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NAVIGATION: METAPHORICAL AND REAL

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Abstract
In preparation for building a dictionary browser, an actual navigational interface (a digital chart plotter) was analyzed for design guidelines to be applied to an interactive semantic navigator. WordNet is a lexical database structured as an inheritance system encoding numerous semantic relationships. The guidelines are applied to the design of a browser for WordNet.

Keywords
Interactive navigation, semantics, instructional design

Introduction

In going from a traditional paper-based dictionary to an computer-based interactive dictionary many possibilities are available. Like dictionaries, another traditional paper-based source of information is nautical charts. In recent years, such charts have been adapted to computer-based presentation, with numerous additions to the traditional form. In preparation for the design of a dictionary browser, an electronic charting interface was analyzed and guidelines were extracted. The motivation for this was two-fold. First, the above mentioned design-by-analogy technique was thought to be appropriate. The second motivation was the underlying nature of the semantic space defined by the dictionary was thought to be analogous, but more abstract than, the geographic space defined by maps. Recently there has been interest in the spatial aspects of cognition. Peter Gärdenfors (2000) argues that the spatial representation of cognition may solve some well-known problems in semantics. Similarly, Fauconnier (1997) concludes that humans typically represent meanings spatially. These ideas have had little impact on instructional design theory,

This Project

At this preliminary stage our objective is to establish guidelines for designing an interactive lexical navigator by investigating the design of an actual ocean navigation system. WordNet (Fellbaum, 1999), a freely downloadable dictionary of the English language, is a lexical database linked in a complex hierarchy defining a semantic space. The spatial nature of WordNet can be appreciated by a short description of its structure. The database attempts to encode a large part of the English language as a set of linked data items. Thus WordNet can be thought of as a semantic space within which words are distributed. Within such a space, distance has meaning. Closely linked words have a close semantic relationship. Words that are more distant are less related. There are two especially interesting things about WordNet. First, sets of roughly synonymous words are grouped into something called synsets. These may thought of as a domain (a bounded area). Secondly, these synsets are linked to other synsets in several ways. Nouns, for example, are linked to their hypernyms or superordinate concept. (Bird may be linked upwardly to animal and animal to organism, etc.) The opposite relation, hyponymy (animal-bird), is also coded. A set of 25 unique beginners classifies all nouns. Thus (virtually) all nouns in English are linked both horizontally and vertically in a large non-exclusive semantic tree. Verbs, adjectives and adverbs are also linked but in somewhat different ways according to their needs. In all about fifteen semantic relationships are represented in the database.

How to represent these relationships spatially and usefully to students is problematic. In recent years there has been growing interest in the visualization of data (Eick, 2000). Maglio and Matlock (2000) have demonstrated that users of Web software perceive themselves as interacting in physical space. In instructional design there has been much use of visualization to represent content, but little interest in the representation of semantic space. Thus we have to look elsewhere for guidelines

Some informal guidelines exist for the design of information navigators. Familiar WWW browsers have reached a certain level of maturity. Likewise, browsers for visual or musical content such as iTunes or iPhoto provide us with hints. Additionally there are numerous books (Fleming, 1998; Nielson, 1993; Nielson, 2000; Rosenfeld & Morville, 1998; Spool et al., 1999) on user interface design and navigation, which, although not all based on empirical studies, provide some guidelines. Fleming, for example, offers ten principles of successful navigation. Good navigation interfaces should: be easily learned, remain consistent, provide feedback, appear in context, offer alternatives, require an economy of action and time, provide clear visual messages, use clear and understandable labels, be appropriate to the site's purposes, and support users' goals and behaviors. Nielson (2000) says browsers should answer these three question: Where am I?, Where have I been?, and Where can I go?

These guidelines are all useful, but they lack physical specificity, so we returned to first principles. An actual navigation system was analyzed for design guidelines as to what functions might be useful to users.

Figure 1. A GPS Chart Plotter

A system such as the Standard Horizon 150c Chart Plotter (Figure 1) using C-Map+ data is designed to support ocean navigation. The design of such systems is relatively mature as they have been in existence for about a decade. The most characteristic feature of this electronic plotter is that it allows multiple (four) basic views. The primary one is the Chart View, which replicates a paper chart. The user may navigate on the chart by moving a cursor in two dimensions. It differs from a paper chart in a number of important ways though. First the color palette is modifiable. Second the user's current location is automatically plotted. Third, the user may zoom in or out to obtain a wider view or more detail. (There are two types of zooming: analog and digital). Fourth, additional detail about important locations is hidden under icons and that information becomes available when the cursor is placed over the icon. In the Chart View the track of the vessel is superimposed on the chart in a contrasting color, thus providing a history, not just the current time and place.

In addition to the Chart View the three other main views are GPS status, navigation, and highway. The GPS status screen provides basic system information concerning the number of satellites being received and the degree of accuracy of the fix. The Navigation View provides a compass and various calculated values based upon location, speed, heading, and destination. This screen is customizable. The Highway View is useful when sailing towards a chosen location. It provides various calculated values plus an analog view of the course allowing the user to see cross track error.

In each view many display options are available. The compass or highway, as well as the calculated values, can be superimposed on the charts view optionally. In the Highway View, for example, each of the six calculated fields can be replaced with numerous other calculated values. The same is true of the calculated fields that may or may not be displayed in the Chart View.

