Is a Picture Worth a Thousand Words?  
Classification and Graphic Symbol Systems

Abstract: Icons are graphic images with functional roles in human-computer interaction. They may be used as conceptual tools to represent the organization of information or as operators effecting an activity such as printing or moving to another document. An icon may represent its referent either as a sign, a purely arbitrary relationship that must be learned by the user; as a pictograph, a visual image of the object represented; or as an ideogram, where the referent is not a concrete entity but an attribute, a set of attributes, or an abstract concept associated with the referent. The symbolicity of an icon reflects the degree of representativeness that obtains between an icon and its referent(s). We propose to examine symbolic languages composed of sets of icons and to assess their effectiveness as classificatory structures in terms of: 1.) representation of hierarchical structure; 2.) level of symbolicity; 3.) contexts that promote the capability of icons to represent organization; 4.) relationship between an underlying metaphorical framework and iconic representation of the organization; 5.) graphic elements of effective symbolic languages; and 6.) social or cultural factors related to the effectiveness of icons.

1. Introduction

One of the most interesting phenomena engendered by recent technological innovations is the enhancement and popularization of computer-based graphics. As recently as 1992, a popular text on information organization claimed that "Documents are comprised of words" (Rowley, 1992, 166). But advances in the generation, storage and transmission of images in digital format have heightened awareness of the information-bearing role of images and have led to a general recognition of the need for increased access to images in both traditional and digitized formats through the development of visually-oriented cataloging and indexing techniques (Austin, 1994; Shatford Layne, 1994).

While classification research has focused on developing new methods for representing the visual and conceptual content of images (Jörgensen, 1995), enhanced graphic capabilities have influenced how information is organized in a host of computer systems and applications. Once the exclusive province of the Macintosh user, the GUI, or graphic user interface, has become the standard interface for Windows operating systems; and traditionally keyboard-driven applications such as WordPerfect have incorporated the use of icons. The point-and-click navigation provided by hypertext-based systems such as the World Wide Web has further enhanced the utility of graphic images by encouraging their use not merely for initiating system activities, but also for providing access to information. Thus, while research is currently investigating how to represent the content of digitized images, graphic images are being employed as icons both to indicate the functional capabilities of a computer application and to represent the intellectual content and the relational or associative organization of collections of information.

2. Signs, Pictographs and Ideograms

Arnheim (1969) observes that an image functions at one of three representational levels: as a sign, standing for "something" but not reflecting the perceptible characteristics of its referent...
(e.g., the diagonally crossed bars within a circle that serve as the traffic sign indicating a railroad crossing), as a picture, employing a relatively low-level representation of the perceivable qualities of its referent (e.g., the silhouette of a deer to indicate a deer crossing on the highway); or as a symbol, representing its referent at a higher level of abstraction that is frequently, but not always, metaphorical (e.g., the profile of a soldier to represent the concept "war").

A sign constitutes a one-to-one mapping of a graphic to the entity or concept for which it stands, but the basis for the relationship established between the sign and its referent is purely arbitrary. Use of an enclosing circle with a single diagonal bar to represent "no" or "not" is a purely arbitrary convention. In contrast, a picture, or pictograph, is the visual image of an object that refers directly to the object represented. It is, as Gittins points out, "a graphic representation whose decomposition makes interpretation impossible" (Gittins, 1986, 520-521). A pictograph provides a one-to-one or one-to-many mapping between the graphic image and its intended referent(s). For example, in a word processing package, an image of a printer is a pictograph used both to represent and to initiate the system's printing function.

Symbols, however, are more abstract than either signs or pictographs. A symbol is an ideogram (Krul, 1988) in that its referent is not a concrete entity but either an attribute, a set of attributes, or an abstract concept that is characteristic of or associated with the intended referent. There is a one-to-many mapping between symbol and referent in that the referent generally exists not as a specific object but as an interaction between the intended category term as referent and the immediate context. For example, a bent arrow at the end of a long hallway is a directional sign indicating simply that the hallway continues in the direction shown, but a highway sign that represents a sharp curve in the road as a bent arrow is an ideogram in that it is not intended to stand for the curve itself, but to indicate to the approaching driver the need to slow down before entering the curve. Similarly, the picture of a cowboy boot placed over a shelf of books is an ideogram indicating the intellectual content or general subject area of those books (i.e., "Westerns").

A set of signs, pictographs and/or ideograms, when used within a single system or system component, is frequently organized around one general metaphor that serves to constrain the range of possible referents for any given image. For example, the dominant metaphor employed by many word processing packages is that of the "office": graphic images represent objects or activities that are readily understood within the context of traditional office tasks. The set of images developed to handle specific tasks, to represent system functions, or to indicate related components within a single application or informational unit exists, therefore, as a symbolic language.

A symbolic language is a visual language. More specifically, a symbolic language can be defined as an integrated set of graphic images—of signs, pictographs and/or ideograms—usually organized around a central metaphor, that represents a specific domain and is intended to convey information about that domain through visual, non-linguistic means. It is important, therefore, to distinguish between a symbolic language and the symbolicity of a visual language. The symbolicity of a visual language refers to the level of representativeness that obtains between individual images and their intended referents. As such, it may range from the purely arbitrary level of the sign, through the concrete level of the pictograph, to the more complex level of the abstract ideogram. The symbolicity of a visual language may be pure, in that it consists of visual images that function at a single level of representation (e.g., all images are arbitrary signs), or it may be mixed and include images drawn from across the three levels of sign, pictograph and ideogram.
3. Icons

A graphic image, whether sign, pictograph or ideogram, that has a functional role in a computer interface is an icon. GUIs rely on icons of familiar objects to facilitate user interaction with the system. The use of familiar objects encourages inferences about system activities. When selecting a particular icon, then, the user must rely on preexisting knowledge or familiarity with the domain to recognize those attributes which will identify the intended referent in order to invoke and manipulate system processes (Benbasat and Todd, 1993). Because both the semantics and the syntax of this interaction are pre-defined (Gittins, 1986), effective dialogue between the user and the system can be established without the user's explicit knowledge of an underlying command language.

An icon is generally defined as a graphic image that conveys a single, unique meaning and serves as a visual label for an object or process (Benbasat and Todd, 1993; Gittins, 1986; Krull, 1988; Lohse, Biolski, Walker and Rueter, 1994). Thus, for example, Lohse et al. (1991, 433) describe an icon as a form of "shorthand notation for a label [from which] the meaning of each icon can be readily extracted," and Ockerse and van Dijk (1979) define icons as "signs which have features in common with the object, and characterize, picture, or imitate the object" (1979). Thus, emphasis has traditionally been placed on the graphic rather than the conceptual component of the icon—on its service as a visual signpost pointing to a concrete entity, rather than on its potential as an organizational tool within the system.

4. Functionality and Modality of Icons

One current phenomenon not accounted for by the more conventional approach to icons is their utility in providing access to specific materials in hypertext-based systems such as the World Wide Web. Associative links between conceptually related materials can be represented by icons that are activated to effect navigation between documents. Furthermore, as the complexity of many web sites is compounded by the introduction of new documents, icons are employed not simply to provide access to information but, more broadly, both to represent the intellectual content of related materials and to indicate the overall conceptual organization of a collected body of information.

The use of icons either as conceptual tools to represent the organization of information or as navigational tools to access information has not received much attention in the literature. There is, instead, a tendency to focus on the visual characteristics of icons and icon sets rather than on their functional capabilities. Thus, Gittins describes a GUI as "a system populated by 'objects' which the icons represent" (1986, 527); and Krull warns against the use of icons to represent abstract topics unless "the referent (the concept to be represented) is concrete, [in which case] it should be possible to find a pictorial symbol for it" (Krull, 1988, 258).

With the enhanced graphic capabilities of current systems, however, it is imperative that researchers distinguish between graphic images whose inclusion is purely decorative or illustrative in nature and those which serve a functional purpose in effecting an activity, whether the object of that activity involves initiating a system process such as printing, navigating between linked documents, or providing access to the conceptual organization imposed upon a body of related materials. As demonstrated by these examples, the component that distinguishes an icon from a decorative image is the ability of the system user to interact with and manipulate the system through the selection and activation of an icon so as to produce a system response.

The functional distinction between visual graphics and icons is critical for a comprehensive definition of icon, but it is also important to distinguish icons from linguistic strings that provide functionality in a computer-based system. For example, while hypertext systems such as the
World Wide Web use words and phrases as concept-based links between related pieces of information, these alphanumeric strings are simply links and should not be considered icons. Krull (1988) clearly distinguishes between alphanumeric, or digital, encoding and graphic, or analog, encoding. He points out that, while digital encoding uses alphanumeric characters to directly represent an object, concept or activity in its entirety, analog encoding is metaphoric in that it employs a selected few of the referent's physical or conceptual properties to indicate the intended meaning. From Krull's perspective, then, graphic icons are simply analog encodings. But such a distinction between analog and digital encoding does not preclude the association of a graphic icon with a linguistic label. There is, in fact, an extensive body of literature that compares the utility of single modality icons that are purely graphical in their composition with that of mixed modality icons that incorporate an alphanumeric label to support the intended meaning of the graphic image.

For the purposes of the present study, then, an icon is defined as a graphic representation of the intended referent—either as sign, pictograph or ideogram—in single (graphic) or mixed (graphic plus text) modality that allows the user to interact with and manipulate the underlying system to produce a desired response.

5. Research Background

Attempts to understand how icons work—and how they work best—have generally focused on the design of icons. One of the most widely cited articles is Easterby's "The perception of symbols for machine displays" which appeared in 1970. This work has served as a jumping-off point for research that assumes a strong correlation between the graphical composition of an icon and its success in conveying information—research that tends to focus on an identification of those graphical components which contribute to the optimum composition of meaningful icons and icon sets.

Easterby identified five components that contribute to the referential meaning of a graphic image. The first three of these components are structural principles and contribute to the establishment of "contextual cues for the observer who is attempting to define the meaning of the symbols" (Easterby, 1970, 150). The last two components are figural properties which determine the shape and form of the graphic within the visual field, thereby either facilitating or hindering an appropriate and meaningful interpretation.

- **Pragmatic component:** The context within which a graphic image is to be used or interpreted.
- **Semantic component:** The relationship between the graphic image and the object, concept or activity to which it refers.
- **Syntactic component:** The relationship between the set of graphic images that comprise the symbolic language.
- **Visibility component:** The visual clarity of the graphic image.
- **Discriminability component:** The ease with which one graphic image can be differentiated from other graphic images in the same set.

While each of these components contributes to the conceptual meaning of the graphic image, it is the sum interaction between the five components that constitutes the essential perceptibility of a graphic. Although perceptibility has been subsequently described as "the degree to which a symbol may be quickly and reliably understood in the context of its intended use" (Boling, Johnson, and Kirkley, 1994, 6), Easterby presented the notion of perceptibility as an evaluative measure of symbol performance that would reflect integration between the processes of perception and discrimination and thereby "ensure that the meaning of a symbol is accurately and readily
perceived" (Easterby, 1970, 152).

In line with his efforts to identify "the optimum definition of more meaningful shapes", Easterby proposed that the evaluation of graphic images should attempt to "define the best features for perception" (Easterby, 1970, 152). In so doing, he established a research agenda whose emphasis on identifying figural properties and their interaction has influenced much of the subsequent research. Geiselman, Landee and Christen (1982) developed an index of perceptual discriminability based upon measures of the configural and graphical attributes that were shared by the images within an existing symbolic language. The index could then be used as a performance-based criterion for selecting candidate images to be incorporated within the existing language. In two studies investigating modality in icon construction, Guastello, Traut, and Korieneck (1989) evaluated groups of icons on the basis of meaningfulness and found that mixed modality icons were generally rated by subjects as more meaningful than either verbal or graphic single modality representations, a preference which extended across a range of domains. The authors concluded, however, that, while there is a strong interrelationship between meaningfulness, memorability and the efficiency of system operation, future research should attempt to define dependent measures that are more closely related to the notion of efficiency than are ratings of meaningfulness.

Gittins (1986) attempted to create a classification for graphic images based upon common design features (e.g., type, form and color) and shared display structures (e.g., boundary, location, and figure grounds). While his effort is interesting, it fails to capture essential commonalities that could be used to construct a true classification of icons. More recently, Lohse et al. (1991, 1994) have undertaken a series of empirical experiments intended to provide the foundation for a taxonomy of visual representations based upon measures of visual similarity across a wide range of graphic presentation methods including, among others, maps, graphs, tables, and time charts. Their research identified eleven classes of visual representations, including a class identified as "icons". It is interesting, however, that their findings indicated that subjects viewed icons as unable to convey much information in that each icon represented a one-to-one mapping between the graphic and its referent.

The studies discussed here provide only a very brief overview of research focusing on the domain of icons, but they are highly typical of work in this area. Published research has concentrated on identifying the figural properties of an effective icon or icon set, on the ease of learning and memorability of single and mixed modality icons, and on measures of user performance that reflect meaningfulness and/or memorability. There appears to be very little research addressing the functional ability of icons to represent the conceptual organization of information.

6. Focus of the Proposed Research

The proposed research will attempt to assess the effectiveness of symbolic languages as classificatory structures. To this end, we will focus on the ability of a set of icons to generate a coherent graphic vocabulary that is capable of representing a meaningful organization for a set of documents while supporting effective and efficient access to materials through manipulation of the icons that comprise the language.

To address the problem of the effectiveness of symbolic languages as classificatory structures, a sample of symbolic languages will be evaluated in light of six specific focus areas.

The first focus area addresses the question of hierarchical structure, which we define as three or more levels of representation that evince a superordinate/subordinate structure. The analysis will concentrate on the overall organizational structure of the information. Although an attempt
will be made to determine if there is an observable preference for either monohierarchial or polyhierarchial systems, the primary emphasis will be on the ability of symbolic languages to represent a hierarchical structure.

The second focus area investigates the level of symbolicity at which graphic images are more effective in representing classificatory structure. Each symbolic language will be analyzed to identify the predominant form of graphic representation—sign, pictograph or ideogram. The symbolic languages examined in the study will then be compared to determine if there is any correlation between symbolicity and the ability to represent classificatory structure.

The third focus area addresses the related questions of context and metaphor. Specifically, it will attempt to determine if there are specific contexts within which a symbolic language can more effectively represent organizational structures. The icons that comprise each symbolic language will also be analyzed, both individually and in association, to identify the presence of a general metaphorical framework.

The fourth focus area extends the notion of a metaphorical framework and investigates the possibility that there is a correlation between an effective representation of the organization of information and either the context or a governing metaphor.

The fifth focus area attempts to determine if there are specific graphic elements that are shared across either the more effective or the less effective of the symbolic languages studied. Because the configural elements of icons are not a primary concern of the proposed study, this focus area may receive relatively less attention.

The sixth and final focus area investigates social and/or cultural differences that limit the effectiveness of the icons in a symbolic language.

7. Scope of the Research

The ability of graphic images to indicate the classificatory structure of a collection of documents constitutes a potentially significant problem. When this problem is extended to the organization of information within a highly unstructured system such as the World Wide Web, performance based on context-free measures of meaningfulness or memorability tends to evaluate individual icons in isolation. This approach may fail either to reflect the underlying utility of the graphic representations or to provide an adequate measure of the effectiveness of a particular symbolic language. Because of the unstructured and evolving nature of the Web and other hypertext-based systems, the performance measure employed to evaluate the efficiency of the dialogue between user and system must be able to reflect the user's ability to "accurately and readily" (Easterby, 1970, 152) infer the meaningful intent of an icon. To this end, efficiency of the symbolic language will be measured as the ability of the user to identify and manipulate icons that locate, or retrieve, the appropriate information.

Because symbolic languages that are used to indicate conceptual structure may demonstrate varying levels of symbolicity, we propose to examine the efficiency of user-system interaction for three different kinds of symbolic languages:

1. Many public and school libraries employ graphic classification labels to provide rapid recognition of the intellectual content of an item. These highly stylized graphic labels are available from commercial library supply companies and rely on simplified metaphorical images that indicate very general categories of content. For example, the shape of a turkey placed on a contrasting background may be used to identify materials related to the American Thanksgiving holiday.

2. The Bookhouse virtual library interface uses icons to represent a range of fiction categories (Pejtersen, 1989). Bookhouse images appear to be less stylized than library classification
labels, possibly reflecting the heightened contextuality provided by the central metaphor of a "house of books".

3. Some sites on the World Wide Web use icons both as indicators of conceptual organization and as tools for discrimination, evaluation and navigation. The precise referent of a graphic representation may be less significant at this level than the insight it provides about the classification of a potentially complex body of information or the ability to distinguish one collection or organization from another. Because the need to communicate a general structure relies upon semantic discrimination between icons, the ability of the symbolic language to indicate organization in such a system may be more dependent on the interaction between icons than it is in the two systems described above.

In order to understand how these three types of symbol systems serve to conceptualize, or organize, the relevant information space, each symbolic language will be evaluated to distinguish the context in which it operates, to identify governing metaphors and to assess the level of symbolicity for the icons that comprise that particular language. Using the structural principles and figural properties that Easterby (1970) has identified as constituting a meaningful graphic, a measure of the perceptibility of each language will also be constructed.

8. Conclusion

The proposed research will investigate the ability of symbolic languages to represent a coherent classificatory structure for a collection of documents. To assess the effectiveness of a symbolic language as an organizational tool, we will use a performance measure that reflects the efficiency of a given language in providing access to documents within the classified set. By investigating the relationship between effective representation of the classificatory structure and the analyses of hierarchy, symbolicity, context, metaphor and social and cultural limitations, it may be possible to identify certain primary characteristics of an effective symbolic language that can be used in the construction of more meaningful and therefore more efficient symbolic classificatory structures.

Notes

1. There are a number of studies comparing single modality mixed modality icons. The following list is short but nonetheless representative of much of the research being conducted in this area:


References


