on any command button presents a line of help.

4.2 CORRECTING DROPOUT

Press the 'Correct Dropout' button between the two images. The dropout correction is effected in a step by step mode showing calculations at every step. Red and Blue highlights (red and yellow outlines on image view) are placed on the data view to attract attention on the pixels under consideration. The user needs to press 'OK' after a pixel has been corrected to move to the next. The "correct Dropout' button is dimmed after completion of calculations and the user can start all over again by pressing the 'Refresh Button' (located in the right pane on top) which resets and presents a fresh screen. Pressing the 'Refresh' button is just like starting afresh.

4.3 CHANGING DATA IN THE INPUT IMAGE

The user can change data in the input image. Click on the 'Change Data' button to start entering new values. The data change process starts from the top left pixel and goes to the bottom right pixel in sequential mode. The user can enter a new data value or press 'OK' to retain the existing data value, which is the default. Attempts to input values below 0 or 0 automatically change the entered value to 1. Likewise if values above 255 are entered, they are automatically changed to 255.

This 'forced pixel redemption' is necessitated as the basic purpose of this module is to demonstrate correction of faulty data and permitting freedom to input 0's can result in image patterns that can impede this demonstration. The module does not accept changes in Row 3. The sequential change process bypasses Row 3 for reasons explained above. All other values in between 1 and 255 are accepted as valid entries.

The user can press the 'Cancel' button on the input box to abort data entry at any point. The image view is changed once data entry is complete. In the event that the values given create an image in which the pixel colour comes close to the background, the image area can be difficult to differentiate from the background. In such cases, the user can switch on 'Pixel Borders' by checking the 'Pixel Borders' checkbox to see the area covered by individual pixels.

4.4 SALT AND PEPPER NOISE SIMULATION

Press the 'Show Salt and Pepper' noise button in the right pane to create a simulation of Salt and Pepper noise. On choosing this option, the Row 3 data is changed to show four alternating dark (0) and bright (255) pixels representing random pepper and salt noise respectively. As this noise is usually random, the user corrects it by pointing to the offending pixel. To effect corrections, just click on any or all pixels in row 3 in the image view. The corrections will be made on that pixel and calculations for the correction displayed. The image view on the corrected image will also reflects these changes which can then be compared with the contrast on the input image. The user can press the 'Refresh' button to go back to line dropout simulation.

4.5 EXPLAIN CONCEPT

The user can press the 'Explain Concept' button in the right pane to get a quick summary of the line dropout problem.

4.6 HELP AND EXERCISES

The user can seek help on this module by clicking on the help button (lower left book with question mark). Learning pointers and exercises on this topic can be seen by clicking on the 'exercise icon' (face with magnifying glass - lower left corner).

4.7 QUITTING

You can quit the module at any time by pressing the quit button or the window cancel button located at the lower right corner of the screen.

CONVOLUTION FILTER EXPLORER

5.0 SUMMARY

Convolution filtering averages a small set of pixels across an image. It is used to change spatial frequency characteristics of an image. A kernel is a small mask of values which is overlaid on a part of the image. A new value for the central pixel is calculated based on an average of the neighbouring pixels. The kernel window then moves one pixel forward. At the end of a row, it moves to the next row.

If the kernel is a low pass filter, then the central pixel value tends to come closer to its neighbours giving the image a smooth homogenous look. If the filter is high pass, it tries to enhance high frequency detail i.e. lower central pixel (CP) values become lower and higher values become higher. Low pass filters decrease spatial frequency while high pass filters increase it. The filter kernel can be 3x3, 5x5, 7x7 or bigger in size. As the size of the kernel becomes bigger, the neighbourhood of the central pixel also becomes larger.

The DIPS Convolution Filter Explorer (CFE) permits users to see and experiment with convolution filtering on a 6 by 6 (36 pixels wide) image. It shows filter calculations in a step-by-step mode and also helps users to see the effect of low and high pass filters on the sample image.

5.1 MODULE START-UP

When invoked, the DIPS Filter Explorer shows the startup screen with a 6 by 6 (36 pixels) input image. The user can choose to apply a 'Low Pass Filter' or an 'High Pass Filter' to this image using the low pass and high pass radio buttons

on the top of the screen. The user can provide custom filter coefficients by clicking on the change buttons beside the low pass and high pass filter kernels. The selected filter can be run on the input image by clicking on the 'Run Filter' button. To see step by step calculations foe each filter kernel movement, the show calculation checkbox can be checked. Input image values can be changed using the rub-and-write (rubber pencil) or point-and -change (mouse) icons. The results of the 'Run Filter' operation are shown on the 'filtered image' which at the time of startup, is the same as the input image (see section 5.3). The digital data is also shown in the image view.

5.2 CHOOSING A FILTER

The topmost section of the screen presents the user with a choice of running a low pass or a high pass filter. This choice can be made by checking the radio button next to the appropriate filter. The use can change filter kernel values by clicking on the 'Change' button and then sequentially giving the kernel values. If a value is not to be changed 'OK' can be pressed to move on.   If you are not sure about what coefficients to try, just press the 'Suggest ' button and a few filter examples will be shown. the default filter is a low pass (averaging) filter will all coefficient values set to 1.

5.3 FILTER MATH

When the filter kernel is seated over the image area (9 pixels within the filter's box) , the following mathematical operations are done :

  a) Each filter coefficient is multiplied by its respective image value .
  b) The sum of the above products are all added together .
  c) All coefficients in the filter kernel are summed together.
  d) The total (as calculated in b) is divided by the filter sum (as calculated in c)
  e) The result (as calculated in d) replaces the central IMAGE pixel within the window.

5.4 RUNNING THE FILTER

To the run the chosen low or high pass filter, press the 'Run Filter' button. If the 'Show Calculation' button is checked (by default it is) , then every movement of the kernel will be graphically shown on the input image and detailed calculations for each pixel will be shown in the calculation pane on the extreme right of the screen. If this option is checked off, the filter will be run and completed instantly.

As the filter is run, the results of the operation are shown in the data view of the filtered image. For convenience of comparison, at startup, the filtered image is a copy of the input image. As the filter is run, the filtered image values are changed one by one highlighting the location of the change in red. The digital data is also shown as image view. You can click on the 'Linear Stretch On'

button to make the image brighter and to separate contrast on pixels. The 'Linear Stretch On' is a toggle button and once pressed it displays 'Linear Stretch Off' to enable you to turn of the enhancement if desired.

Once the filter operation is complete, the 'Run Filter' button is replaced by the 'Copy Filter' button. This is has been provided such that the user can re-run the filter as many times as required to see the effects of repeated low or high pass convolution on the image. Once the 'Copy Image' button is clicked, the filtered image data becomes the input data and the 'Run Filter' button reappears and the user can run the filter on the data again.

5.5 CHANGING DATA IN INPUT IMAGE

You can change data in the input band easily. To do this, you can press the 'rubber-pencil' icon on the left edge of the data block. You will be prompted for a new data value for the first pixel. The default value is the current value of the pixel. If you wish to change that value, type in a new value. If you wish to leave the value unmodified, just press 'OK'. You can quit changing anytime by pressing 'Cancel'. Only values between 0and 255 are accepted. Blank inputs will leave the pixel unchanged. Values being changed are highlighted by a red marker rectangle. Alternatively, if you selectively wish to change values on individual pixels, just click on the 'Mouse' icon and the click on the pixel value to change. Values less than 0 and values above 255 are not accepted.

5.6 HELP AND EXERCISES

Press the Help or Exercises icons (bottom left corner) to see help or exercises on this topic. You can get a 'Concept' summary of convolution filtering by pressing the 'Concept note' (paper / pin) icon next to the exercises icon.

5.7 QUITTING

You can quit the data reader module by pressing the 'quit' button (displaying a red cross) or the cancel button on the window.

Related Module
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Please see help on the EDGE ENHANCER MODULE for more on filters.

RATIO BUILDER

6.0 SUMMARY

The DIPS Ratio Builder has been designed to demonstrate how images can be ratioed and the results of the ratio, displayed as a ratio image. Ratioing is an important digital image processing technique and is used for a variety of analytical purposes. One of the interesting applications of ratios is in creating vegetation indices where the infrared band is divided by the red band to get a vegetation index image. As actively photosynthesizing vegetation reflects high quantum of IR and low quantum of red (used in photosynthesis) from the EMR incident upon it, dividing the IR band by the red band yields higher ratio values from vegetated areas. A large number of vegetation indices try to exploit this basic IR/R relationship. One such important index is called the Normalized Difference Vegetation Index or NDVI which is expressed as (IR - R)/(IR + R) and results in ratio values in the range of -1 to +1. In general, NDVI values below 0 indicate areas dominated by water / snow etc while values above 0 indicate vegetation in varying degrees.

