

SOLSTICE: An Electronic Journal of Geography and Mathematics.

(Major articles are refereed; full electronic archives available)

- *Solstice* was a Pirelli INTERNETional Award Semi-Finalist, 2001 (top 80 out of over 1000 entries worldwide)
- One article in *Solstice* was a Pirelli INTERNETional Award Semi-Finalist, 2003 (Spatial Synthesis Sampler).

Congratulations to all *Solstice* contributors.

CURRENT ISSUE SOLSTICE, VOLUME XVI, NUMBER 1; SUMMER, 2005.

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Sandra Lach Arlinghaus

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Solstice Archive

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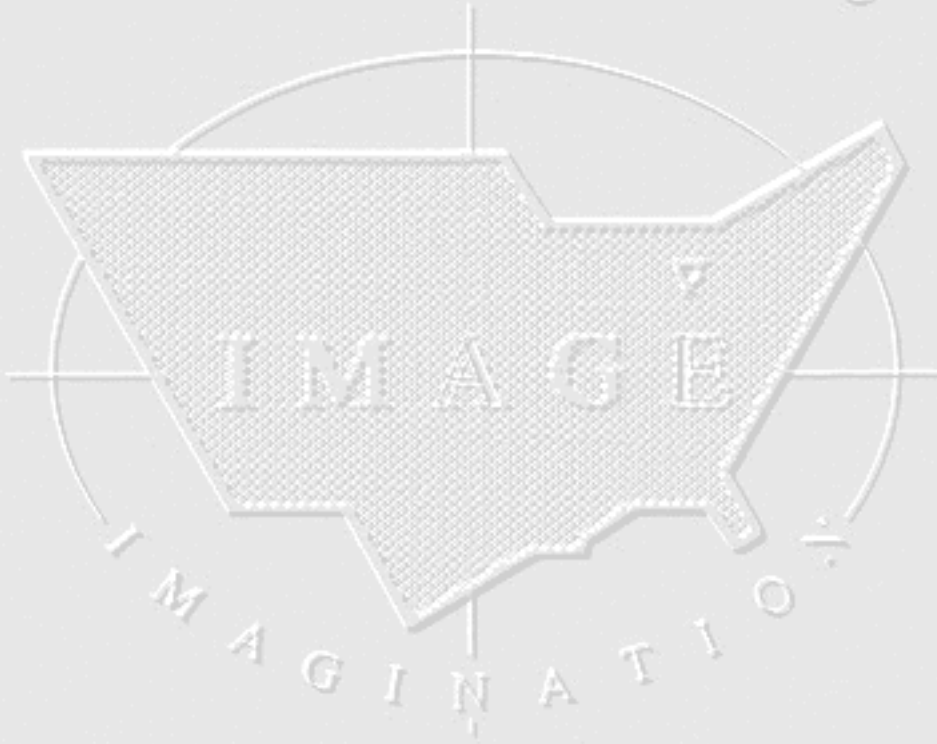
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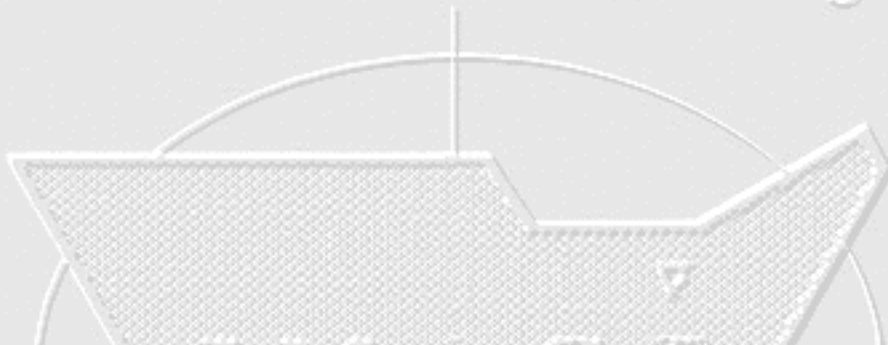
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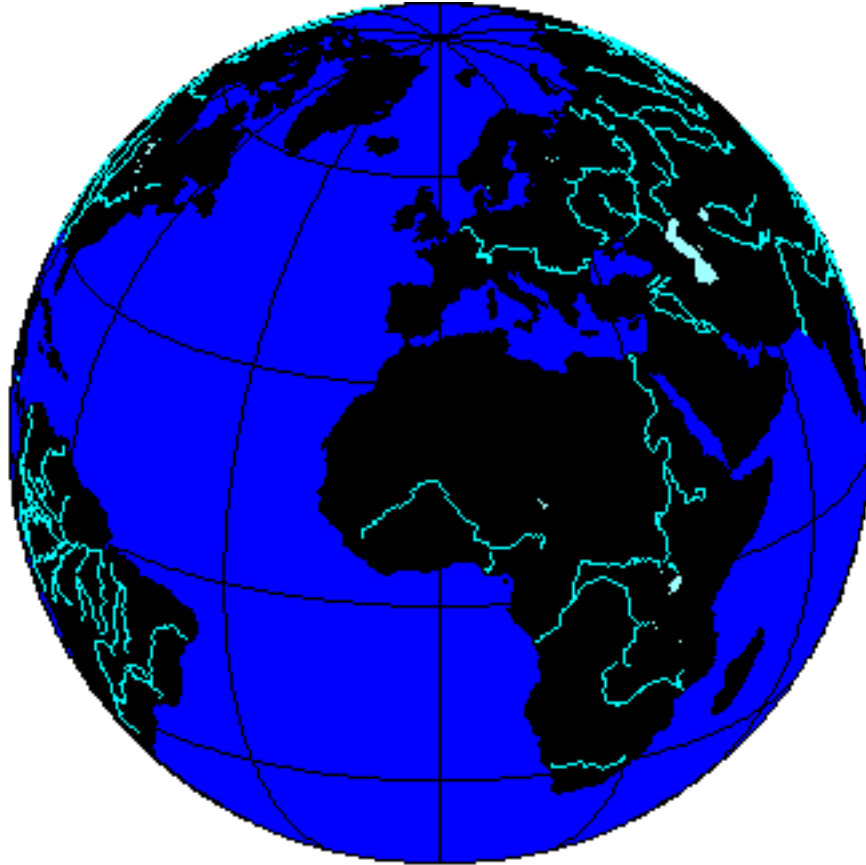
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Solstice:

An Electronic Journal of Geography and Mathematics



Earth: with 23.5 degrees north latitude as the central parallel.

Volume XVI

Number 1

June, 2005

Institute of Mathematical Geography (IMaGe)

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SUMMER, 2005

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ANN ARBOR, MICHIGAN

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MISSION STATEMENT

The purpose of Solstice is to promote interaction between geography and mathematics. Articles in which elements of one discipline are used to shed light on the other are particularly sought. Also welcome are original contributions that are purely geographical or purely mathematical. These may be prefaced (by editor or author) with commentary suggesting directions that might lead toward the desired interactions. Individuals wishing to submit articles or other material should contact an editor, or send e-mail directly to sarhaus@umich.edu.

SOLSTICE ARCHIVES

Back issues of Solstice are available on the WebSite of the Institute of Mathematical Geography, <http://www.imagenet.org> and at various sites that can be found by searching under "Solstice" on the World Wide Web. Thanks to Bruce Long (Arizona State University, Department of Mathematics) for taking an early initiative in archiving Solstice using GOPHER.

PUBLICATION INFORMATION

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To cite the electronic copy, note the exact time of transmission from Ann Arbor, and cite all the transmission matter as facts of publication. Any copy that does not superimpose precisely upon the original as transmitted from Ann Arbor should be presumed to be an altered, bogus copy of *Solstice*. The oriental rug, with errors, serves as the model for creating this weaving of words and graphics.

Awards and Recognition

(See [Press Clippings](#) page for other.)

- Sandra Lach Arlinghaus, recipient, The President's Volunteer Service Award, March 11, 2004.
 - Jeffrey A. Nystuen, won the 2003 Medwin Prize in Acoustical Oceanography given by the [Acoustical Society of America](#). The citation was "for the innovative use of sound to measure rainfall rate and type at sea". It is awarded to a young/mid-career scientist whose work demonstrates the effective use of sound in the discovery and understanding of physical and biological parameters and processes in the sea.
 - [Sandra L. Arlinghaus](#), William C. Arlinghaus, and Frank Harary. *Graph Theory and Geography: an Interactive View (eBook)*, published by John [Wiley](#) and Sons, New York, April 2002. Finished as a Finalist in the 2002 Pirelli INTERNETional Award Competition (in the top 20 of over 1200 entries worldwide). [Link](#) to general Pirelli website.
 - *Solstice*, Semi-Finalist, Pirelli 2001 INTERNETional Award Competition in the Environmental Publishing category.
 - *Solstice*, article about it by Ivars Peterson in *Science News*, 25 January, 1992..
 - *Solstice*, article about it by Joe Palca, *Science* (AAAS), 29 November, 1991.
-

IN MEMORY OF
**FRANK
HARARY**

1921-2005

IMaGe FRIEND AND
COLLEAGUE

[Link](#) to Frank Harary
Home Page

From his friends, co-authors,
and colleagues
Bill and Sandy Arlinghaus

Frank was a mentor to Bill.





Floral arrangement by S. Arlinghaus from a single scanned lily by Alma S. Lach.

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Volume XVI, Number 1.

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IN MEMORY OF
**SAUNDERS
MAC LANE**
1909-2005
IMaGe FRIEND AND
COLLEAGUE

[Link](#) to Saunders Mac
Lane memorial page

From his friends and
colleagues
Sandy and Bill Arlinghaus

Saunders was a mentor to
Sandy.





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Spatial Synthesis

The Evidence of Cartographic Example: Hierarchy and Centrality*

Sandra Lach Arlinghaus

The cartographic example presented below displays principles of spatial synthesis as they focus on centrality and hierarchy.

- **Classical example:** The dot density map employs a nested hierarchy of regions to convert information about dots to information about regions; in so-doing, the clusters of dots emerge as centers of activity associated with the nature of the underlying data from which the dots were extracted.
- **Contemporary example:** The interactive online map may employ a nested hierarchy that, in a single map, offers not only information of the sort available in a dot density map but also a host of other previously impossible features, as well. It may be linked to the underlying database in a manner that also permits
 - scale transformation
 - views of the database corresponding to small regions on the map
 - searches of the underlying database.

Interactive capability can be far more than an interesting visualization tool; it can be one offering synthesis of spatial information at a level far greater than that available with any classical map.

These traditional (but perhaps under-utilized) cartographic techniques, are based on synthetic geometric and or number theoretic considerations. The focus of *Spatial Synthesis: Book 1, Volume I*, will be to present further theory and example of such intellectual interaction and to do so in a manner that allows the reader to participate in that interaction.

A scatter of dots might represent any real world phenomenon: from the location of emergency telephone kiosks, to small villages, to national capitals. Dots pinpoint geographic position. At a global scale, national capitals may appear as dots; at a local scale, they may appear as areas containing dot scatter of their own. What matters is geographic scale: dots at one scale may not be dots at another scale. In that regard, it does not matter what the dots represent.

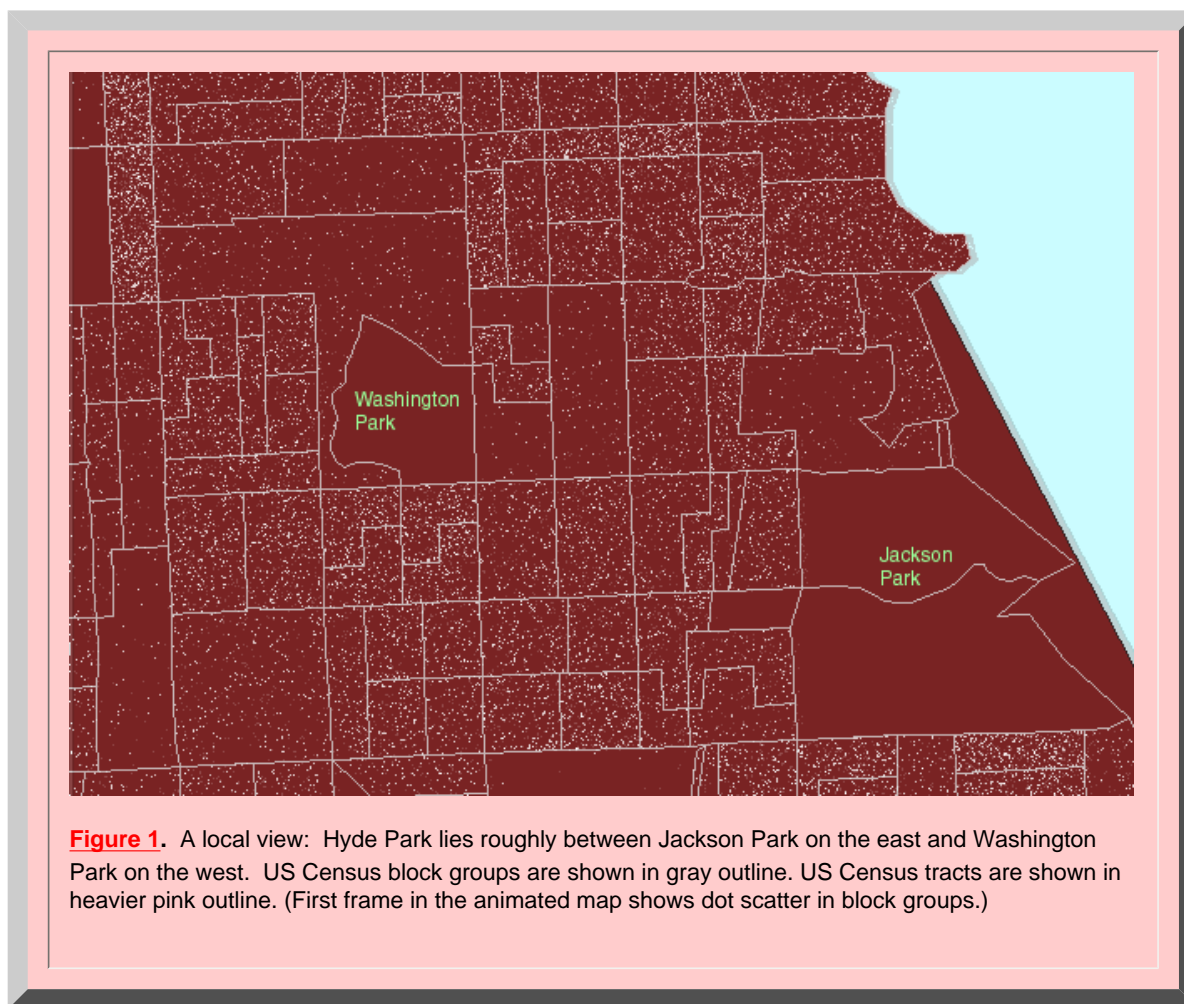
Dot density maps

Dot density maps might show 1 dot representing 200 people in some spatial unit or 1 dot representing 1 percent of the population of yet another spatial unit. One might see a map in a newspaper showing concentrations of voters of different political persuasion, by ward, prior to an election. Often, though, these maps might appear to be (or actually be) in error: a glance at one's own home ward generally elicits reactions such as "no one lives over there where that dot is!" Dot density maps should not be confused with pushing pins in a wall map to indicate position; dot density maps show pattern, not specific position tied to address or latitude/longitude.

When the dot density map is properly constructed it can serve as a tool offering valuable insight into clustering. A variety of examples are shown below: they range in scale from a local neighborhood example, centered on Hyde Park (in Chicago, Illinois, USA) the University of Chicago neighborhood, to the city level, to the state level, to the watershed level. The lessons they suggest should lure the thoughtful reader away from error in interpretation and use.

Nested Hierarchies of Polygons

To be effective, the dot scatter should be randomized at a relatively local scale and then viewed for pattern at a scale more global than the scale of randomization. In Figure 1, dot scatter has been randomized at the U.S. Census Block Group level; it is then viewed successively at the U.S. Census Tract level (tracts are larger than block groups) and then at the state level (in the animation): a hierarchy of regions. Any pattern in the scatter of dots within individual block groups is meaningless: the scatter is random. Within tracts, broad clusters, or centers of activity, are evident; and, even more obviously within the state, clusters of dots delineate urban (central) areas.



The dots in the animated map in Figure 1 are simply counts of population: 1 dot represents 10 people according to the 1990 U.S. Census of the Population. Dots are scattered randomly, by the computer, throughout each block group. Thus, because the scatter is random at the block group level, clusters of dots within block groups boundaries (gray in Figure 1) are meaningless and the location of dots within block groups does not correspond to locations of individuals either in relation to the underlying base map or to other individuals. The most common error in using dot maps is to show the dot scatter within the polygons used for randomizing the scatter; hence, the common complaint that these are "not accurate."

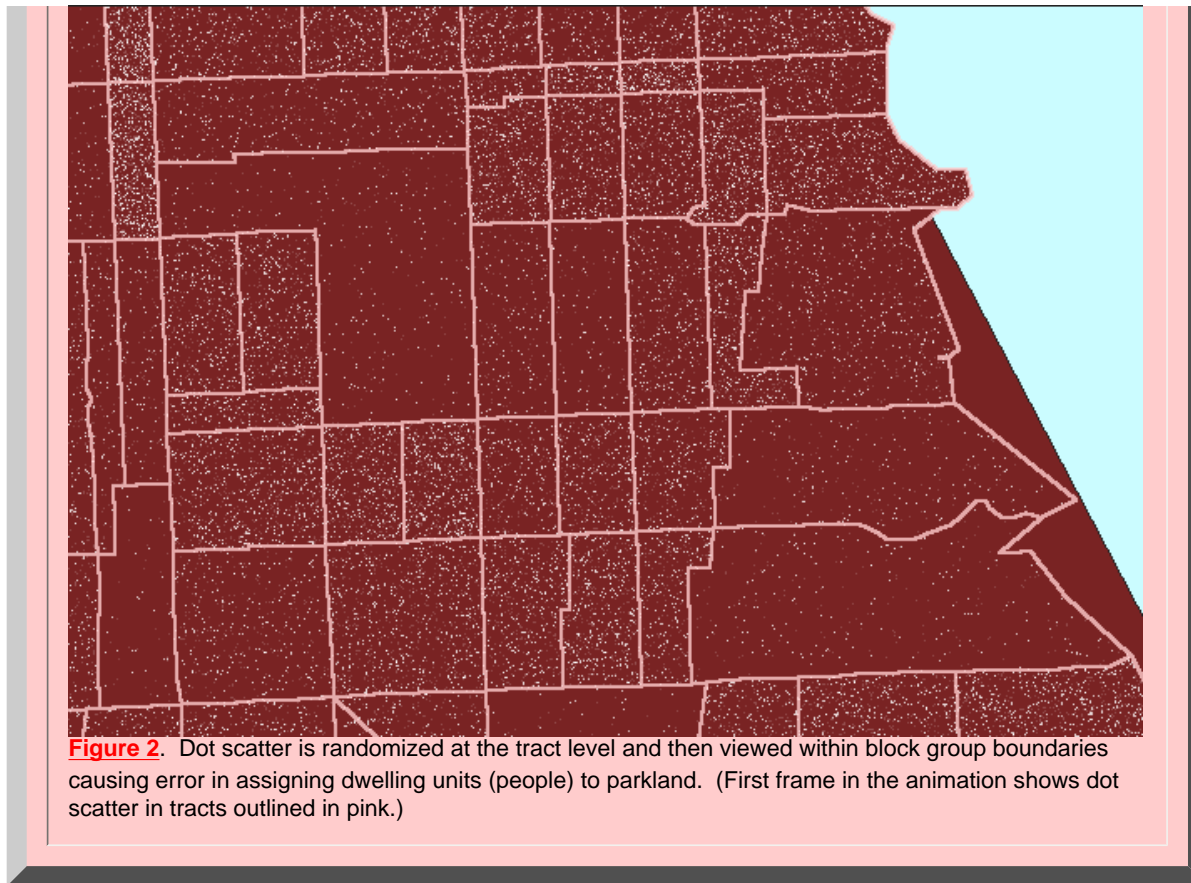
For the clustering of dot scatter to have meaning, look at it, for example, through the lens of the more regional US Census tract boundaries (heavy pink lines in Figure 1). Figure 1 moves the reader's eye from block group boundaries, to block group boundaries nested inside tract boundaries, to tract boundaries alone, to no boundaries. As boundaries increase in generality, and dot scatter remains the same, clustering of dots becomes sensible. Thus, in Figure 1, one sees no dots in the block groups containing Jackson Park and Washington Park so that when the block group boundaries are replaced by tract boundaries, which contain the park and dwelling units, the dots are not scattered across the park but remain in the region of the tract where people live. The clustering to the west of Jackson Park means something at the tract level.

