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DESIGNING THE FACE OF AN INTERFACE

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ABSTRACT

Graphic design can assist in creating more effective communication at the human-computer interface for computer graphics systems. Graphic design principles concern the selection of visual symbols, their arrangement and sequencing, their relationship to the functions of a computer system, and their relationship to a user's expectations and needs. This paper presents a set of principles and discusses an example of their application to a large information management system's interface.

INTRODUCTION

As computer systems have developed over the last quarter century, the number and complexity of interfaces have also evolved. Of particular note is the increasing sophistication of the graphic quality of human-computer interfaces for computer systems. High resolution and/or color display screens are beginning to display symbols, words, and diagrams in complex layouts and sequences of frames. In the early days of computer technology, little consideration was given to the precise selection of words and symbols, or their layout and sequencing. These facets of interface design increasingly have come to the attention of computer technology in its search for "friendly", user-oriented computer systems. As more care is given to the visual form of the human-computer interface, this graphic communication entity will become a significant feature of computer systems.

Unfortunately, there is currently a lack of specific guidelines for designing interfaces. Some compilations have appeared [Engel and Granda, Smith]; however, they tend to be at too fine a level of detail. They concern themselves with factors of legibility and ergonomic efficiency. They do not address the over-all strategies of the graphic design of major components of an interface. The

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greatest lack is in dealing with matters of readability, i.e., what aspects of interfaces encourage users who may have limited abilities, failing interest, antipathy towards computer systems, etc. As computer systems reach out to ever wider audiences, the notion of attracting and holding a user's interests and emotions will not seem so foreign a goal.

In order to create and organize interfaces which have a high degree of efficiency, sophistication, and attractiveness, it is useful to consider the discipline of graphic design which has traditionally been concerned with the effective clothing of words, concepts, structures, and processes in visible form. It is the aim of this article to acquaint the computer graphics community with graphic design, some of its relevant literature, and to describe experimental changes made in one information management system on the basis of these principles.

GRAPHIC DESIGN

Graphic design is a discipline concerned with creating effective visible languages in which to communicate facts, concepts, and emotions. Traditionally the media employed have been typography, cartography, photography, etc., in the context of printed books, posters, maps, diagrams, etc. There exists extensive literature concerned with typographic legibility, composition, sequencing, color, etc., which have a bearing upon the emerging forms of visual communication in computer graphics systems. In an earlier article [Marcus] we dealt with the relationship of graphic design to the images of information created by computer graphics systems, i.e., to charts, diagrams, maps, etc. This present article extends the relevance of graphic design to the design of human-computer interfaces.

Because interfaces can vary so greatly in their visual form, this article will focus on relatively simple text-oriented interfaces with fixed-width characters. One advantage of this approach is that these interfaces are currently the most widely used. In order to emphasize graphic design principles from traditional book design that are immediately relevant to the design of interfaces, most of the following discussion will concentrate on display of information rather than the user's entry of information from a keyboard or other device.

Interface design involves selection of symbols and formats for the standard functional components of a system: menus, prompts, help messages, status reviews, etc. Interface design also involves the detailed specification of standards at a lower level: the determination of a layout grid, selection of typographic styles, sizing, spacing, and means of emphasis, the standard treatment for continuous prose, interrupted prose (messages), lists, titles, etc. Graphic design seeks to use principles of similarity, proximity, clarity, consistency, and simplicity in organizing visible language [Marcus] and making effective and attractive frames of information. These frames must aid learning of a complicated text, aid memorization, encourage accurate decision making, assist in building a clear conceptual image of the system in the user's mind, and attract and retain the user's attention in situations when the user may be uninterested, unmotivated, or distracted.

There exists much traditional research on typographic legibility for printed texts [Rehe, Zachrisson, Tinker]. Although the research is not usually based on computer graphics displays some of the findings are relevant to interactive terminals.. Legibility of individual characters or small clusters of characters for computer graphics displays has been studied, but larger issues of readable interface design are only recently being explored [Bleser, Spencer et al, Reynolds et al]. Some useful principles follow which are based upon the literature and the author's own professional experience as a graphic designer.

