New York State Geographic Information Systems
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Workshop on Grid-based Map Analysis Techniques and Modeling

Points, Lines and Polygons to Continuous Geographic Decision Space: Applying Raster Analysis in a Vector World

Presented by

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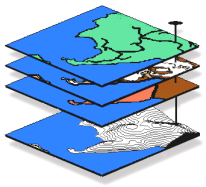


Situation: Most desktop mapping and GIS applications have focused on mapping and spatial data management responding to inventory assessments of "***Where Is What***" involving digital maps and linked databases (computer mapping and geo-query). Map analysis provides new processing structures and analytical tools for investigating and incorporating spatial relationships of "***Why and So What***" in both research and decision-making contexts. While the new tools of Spatial Analysis, Surface Modeling/Spatial Data Mining and GIS Modeling might at first seem daunting, their roots are in basic math/stat and are less challenging than balancing your checkbook. However, the extension of effective GIS applications from descriptive to prescriptive mapping involves new spatial reasoning concepts and skills that are not reflected in our paper map legacy, manual processing procedures or contemporary "spatial object" mindset. This workshop introduces the new map analysis approaches and procedures taking GIS well beyond mapping …*to thinking with maps*.

Description: This 1.5 hour introductory workshop discusses and demonstrates numerous techniques for spatial analysis and data mining using application examples from *natural resources*, *infrastructure*, *geo-business* and *precision agriculture*. The discussion focuses on concepts, procedures and practical considerations in successfully applying grid-based map analysis within in a map-*ematical* framework. The material presented encapsulates numerous "Beyond Mapping" columns published in GeoWorld and compiled into the new book Map Analysis: Understanding Spatial Patterns and Relationships (Berry, 2007).

Who Should Attend: GIS managers and specialists who are interested in or currently involved in the development of systems that analyze spatial data should attend. The material presented is designed to illustrate the common threads of map analysis used in a wide range of applications. Prior GIS exposure and a basic familiarity with statistics are recommended.

About the Instructor: Dr. Joseph K. Berry is the Principal of Berry and Associates // Spatial Information Systems, consultants and software developers in Geographic Information Systems (GIS) technology. He also serves as the W. M. Keck Scholar in Geosciences at the University of Denver and is a Special Faculty member at Colorado State University.

General Notes for the Introductory Workshop on

Grid-based Map Analysis Techniques and GIS Modeling

Joseph K. Berry, email ***jberry@innovativegis.com****, website* ***www.innovativegis.com/basis***

Beyond Mapping III *online book posted at…*
www.innovativegis.com/basis/*, select "Beyond Mapping III"*

Example Applications *posted at…*
www.innovativegis.com/basis/*, select "Example Applications"*

Cartography– manual map drafting (paper map legacy for thousands of years)
Computer Mapping– automates the cartographic process (70s)
Spatial Database Management– links computer mapping techniques with traditional database capabilities (80s)
GIS Modeling and Analysis– representation of relationships within and among mapped data (90s)…

- ✓ *Surface Modeling*– maps the spatial distribution of a set of point sampled data,
- ✓ *Spatial Data Mining*– characterizes the "numerical" relationships among mapped data and develops predictive models,
- ✓ *Spatial Analysis*– derives new information based on "contextual" relationships among mapped data, and
- ✓ *GIS Modeling*– logical processing of spatial information to characterize a system or solve a problem.

*(See Beyond Mapping III online book, "**Topic 4**" and "**Topic 27**" for more information)*

Raster refers to image display (map values represent the color assigned to each dot; e.g., scanned topographic maps–DRGs or aerial photos–DOQs) while **Grid** refers to map analysis (map values have all of the rights, privileges and responsibilities of a map-*ematics*).
Grid data structure the *Analysis Frame* provides consistent "parceling" needed for map analysis and extends points, lines and areas to *Map Surfaces.*
*(See Example Applications, "**Short Video Demos**" for more information)*

Surface Contouring options include *# of Ranges*, *Calculation Method* (e.g., Equal Ranges with same range for each interval and Equal Count with same number of cells for each interval) and *Color Pallet/Ramp* selection.
Grid Display Types are *Lattice* that forms a smooth "wireframe" by connecting cell centroids with lines whose lengths are a function of elevation differences and *Grid* that forms extruded grids whose heights are a function of elevation differences.
*(See Example Applications, "**Display Types**" for more information)*

Grid Data Types are characterized by their *Numeric Distribution* (independent integers versus range of values) and their *Geographic Distribution* (abrupt boundaries versus gradient). A *Discrete* map has values that simply represent categories (e.g., a Cover type map) that form sharp abrupt boundaries) whereas a *Continuous* map has values that represent a spatial gradient (e.g., a slope map).
*(See Example Applications, "**Data Types**" for more information)*

Spatial Analysis investigates the "contextual" relationships in mapped data…

- **Reclassifying Maps**– New map values are a function of the values on a single existing map… no new spatial information is created
- **Overlaying Maps**– New map values are a function of the values on two or more existing maps… new spatial information is created
- **Measuring Distance**– New map values are a function of the simple or weighted distance or connectivity among map features
- **Summarizing Neighbors**– New map values are a function of the values within the vicinity of a location on an existing map.

