Envisioning Neighborhoods: GIS Information Design to Facilitate Understanding Places

By Earl G. Bossard and David Roemer

Abstract

A cacophony of place data is a by-product of the digital information that cries out for a sense of order so that the world's increasingly networked resources can be better utilized to understand neighborhoods and other places.

This paper presents information design techniques for area analysis building on 'Envisioning Neighborhoods' concepts by Bossard and principles developed by Tufte. It introduces the rationale for systematically organized layouts, called schema, of small replicate GIS maps, charts, and photos to facilitate comparisons across space, scale, time, and conditions because data is best understood in a comparative context. Schema are the basis of computer templates which synthesize data downloaded from the world's networks into logically arranged layouts which facilitate understanding by using vision to think, enabling persons to use their powerful, but often underutilized abilities to recognize patterns and anomalies as they compare and contrast sets of small multiple GIS maps, charts, and photos.

"The most important skill for almost everyone in the next decade and beyond will be the ability to create valuable, compelling, and empowering information and experiences for others. To do this, we must learn established ways of organizing and presenting data and information as well as develop new ones." (Shedoff 1999, ch. 11).

The digital information revolution creates both problems and opportunities for those wishing to understand neighborhood places. One solution is to use vision to think; visuals can facilitate thinking and understanding, and context is often explicitly needed to understand data and visuals. Small multiples provide context and play a key role in envisioning schemas that provide an organizational context for map, chart, photo, and table visuals. Schema templates should be part of a systematic, comprehensive envisioning study process designed to facilitate movement up the understanding data-information-knowledge-wisdom continuum.

1. The Digital Information Revolution, Creates Both Problems and Opportunities for those Wishing to Understand Neighborhoods and Other Types of Places.

The computer revolution is racing ahead with phenomenal increases in capabilities to gather, store, process, and distribute data. Witness the explosion in interest regarding the Internet, on-lines services, as well as the increase in personal computer capabilities. The term "information" is often associated with this phenomenon, but a more appropriate term might be **"**data revolution." The problem is that the data revolution has produced the potential for accessing vast quantities of raw, unsorted data without a corresponding increase in the human competence of filtering and processing this data into information useful for making decisions. Like the old saying about not seeing the forest for the trees, we can be buried in confusing, perhaps erroneous data, unable to effectively use it for informed decision making. This is nowhere more apparent than with the present flood of data regarding urban conditions.

2. Using Vision to Think (Enlightenment)

The good news is the emerging field of information design is rapidly devising better ways to organize and present data. (Card *et al* 1999; Jacobson 1999; Tufte 1983, 1990, 1997; Davenport

1997) Effective information design depends in part, on knowing how information visualization facilitates understanding. Enlightenment regarding the relationships between vision and thinking have been provided by Card, Mackinlay and Shneiderman in their path-breaking compendium, *Readings in Information Visualization – Using Vision to Think.*

> 'To understand something is called "seeing" it. We try to make our ideas "clear," to bring them into focus," to "arrange" our thoughts. The ubiquity of visual metaphors in describing cognitive processes hints at a nexus of relationships between what we see and what we think. When we imagine someone hard at mental work, we might picture a scholar drawing a diagram, a book of sources open at her side. ... Whatever the activity, mental work and perceptual interactions of the world are likely to be interwoven.
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> The interweaving of interior mental action and external perception (and manipulation) is no accident. It is the essence of how we achieve expanded intelligence. " (Card *et al* 1999, 1)

P.A. Norman helps make the case that visualization facilitates understanding, stating:

> "The power of the unaided mind is highly overrated. Without external aids, memory, thought, and reasoning are all constrained. But human intelligence is highly flexible and adaptive, superb at inventing procedures and objects that overcome its own limits. The real powers come from devising external aids that enhance cognitive abilities. How have we increased memory, thought, and reasoning? By the invention of external aids: It is things that make us smart." (Norman 1993, 43)

Continuing their case for using vision to think Card *et al* say:

> "An important class of the external aids that make us smart are graphical inventions of all sorts. These serve two related but quite distinct purposes. One purpose is for communicating an idea, for which it is sometimes said, 'A picture is worth ten thousand words.' Communicating an idea requires, of course, already having the idea to communicate. The second purpose is to use graphical means to create or discover the idea itself; using the special properties of visual perception to resolve logical problems, as Bertin (1977/1981) would say. 'Using vision to think.'" (Card *et al* 1999, 1)

"Data must be imbued with form and applied to become meaningful" as information. (Davenport 1997, 116) Information visualization facilitates understanding in six ways: (1) increasing memory and processing resources available to users, (2) reducing the search for information, (3) using visual representation to enhance the detection of patterns, (4) facilitating conclusions via perceptual inference, (5) enhancing monitoring by having visualizations draw attention to special circumstances, and (6) encoding information in a malleable medium. (Card, *et al* 1999, 16).