As ratios cannot be directly used to create a digital image (values must be between 0-255 for display), the ratios are scaled to 'acquire' values between 0-255 for display purpose using one of the many available techniques. DIPS does this by using linear stretch scaling. You can see how this is done by checking the 'Show Stretch Math' checkbox as explained in section 6.3 below.

6.1 MODULE STARTUP

When the DIPS Ratio Builder module starts it shows digital data of two 6 x 6 (36 pixel) images which have been designated as Band A and Band B. Although these two bands can be thought to contain any type of data, it would add considerable perspective to presume that Band A contains IR data while Band B contains red data. The data on Band A has been organized (for visual effect) in manner that alternate rows (starting with the first having high values) have high and low values. As this is presumed to be the IR band, rows on this image having high values can be presumed to have vegetation (i.e. rows 1,3,5) and should therefore appear brighter on the ratio images as compared to the other non-vegetation rows(i.e. rows 2,4,6). This is just a hypothetical situation to demonstrate the effect of high NDVI or IR/R ratios more clearly on the ratio image.

The screen shows a 'Divide' button that can be used to divide the two bands. The startup screen shows the 'rub and write' (pencil rubber icon) and 'Click and change' (mouse) icons beside each image which can be used to change image values. A 'ratio settings' box permits the user to choose either a simple IR/R ratio or an NDVI ratio. The 'Reverse Band ' button swaps the position of the two bands. The 'start afresh' button allows the user to reset the screen and start again.

6.2 CREATING A RATIO IMAGE

To create a ratio image i.e. an image that has been created by dividing pixel values in band A by respective pixel values in band B, just press the 'Divide Button'. The ratio image is created immediately and is shown in an 'image view'. The important point to note is how a ratio value (eg pixel 1 in Band A / Pixel 1 in Band B = 91/63 = 1.44444) is converted to a value in the 0 - 255 range. The 'Ratio Settings' box permits the user to choose between a simple ratio or an NDVI ratio. The default is the simple ratio.

6.3 OBSERVING RATIO CALCULATIONS

To see how ratio calculations have been performed, just click on any pixel on the resultant ratio image and ratio calculations are displayed for that pixel. Both pixels involved in the ratio are highlighted on Band A and Band B images and their ratio shown in a message box. If you wish to see how a ratio value like 1.444 has been converted into a value between 0 - 255, check the 'Show Stretch Math' checkbox in the 'View Tools' box and click a pixel on the ratio image again. Detailed stretch calculations will be shown in the right display pane. If the mouse moves over any pixel (without clicking) of the ratio image, the stretched value for that pixel which is being used for display is shown in a small tip box beside the mouse pointer.

The user can use the 'Pixel Borders' check box to see the borders of the pixels on the image in case some pixels are visible with difficulty being close in colour to the background of the form.

6.4 CHANGING DATA IN BANDS

The user can change data in the input bands A and B to simulate ratio situations of his/her preference. To do this, you can press the 'rubber-pencil' icon on the left edge of the data block. You will be prompted for a new data value for the first pixel. The default value is the current value of the pixel. If you wish to change that value, type in a new value. If you wish to leave the value unmodified, just press 'OK'. You can quit changing anytime by pressing 'Cancel'. Only values between 1 and 255 are accepted. Blank inputs will leave the pixel unchanged. Values being changed are highlighted by a red marker rectangle. Alternatively, if you selectively wish to change values on individual pixels, just click on the 'Mouse' icon and the click on the pixel value to change. Values equal to or less than 0 and values above 255 are not accepted.

6.5 SEEING NDVI CALCULATIONS

To create an NDVI image, just choose NDVI in the 'Ratio Settings' box and press the 'Divide' button. The NDVI image will be shown as Image View. To see NDVI calculations for a particular pixel, just click on that pixel on the ratio image as described in section 5.4 above.

6.6 HELP AND EXERCISES

Press the Help or Exercises icons (bottom left corner) to see help or exercises on this topic.

6.7 QUITTING

The user can quit the data reader module by pressing the quit button (displaying a red cross) or the cancel button on the window.

IMAGE SUBTRACTION

7.0 SUMMARY

The image-differencing module demonstrates the subtraction of digital values of one image from the other to produce a difference image. The operation is usually done on registered images of an area taken at two different times to see what changes have taken place during the time interval on a pixel to pixel basis.

The underlying presumption in image differencing is that if there has been no change in an area covered by a pixel, the difference in digital values be tween the two dates would be zero. However, if there have been changes on the ground digital values would be different and they would be appropriately seen as "-" or "+" difference values. After subtracting one image from the from the other, appropriate scaling techniques are used to map differences on a 0 - 255 scale for display purpose (as values like -2 etc cannot be displayed).

7.1 MODULE START-UP

When the DIPS image differencer module is invoked, the start-up screens shows two 8 x 8 (64 pixels) images. By default, both these images are almost identical accept for the 4 central pixels which are different. Image 1 and 2 can be presumed to be two images of the same area taken at different times. The central pixels, for demonstration and understanding of the concept, show the change.

The 'subtract' button, which is seen in the lower middle section of the screen, is used to subtract image 2 from image 1. Results of the subtraction are shown of a third image, which can be seen both in 'image view' and 'data view'. A 'swap image' button located on the lower right hand side of image 2 can be used to swap band position making band 2 as band 1 as band 2 if required. The 'Explain Concept' icon (note and Pin in lower left) to get a summary of the image subtraction concept.

7.2 CREATING A DIFFERENCE IMAGE

You can press the 'subtract' button to create the difference image that is the result of subtracting image 2 from image 1 on a pixel by pixel basis. The difference image is by default shown in the 'data view' such that the user can see the results of the subtraction operation in terms of values. The 'image view' button can be pressed to see the displayed data as an image. The conversion of subtracted values (as shown in the data view) into a displayable image is facilitated through a scaling equation. The user can click on any pixel on the 'image view' to see how the subtracted value has been converted or mapped on the 0 - 255 scale. Clicking on any image value displays detailed calculations in the calculation window, which appears on the left hand side on the difference image. The user can press the '?' button to see the scaling equation used or the close button to dismiss the calculator window.

7.3 SWAPING INPUT IMAGE

The user can swap input images by clicking on the 'swap image' button (lower corner of image 2). The images will be relocated the position of both the images are interchanged as a result of this operation.

7.4 CHANGING DATA VALUES IN INPUT IMAGES

The user can change data in the input bands A and B to simulate ratio situations of his/her preference. To do this, you can press the 'rubber-pencil' icon on the left edge of the data block. You will be prompted for a new data value for the first pixel. The default value is the current value of the pixel. If you wish to change that value, type in a new value. If you wish to leave the value unmodified, just press 'OK'. You can quit changing anytime by pressing 'Cancel'. Only values between 0 and 255 are accepted. Blank inputs will leave the pixel unchanged. Values being changed are highlighted by a red marker rectangle. Alternatively, if you selectively wish to change values on individual pixels, just click on the 'Mouse' icon and the click on the pixel value to change. Values equal to or less than 0 and values above 255 are not accepted.

7.5 HELP AND EXERCISES

Press the Help or Exercises icons (bottom left corner) to see help or exercises on this topic.

7.6 QUITTING
The user can quit the data reader module by pressing the quit button (displaying a red cross) or the cancel button on the window.

EDGE ENHANCEMENT

8.0 SUMMARY

The DIPS edge enhancement module demonstrates the edge enhancement procedure on digital images using a default or user defined filter. An edge is a discontinuity or a sharp change in greyscale value at a particular pixel point. Edge enhancement is commonly applied to digital images were the analyst aims to highlight edges in a particular direction or in any direction. The process is usually accomplished by using high pass digital filters, which try to highlight edge areas by increasing contrast.

8.1 MODULE START-UP

The edge enhancement module presents a start-up screen that shows an input image having a North / South edge (right in the middle of the image). The input image is shown both in data and image views and the edge trending across the middle of image is highlighted by a marker line on the image view (with labels titled 'edge'). An examination of the input data clearly shows how an edge manifests on an image due to change of contrast due to difference in adjoining pixel values (99 / 69). The data in the input image is in two distinct blocks. Pixels in the left block have a pixel value of 99 while pixels in the right block have pixel values of 69. The transition from 99 to 69 highlights the north south edge as seen in the image view.

