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Intellectual Access to Graphic Information

Mark E. Rorvig
Issue Editor

University of Illinois
Graduate School of Library
and Information Science

LIBRARY TRENDS

Library Trends, a quarterly thematic journal, focuses on current trends in all areas of library practice. Each issue addresses a single theme in-depth, exploring topics of interest primarily to practicing librarians and information scientists and secondarily to educators and students.

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Introduction

MARK E. RORVIG

NOT QUITE A GENERATION HAS PASSED since Patrick Wilson (1968) published his slender volume entitled *Two Kinds of Power: An Essay on Bibliographic Control*. In this work Wilson described two simple teleologies guiding bibliography—the power to list and the power to find. Though this *Library Trends* issue is not concerned with the control of the documents used as examples by Wilson, but rather with graphical objects—i.e., pictures, line drawings, and images of pages—nothing much has happened to change the basis of his philosophical exposition. To be sure, the technology of bibliography has changed (and there is much to say about technology in this issue), but the underlying sense of things remains the same.

For example, the article by Petersen, "Developing a New Thesaurus for Art and Architecture," does not deal much with technology, but addresses the more homely issue of linguistic meaning (or descriptive unraveling) and the management processes used to control the international development of controlled vocabularies. The issue addressed by this volume boils down to only one point: What can be listed cannot always be found, and the relationships among the components of the list enrich or impoverish the finding process.

Indeed, this *Library Trends* issue, taken as a whole, describes the great revolutionary transfer of ideas once confined to documents, to the universe of nonlinguistic knowledge; a great stripping away of the "biblio" portion of bibliography from the graphic component. Moreover, this truly *is* a revolution. Usually when an author uses the word *revolution* it is a misnomer for the real word *evolution*. But intellectual access to graphic records, as opposed to textual records, has returned bibliography to the same complex of concerns

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it had twenty-five years ago. We are exactly at the point of inquiry on descriptive processes that was abruptly terminated by advances in computer storage and memory during that period. The IBM 360 of the mid-1960s replaced more than clerical workers in accounting departments; it replaced whole sets of intellectual problems as well.

In the mid-1960s the literary picture of bibliography was one of limitation. Authors addressed the problems of documents as mere objects; things to be retrieved by the assignment of a few meager linguistic phrases to a complicated body of thought. It was much like trying to distinguish individual elephants by regarding a common set of handkerchiefs assigned to a herd of elephants in an orderly way. Quite a few articles were published. A little progress was made. But, in general, everyone seemed quite happy when the character of the problem changed so that the insides of texts, the many words of titles, abstracts, and the text itself, could be turned inside out by application of basic principles of relational database organization (then referred to by the weird phrase "inverted files").

With graphic records though, we are again confronted by these same gross limitations. But this time we will not be rescued by the machine of the gods. A photograph has no way to tell us about itself as a document is able to so inform us (see Howard Besser's "Visual Access to Visual Images"). An engineering drawing cannot be decomposed into words but only into lines and angles (see Bill Beazley's "Impact of CALS on Electronic Publishing Systems"). And as for the beautiful systems that retrieve images of documents as pages (see Frank L. Walker and George Thoma's "Access Techniques for Document Image Databases"), without an index and browsing tools they are as dumb as fishes and pigs.

This issue of *Library Trends* has thus been divided into two sections following the line of Wilson's thought. Section one deals with the power to list while section two addresses the power to find. Within each section the articles are arranged in order from concrete tools and applications to the more arcane theoretical issues and applications. In keeping with the policy of *Library Trends,* the authors have been encouraged to describe their use of specific machines and techniques as fully as possible and to make the reader an insider to the decision paths that were discarded or followed. All of these topics and issues are quite recent. Indeed, most of these articles describe systems and products that are either still in development or that entered into production only in 1989/90. A few articles describe developments that are prototypical only and that may never reach production status. Harold Thiele's "Heraldry and Blazon," article in section one is purely theoretical and has been included only for providing a view of what may be necessary to retrieve graphic records as directly as we now retrieve documents by words.

Section one directly addresses the power to list graphic records, not only by descriptive rules (though as noted throughout, the formal systems of descriptive cataloging available for monographs must be adapted for application to graphic records) but also by intellectual content. The chief tools for this effort are controlled vocabularies of several types applied by various automated techniques to assist the intellectual task. Broadest in applicability among these vocabularies is the *Art and Architecture Thesaurus* (AAT) described in Toni Petersen's lead article. As in the 1960s work addressing document description, cost elements play the major role in determining the applicability of controlled vocabularies to graphic records. Jeanne Keefe's article, "The Image as Document," describes some of the Yankee ingenuity required to structure system dynamics so that cost effectiveness may be achieved. Gary Seloff's work, "Automated Access to the NASA-JSC Image Archives," details the steps used to create a subset of the *NASA Thesaurus of Technical Descriptors* for application to photographs. Further, Seloff's final production tool—a "visual" thesaurus—incorporates not only relational database technology for the presentation of descriptors, but also the machine linkage of image and text to add greater uniformity to term assignments. In the next two articles, the past is used to recreate the future in two forms. Lois Lunin, in "Descriptive Challenges of Fiber Art," takes us to the world of an art form that dates from the eleventh century Bayeux Tapestry and the ancient art of the Navajo. In this work, the problems of description involved in even a small subset of the art world are described in terms of record users and uses, vocabulary control, and vocabulary development. Finally, Thiele applies the medieval art of heraldry to the problem of reducing trademarks to searchable machine strings, equivalent to string-matching textual systems. The article, "Heraldry and Blazon," may tax readers unfamiliar with algorithmic description, but the application fully formed in his appendix will be a delight.