One reason for the rapid growth in use of GIS during the past decade has been the increasing acknowledgement that maps can present effective representations of the real world in ways unavailable with tabulated columns of numbers. Longley, Goodchild, Maguire, and Rhind in their influential text (*Geographic Information Systems and Science*) state:

> "…representation is at the heart of our ability to solve problems using digital tools. Any application of GIS requires clear attention to questions of what should be represented and how. There is a multitude of possible ways of representing the geographic world in digital form, none of which is perfect, and none of which is ideal for all applications. (Longley *et al* 2001, 64)

The use of GIS for map making has increased phenomenally due to the growing availability of increasingly powerful and decreasingly expensive computers, the availability of digital data, and more intuitive GIS programs. But there have been problems with the application of these maps, which have been too often produced by GIS novices who have learned what keystrokes to press to produce maps, without being fully aware of what these maps actually should or need to represent. Peter Burrough and Rachael McDonnell discuss these problems:

> "Everyone thinks they understand GIS because they think they understand maps. But to understand a map is to understand how a person once observed the world, how they formulated imperfect, but plausible models to represent their observations, and how they decided to code these models on paper using conventional technology. All these processes depend strongly on culture, on age, on discipline, and on background. With GIS we go even further down a path in the labyrinth that leads from perception to presentation of spatial information, because though computers can mimic human draughtsmen, they can do so only according to the ways they are programmed. The basic tenets of spatial interactions needed to describe given spatial process or phenomenon may or may not be shared by the ground rules of …(your) GIS .
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> But electronic GIS provide an enormous wealth of choice not possible with conventional mapping. Whereas with conventional mapping (and even the earliest digital mapping) the map was the database, today the map is merely an evanescent projection of a particular view of a spatial database at a given time. On the one hand this gives us enormous power to review an unlimited number of alternatives and to make maps of anything, anyway we like, including dynamic modeling of spatial and temporal processes; on the other hand it may leave us swimming in the dark." (Burrough and McDonnell 2001, vii.)

Webster's New World Dictionary defines "envision" as "…picture in the mind". Synonyms include: "anticipate, construct, contemplate, envisage, foresee, imagine, and visualize." When we "envision a neighborhood" we picture it in our mind, constructing views as to how it is organized and operates, imagining how people interact in and with the place, visualizing how it appears and perhaps will change over time.

Note also that while "neighborhoods" are used as examples in this paper, the basic information design concepts are much more broadly applicable, not only to other place levels such as towns, cities, counties, or states, but also to non-place applications as well.
John O'Looney, in his excellent book *Beyond Maps, GIS and Decision Making in Local Government*, explicitly recognizes the visual role of GIS and provides sound advice on "making information visual" that is reproduced in figure 1. While O'Looney is a believer in "using vision to think", he is a pragmatic realistic who recognizes in some cases numeric, rather than visual displays will be needed where "… a high level of accuracy is needed…"

Figure 1: Making Information Visual - Representing Problems to Reveal Solutions
by Dr. John O'Looney

GIS displays can provide visual approximations of the real world,
but in addition these displays can be:

- Customized to individual interests
- Repeated overtime or copied
- Examined at different levels of detail or from different spatial or conceptual perspectives
- Shown in various formats
- Customized for particular audiences

- Designed to facilitate understanding.

GIS displays can maximize our ability to visualize, experience, and ultimately solve problems that have or could have geographic or spatial features.

For the most part, public-sector policy makers are required to analyze problems that are presented as a narrative or as a series of numerical tables. However, research on problem solving suggests that this is not always the best: if the problem can be presented in visual terms, the solution may be grasped more quickly. …

Two important design principles relevant to the development of GIS displays to be used for problem solving or policy making (are):

- The display should simplify and abstract certain features from the real world to convey information effectively.
- Visual/Spatial displays are often more effective in conveying information about complex relationships than are displays that use only words or numbers.

