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IKONOS Image of Hong Kong

This one-meter resolution black and white image of Hong Kong, China was collected November 21, 1999 by Space Imaging's IKONOS satellite. The image features the Hong Kong Convention and Exhibition Centre, Bank of China Tower and Star Ferry Pier. Credit: Space Imaging. (Further information on page 2)

Delineating a Study Area Within a Rectangular Data Set: A Class Exercise

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Abstract

This article deals with an image processing exercise used in a university undergraduate remote sensing course. The exercise shows students some techniques for delineating a non-rectangular study area within a rectangular image data set. Rectangular data sets frequently create problems for students when their areas of interest are polygonal in shape. An inexpensive image processing software package called Earthscope is used in this exercise.

A problem frequently encountered by students working with image data sets deals with the rectangular nature of such data sets. Because of this condition, these data sets generally encompass areas beyond the particular area being studied, and thereby, create a situation where students find it difficult to produce reasonable land cover classifications along with accurate area counts of each land cover class. Many schools do not have access to expensive image processing software packages that permit students to cut out specific areas within rectangular data sets. This paper describes an exercise used in an undergraduate remote sensing course, which has students, with the use of an inexpensive software package, addressing the problem of delineating a particular geographic area within a rectangular data set. This paper provides the step-by-step procedures used by the students. These procedures can be used with other data sets.

Data Set

The data set used in this exercise is a Landsat TM image, which covers a small section of the Mississippi Lowlands south of Memphis, Tennessee, U.S.A. (Figure 1.) The image contains the Mississippi River with a number of backwater areas, an unprotected floodplain, and areas protected by levees. The objective of this exercise is to segregate the unprotected floodplain from the water areas and the levee protected areas, and in the process, create a new data set where only the land cover on the floodplain can be studied and classified.

The image was taken on January 13, 1983 and relates to an area of 512 by 512 elements in size, with each picture element (pixel) covering a land area of 30 m by 30 m. Overall, the image relates to an area, which is 9.54 miles (15.35 km) by 9.54 miles (15.35 km) or 91 square miles (235.72 km²) in size. The center of the data set is located at

34° 46' N and 90° 27' W. The data set can be downloaded from the following URL address: <http://observe.ivv.nasa.gov/nasa/education/tools/stepby/achive.html>. This site provides a variety of free Landsat TM data sets. The two main United States Geological Survey (USGS) 7.5 minute quadrangle maps, which correspond to this area, are the Council, Arkansas, and Tunica, Mississippi, maps. It might help also to have Brickeys, Arkansas, and Stubbs Island, Mississippi. All four maps were updated in 1990 and can assist students in identifying features on the image and classifying the data set.

Figure 2 represents a section of the USGS Helena map sheet at the scale of 1 : 250,000. It shows the study area and environs. Most of the small communities as well as the railroad lines and major roads are situated behind the levees. Note that the major roads are located with the railroad lines between them and the river. Railroad beds are frequently elevated on floodplains and act as levees, which in this case, are backup levees to the main levees. This map provides some general land cover patterns on the unprotected floodplain, and reference points such as "Whiskey Island" and "Old River Lake."

Preprocessing

The data set is first loaded into an image-processing package called Earthscope, which was developed by Eidetic Digital Imaging Ltd. This is an inexpensive software package, which contains a number of basic image-processing functions. It is also quite easy for students to use, a nice feature in an introductory remote sensing course. Earthscope works on Windows-based machines. This exercise is predicated on using this software package, but it is possible that other image-processing packages provide the same capabilities.

