Raster GIS
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1. Raster Data Models
2. Raster Data Structure
3. Advantages and Disadvantages
4. Other data model
5. GRID in ARCVIEW
6. Exercise

Prepared by Mona Lacoul, July 2004
1. Raster Data Models

Prepared by Mona Lacoul, July 2004
1.1 Raster representation of location
1.2 Raster Accuracy
1.3 Raster Resolution

Original Vector Data

High Resolution

Low Resolution

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1.4 Raster Resolution

Resolution is defined as content of geometric domain divided by number of observations, normalized by spatial domain.

Mean resolution element = $\sqrt{\text{area}/\text{no of observation}}$

According to Tobler W.R., (1987)

Example, for provincial level (76) mapping of Thailand (area, 514,000 km²), representative value for spatial resolution to portray the provinces is approximately 82km.
1.5 Raster Topology

<table>
<thead>
<tr>
<th>Value</th>
<th>Count</th>
<th>Soil Charact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
1.6 Raster representation of discrete features

Raster representation of discrete features

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2. Raster Data Structures

- Run-length encoding
- Chain Codes
- Block Codes
- Quad-tree Model
2.1 Raster Data Structure Types

Run Length

Chain Codes

Block Codes

Quad-tree Model

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## 3. Advantages and Disadvantages

<table>
<thead>
<tr>
<th>Raster</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Collection</td>
<td>Rapid</td>
</tr>
<tr>
<td>Data Volume</td>
<td>Large</td>
</tr>
<tr>
<td>Data Structure</td>
<td>Simple</td>
</tr>
<tr>
<td>Geometric Accuracy</td>
<td>Poor</td>
</tr>
<tr>
<td>Area Analysis</td>
<td>Good</td>
</tr>
<tr>
<td>Continuous phenomenon</td>
<td>Average</td>
</tr>
<tr>
<td>Modeling</td>
<td>Easy</td>
</tr>
<tr>
<td>Compatibility with image</td>
<td>good</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>low</td>
</tr>
</tbody>
</table>

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4. Other Data Model

- **Triangular Irregular Network Data Model**
  - Alternative to represent continuous surface.
  - Effective display terrain, other types of continuous data.

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5. Grids in ArcView

Floating Point Grids
- no attribute table associated
- can be converted to integer by classify

Integer Grids

Value Attribute Table (VAT)
- contains value and its counts for each record.

No Data Value
- assigned to cells which are doesn’t have data value.

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6. Exercise

6.1 Working with grid themes
   - Activating spatial analysis
   - Open existing data
   - Delete grid theme
   - Converting shape file to raster grid
   - View Theme Properties
   - Retrieve information of individual cell
   - View Histogram

6.2 Available Functions
   - Calculate density
   - Reclassify
   - Map query
   - Map calculator
   - Tabulate area
   - Histogram by zones
   - Summarize zones
   - Find distance
   - Assign proximity
   - Neighborhood statistics
   - Create contour
   - Derive slope
   - Derive aspect
   - Interpolate Surface

6.3 Surface Modeling with TIN and DEM
6.1 Working with grid themes

1. Activating spatial analysis

Start ARCVIEW .

Select EXTENSION from FILE dropdown menu.

Click SPATIAL ANALYSTS on EXTENSION window.

Two drop down selection menus will be available when view is active.
6.1 Working with grid themes

2.1 Open existing data

Open a view window by clicking on NEW on project window.
Click add theme button.
Change the DATA SOURCE TYPES to GRID DATA SOURCE.
Select the data “road-g” to load.
Click OK.
2.2 Open existing data
6.1 Working with grid themes

3. Delete grid theme

Select MANAGE DATA SOURCE from FILE menu.

Select “road_g”.

Press DELETE to delete the grid data.
4.1 Converting shape file to raster grid

Load shape file “roads.shp” to view window. Select **CONVERT TO GRID** from **THEME** menu. Specify the output grid name “road-g”.

Prepared by Mona Lacoul, July 2004
6.1 Working with grid themes

4.2 Converting shape file to raster grid

Specify \textit{CELL SIZE} and \textit{OUTPUT GRID EXTENT}.

Note, The View property should be defined before specifying cell size and extent.

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6.1 Working with grid themes

4.3 Converting shape file to raster grid

Specify conversion field “road_network”.