In section two, working systems that assume an intricate index already exists are presented as examples of the power to find. In this section we are not so much concerned with describing retrieval objects (though descriptive problems are also addressed by these authors) as we are with their presentation as analog and digital displays. This section is intended for those most interested in current technology and its application to the retrieval of graphic records. Significantly, and well in keeping with the cost sensitivity of graphic record intellectual access, many of these systems are personal computer and workstation oriented, making full use of optical disc storage media. The first of these articles, "ArchiVISTA," written by Stone and Sylvain (two systems engineers at the Public Archives of Canada), describes the development path for a cost-effective blend of analog and digital techniques in the presentation of caricature art to the general public. George Thoma's "Access Techniques for Document Image Databases" details the latest product of the National Library of Medicine's longstanding program for optical disc publication of journal articles. His article is the most complete presentation of this large-scale program presently available in the journal literature. Besser's "Visual Access to Visual Images" describes the prototypical work in image collection access carried out over the last five years at the University of California at Berkeley. The Berkeley program is a very ambitious one and will require liberal applications of money for completion to production status. In some respects, this article should be read in parallel with Seloff's in section one since both authors conclude that presentation of text alone in either the descriptive or retrieval processes associated with graphic records will be insufficient for outstanding system performance. Finally, Beazley's report on the development of graphic exchange standards ("Impact of CALS on Electronic Publishing Systems and Users") within government and industry brings the work of the field up to date on the most ambitious technical publication standard to be developed since the inception of the scientific journal.

For any collection of articles such as these, it is the dubious honor of the editor not only to present what was found in the field as the collection of works developed, but also to comment on significant elements that were missing. Most important among these is a total absence of regard for the role that probabilistic indexing (see Maron & Kuhn, 1960, pp. 216-44) might play in systems for graphic record intellectual access. This is a strong departure from the work of the 1960s in which the role of probability assignments to terms applied to documents as retrieval objects was a major source of debate, but one need not be very prescient to see its applicability to graphic records.

A fundamental problem of retrieval is that too much material is retrieved in response to any query. The present thinking is that it is much better to rank the objects to be retrieved in the most likely order of relevance to the query than simply to list them. Conventional methods for creating rankings of retrieval objects usually rely on a large corpus of text terms or a "fine grained" linguistic base. Graphic records, however, are usually not finely grained but coarsely grained in that only a limited number of descriptive elements are present for each record. The cost of indexing is usually too great to do otherwise.

Probabilistic indexing as developed in the 1960s, however, does appear to meet the needs of graphic record ranked-retrieval since it was originally developed for use in document retrieval in a coarse grained, limited description environment. Although, as described earlier, the technique was not widely implemented because advances in hardware (storage and speed) made fine grained retrieval possible from the large source of textual components of the bibliographic record. The technique may be expressed with respect to graphic records by the following formula: $P(I_j,GR_i) \sim P(GR_i,I_j)$ where, $P(I_j,GR_i)$ denotes the conditional probability of relevance that a user will ask for the *i*th graphic record by the *j*th index term, $P(GR_i)$ denotes the absolute probability that a system user will want the *i*th graphic record, and $P(GR_i,I_j)$ denotes the conditional probability that if the user were to be satisfied by graphic record *i*, the user would request it by index term *j*.

The outcome of this method is that, with respect to any given graphic record, a user will retrieve or view records ranked by order of the weights assigned to them as modified by their absolute probability of choice. In implementing this technique, it may be assumed that the initial weights will be assigned by an indexer, and absolute probabilities assigned by a behavioral proxy of some type, perhaps that of ordering a print of a particular item in a given search session.

The editor wishes to thank the authors of this issue and the many individuals and institutions that supported the authors in these writings. Revolutions are profound events. I have not seen many in the field before this one.

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Developing a New Thesaurus for Art and Architecture

TONI PETERSEN

ABSTRACT

THE *ART AND ARCHITECTURE THESAURUS*, currently consisting of almost 40,000 terms, is midway in its development. Methods for constructing the thesaurus were modeled on existing standards and on other thesauri such the National Library of Medicine's *MeSH Thesaurus*. It was designed to provide the "hinge" between the object, its images, and related bibliographic material. In the decade since it was begun, however, attitudes toward the use of terminology to describe visual images and museum objects have changed, impelling *AAT* constructors to develop policies that would make the thesaurus flexible enough to meet the needs of a new generation of database producers. This article describes the processes and policies that were developed to construct a language that would represent knowledge in the field of art and architecture as well as be surrogates for the images and objects being described. The *AAT's* presentation of an "atomized" or faceted language is detailed.

INTRODUCTION

In 1979, when the meeting was held that resulted in a proposal to develop a new art thesaurus, vocabulary control in the field of art and architecture was extremely limited. Yet this field had a long history of documenting its objects of study. A strong organization of art librarians, the Art Libraries Society of North America (ARLIS/NA), had existed for almost a decade. The Research Libraries Group

*Since this article was written, the *Art and Architecture Thesaurus* was published by Oxford University Press. The thesaurus contains a chapter on the history of the project that includes some of the same material published here.

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(RLG) had organized the Art and Architecture Program Committee (AAPC) which comprised a growing group of the largest and most prestigious art libraries in the country to advise RLG in this field. A number of indexing and abstracting services existed, some of them decades old. In addition to these, there were visual resource collections (slides, drawings, and photographs), archival collections, and museums, all of which cataloged art objects, their surrogates in picture form, or documents related to art.

Most art librarians, whether cataloging on RLG's Research Libraries Information Network (RLIN), the Online Computer Library Center (OCLC), or other bibliographic utilities, used *Library of Congress Subject Headings (LCSH)* as a source of subject terminology although there was general dissatisfaction with its coverage in the field of art and architecture. Some art libraries, especially those with old and large collections, had developed their own subject authority files or had enhanced *LCSH* with additional headings according to their needs. The indexing and abstracting services, most of which were automated to some degree, had their own subject lists. Visual resource collections, archives, and museums almost all had manual systems with either no or little subject access and no control of their subject terms.

