Remote Sensing in Geosciences
GEOG 361
Department of Geography
Texas A&M University

Course Instructor: Dr. Anthony M. Filippi

LABORATORY 3
Introduction to Digital Remote-Sensing Images

Points Possible: 10

Objectives

- To become familiar with the basic nature of digital remotely-sensed imagery.
- To determine how to order/obtain remotely-sensed imagery on the internet.
- To learn how to use the ENVI software package to create map compositions based on the imagery acquired.

Materials Required

- A computer workstation with ENVI 5.x and ENVI Classic installed; Access to the internet;
- Image data sets supplied;
- Pencil/pen
- Your textbook, as a reference: Jensen, J. R., 2007, *Remote Sensing of the Environment: An Earth Resource Perspective*, 2nd Ed., Upper Saddle River, NJ: Prentice Hall, 592 pp., ISBN 0-13-188950-8.

1. Patterns of Brightness Values

Digital remotely-sensed imagery is comprised of a matrix of numbers. Before one begins to work with such data, it is useful to understand the structure of the data. This portion of the exercise will deal with manually delineating regions of land-use/land-cover types within an image subset; it will essentially constitute a single-band classification exercise.

Printed below on the next several pages are image data extracted from a digital Landsat 7 Enhanced Multispectral Plus (ETM^+) scene (30 × 30 m spatial resolution) (Figure 1, below). These numbers represent a 21 × 21 (21 rows × 21 columns) matrix of brightness values (BVs), sometimes referred to as digital numbers (DNs), for individual pixels derived from a small subset of ETM^+ bands 2, 3 and 4. (You may consult your Jensen (2007) text (Chapter 7) for an overview of the characteristics of the Landsat ETM^+ sensor.) These BVs represent three major land-cover types within the scene: non-irrigated agriculture, water, and riparian forest.

(1 point) Based on the numerical values in the matrices, outline in pencil or pen the three major land-cover areas on the Band 2 (visible green, 0.525-0.605 μm), Band 3 (visible red, 0.630-0.690 μm), and Band 4 (reflective near-infrared (NIR), 0.750-0.900 μm) data sets. **Answer the following questions, based on your interpretation and analysis of the numerical BVs:**

1) **(0.5 point)** Is ETM^+ Band 2 more similar to Band 3, or Band 4? Explain why.
2) **(0.5 point)** Which ETM^+ channel, or band, exhibits the greatest degree of variation in BVs?
3) **(0.5 point)** Which of the bands facilitated discrimination of the various land-cover types the most?

Using ENVI, open the in the file named "subset.img," located in the Lab_03 directory on the **\\geogshare.geog.tamu.edu\geog361filippi** class network volume (path: **\Lab_Data\Lab_03**), and *separately* display bands 2, 3, and 4 (i.e., view each band as a grayscale image). (Hint: load each band as grayscale using the Data Manager) The BVs you just examined were extracted from these image bands. We simply visualize these data values differently when viewing them as a digital image. **Answer the following questions**. Even though you will not know the true land-cover class distribution in the image, base your answers on your image-interpretation skills.

4) **(0.5 point)** ***For each image band***, discuss how well your manual land-cover classification based on the numerical values compares with the land-cover types that you can discern from the image.
5) **(0.5 point)** Which land-cover type was most difficult to distinguish, using either the numerical values or visual image display?
6) **(0.5 point)** Which ETM^+ channel enables the clearest/easiest discrimination (classification) of the land-cover types? Which band provides the least amount of information concerning the variation in land cover within the image subset?

Display a color composite (bands 2,3,4 as R,G,B) of the Landsat subset, as well as false color infrared (IR) (bands 4,3,2 as R,G,B). This can be accomplished by displaying the color composites sequentially in the same view, or they can be displayed simultaneously in two separate views (by opening up a new view from the View menu: select "**Two Vertical Views**" or "**Two Horizontal Views**"; make sure the view of interest is active when trying to display the imagery). Do either of these land-cover types improve your capability to visually discriminate among the various land-cover types?