The pattern of boundary removal, to make sense of dot scatter, is not symmetric. In Figure 1, dots were randomized at the block group level and then viewed at the tract level. Because

- tracts are larger than block groups, and
- block groups are nested within tracts

the opportunity to observe clusters at the tract level is optimized. If the situation exhibited in Figure 1 were reversed, and dot scatter randomized at the tract level, and then viewed through the block group boundary lens, clear clustering errors would result. Figure 2 shows this sort of reversal. In it, note that now dot scatter is present in the parks suggesting that there are numerous dwelling units in the parks: a clear erroneous situation.





Principle 1: Randomizing Principle

In a dot density map, dot scatter is randomized at one scale and then, to have the map make sense, must be viewed at a scale more global than that of the randomizing layer.

A dot density map that is constructed to follow **Principle 1** will be said to be a "properly constructed" dot density map. Any that does not follow **Principle 1** will be viewed, therefore, to be improper and likely to convey error.

In a properly constructed dot density map, if a more global layer is composed of polygons that contain the randomizing layer in a nested fashion, then there is no problem of overlapping regions and possible confusion about assignment of dot to polygon. Thus,

Principle 2: Optimization Principle

A nested hierarchy of layers provides optimized assignment of dots to more global layers.

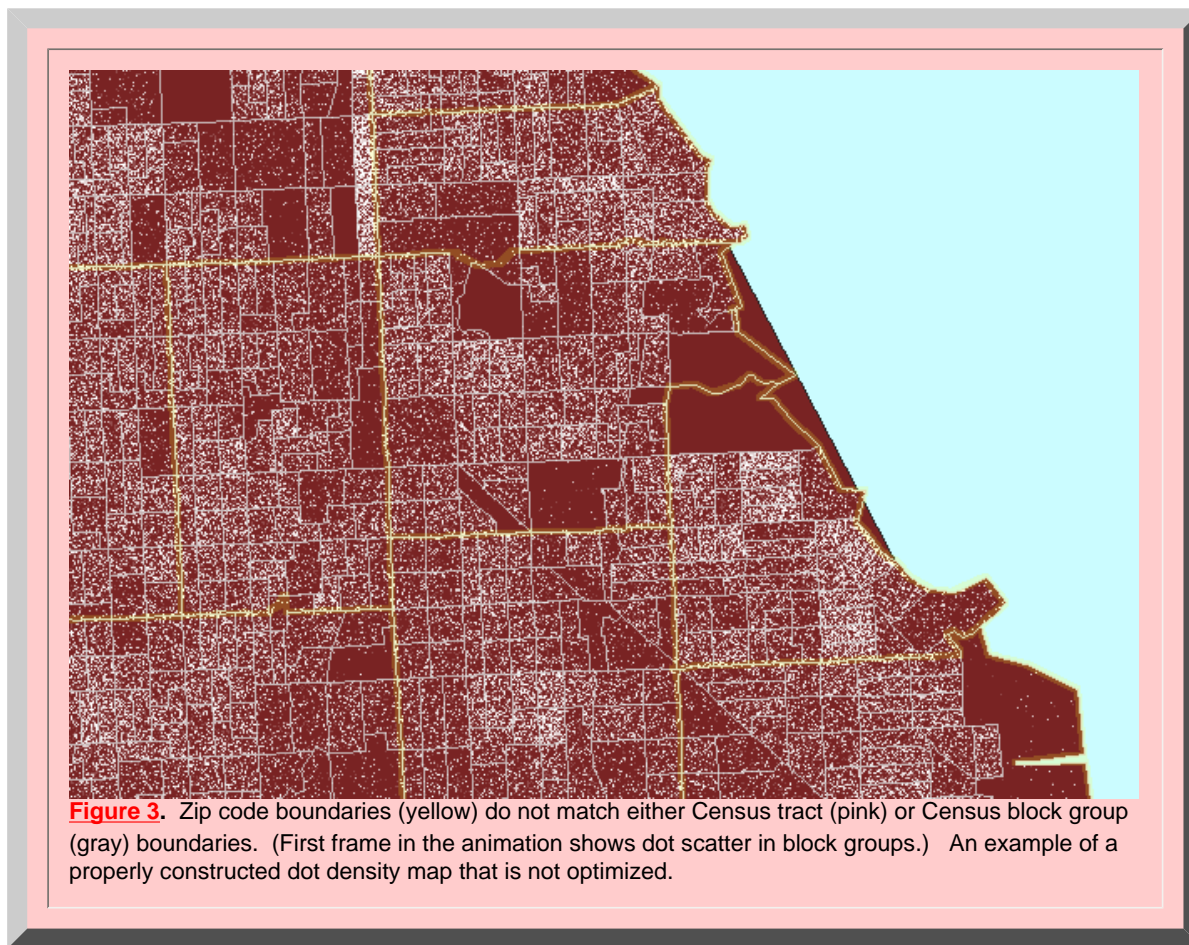
A dot density map that is constructed to follow **Principle 1** and **Principle 2** will be said to be an "optimized properly constructed" dot density map. In the next section, example will be given of a properly constructed dot density map that is not optimized.

Hierarchies with Overlapping Layers

Often, unfortunately, one is not able to obtain data arranged in a nested spatial hierarchy, such as the tract

and block group units shown above. It may be desired, for example to use Census data to obtain information about zip code polygons, school districts, minor civil divisions, and so forth. Census boundaries, however, are not generally commensurate with zip code boundaries and various other spatial units.

There are a number of ways of extracting information from Census units about, for example, zip code areas. One way involves using computer software to calculate the centroids of Census units and count the Census unit as lying "within" the zip code area if the centroid of the Census unit lies within the zip code area. Zip code areas are often larger than tracts and block groups, especially in urban areas (as Census units are scaled in area according to population). Thus, in an urban setting, one might properly construct a dot density map randomizing the dot scatter at the block group level and then viewing that scatter through tract boundaries and ZIP code boundaries, creating a properly constructed dot density map that is not optimized because the hierarchy of spatial units on which it is based is not a nested hierarchy. Figure 3 illustrates the process for a region on the south side of Chicago centered on Hyde Park.



Scale Change

Beyond the two principles above, there are a number of other issues to consider when using a properly constructed dot density map. Often, randomizing at the most local level is best. When one looks at a more regional view, however, local randomization may introduce clutter into the map. In Figure 4 the scale

has been made more global to include much of the Chicago metropolitan area. In that view, the white dots nearly fill space and clustering is not evident. Conceptually, in order to reduce dot clutter, one might randomize at a more global level or one might alter what the dots represent. Sacrifice in accuracy of dot position always undermines the fidelity of the dot density map; alter what the dot represents, instead of its position.

Principle 3: Scale Principle

When a change in scale produces dot clutter from dot density, randomize at the most local scale available and alter dot representation to retain a properly constructed dot density map.

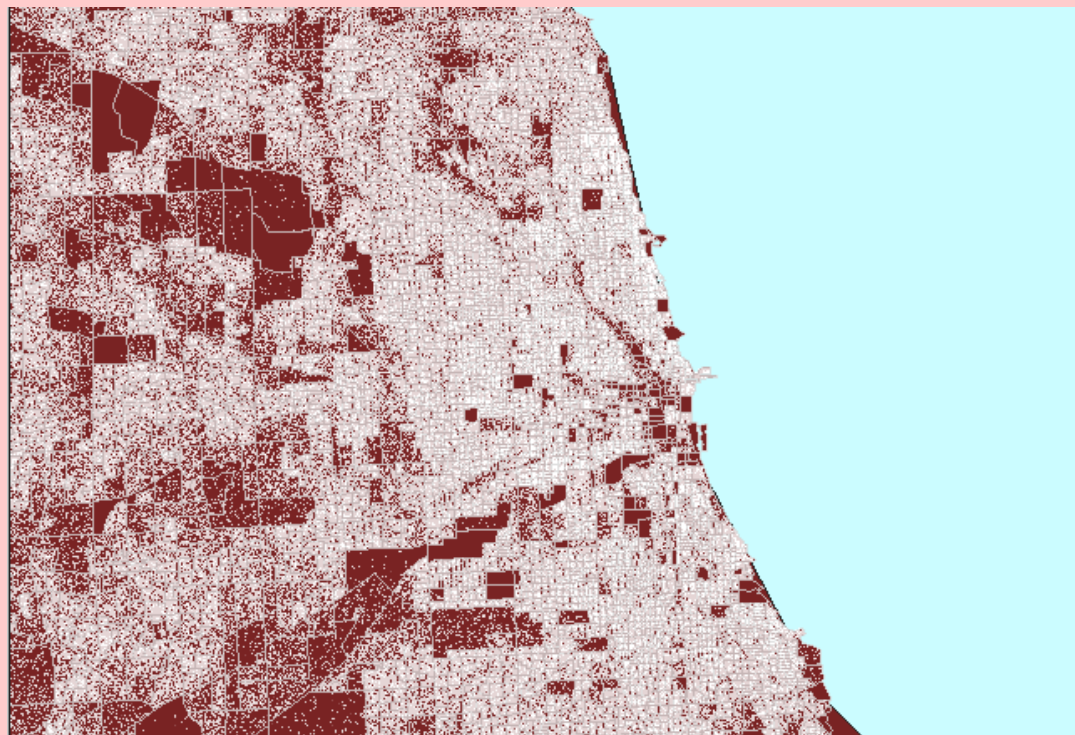
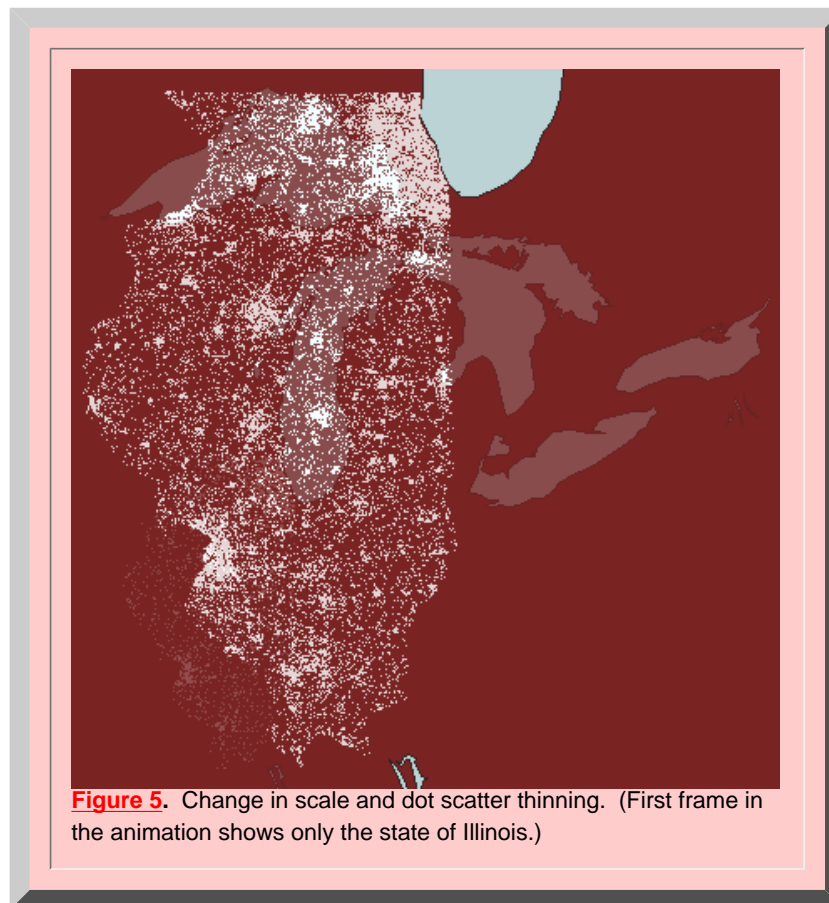


Figure 4. Dot clutter followed by a properly constructed dot density map of Chicago, Illinois. (First frame in the animation shows heavy white dot scatter in block groups.)

The animated map in Figure 4 shows dot clutter resulting from using 1 dot to represent 10 people. A better choice, at this scale, of 1 dot to represent 100 people reduces the number of dots by a factor of 10 so that clusters become evident, particularly when no Census boundaries are overlain. In both cases, the dot scatter is randomized at the block group level: the most local level for which data was readily available in this example. Thus, there is no sacrifice in accuracy of dot position in removing dot clutter by thinning the number, rather than by altering the position, of dots.

When the '1 dot to represent 100 people' representation is transformed to the state level, portrayal of urban areas is evident. Dot clutter, from this particular representation, once again enters the picture at the watershed

level (Figure 5). The first watershed frame in Figure 5 shows Illinois at 1 dot to 100 people: dot obscures dot clusters. The second watershed frame shows Illinois at 1 dot representing 1000 people: dot thinning may appear to have removed clusters. The final frame shows a compromise at 1 dot representing 800 people: a view that reduces dot clutter yet retains dot clusters.



The Importance of the Equal Area Projection

Map projections on which a geometric unit square represents the same amount of geographic area, independent of position, are called "equal area projections." On an equal area projection, relative land mass sizes appear as they do on the globe: Brazil is larger than Greenland, for example. Dot density maps can be used to make comparisons; the animated map below (Figure 6) suggests comparing population (either as total numbers or as a percentage) in Chicago (green square) to that of Milwaukee (yellow square) and Traverse City (red square). The underlying projection employed is an Albers equal area projection. Thus, the squares represent the same amount of area on the earth and comparisons at different latitudes are valid. Had a Mercator projection (for example) been employed, the red square would have represented less geographic area than would have the green square and comparisons based on area would have been invalid.



Principle 4: Projection principle

A properly projected dot density map must be based on an equal area projection.

If any projection other than an equal area projection is employed in making a dot density map, then comparisons involving area will be in error.

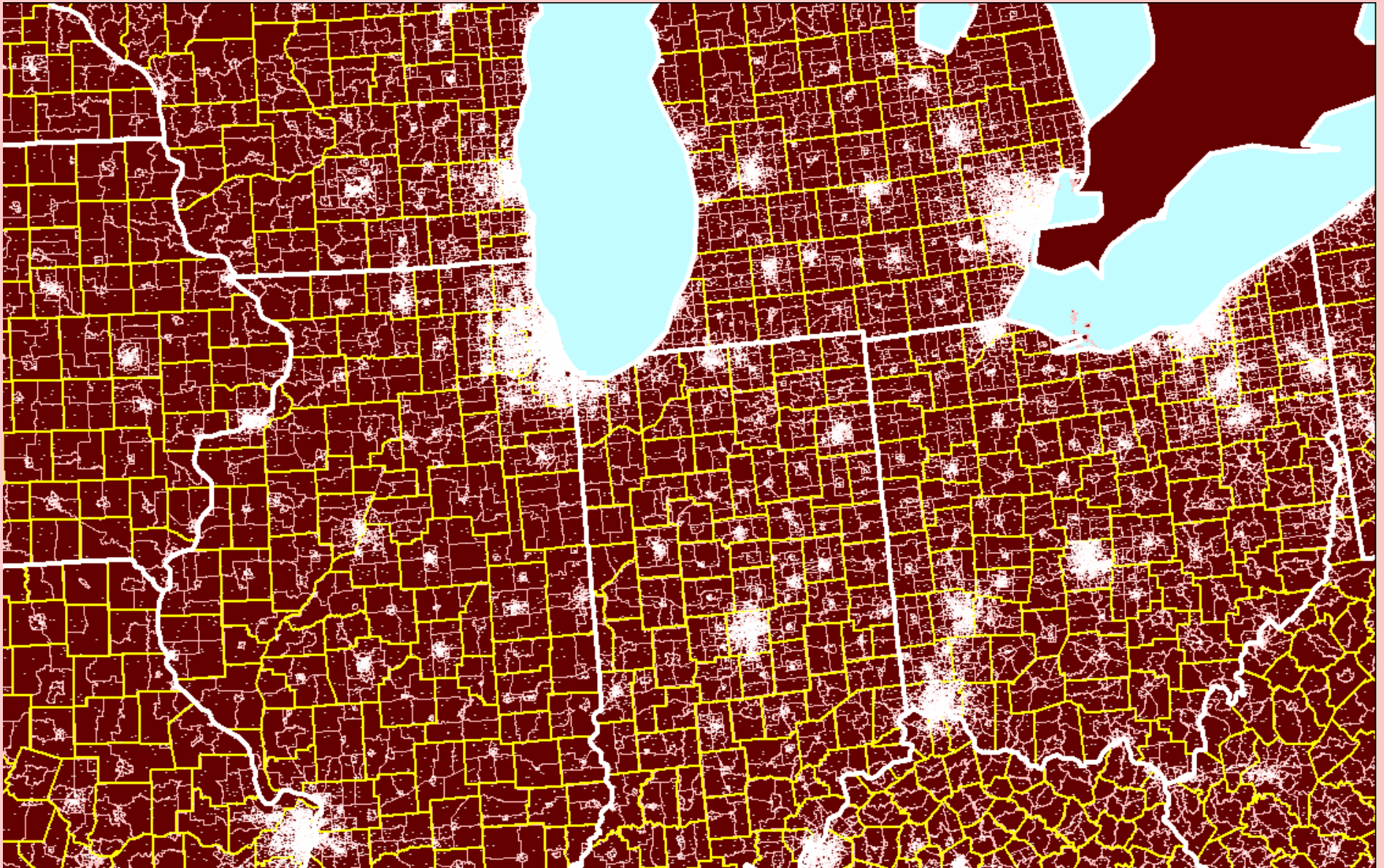
In order of importance the Principles for making these maps are:

- If dot density maps are to be properly constructed, then they must follow ***Principle 1: Randomizing Principle***
- If dot density maps are to be used to make comparisons involving area, then they must follow ***Principle 4: Projection Principle***
- If dot density maps are to optimize assignment of dot pattern, then they must follow ***Principle 2: Optimization Principle***
- If dot density maps are to succeed in transcending scale change, then they must follow ***Principle 3: Scale Principle***

Dot density maps offer one way to synthesize information derived from point sources to suggest information about areas.

Interactive Maps

Interactive maps are tools that may offer both vertical and lateral movement within a hierarchy. Figure 7 shows a screen shot of an interactive map that includes state boundaries (heavy white lines), county boundaries (yellow lines), Census tract boundaries (pink lines), and dot scatter at the 1:800 level as in Figure 5 above. Click on [this link](#) to go to the map in its interactive form. Once there, use the zoom feature to shift hierarchical levels in a scale transformation. Within a given hierarchical level, click on single polygons to view associated database information. Or, search the underlying database using the "search" feature to find polygons with attributes of special interest. In this instance, the technological realm offers a form of spatial synthesis not available in the classical realm.



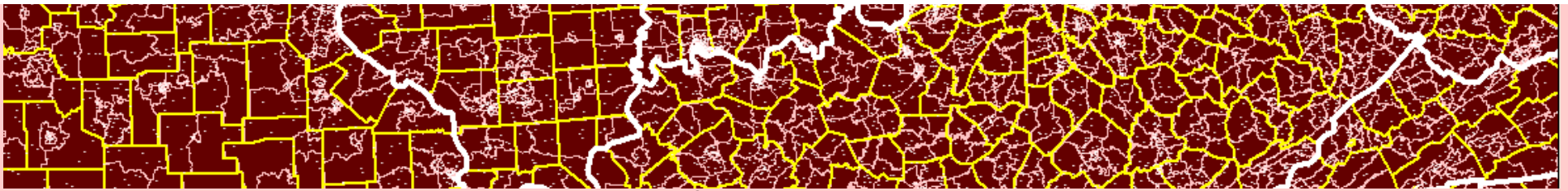


Figure 7. An example of a dot density map that follows all four basic principles. State boundaries in white contain county boundaries in yellow which in turn contain tract boundaries in pink. Click on the map to go to the associated interactive map.

***Synthesis in which one discipline sheds light on another**

Sarastro: Die Strahlen der Sonne vertreiben die Nacht

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Composer: Wolfgang Amadeus Mozart

Conductor: Karl Böhm

Performers: Evelyn Lear, Roberta Peters, Lisa Otto, Fritz Wunderlich, Dietrich Fischer-Dieskau, Franz Crass, Hans Hotter, Friedrich Lenz, Hildegard Hillebrecht, Cvetka Ahlin, Sieglinde Wagner, Rosl Schwaiger, Antonia Fahberg, Raili Kostia, James King, Martti Talvela, Hubert Hiltten, Martin Vantin, Manfred Röhl

Orchestra: Berlin Radio Chamber Choir, Berlin Philharmonic Orchestra

Label: The Originals

Catalogue Number: 4497492

Released: February 10, 1997

Audio CD A-D

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Kioskland: A Strategy for Linking Hierarchical Levels of Virtual Reality Maps*

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The University of Michigan

with input from**:
Klaus-Peter Beier, Matthew Naud, John D. Nystuen
Taejung Kwon, Adrien Lazzaro, Paul Oppenheim, Aaron Rosenbaum (Fall 2003)
Nikolai Nolan, Rasika Ramesh, Itzhak Shani (Fall 2004)

Technical note:

The images linked to this article require the reader to install Cosmo Player or Cortona or another browser plug-in designed for viewing Virtual Reality files on the internet.
Use a recent version of Internet Explorer as the browser (or an early version of Netscape, series 4.7x) or other browser that supports virtual reality.
These images are also best viewed on a current computer with at least 512 MB of RAM (more is better!) with the screen resolution set as high as possible.

The electronic pages of this journal have, for the past few years, contained numerous examples of virtual reality maps: from planning for extra residential units in downtown [Ann Arbor](#) to tracking rugged voyages of [Lewis and Clark](#). Many maps cover large areas of terrain; they are global in scale. Virtual reality, however, often is best executed in the small, at a local scale (Beier (lectures in [Engineering 477](#), The University of Michigan), [Crispen](#)). The virtual maps tend to become large in file size quickly, causing the maps not to load properly. One problem is that software that easily creates virtual maps may not also optimize file size. That persistent problem of the virtual modeler can be partially addressed by importing Virtual Reality Modeling Language (vrmf) files exported from Geographic Information System software (GIS software) into a software package that executes polygon reduction of the vrmf code. Beyond such reduction, however, there remains the geographer's dilemma of scale transformation and a need to map both globally and locally. A [classical](#) way to execute such transformation is to arrange the spatial information in layers of a nested hierarchy and use a well-defined transformation to move from one level of that hierarchy to another. In the case of virtual reality maps (VR-maps), one puts individual maps in separate layers, separating maps before they become too heavy to run smoothly, or adequately, on current computing equipment (the creator, of course, needs to decide the target audience and the computing environment in which its members are likely to function).

Earlier work on creating a 3D Atlas of Ann Arbor has produced thousands of separate virtual maps of the downtown ([inventory](#) of previous work; click on the "Archive" button). Some are maps that show the current stock of buildings. Others are maps that suggest future buildout scenarios based on concepts provided by leading architectural and construction experts. The images below show screen capture of separate virtual reality models. The image on this offers a simple solution to link the different hyperlinked images, using kiosks

that transform the user, via the internet, from one hierarchical level to another.

File Navigation Notes

- Click [here](#) to download a copy of Cosmo Player to use as a plug-in for your browser in order to view virtual reality files.
- The screen captures of virtual reality models in this article are taken from browsers with Cosmo Player installed.
- View the virtual reality models in your browser:
 - To use pre-defined viewpoints, and have controlled navigation of the model, pull down the "[viewpoints](#)" menu in the lower lefthand corner.
 - When using the driving controls to navigate the model freely, adjust driving speed using the "[preferences](#)" menu in the lower righthand corner.
- Other plug-ins for viewing virtual reality files in browsers are available for free download. Cortona is one such option. Go to Google, Yahoo, or other to search for them if the links on the page for Cosmo Player, above, fail to work.

This [linked](#) image shows a screen capture of an associated [virtual reality](#) model of downtown Ann Arbor with buildings represented as simple boxes extruded from digitized building footprints. Over several years, such images, of both actual and projected cityscape, served as one set of basic materials for planning efforts for city officials involved in various aspects of municipal planning. Visualizing alternative outcomes associated with different zoning types and land use patterns was helpful in understanding how decisions might be reached. Maps and decisions often go hand in hand.

These maps and box-models were useful in a general way: for looking at patterns of vacant land, possible infill sites, general skyline resulting from proposed infill, relation of topography to the built environment, and as a general inventory of the existing downtown scene by building height, zoning type, and special designation (such as historic district or floodplain designation or State-owned property, as are University of Michigan buildings). Many buildings, however, are not boxes, and all buildings have texture. In the municipal arena of professional planning, supplementary architectural drawings and models are therefore critical (until the day arrives that virtual models are easy and inexpensive to make at all levels of detail). Thus, one wishes for virtual maps that show more detail: not only for planning purposes but for others as well. An important other use centers on [emergency response](#): of [firefighters](#) (using virtual training of firefighters in their downtime in the firehouse, for example), of [police officers](#), of [environmental management personnel](#), and of a whole host of [first responders](#) ([link](#) to the 3D Laboratory, Duderstadt Center, The University of Michigan).

The introduction of photographic textures on files causes rapid enlargement of file size. The map in this [linked](#) image shows a screen capture of one view of a [virtual reality](#) file in which textures have been applied to a number of buildings in the downtown area. The file is about at the limit of what a typical desktop modern machine running 512 MB of RAM can run in a reasonable (not optimal) time (anywhere from 1 to 5 minutes to

load the model depending on various local conditions such as amount of free hard drive space, fragmentation of the hard drive, internet connection speed, age of machine, and so forth). In this file, there are textures only on selected buildings. There are no street or sidewalk textures and there is no street "furniture" nor are there any other related accessories such as traffic lights, lane markers, or cars.

The extra detail that comes at high cost in terms of file size is quite attractive for many applications. Another way to introduce extra detail is to put links on the virtual buildings. Thus, in the last [linked](#) virtual reality model, one can click on selected buildings to look inside: not at an image of the interior but to internet links to the interior via a firm's own webpage and so forth. Try [219 S. Main Street](#): look at the bottom of Cosmo Player to see building addresses as the mouse is moved across virtual buildings with active links to html pages. The corresponding html page that comes up when the building is clicked on in the virtual reality model is [linked](#) here. The background color of the html page is significant. All buildings in the same physical, four-sided, block have the same color background. Buildings in adjacent blocks (with adjacency defined as being "across the street from") have a different color.*** When environmental managers choose to insert, in the html pages, detail about environmental hazards known to be in particular buildings (for private municipal use only), then this model provides even more information valued by these managers, and other first responders, in times of disaster. One advantage to this approach using html files linked to virtual buildings is the small file size of the linked web page; another is that no special knowledge, beyond simple html, is required to maintain the model.

Finally, one may wish to introduce even more detail with street textures, benches, trees, and so forth. All of this detail quickly increases file size. Over the course of two years, student groups worked for three months to produce more detailed files. In the Fall of 2003, in Professor Klaus-Peter Beier's Engineering 477 course (The University of Michigan), with Faculty Advisors Arlinghaus, Naud, and Nystuen, students Kwon, Lazzaro, Oppenheim, and Rosenblum produced a detailed model of the intersection of Main and Liberty Streets that Beier edited substantially (look both at the [screen capture](#) and at the [virtual reality](#) model). In the Fall of 2004, again in Engineering 477, students Nolan, Ramesh, and Shani, produced a detailed model of Main and Huron Streets that Beier edited substantially (look both at the [screen capture](#) and at the [virtual reality](#) model). Both of these models were edited by the author in terms of cleaning of photographic images (removing the foreground where it remained), adjusting building shape and height to be correct and to be compatible with materials from the City of Ann Arbor and The University of Michigan, and adjusting building location so that the detailed models would fit correctly and seamlessly with the City of Ann Arbor files and with The University of Michigan files. These adjustments involved the use of ArcView GIS software from ESRI, Adobe PhotoShop, Windows notepad as a vrml editor, and 3D Studio Max from Discreet. The adjustments were executed in the Usability Lab of the Duderstadt Center of The University of Michigan using computing equipment configured with a double flat-screen monitor for wide-angle viewing, and also on a home desktop with a large single flat screen monitor.

While each model has its own uses, an obvious desire is to be able to move from one to another without returning to a page and links: to move directly from one level of the hierarchy to another and stay within the virtual world. One way to execute such movement is to insert markers, "kiosks," in files to link from one one level to another. Each virtual kiosk has an internet link on it: the virtual kiosk serves as a center of information based on the virtual matter of the internet much as its real-world kiosk counterpart serves as a center of information based on printed matter. Thus, the virtual kiosks, when loaded with correct information regarding Uniform Resource Locators (URLs), serve as well-defined transformations from one hierarchical level of virtual map to another. The table below shows how to use this single file. The rows represent layers in a hierarchy: moving across the rows is a lateral move within the same hierarchy or virtual image. The columns represent movement from one virtual image to another; in this case, using kiosks loaded with

appropriate URLs to execute that movement.

Enter the Virtual World [here](#)

The links to images below show the path through that World

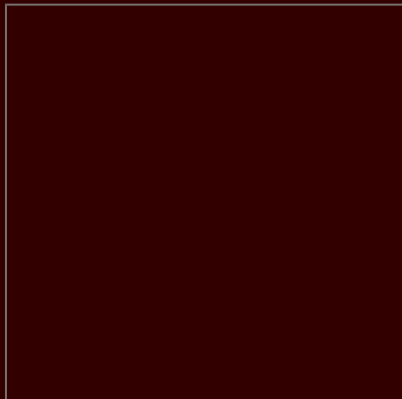
Entry to file. The viewpoints menu suggests the lateral move (blue highlight).

[Image](#)

The direct link to this world is given in the table heading, above.

Lateral move to kiosk, at Main and Liberty, to next level. Click on the kiosk, in the virtual reality file, to go to next image, below.

[Image](#)



More detailed view of scene at Main and Liberty. Note the kiosk in the street. Click on it, in the virtual reality file, to go to the next image below, showing even more detail of a region more local than that shown here.

[Image](#)
[Panorama](#)
[Direct link to this world](#)

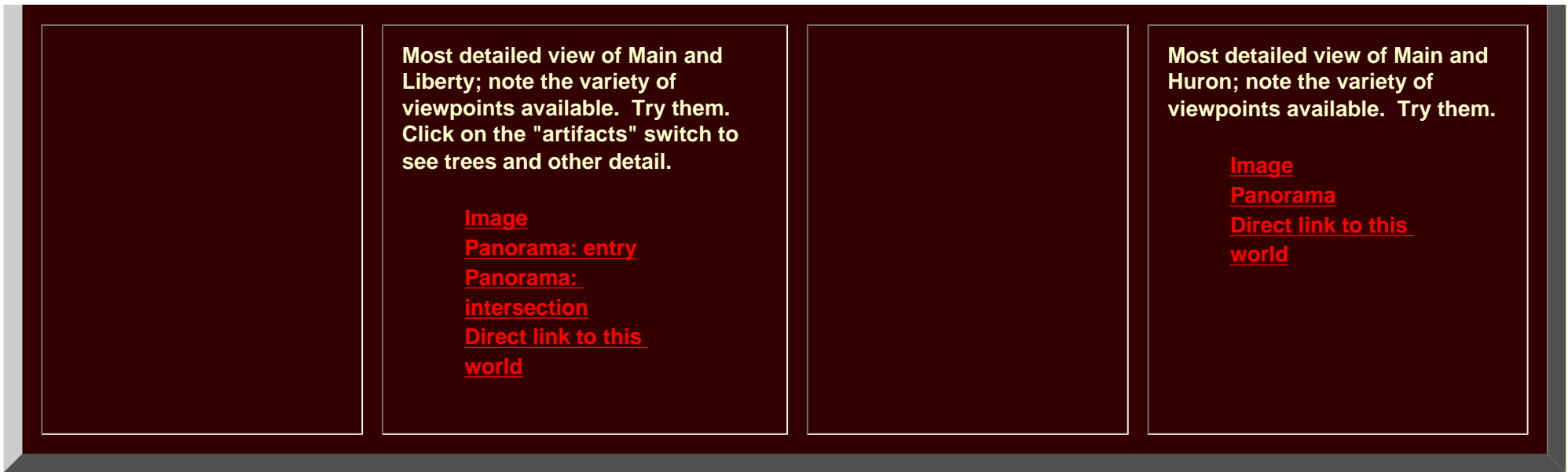
The viewpoints menu suggests the lateral move (blue highlight).

[Image](#)

In the various views at this hierarchical level, the streets outlined in white lie within the Downtown Development Authority (DDA); those outlined in yellow do not.

More detailed view of scene at Main and Huron. Note the kiosk in the street. Click on it, in the virtual reality file, to go to the next image below, showing even more detail of a region more local than that shown here.

[Image](#)
[Panorama](#)



Most detailed view of Main and Liberty; note the variety of viewpoints available. Try them. Click on the "artifacts" switch to see trees and other detail.

[Image](#)
[Panorama: entry](#)
[Panorama: intersection](#)
[Direct link to this world](#)

Most detailed view of Main and Huron; note the variety of viewpoints available. Try them.

[Image](#)
[Panorama](#)
[Direct link to this world](#)

Follow the path suggested in the table above to become familiar with navigation through the various layers of the model. Use viewpoints or drive freely within layers. One entry point to the virtual world offers access to a wide range of virtual files. An important aspect of such transformation is thus that one can have many files together in a single file no heavier to view than the single heaviest layer of the hierarchy. It would not have been possible, using merging techniques or some such equivalent strategy, to create the entire set as a single file. When kiosks (or some conceptually equivalent mechanism for jumping between hierarchical levels) are employed, it is easy to imagine emergency managers training first responders to fly through a small file of the entire city with chunky buildings in order to learn the general city layout. When each street corner or other strategic location in this general model is marked with a kiosk then with one click of the kiosk a detailed model pops up, while additional clicks on individual buildings in this detailed view reveal the interiors of buildings as html files. This sort of arrangement has been created for the City of Ann Arbor (and given to them). Creation of the model has taken several years and involved the use of a wide variety of resources, both human and digital. Maintenance, however, can be achieved using a simple text editor to alter the underlying code in either the html files or in the vrml files (part of the code for one building is [attached](#)). Thus, highly computer-literate City employees, armed with digital cameras and good computing resources can maintain the model and insert changes and additions to suit a variety of needs and interests: the process is in place. The arrangement of spatial information in a hierarchy is an efficient arrangement not only in the classical worlds of pen and paper but also in the contemporary world of digital models as well as in the practical implementation of such hierarchical arrangements in the real world.

*

The author thanks Merle Johnson of the City of Ann Arbor ITS Department and Chandra Hurd of the City of Ann Arbor Planning Department: the former for his generosity in sharing aeriels and maps from City of Ann Arbor files and the latter for sharing her expertise in analyzing city data and in checking selected files related to material on this site. She also thanks Donald T. Uchman, Coordinator of Space Graphics, Space Information and Planning, Plant Extension--

AEC, The University of Michigan, for his willingness to share official University map files on locations and sizes of buildings.

Prof. Klaus-Peter Beier, Ph.D., Director of the 3D Laboratory of the Duderstadt Center of The University of Michigan has offered extraordinary insight and support on various phases of this project. The author is indebted to his graciousness in sharing computing as well as intellectual resources. She is also extremely appreciative of the assistance and wise advice from staff members in the 3D Laboratory of the Duderstadt Center, Scott Hamm, Steffan Heise, Brett Lyons, Eric Maslowski, and Lars Schumann, and also to Graduate Student Instructors in Engineering 477, Thana Chirapiwat, Jamie Cope, and Bonnie Congxi Bao.

The name "Kioskland" derives from a paper by that name by the author (1976, Department of Geography, The University of Michigan, unpublished).

** Matthew Naud, M. S. and M. P. P., is Environmental Coordinator for the City of Ann Arbor and a principal member of the Emergency Management team.

John D. Nystuen, Ph.D. is Professor Emeritus of Geography and Urban Planning, The University of Michigan.

In the Fall of 2003, Taejung Kwon was a Ph.D. Candidate in the Taubman College of Architecture and Urban Planning, The University of Michigan, Adrien Lazzaro was a Master's degree Candidate in the School of Information, The University of Michigan, and Paul Oppenheim and Aaron Rosenbaum were undergraduates (Seniors) majoring in computer science.

In the Fall of 2004, Nikolai Nolan was an undergraduate majoring in General Studies, Rasika Ramesh was a beginning graduate student in the School of Information, and Itzhak Shani was an undergraduate (Senior) majoring in Engineering.

***[The Four Color Theorem](#) is used in color assignment; thus, in a grid street pattern, two colors are both necessary and sufficient to distinguish all blocks (animated Four Color map [link](#)). No more than four colors are ever required (viewing the block geometry as part of a plane or a sphere). Thus, background color of the linked html page also gives subtle information as to location.

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Research Announcement

A Methodology for Historical Geography: Internet Implementation*

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with

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In the study of the past, especially of dynamic sequences of events such as resolved and unresolved conflicts, linear narrative and exposition techniques used in book-length text production limit the juxtaposition of text, graphic images, maps, and source materials. These limitations shape analysis and understanding of the events that we are investigating. Rather than forming a purely linear progression or a single narrative, historical events and processes are in fact the results of a vast network of related actions and events, some more obvious than others. The historical dynamic of cause and effect, action and reaction, is broad and dispersed. No matter how well this characteristic of history is understood, it is still often the case that paper-based narrative techniques of book production favor portraying such complex networks as a series of linear narratives. The scholarly techniques most readily available to the student of history often provide a stylized simplified picture of history removed from the complexity and variety of available sources and information. The current technological scene, however, offers the scholar remarkable opportunities to present research results in media which much better reflect the dispersed occurrence of intricately interconnected past events. Thus, it becomes possible to fuse the spatial approach of geography and the temporal approach of history. When the technological scene works interactively with the research effort, such fusion is the consequence.

This manual/handbook being prepared presents an introduction to a methodology which integrates familiar techniques of historical and geographical scholarship with maps, timelines, and other visualization tools using the power of the internet to create an elaboration of sequences of past events in the form of a web or network of actors and events rather than as a single linear narrative. Our overall approach is ecological conceptualizing "actors" as encompassing not only human actors but all kinds of natural beings, features, and events such as plants, animals, mountains, weather events, and so on. This methodology makes possible a certain level of creative and playful thinking: that we be willing to experiment with new ways to organize the data and original sources for our own understandings of historical events and to open ourselves to new possibilities and forms of scholarship. At its heart, this methodology takes recent advances in communication technologies such as the internet, especially web page design, and data management technologies such as database management and geographic information systems (GIS), to provide a new method for linking historical and geographical scholarship. Part of this manual/handbook being prepared is meant to demonstrate how these technologies and techniques can be taken up by the historian, and other students of the past in various disciplines, and integrated with accepted methodology and practice in order to advance and enhance the study of past events. (See the excellent online guide, [*A Place in History: Guide to Using GIS in Historical Research*](#), by Ian Gregory.) The methodology, itself, transcends the current technological scene so that changes in that scene can be integrated into the strategy. Thus, the document to come will be more than a guide to current technology (always a moving target).

By integrating textual scholarship with maps, timelines, charts, images, and other visualization tools in a non-linear manner through the use of the internet, the researcher is able to explore and present history as

a network of actors and events, articulated in multiple directions. Such webs of information alleviate the need to exclude information in order to fit the limits and forms of traditional scholarship (books) but instead allows for a more open and comprehensive approach to scholarly research and publication. Use of the electronic hierarchy to capture scholarly hierarchies and networks is not new. It is well established in both a teaching and a scholarly setting. What is new, however, is its application in developing a replicable and specific method for historical geography. It should be thought of as an innovative method of data analysis, writing, and presenting synthetic results in which images of original documents of all kinds can easily be inserted, articulated and made visible, not as a way of simply integrating audio/visual materials or appendix materials into text. The content guides the form of the web; and, the form of the web then may help to guide the content selected. Interaction between form and process leads to the fusion noted above and serves as the keystone for integrating future change into an information web.

The key to understanding the methodology presented here is in understanding the ability it provides the researcher to compartmentalize and then synthesize all available data. By looking at actors, comprehensively defined to include not just individuals but also groups and organizations and non-human actors (plants, animals, geographical features, weather and others) and events as individual units which are then encapsulated within a web of related information, each component can be explored to its fullest while still playing a part in the grander narrative being investigated. Historical and geographical patterns are not the result of a direct line of cause and effect, but rather the outcome of a vast network of actors and events which all come together to create changes in time and space. This methodology, is equally effective at global and local scales (spatial or temporal). Unlike traditional scholarship in which it is impossible to portray the complex interweavings of human and other activities at the level of the individual, this methodology can be taken to a very fine level of detail. It is ideal for illustrating complex detailed networks by giving each individual actor, agent, and event which leads in its own way to the broader historical changes the historical geographer is seeking to understand, a fully developed history and presentation of its own. By fully exploring each of these agents in depth together with the often intricate linkages among them, a new complex level of historical understanding can be opened to the researcher.

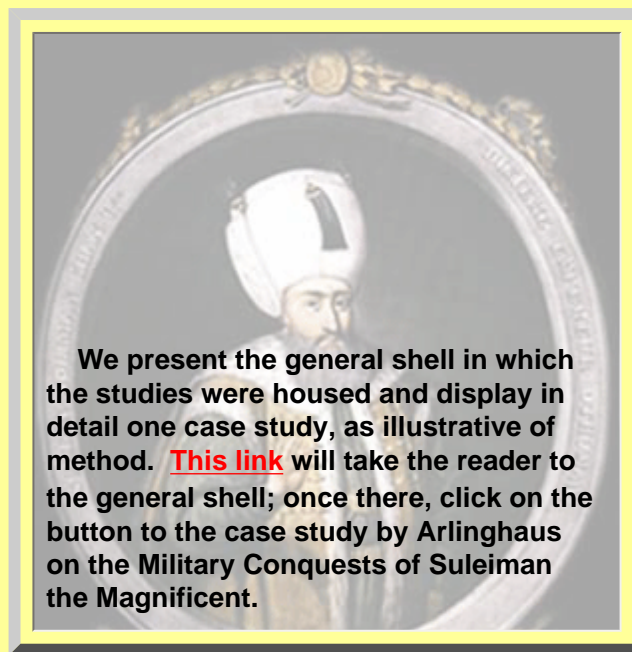
This methodology also enables the researcher to include a wide variety of original sources within its web structure, easily viewable at a click. Documentary evidence can be included practically seamlessly alongside literary, material, demographic evidence, and a rich variety of others, with each source contributing its own unique imprint on our understanding of historical process. The methodology also provides the opportunity not only to indicate these sources textually, but also to replicate any form of evidence and put it directly in the hands of the internet reader. Primary source documents, maps, charts, art reproductions, architectural plans, and a host of others, can all be brought together into a single study, giving a much richer and fuller depiction of historical events while at the same time making the actual original sources visible directly alongside the researcher's own discussion of these sources.

Many of the capabilities of this methodology have leaned in the direction of expanding and, in many ways, complicating scholarly investigations. What is truly revolutionary and powerful about the usage of web architecture in order to organize and present information is its ability to make the information presented available in many different designs and to thereby simplify understanding by extracting cores of information. The possibilities available as to the ways in which information can be introduced and conveyed and as to where within an argument it can be placed are myriad. The web nature of this methodology means that one does not have to make single irrevocable decisions about placement of information within a narrative as links to this information may be made repeatedly throughout a text. Does a reproduction of a primary source material, in one shape or another, belong at a certain key point in the argument or is it necessary to present this information at each point in which the document is referenced or could be referenced? This question does not necessarily need to be answered when using a methodology such as this because the web of compartmentalized information which this methodology presents allows for a wide variety of opportunities.

Finally, the ability to work collaboratively is of great importance in understanding the effectiveness of this methodology. Because of the compartmentalized web nature of this methodology, it is as easy to include the work of multiple researchers into the architecture as it is to include a variety of sources and multiplicity of actors, agents, events, and source documents. The articulation of the ideas of a variety of individuals is made possible by the architecture itself and does not have to be done within the confines of a narrative text. As spatial and temporal synthesis of matters from the past are drawn together, so may the efforts of current researchers be linked seamlessly into that fusion.

To develop this methodology as more than an idea for discussion, the authors presented the idea at a national conference ([link](#) to MS PowerPoint display; [link](#) to MS Word document) to get feedback from other scholars and then implemented the ideas in a small experimental workshop course at The University of Michigan in the Winter term of 2005. It was conducted as an undergraduate/graduate workshop in the Residential College

and in the Center for Middle Eastern and North African Studies. We met in the technological jewel of the university, the Duderstadt Center, on the Engineering Campus of the university. In one of the electronic classrooms, instructors had state of the art machines linked to overhead projectors (two if need be, paired to show the same screenshot simultaneously) and each participant had a new desktop computer with high resolution flat screen monitor. A technical consultant was always readily available by telephone and would appear within two minutes if the need arose. In brief, the hardware always worked and there were none of the glitches that some of us familiar with electronic classrooms have faced in the past. The classroom was set with a custom software load in advance of the beginning of the term. That load set included, in addition to the standard set running on Microsoft Windows XP, GIS software from ESRI (ArcView and ArcGIS), 3D software from Discreet (3D Studio Max), Adobe Photoshop, Image Ready, and Illustrator, Macromedia Dreamweaver and Flash, and Cosmo Player virtual reality software to work with an internet browser (Microsoft Internet Explorer). We attempted to present any software that one might wish to have. In addition, movie editing software, scanners of various sorts, equipment to convert videotapes to computer files, and the full range of capability of the Duderstadt Center was available to us during the 3 hour class time. Instructors and students worked together, side by side as equal participants. Decisions made were logged in a notebook as metadata for the individual project as well as for the broader implementation envisioned in the future. Thus, the research and teaching components became fused, as well.



When viewing this case study, note the subtleties. For example, the age of Suleiman the Magnificent is often referred to as the "golden" age of the Ottoman Empire. Decisions in web design may follow the historical lead; thus, backgrounds on pages were made "golden". Note the timelines on either side of the top of the page; they are paired to resemble an abstract "gate" as an entry to study much as Suleiman used the Gate at Adrianople as an entry to his adventure. This sort of "play" between current capability and historical context forges mental links in the viewer that are not possible in conventional publications. Animation offers the viewer an opportunity to "see" Suleiman marching through the Danube River basin in his conquest of Hungary. Sounds accompany the sieges; cannons, sounds of inclement weather that hastened a retreat at Vienna in 1529, hoofbeats; all enliven the process and embed it in the mind of the reader, as he or she initiates it through the action of clicking. The purple spider lines at locales along the way represent the infusion of resources, be they soldiers, camels, horses, barley, or other. Different sources estimate vastly different numbers for the Ottoman Army and for provisioning point locations: the locations above are therefore deliberately abstract but do show spatial pattern and temporal spacing---possibly suggestive of added research directions. The purple spiders fade as the army moves away from the added resource point: floods along the way might cause camels to break legs; delays might use up food supplies more quickly than anticipated. Independent, however, of such incidents, mere distance from a supply point means a reduction in that initial infusion. Hence the need for another provisioning point. The pattern of the Ottoman Army in keeping a source of fresh supplies is quite clear: conquer near, then a bit farther. Use previously conquered locales as provisioning points to extend Ottoman control into farther reaches.