The advent of the large automated bibliographic utilities, the stricter use of the MARC format in automated cataloging, and the emergence of the microcomputer encouraged the proliferation of online databases and tighter control of collections of materials, whether books, journals, or objects. Automation also allowed vast quantities of data to be stored and retrieved easily and cheaply, and there was the promise of relational databases in which scholars could link a variety of information within one system. All of this new-found functionality had a significant influence on the move toward the automation of collections of materials in the field of art and architecture.

It is often frustration that serves as the catalyst for change. In 1979, Dora Crouch, an architectural historian and professor at Rensselaer Polytechnic Institute in Troy, New York, found herself increasingly frustrated with the constant difficulties she encountered in trying to assemble slides for her lectures. To solve this problem, Crouch called a meeting in February 1979 of archivists, librarians, prints and drawings curators, and indexers in order to initiate the Universal Access System for Slides (UAS). During this and a subsequent meeting in May 1979, the need for a controlled vocabulary, or thesaurus, was seen as the first and necessary step toward a system for the control of visual resource collections.

A thesaurus would provide for the consistent representation of information by determining the preferred ways of referring to concepts, bringing together synonyms, and noting other relationships such as broader and narrower terms. It would lighten the burden of indexers and catalogers and bring about the most comprehensive retrieval of information possible on a particular topic by linking together terms whose meanings are related.

The May meeting included new participants: Pat Molholt, associate director of Libraries at Rensselaer, and this author, executive editor of *RILA (International Repertory of the Literature of Art)*. Discussion focused on the need for a means to use the latest technology in these computerized cataloging and indexing projects. Henry Millon, dean of the Center for the Advanced Study of the Visual Arts (CASVA) at the National Gallery of Art, who was unable to attend, sent his recommendation for the ideal thesaurus. His concerns summarized the issues addressed by the committee. He wrote:

> A thesaurus for computer needs to be arranged hierarchically, so that it collapses within itself, to make a nest of terms. This is a key problem in making subject categories. Designing such a thesaurus will take real collaboration among architectural historians.

In this statement Millon identified key elements that became guiding principles in the development of the *Art and Architecture Thesaurus (AAT)*—that it should be hierarchically structured and that it should be based on the collaboration of scholars in the field. Millon's understanding and forethought regarding the pivotal role of his colleagues gave him a critical role as chair of the *AAT's* Architecture Advisory Group which was established in 1983 to review and guide *AAT* research and production.

At the time, most thesauri were strictly alphabetical lists of terms, although they contained rudimentary hierarchical structures with broader and narrower term references. They were usually constructed by indexers or librarians to suit the indexing and cataloging needs of a particular application, and their compilers did not often seek the advice of their scholarly communities. As we enter the 1990s, we are witnessing a move toward natural language system interfaces which require sophisticated concept and term mapping. It is actually becoming more essential to have well-structured hierarchical thesauri mounted within natural language processors to form the basis of semantic networks. Millon's "nest of terms" was not far off the mark.

As it happened, the Universal Access System never materialized, and the group disbanded after the second meeting, but its momentum and the energy it had germinated was captured by the formation of the *Art and Architecture Thesaurus*. A trio from the UAS meeting consisting of Pat Molholt, Dora Crouch, and this author set to work to prepare grant proposals and to plan the thesaurus.

Our first grant, received from the Council on Library Resources in early 1980, enabled us to investigate and establish the need for an art and architecture thesaurus. This work prepared the way for the filing of subsequent grant proposals to other funding agencies. The resulting report, *Indexing and Abstracting in the Arts: A Survey and Analysis,* was finished later that year and was made available through the ERIC document service (Crouch et al., 1981). The report detailed the status of subject indexing lists in the field of art and analyzed each of the major lists. It concluded that, while each was tailored to meet the needs of its own project, none was adequate in itself to provide the comprehensive thesaurus needed for the whole field. It also noted a willingness on the part of the persons who had been approached to cooperate in the production of a new thesaurus.

In September 1980, a one-year planning grant from the National Endowment for the Humanities (NEH) was received, followed by a second grant for 1981-82 to construct the architecture section. Rensselaer became the administering institution for the grants and agreed to give the infant project a home in its Folsom Library.

The thesaurus was envisioned as a set of terms that would include the history and the making of the visual arts; that is, it would form a hinge between objects and their replicas or representations and the bibliography about them. Its coverage would be geographically and historically comprehensive but would not include terminology for iconographical themes. The terminology would be hierarchically organized, based on the model of the National Library of Medicine's *Medical Subject Headings* (NLM, 1990), and optimized for computerized use. Scholars in the field would review the work at all stages.

The initial task was to gather terminology from existing glossaries, subject lists, and thesauri. This underscored yet another basic principle of the *Art and Architecture Thesaurus;* that it would build upon vocabulary already in use in the field. In this way, we hoped to maximize its relevance and enable indexing and cataloging organizations to absorb the new thesaurus easily. With this in mind, priority was to be given to *LCSH* as a source for *AAT* terms.

As the work progressed over the next decade, however, more and more differences began to emerge between Library of Congress Subject Headings and the developing *AAT.* Basic differences in the way terms were chosen and structured were analyzed in a 1983 article in which issues such as inverted versus natural word order as well as other more serious problems that violated thesaurus standards for term construction (such as inconsistencies in LCSH's syndetic structure) were raised:

—The *Art and Architecture Thesaurus* is hierarchically arranged according to a rigorously constructed, internally consistent structure. This allows terms to be graphically displayed in a nested conceptual array with terms that are broader and others that are narrower or more specific in meaning (see Figure 1 for an example of the *AAT's* hierarchical structure). *LCSH* terms are available only in an alphabetical array, leading to omissions and inconsistencies in the syndetic structure.