The 'load edge scene' button permits an user to change the input data from a single edge scenario to a two edge scenario. The user can click the 'Load Edge Scene 2' button to view two edge lines on the image. The default edge enhancement filter is a Laplacian non-directional (enhances edges in all directions) filter. The coefficients of this filter are shown in the filter box that can be seen on the top right. The user can change the filter coefficients by pressing the 'change' button. The 'load monotone image' button can be used to simulate a data situation with no edges. This can be useful to theoretically understand how enhancement filters behave on a scene with no edges. The 'run filter' button can be used to apply edge enhancement on the input image, the results of which are shown on a second enhanced image.

8.2 RUNNING THE EDGE ENHANCEMENT FILTER

The user can load a single edge image or a double edge image using 'the load edge scene' button. The 'run filter' button can be clicked to apply the edge-enhancing filter on to the input image. The results of the enhancement operation are shown in data and image views on the enhanced image. To make the displays on the enhanced image brighter and more clearly visible, the user can 'switch on' the linear stretch button. This is a toggle button and the contrast stretch can be switched on and off by pressing this button. The edge contrast on the input and enhanced images are also shown just below the respective image views.

If the 'show calculation' check box (just above 'run filter' button) is ticked, step by step calculations of the edge enhancement operation are shown in the right pane. The user can press the 'Next' button in the message box to move to the next calculation. The effect of the

edge enhancement procedure can be clearly seen on the enhanced image. Regions bearing edge feature, after enhancement, acquire a higher contrast becoming much more prominent on the enhanced image as compared to the input image.

Moving the mouse pointer over any pixel on the enhanced image shows the digital value of that pixel.

8.3 CHANGING FILTER VALUES

The user can press the 'change button' (top right) to input new values for the filter Kernel.

It should be noted that DIPS supports only a 3 x 3 filter kernel which operates in the following manner:

Kernel coefficients are multiplied by respective input image pixel values. The products of the pixel values and filter coefficients are added together. The result of this addition is then added to the central pixel value on which the Kernel is operating. This value now becomes the new central pixel value of the enhanced image.

The filter calculator (activated by checking the 'Show Calculation' checkbox) shows the edge enhancement calculations in detail.

8.4 LOADING DIFFERENT EDGE SITUATIONS

 The DIPS edge enhancement module provides the user with an option of 2 edge scenarios. 'Edge Scene 1' shows an input image with a single edge trending from North to South. Edge scenario 2 shows an input image with two edges, one trending from North to South while the other from East to West. The user can choose either edge scenario by clicking on the load scene button (top left). In addition to the above, a monotone image having no edges (all pixel values are similar) has also been provided such that the user can see the operation of the edge enhancement filter in a situation where no edges exist. The user can start 'afresh' at any stage by pressing the 'start afresh' button.

8.5 HELP & EXERCISES

Press the Help or Exercises icons (bottom left corner) to see help or exercises on
this topic.

8.6 QUITTING

The user can quit the data reader module by pressing the 'quit' button (displaying a red cross)
or the cancel button on the window.

DENSITY SLICING

9.0 SUMMARY

DIPS Density Slicing module allows users to understand the density slicing process on a sample 64 pixel (8 by 8) image. The module permits the user to define upto 10 classes based on digital number ranges and assign colour codes to these classes. The classes set by the user are the used converts the input image into a colour coded density sliced image. The user can change the input image data and change default colours set by DIPS.

9.1 MODULE STARTUP

When the Density Slicing module starts up, it shows a sample image in data view displaying values for each pixel. On the left-hand side of the image, the change-by-mouse-click icon (mouse) and the bulk-pixel-change icon (a rubber pencil) are visible. These icons allow the user to change a single pixel value or change many pixel values respectively. The 'add slice' button permits the user to define density slice ranges.

The data view can be replaced by an image view in case the user prefers to view the image data as an image rather than data. Data change operations through the mouse and the pencil icons are not permitted in this view. To turn on the image view, click on the 'Image View' radio button. The image is displayed without any stretching. Two display options accompany the image view. The 'Linear Stretch' checkbox allows a user to apply a linear stretch to the image making the image more bright. Moving the mouse image show un-stretched pixel values for that pixel as seen in the data view. The stretched values are just used for the display. The second checkbox is for switching on pixel borders. This feature can be useful if the grayscale shade in which a pixel is being displayed is similar to the background. In such cases switc hing on pixel borders helps identify the area covered by the pixel clearly. Un-checking these boxes remove these display enhancements from the image.

9.2 DEFINING IMAGE SLICES

The user can define image slices quite easily, by clicking on the 'Add Slice' Button. Clicking on this button displays a line of input boxes in the slice frame. The user can input a title for the class, its lower limit and its upper limit. The lower and upper limits have to be values between 0 and 255 and as permitted by the softw are in different input conditions. DIPS assigns a default colour to this class. The user can change this colour by clicking on the colour box and choosing another colour from the displayed colour palette. In case the user decides do not change the colour after clicking the colour box, he/she can click on the same colour to dismiss the colour palette. The user can define upto 10 slices.

After the last slice parameters have been given, please press the 'Add Slice' button once again to register the last slice. This operation is needed because DIPS ensures that all slice boundaries provided upto a point by the user do not overlap . As this process of checking is done on the press of the 'Add Slice' button, the user needs to send the last slice values also through the same process. If this is not done , the last class is ignored.

Once finished, the user can press the "Done" button to indicate closure of class definitions.

The user is not permitted to give overlapping classes. Classes have to be distinct and comprising of valid values. Once a class has been defined and the user moves to input values for the next class, the parameters for the previous class (except change of colour) are frozen.

9.3 CREATING THE DENSITY SLICED IMAGE

Once the parameters have been defined as indicated by pressing the 'Done' button, the user can then press the 'Density Slice Image' button to create the density sliced image. In the event that the class definitions do not cover the entire range of pixel values in the input image, values falling outside the range of the defined classes are displayed on the sliced image using black colour. Moving the mouse over the sliced image reveals the identity of the class.

At this stage, if the user is not satisfied with the colours on the sliced image, the user can click on any colourbox in the class definition box and press the 'Density Slice Image' button once again and implement the new colour scheme.

The 'Redo' Button permits the user to give another set of class definitions and create a new sliced image with the new set of class definition parameters.

9.5 HELP AND EXERCISES

The user can seek help on this module by clicking on the help button (lower left book with question mark). Learning pointers and exercises on this topic can be seen by clicking on the 'exercise icon' (face with magnifying glass - lower left corner).

9.5 QUITTING

You can quit the module at any time by pressing the quit button or the window cancel button located at the lower right corner of the screen.

IMAGE CLASSIFIER

10.0 Summary

DIPS classifier helps a user understand the basic concepts involved in supervised classification of digital images. Classification of remotely sensed data is usually an important end objective of image analysis. The goal of classific ation is to assign each pixel value in the input image to an interpretation category and create a colour-coded map. For example an analyst might want to create a land cover map of an area using digital satellite data and might want to know the location of water bodies (to be shown in blue colour) , urban areas (to be shown in yellow colour), forest areas (to be shown in green colour) etc. In simple terms, the process of classification examines each pixel of the input image and tries to assign the pixel to one of the above classes. The result of classification is a colour coded map (or classified image if you would like to call it that) which shows regions of yellow, blue or green (as mentioned in the above example) each representing a cover type on the ground. Detailed descriptions of the supervised classification process are available in all remote sensing textbooks.

The DIPS classifier permits a user to create or define signatures for different classes and run a Minimum Distance to Mean (MDM Euclidean distance) or Parallelepiped classifier. The user can see step by step calculations involved in the process of classification. The module also provides facilities for comparison of classifications outputs from the two different classifiers or two options of the same classifier.

10.1 MODULE START-UP

When the DIPS classifier module is invoked, the start-up screen presents a single band 8x8 image (64 pixels). The 'rub & write' (pencil-rubber) and mouse icons are displayed on the left of the input image, which permit the user to change data in the

input image. The 'create new signature' button permits the user to demarcate / define signatures for different classes in which the input image is to be classified. As the classification process is sequential i.e. proceeding in steps, the start-up screen shows only the first step, which is 'signature creation'.

10.2 CREATING SIGNATURES

A user can easily define class signatures on the input image. The user can define a maximum of 10 signatures using the following iterative sequence (Suppose a user wants to define signatures for water, urban, forest etc, steps a to e below can be followed for each signature):

a) Press the 'create new signature' button, which enables the data view and image view.

b) The user can now point to any number of pixels, which make the first signature in either the data view or the image view. The pixels to be assigned to a signature can be selected in two ways. One is by dragging the mouse (keeping the left mouse button depressed and then dragging) around a region or block of pixels (called the block mode) and the other by pointing and clicking on a particular individual pixel. To select a pixel to be included in a signature as mentioned above, the user can use either the image view or the data view. The bock and individual pixel selects are operative on both views. Any number of contiguous of non-contiguous pixels can be included in a signature by selecting them.

