

G492-GIS for Earth Sciences

Raster Data Structure

I. Introduction

A. Basis - grid cell structure

1. representing map elements as dimensional pixels that are attached to cell attributes
2. Raster Data - applicable to map data that varies continuously in 2-D and 3-D
 - a. e.g. elevation / topographic data
 - b. precipitation data
 - c. slope gradient
 - d. any geologic data that can be contoured from discrete data points
3. Contrast Vector Data-
 - a. best applied to discrete data in the form of points, lines, polygons

B. Raster Structure

1. regular grid cells, spaced at even increments
2. attributes attached as cell values
 - a. e.g. analogous to digital "pixel-based" images, where each cell is assigned a color value to recreate an image

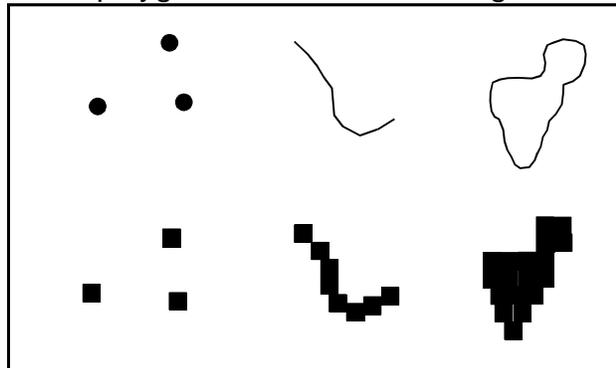
C. Example Raster Formats

1. Digital Elevation Data (DEM)
2. Satellite Images
3. Digital Orthophotos
4. Scanned Maps
5. Graphics Files (scanned graphics)

II. Elements of Raster Data Model

A. Terminology / Concepts

1. Grid - map is divided into columns, rows, and cells
 - a. grid origin - commonly upper left corner of raster file
 - b. rows - y values
 - c. columns - x values
 - d. cell address - row and column address
2. Raster representation of vector building blocks
 - a. point = 1 pixel box (cell)
 - b. line - string of pixel boxes (cells)
 - c. polygon = collection of contiguous cells



Vector Representation

Raster Representation

3. Cell Values (attributes of cell)
 - a. Integer - whole, positive or negative number
 - (1) e.g. 1 = sandstone, 2 = shale, 3 = limestone
 - b. floating-point value - a value with decimal digits
 - (1) e.g. precipitation data (average annual rainfall in mm)

cell values: 12.34 24.567 56.987

CLASS QUESTION: Do you think that raster-based gis data require an attached database file, like vector data?

- c. Grid Resolution = cell size in ground distance units
 - (1) e.g. 30 m DEM: cells are spaced 30 m apart, each cell is 30 x 30 m in area = 900 sq. m.
 - (2) Spatial Resolution: the smaller the cell size (the closer the spacing of rows and columns) the greater the resolution of the grid, but this does not necessarily increase the accuracy of the grid.

4. Georegistration of Raster Data

- a. Grid file requires a real-world coordinate file to place the cells in geospace (e.g. UTM, State Plane North, etc.).
- b. Example world file that accompanies the Monmouth Quad DRG (UTM zone 10N)

Text File Contents

2.438400
 0.000000
 0.000000
 -2.438400
 479098.499289
 4969672.872110

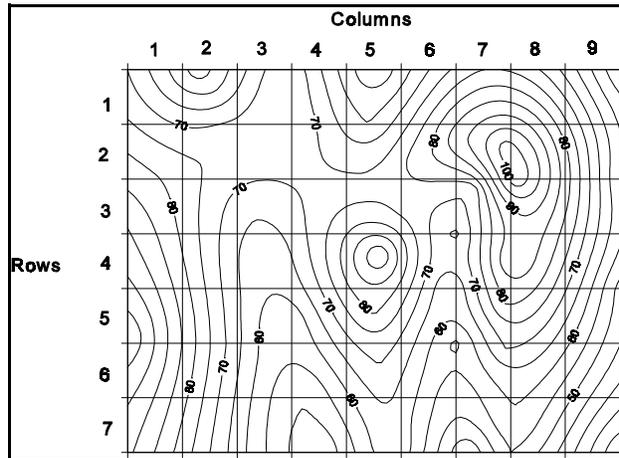
Explanation

Grid size in x direction (meters)
 rotation factor for row
 rotation factor for column (0 = no rotation, 90 = 90 deg. rotation)
 Grid size in Y direction (meters)
 Easting (X) coordinate position of upper left (NW) corner pixel in UTM
 Northing (Y) coordinate position of upper left (NW) corner pixel in UTM

- c. Advantage of Raster (Grid) Data - pixel grid format is the essential structure upon which computer processing is based. It is much easier for the processor to process large amounts of raster data compared to vector data with dbase tables

In-Class Exercise:

(1) The vector-line topographic map below is overlain with a raster grid of columns and rows. Determine the elevation of the center point of each cell in integer form, then fill in the grid-table below and create a raster-based, grid DEM data set.



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — |

(2) Assume that the scale of this map is 1:10,000, based on the grid structure, what is the resolution of the DEM in meters? (hint: you will need a ruler for this).