Click OK to join remaining database.

Click OK to view it on screen.
6.1 Working with grid themes

5. View Theme Properties

Make the theme active.

Select PROPERTIES from THEME menu.
6.1 Working with grid themes

6. Retrieve information of individual cell
Make the theme road-g active.
Pick IDENTIFY tool.
Click on the cell of interest.
6.1 Working with grid themes

7. View Histogram
Make the theme road-g active.
Click the histogram button.
6.2 Available Function

1.1 Calculate Density
-calculates Density
-distributes to produce a continuous surface.
-two types of density methods are
- Simple (simple average method)
- Kernel (quadratic kernel function)
-the occurrences of the measured quantity per specified Area Unit.
-finding density of houses, population, wildlife observations, or crime reports

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6.2 Available Function

1.2 Calculate Density

Click add theme button to display “pop95_p”.

Make the theme “pop95_p” active.

Select CALCULATE DENSITY from ANALYSIS menu.
1.3 Calculate Density

Specify output cells size, output extent and press ok.

Specify population field, search radius, density type, area unit and press ok.
6.2 Available Function

1.4 Calculate Density

Save “density from population95_p” as “density”.

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6.2 Available Function

2.1 Reclassify

- Allows set standard classification methods
- Set the parameters for that classification
- Equal Area, Equal Interval, Natural Breaks, Quantile, Standard Deviation
- Classify grid to assign weight
- perform suitability analysis
6.2 Available Function

2.2 Reclassify

Make the theme “density from pop95_p” active.

Select RECLASSIFY from ANALYSIS menu.
6.2 Available Function

2.3 Reclassify

Reclassify values window will popup. Click **CLASSIFY** button.

Specify type and number of classes

Press OK.
6.2 Available Function

2.4 Reclassify

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6.2 Available Function

3.1 Map Query

allows to select areas spatially by defining a Boolean query based on the values of one or more grid themes.

The output- a grid theme with areas that
1 (TRUE)
0 (FALSE)
6.2 Available Function

3.2 Map Query

Add grid theme “density”.
Make the theme “density” active.
Select MAP QUERY from ANALYSIS menu.
6.2 Available Function

3.3 Map Query (single grid)

Enter query in the map query window.

Selects cells that are having density less than 15 person/sq km and returns value 1 in output grid.

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6.2 Available Function

3.4 Map Query (single grid)

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6.2 Available Function

Exercise I:

Find out low population density area in

1. Othuomphun district
2. Nong, Thapngthong and Songkhon districts.

The available dataset are

Population data (pop95_p)
District map (district-p)

Form your own criteria for the analysis.
6.2 Available Function

4.1 Map Calculator

- Performs analysis on grid themes using mathematical expressions.
- Available operations
  Arithmetic
  Trigonometric
  Boolean, and
  relational operations.
- Creates a grid theme as output.
  (change the expression and re-evaluate the grid theme without having to create a new grid theme.)
6.2 Available Function

4.2 Map Calculator (arithmetic operators)

The four basic arithmetic operators

Multiplication
Division
Subtraction
Addition
Other (float..)

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6.2 Available Function

4.3 Map Calculator (arithmetic operators)

Make the theme “density” active.

Click add theme button to display “district-g”.

Select MAP Calculator from ANALYSIS menu.
6.2 Available Function

4.4 Map Calculator (arithmetic operators)

Type following expression.

Note, spatial extent of population density grid is larger than the actual study area. Above expression will create the population density map for the study area.
6.2 Available Function

4.5 Map Calculator (arithmetic operators)

Need to save the map calculation as grid.

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6.2 Available Function

4.6 Map Calculator (relational operators)

- compare the values of two grid themes or numbers on a cell by cell basis.
6.2 Available Function

4.7 Map Calculator (Boolean operators)

- compare the values of two grid themes or numbers on a cell by cell basis.
6.2 Available Function

4.8 Map Calculator (Logarithmic operators)

- perform logarithm and exponential analysis on grid themes or numbers.
6.2 Available Function

4.9 Map Calculator (Trigonometric operators)

- perform trigonometric analysis on a grid theme or number.
- input values should be in radians \((\text{rad}=\text{angle} \times \frac{\text{pi}}{180}\text{deg})\).
6.2 Available Function

4.10 Map Calculator (power operators)

- raise grid themes or numbers to certain powers.