The selected pixels are highlighted in light pink colour. To unselect a pixel the user needs to click on a selected pixel once again (select / unselect is a toggle operation) and the pixel is removed from the selection set. To clear an entire selection at one go, the user can click the 'clear selection' button.

c) Once all pixels to be included in a particular signature have been selected, the user can press the 'save signature' button to give the signature a name and a display colour. For example, if you wanted to create a signature for class water, you can click on pixel 1, 6, 10 etc to point which pixels are water. Then you can press the 'save signature' button to save the signature for water.

d) As the 'save signature' button is pressed, the user is prompted to enter the name for that signature (like water, urban etc.). After entering a name, the user can press OK to move forward. The DIPS classifier immediately displays basic statistics for the collected signature showing minimum value, maximum value, mean value and standard deviation.
This is just an information message to show what basic statistics is derived from the selection set. The user can press the OK button to proceed. The signature is now shown against a default display colour in the signature box.

The user has full freedom to change the colour of the signature or its name. To do this the user can click on the colour box to see a colour palette (not very generous though) and change the default colour. The name of the signature can also be edited or changed by clicking on the name box.

e) Using the steps outlined above (from a - d) the user can press the 'create new signature' button once again input a new signature. This process can continue till all signatures are defined.

f) When signature collection is complete, the user can press the 'stop collecting' button located at the bottom of the signature box. The signature collection process is now complete and the user can start classification.

10.3 PERFORMING CLASSIFICATION

To perform supervised classification, the user can choose the 'MDM' or 'Parallelepiped' classifier by checking the appropriate radio button seen in the 'perform classification' box. After choosing a classifier, the user can press the 'classify' button to perform the classification. The classified image is immediately shown as a colour coded image. The class identity of each pixel is shown by a text label comprising of the first 2 letters of the class. These labels can be switched on or off by checking or unchecking the 'text label' check box.

If the user chooses the Parallelepiped classifier, then the user has to provide the number of standard deviations that will be used to create a decision box around the class mean. The default is 1 standard deviation but the user can give 2 or 3 standard deviations. Choosing a higher standard deviation value reduces the number of unclassified pixels as the decision boundaries for each class become more liberal. This however increases overlap and reduces classification accuracy. If a pixel fits within the boundary of a class, it is assigned to that class without any further inspection of other classes that might also accommodate it. In summary, the pixel is assigned to classes on a first come, first served basis. Pixels not falling in any class are shown in black and are labelled as unclassified.

The MDM classifier calculates the spectral distance of the pixel in the input image from each class mean using the Euclidean distance equation. The pixel is assigned to the class whose mean is the closest to the pixel value. No unclassified pixels result as classification of every pixel is guaranteed due to the shortest distance criteria.

10.4 Classification Algorithms

The primary objective of the DIPS classifier is to elucidate the concept of classification and all associated processes. It therefore uses to simple classification schemes, which are commonly available on most image processing systems. More importantly, it tries to concentrate on the showing the anatomy of the classifier and common processes like signature extraction and comparison of the results of different classifiers. The module has been designed for the teachers to communicate the concept of classification lucidly and also for the student to work on examples to imbibe the basic idea behind classification.

As stated earlier in the section 9.3, DIPS provides the user with an option of two classifiers - a) The Minimum Distance to Mean and b) the Parallelepiped classifier. Details of the classification algorithms have been described in detail in Jensen (1986).

A summary however is presented. As I use a text file for help, I am unable to write equations in their proper form. I am therefore using algorithmic descriptions instead.

10.4.1 Parallelepiped Algorithm

The parallelepiped classification proceeds as follows:

a) After the user has given all signatures, the class mean and standard deviation for each class is calculated. Recall that this is shown just after you save a signature.

b) The user is asked to define number of standard deviations to use for creating a decision box for each class. The default is 1 but the user can give 2 or 3 . Choosing a higher standard deviation value reduces the number of unclassified pixels as the decision boundaries for each class become more liberal. This however increases overlap and reduces classification accuracy.

c) The number of standard deviations specified are then used to create a decision box boundary for each class by adding and subtracting the number of standard deviations from the class mean. For example consider water has a mean of 16 and a SD of 1.5 and urban has a mean of 65 and a SD of 3.5. Now if the user chooses to use 1 standard deviation to create boundaries, then the decision box for water will be 14.5 to 17.5 (16 minus 1 SD i.e. 16 -1.5 = 14.5 lower limit and 16 + 1.5 = 17.5 the upper limit). Likewise for urban, the decision boundary will be 61.5 to 68.5.

d) Now starting from the top left pixel i.e. pixel 1 to the last pixel i.e pixel 64, all pixels in the input image are examined one by one. The digital value of the pixel is examined against each class boundary. If the pixel value falls within the boundary of a particular class, then that pixel is classified to be a member of that class. No further examination for membership is conducted (this is a crude and undemocratic conflict resolution strategy but in pixel land, no pixel seems to mind it much, so its OK!).

e) Any pixel value not falling within any class boundary is assigned to the 'unclassified' category and is shown as black on the classified image with a text label 'Un'.

f) When we deal with more than one bands (not covered by DIPS Classifier), the stated number of SD's are, as shown above, subtracted from means of each band for a class and decision box for each band for a class is created. A pixel is assigned to a class only and only if , its digital values in each band fall within the decision boundary for that class in each band. See Jensen (1986) for a very good explanation and a solved example.

10.4.2 The MDM Algorithm

The MDM classifier calculates the spectral distance of a pixel in the input image from each class mean using the Euclidean distance equation (Pythagorean theorem). The pixel is assigned to the class whose mean is the closest to the pixel value. No unclassified pixels result as classification of every pixel is guaranteed due to the shortest distance criteria.

The algorithmic steps are as follows:

a) After signatures are given , the mean for each signature or class is calculated .

b) Starting from the top left i.e. pixel 1 to the last pixel i.e. pixel 64, all pixels are examined one by one. The distance of the pixel is calculated to all the class means. Taking the same example of the Parallelepiped classifier, we have two calsses i.e water (mean 16) and urban (mean 65) . If the first pixel value is 22 then the distance of 22 from 16 (water) and 65 (Urban) is calculated as follows :

> A = 22 (pixel value)
> B = 16 (Class mean value for water)
> A - B = 22 - 16 = 6
> C or Distance of A to B = square root of (A - B) * (A - B) = square root of
> (6 * 6) = Square Root of (36) = 6
>
> Distance from Water = 6

 Like wise now we calculate the distance of the pixel from the Urban Class

> A = 22 (pixel value)
> B = 65 (Class mean value for Urban)
> A - B = 22 - 65 = - 43
> C or Distance of A to B = square root of (A - B) * (A - B) = square root of
> (-43 * -43) = Square Root of (1849) = 43
>
> Distance from Urban = 43

As the pixel is closer to Water (distance is 6) than to Urban (distance 43), it is assigned to Water.

(c) On Multiband Images (not covered by DIPS) the means of a class in all bands are calculated and the pixel value in each band is subtracted from their respective means as shown above. Before taking the square root all values are added together and then the square root is taken to get a single value of distance of a pixel from a class.

10.5 SEEING CLASSIFICATION CALCULATIONS

To see detailed calculations of classification process, the user can press the 'calculator' check box, which is located just below the classified image. The user is prompted to give the number of pixel for which calculations will be displayed. This feature has been included such that the user does not have to wait inordinately for detailed calculations to be completed on all pixels. The classification process is repetitive and can be easily understood with just a few repeats. The default value is to show calculations five pixels. After specifying the number of calculations to be shown, the user can press OK followed by the click on the 'classifier' button once again.

The calculation window appears on the lower middle section of the screen. The pixel being considered for classification is highlighted on the input image by a rectangle and all calculations with reference to the classifier are shown in the calculator window. The user can press NEXT on the calculation box to move to the next step. A message informing the user of the assignment of a pixel to a class is shown on the screen and the classified pixel is displayed on the classified image. The user can keep pressing NEXT button to move to the next pixel seeing calculation at each step.

10.6 RETAINING RESULT OF CLASSIFICATION FOR COMPARISON

The user can click on the 'retain classification' button (located on the right hand side of the classified image) clicking this button moves the classified image with its label to the bottom half of the screen. The user can now choose a different classifier and press the classified button to see the result of that classification. The comparison to the earlier classification can then be made.