(3) Based on the map and grid layout, are the rows and columns of equal dimension?

(4) Assume that the UTM coordinate of the upper left grid cell is 464091.499289, 4968737.872110 and that the grid system is unrotated. Write out the associated world file for this hypothetical raster-grid data structure (i.e. in the space below, what will the world file look like?)

III. Types of Raster Data

A. Satellite Imagery

1. Basis - reflected electromagnetic radiation from Earth's surface
 - a. spectral bands = ranges of reflected radiation wavelengths collected by the satellite cameras
 - (1) advanced digital cameras - can detect selected wavelengths
 - (2) Panchromatic Images = single spectral wavelength band
 - (3) Multispectral images = multiple bands

Example multispectral scanner range:

| Band | Wavelength (μm) | Spectral Band |
|------|------------------------------|--------------------|
| 1 | 0.38-0.42 | UV and Blue |
| 2 | 0.42-0.45 | Blue |
| 3 | 0.45-0.50 | Blue |
| 4 | 0.50-0.55 | Green |
| 5 | 0.55-0.60 | Green |
| 6 | 0.60-0.65 | Red |
| 7 | 0.65-0.70 | Red |
| 8 | 0.70-0.80 | reflected infrared |
| 9 | 0.80-0.90 | reflected infrared |
| 19 | 0.90-1.10 | reflected infrared |

Combining bands 2 (blue), 4 (green), and 7 (red) produces a normal color image. **NOTE: all colors on your computer screen are formed by admixtures of ratios of RGB (red, green, blue).

2. Landsat imagery - various editions since 1970's through present
 - a. image resolution = 79 meters
 - b. more recent satellites = 30 m
3. SPOT - French satellites
 - a. multi-spectral and single band imaging devices
 - (1) single band = 10 m
 - (2) multi-spectral = 20 m
4. AVHRR (Advanced Very High Resolution Radiometer)
 - a. resolution = 1.1 km

B. Digital Elevation Models

1. USGS DEMs derived from topographic maps
 - a. 7.5 minute DEM
 - (1) 30 m resolution
 - (2) 10 m resolution
 - b. 30 minute DEM
 - c. 1 degree DEM

C. Digital Orthophotos (DOQ)

1. DOQ -Digital aerial photographs of entire 7.5 minute USGS quadrangles
 - a. photos are rectified to eliminate camera distortion
 - b. photos (pixels) are georeferenced to real world coordinates using world files
2. Digital Quarter Quads
 - a. 1/4 of 7.5 minute quad - smaller file size, easier to handle and view

D. Digital Raster Graphics (DRG)

1. Scanned tif images of USGS topographic maps
 - a. georeferenced to UTM coordinates
2. tiff, tiff world file

IV. Raster Data Structure

- A. Data Matrix - see the in class example that you created above with the topo map.

V. Data Compression

- A. software techniques to compress the memory and file size of raster data

1. Tiff - tagged image file
2. GIF - graphics image file
3. JPEG
4. MrSID - Multi-resolution Seamless Image Database
 - a. developed at LANL
 - b. uses variable resolution over different parts of the image
 - (1) < resolution in less detailed portions
 - (2) > resolution in more detailed portions

- B. Raster Data Files

1. Header File - *.hdr - contains information about the raster data including data structure, no. of rows / columns, etc. (essentially metadata about the raster grid)

VI. Projecting / Georeferencing Raster Data

- A. Georeferencing
- B. World Files
- C. Ground Control Points
- D. Image Registration - Image Rectification
 1. warping / rubber sheeting
 - a. variable polynomial math models applied to the image
 - (1) eliminates distortion across the image

VII. Data Conversion

- A. Vectorization - converting raster features to vector features (points, lines, polygons)
- B. Rasterization - converting vector features to raster cells

Class Exercises: Working with Vector and Raster Data

1. Download and unzip the following files from the class website (these are from your text book CD in the DATA Folder for Chapter 7): go to www.wou.edu/taylor follow links to G492/GIS; go to "Lab Data" Section, click on "Working with Vector and Raster Exercise" (vecras.zip) Data, download the *.zip file to your H:\drive, use winzip to extract the following files into a new lab exercise folder.

filer.dem
tmrect.bil
nwroads.shp
nwcounties.shp

NOTE: In spatial analyst the folder or file names must follow the old DOS protocol (8 character limit and no spaces)!!! Otherwise you will receive a "segmentation violation error".