BASIC PLANNING: THE REFERENCE GRID

Unlike conventional prose texts, interfaces have many components and corresponding layouts. These include tables, indexes, lists, numbered items, diagrammatic presentations, explanatory notes, and pictorial images. The interface is not intended for continuous reading as for prose text, but is a framework for complex movement with constant shifts of instruction and attention. Hartley, who has written a manual for designing instructional texts, refers to the need of the layout to be a "consistent and trustworthy" guide, which must advise viewers on their next moves, remind them of their origins, and provide a mental map of the over-all system [Hartley, 13].

Designing the layout requires a sensitivity, first of all, to the limitations of the viewing area, i.e., the display screen, as well as printed copies made at a later time. One must begin with a reference grid, a series of lines that determines the overall dimensions of a frame, the essential areas for text, the number of columns of text, their widths, the spaces between columns, some of the intervals above and below standard items, such as frame numbers, etc. Many interfaces currently employ fixed-width, non-proportional characters. In such cases, the basic measuring units can be a single character in the horizontal direction and a line spacing in the vertical direction. A reference grid allows the designer to block out the kinds of information that will generally appear in frames. The grid both determines fixed positions, margins, and interblock spaces, as well as providing a framework for variations of composition. The grid lies "invisibly" behind every frame. Sometimes the grid must be "broken" or ignored for special materials. It is not an absolutely unviolated device, but it must work most of the time or else a new grid needs to be devised.

TYPOGRAPHIC PARAMETERS

In the situation of fixed-width, non-proportional characters, variation in typesize is either non-existent or very limited. This is not necessarily a limitation; it can be an incentive to make spatial cues and typographic emphasis more potent. As more sophisticated display screens become available, size selection will become more crucial, e.g., to distinguish footnotes from main text, and main text from titles.

Line length is often pre-determined in the sense that typesize variation is limited to one or two sizes. The crucial factor in typography is often the width of lines [Hartley, 21]. Long lines slow down reading. Most typographers recommend 40-60 characters per line [Rehe, Chaparos, Hartley, Craig]. Doubling (reading the same line twice) results when lines are too long and without enough space between lines. In interrupted prose, typical of instructional text in interfaces, the lines are essentially unjustified or "ragged right". Their effective visual length will be shorter than the actual maximum.

Line spacing is measured from baseline to baseline between lines of text. This line spacing should be optically at least equal to the word spacing and should be consistent to contrast with transitions to new material, to highlight elements, etc. Normally one to three variations in line spacing suffices.

Letter Spacing and Justification

For maximum legibility and reading ease, the amounts of space between each letter in a word should be optically equal. Likewise, the spaces between each word in a line should be optically equal. Fixed-width characters on many terminals and printers are usually not well designed for good leter and word spacing. They often have too much space between letters and between words and too little space between lines.

Typesetting style should ensure a natural flow of text. In justified typography, space is added between words (and sometimes letters) to make all lines the same length. In unjustified typography, equal word spacing and equal letterspacing cause lines to end unevenly. There is a tendency in computer science and information science to assume that justified texts are in some way better, but research shows there is no difference in legibility or comprehension [Rehe, 33].

Good quality justified typography has nearly equal amounts of space between words. This does not disturb the flow of text. In poor quality typesetting, unequal word spacing from line to line creates strong patters that are visually confusing. These large spaces sometimes amount to unintended punctuation that interrupts the flow of ideas, especially in formats that have short lines. Variations in spaces between words tend to be greater than they are in longer lines. As mentioned above, justification with fixed-width characters is usually poorly done.

Good quality unjustified typography will have few hyphenations and small differences in line lengths. Line lengths of unjustified typography can be controlled with hyphenation style. No hyphenations will cause large variation in line lengths. Proper hyphenations tend to even out line lengths.

Space and Structure

The intention of a designed text is to co-ordinate the semantics of all symbols including spaces. Many structured texts underutilize spatial cues or create conflicting and confusing spatial cues. One typical user task in interactive systems is to quickly scan previous material on the screen in order to check for certain items of information. Spatial structure can assist this seach by limiting the amount of variation and making each variation significant. Consider paragraph indentation: line skips between paragraphs may be preferable since each new statement is often a very distinct entity. Items which are indented can be used as subgroupings of major blocks of text.