As indicated the seven Landsat TM image bands are

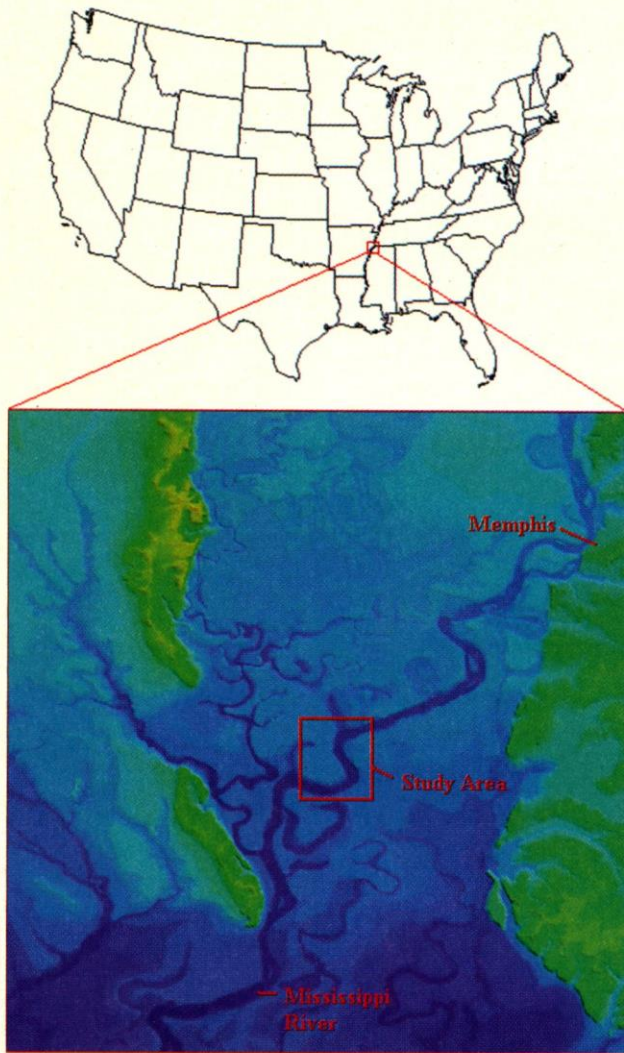


Figure 1 General map location of the study area on the Mississippi Lowlands. This area is very flat and low with the lowest elevation (dark blue) being at 138 feet (42 meters) and the highest elevation (mustard) being 407 feet (124 meters) above sea level.

loaded into Earthscope, which creates a master file for this specific data set. Each of the seven image bands is previewed through the software and each will produce an almost solid black picture containing little spectral or spatial detail. This situation, which should be pointed out to students, indicates a strong clustering of the data within each band and that the clusters are situated at the low end of the potential spectral data range. To rectify this condition, the bands need to be stretched to take advantage of the full data range. Because the exercise centers on an area with many water and wetland surfaces, only the three infrared bands (4, 5, and 7) are needed. Water conditions in the near and mid-infrared sections of the spectrum are generally well identified and delineated.

The students generate histogram statistics of the three bands, and these statistics confirm the heavy clustering of

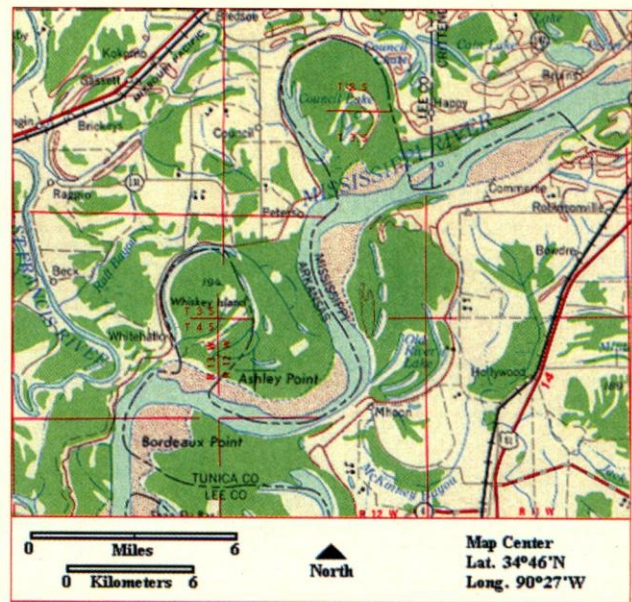


Figure 2 Study area and immediate environs

Table 1 Histogram Statistics for Three Bands

	Band 4	Band 5	Band 7
Minimum Value	6	1	1
Maximum Value	79	113	97
Average	24.7	38.7	18.0
New Minimum Value	6	1	1
New Maximum Value	53	84	41

the data and the concentration in the lower portions of the potential spectral data range. Table 1 shows the minimum and maximum spectral data values in each band plus the average of the data values. The other two values shown in the table are the minimum and maximum values used to stretch each of the three bands. Since the data values are highly clustered at the lower end of the potential data range, the minimum values used in the stretching process are the same as the original minimum values. The histograms for the three bands illustrate that the number of data values at the upper end of the data range decrease significantly before reaching the maximum values. Consequently, in order to obtain a good stretch of the data, lower maximum values are used. A cut-off of 0.5 percent is used in obtaining these maximum values. In other words, 99.5 percent of all of the data values falls between the new minimum and maximum values, and the remaining .5 percent of the values are pushed as a group to the upper limit of the potential data range. Figure 3 illustrates the difference between the non-stretched and stretched images for Band 5. The three stretched bands will be used throughout the rest of the exercise.