Task 1 - Import a USGS DEM into ArcView

1. Start ArcView, load Spatial Analyst Extension (file - extensions - check box)
2. Open new view, File - Import Data Source
 - choose USGS DEM as import file type, click OK
 - browse out to your H:\drive folder, look for the file filer.dem (that you just extracted from Zip)
 - double click on filer.dem
 - save output grid as "filegrd" and add it to the view, check the box in table of contents
 - make the grid theme active in the table of contents
3. Select properties from Them menu
 - properties shows you the cell size, no. of rows and columns, the area extent (boundaries), and whether grid is floating point or integer (the file is in UTM - meters)

Record the following information below:

cell size resolution (meters): _____
No. of Rows _____
No. of Columns _____
Left boundary coordinate _____
Right boundary coordinate _____
Bottom boundary coordinate _____
Top boundary coordinate _____
Cell Attribute Type _____

4. Double click on the legend or use the Theme-Edit Legend menu to edit the grid patter

- change the legend type to "unique value" and see what happens
- change the legend type back to "graduated color", set the classification field to "value"
- change the color ramps to orange monochromatic and see what happens
- change the color ramps to some other color scheme, pick your favorite

- Go to Layout and Create a series of map print outs demonstrating successful completion of this task, include a map title, north arrow, name, data, scale bar, view frame.

5. Close the view

Task 2 - Viewing Satellite Imagery

1. Start ArcView, open a new view
 - add theme
 - select image data source as the data source type
 - go to your H:\drive and find the "tmrect.bil" satellite image file (you just downloaded and unzipped it!)

2. Select Theme - Properties
 - examine the coverage parameters
 - list the following information

left image coordinate boundary (UTM m) _____
right image coordinate boundary (UTM m) _____
Top image coordinate boundary (UTM m) _____
Bottom image coordinate boundary (UTM m) _____

3. close the property box

4. double click on the "Tmrect.bil" theme in the table of contents
 - this opens the image editor
 - click multi-band, and select Band 1 for red, Band 2 for green, Band 3 for Blue
 - note that photo appears as a normal color photo

5. set the Red, Green and Blue for Bands 4,3, and 2 respectively, click apply
 - note the change in the appearance of the image
 - click default to change the image to normal color

6. Your job is to now create a digitized shape file with a polygon defining the clear-cut area immediately northwest of the river

- View - New Theme- select the polygon option - OK
- browse to your H:\drive a choose an appropriate folder to place the new shape file, name the file "clearcut.shp"

- note that the new shape file appears on the table of contents with a "dashed box" highlighted, the dashed box indicates that the theme is in "edit mode" (i.e. you can add or delete map elements)

- make sure that your new "clearcut.shp" theme is the active theme

- now start digitizing your clearcut polygon of the bare area northwest of the river:

- on the toolbar above the view, next to the Text tool, pull down the drawing tool box options and select the "polygon tool", the irregular shape polygon icon with open interior

- "Heads Up Digitizing", now with your mouse and icon, start digitizing a polygon outline of the clearcut area

- click a series of points (vertices) around the clearcut
- double click when you return to the beginning node to finish the polygon
- you should now see a new polygon on your clearcut.shp theme

- Go to Theme-Stop Editing-Save Edits to Clearcut.shp (YES)

- note that your new clearcut polygon is now highlighted yellow, go to Theme-Clear Selected Features to deselect the polygon.

- from the legend editor, change the color of the polygon to a clear, open polygon
- change the line wt. to a 2 pt.

- Go to Layout and Create a series of map print outs demonstrating successful completion of this task, include a map title, north arrow, name, data, scale bar, view frame.

-save your work and project file to the H:\ drive

- close your view

Task 3 Vector to Raster Conversion

Goal: to convert vector shape files to raster grid files.

This exercise involves use of the nwroads.shp and nwcounties.shp files that you downloaded and unzipped to your H:\drive (these are roads and county boundaries for the Pacific Northwest)

(1) Start ArcView, add a new view, load the spatial analyst extension

(2) Add the nwroads.shp and nwcounties.shp files to your view

- briefly explore the data, make the roads and counties themes active, use the "inquire" tool to check out the related attribute data, find your favorite roads and counties.

(3) do this: View - Properties - Map Units = meters

(4) Activate the nwroads.shp

- open the theme table (see the table icon on the toolbar at the top)
- note the data in the database, you will use the field "Rte_num1" as the cell value for for the raster grid data, this is the route number
- close the table

(5) Activate the nwcounties.shp

- open the theme table
- note the data, you will use the "FIPS" field as the cell values for the raster grid data, this is a federal code for county identification
- close the table

(6) Activate the nwroads.shp

- do this: Theme - Convert to Grid
 - choose the folder location (H:\drive) for the new file, name it "nwroads_gd"
 - Output Grid Extent: select "Same as "Nwroads.shp"
 - Output Grid Cell Size = 5000 (meters)
 - default to the No. of Rows and No. of columns -- click OK
 - Pick Cell Values for Grid: - choose the "Rte_num1" field --- click OK
 - "joint attribut to grid?" - click OK
 - "add grid as theme to View" -click OK

- check your new nwroad_gd grid theme to see how the vector shape file was rasterized, compare the two.

(7) Activate the nwcounties.shp

- follow the same procedure as above to convert it to a raster grid
 - name the grid nwcounties_gd
 - specify nwcounties.shp for the grid extent
 - specifiy 5000 m for the cell size
 - pick Fips for the conversion field

- Activate each of the raster and vector themes, using the identify tool, explore and compare the data structure types, move your themes on top of and below one another

- Go to Layout and Create a series of map print outs demonstrating successful completion of this task, include a map title, north arrow, name, data, scale bar, view frame.