10.9 STARTING ANOTHER SESSION

If the user wishes to start a new session without quitting the classifier, two options are available. The 'Redo' button can be chosen when the user wishes to preserve input image data that might have been entered. Using the same data, the user can start afresh with the 'Redo' button. However if the user wants to start afresh altogether with the default input image values, the Restart button can be pressed. This button is equivalent to exiting the classifier module and starting it again.

10.8 HELP & EXERCISES

Press the Help or Exercises icons (bottom left corner) to see help or exercises on this topic.

10.9 QUITTING

The user can quit the Classifier module by pressing the 'quit' button (displaying a red cross) or the cancel button on the window.

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Reference Cited: Jensen, J.R. (1986): Introductory Digital Image Processing - A Remote Sensing Perspective . Prentice-Hall Englewood Cliffs, New Jersey.

DIPS ACCURACY ASSESSMENT MODULE

11.0 SUMMARY

The accuracy assessment module uses a classified image and a ground reference map to create an error or confusion matrix, show errors of omission and commission and show the kappa (K Hat) coefficient. It permits the user to see the error matrix, kappa coefficient and omission and commission error calculations in a step by step mode through the use of calculator buttons.

11.1 MODULE SARTUP

The accuracy assessment module displays two images at startup. The Image on the top is a small, 64 pixels (8 by 8) mock-classified image having 5 cover classes - Water, Urban, Forest, Barren and Scrub. The Image below is a ground reference image showing the true identity of these pixels as seen on the ground. The identity of the pixels on the ground is usually established using site visits with a GPS, maps or aerial photographs.

The two mouse icon buttons on the left of each image permit the user to change the cover characteristics on both these images. This feature should be particularly useful for teachers who can set up the classified and ground reference in a particular manner to illustrate nuances of error matrix calculations. The class names however have to be one of the 5 classes (Water, Urban, Forest, Barren or Scrub) mentioned above. The legend button can be checked or unchecked to show or hide the legend.

11.2 CHOOSING SAMPLING INTENSITY

A user can proceed to create an error matrix by first choosing a sampling intensity value by clicking on the "Set Sampling Intensity" button highlighted by a small green bullet. This presents a radio button set which has options for 10%,20%,30%,40% and 50% sampling intensity. Make a choice and press OK to set sampling intensity out of total of 64 pixels.

11.3 IDENTIFYING SAMPLE PIXELS

The green highlight now moves to the "Identify Sample Pixels" button. Pressing this button randomly selects n (determined by sampling the set intensity in the previous step) number of pixels and highlights (depresses these pixels) them on both the classified image and the ground reference. Moving your mouse over any of these pixels selected in the sample shows a message "SEL" indicating that the pixel under the mouse is selected in the sample.

You can press the "Identify Sample Pixels" button again at this stage to select another random set. You can also go back and set a fresh sampling intensity and reselect pixels by pressing the "Identify Sample Pixels" button again.

11.4 CREATING AN ERROR MATRIX

After the pixels have been selected, the green bullet travels beside the "Create Error Matrix" button. Just press this button to calculate and display the error matrix.

11.4.1 Seeing Step-by-Step Calculations

You can see step by step calculations of the error matrix by pressing the 'Calculator Icon' seen at the bottom left of the error matrix. Moving your mouse over this button shows a line of explanation. Just press this button to start the calculation of the error matrix in a action-replay, step-by-step mode. The pixels under consideration are highlighted one at a time by a red rectangle on both the image and the ground reference. You can go through the calculations seeing the identity on the ground and identity on the classified image and following the tabulation in the calculator sheet. To move to the next pixel, press enter or space bar or next button in the 'DIPS Calculator Pause" window in the bottom left of the screen.

You can bypass the step-by-step calculation at any stage by pressing the "Canc el" button.

The error matrix calculator button is a toggle button. You can click to activate and re-click it to deactivate the calculator tabulation sheet.

11.4.2 Seeing the Omission & Commission Errors

Press the O|C icon (red and blue) on the top right of screen (beside the error matrix) to see the omission, commission and percent correct values for each cover class. You can compare this tabulation sheet with the error matrix results to follow calculations.

Click on the O|C button once again to dismiss the omission / commission tabulation sheet.

11.4.3 Seeing the Kappa Coefficient

Press the K icon (with the yellow Border) on the top left of the screen (Just below the O|C Icon). The Kappa calculator is started and you can see step-by-step calculations of the Kappa coefficient. Red rectangular highlights on the error matrix show the elements of the error matrix that are used for calculations at that step. To move to the next pixel, press enter or space bar or next button in the 'DIPS Calculator Pause" window in the bottom left of the screen.

You can bypass the step-by-step calculation at any stage by pressing the "Cancel" button.

The Kappa button can be pressed again to dismiss the Kappa tabulation sheet or activate the kappa calculator at any time.

11.5 RE-COMPUTING THE ERROR MATRIX

You can re-compute the error matrix with a different selection of pixels by following steps 2.2, 2.3 and 2.4 as described above.

11.6 CHANGING IMAGE AND GROUND REFERENCE PIXELS

DIPS provide the user with an option to change the identities of the classified image and ground reference pixels permitting users to set up their own examples. To change a pixel identity on the ground or classified image, just click on the change-by-mouse-click (mouse) icon on the left of the respective images. Then click on a pixel to initiate change. DIPS asks you to type in a new identity of the pixel which has to be one of the five preset classes (W, Ur, Fo, Ba and Sc). Just type in any of these abbreviations and the identity of that pixel will be changed along with its identity colour. You can point to another pixel and make as many changes as you wish to both images. You can move your mouse over a pixel to see its identity in a small mouse highlight.

You need to click on the mouse icon only once to make changes. The changes remain alive during a session. When DIPS accuracy assessment module is invoked again, the default pattern is re-established.

11.7 HELP AND EXERCISES

Click on the 'Show Exercises' Button (Distraught Guy with a magnifying glass) to see learning pointers and exercises. Press the help icon to get help on this topic.

11.8 QUITTING

Click on the Quit button or the window cancel button to quit the accuracy assessment module.

RGB VIEWER: EXERCISES AND LEARNING POINTERS

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1. What values can you give to create white colour on the display pixel? What is the reason for this white Colour?

2. How can you create Black colour on the displa y pixel? What is the reason for this white Color?

3. Try creating the pixel colors for the following cover types (Typical values):

     Forest   : IR - 75   , Red - 25   , Green - 53
     Green Crop   : IR -154 , Red - 28   , Green - 34
     Deep Water   : IR - 15   , Red - 26   , Green - 55
     Shallow Water : IR - 19   , Red - 47   , Green - 86

    Why does the crop pixel appear red? Why do the water pixels appear dark?

4. Match the following colors with the appropriate RGB intensities ? (Verbyla, 1995). [Tip : Recreate intensities on DIPS RGB Viewer to create displayed color and match with color in column 1.]

_____

Color	Displayed Color	R	G	B
1. Red	_____	255	255	255
2. Green	_____	125	125	125
3. Blue	_____	0	0	0
4. White	_____	255	0	0
5. Black	_____	255	150	0
6. Gray	_____	0	255	0
7. Cyan	_____	0	0	255

8.	Magenta	_____	255	255	0
9.	Yellow	_____	0	0	70
10.	Brown	_____	65	25	130
11.	Sand	_____	150	150	0
12.	Orange	_____	0	255	255
13.	Navy Blue	_____	255	0	255
14.	Mint Green	_____	215	167	116
15.	Avocado	_____	95	60	0

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Reference:

1. Verbyla,David.L (1995): Satellite Remote Sensing of Natural Resources, Lewis Publishers (CRC Press), NY.

PIXEL ANIMATOR :EXERCISES AND LEARNING POINTERS

1. Press the 'Create Composite' button and see how individual pixel values in each band assigned to each gun, recreate pixel colour. Notice that some pixels have a distinct blue of green colour which is because of high pixel values in the band assigned to that colour and low values in the other two bands making colour contributions of those other guns very small.

2. Press the 'Refresh' button and check (tick) the 'Apply Linear Stretch' checkbox (should be ON). Now press the 'Create Composite' button once again to see the application of the linear contrast stretch algorithm to input pixels. The original values are sort of made to de-tour through the linear contrast equation. Notice that the resultant colours are much brighter than the image that you saw in exercise 1. The reason is that the full display scale is used and the separation in pixel colours as a result, is much higher.