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6.2 Available Function

5.1 Tabulate Area

- Performs a cross tabulation of the zones between two input themes.
- Creates an output table.
- Values in the resulting table identify the area of each zone in one theme encompassed within each zone in another theme.
- Available at least two feature or two integer grid themes, or one of each.
- Summarizing the area of each land use type within each county.

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5.2 Tabulate Area

Make themes “density” and “district-g” active.
Reclassify the density grid into four classes.
Save output as “recla_density” by using “SAVE AS
DATASET” button on theme menu.
Select TABULATE AREA from ANALYSIS menu.
5.3 Tabulate Area

Select row theme, row field, column theme and column field.

Press ok.
6.2 Available Function

5.4 Tabulate Area

Table can be exported to other file formats (excel, dbase, text..) for further analysis of result.

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6.2 Available Function

6.1 Histogram by zones

-points, lines, or polygons in the active theme are used to define what cells are used to create the histogram.

-allows you to examine the number of cell values for each class in a grid theme in a localized area defined with another theme.

-An integer grid theme, polygon theme.

-examine the number of cells of each land use type that intersect roads that have a 45 or 65 mph speed limit

Prepared by Mona Lacoul, July 2004
6.2 Available Function

6.2 Histogram by zones

Add themes “recla_density” and “district-g”.

Make the theme “district-g” active.

Select HISTOGRAM BY ZONES from ANALYSIS menu.
6.2 Available Function

6.3 Histogram by zones

Select the field to define zones for district grid.

Press OK.

Select the theme defining values to histogram.

Press OK.

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6.4 Histogram by zones

The chart displays proportion of population density in each district and can easily compared among the districts.

Different chart options are available.

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6.2 Available Function

7.1 Summarize Zones

- computes a chart and a table.
- output values are a function of the value of the cells in an input value grid theme found within each zone in the zone theme.

-zone theme:
  - an integer grid theme or a feature theme.
  - parcels in a city, land use categories, forest types, or buffer zones.

-value theme:
  - a grid theme
  - value theme(input grid): endangered species, vaccinations, housing prices, and sales.
7.2 Summarize Zones

Add themes “density” and “district-g”. Make the theme “district-g” active. Select **SUMMARIZE ZONES** from **ANALYSIS** menu.

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6.2 Available Function

7.3 Summarize Zones

Select theme containing variable to summarize.
Press OK.

Select statistic to display on chart.
Press OK.

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6.2 Available Function

7.4 Summarize Zones

Table lists statistics of population density for each district.

Chart displays range of density for each district.

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8.1 Find Distance

-Finds the distance to the closest feature in the active theme.

- Creates a grid theme as output.

- Each cell in the output grid theme contains the distance from that location to the nearest feature.

- similar to generating buffer.

- find nearest hospital, define buffer zone, study hazard vulnerability to settlements...
6.2 Available Function

8.2 Find Distance

Add theme line feature “road-p”. Click on the theme to activate. Select FIND DISTANCE from ANALYSIS menu.

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6.2 Available Function

8.3 Find Distance

Enter output grid specifications.

Press OK.

Prepared by Mona Lacoul, July 2004
6.2 Available Function

8.4 Find Distance

National roads and provincial roads were selected as features to find distance.

Prepared by Mona Lacoul, July 2004
6.2 Available Function

9.1 Assign Proximity

- Assigns areas of proximity to features found in the active theme.
- Creates a grid theme as output. Each cell location in the grid theme is allocated to the closest feature, determined by Euclidean distance.
- To find the closest feature in another theme
- To define the area of space allocated to each feature
6.2 Available Function

9.2 Assign Proximity

for each cell, the distance to each source cell is determined by calculating the hypotenuse with the x_max and y_max as the other two legs of the triangle.
6.2 Available Function

9.3 Assign Proximity

Add theme line feature “village-p”.
Click on the theme to activate.
Select ASSGN PROXIMITY from ANALYSIS menu.

Prepared by Mona Lacoul, July 2004
6.2 Available Function

9.4 Assign Proximity

Enter the specification for output grid.
Press ok.

Select the field to assign values to proximity area.
Press ok.

Prepared by Mona Lacoul, July 2004
6.2 Available Function

9.5 Assign Proximity

Features can be selected based on certain criteria to calculate proximity area. Instead of feature theme, Grid theme can be used for proximity analysis.

Villages are selected randomly to retrieve the proximity area.

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6.2 Available Function

10 Neighborhood Statistics

- Calculates a statistic for the values found in a specified neighborhood.
- Assigns the desired statistic value for the neighborhood defined around each cell.
- Input theme: a point or grid theme
- Output: a grid theme
- Statistics include majority, maximum, mean, median, minimum, minority, range, standard deviation, sum, and variety.
6.2 Available Function

**Exercise II:**

List the statistics for population density in for all the districts. Prepare a charts comparing statistics of the districts.

The available dataset are

Population data (pop95_p)
District map (district-p)
6.2 Available Function

11.1 Create Contour

- Creates a line of constant value, a contour line, from a point selected on a grid or TIN theme.

- Input: a single grid or TIN theme is active.

- Use only on themes representing a continuous attribute, such as elevation or density.

- To create Iso-lines, precipitation, temperature, humidity, contour, population density
6.2 Available Function

11.2 Create Contour

Add grid theme “density of pop95”.
Click on the theme to activate.
Select CREATE CONTOUR from SURFACE menu.
6.2 Available Function

11.3 Create Contour

Enter parameters to create contour (isolines).

Press OK.
6.2 Available Function

11.4 Create Contour

Population density iso-lines at 5 person/m² interval.

Prepared by Mona Lacoul, July 2004
6.2 Available Function

12.1 Derive Slope

- maximum rate of change in value (each cell to its neighbors)
- Output: Grid in percent slope or degree of slope

\[
\text{Degree of slope} = \theta \\
\frac{\text{rise}}{\text{run}} = \tan \theta \\
\text{Percent of slope} = \frac{\text{rise}}{\text{run}} \times 100
\]
The actual algorithm to calculate slope is:
rise_run = SQRT(SQR(dz/dx)+SQR(dz/dy))
degree_slope = ATAN(rise_run) * 57.29578
where the deltas are calculated using a 3x3 roving window, where a through i represent the values in the window:

```
<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>e</td>
<td>f</td>
</tr>
<tr>
<td>g</td>
<td>h</td>
<td>i</td>
</tr>
</tbody>
</table>
```

\[
(dz/dx) = ((a + 2d + g) - (c + 2f + i)) / (8 \times x_{mesh\_spacing})
\]
\[
(dz/dy) = ((a + 2b + c) - (g + 2h + i)) / (8 \times y_{mesh\_spacing})
\]
6.2 Available Function

12.3 Derive Slope

- Calculates the rate of maximum change for locations
- Input: grid or TIN themes
- GRID: using a 3 by 3 window.
- TIN: using the triangle the cell center falls in.
- Output: a grid theme (value represented in degrees)
- Use only on themes representing a continuous attribute, such as elevation or density.
6.2 Available Function

12.4 Derive Slope

Add grid theme “DEM_cut”.
Click on the theme to activate.
Select *DERIVE SLOPE* from *SURFACE* menu.
6.2 Available Function

12.5 Derive Slope

Output grid “slope” is degrees.
Save the output grid as “slope”.

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6.2 Available Function

13.1 Derive Aspect

- the down-slope direction of the maximum rate of change in value from each cell to its neighbors.
- the slope direction.
- Output: Grid (compass directions)
6.2 Available Function

13.2 Derive Aspect

- Calculates aspect for each cell
- Represents the direction of maximum slope of the input grid or TIN theme.
- Starting at 0 degrees (north) and increasing clockwise until 360 degrees

Input: a grid theme a TIN theme

Grid: calculates for each cell using a 3x3 window.

TIN: aspect of the triangle its center falls

Output: a grid theme

- Themes representing a continuous attribute, such as elevation or density.

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6.2 Available Function

13.3 Derive Aspect

Add grid theme “Slope”.
Click on the theme to activate.
Select **DERIVE SLOPE** from **SURFACE** menu.