Mississippi River and Other Water Areas

Once the students have completed the preprocessing of the data set, the next step is to segregate the river and other water surfaces from other land cover conditions. Features of this nature are not easy to cut out due to their complex shapes. It is better to separate them rather than cut them out. Using the stretched Band 7, one will be able to identify the water surfaces, which correspond basically to the spectral value range of 1-35. A density slice classification is conducted on the band creating two classes, water (1-35) and all other surface conditions (36-250). The classified image is stored in the Earthscope master file and contains data values of 1 (water class) and 2 (other surfaces). In displaying the classified image a number of individual, misclassified pixels will appear over the water areas, especially the Mississippi River. One must not confuse these pixels with several river

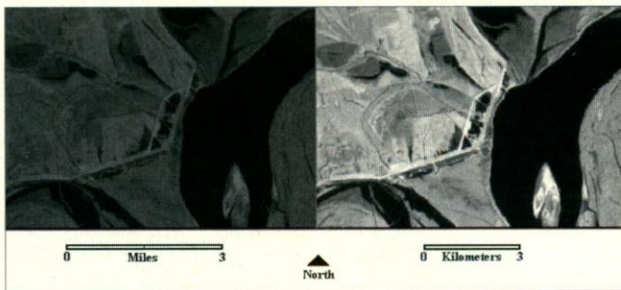


Figure 3 Band 5, Original image and stretched image.

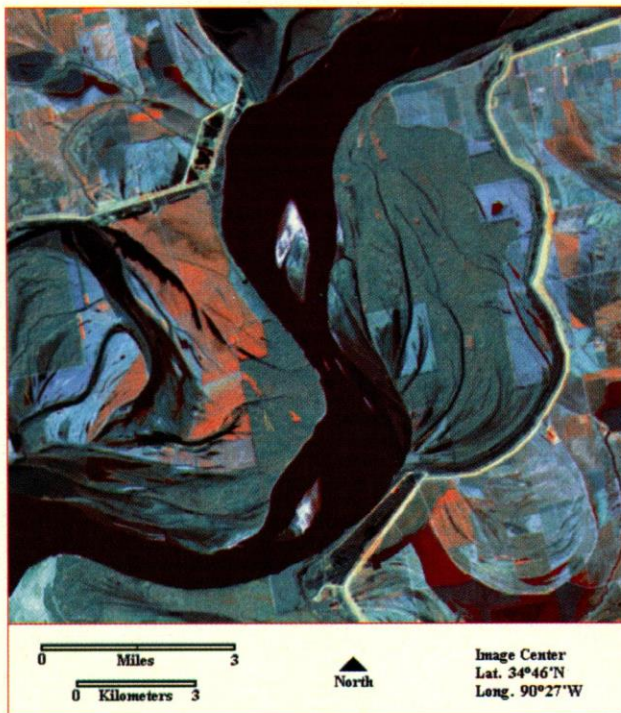


Figure 4 Color composite image based on stretched bands 4 (red), 5 (green), and 7 (blue).

tugs and barges on the river. A river tug with barges can be up to 1,200 feet (366 meters) in length and 150 feet (46 meters) wide, approximately 18 pixels in size. To deal with these misclassified pixels a 3 x 3 filter is sent across the classified image.

The classified image, which the Earthscope master file views as another regular image with a potential data range of 1 to 250, is stretched. This stretching process results in the water class pixels still having data values of 1 and the pixels related to the other surface classes having values of 250. The next objective is to reverse these pixel values, which normally could be handled by doing a reciprocal of the data values. Earthscope, however, does not provide the mathematical function for doing a reciprocal. To overcome this problem, a second density slice classification is done of Band 7, but in this classification only one land cover class is developed with the resulting file only having pixel values of 1. This classification, like the first classification, is stored in the master file. The stretched version of the first classification is divided into the second classification, creating a reciprocal condition. The pixels of the water surface class now have the value of 250 and the pixels associated with the other surface classes have the value of 1.

The last step is to add the classified image with the reciprocal values to each of the three original stretched bands. In doing this mathematical step, all values are scaled to keep the data range between 1 and 250. Again, the results are stored in the master file. This procedure superimposes the river and other water surfaces classified through Band 7 onto bands 4, 5, and 7 at the value level of 250. Each of these three bands now has the same delineated water areas at the same pixel value level. Figure 4 shows a color composite image of the original data set based on the three stretched bands. Figure 5 shows the water areas separated from the other portions of the color composite image and shaded in blue.