Letterforms and Capitalization

Where type font selection is limited or non-existent, the major task for the designer is to choose from among available non-alphanumeric symbols effectively for special means of emphasis (e.g., for rules, "bullets", etc.). For many fixed-width character displays, italic and bold characters may not be available, but reverse video and blinking characters may be accessible. Typographic emphasis must be co-ordinated with spatial location. This will usually require testing of variations to determine optimum combinations. In general, one should avoid overly redundant coding (e.g., a size and position change in addition to a special symbol to call attention to an item).

Lowercase typography is more varied in its shapes; it is more legible because words are perceived by the shape of their outline, not deciphered letter by letter. All-capital words are more uniform in shape and must be deciphered letter by letter. Reading speed may be slowed by as much as 13% [Rehe, 36, Chaparos]. Occasional use of capitals for special emphasis, especially with fixed-width characters, is necessary, but should be kept to a minimum. The use of fixed-width all-capital settings with close line spacing, so common in computer display devices, is a gross departure from traditional typographic practice. Some researchers and designers feel that lowercase letters, set off by space or typographic emphasis (e.g., boldness) are entirely sufficient for titles and subtitles, making all-capital settings rare [Rehe, Hartley].

Tables and Lists

Tables and lists of various kinds for indexes, file directories, etc., are features of many interactive computer systems. Their formats vary considerably, but research suggests that items need to be carefully grouped, both horizontaly and vertically so as to convey the content efficiently [Hartley, 50]. For example, Spencer [Spencer et al] examined ten variations for presenting bibliographic material and determined the three best ways of presenting it. Such studies indicate that attention to layout can have a noticeable effect on ease of use of lists. However, research in this area is still limited. Linear rules can be used to group selected components of the tables (e.g., column titles) but they should not be over-used. Generally, no more than two varieties of rules should be used [Hartley, 51].

AN APPLICATION: SEEDIS

Seedis is an experimental information management system developed over the last eight years in the Computer Science and Mathematics Department of Lawrence Berkeley Laboratory for the US Department of Energy and the US Department of Labor [McCarthy et al]. Users of the system can make reports, maps, and charts from large databases about energy, demographics, environmental conditions, economics, etc. During the original development of Seedis (1972-80), relatively little effort went into designing the interface which was characterized by inconsistency and incompleteness. The author has proposed graphic design changes based on the principles outlined above, and these changes have been implemented recently. The author is also preparing a graphic design manual which definitively describes these changes and prescriptions for Seedis.

The goal of the graphic design effort has been to increase the effectiveness of the interface by increasing its consistency and clarity, developing trust in the user, and thereby increasing the perceived "friendliness" of the system. This will lead to more positive response in the user, to a better conceptual framework in the mind of the user, and more effective communication between human being and machine.

Although the current Seedis environment (6 nodes on a network of VAX's) includes a variety of high resolution graphics terminal, printers, and paper terminals, many Seedis users communicate with Seedis via very simple terminals such as the Lear-Siegler ADM3. Therefore, Seedis frames of informational text are designed for a frame 80 characters wide by 24 lines deep. This is an industry wide standard that will be valid for at least another 5 to 10 years for many simple terminals.

Because most of the computer's replies are of fairly brief extent, even for lengthy help messages, a line of text 40-60 characters wide is appropriate. In order to separate the computer's statements from the user's, the computer will generally type in character positions 21 to 80, while the user will begin typing in character position 1. Examples of typical frames appear in the accompanying Figures. The visual separation of "voices" in the human-computer dialogue allows the user to scan lines on the screen or on paper output more effectively. The user can see the unfolding dialogue to observe patterns of decision making and to find specific information quickly. It is important to assure the user that s/he is driving the system, not the other way around. The intention of this layout is to emphasize the user's selections from a menu or a menu-prompt and the computer system's responses to that selection.

Upper and lower case typography has been used wherever possible because of its greater legibility for lines of text and short phrases. All cap settings of words and phrases are used sparingly and only where there is an important semantic reference to denote: All-cap settings are used as key words that identify the module from which the current command prompts are coming, and titles for pages of textual or tabular information.

A standard title, page number, prompt line and user request line are usually displayed on every page. In this way the user's present location, past history (the context part of the prompt message), and future locations (the options of the prompt) are always present. The frame layout has also tried to account for typed paper presentation. Note that the full 80 character width can be typed out on standard width paper (8.5 x 11 inches). Using pica or elite typewriters (10 or 12 pitch) non-proportional letters, a full width of 8 or 7.2 inches is obtained for 80 characters. Use of 12 pitch typing is recommended to allow a left hand margin for binding and an ample right-hand margin.

The graphic design of the page assumes that most text will appear between character positions 21 through 79 (one less than maximum to avoid a the terminal's automatic line feed). Occasionally tables and lists occupy the entire screen. Because most lines begin or have fields beginning in column 21, there will be a strong visual axis vertically along character position 21. It is along this invisible, implicit vertical line that a user can efficiently scan when searching for information. To reinforce this significance, most database titles, prompts, etc., begin in character position 21. After experimentation with variations the most useful tabular settings appeared to be every 5 characters beginning in column 1 and continuing across the screen. The tab settings are simple divisions of the jump between the user's starting position (position 1) and the computer system's starting position (position 21). A tab width of 5 or 10 characters allows short fields of 4 or 9 characters and encourages a limited, consistent set of tab stops.

Whenever possible, the codes or other items to be selected in a list are placed immedately preceeding position 21, i.e., beginning in positions 16 or 11. When more than one field must be placed in columns 1 through 19 (assuming one skipped character in position 20), the most important field, usually the one containing items to be selected, is placed at the far left so that it can be easily detected. The left-most field and the one beginning in position 21 are the two most important locations. Remaining fields are placed at the far right. Wherever possible, consistency of location is maintained, and fields are arranged in conceptually linked groups, e.g., units and variables.

Page numbers include the word "Page" to reduce confusion about the appearance of isolated digits in the display and to avoid confusion with possible section numbers. Although not completely implemented, it is recommended that "Page 2 of 15" be the convention to indicate further pages. The user will be aware of how much other material might lie in a module or section.

Horizontal lines formed by hyphens are used to call the reader's attention to titles of tabular or prose material that is subordinate to the main title. The hyphen rule replaces a blank line of space, which normally would have been necessary for visual clarity. The width of the hyphen rule, 59 characters maximum, follows the standard width in order to emphasize the title and the full column width. Within tables, the hyphen rule may be wider than 59 characters in order to include fields in character positions 1 through 19. Normally one character space interrupts the rule between fields.

Where possible, lists of short keywords allow reading down in columns of greater than 3 lines. Lists usually begin with a header, a title, and a hyphen lines, and end with a line skip, then the prompt. If necessary, lists may occupy the full width of the page, with correspondingly wider hyphen lines. It is generally recommended that lists take up horizontal bands so that as they grow in length, they can easily expand into a next frame.

EVALUATION AND CONCLUSIONS

Many variations of page formats were studied before the conventions for Seedis were proposed. The new graphic design format has been introduced into the system wherever it did not require major reprogramming. Since implemention of these changes, users appear to notice the differences and to respond favorably to them. The new graphic design has also served as a model for staff preparing new modules and components of Seedis. It appears that carefully controlled graphic design within Seedis can result in an improvement in the efficiency of the interface and production of system components. The application of the design principles outlined in this article and included in the graphic design manual should enable future programmers to economically prepare, produce and install the various modules being developed in such a way as to use their resources to their full potential and to retain over-all visual coherency of the system.

Throughout the industry, testing of interface design often remains rudimentary. Partial testing of limited aspects has taken place [Spencer, Bleser], but no means of high level evaluation is widely accepted. Partial tests can show where some features of an interface are seriously deficient or where effective approaches are counter-intuitive. The application described above has only recently been implemented; detailed evaluation remains to be carried out, and much more graphic design remains to be done.

The graphic design of interfaces is not a science, nor is it solely an art. It is an activity of design, a mixture of articulated analytical methods plus intuition and creative insight. The forgoing discussion has attempted to clarify what graphic design is, to identify some principles that are relevant to interface design, and to show how they can set the context for, but not necessarily guarantee effective design of the human-machine interface. As interfaces become more visual and less textual, graphic design may again be used to assist with even more complicated issues than those addressed above, e.g., to create diverse styles of interfaces for a single system (third world versus first world, novice versus expert, etc.), to create complex non-verbal symbols, diagrams, and map-like interfaces, and to improve the overall documentation of a system (tutorials, reference manuals, users guides, etc.) The role of graphic design in helping to design the face of interfaces is now beginning to emerge.

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FIGURE 1: SINGLE FRAME WELCOME MESSAGE

```
                   ---------------------------------------------------------
                   WELCOME TO SEEDIS, VERSION 2.0
                   ---------------------------------------------------------
                   At any point in Seedis, you can type the following global
                   commands to get these responses:

Input              Description
------------------ ---------------------------------------------------------
?                  list and describe commands in this menu
help               describe the purpose of this menu's commands
show               list and explain items to be selected
review             list current session status and history
cancel             delete current selections (depends upon context)
quit               return to previous menu

                   If you exit abnormally, type "restore" to recover.
                   Then, to restart Seedis, type "seedis".

                   Non-Seedis symbols are now being put aside.
                   Please wait. Your menu-prompt will appear shortly.

                   SEEDIS: area, data, display, profile
:
```

FIGURE 2: SINGLE FRAME COMMAND MENU DESCRIPTION

```
                   DATA: <line letter(s)>, table, <page number>, CR
: ?

Input              Description
------------------ ---------------------------------------------------------
<line letter(s)>   select one or more data elements by line letter codes
table              display table of contents for this database
<page number>      display a particular page
CR                 (carriage return) display the next page

?                  list available commands in this menu
help               describe data element selection
show               display table of contents for this database
review             list current data element selections and history
cancel             delete current data element selections for this database
quit               return to database selection menu

                   DATA: <line letter(s)>, table, <page number>, CR
:
```

FIGURE 3: SINGLE FRAME HELP MESSAGE

```
                     SEEDIS: area, data, display, profile
: help
                     USING SEEDIS
                     ----------------------------------------------------------
                     LBL's Seedis is an experimental information system that
                     includes integrated program modules for retrieving, analy-
                     zing, and displaying selected portions of large databases.
                     Seedis contains a wide variety of geographically linked
                     databases on U.S. population, economy, employment,
                     mortality, air quality, energy production and use, etc.
                     Program modules in Seedis include the following:

            area     select geographic area (level and scope of analysis)
            data     select, extract, or enter data for specified areas
            display  manipulate and display data in tables, maps, and charts
            profile  produce standard socio-economic reports for selected areas

                     Normally Area, Data, and Display are used in the order
                     given. However, once the geographic study area is defined
                     in Area, you may alternate between Display and the
                     selection, extraction, or entering of additional items
                     in Data.

                     SEEDIS: area, data, display, profile
:
```

FIGURE 4: SINGLE FRAME SHOWING LEVELS OF DETAIL FOR AREA SELECTION

```
                     AREA: nation, state, county, <other level>
: show
                     LEVELS OF DETAIL FOR GEOGRAPHIC UNITS AS OF 24 APRIL 81

                     Interstate: unit crosses state boundaries
                     ----------------------------------------------------------
                     AQCR      BECHT     LMA       NPC       SMSA71    SMSA79
                     BEA       CENSUS    NATION80  PAD       SMSA73    WATER
                     BEA69     COAL      NECMA77   PUS70     SMSA75    WRASA
                     BEA77     FED       NECMA79   SCSA79    SMSA77    WRSA

                     Substate: unit crosses county boundaries within a state
                     ----------------------------------------------------------
                     BEAPART77 NCI       STAQCR    STNECMA77 STSMSA75  STWRSA
                     COUNTY80  PLBLS     STATE     STNECMA79 STSMSA77  TOWNSHIP
                     LMPM      PLEPA     STBEA69   STPUS70   STSMSA79
                     MSP       PRSP80    STBEA77   STSMSA71  STWATER
                     NCHS      SEA70     STLMA     STSMSA73  STWRASA

                     Subcounty: unit entirely within a county
                     ----------------------------------------------------------
                     AQMS      COUNTY    MCD70     PLACE     TRACT

                     SHOW: table, <page number>, CR
:
```

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