These two principles of effective problem solving need to be qualified, however, by two more principles:

- When a high level of accuracy is needed, numeric or digital displays may be superior to visual/spatial displays.
- When there are large amounts of data to be displayed, it is often effective to combine numerical (or word) displays with visual and spatial cues.

What makes a GIS an excellent tool for problem solving is its ability to create simplified visual displays and representations while at the same maintaining accurate numerical data at the foundation of the system, the user has to but ask the GIS.

Source: (O'Looney 2000, pp 21-22 used with stylistic modifications)

Edward R. Tufte, one of the leading pioneers of the information design movement, awakened many (including this author) to the critical importance of information design with his 1983 book, *The Visual Display of Quantitative Information.* (http://www.edwardtufte.com/tufte). Figure 2 presents the essence of Tufte's ideas on "Graphical Excellence" that have inspired many of the envisioning neighborhoods concepts. Tufte advises us to use statistical graphics (including maps) to communicate complex ideas with clarity, precision, and efficiency by focusing on showing much data in a small space in a way to induce the viewer to coherently think of its substance in an undistorted way. He suggests that we encourage the eye to compare different pieces of data, revealed at several levels of detail, from broad overview to fine structure, and designed to serve a reasonable clear purpose.

Figure 2: Edward R. Tufte on Graphical Excellence

Excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency. Graphical displays should

- show the data
- induce the viewer to think about the substance rather than about methodology, graphic design, the technology of graphic production, or something else

- avoid distorting what the data have to say
- present many numbers in a small space
- make large data sets coherent
- encourage the eye to compare different pieces of data
- reveal the data at several levels of detail, from a broad overview to the fine structure
- serve a reasonably clear purpose: description, exploration, tabulation, or decoration
- be closely integrated with the statistical and verbal descriptions of a data set.

Graphics reveal data. Indeed graphics can be more precise and revealing than conventional statistical computations.

(Source: Tufte 1983, 13)

3. Context is Often Explicitly Needed to Understand Data and Visuals; Small Multiples Provide Context

One problem in attempting to understand a complex neighborhood place using a map or a chart is that a single visual or two cannot do justice to complex situations. Webster's New Word Dictionary defines "context" as "…the whole situation, background, or environment relevant to a particular event, personality, creation, etc." We could add "place" as also being relevant to context as well as noting that information is context dependent. (Devlin 1999, 37) While there are a variety of "contexts" which could be used to understand neighborhoods, we will focus on four: space, scale, time, and conditions.

The spatial context of a neighborhood includes its location relative to the rest of the world, with particular attention given to the adjoining areas. Often a small map can best provide the general location spatial context for a place. The scale context of a neighborhood can consider places in larger or smaller scale. For a neighborhood, scale context can be provided relating it to the city, county, state and nation of which it is a part, while considering its components such as parcels, blocks, block groups, and perhaps census tracts, school attendance areas, or other areas. The time context of a neighborhood can include descriptions/pictures/maps at various times in its history, maps depicting change over time, as well as possible conditions it may experience in the future. This final point introduces one aspect of a fourth context we will be considering – conditions. Context conditions might include different what if? future conditions depending on the possible outcomes of different policies. Later in this paper we will focus on conditions contexts that deal with the uncertainty associated with data measurements. Another reason to use multiple context visuals for understanding neighborhoods and conditions may be if we wish to see the "…possible, probable, and necessary interrelationships" (Curry 1998, 32) between conditions in our neighborhood study area. Mike Cooley in his "Human-Centered Design" chapter in the seminal book, *Information Design*, has discussed the need for context in the computer systems designed for problem solving:

> "Most current systems tend to encourage the user to converge on narrower activities. Good embedded systems should also provide windows or apertures through which one can take a wider or more panoramic view. This encourages the acquisition of boundary knowledge and allows the user to act more effectively and competently by locating what he or she is doing in a wider context." (Cooley 1999, 70).

"Social Context", is another type of context that should be considered. John Seely Brown and Paul Duguid, have titled their book "*The Social Life of Information*" to draw attention to "…the social periphery, the communities, organizations, and institutions that frame human activities..." and "… are too often missing from the design stylebooks of the information age." (Brown and Duguid 2000, 5).

While for some problems or circumstances a single visual or two may suffice to provide understanding, often multiple visuals will be required to understand a place or its problems within the needed context. Note when Keith Clarke says "…the purpose of geographic inquiry is to examine the relationships between geographic features ***collectively*** (emphasis added) and to use the relationships to describe the real-world phenomena the map features represent," (Clarke 1997, 184) he includes the key word "collectively" to highlight the likely multiple nature of relationships. Oftentimes multiple visuals are required for "collective" examination.

4. Envisioning Schemas can Provide an Organization Framework Context for Map, Chart/Diagram, Photo, and Table Visuals.

To understand neighborhood places, their context matters. Understanding spatial settings is usually particularly important. But provision of too much contextual information can obscure the main point, and surely can overwhelm any one map or other visual. Small multiples, a concept promoted by Tufte, can be an answer. (Tufte 1983) Small multiples can effectively provide rich contextual information in individual bites small enough to digest.

The heart of the "Envisioning Neighborhoods Concept" is "schemas". Schemas are organizational frameworks for small multiple visuals which can provide both information and context. Schemas are spatial layouts of maps and other visual media to facilitate presenting of contextual and other information over space, scale, time, and conditions. Schemas facilitate envisioning by organizing multiple GIS maps, charts, photos, and tables. Previously created schemas may be used as templates that can be filled in with data designed to envision particular neighborhoods. In many cases these general schema templates can be customized to meet particular circumstances.

5. Schema templates should be part of a systematic, comprehensive envisioning study process designed to facilitate movement up the understanding-data-information-knowledge-wisdom (DIKW) continuum.

Beware of using schemas in isolation. Ideally they should be used as part of a systematic, comprehensive envisioning study process. So far we have discussed how envisioning is concerned with working with data to improve "understanding" of neighborhood conditions. Theorists recognize that there is a spectrum of understanding that ranges from simple data facts that don't have much value without being placed in context through information, knowledge, and finally wisdom. (For discussion of the DIKW continuum see: Longley 2001, 7; Shedroff 1999, 271; Devlin 1999; Davenport 1999, 9; and Laurini 2001, 41-44)

While most information theorists agree that there is a continuum related to levels of understanding starting with data and moving up to knowledge or wisdom, there is little consensus on the number of terms and on the meaning of several of the terms. Most theorists agree that the lowest level of understanding is provided by data, which are observations of the state of the world and are usually produced and recorded without providing context. Data can be easy to store in digital form and therefore can be easily shared with others. Data is created by research, gathering, discovery, and creation, while information is associated with data that has undergone organization. Knowledge is where understanding moves to the personal level. Knowledge is information which has been personally experienced and to which value has been added by interpretation based on reflection, context, and synthesis to evolve into usable form. Finally the highest level of understanding is achieved with wisdom, which is associated with contemplation, evaluation, interpretation, and retrospection.

Information is data with meaning. Meaning may be provided to data by organizing it; simply computing summary statistics for numerical data can give it meaning by enabling each piece of data to be related to norms, such as means and standard deviations. Sorting data can also provide meaning to data by enabling relative rank comparisons. Schemas are a way of organizing data and turning it into usable information. Organization and transformation of data, in addition to other context providing actions, including schema creations, can facilitate creation of measures providing increased levels of understanding from information, to knowledge, to even perhaps wisdom.

The function of schemas is to take raw data and organize it into information. While this is has been primary function for GIS to date, a desired role for both GIS and schemas is to facilitate the creation and dissemination of knowledge. Schemas can help develop tacit knowledge within the mindset of persons with extensive schema experience who have used their vision to think about schema based information, undertaking the process of interpretation based on reflection, context, and synthesis. A secondary role of schemas for knowledge enhancement is to use refined schemas as a way for storing and sharing codified knowledge. This codified knowledge may be used in artificial intelligence based planning support systems.

Finally the often-elusive goal of wisdom is sought at the top of the understanding spectrum level. While sharing wisdom with others is very difficult, perhaps impossible, this broad, personally internalized knowledge, which understands circumstances, relationships, and likely consequences, may be developed within the minds of thoughtful schema users and developers. Richard Klosterman gives the name "intelligence" to what we call knowledge, defining it as the "ability to deal with novel situations and new problems, to apply knowledge acquired from experience, and to use the power of reasoning effectively as a guide to behavior" (Klosterman, 2001, 11) Nathan Shedroff reveals the ultimately personal nature of wisdom:

> "We cannot create wisdom as we can data and information, and we cannot share it with others as we can knowledge. We can only create experiences and describe processes that offer our audiences opportunities to find wisdom. Ultimately, wisdom is an understanding that must be gained by the individual." (Shedroff 1999, 274).