![Screenshot of menu with Derive Aspect highlighted]
Most of the area is flat terrain.
6.2 Available Function

14.1 Interpolate Surface

-Fills in the gaps by analyzing the points around each location
-Create a continuous surface.
-Input: a point theme
-Output: a grid theme

-Method of Interpolation
  -IWD
  -Spline
14.2 Interpolate Surface (Spline)

- Fits a curve through the points surrounding the cell being analyzed and gives the cell the value of the curve at that location.

- best for gently varying surfaces such as elevation, water table heights, or pollution concentrations.
6.2 Available Function

14.3 Interpolate Surface (Spline)

Regularized method:
- yields a smooth surface.
- weight parameter: weight of the third derivatives of the surface in the curvature minimization expression.

Tension method:
- tunes the stiffness of the surface
- weight parameter: defines the weight of tension.

number of points parameter:
- identifies the number of points per region used for local approximation.

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6.2 Available Function

14.4 Interpolate Surface(IWD)

- weighting the value of each point by the distance that point is from the cell being analyzed and then averaging the values.

- Power parameter :
  - controls the significance of the surrounding points upon the interpolated value.
  - a higher power » less influence from distant points
  - to interpolate a surface of consumer purchasing
  - more distant locations have less influence

Barrier :
  - input line theme
  - a break that limits the search for input sample points
6.2 Available Function

Exercise III:

Given the following datasets:
(i) road, (ii) Village, (iii) hospital location, (iv) population

Formulate your criteria for analyzing health facility in the province based on

   accessibility (hint: use road)

   population served (hint: population).

Propose locations of new hospitals if needed.

Prepare summary tables and chart whenever possible.
1. Surface

- to represent continuous spatial phenomena.
- a z-coordinate value for each planimetric location
- surface object represented by a single-valued function
  \[ z = f(x, y), \]

Where, z can be an elevation value or any other kind of measurement
2. Surface Sampling Method

-infinite number of point to measure
-a sampling method to represent the surface model
-a surface model should
  -Accurately represent the surface
  -Be suitable for efficient data collection
  -Minimize data volume
  -Maximize data handling
  -Suitable for surface analysis
6.3 Surface Modeling with TIN and DEM

3. Surface Sampling Method (Contour)

- Isolines of constant elevation
- Most commonly used
- Poorly represented the variance between isolines
- Accuracy depends on data source
4. Digital Elevation Model

-represented by equally spaced sample points

-two ways to determine surface values between points
  -Interpolate between adjacent points: lattice
  -Considers each point as a square cell with a constant value: surface grid
5. Triangular Irregular Network Data Model

- Alternative to represent continuous surface.
- Effective display terrain, other types of continuous data.

Triangular Irregular Network (TIN)

Prepared by Mona Lacoul, July 2004
6. Triangular Irregular Network Data Model

- triangulation method satisfies the Delaunay criterion.

**Linear Interpolation**

\[ z = ax + by + c \]

\( a, b, c \) is determined by using co-ordinate values \( A, B, C \).
6.3 Surface Modeling with TIN and DEM

7. Triangular Irregular Network Data Model

![TIN Triangle List](image)
8. Triangular Irregular Network Data Model

A surface-feature type influences the triangulation definition of the resulting surface.

Supported surface-feature types:

- Mass point
- Breakline
- Replace polygon
- Erase polygon
- Clip polygon
- Fill polygon
9. Triangular Irregular Network Data Model

Mass point
- entered as nodes to the triangulation
- Input: point data, lines and polygon boundaries

Breakline
- linear features maintained as a sequence of one or more triangle edges.
- Input: line data, polygon boundaries.

Replace polygon
- polygonal features maintained as a sequence of one or more triangle edges.
- boundary and all enclosed area assigned single value.
10. Triangular Irregular Network Data Model

Erase polygon
- polygonal features maintained as a sequence of edges.
- areas inside the polygon - outside the zone of interpolation

Clip polygon
- polygonal features maintained as a sequence of edges.
- areas outside polygon - outside the zone of interpolation.

Fill polygon
- triangles falling inside the polygon are assigned an integer.
- No height replacement, erasing, or clipping takes place.
6.3 Surface Modeling with TIN and DEM

Exercise IV:

Given the following dataset:

- contour.shp
- Boundary.shp

Create Tin and Digital Elevation Model for the area.

Hints

Use spatial analyst and 3D analyst.

Choose mass point and clip polygon options while creating TIN.