—*AAT* terms are chosen from available sources to make a conceptual whole within their hierarchical arrays. This does not mean that there are not general terms in the *AAT.* "Houses" is an available term as are numerous narrower terms related to it such as "country houses" and "bungalows." *LCSH* terms are often general because they are used to describe the subject of whole books rather than a specific object in an image or the subject of a periodical article. They are also generated only when a need for a term arises. Thus many terms available in the *AAT* will not be found in *LCSH.*

—Rather than expressing single concepts, *LCSH* terms are often "precoordinated"—that is, they are complex concepts put together at the time the heading is generated, and they remain in the authority list in that specific combination. For example, "Wooden doors" is an *LCSH* heading as is "Renaissance painting." In the *AAT,* because of its faceted structure, "wood" is found in the Materials hierarchy, "doors" in the Built Works Components hierarchy, "Renaissance" in the Styles and Periods hierarchy, and "painting" in the Disciplines hierarchy. Indexers are free to use terms separately or to combine them into headings that are precoordinated at the time of indexing to match the item they are describing (Petersen, 1983).

Despite these divergencies, the *AAT* still sought to give priority to *LCSH* terms because of *LCSH's* long-term preeminence as an indexing vocabulary, so long as the term form met the strict requirements for thesaurus construction set out in national and international standards. However, when necessary, *LCSH* terms were modified. Each concept in *LCSH,* whether adopted intact or modified, was noted in the corresponding *AAT* term record. It was hoped that this would enable libraries that used the *AAT* to track their older bibliographic records containing *LCSH* headings and to connect bibliographic records for like subjects.

After gathering the terminology, all the categories or possible hierarchies that would be necessary to cover the field of architecture and associated areas were identified and a computer program was written to generate term sheets for each term from the computerized lists that had been generously supplied to the *AAT* by the *Journal of the Society of Architectural Historians,* the *Avery Index to*

Architectural Periodicals, the Picture Division of the Public Archives of Canada, *RILA*, and the *Architectural Periodicals Index* of the Royal Institute of British Architects. Since there was no computerized *LCSH* file available at the time, relevant terms had been painstakingly identified in the printed *LCSH* volumes and a computerized file made.

VD.1	drawings
VD.2	*<drawings by method of representation>*
VD.3	composite drawings
VD.4	cutaway drawings
VD.5	exploded drawings
VD.6	pictorial drawings
VD.7	scale drawings
VD.8	full-scale drawings
VD.9	*<drawings by method of projection>*
VD.10	axonometric drawings
VD.11	dimetric drawings
VD.12	isometric drawings
VD.13	oblique drawings
VD.14	elevation oblique drawings
VD.15	cabinet oblique drawings
VD.16	cavalier oblique drawings
VD.17	general oblique drawings
VD.18	plan oblique drawings
VD.19	trimetric drawings
VD.20	orthographic drawings
VD.21	auxiliary views
VD.22	elevations
VD.23	exterior elevations
VD.24	interior elevations
VD.25	laid-out elevations
VD.26	partial elevations
VD.27	half elevations
VD.28	sectional elevations
VD.29	*<ship elevations>*
VD.30	body plans
VD.31	outboard profiles
VD.32	rigging plans
VD.33	sail plans
VD.34	sheer plans
VD.35	multiview drawings
VD.36	plans
VD.37	*<area plans>*
VD.38	city plans
VD.39	site plans
VD.40	block plans
VD.41	grading plans
VD.42	landscaping plans
VD.43	planting plans
VD.44	traces (area plans)
VD.45	*<building plans>*
VD.46	floor plans
VD.47	ground plans
VD.48	typical floor plans
VD.49	foundation plans

May be used in combination with other descriptors (e.g., Japanese + watercolors; ink + drawings; brush + drawings; landscape + drawings).
Source: *AAT Thesaurus,* 1990.

Figure 1. Example of *AAT*'s hierarchical structure

This first gathering of potential candidate terms for the *AAT* resulted in a stack of approximately 30,000 separate term sheets. The terms were studied for overlaps and omissions as well as style of headings. Term sheets for like concepts were merged, and the sheets were arranged in rough stacks according to about eighteen hierarchical categories.

The next job was to arrange each stack of term sheets into hierarchies, a process called "shingling." By May 1983, a great deal of progress had been made. The first rough hierarchical arrangements were completed, and the staff began to edit them.

It had been thought that the matching and merging task would generate every known term for the cataloging and indexing of architectural materials. However, the most striking fact that emerged from this first attempt to create hierarchies was the presence of large gaps throughout. The tens of thousands of term sheets that had been generated did not, in fact, provide a complete set of terminology. The explanation was twofold. First, when terms that have been developed for an alphabetically arranged list are rearranged by concepts, missing terminology quickly becomes apparent. As Molholt said: "When the parts of a bicycle are laid out by size it's hard to see what may be missing. When those parts are laid out in the form of a bicycle, missing parts are easy to detect." The second reason for gaps was that most subject lists derived from indexing and cataloging systems contain only those terms needed to index or catalog actual documents or objects encountered.

To gain some idea of the proportion of the problem, a small experiment in "infill" was conducted; that is, terms felt to be absolutely necessary to provide a comprehensive set that would be acceptable to the scholarly community were added to one subsection of one hierarchy. That section more than doubled in size as a result. This was a major watershed for the *Art and Architecture Thesaurus* for it was now clear that the original set of lists could not be depended upon to provide a comprehensive set of terms in a hierarchical array. The scholarly mandate of the *AAT* required a decision to search out missing terms in reference works and scholarly monographs, a costly and labor-intensive task.