Levee Protected Areas

A different technique is used to neutralize the areas located behind the levees so that all the pixels have the same value. The levees can be readily detected on the images and the areas behind the levees are very geometric in shape, which makes it relatively easy to shade them out. A color composite image based on the stretched bands 4 (red), 5 (green), and 7 (blue) is used to accomplish this procedure. (Figure 4) Through Earthscope the color composite is exported as a 24-bit (.BMP) file, which is then imported into Microsoft Paint. Using the functions available in Paint, the areas behind the levees are delineated and colored white. The color "white" is selected because of its high amount of intensity. Finally, the modified color composite bitmap file is imported back into Earthscope where it is separated into three new image files. All three of the new files are identical with respect to the modified areas. Figure 6 is a color composite of the three new files. For cosmetic reasons, the areas behind the levees in this figure are shown in a solid gray color. If one wants to

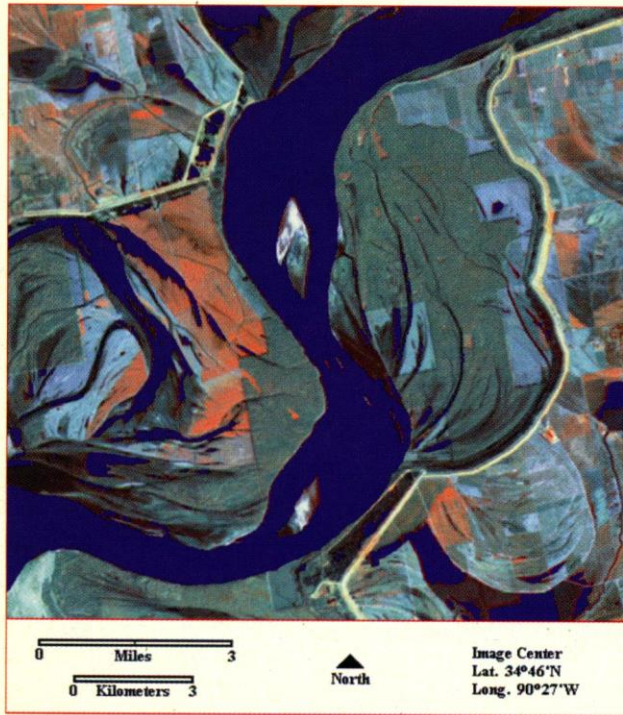


Figure 5 Color composite image with river and water areas segregated from image and cosmetically shaded blue.

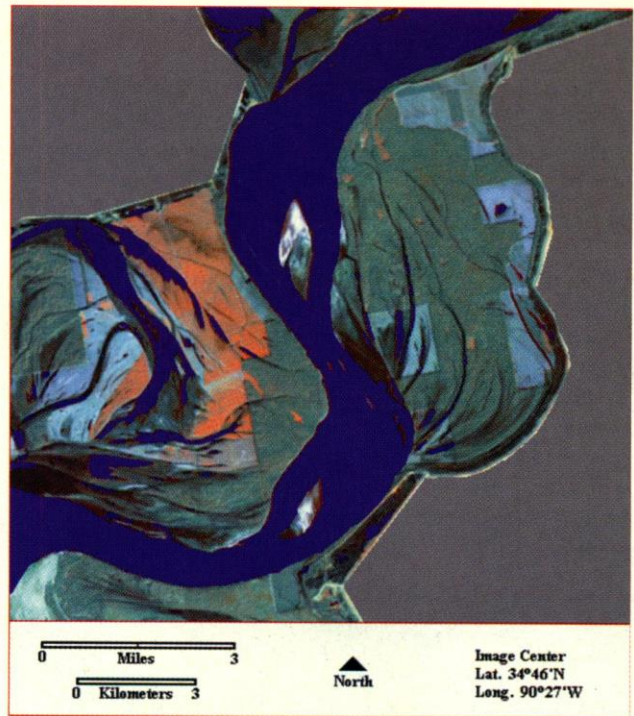


Figure 6 Color composite image with the areas behind the levees segregated from the image and cosmetically shaded gray. The unprotected floodplain is shown in a mosaic of colors.

create a data set which has more than three modified bands, it is possible to produce a second color composite using one or two of the new image files in conjunction with one or two of the original stretched files. The new image files provide a template for modifying the desired areas in the original files. Like the first color composite, the second color composite is exported from Earthscope, modified in Paint, and then imported back into Earthscope.