One very interesting aspect of the interface is how information is hidden or suppressed until the user needs it. Partly this is a physical necessity associated with the small screen (about 12 cm wide) but it also is related to the fact that digital charts contain much more information than their paper counterparts. For example, when the cursor is moved over a port, a popup window appears (this function can be suppressed) offering access to various kinds of information. One especially interesting kind of information for ocean navigators is the tide cycle. Accessing this information produces a separate screen that graphically illustrates the times of high and low tides for that date as well as providing other calculated data.

As might be expected a navigation plotter provides multiple ways to move about the chart space. The most obvious is by cursor control. When the cursor is moved to the left-most margin (for example) the chart moves on the screen to reveal the area to the left. This is convenient if the distance to be navigated is small, but if the distance is great, it is time consuming. In this case the user can zoom out. (In actual paper chart navigation the user would switch to a small-scale chart.) Since this is a common function, dedicated buttons are provided for zooming. Two types of zooming are provided: The first accesses the next smaller or larger scale chart directly; the second provides a menu of charts sizes to choose from. Once the appropriate scale chart is accessed the user can move to the desired location with the cursor.

The other way of moving to another location is to use the menu-based find function. This function gives several choices, such as finding the nearest port that has (for example) medical facilities. A list of ports is generated with distances and bearings, so the user can select the preferred location. Upon selection, the cursor and chart are moved to that location. By pushing the GOTO button, a bearing to that destination is calculated and a course from the current location is plotted on screen. By accessing the Highway View, a visual representation of the course and various calculated data (like estimated time enroute) are displayed. Other data that can be searched for are tide stations, wrecks, and obstacles. As with ports, they are displayed as a list, and upon selection, are displayed directly with the cursor on top. There is a Clear button that allows the user to return to the current location with two clicks.

Some aspects of this navigation interface, no doubt, are a result of the somewhat impoverished control environment. The screen is small and the number of buttons is limited. Thus the interface designer was forced to make do with what was available. However, we can extract a number of general principles that may transfer to our semantic navigator.

1. Provide multiple views of the same data. The Chart Plotter provides what we might call analog, digital and hybrid views of the spatial data. These views are customizable in many ways.
2. Provide direct and indirect access to locations. Direct access is provided through cursor movement. Indirect access is provided through menu-driven searches.
3. Afford information-based choices. When the nearest ports with hospitals are displayed, their distance and bearing are also displayed allowing the user to make reasoned choices.
4. Suppress information under icons until the user decides that information is required. To some extent this is dictated by the small user-interface, but that restriction seems to have resulted in a better design. Some of the existing online implementations of WordNet have suffered from a surplus of onscreen information, making the interface less than useful.

Although these design principles may seem obvious in retrospect, it is not that case that conversion from a paper interface (charts) to a digital interface is an entirely trivial exercise. Many aspects of the digital interface represent features that would be difficult if not impossible to implement in a paper medium. For example, the digital chart plotter has a look-ahead function that can warn of obstacles near the vessel's course. Other systems have 3-D displays that show the undulation of the bottom of the ocean from the perspective of the current location. Whether such views are useful is an empirical question, but they seem to be gaining popularity.

In some ways, the transition from 2-D paper representations to multi-perspective digital plotters we have a good example of a traditional and much-used technology being transformed into a new tool. Dictionaries are another example of a traditional technology being transformed by technology, so design guidelines are needed.

That being said, it is not immediately clear how semantic relationships should be mapped onto visual representations. Some relationships like hypernymy-hyponymy, which are categorical, can clearly be represented like files structures in typical computer systems. It now seems conventional to put higher-level objects on the left and then represent branches as opening to the right. Most systems allow branches to be opened or closed by clicking on icons. It is not clear what level of detail should be represented by default. Dictionaries have far more entries than typical file folders (WordNet has about 100,000 entries) and representing all or most would be impossible, but, in any case, the principle of suppression of information until needed tells us to avoid busy displays. Additionally, since an entry may have not only hyponyms but also meronyms, coordinate terms, and other relationships, multi-level representation is required, but ordinary file structures do not have this complication. In addition, although this is not yet implemented, the illustration of parts is conceivable. Such additional information (pronunciation, glosses, grammatical frames, pictures) typically would suppressed by default, but when displayed must be squeezed onto a limited amount of screen real estate without seeming forced.

Our navigation guidelines suggest that we should have customizable multiple views, perhaps both digital and analog. To some extent, expandable hierarchies, represented by icons as we commonly see with file structure browsers combine both digital and analog representations. WordNet is hierarchical but it is not exclusively hierarchical. Through a set of user options, only certain paths through the data could be displayed, while others could be suppressed completely.

As with the Chart View, a record of the user's path is needed to retrace steps on a semantic journey. The conventional way of representing this is with a list of locations. However, it is worth considering whether an analog representation is possible or useful.

Conclusion

An actual (not metaphorical) navigation interface was analyzed. Broad design guidelines were obtained from that analysis. The needs of a student studying a foreign language differ somewhat from the conventional needs of the native speaker. How this will interact with our design choices is not yet clear. At this point we (myself and students) are implementing these guidelines in constructing the dictionary browser. Various possibilities are being tested, but it is not obvious that a multidimensional space such as that represented by WordNet can be as intuitively displayed as the two-dimensional space represented by navigational charts.

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