BEST-GIS

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Guidelines for Best Practice in User Interface for GIS

Section 2
"Introduction to the problem"

2. Introduction to the problem

"It is often only after selection and installation of the GIS that users, who may not have been consulted in the process of choosing the GIS, then observe that the GIS would perform very quickly, if only somebody knew the commands to type! Unfortunately, this insight comes too late. There is a need for research into developing methods for formally assessing usability so that it can be introduced into the selection process, thus forcing GIS vendors to pay attention to this aspect of their products". (Frank, 1993, 13).

Frank also stresses, as in the title of his book chapter, that the user interface should not be treated as just another layer of software to be added when the system is more or less functional, rather **the interface design should be done first because from the perspective of the non technical (typical) GIS user, the interface *is* the system.**

2.1 Current practice of the development of GIS applications

2.1.1 Initial GIS development

Let us look at the roots of GIS development. GIS software packages traditionally have been developed by experts for experts. These experts were, necessarily, knowledgeable enough in a spatially-related domain to be interested in GIS in the first place, and skilled enough at programming to be able to undertake software development: a narrow group indeed. Thus, traditionally only a narrow range of user needs, normally based on introspective analysis (”this is what I would want”), has been considered.

Only recently (in this decade, coinciding with the adoption of Windows) has it become acceptable practice to develop GIS for non-programmers. The move toward more user-friendly graphical systems (MS-Windows, X-Window) probably was driven more by marketing than by technical competence, however, as the GIS market grew rapidly during this decade to include a new set of end-users. Whereas traditionally the GIS user was a scientist, academic researcher or government employee, none of which are especially demanding of their tools' performance, the mid-1990s saw the adoption of GIS by many commercial organisations which have, in fact, demanded improved performance, as measured by cost/benefit analyses.

During the past 3 years the popularity of rapid application development (RAD) software such as VisualBasic, Borland Builder, Delphi, etc., as well as demand for gateways to the WWW has pushed GIS developers even further toward supporting the general public, or at least that group called ”spatially aware professionals”. What were once huge collections of FORTRAN and C programs, hidden from users within proprietary systems, are now evolving to more open and interoperable systems, in part due to the efforts of the Open GIS Consortium (see section 8).

Despite these improvements in usability, we should not be prepared to accept the status quo, because the situation described by Frank (1993) still exists. It is important to recognise that these usability changes are taking place by default, without any special demand on the users' part. It is often said that the user speaks with his/her pocketbook, but if all the options are similar then that user is bound by a limited range of real choice (like Henry Ford's statement that buyers could have their Model-T car in any colour, as long as its' black).

These guidelines stress the use of user-centred design (UCD) and development, a methodology which has been adopted by other industries but which has yet to show its impact in GIS. UCD has shown commercial benefits -increasing user satisfaction- by including sample users directly in the initial design process.

This involves not only programming skill but social science skill as well, because the process of extracting user needs is not a tightly controlled, technical exercise but rather one based on observation and face to face data collection (Gould, 1994).

This guidelines document should assist both (active) users and developers in this needs-to-functionality translation process, because each has a key role (probably of equal importance) in that process.

2.1.2 Customisation of GIS applications to end-user needs and requirements

Geographic Information Systems software is not normally sold as a one-size-fits-all solution, such as MS Word, but rather as a collection of spatial data processing tools; some GIS packages contain over 2000 such tools. Frank (1993) has noted that in the absence of a concrete mental model of how the system functions, and without proper training, a user of a non-customised GIS (”out of the box”) will likely find use for only 5% of the available functionality as has been demonstrated with the use of word processors.

These scattered tools need to be assembled into a specific GIS application, by experienced technicians/programmers. Application generation involves, among other things, grouping individual tools into functional subsystems, menus or macro commands. The GIS often comes with an internal macro language for this customisation, and the most recently released versions allow customisation in de facto standard Windows development tools such as Visual Basic and Powerbuilder.

Many of the tools in the GIS are interface-related tools: menus, dialogue boxes, pointing and data input device support, etc. It is the experienced technician’s job to translate end-user needs into workable solutions given the GIS toolbox selected. This translation is best done using the user-centred design methods described here.

2.2 Status of usability engineering in the GIS domain

Usability engineering in general is highly developed. Usability testing originated for safety reasons, i.e. how can a fighter plane perform optimally and be safely piloted; same for nuclear reactors, cars, etc. Today it is common practice to perform usability tests even with products and services which are not safety critical, i.e. office software. Appropriate methods are available which can be applied to the GIS domain.

The discussion about GIS specific usability issues has started in the last few years. However, end user and customer requirements are not sufficiently taken into account in the development process of GIS applications. Usability engineering in the GIS domain can be best described as ”reactive” rather than being ”proactive”, e.g. a GIS version 1.0 is released, and then subsequent versions are changed according to user complaints.

Representatives from GIS developers and companies which customise GIS applications (systems integrators) were interviewed. Some of the interesting results include:

- GIS users (beginners and experts) were interviewed to extract their opinions on the current state of usability engineering within their organisations. The amount of time they claim to spend on this activity during GIS project development varies from 10-80 % depending on how the term is defined and extended. Most of the interviewees were unfamiliar with the UCD concept, they responded according to the normal stereotype: Users wait for the solution to arrive. Thus, they respond that little time was spent on usability issues. Expert users do their own customisation, implying a sort of introspective usability analysis, so they respond that considerable time was devoted to it.
- The objectives of GIS evaluation considered (presented in the order of importance) are: cost/benefit for the customer, conformance with minimum requirements, user acceptance, and comparison with competitive solutions.

- Success factors for GIS user interface development and customisation (presented in the order of importance) are: user satisfaction, ease of learning and training, predictability, sales, aesthetic and minimalist design.
- Quality factors considered important for the users (in the order of importance) are: (1) user problems, efficiency of task performance, robustness, error frequency, (2) learning cost and information content, (3) workload, visibility of system status, users opinions.

These results justify the necessity of these best practice guidelines. Often quality-of-use evaluation and assessment starts during customisation or when the GIS application comes into use. Usability is simply not being considered sufficiently before the initial system is built and delivered to the end-users.

2.3 Important GIS user interface issues

This section describes the major issues of GIS user interfaces. The focus here is on quality of use, not functionality. However, the amount of functionality is a usability issue. Too much functionality puts additional burden on the user because the user may need to select functions from a larger list of items. Too little functionality may force the user to search out tricks and shortcuts during the execution of tasks, if s/he is able to execute these tasks at all.

2.3.1 Geographic visualisation

As the name indicates, geographic data are very graphic. But the prefix *geo-* is added not necessarily because many GIS experts are geographers/geologists, but rather because the graphics managed by GIS depict data of a certain spatial scale, geographic scale. This leads to interesting problems/situations not encountered in the neighbouring worlds of CAD or CAM, and others which are common to the two:

GIS displays wide regions on small screen. Mark (1993) has shown how objects in differing scales of space (haptic, pictorial and transperceptual or geographic) are treated differently by humans and, thus, place specific requirements on interfaces which attempt to display objects from one space within another. Without getting overly scientific, we should just note that often the richness and multisensory experience we gain within a geographic environment is frequently difficult to recreate or model on a 2-dimensional CRT screen.

GIS allows navigation in large spaces. Unlike the bird's eye, overall view map of an area, the user often deals with only a part of a large scale space (not visualised entirely from one viewpoint). This is related to the point above. It is not uncommon for the user to get ”lost” when zoomed into a small area without reference text (e.g. place names).

GIS may support various methods of zooming and panning. Harnold and Kuhn (1994) have shown that about 11 % of time is spent on these tasks during data entry, which are related to the navigation of the previous point. Furthermore, they found that optimisation of zooming and panning can save a good deal of time (money) over the course of the average data entry (digitising) project.

GIS permits different views with scale change. Just as when we descend in an airline we begin to see (or resolve) smaller and smaller objects, the cartographic display should be able to display certain graphic elements at certain scales or levels of resolution (or zoom). Of all the objects in a GIS database, the database designer should ask: ”which are to be shown at 1:10.000 (town) scale and which at 1:1.000.000 (nationwide) scale?”. A house for example, might be represented as a polygon at one scale, a point at another scale, and then disappear as we zoom out again.

GIS may include reference maps (”You are here”). Again, this facilitates the navigation discussed earlier. This reference or digital landmark is now common in WWW navigation (the list of pages visited and the ability to go ”home”).

GIS allows customisation of the view. Users have certain control over the changing of views, including parameters to hide/show information, create perspectives (3-D), etc.

GIS permits transformation from 2-D to 3-dimensional representation. The high-end GIS packages generally offer perspective views, but these may require different interfaces. Most users of GIS do not need true 3-D because they do not deal with solids. Terrain models are not true 3-D (2.5-D) because we do not look inside the mountain, only at the surface. The transition from 2-D to 3-D is very complex procedure and thus costly.

2.3.2 Geographic query languages

The interface encompasses more than just the graphic look and feel of a system, following the windows, icons, mouse and pointer (WIMP) model. Users must also be able to express ad hoc queries and other orders and must receive information from the system, using a system-specific language. These languages are usually modelled after, or are, standard relational database manager languages (based on SQL) and, as such, are not at all optimised to geographic elements or problems.

Despite the presence of several prototypes, a true ”spatial SQL” still does not exist, though some useful extensions are present in SQL3. SQL is designed for one-dimensional (tabular) operations, in what we might call ”name space”. Queries such as ”select all the cities *near* this spot <point with the mouse>” are not handled well, or at all, in most GIS because of the query language’s lack of support for fuzzy concepts such as near, and for x,y coordinate input from peripheral devices.

Another often overlooked characteristic of the GIS user interface (query language, commands, and messages) is that the interface normally is in English, primarily for commercial reasons. Although different languages express spatial relations differently (Mark, 1993), in most cases a GIS user must communicate with the system using English terminology. (The customisation process can remove this impediment, however some user sites prefer to keep English terms so that the system coincides with the user manuals and training materials!) A yet unanswered question is whether or not the technical language of GIS (command names) is really understood by non-native English speakers, or if it is simply memorised and repeated mechanically, and whether translation of all system concepts to native languages would significantly improve usability.

2.3.3 Compatibility and portability of systems

Apart from internal interface concerns we should also consider system-to-system interfacing as well. This is more an integration and a database problem than a direct-manipulation problem, but it figures centrally in the workflow of many users. Today’s GIS normally cannot be thought of as an island, isolated from the rest of the organisation; it must function as a node in larger systems. The GIS customisation process must account for this integration, and make sure that the proper gateways are included, in order to connect, for example, to a corporate mainframe system running a different operating system, file system, data encoding system and DBMS. The linking to external systems from the GIS should be made as transparent and natural to the user as possible, creating the impression that the user is using a single, seamless system. From the user's point of view, any significant time spent on manually making and adjusting these system-to-system connections is time which is stolen from his/her real professional tasks (i.e. terrain modelling, flood control, urban planning).

2.4 Future GIS user interfaces

Fifteen years ago very few computing or GIS experts predicted the graphical user interface revolution brought about by the X-Window and MS-Windows environments. Equally, we cannot predict with certainty what the next generation of GIS user interfaces will be, but we can address the strong trends which we see today. There are several technological trends to be expected to continue in the near future:

Internet use. (Parsons 1996) This has wide-ranging implications, because it is already transforming the architecture of GIS software, where instead of a dedicated workstation and GIS package, some users are able to utilise WWW browsers (at zero cost) to access server-based geographic information. These *distributed* applications require simple user interfaces to support only visualisation and interaction (query) tasks, and they assume the processing will be handled at the server side.

Object-orientation. Together with Internet, object orientation (as a new software development paradigm) is changing the way GIS software is developed, customised and used. The user interface of the future will need to greatly facilitate the customisation process, allowing users to pick and choose the software modules (objects) needed at any given time. Note that this topic is directly related to the de facto standards of the Open GIS Consortium, especially their distributed object model (see section 8).

Portable computing. The distributed architecture and object orientation described above, is leading to GIS systems which are more portable. The former allows for the various modules and data to reside in various sites on the network, and the latter allows for a portable computer to load and run only the specific modules needed at any moment. Portable software applications will require compact and simple interfaces, due to the small size and processing capability of the (hand-held) hardware units.

Near-real-time access to high-resolution satellite data. Increased processor speed, higher disk volumes and the immanent availability of near-real time satellite imagery will allow future GIS to monitor quickly changing conditions, such as in traffic or forest fire applications, instead of simply displaying historical data (maps produced months earlier). This will require interfaces capable of filtering huge amounts of information and perhaps allowing users to view only the changes since the last dataset was downloaded.

Resuming, the future of GIS seems to be in increasing portability, modularity and flexibility. User interfaces must adapt to this trend, and allow better and faster user-customisation.

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