*(See Beyond Mapping III online book, "**Topic 24**" for more information)*

Reclassifying and Overlaying Maps– reclassifying operations involve the reassignment of the values of an existing map as a function of its initial value, position, size, shape or contiguity of the spatial configuration associated with each map category; overlay operations involve the creation of a new map where the value assigned to every location is computed as a function of the independent values associated with that location on two or more maps (point-by-point, region-wide and map-wide)

*(See Beyond Mapping III online book, "**Topic 22**" for more information)*

Measuring Distance and Connectivity– the concept of *Distance* as the "shortest straight line between two points" is expanded to *Proximity* by relaxing the assumption of only "two points" then expanded to *Movement* by relaxing the assumption of "straight-line" connectivity.

*(See Beyond Mapping III online book, "**Topic 13**," "**Topic 14**" and "**Topic 25**" for more information)*
*(See Example Applications, "**Determining Proximity**" and "**Creating an Up-Hill Road Buffer**")*

Calculating Visual Exposure– a *Viewshed* identifies all locations that can be seen from a view point(s) while *Visual Exposure* develops a relative scale indicating the number of times each location is seen from a set of viewer points (e.g., a road network).

*(See Beyond Mapping III online book, "**Topic 15**" for more information)*
*(See Example Applications, "**Determining Visual Exposure**" and "**Modeling Visual Exposure**)*

Summarizing Neighbors– a *Diversity Map* indicates how many different types, a *Roughness Map* identifies the variation in slope values, and a *Density Map* reports the total value within a specified distance of each grid location.

*(See Beyond Mapping III online book, "**Topic 11**"and "**Topic 26**" for more information)*
*(See Example Applications, "**Assessing Covertype Diversity**")*

Surface Modeling maps the spatial distribution and pattern of point data…

- ✓ **Map Generalization**– characterizes spatial trends (e.g., titled plane) by considering all of the samples at once as it fits a surface,
- ✓ **Spatial Interpolation**– derives spatial distributions (e.g., IDW, Krig) by considering small, localized set of samples throughout the map area (roving window), and
- ✓ **Other**– roving window and facets (e.g., density surface; tessellation)

*(See Beyond Mapping III online book, "**Topic 2**", "**Topic 3**" and "**Topic 8**" for more information)*

Spatial Data Mining investigates the "numerical" relationships in mapped data…

- ✓ **Descriptive**– calculates aggregate statistics (e.g., average/stdev, similarity, clustering) that summarize mapped data,
- ✓ **Predictive**– develops relationships among maps (e.g., regression) that can be used to forecast characteristics or conditions at other locations or times, and
- ✓ **Prescriptive**– uses descriptive and predictive information to optimize appropriate actions.

*(See Beyond Mapping III online book, "**Topic 7**", "**Topic 10**" and "**Topic 16**" for more information)*

GIS Models come in three basic types…

- ✓ **Suitability Models**– based on logically sequenced decision criteria similar to a recipe (e.g, animal, shopper and pipeline "habitat")…
  - **Binary Model**– identifies areas that are acceptable based on combining binary maps (0 and 1),
  - **Ranking Model**– develops a ranking of areas based on the number of criteria that are acceptable (0 to 3), and
  - **Rating Model**– develops a "goodness" scale (0 to 9 best) and calculates the average rating for each grid cell.
- ✓ **Statistical Models**– based on numerical relationships (e.g., crop yield), and
- ✓ **Process Models**– based on physical (e.g., erosion potential)

*(See Beyond Mapping III online book, "**Topic 17**", "**Topic 19**", "**Topic 20**" and "**Topic 23**" for more information)*

Capturing and Communicating Model Logic– a flowchart is used where boxes represent maps and lines represent analytical operations to identify the processing steps linking command scripts to mapped data.

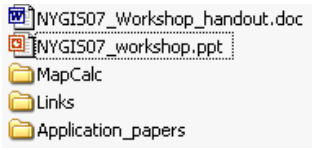
*(See Beyond Mapping III online book, "**Topic 21**" for more information)*

Data Conversion investigates vector to/from raster data exchange…

- ✓ **V to R–** burning the points, lines and areas into the grid (fat, thin and split),
- ✓ **R to V–** connecting grid centroids, sides and edges (line smoothing), and
- ✓ **Pseudo Grid–** each grid cell is stored as a polygon

*(See Beyond Mapping III online book, "**Topic 18**" for more information)*

Workshop CD contains a Word version of this handout, the PowerPoint slide set used in the workshop (with embedded links), application papers referenced and a hands-on tutorial using MapCalc Learner software (14-day evaluation). See the \MapCalc folder for instructions on installing and using the software.



You are encouraged to review these materials to further your understanding of grid-based map analysis. You may use the materials in educational presentations; contact the author for written permission.

Note: the PowerPoint slides contain hyper-links to the topics in the Beyond Mapping III online book (must be connected to the Internet) and the Application Papers on the Workshop CD (must have the PowerPoint and the \Application_papers folder in the same folder as the PowerPoint on your computer).