3. Take a good look at the image generated by exercise 2. Notice that there are bright red pixels, one bright blue pixel and two bright green pixels. Try to see why the green pixels are green or why the red or blue pixels are red or blue. You will see that this is

because of high digital values in the band, which is being displayed by the gun of the dominant colour.

Now using the left arrow button (click once) on top of the image, swap the band positions. You will see that Band 2 which had been assigned to the GREEN gun is now assigned to the RED gun and Band 1 which was assigned to the RED gun is now assigned to the BLUE Gun. Now click the right arrow key once and swap Band 1 with Band 3 such that Band 3 is now assigned to GREEN and Band 1 to the BLUE.

Try to visualize what you are going to see in the following Table:

Predicted Changes in the Colour of Pixels after Swapping Bands
_____ ____

Pixels now Seen as RED should appear in _____.

Pixels now Seen as GREEN should appear in _____.

Pixels now Seen as BLUE should appear in _____.

_____

Now press the 'Create Composite' key to see the results. Do the pixel colours match with your predictions?
4. Try to play around swapping bands and see changes in pixel colours. Try seeing the RGB digital values pixels in strange hues. You can use RGB Viewer to recreate some typical hues by noting down their digital numbers and then reproducing them in the RGB viewer.

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DATA READER:EXERCISES AND LEARNING POINTERS

1. Perform a slow read choosing all the three data formats and note the sequence used to reconstitute individual bands of data. Make yourself familiar with all the formats.

Learning Pointer

On image processing systems, once data that you get from your remote sensing agency on CD (earlier on this data used to come on tape) has been read, it is stored by the image processing system in its own formats and the user uses these files for subsequent image processing. On ERDAS for example, once data that you have purchased has been read, it is stored as erdas .img files. It is therefore very important that the correct parameters and formats are given/used when the data is being read by the image processing system for the first time.

2. A person ordered digital data from the remote sensing agency of his country and got the following 3 band (Band 1 Green, Band 2 Red , Band 3 IR) 3 rows and 3 column data (27 Pixels in all) written in BSQ format on a CD:

21,22,23,24,25,26,27,28,29,31,32,33,34,35,36,37,38,39,
41,42,43,44,45,46,47,48,49

Although the data was written in BSQ format by the agency from which it was bought, this person, by mistake, read the data in BIL format.

Tasks and Questions on the above situation

(a) In the data reader module, enter the above data in the data strip by clicking on the 'pencil rubber' icon just located just below the data strip.

(b) Read the data, using BSQ format (choose BSQ in the image read box) to see how the data should have been correctly read.

(c) Now press 'Refresh' and read the data in the BIL format (choose BIL in the image read box) to see what mistake was made by the person who read the data in the wrong format.

(d) Analyze the results of this wrong read operation in the light of spectral characteristics of each band (band 1 was green, band 2 was red and band 3 IR as written on the CD). What spectral properties do the wrongly read bands have? For example would the Band 3 show water pixels in dark shades, as one would characteristically expect on an IR image?

3. There can be situations when the number of rows or columns is wrongly given by the analyst at the time when the image data is being imported into an image processing system from the tape or CD on which image data was procured. If this happens, it is perfectly possible to create valid image files in the specified number of bands but the data values in those bands is spectrally incorrect because the bands have not been read in the correct sequence.

Subsequently when such data is displayed or analyzed, it does not exhibit the spectral properties that the analyst expects to see for a particular band. To simulate this problem in DIPS, let us presume that the correct number of rows and columns in which data was written by the remote sensing agency was 3 rows and 3 columns. You can presume any format to be correct but to begin with we can presume that BSQ was the format in which data was written by the agency. Now read the following situation and using the 'row/col change' button (the one under 'Header' on the upper left of the form) to alter number of rows and columns and see the results of such faulty reads :

An analysts ordered digital data in three bands. The data comprising of 3 rows and 3 columns in each band was recorded on a CD and sent to the analyst. While reading this data on his image processing system, the analyst by mistake gave the wrong number for rows or columns (like 2,3 or 3,2 or 2,2) and

imported the data. What would have been the content of the resulting bands? For example, if instead of specifying 3 rows and 3 columns as was rightly the case, if the analyst were to specify by mistake, 3 rows and 2 columns or 2 rows and 3 columns while reading data in the correct format i.e. (try BSQ first but you can presume any format to be correct), what would be the data content of the 3 read bands (3 Rows and two columns each or 2 rows and 3 columns each etc.)? Would this content be spectrally correct?

Task

Using the row/col change button (under 'Header') and pressing the 'slow read' button, examine the data strip from left to right following the highlights to graphically see this situation and see what data has been stuffed in each band.

Try out different combinations of rows and columns. Try to see which pixel values were not read at all and to which spectral band they belonged? If Band 1 was Green, Band 2 Red and Band 3 Infra Red , do bands 2 and 3 after such a faulty read contain RED and IR Data?

NOISE REMOVAL: EXERCISES AND LEARNING POINTERS

1. The effect of the dropout data and its correction can be more dramatically seen if all other (non row 3) pixels are given a single value. Using the 'Change Data' button, change all pixel values (except row 3, which cannot be changed) to 180. If the image in the 'Image View' is not clearly visible, switch on pixel borders. Now press the 'correct dropout' button. Compare the resultant image with the input image. Does the resultant image offer a better visual appeal ?

2. Click on the 'Salt and Pepper Noise' button (right pane, button two) to introduce 'Salt and Pepper noise. Click on any of the Row 3 pixels to effect corrections. Are the bight and dark pixels treated in a similar manner?

3. What is your opinion about this method of noise correction? Does it replace one set of spurious values with another in the sense that corrected data is user created and not collected by the satellite? Can introducing new data through corrections artificially effect other enhancements and classification?

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FILTERS: EXERCISES AND LEARNING POINTERS

Q1. The default-input image contains data, which has all border rows set to 55. The central part of the image (minus the borders) has the following data:

$$
\begin{array}{cccc}
80 & 95 & 96 & 85 \\
60 & 65 & 66 & 59 \\
80 & 78 & 76 & 88 \\
65 & 68 & 72 & 66 \\
\end{array}
$$

It is these image pixels that are under the view of the filter.

a) Choose the default low pass filter with all coefficients set to 1.

b) Run the low pass filter on this image (use 'Run Filter' button). After the first run, copy (use the 'Copy Image' button) the filtered data and run the filter again. Repeat the process 9 times seeing at each stage what is happening to the above data values? At each stage observe the image view of the data comparing the input image and the output image.

c) Do the values converge coming closer and closer to the border (surrounding) pixel removing the detail that the image had when you first started?

d) What are the values of the above central pixels on which the low pass filter operates after the 9th run?

e) Looking at the operation of the above filter, can you conclude that low pass filters try make the pixels on which they operate come closer and closer to their

neighbours removing detail and creating homogeneity (blurring of image as all pixels have very close or similar values)?

Q2. Try other low pass filters as given in the 'suggest' message box and compare their results with those of the default (all values to 1) low pass filter. Run the other filters 9 times and see if they produce similar results to what you see in question 1. If not, then can you say that these filters have a less blurring effect on the image ?

Q3. Choose the default high pass filter (all -1 except central pixel which is 16) and run the filter 6 times on the image. Take a note of what happens at each step and try to see the behaviour comparing it to the behaviour of the low pass filter in Q1. Think about the following:

a) Do the central pixel values merge with the border values are do they separate from their neighbours creating a widening value rift and high contrast?

b) What do you see after the 6th iteration?

Q4) Try other high pass filters given in the high pass 'suggest' message box. Run these filter 6 times and see if similar results are produced as compared to the default high pass filter. If not, try to analyze how these other high pass filters are different from the default filter. Try to see how many passes are needed to create a saturated image (like 6 times for the default high pass filter).

Learning Pointer

Try some other high and low pass filters on the default image. You can get these filters from Digital Image Processing textbooks. You just have to ensure that they work using similar kernel math as what the DIPS filter explorer uses.

Try changing the default image to something different and see the effect of these filters on your image.

The EDGE ENHANCER MODULE also allows you to run high pass filters on sample image data. Filters in the EDGE ENHANCER module use slightly different kernel math. Some high pass filters that you might come across in textbooks could be implemented using the EDGE ENHANCER MODULE.