We have discovered that seeking understanding entails working at several levels, often starting with data and information which may reside in digital form in computers, and working up to knowledge and wisdom which principally reside in human minds.

6. Schemas and Personal Understanding.

A person's understanding of what they see is conditioned by their background, culture, training, and experience. Therefore no two people are likely to react identically to the same schema. Because people are different, different schema designs may be needed to effectively enable the intended audience to envision a neighborhood, or other place or a particular condition. The amount of contextual knowledge people have regarding a place or condition will effect the amount of contextual information they need in a schema to felicitate effective envisioning. One benefit of increasing computer literacy and more powerful computer programs is that increasingly envisioners will be able to design their own envisioning schema schemas on the fly as needed for particular situations.

"In the digital world … many of the distinctions between designers and users are becoming blurred. We are all, to some extent, designers now. Many questions about design are thus becoming questions for us all." (Brown and Duguid 2000, 4).

7. A Scenario of Steps for Envisioning Neighborhoods

While the focus of this paper is on information design schemas for envisioning neighborhoods, we would be remiss not to mention how the envisioning and schema building process could be undertaken. Figure 3 outlines a process for envisioning based on Card *et al*. (Card *et al* 1999, 10-12). The steps for envisioning neighborhoods presented here should be considered as general guidelines for structuring inquiry. Figure 3 graphically portrays the steps for envisioning neighborhoods in a flowchart venue starting with posing a question, browsing or data brainstorming, then moving through the steps of foraging for data, searching for a schema, applying data, examining outcomes, determining sufficiency and either packaging the patterns/solutions into appropriate output or trying new schema. The Exploratory Data Search and Analysis part of this procedure starts with the traditional "forage for data or information" regarding the neighborhood to be studied, but them shifts to searching for, and filling, a schema.

Envisioning tasks can be "characterized by the use of large amounts of heterogeneous information, ill-structured problem solving, but a relatively well-defined goal requiring insight into information relative to some purpose." (Card *et al* 1999, 11). The envisioning neighborhoods technique utilizes human information processing to meld innovative technology and human intellectual curiosity to stimulate a unique understanding of urban places.

Typical envisioning of neighborhoods can be done following the steps outlined in figure 3 and using as standard templates summary overview schema that combine small replicate GIS maps, charts, photos, and tables. These schemas can facilitate comparisons and choices of places for further study. In depth understanding of a particular neighborhood will best be achieved using custom schema giving central positions to the special factors making the place unique.

There is no such thing as one correct schema for envisioning all neighborhoods. Every neighborhood-envisioning problem can be envisioned by many possible schemas. Each envisioning schema is designed for a specific purpose, or several general purposes, and may be sub-optimal for other purposes.

The envisioning neighborhoods schemas developed over the past several years (Bossard 1998, May 2002, June 2002) have been designed to serve as guidelines for others. Because " …the way in which we represent information to others is of crucial importance in communicating the meaning of the information." (Raskin 1999, 343) great care should be devoted to developing effective schemas.

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8. Uncertainty Conditions Schema

The Uncertainty Conditions Schema is presented in figure 4 as an example of an envisioning neighborhoods schema. It makes explicit the ranges of uncertainty regarding values which are displayed in maps, charts, or tables by providing: the published values, low and high confidence level estimates of various conditions, along with maps of possible misclassifications resulting from the use of a single published estimate of sample based data, such as Census 2000 SF3 data based on the 1-in- 6 sample of households typically answering the "long form" questionnaire. (Figure 4 is the Uncertainty Conditions Schema poster prepared for the ESRI 2004 UC by David Roemer.)

9. Dreams for Envisioning Neighborhoods

Figure 5 closes this paper on envisioning in the digital information era on a somewhat whimsical note, presenting the authors' dream for envisioning neighborhoods.

Figure 5: Dreams for Envisioning Neighborhoods

Envisioning Neighborhoods can be about personal journeys through data,
finding patterns that matter to you,
flying through information that is constantly accessible and understandable,
that tickles a random thought until it becomes an idea, and
combines ideas until they become invented schemas and
packages those schema so they become available for others.
Now is the time to dream!

Source: based on the poetic words in Richard Saul Wurman's foreward in the book *Information Design.* (Wurman 1999, x).

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