Landsat 7 ETM$^+$ Band 2 BVs (row ↓; column →)

90	85	87	89	88	91	87	89	85	86	84	85	82	85	83	85	82	82	84	84	86
87	90	85	85	87	85	88	83	84	81	83	81	82	84	84	83	83	84	85	84	86
86	86	87	85	87	87	84	84	82	83	82	83	82	84	81	83	82	82	82	87	86
85	87	81	85	87	85	85	84	81	84	85	84	83	82	81	81	78	74	71	83	81
82	77	73	74	77	82	82	83	81	81	84	83	82	82	82	72	67	66	66	72	75
73	69	68	67	69	76	74	76	79	78	73	72	81	80	75	68	65	64	63	65	67
66	65	66	70	66	69	66	67	67	67	65	64	72	73	67	65	63	63	63	66	66
69	67	65	64	62	65	64	65	63	64	65	65	63	64	63	65	63	63	63	64	65
64	66	61	63	62	61	62	61	62	61	64	64	66	64	63	61	62	62	60	63	63
61	61	61	63	62	61	60	61	62	61	63	64	63	64	62	61	62	60	60	59	62
66	65	61	62	61	61	61	63	62	62	63	63	63	62	61	59	61	61	61	60	63
66	65	64	66	65	60	62	62	62	62	60	64	63	63	59	61	60	61	61	61	60
67	65	66	66	64	60	58	60	64	62	62	60	65	62	61	61	60	60	60	62	61
69	67	66	66	68	61	61	61	64	59	61	60	62	64	61	58	61	61	63	62	62
70	68	67	66	66	66	61	60	62	60	61	61	60	61	61	60	61	61	59	62	62
69	67	68	68	66	64	60	62	60	61	60	60	61	58	58	59	60	59	62	62	66
70	69	70	68	69	65	65	63	62	61	61	62	62	63	61	60	60	61	63	63	61
67	71	66	70	69	67	65	66	63	62	63	63	63	65	64	63	62	64	62	64	61
66	69	68	69	68	67	67	67	63	62	61	62	61	63	61	62	62	61	61	61	61
67	69	67	68	67	69	68	67	67	64	64	61	63	60	61	62	61	59	61	59	60
66	68	68	66	69	67	67	67	66	66	64	65	62	63	62	62	61	62	61	61	64

Landsat 7 ETM$^+$ Band 3 BVs (row ↓; column →)

110	109	105	109	106	109	110	110	109	104	103	108	105	106	103	104	104	106	103	110	106
111	109	106	108	108	106	107	103	103	102	103	101	103	103	103	102	102	101	108	105	107
105	101	105	104	106	102	104	100	104	100	100	100	105	99	101	99	105	98	98	107	110
103	102	97	99	102	104	102	100	99	103	103	98	99	97	99	96	92	78	78	98	97
97	89	76	78	81	94	97	96	100	100	98	95	100	97	93	83	67	61	63	76	84
83	69	67	69	69	82	77	82	89	88	80	74	98	95	85	68	65	65	63	65	70
63	63	64	72	62	69	69	67	67	67	63	67	72	75	67	70	64	60	60	60	68
65	64	63	60	58	63	61	61	62	63	65	63	65	67	64	65	65	62	63	64	63
63	60	57	57	56	57	57	57	53	58	63	61	63	65	61	61	57	57	58	62	57
56	56	57	57	56	56	54	54	58	56	56	60	62	59	61	58	56	55	54	56	55
60	61	57	56	56	54	58	60	56	59	56	60	60	60	56	58	55	54	54	56	53
62	62	60	65	58	56	57	59	57	59	54	61	60	59	56	55	55	54	56	55	57
65	62	65	64	61	55	55	59	57	56	56	54	57	58	56	55	55	54	55	52	51
68	65	65	65	66	58	52	57	59	56	56	56	59	57	57	54	54	52	54	54	52
67	66	66	62	65	60	57	56	57	54	57	53	54	53	52	53	53	50	55	52	58
70	67	67	65	66	62	58	58	56	58	55	55	55	55	57	54	54	50	53	58	61
70	70	68	70	66	65	63	57	56	55	58	57	57	56	59	54	53	54	60	58	55
65	71	69	68	68	68	65	62	61	57	60	61	60	60	57	56	53	58	58	58	56
70	68	68	68	67	70	69	66	59	58	57	56	60	56	56	57	54	58	53	55	55
67	68	70	68	69	69	68	67	67	62	57	61	56	56	55	56	53	55	54	55	55
70	69	68	67	68	68	68	67	65	67	63	63	61	57	58	56	53	60	56	55	59

Landsat 7 ETM$^+$ Band 4 BVs (row ↓; column →)