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RATIOS: EXERCISES AND LEARNING POINTERS

Q1. Ratios can also be used to offset effects of differential illumination. For example, if a feature occupies both the sunlit and the shady side of hill, reflectance values from the same cover type would be different. The following problem scenario is adapted from an example adapted from Lillesand and Kiefer (1987) :

A Hill is receiving sunlight at an angle at the time of a satellite overpass. In this peculiar situation, one side of the hill is brightly lit while the other is in shade. The hill on both sunlit and shady sides is covered by trees of species A. In other words the cover type is identical on shady and sunlit sides. When satellite data in two bands in seen, the area falling on the sunlit side (being better illuminated) has much higher digital values as compared to the area falling on the shady side . The 36 pixel data in the two bands is given below. In the following images, the top three rows are from the illuminated side and the bottom three rows are from the shady side :

Band A	Band B
48 50 52 53 49 50	60 62 65 67 63 60
50 55 53 49 48 52	63 65 64 59 61 63
53 52 50 49 47 49	65 62 64 58 59 57
15 18 17 16 18 17	20 21 19 20 22 21
16 14 18 19 17 16	19 18 22 23 21 19
15 18 19 17 19 18	21 23 21 20 24 23

TIP : To enter the se values just click on the rub-and write icon and the use the numeric keypad to enter values. To move to then next pixel, press enter on the keyboard. This way you need not use the mouse to input data.

If the above bands were to be displayed, the upper three lines would appear much more brighter than the bottom three lines in each band even though they are the same cover type.

Tasks to be performed:

a) Using the 'rub-and write' (rubber pencil) icon, enter the above data in bands A and B.
b) Using the 'Simple Ratio' setting, press the divide button and see the appearance of the image.

Learning Pointers
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c)Does it appear bright in the upper half and dark in the lower as the original would have appeared ?

d) If not, what has been the reason for this transformation? Try clicking on pixels from the upper three rows and note the ratios. Now click on the pixels from the bottom 3 rows and see the ratios?

e) Even though the values in the lower rows are lower, are the ratio's in the upper and bottom rows very different? Also see what display values have been finally assigned to the upper 3 and lower 3 rows on the ratio image?

Q2. There is a L shaped plantation in a large urban sprawl. The following two band data, Band A - IR and Band B - Red, has been acquired for the area. Using and NDVI ratio image can you locate the L shaped plantation on the image:

Note : This problem has NOT been inspired by M. Night Shyamalan's - SIGNS

        Band A (IR)   Band B (Red)
------------------------   -------------------------
  41 43 51 52 49 51   59 63 64 68 66 62
  44 46 88 49 48 52   61 68 34 66 63 59
  53 52 83 49 47 49   68 66 36 68 62 66
  55 51 81 46 55 48   63 67 34 69 58 57
  49 50 83 81 84 56   59 70 35 37 32 69
  55 49 51 55 54 55   65 63 71 70 68 69

Tasks:

a) Enter data in the two bands
b) Choose NDVI ratio setting
c) Divide and create a ratio image

Learning Pointers
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d) What is the reason for what is visible on the image? Click on the bright and dark image pixels to see ratio values and try to examine the cause.

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Reference: Lillesand,T.M. and Kiefer,R.W.(1987): Remote Sensing and Image Interpretation, 2nd Edition , John Wiely , NY

DENSITY SLICING: EXERCISES AND LEARNING POINTERS

1. Alternately click between the data and the image view and examine the image. Let us now make some presumptions after having examined this image. Notice that a dark feature from North to South bisects the image. This is a river having a range of digital values between 3 - 19. The upper left block of pixels (on upper left side of the river) is a barren open area with values ranging between 60 - 69. The lower left block of pixels is a heavily built-up area with pixel values ranging between 28-40. The upper right block (located on the upper right side of the river) is a forest area with pixel values ranging between 88 - 99 while the lower right block of pixels is a semi-urban area with pixel values ranging between 49 - 58 . The above ranges are summarized in the following table:

Class / Slice Title	Range of Digital Values
Water	3 - 19
Barren/Open Area	60 - 69
Built-up Area	28 - 40
Forest	88 - 99
Semi-Urban	49 -58

a) Create a density or level sliced image using the above ranges. Click on the 'Add Slice Values' button. Type 'Water ' in the slice title, enter 3 in the low box and 19 in the high box. Click on the green colour box and pick a shade of blue from the palette to assign it to water.

b) Click on the 'Add Slice Button' and repeat step (a) for all the other remaining slices entering their name, low and high values. Choose a different colour for each class.

c) Once all 'slices' have been entered, press the 'Done' button.

d) Now click on the 'Density Slice Image' button to create the density sliced image.

e) Compare the colour regions shown in the density sliced image with the slice ranges. Is the density sliced image in tune with what you expected to see?

2. The river water is polluted at places and we are now interested only in the river feature. As you have seen from the above exercise, the river water values range from 3 - 19. With reference to pollution levels in the river, the following has been determined from a correlation of pollution levels and radiometric values of polluted water :

Pollution Level	Pixel Range
Low	3 - 9
Moderate	10 - 13
High	14 - 19

a) Press the 'Redo' button and create a density sliced image as shown in 1 giving 'Low', 'Moderate' and 'High' as slice titles and the low and high values of each slice. Create a fourth class and title it 'Others' and enter its Low as 20 and high as 255 to mask off all other features in the image to a single colour (they don't interest us in this exercise!). MAKE SURE YOU PRESS THE 'ADD SLICE VALUES' BUTTON AFTER YOU ADD THE LAST CLASS ELSE IT WILL NOT BE INCLUDED in the list.

b) In your opinion, is the density sliced image helpful in showing pollution levels inside the 'river' feature?

3. You can visualize another situation. Change data values on either side of the river with values ranging from 70 to 99 (use rub n write icon). Now imaging that this is a forest area, which has been infected by a leaf-eating pest in varying degrees. Create a hypothetical list of damage categories imagining that the data comes from the IR band. Categories could be like 'Severly Damaged', 'Moderately Damaged', 'Unaffected' etc. and assign pixel ranges for each category with lower values to the damaged groups and higher values to the 'unaffected' categories. Create a density sliced Image and study the results.

SUPERVISED CLASSIFICATION: EXERCISES AND LEARNING POINTERS

1. You can perform an example land cover classification involving four classes. To perform this classification, follow the sequence given below:

Create Signatures

We plan to classify the image in 4 classes - Water, Barren, Forest and Urban

a) Click the 'Create New Signature' button. The data view and the image view become enabled.

b) We will first create a signature for WATER. Individually Click on the 4 pixels on the top left corner (18,21,16,19) of the image. You can click them on the image view or data view. As you click them the pixels in the data view get highlighted in a pinkish hue. These pixels will form our signature for 'Water'. You can also select these four pixels by keeping your left mouse button depressed and then dragging the mouse around the four pixels. To unselected just click once again on a pixel and it will get unselected.

c) Click on the 'Save Signature' button. You will be prompted for a name of the signature - type 'Water' . DIPS Classifier will show you the basic statistics for this signature. Press OK and the signature will appear in the signature box. A default colour will be assigned. Click on the default colour and choose the blue colour for water.

d) Now we can create the second signature for BARREN. We will select the 4 pixels on the top right (66,58,66,68) corner of the image following steps B and D described above. the name of this signature will be BARREN . Likewise to create a signature for FOREST, choose the 4 pixels in the lower left corner of the image (96,98,103,105) . Finally for URBAN, select the four pixels in the Lower Right corner (46,41,39,42) of the image .

e) Click on colour box against each signature to give each signature a proper colour of your choice. If you made a typing mistake while typing in the name of the class earlier, you can click on the 'Signature Name' box and reenter the name.

f) Press the 'Stop Collecting' button. Signature definition is complete.

Performing Classification

You will now see 'Perform Classification ' box with the Minimum Distance to Mean (MDM) option checked.

g) We will take the default MDM Classifier . To classify the image , press the 'Classify' button. The image will be classified and shown in the top middle of the screen.

h) you can change colours on the classified image also by changing the colour in the signature for a class and then pressing the 'Classify' button once again.

i) To see the calculations and to know how each pixel has been classified using the MDM algorithm, just check the 'Calculator' checkbox and press 'Classify' button again. Choose default 5-pixel show and you will be shown detailed calculations.

2. Press the 'Retain Classification' icon (two pinned notes on the right of the classified image) to hold the MDM output. The MDM classification will be shifted to the lower half. Now choose the 'Parallelepiped' classifier by checking the 'Parallelepiped' checkbox. Choose the number of SD to use (Choose default 1 to start with) and press OK . The parallelepiped classification will be shown. Unclassified pixels will be shown in black (see help on this topic for more description). Compare the two classifications. Which one is better? If you wish to see how the parallelepiped classifier works, start again and as explained in step (g), check the 'Parallelepiped' option and then follow step (h) and (I).