Because the reader can initiate and control some of the action, there is greater participation in the

historical events than there is reading a conventional book, and even more than there is in passive watching of a movie or a television show. When the "reader" becomes the creator and an active participant, he or she acquires a comfortable spatial/temporal framework, embedded in the mind, within which to consider more intricate elements of intellectual or other elements of the past. Music and art representative, or derivative, of the times are also incorporated as are a variety of links to various sources on the internet. The deep layers of subtlety within the web site mirror those within the historical/geographical process; links on a website suggest mental links for the student of the past to make with elements of the geographical environment. Virtual links become reality; the past comes alive; the reader's understanding is enriched in multiple directions. Thus, one is exposed to a full panorama of the civilization of the times while also having an imprint of a complex dynamic system placed in his or her mind. The opportunity to overlay extra materials, and enrich even further the historical geographical vista of the reader, is an exciting one.

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Research Announcement

Spatial Synthesis: Investigations in Progress Sandra Lach Arlinghaus

Current investigation continues to consider both theory and far-flung applications of theory.

- Theory: the Diophantine equation $K = x^2 + xy + y^2$ represents, also, an elliptical paraboloid in three-dimensional Cartesian space with major axis lying along the line $y=x$. When this surface is viewed as a generating surface, different K -values might be seen as level curves (ellipses) dropped down into the plane in much the way that topographic contours can be seen as level curves of a mountain. The difference is that here we know the equation for the "mountain" and so this viewpoint is feasible because the situation is exact. Consequently, the entire geometry captured in two-dimensions might be seen as a special case of this more general observation. Exploration of this approach has been underway for a number of years and it continues.
- Connection: projection and transformation are powerful tools, used frequently in late 20th century pure mathematics as well as in works by D'Arcy Thompson, Waldo Tobler, and others. Still others, who did not specifically adopt this sort of view, might have work that readily fits it. One example might be found in the work of Zipf, in viewing his set of "parallel lines" in the plane as being dropped down as level curves from an hyperboloid of two sheets, $xy = K$. Work progresses in this direction, as well.
- Real-world: the pointilist world of Seurat when captured on a cathode ray tube is formed using a square brush. What art might be generated using an hexagonal brush and concepts from central place geometrical hierarchies. Experiments using software to maneuver images have been underway for several years and these also continue.

Perhaps a future volume in the [Spatial Synthesis](#) series will be based on the work that comes from these ventures.

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Mail

(in reference to material from *Solstice*, Volume XV, Number 2, Winter 2004)

Hello Sandy,

I was reviewing your very awesome studies of the Ann Arbor Downtown in your Virtual Downtown Study document - I was wondering when that study was done (month, year) as I am interested in citing your work in a casestudy document?

I appreciate your help,
Melissa Marks

Quoting gavynn@comcast.net:

> Ms. Sandra Lach Arlinghaus,
>
> I am master's student at the University of Alabama. I am trying to find a
> definition of the the feild of mathematical geography. So far I have
> ascertained that it might include geodesy, the earth's magnetic fields, the
> creation of projections, and the location of exact points of the earth, but I
> need a definition from an official source. Could you point me to a web site,
> journal, book, or lexicon that properly defines the field. Unfortuanlty the
> term has become obscure in today's world, such that even my professor's in
> geography have been unable to define the discipline, and cannot point me to
> any printed source to find the definition. Any help you can render would be
> greatly appreciated.
>
> Thank you for your time,
> Heath Robinson

ONE ANSWER ALREADY E-MAILED TO THE AUTHOR OF THE NOTE ABOVE; OTHERS...??

Dear Heath Robinson,

You ask an interesting question. One reason I find it interesting is to consider if one can ever "properly define" any field. Let's consider "history" for example, as a kind of neutral example. Suppose we take a simple answer and say "history is the study of the past." Then someone can counter and say, what

is the "past"...the instant I say anything, it too belongs to the past...where is there a starting point to the past...as soon as one defines a starting point to the past, it too belongs to the past and there is space, belonging to the past, between that starting point and the present, and that space is now not included in the definition. That is a kind of "Achilles and the Tortoise" argument. Some might find that view to be a bit "small" and to beg the question. Now back to the "simple" definition of history. Others might say that the given definition is too broad and does not make clear what belongs to the field of history; after all, mathematics has a history of its own, but does that mean that mathematicians who study and write about the history of mathematics are therefore historians (of course not, they are writing about the history ... the study of the past...of their own discipline from their own vantage point or frame of reference). Others might carry this idea further and claim that the simple definition of history is wrong and that the reason it is wrong is that since every field and every person and every thing has a history of its own that therefore this definition claims all for history...that is an error in logic. Thus, we arrive at a situation in which we can talk for a long time about this matter and probably never achieve universal agreement. To me, there are at least two facts that emerge from such discussions, however. First, simple definitions that are broad are best: they stimulate further discussion and thought and they err on the side of being overly inclusive rather than on the side of leaving someone or something out. Second, overlap among fields, in terms of definition, is to be expected. The world of academic discourse cannot be partitioned into a set mutually exclusive, yet exhaustive, categories, even though the curricular interests of university administrators might wish it were so. It is in these areas of overlap that so-called "interdisciplinary" studies take place and are often overlooked. A related, but not derivative, observation is that any field of endeavor has both an analytic and a synthetic approach. Different fields have a different balance on which dominates (at a particular time or at any time). When the analytic approach dominates, it appears easier to "define" what is done, because one can look at the small pieces and focus on some of them in order to give specificity to broad definitions such as the one above. When one starts with the big picture, in the synthetic approach, then that specificity is not in focus.

With these thoughts in mind, let's return to "mathematical geography." An obvious definition of it is that "mathematical geography studies the mathematical components of geographical problems and issues: it lies in the interface between geography and mathematics." It is of course distinct from geographical mathematics: the adjective modifies the noun, by our linguistic agreements in grammar. So, with that sort of "simple definition" one is led to ask "what is geography" and "what is mathematics." As long as I know, and a lot longer than that, people have been asking "but what really is geography?" One

can spend a lifetime debating this and never have a good answer, as was the case with "history". Personally, I like the simple one: "geography is the study of the surface of the earth." One can make all the same arguments about it as one can make about the simple definition of history (or of any other field). Naturally, geographers do things like study patterns they observe on the earth's surface (of course defining "surface" is rather like defining "past" (above)). If they use geometry to help them describe or understand these patterns then they are using a mathematical approach to geography, and hence that work could, if they chose, be properly classified as "mathematical geography" (but not as geographical mathematics). It could also be classified as "geography" and depending on what the pattern is, as the "geography as x." For example, Skinner's work on periodic marketing in China, and its relation to classical central place theory, might fall under any of: "geography," "marketing geography," "mathematical geography," "geography of China," "cultural geography," "spatial analysis," and so forth. The category one chooses for anything is not unique.

Another simple definition of geography is the Kantian one, that makes use of relativity, in a way: "history is the study of time; geography is the study of space." Again, one is led to question but is time the domain only of history (and the corresponding about geography). Again, there is an error in logic here...the definition does not claim it to be the domain of only those disciplines. Of course, what is in the overlap area, in space/time, is of critical importance not only in history and in geography, but in other fields as well (such as physics). Once again, the same discussion as above applies here.

Yet another simple definition, that I might class as being a bit "hostile" in that it clearly begs the question is: "geography is what geographers do" (naturally a bad "definition"). This sort of definition can be elucidated mentioning a few key concepts that many geographers focus upon (but they are not the only ones who do so): scale, hierarchy, and so forth--the Education Community has identified a set for the training of social studies teachers...again, the same kinds of discussions can take place around identifying any set of concepts...no one is definitive and no one is unique.

In any event, mathematical geography, from the viewpoint of grammar, is the study of the mathematical attributes of geography. ("Mathematical" is the adjective modifying the noun "geography.") One is then left to consider "what is geography" and "what constitutes a mathematical approach." There are probably more attempts to define "geography" than there are geographers and there is more written on the topic than is probably useful. What constitutes a mathematical approach might be learned from a study of literature: but, one

issue here is that the mathematics used must be correct (within the logic system agreed upon).

Thus, I'm sure your library has much information on the "what is geography" issue. As to references about mathematical geography, I'll offer you a few, so you might see some example. To me the clearest example of interaction between mathematics and geography, in using a mathematical tool to solve a geographical problem, is in Eratosthenes of Alexandria's use of Euclidean geometry to measure the circumference of the Earth. So, I'd start there, move forward through the work of Varenus, to consider the Konigsberg Bridge problem, the four color theorem and the Jordan curve theorem (and their implications for geography) to wherever your mind leads you. You note that the term mathematical geography has become "obscure"--out of vogue, perhaps, but certainly NOT obscure...it represents a great tradition that has endured at least from the time of the Library at Alexandria...it is, however, a difficult field---one must have extensive training in both mathematics and in geography. In that regard, it is most like "theoretical physics"...there are not that many practitioners because of the need to acquire so much mathematical background with accompany small tangible reward for doing so (mathematical geography might, from some standpoints, also be called "theoretical geography"--it is not, today, by most of us because of some unfortunate incidents in the past (that I do not personally remember but others still alive do)...that is, if one views "theory" as being composed of a set of theorems deduced using some mutually agreed-upon system of logic).

Anyway, those are a few thoughts...I don't know what your level of interest is, but I'm happy to discuss the matter further with you. There is also a good deal of work posted on the website of the Institute of Mathematical Geography: some is heavily geographical, some heavily mathematical, and some lies in the interface that is mathematical geography. (<http://www.imagenet.org> and other URLs).

Please let me know how I might be helpful. Thank you for your interest!

Best wishes,

Sandra Arlinghaus.