70	70	71	73	71	71	73	72	70	68	68	67	66	68	66	66	66	66	67	67	71
69	69	70	73	71	71	72	70	68	66	66	67	66	66	64	65	65	66	70	68	69
65	68	68	71	75	70	71	69	65	65	65	66	66	66	65	65	66	66	69	71	68
67	68	70	73	74	70	72	70	66	66	65	67	66	64	64	65	65	66	63	70	70
66	66	67	70	69	73	74	70	67	66	65	67	66	64	62	63	60	58	57	64	65
63	61	64	60	60	70	71	67	68	69	67	68	64	65	63	54	51	51	50	57	59
59	58	55	57	52	58	58	55	60	58	52	53	64	66	57	50	48	47	47	50	51
52	53	52	47	43	51	48	47	46	49	51	48	53	49	48	48	48	45	45	48	50
53	50	45	45	38	40	36	35	35	39	48	48	49	48	46	42	36	36	36	45	44
39	42	36	45	38	31	31	29	37	34	39	40	49	47	42	39	34	30	28	29	28
48	50	36	34	36	36	41	40	43	43	39	40	43	44	36	35	31	29	27	28	30
54	53	49	48	43	39	39	45	44	43	34	44	46	37	31	30	29	29	27	31	29
53	51	52	50	44	38	36	41	44	43	34	34	38	40	37	31	29	27	26	24	24
53	53	54	54	49	42	34	40	40	40	38	30	38	40	32	31	29	25	23	23	24
54	53	56	56	51	46	40	38	40	37	38	31	30	30	29	31	25	24	24	27	33
55	56	55	52	51	46	39	38	34	37	30	30	29	31	32	27	25	26	24	34	41
51	52	52	52	52	50	46	43	39	35	34	37	39	37	32	27	25	25	36	39	29
50	51	51	51	49	48	51	48	43	43	41	37	37	37	36	29	28	33	36	34	31
48	50	50	46	47	46	47	49	44	42	36	36	36	36	35	32	29	32	31	31	33
48	47	47	46	49	47	46	47	47	46	39	42	40	35	33	31	29	30	30	30	37
46	46	46	46	47	47	45	47	47	47	45	48	46	40	40	32	33	35	35	36	39

Figure 1. Image subset shown relative to the rest of the Landsat 7 ETM$^+$ scene. Size of the image subset (21 × 21 pixels) is denoted by the red box at the bottom center of the image.

2. Obtaining Remote Sensor-Image Data on the Internet

(1 point) Although many data sets may incur a considerable cost, it is possible to obtain free remote-sensor data sets on the Internet. Some potential websites are listed below, though you are encouraged to locate others. Also listed are some other related website URLs that may be of interest to you at some later time. If you are viewing a digital version of the laboratory instructions, you can simply press the Ctrl button on your keyboard and use the lmb to click (CTRL + click) to follow the link; a new web browser should open if you are using the Windows OS. After browsing these sites, you will download an image of your choice, which you may use to create a map composition (section 3, below). You may select any type of imagery of your choice (e.g., aerial photography, multispectral, radar, etc.).

Image Data Sites

Texas Natural Resources Information System

http://www.tnris.org

TexasView Home Page

http://www.texasview.org/

United States Geological Survey's Earth Explorer

http://earthexplorer.usgs.gov/

Earth Resources Observation and Science (EROS) Center

http://eros.usgs.gov/

The Gateway to Astronaut Photography of Earth

http://eol.jsc.nasa.gov/sseop/clickmap/

National Weather Association's (NWA) Remote Sensing Committee

http://www.nwas.org/committees/rs/nwasat.html

Michigan State University: Landsat.org

http://landsat.org/

Global Land Cover Facility Homepage

http://glcfapp.glcf.umd.edu/

Earth from Space (Johnson Space Center)

http://earth.jsc.nasa.gov/

Visualization of Remote Sensing Data

http://rsd.gsfc.nasa.gov/rsd/

NSSDC Photo Gallery: Earth

http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-earth.html

NASA Goddard Space Flight Center

http://rsd.gsfc.nasa.gov/goes/

NASA Langley Research Center

http://angler.larc.nasa.gov/armsgp/

The NASA/JPL Imaging Radar Home Page

http://southport.jpl.nasa.gov/

NASA Image Gallery

http://www.nasa.gov/multimedia/imagegallery/index.html

NASA Visible Earth

http://www.visibleearth.nasa.gov/

Remote-Sensing Image Providers

Space Imaging

http://www.spaceimagingme.com/

TerraServer.com

http://www.terraserver.com/

SPOT Image

http://www.astrium-geo.com/en/143-spot-satellite-imagery

Digital Globe

http://www.digitalglobe.com/

Google Earth

http://earth.google.com/

RADARSAT International

http://gs.mdacorporation.com/

WorldSat International Inc

http://www.worldsat.ca/

GIS Data & Resources

GIS Data Depot

http://data.geocomm.com/

USGS Publications and Data Products

http://www.usgs.gov/pubprod/

USGS Water Resources: Maps and GIS Data

http://water.usgs.gov/maps.html

GIS Online Data

http://library.tamu.edu/about/collections/map-gis-collections-services/gis-data-online-interactive-maps/gis-online-data.html

ArcScripts

http://arcscripts.esri.com/

Now that you have obtained a free image from the internet, you have the option of using that image—if it is georeferenced (i.e., if it has real-world/projection coordinates assigned to it)—to create a map composition in the following section. Regardless of whether you create a map composition using the image you downloaded, for your first ENVI map composition, you should still at least utilize the default image data set specified in the tutorial (or by your lab instructor), discussed below.

3. Creating a Map Composition in ENVI

(5 points) Complete the ENVI "Map Composition" Tutorial (pp. 1-17) (Note: this tutorial will require that you use ENVI Classic (4.x)); you can access the instruction file at the following internet URL:
http://www.exelisvis.com/portals/0/pdfs/envi/Map_Composition.pdf

This is an Adobe Acrobat PDF file, which requires Adobe Acrobat or Adobe Acrobat Reader to open the file.

You can access relevant data sets for this tutorial on the **\\geogshare.geog.tamu.edu\geog361filippi** class server in the **\Lab_Data\Lab_03** subdirectory, and specifically in the **\Lab_Data\Lab_03\ys_tmsub** subdirectory. It is recommended that you begin by copying these files to your own H: drive (i.e., your student account). (Note: You can generate your own annotation and grid parameter files.) In addition, if you were able to obtain a geometrically rectified/georeferenced image via the Internet, you may (optionally) use that image to create another map composition, in addition to the map composition specified in the tutorial.

Although there is other information that you can add to your map composition, as explained in the tutorial, at a minimum, your map should include the following information, as applicable (and if such information is available):

- Title/location of acquired image
- Sensor
- Bandwidths displayed (i.e., RGB = 3,2,1)
- GIFOV (spatial resolution)
- Altitude/scale
- Date of image data collection
- North arrow
- Short description of the data
- Your name

If not all of this information is available, please specify that in your lab write-up. You can print your map composition in color, if desired, though it is not required. Information regarding printer setup is given in a previous laboratory instruction set (i.e., Lab 0). Recall that **Gisprinter** prints in black & white/grayscale; **Ugradcolor** prints in color. All map composition printouts should be on standard 8.5" × 11"-in. paper.

If you determine that some of the annotation tools are perhaps less than user-friendly, or that the quality of the cartographic output is less than desired, then you could decide to perform the majority of image annotation using a general-purpose graphics package, such as Photoshop, Adobe Illustrator, Freehand, etc., or a the map-layout capabilities of a geographic information system (GIS) (e.g., ArcGIS, etc.). If you are familiar with another

such graphics software package, then you may choose, after working through the tutorial exercise, to add some of the annotation, including text annotation, using a software package external to ENVI. However, if you decide to use a general graphics program, which does not read georeferenced coordinates, you should add, at a minimum, the graticule and scale bar using ENVI to ensure that these map elements/features are correct.

DELIVERABLES:

Your write-up should be typed and coherent. **Turn-in**: 1) your answers to the questions posed; 2) the numerical matrices for each image band with the land-cover classes that you delineated by hand in pencil or pen; 3) if not using the image that you acquired from the internet in a map composition, insert the internet-acquired image file into your word-processing document (if necessary, first save it to a generic image format (word-processor compatible) (e.g., JPEG, BMP, TIFF)); and 4) the completed hard-copy map composition(s) from section 3.

Acknowledgement: This lab was modified from exercises written by J. R. Jensen and B. C. Rundquist et al.