3. Like the comparison between two classifiers as shown in exercise 2, compare the classification performed by the parallelepiped classifier giving 1 SD, retaining the classification, then redoing the classification with 2 SD's. See how many pixels remain unclassified and why? You can then retain the 2SD classification and then redo the classification with 3SD and compare the results. Why do less number of unclassified pixels remain when you increase the number of SD's?

4. Try formulating your own examples by changing image data and then performing a classification.

IMAGE SUBTRACTION: EXERCISES AND LEARNING POINTERS

Q1. Using the default image data on both images, create a difference image by clicking on the 'Subtract' button. Click on one of the four central pixels and in the calculator box (which appears on the left) , press the '?' button to take a note of the displayed scaling equation. Analyze the following:

Learning Pointers

a) In the data view take a note of the differences obtained by subtracting the central four pixels on image 2 from those on image 1.

b) click on central pixels and see how the subtracted values have been converted using the equation to a display range between 0 - 255.

c) Swap the two images and see tonal differences in the central pixels.

d) Why do all the pixels surrounding the four central pixels appear in a monotonous gray tone? What display value has been assigned to such pixels and how (click on any of the outer gray pixels to see calculations)?

Q2. Seeing the extreme limits of subtraction

a) In the above scenario if the difference between two image pixels was -255 or +255, what display values would have been assigned to them by the equation? Try creating such a situation and study the results. Use the 'mouse icon' and change the top left (pixel 1) value on the Image 1 to 255 and the same pixel value on image 2 to 0. Now subtract the two images. Do you see the top left pixel very bright ? Click on it to see what display values it has acquired?

b) Clik on 'data view', and swap the two bands using 'Swap Image' button. The situation is reversed and the first pixel in image 1 is now 0 and that on image 2 is 255. Now subtract and see the result. Is the left top pixel very dark. Click on the dark pixel to see how extreme negative values are mapped on the display scale by the equation.

You have now seen how, 0, 255, -255 and in-between values are handled by the scaling equation.

EDGE ENHANCEMENT : EXERCISES AND LEARNING POINTERS

1. U ncheck (off) the show calculation checkbox and run the default filter on the default single edge input image. Click the 'Linear Stretch on' button and examine the area of the edge (north to south as shown in input image). Analyze the following :

a) Can you see the edge area more pronounced on the enhanced image?
b) Find out why this is so? Move your mouse over the edge pixels on the input image and the enhanced image. See the contrast value of edge pixels (99/69) as shown just below each image. What has the filter actually done?
c) Repeat the above process with the show calculation checkbox checked and observe how this filter actually works and changes values .

2. How would this filter work on an image, which has no edges? Does the filter change values on the enhanced image like it does in the above case ? Try the following and see :

a) Press the 'Load Monotone Image' button. Are there any edges on this image?
b) After checking the show calculation checkbox (on) , run the default filter on this image.
c) Have any pixels on the enhanced image changed? Can we say that this filter only impact edge situations?

3. Now press the 'Load edge scene 2' button. You now see an image with edges in two directions (N - S and E - W) . Run the default filter on this image and analyse the results as you did in the first exercise. Also try to reflect on the following :

a) Has the default filter , enhanced edges in both directions (EW and NS)?
b) Can we say that this filter has no particular preference for edges of a particular direction or is non-directional?

4. Press the 'suggest' button and try the first of the two suggested filters on the single and double edge images and compare the results with the default Laplacian filter.

 (a) Does this filter (all -1 and central 8) create a more pronounced edge enhancement as compared to the default filter?

(b) Now try filter number 2 (central 5) on the single edge image and see the effects . Does this filter create a better enhancement by widening the edge area to span four columns as compared to the two from the default filter?

5. Have a look at the following filter:

```
 1   -2   1
-2    4  -2
 1   -2   1
```

(a) Run this filter on the monotone image (no edges) and see the results.
(b) Run this filter on the Single edge (N - S) and see the results .
(c) Now load the 'Edge scene 2' with two edges and see the results ?

What can you make out from the behavior of this filter? Have a closer look at the calculations and try to see why it does not impact the image with only one edge (N - S)? Also why only the center of the second two-edge image is impacted?

6. Two new filters are presented below (from 1 - 9 in the filter kernel):

Filter 1 (west) :

```
 1 ,  1,  -1
 1 ,-2 ,  -1
 1,   1,  -1
```

Filter 2: (north)

```
 1,   1,   1
 1,  -2,   1
-1,   -1, -1
```

Now try the following

a) Press the 'Load edge Scene 2' button to load the two edge image .
b) Use the 'change' button to enter coefficients of filter 1 above.
c) Run the filter.
d) Move your mouse over the edge 1 and edge 2 area on the enhanced image. In terms of contrast, has this filter acted selectively to improve the north-south edge more as compared to the east -west edge. In other words can you say that the response of this filter is more for north - south edges as compared to east - west edges?

e) Following steps, a to c above, load the coefficients of the second filter and run it on the image with two edges. In terms of contrast, is this filter giving more response to highlight the east-west edge as compared to the north-south edge ?

f) If you try any of the above filters on the monotone image (no edges), do you see any effect of these filters in no-edge situations.

ACCURACY ASSESSMENT: EXERCISES AND LEARNING POINTERS

1. Try creating an error matrix for the default data. Follow these steps:

a) Click on the 'Select Sampling Intensity' button and choose 50% sampling intensity and press 'OK'.

b) Now click the 'Identify Sample Pixels' button to randomly identify 32 pixels on input and reference images (32 because you chose 50 %. There are 64 pixels in total on the input image). The selected pixels are highlighted on both images. If you click on the 'Identify Sample Pixels' button again, you can identify a different set.

c) Now click on the 'Create Error Matrix' button to generate the error or confusion matrix. The error matrix is calculated and shown.

d) To see how the error matrix has been computed, click on the 'Calculator' button just below (left corner) of the error matrix. Each step in the calculation of the error matrix is shown. Notice that the error matrix is reset and starting with the first class, one of the selected pixels is taken on the ground image and its identity is confirmed on the classified image. Scores are kept and shown in the calculator table. You can press enter key or spacebar key (or use the mouse) to move to the next pixel. To come out of the step by step mode, you can bypass the calculator by clicking on the 'Cancel' button.

e) Repeat step d once again but this time can you spot for each class 'omission' and 'commission' errors as calculations progress ? A pixel on the ground shown for example as urban is not urban on the classified image. This is 'omission'. Something shown as urban on the classified image which is actually something different on the ground, is 'commission' i.e. unjustified inclusion of a pixel into the category urban when it is really not urban.

f) To see a detailed analysis of the errors or omission and commission and % correct (correctly classified) , click on the 'Omission/Commission' icon (displayed as O/C) on the right of the error matrix. Try to analyse the matrix to assure yourself that it is as you expect it to be. Which classes have the maximum confusion in terms of omission and comission errors? With which classes is 'Barren' most confused with ?

g) There are two terms commonly used in the above context. These are 'Users' accuracy and 'Producers' accuracy? Read about thee terms. Can you spot users and producers accuracy in the table?

h) To see the Kappa Coefficient (KHAT Statistic), press the 'Kappa' icon (displaying a K) on the right of the error matrix. The calculation of the Kappa coefficient is shown in a step by step mode. You can follow the calculations tracing the highlights on the error matrix and the resulting calculations on the Kappa calculator table. The basic 'ingredients' in the Kappa calculations are the row and column totals in the error matrix. If the kappa value is .75 for example,

it basically means that the classification is 75% better than that expected if we randomly assigned a cover type class (rather than classify) to each image pixel.

For the present example, How do you interpret a KHAT value of .67? Is it good?

2. Can you think of an example error matrix, which would have a KHAT value of 0? (Verbyla,1995) (This question can be categorized as a mild teaser!)

3. Using steps highlighted above, experiment with different sampling intensities as you did in step (a) in 1 above and then Calculate the error matrix. Is there any effect of low or high sampling intensity on the overall classification accuracy? Keeping the sampling intensity is low (like 10 %) try pressing the 'Identify Sample Pixels' button a few times. Is there a chance that in some selection, some cases a class is completely underrepresented in the sample? Would a stratified random sample be a better sampling approach?

4. Simulate some changes on the input and ground reference images using the mouse icon and try computing error matrices.

5. What might be the consequences if we had no effective means of assessing the accuracy of classification of a remotely sensed image? (Campbell, 1987)
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References:

1. Verbyla,David.L (1995): Satellite Remote Sensing of Natural Resources, Lewis Publishers (CRC Press), NY.

2. Campbell,James.B(1987) : Introduction to Remote Sensing, The Guilford Press, New York.