For students to understand fully what occurs during the import/export processes, it helps if they have a working knowledge of the computer terms, "bits" and "bytes." A bit can hold only one character, either a "0" or "1." A byte contains 8 bits and the combination of eight "0s" and "1s" can create 256 data levels ranging from "0" to "255." Most remotely sensed data sets have one byte for each pixel within an image band which allows for only values between "0" and "255." This data range relates to the intensity of the reflected or emitted spectral energy. In a color composite, the individual pixel values associated with the three selected image bands are placed into one of the three bytes related to each pixel of the color image. This condition results in a 24-bit (3 bytes) color image file. The data values from the first band govern the color intensity for "red", the second band the intensity for "green", and the third band the intensity for "blue." When the color "white" is inserted in the color image, the intensity level for all three bands becomes 255.

Earthscope is designed to deal with image values between 1 and 250. When reading in a band file, zero values are converted to 1's and values above 250 are compressed to

250. However, in importing the modified color composite file from Paint, Earthscope permits the full data range of a byte to be used, resulting in values from 0 to 255. Also, when a color composite file is imported, the three original image files used to create it plus any changes made to these files in Paint are imported as three new, separate image files back into Earthscope's master image file. They are basically the same files with respect to their original data values except for the pixels, which were modified in Paint. Consequently, all the original values fall between 1 and 250 and the areas changed to "white" have values of 255. This procedure segregates the pixel values associated with the active section of the image from the sections falling outside the area of interest. This portion of the exercise also forms a good way for students to understand "bits" and "bytes," the building blocks of any image data file, and to work with a software package beyond the "black box" approach of just inserting data and permitting the software to create a "pretty-looking" picture.

Final Step

For the final step of the exercise, students must calculate the size of three major classes. A density slice classification is... done on one of the modified images. This is a two class classification, which covers the data range from 1 to 250. This classification provides a numerical count of all the pixels within the two classes. The first class covers all the values from 1 to 249, which corresponds to the unprotected

floodplain. The second class relates only to the value 250, the water surface areas. The pixels with values of 255 are not recognized. However, the number of pixels with values of 255 can be ascertained by subtracting the count values for the other two major classes from the total number of pixels in the data set, which is 262,144 (512 x 512). Using the count values (128,977 unprotected floodplain, 50,233 water surfaces, and 82,934 levee protected areas), it is possible to determine the amount of area covered by all three classes. A 30-meter pixel relates to 9687.5 square feet. This number is multiplied by the count values for the three classes and these values are then divided by 43,560, which is the total number of square feet in an acre. The results are 28,683, 11,171 and 18,444 acres for the unprotected floodplain, the water surfaces, and levee protected areas, respectively. These numbers are divided by 640, the number of acres in a square mile, producing the figures of 44.82, 17.45 and 28.82 square miles. The entire image covers an area of 58,299 acres or 91.09 square miles. Consequently, the unprotected floodplain covers about 49.2 percent of the entire image. In the metric system, the unprotected floodplain, the water surfaces, and the levee protected areas relate to 116.0, 45.19 and 75.10 square kilometers, respectively.

Students need to be made aware that obtaining these very basic area figures represents major pieces of information, which are not readily available from any other source. The data set is now ready to be classified. The areas behind the

levees and the water surfaces are well separated from the unprotected floodplain. The students can now select the classification method they wish to use to determine the different land cover conditions on the unprotected floodplains, and not be concerned about land cover conditions in other sections of the data set.

For this exercise to be meaningful for students, it is best that they first try to classify the full data set and experience the problems associated with how the spectral data values outside the study area impact the accuracy of the desired land cover classes. Rather than the instructor predefining the study area and preparing the new data set using the procedures previously outlined, students should go through the process of delineating the study area and developing the new data set. Approximately, two hours are needed by the average student to prepare the new data set. The amount of time will vary with different data sets depending on their size and the complexity of the study area. The data set used in this exercise is nice since the levees are easy to detect making it relatively simple to delineate the unprotected floodplain. Students will not have the same results in delineating the study area since they will not be able to separate precisely the same area. This exercise works best toward the end of a course, after students have had the opportunity to try various classification techniques. The exercise also allows students to overcome the frustration of producing less than desirable results when limited to rectangular data sets.