A number of other important problems were identified in this early stage, including issues of term form, pre- and postcoordination, and subdivisions. It quickly became apparent that many of the combinations of terms provided from the original sources could not be maintained in the *AAT* because of enumeration problems. The most frequently used combinations in the indexing of art and architectural materials were those of style or period and object name, or material and object name, such as "Victorian cottages" or "marble floors." To have enumerated all such possible combinations, the size of the thesaurus would have burgeoned uncontrollably. It was relatively simple to make a first decision to group style and period and material terms in what were then called "quasi-hierarchies" of their own rather than keep them precoordinated with other terms. Indexers and catalogers could then choose their own combinations as required using a standard set of rules and instructions. However, as work progressed, the more difficult task of fully articulating rules for other types of pre- and postcoordination had to be undertaken.

Another problem was the fact that there is often no "real" indexing term to use as a broader or collocating term under which to array a group of like terms or siblings. The *AAT* followed the lead of some other thesauri in establishing node labels or "guide terms"—terms within brackets that express the broader concept but are not suitable as indexing terms.

We also found, surprisingly, that organizing terms into hierarchies limits their classification as well. The semantic network of a hierarchical structure stretches just over broader and narrower terms and through synonyms and near variant lead-in terms. Building a network of related terms—the next step in the process and a feature that will be added once the *Art and Architecture Thesaurus* is completed in the next few years—takes on additional significance, especially for the representation of knowledge in a field. In a sense, one builds alternative hierarchies from the paths made by related terms. For example, in the architecture hierarchies, all single architectural structures are classified within their genus-species relationships—"chapel" is a type of "church" as is a "cathedral." Through related term references, one is able to add the ability to construct the parts of the whole. "Pews" and "pulpits" will point to "chapels," "churches," and other religious structures.

To sum up the basic operating principles developed for the *Art and Architecture Thesaurus* in this first stage, the following points can be enumerated:

—The *AAT* would be constructed using standard thesaurus conventions, such as those outlined in the American National Standards Institute's (1980) *Guidelines for the Construction of Monolingual Thesauri.*

—It would be structured hierarchically, drawing on the model of *Medical Subject Headings MeSH* for its tree structures and alphabetical displays.

—It would be based on terminology that is current, that is warranted for use in standard literary sources, and that is validated by the scholarly community. If possible, it would incorporate existing lists that may be enhanced or modified.

—It would be responsible to its constituency and take cognizance of the needs of that constituency in the depth and scope of its terminology.

—The data comprising the thesaurus would be made available in machine-readable forms lending themselves to a variety of automated systems.

—The necessary financial commitment would be sought, not only to build the original vocabulary but to maintain it over the long term.

—A commitment would be made to the user groups that the vocabulary would not be changed arbitrarily. Although change is inevitable, it should be planned for and promulgated with the agreement of the user community.

Scholarly input has turned out to be crucial to the *AAT*. Its staff is composed of a combination of art historians and information scientists. All of the editors who choose the terminology and construct the hierarchies are art historians and/or architects. Most of the authority work on the terms and the management of the thesaurus system is done by information scientists/librarians. Regular editorial meetings to develop policies and to review work in progress include both elements of the staff.

During the editorial process, editors often call on outside experts to answer specific questions about terms. During the course of authority work on terms, scholarly literature as well as general reference works are consulted to make sure that the term is in use and to determine its scope and definition.

Scholarly review groups are assembled during the final stage in the construction of hierarchies. Twenty-eight of these reviews, lasting from a half to two and a half days, have occurred between 1983 and 1989. The most cohesive and enduring of the review teams is the Architecture Advisory Group, chaired by Henry Millon, comprising five other scholars and architects representing all elements of the field. This group met seven times between 1984 and 1989 to review the architecture hierarchies in their development and has played a major role in the way these sets of terms are structured and chosen.

Work with the scholarly community and with a growing group of *Art and Architecture Thesaurus* test users has underscored the conviction that, while comprehensiveness and standardization of vocabulary is an important goal, successful thesauri can be neither stagnant nor dictatorial. They must be able to respond to the living, evolving language from which they are drawn—to assimilate both the language of scholars in the field and the more popular language found in basic literary sources. The *AAT* seeks to maintain a delicate balance between providing standardization of a body of terms that is as full a representation of an area or field as possible, and responding to patterns of usage and the subtleties of language. It must be understood that total comprehensiveness is not truly possible, given the restraints of time and resources and the changeable nature of language itself. A thesaurus must be seen as a living tool; a body of language that can be added to and changed as it responds to the needs of its users.

It was only with the advent of J. Paul Getty Trust support in 1983 that resources became available to carry out some of the more important methodological decisions that had been made. Prior to this, with a very small staff and with the NEH mandate to complete the architecture section in a year, there had been no opportunity for the rigor that was subsequently applied to the research aspects of choosing terms and conceptualizing them into hierarchies. From this point on, the rule of literary warrant was emphasized for each term. Rather than accept terms, even with modifications, as they were received from various indexing sources, each term was also researched in several reference sources, including scholarly monographs, glossaries, and catalogs. A record was kept of all sources consulted, and definitions of the term as found in the sources were noted. Variant forms were included as lead-in terms. Definitions or scope notes were added to many terms. These data became the basis for the *AAT's* alphabetical index entries (see Figure 2).

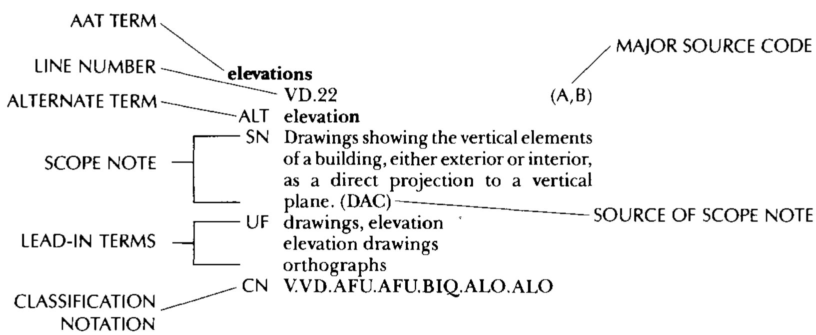

Figure 2. Sample from alphabetical display

In 1985 the *Art and Architecture Thesaurus* entered a new phase with the formation of the Getty Art History Information Program (AHIP) under the direction of Michael Ester. Half a decade of work had not generated a product that could be officially distributed. With AHIP's help, a series of more realistic goals were set. The scope of the thesaurus was narrowed to focus on Western art and architecture. Work on the decorative arts and fine arts sections was suspended until architecture, and all its supporting sections, could be completed. By the fall of 1989 a contract had been signed with Oxford University Press to publish twenty-three of the projected forty hierarchies by spring 1990 (see Figure 3 for a list of *AAT* hierarchies). The publication will consist of a set of three printed volumes and an electronic edition on floppy discs.

AAT Facets and Hierarchies

Associated Concepts Facet

Physical Attributes Facet
- Design Attributes
- Design Elements
- Colors

Styles and Periods Facet
- Styles and Periods

Agents Facet
- People and Organizations

Activities Facet
- Disciplines
- Functions
- Events
- Processes and Techniques

Materials Facet
- Materials

Objects Facet
- *Built Environment*
  - Settlements, Systems and Landscapes
  - Built Complexes and Districts
  - Single Built Works and Open Spaces
  - Building Division and Site Elements
  - Built Works Components
- *Furnishings and Equipment*
  - Tools and Equipment
  - Measuring Devices
  - Hardware and Joints
  - Furniture
  - Furnishings
  - Personal Artifacts
  - Containers
  - Culinary Artifacts
  - Musical Instruments
  - Recreational Artifacts
  - Armament
  - Transportation Artifacts
  - Communication Artifacts
- *Visual and Verbal Communication*
  - Image and Object Genres
  - Drawings
  - Paintings
  - Prints
  - Photographs
  - Sculpture
  - Multi-Media Art Forms
  - Communication Design
  - Exchange Media
  - Book Arts
  - Document Types

Figure 3. *AAT* facets and hierarchies

In January 1986, this author assumed the full-time directorship of the *Art and Architecture Thesaurus.* Pat Molholt returned to her full-time position at Rensselaer, although her association with the *AAT* remained close. The *AAT* moved to a long-term site in Williamstown, Massachusetts, close to its sister AHIP organization, *RILA,* in summer 1986, where it will remain until its last anticipated move in the mid 1990s to the permanent Getty facility under construction in Brentwood, California.

From the earliest days of the project, financial support was only one kind of support sought by the codirectors. The *Art and Architecture Thesaurus,* as a thesaurus that is independent of any particular application, is almost unique. It must provide for a wide range of environments, building a vocabulary that fills the needs of such different indexing systems as those for books and periodicals, images, and museum objects. From the beginning, the *AAT* set itself the task of becoming the standardized vocabulary for these varied constituencies. In order to achieve this, the support of these constituencies had to be sought. Preparing for the NEH grant proposals brought the endorsements of the Society of Architectural Historians, the College Art Association, and ARLIS/NA (Art Libraries Society of North America). In addition to these, many other elements of the art and architecture community that might benefit from the *AAT* were canvassed for advice and endorsements.

At the 1982 ARLIS annual conference, an *Art and Architecture Thesaurus* advisory committee was formed with the aim of serving as a liaison between the *AAT* and the ARLIS membership. The previous year, the Subject Heading Task Force of the Art and Architecture Program Committee had officially endorsed the *AAT.* At their meeting during the 1982 ARLIS conference, Molholt and Petersen requested further support of AAPC suggesting that the *AAT* might serve as an alternative subject heading authority file in RLIN (RLG's Research Libraries Information Network). AAPC's response was to form a Subcommittee on AAT Implementation which has been working with RLG staff toward this goal since 1984. The *AAT* was mounted as an authority file on RLIN in June 1990. *AAT* records in the MARC Authorities Format will be available as well as the ability to scroll through complete hierarchies.

It was not only endorsements and working groups that influenced the direction of the *Art and Architecture Thesaurus.* The first critique of the project was delivered by Trevor Fawcett in his keynote speech at the International Seminar on Information Problems in Art History at Oxford in 1982, the precursor to the 1984 Pisa Conference. Among his recommendations were that the *AAT* should be highly prescriptive; with detailed instructions for the application of terms; that there be copious scope notes; and that there be a high degree of specificity qualified by clearly stated constraints. He also stressed the importance of having the *AAT* accepted by the major producers of bibliographic records. Prophetically, each of these recommendations has proven to be a necessity. Everyone has asked for greater comprehensiveness in the choice of terms and for definitions and scope notes to lay out clearly the meaning of the terms. Work with test users has emphasized the necessity for training and for guidelines in the use of the *AAT*.

Seeking the acceptance of the major producers of bibliographic records necessitated several years of preparatory work. Although producers of indexing services like the *Avery Index to Architectural Periodicals* and *RILA* have had little problem in adopting the *AAT* (and indeed have been using the terminology in draft form since late 1984), the art library community, which expressed the most dissatisfaction with its existing subject heading list, LCSH, and had expressed the most need for an art and architecture thesaurus, was the least prepared to adopt it. Millions of its records already existed in national bibliographic networks with LCSH headings. Not only would it be difficult to switch to a new subject authority list, but the costs involved in training catalogers and in having to generate more specific headings to describe the contents of books would be considerable.

In the course of mapping the *AAT* into MARC, it became clear that the USMARC Authorities Format would need modifications and the addition of new fields to hold and display hierarchically organized thesauri. The *AAT*, with the support of the AAPC, proposed and successfully shepherded a set of modifications and new fields through the Library of Congress Network Development and Standards Office, and then through the national committee that passes on changes to the MARC format, the MARBI (Machine Readable Bibliographic Information) Committee.

In addition to requiring changes to the MARC Authorities Format, the topical subject field (650) in MARC presented a problem. It was inadequate for coding terms drawn from a faceted thesaurus. This problem was resolved through the implementation of a new subject field (654) for faceted thesauri like that of the *AAT*. The new field was passed by the MARBI committee in January 1988 and allows catalogers to code and identify uniquely each term that is a component of a more complex heading, noting the facets from which the terms come and also coding a "focus" term—i.e., the term that is the main concept of the indexing string. Seen first as a means of solving the problem of enumeration caused by the combining of concepts like styles and object names, the *AAT* arrived at its current faceted structure slowly and with some prodding from classification experts.

Some light on the problem had been shed at meetings in London in 1984 with Jean Aitchison, a British thesaurus expert, and then at a gathering of British librarians and classification experts hosted by the British Architectural Library at the Royal Institute of British Architects (RIBA). British classification theorists have led the way—following S. R. Ranganathan in the 1930s—in the movement toward the classification of knowledge into faceted categories. Facets are seen as homogeneous, mutually exclusive units of information which share characteristics that demonstrate their differences from each other. For example, materials are different from the objects of which they are comprised; each is considered a different facet of information. At the RIBA meeting, the simple alphabetic listing of hierarchies hitherto developed for the *AAT* was roundly criticized. Hurried meetings with some of the attendees at this meeting, especially one or two who had worked with the Bliss Classification System, resulted in a rough arrangement that started with the most abstract concepts and proceeded to hierarchies containing terminology for styles and periods of art, agents, activities, materials, and then object types.

The development of the *AAT's* faceted classification scheme has been continually refined. In 1989, a classification notation was developed that provides a unique code for each term. The code places a term in its facet and hierarchical location and allows for the machine reconstruction of the hierarchy and for automatic explosion of terms for researchers needing to broaden searches.

With pressure building on the *AAT* to distribute its terminology to the many automated database producers (especially slide librarians and archivists, who were badly in need of it), at the end of 1984 it was decided that a small test group of *AAT* users should begin to apply the terminology in their databases. The first seven hierarchies, which were then considered completed in first draft (the Styles and Periods, Drawings, Document Types, and the four architecture hierarchies), were distributed to about twelve organizations that had requested them. By 1989 the test user group had grown to over 150 organizations. It continues to grow at the rate of about five new users per month. This process has had a two-way benefit. Indexing and cataloging organizations in the field of art and architecture which were just beginning to build online databases needed a controlled vocabulary, and the *AAT* needed to find out if the vocabulary it was building was adequate and useful.

In spring 1988, visits were made to over fifty *AAT* users to better understand what kinds of organizations they were, what computer systems they used, and how they were making use of the thesaurus. *AAT* users at this initial phase tended to be those handling architectural and archival information, not surprising given that these sections of the *AAT* were the first constructed. There is an especially strong contingent of archival and visual materials collections among them. Archives and slide and photograph collections have little subject access to their manual systems; they are therefore more open to new thesauri as they begin to automate their collections. The *AAT* has worked with both the Society of American Archivists and with the Visual Resources Association to provide for the special needs of both of these fields in the areas of subject terminology, giving workshops and demonstrations and meeting with groups within these societies to develop particular areas of the thesaurus.

Although *AAT* users employ a wide variety of computer systems, most are microcomputer based. The survey has helped to plan for the types of machine-readable distribution of the *AAT* that will be most desirable and has pointed out that users will need software and training in mounting the thesaurus in their systems.

Through the 1988 survey—and through personal contact with a number of actual and potential *AAT* users—a clear sense of the need to provide guidance and training in the use of controlled subject vocabulary has developed. Guidelines ranging from general rules on subject analysis and term selection to the use of *AAT* terms in complex indexing systems are needed. A series of training workshops that began in 1987 will be expanded to reach all constituents who need such guidance. The *AAT's* primary focus toward its users has tended to be one of openness and flexibility: openness to a variety of information systems and their particular needs and flexibility to change the *AAT* as required by both, the user community and new developments in the field of information science. The *AAT*/user liaison will continue to be an indispensable element of the long-term maintenance and growth of the thesaurus.

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The Image as Document: Descriptive Programs at Rensselaer

JEANNE M. KEEFE

ABSTRACT

THIS ARTICLE CHRONICLES the design, development, and implementation of a MARC-based online cataloging system for visual images. It defines many of the problems encountered during the process and the often unique ways in which attempts were made to solve these dilemmas. It outlines the specific adjustments that needed to be made to accommodate the use of nonbook materials and descriptive language within an existing MARC-based system and how that database was successfully integrated with the library's online catalog for books.

INTRODUCTION

Descriptive terminology, as it applies to architectural spaces and elements, has suffered a long history of subjective interpretation and definition. One person's porch can be another person's portico, just as a column can also be called a pillar depending on the circumstances of its use. For the people who have to use this type of descriptive terminology constantly there is a natural inclination to be as precise as possible without jeopardizing the term's symbolic or historical connections.

This dichotomous situation is especially frustrating to those professionals responsible for the description and interpretation of visual images. The catalogers of large collections of such images usually find it extremely difficult to limit their descriptions to the usual "twenty-five words or less" needed in order to remain within

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the standard confines of catalog and reference cards. Even those collections that have automated their visual image catalogs have, out of necessity, limited their use of descriptive language. By limiting the range and number of possible search terms it naturally follows that potential access to your collections is limited. New technologies have provided the catalogers of visual images the opportunity to test the limits of the use of language within new contexts while at the same time providing the patrons of such collections much broader access to these materials. This article describes the process used to develop the online database for art and architectural slides at Rensselaer Polytechnic Institute.

In 1985, the Rensselaer Architecture Library's Slide Collection used funding from the National Endowment for the Arts to test the applicability of the *Art and Architecture Thesaurus (AAT)* within the context of a working slide library. This coincided with the administration's determination to reorganize and convert the library card catalog to an online public access system and to integrate the slide catalog within it. Several of the questions we were asked to consider during the conversion process were:

—Is *AAT* terminology useful for catalogers and/or patrons?
—What problems are encountered when *AAT* terminology is applied to an established collection?
—What level of expertise is necessary for an indexer or cataloger to use the *AAT* to its fullest extent?
—How much time would be involved in converting a small part of a collection to the online catalog format?

In addition to these questions were several more of our own. This is an account of an evolutionary process and the many problems encountered before final implementation of the system. It is hoped that this account will be of use to those planning to computerize their cataloging systems.

Background Information

The Rensselaer Architecture Library's Slide Collection was established in 1932 and contains approximately 70,000 slides. The collection has increased at an average rate of 6,000 slides per year for the past few years and increased by nearly 10,000 in 1987. Nearly one-third of the collection consists of 3 ¼ × 4 inch glass lantern slides which present problems with regard to storage and projection. Fortunately, many of these lantern slides have been duplicated into a 2 × 2 inch format. Staffing for the Slide Library is limited; there is one full-time Graphics Curator, one half-time temporary research clerk, and two or three part-time student workers. The staff is responsible for all the normal cataloging, reference, circulation, and general housekeeping duties and also for the in-house production of new slides. During the conversion project they also performed all research, worksheet completion, and data-entry associated with the process. The staff is also responsible for collections of architectural drawings, maps, plans, models, microfiche, microfilm, records, and tapes which are anticipated to be included in the online catalog at a future date.

Although the Slide Library is housed within the Architecture Library, it is a separate entity which developed "organically" to support the faculty and curriculum of the School of Architecture. The old classification system was based on medium (architecture, painting, etc.) and filed according to a loose combination of historical, chronological, and geographical determinants. The scheme was changed several times over the years and by 1985 resembled a synthesis of the *Metropolitan Museum of Art* classification listing for periods and styles and the *University of California at Santa Cruz (Tansey)* system for categorizing visual content. Architecture slides were arranged chronologically and fine arts slides were arranged alphabetically by artist's name. Subject areas such as Architectural Design, Architectural Practice, Planning, and Building Construction were given new classification numbers in accordance with the Architecture Library's Vertical Filing System. By 1985, there were over thirty separate subject categories, each with its own distinct classification scheme. Some were arranged alphabetically, others numerically, and still others by subject. Despite the fact that an authority file and card index had been developed and maintained to help the user, slide retrieval became an art form in and of itself and only the most sophisticated patrons could hope to find what they might need in a reasonable amount of time.

Identification of Requirements and Special Problems

Before beginning to give serious consideration to a retrospective conversion of the slide collection, the particular problems requiring correction needed to be identified. By monitoring usage and patron commentary several areas of difficulty quickly became apparent:

—The existing system was extremely limited in its capacity to accommodate new or expanded subject areas. If catalogers wanted to integrate new material into the existing system, they would have to *force* it into the beginning of an existing subject or style area—i.e., a slide of a Viking fishing village would be forced to fit between English Norman and Gothic.

—The system was not designed to accommodate particular nonwestern and technological subject areas needed to support the changing curriculum of the School of Architecture.
—The existing catalog suffered from severe fragmentation in some very important architectural subject areas. One particular building (e.g., St. Peter's in Rome) could be found listed and stored in as many as nine different categories ranging from Early Christian through 20th Century to Architectural Practice and Maps.
—Most importantly, there had never been a professional curator or librarian in the Slide Library and this situation resulted in inconsistent and sometimes erroneous cataloging.

User complaints centered upon the lack of thorough cross referencing, difficulty in browsing because both sizes of slides were filed in the same drawer, and the extensive search time required to retrieve the needed slides because of the dispersion and fragmentation of subject areas. These and other less immediately obvious problems demanded attention during the development of a new system.

The identification of specific requirements and considerations was the second area to be explored. The main purpose of the project was to develop and implement a system that would serve patrons more effectively and efficiently. If it also made the curator's duties less complicated, all the better. Several distinct areas of consideration were identified:

—A new call number system had to be devised which would allow the entire collection to be integrated into only three distinct headings (architecture, fine arts, and generic subjects/reference examples) and yet be flexible enough to accommodate new or different subject areas within that framework.
—Cataloging practices and descriptive terminology should be standardized to the greatest extent possible to improve consistency. Extensive cross-referencing was needed to improve retrieval time so that a topical lecture on daylighting, for example, or a survey of bridges, might be compiled quickly and efficiently without the patron having to know the names or locations of specific subjects.
—New subject areas needed to be developed to meet the changing demands of not only the faculty of the School of Architecture but also patrons from other curricula and from those outside of the Rensselaer community as well.
—Labor saving devices should be built into the system to whatever extent possible. Particular attention needed to be given to the automatic printing of slide labels and accession cards, and to future compatibility with videodisc technologies.

In order to accommodate these special considerations, the material had to be approached in an entirely different way.

Conventionally, art and architecture slides have been viewed and cataloged as surrogates for works of art. Compositions have focal points and those focal points become the primary subjects described by the cataloger. It appeared, however, that it would be more appropriate to view a slide as a document similar to a manuscript which contains more information than just the title page and author.

Remaining true to the old adage "A picture is worth a thousand words," we set out to prove it. This was accomplished through various means but primarily through visual interpretation and extensive research. By projecting the particular slide being described, the cataloger would constantly scan the image while reading descriptions of the building found in books and journals. This dual process helped the cataloger expand the record past the obvious characteristics and elements to such areas as the types of materials used, site orientation, and stylistic nuances. This extensive use of descriptive vocabulary provided the user with greater access. While the title (Sydney Opera House) is still the primary denotation, the slide document itself also contains information on a variety of subjects (e.g., Ridge Beams, