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CAD/CAM FROM THE GRAPHIC DESIGN PERSPECTIVE

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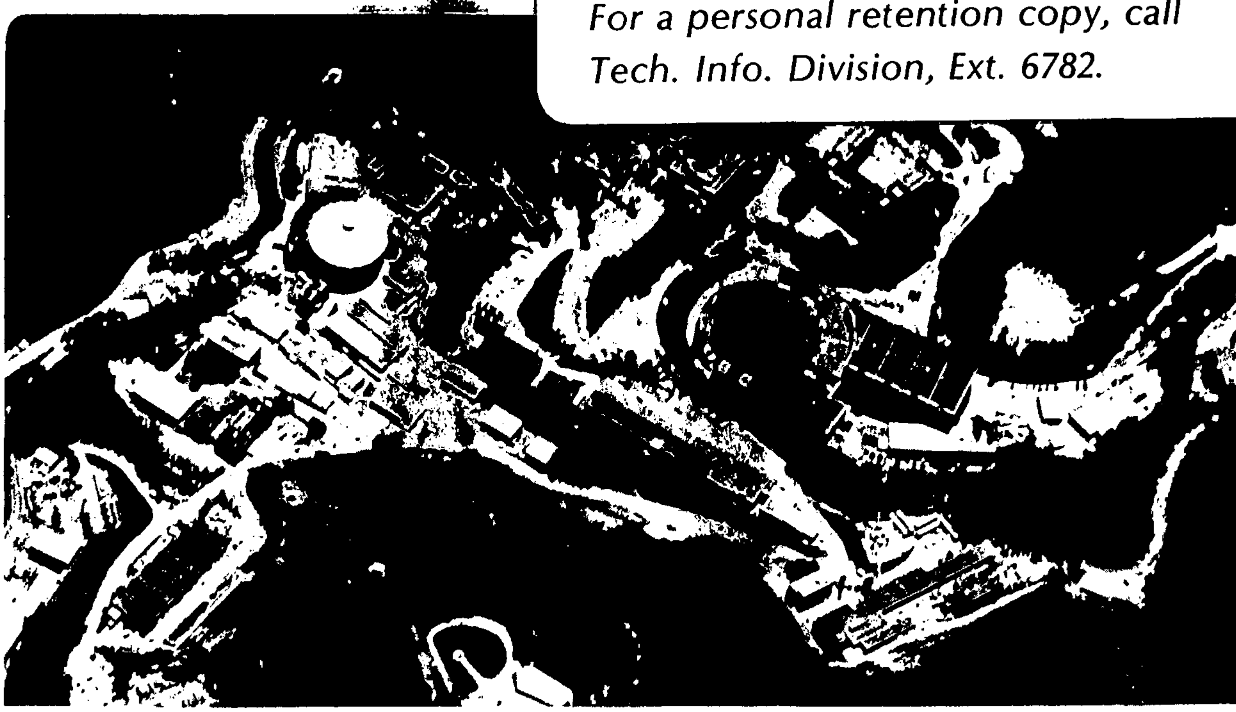

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# CAD/CAM from the Graphic Design Perspective

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**Abstract**

CAD/CAM systems have evolved elaborate human-computer interfaces in order to facilitate the creation of highly detailed and specialized schematic diagrams and texts. Although these systems have powerful capacities in terms of graphics editing, data manipulation, and data storage, insufficient attention has been given to making the online interface (together with supporting documentation) user-friendly, i.e., understandable, memorable, and appealing to the general user. Graphic design considerations in particular have been routinely overlooked. Graphic design concerns typography, symbol design, color, spatial layout, and temporal sequencing. Graphic design can assist computer science by providing insight and expertise in designing effective communication between human being and machine.

## Introduction

Computer-aided design and manufacturing (CAD/CAM) systems are intended to provide highly skilled professionals with computer-based tools for enhancing their design and production activities and permitting them to work more effectively. The traditional working environment is one in which facts and concepts are embodied and communicated through large, complex presentations of diagrams, charts, and tabular/textual forms. CAD/CAM systems of all kinds have increased their sophistication in terms of the functional abilities that computer science and technology have provided. These systems permit the storage of large databases, the detailed manipulation of this data both in alphanumeric and in graphic form, and their display or communication in a variety of formats.

In achieving this functional sophistication, however, comparatively less attention has been given to the visual quality in which schematic, typographic, and other visual materials are displayed. This area of communication is the concern of the discipline called graphic design, particularly those professionals whose activity is oriented toward the display of information rather than the creation of persuasive or purely aesthetic forms. It is the intention of this brief article to acquaint the CAD/CAM community with the expertise of graphic design and to indicate the nature of the interaction between these two professional communities that would produce more effective visual communication in CAD/CAM systems.

## The Three Faces of Computers

Since all CAD/CAM systems utilize graphic as well as alphanumeric display, it can be asserted that they communicate with human beings in what the author as elsewhere [5] described as the "three faces" of computers: outer-faces, inter-faces, and inner-faces.

Outer-faces are the frames of information that are the end products of data processing or information management in computer graphics systems from the communication point of view. Examples of outer-faces are texts, tables, forms, charts, maps, and diagrams. In the CAD/CAM environment these include the planning and production documents for any project. They may be viewed and used by persons with little or no familiarity with the computer system that produced these drawings or verbal materials.

Inter-faces are the frames of command/control and documentation that the user of the CAD/CAM system encounters. These include such activities as textual/graphical querying, decision support displays, as well as command selection, qualification, and execution. The documentation may appear as online help or offline guides, reference manuals, cue-cards, and other means of retaining the user's attention, comprehension, memory, as well as a positive working attitude.

Inner-faces are the frames of command/control as well as documentation that the builders and maintainers of CAD/CAM systems encounter. Usually, these materials are more numerous, less understandable, less completely documented, and less coherent than those materials oriented toward sale and user-service of the system. These frames are crucial to the programming environment that originally built the system and to the maintainance and upgrading of its performance.

A particular individual may have familiarity with more than one of these faces. In general, however, the viewers of these faces are distinct with respect to their familiarity with computer technology, the detailed operation of the CAD/CAM system, the subject matter of the frames which they view, and their general needs for conveying information (e.g., urgency, complexity, rate).

The frames of information in any of these three faces may differ in their visual characteristics. They may be generated on offline or interactive displays. The frames can be recorded on paper, glass, or film in high or low resolution environments. High or low resolution refers to space, time, or color. The frames may be incorporated into other communication media (e.g, a videotape training program which shows examples of vector screens). It may be necessary that the frames appear interchangeably in black-and-white vs. color or in high vs. low resolution environments. These alterations create special demands upon the design of symbolism, typography, and other graphics.

Each of these special conditions changes the visual qualities of the frames of information. Taken together, all of these visual qualities in a CAD/CAM system express a visible language, or at least a coding, which facilitates and enhances the communication between people and people, and between people and machines. The development of a visible language involves the coordination and specification of the typography, symbolism, color, spatial arrangement, and sequencing of generic as well as special frames. A well-designed CAD/CAM system must account for this consistency and clarity in its planning, development, and implementation stages. Unfortunately, profession skills in visible language design are often lacking in the personnel who build such systems. It is for this reason that information-oriented graphic design can be of some assistance.

## Information-Oriented Graphic Design

Information-oriented graphic design can be considered related to, but not identical with ergonomics or human factors. As scientific disciplines, ergonomics and human factors are primarily concerned with scientifically established, factual, prescriptive statements about visible language for any of the three faces of CAD/CAM systems. Graphic design is a discipline stressing synthesis, not only analysis, in a decision-making environment where there is insufficient scientific knowledge. As a design discipline it is a mixture of science and art, of reliable fact and useful assertion.

Traditionally, information-oriented graphic design has played a role in the design of graphics for large corporations. Examples include the CAD/CAM corporate graphics for product literature, building signage, and product appearance, Graphic design has also been involved with the design of complex graphic descriptions of structure and process (e.g., the London or New York subway maps), and command/control environments (e.g., signage systems for international exhibits and highway systems). Considerable literature [2,7,12] exists on matters of legibility, readability, and psychological/cultural factors in designing typography, symbolism, color, spatial arrangement, and temporal sequencing.

It would appear appropriate and beneficial if this literature and expertise were available now to the decision making on all aspects of how CAD/CAM systems interact with human viewers. The author has already been involved as a graphic designer with the improved design of outer-faces [4] and interfaces [6] of a large geographic database management system called Seedis [10,11], and initial inner-face design prototypes for the display of textual programs [9]. In so far as graphic design specifications can be articulated in a precise manner, e.g., in a graphic design manual [8], these generic decisions can be studied by the programmer and incorporated into input and output specifications of the system. In this way, more effective communication can be built into the automatic, default displays of the system.

The graphic design of frames for CAD/CAM systems involves establishing basic principles for the location and appearance of all graphic elements. These elements can appear in various sizes, orientations, colors, positions, shapes, etc. The graphic design specification limits the amount of variation according to cognitive and perceptual limitations of the human being. The graphic designer selects these limitations on the basis of available research plus intuitive knowledge of how to apply basic principles of visual organization. These principles include proximity, similarity, clarity, consistency, and simplicity [4].

## Basic Graphic Design Principles

### The Layout Grid

For all faces of a computer system, the frame on paper, glass, or film requires a set of lines that control where alphanumerics and other symbols appear. This layout grid usually consists of horizontal and vertical lines that indicate the location of particular items such as frame numbers, headers, or other special purpose notation. The grid also indicates the limits of zones for columns of text, areas for interactive buttons, and other regularly appearing material such as illustrations. The grid reflects both the needs of the hardware/software support of the display as well as the logical requirements of the content for a series of frames. The grid must accommodate the arrangements of most frames that will be generated; therefore the lines must accommodate most repeated elements of any frame encountered in the system. In some CAD/CAM system interfaces, for example, frame layout changes are erratic and confuse the eye of both the novice and expert user.

**Typography**

Typographic distinctions must be made to signify different kinds of messages, varying levels of importance, and varying layouts. In most current CAD/CAM systems, fixed character-width letters are used. In some recent systems, variable width fonts of higher resolution characters are being used [3]. Many of these systems overlook the traditional principles of typographic legibility and readability [1,12]. Information-oriented graphic design would generally recommend the following:

Font differentiation should be limited usually to one or two typefaces. Within a typeface family, distinctions of slant (roman and italic) and weight (bold, medium, light) should be used sparingly to highlight (e.g., keywords) and to differentiate (e.g. main titles vs. subtitles) text elements. If multiple typefonts are available, those which are currently accepted by professional graphic designers for use in text presentations should be selected, e.g., Times Roman, Helvetica, Garamond, Univers, etc. Distinctions of type such as blinking should be kept to a minimum because they tend to distract and annoy if they are over-used.

Type size variations should also be limited. A practical rule is to use only three variations in size for most textual material. The optimum primary text size will vary with conditions of the display device and the environment in which the display is viewed. Traditionally, textual material is set in columns that are 40-60 characters wide [1,12]. This column width measure holds for both screen and page displays. Since many portions of text in CAD/CAM systems are clusters of phrases and groups of short paragraphs, the lines are often irregular in length. For this reason a flush-left, ragged-right approach to justification would seem appropriate. Wherever possible, supplementary elements of text should also be flush-left, ragged right to correspond with a standard approach to the appearance of text. Legible lines of type should have word spaces that are optically smaller than the space between lines. For most text presentation, the line spacing should be constant, but the exact amount will vary according to such factors as the way in which the typeface is drawn, contrast with the background, and the size of type. Horizontal variations of type positioning for such items as paragraph indentations, tables, and lists should also be kept to a minimum. Because all-capital lines are harder to read than upper and lower case settings [1,12], all-capital settings should be kept to a minimum except for codes and other special keywords and phrases.

**Sequencing**

Because frames of printed documentation pages and screens of the user interface contain much material that is read in a random fashion, pages and screens should contain standard frame elements such as frame numbers, repetitive titles, and other indices that help a viewer understand immediately the general context and the local attributes of a frame. This may include extra titling for lists, symbolic references to the organization of the entire document or system modules, and other graphic devices.

**Research Themes**

Besides utilizing graphic designers to help implement better CAD/CAM systems, another way of incorporating their expertise is to use them in helping to envision prototype frames for innovative faces of computer systems. This would involve a professional visualizer in exploring graphical documents that enhance viewer comprehension through non-verbal symbolism, graphical interfaces to CAD/CAM systems, and graphical programming environments. There appear to be some generic themes [9] for research in the graphic design of computer graphics for CAD/CAM systems. These are outlined in the following paragraphs.

For any kind of frame there must be adequate semantic relationships between typographic variations in appearance, layout, or sequencing and the content which these typographic distinctions encode. The typographic and textual features of command/control frames and documentation frames, whether on paper or glass, have been inadequately developed thus far. It is now appropriate to explore how changes in type family, size, slant, boldness, color, or figure-field relationship can be used to enhance legibility, comprehension, and appeal. Likewise, the role of a spatial grid which regularizes the position, shape, and orientation of visual elements must be explored. The value of redundancy and proportion in changes within the grid have yet to be precisely determined.

Another theme for research is the use of pictographic or ideographic signs to enhance communication in the inter-face of CAD/CAM systems. In what situations can these non-verbal symbols demonstrate increased efficiency in space requirments for display, ease of manipulation or change, or ease of comprehension? In what ways can these glyphs interact with spatial grids to take advantage of their non-linear ways of grouping? In this way command/control and documentation can become more diagrammatic in appearance. These diagrams are actually representations of directed graphs of great commplexity. Research must propose visual prototypes for what these multiple frame display environments might be like.

A third area for research is the role of dynamic, interactive changes in the signs that constitute a CAD/CAM face. What can be done beyond merely blinking something or making it appear to move? How can attributes of appearance, disappearance, translation, re-orientation, and static/dynamic qualities affect the communication of the outer-, inter-, or inner-face?

A final direction for research is CAD/CAM's version of the general problem to find a way to relate detailed views of complicated functionality to more simple perspectives. In this way the computer system can adapt its display to the amount of complexity that an individual viewer might require.

## Summary

The purpose of this brief exposition on graphic design in relation to CAD/CAM system development has been to acquaint the reader with the nature of information-oriented graphic design, some of its issues and principles, as well as references and projects that document the interaction between these two disciplines. If a professional involvement of graphic design can be included in the planning and development schedule for CAD/CAM systems, it may be possible to enhance the functionality as well as the friendliness of human-machine systems.

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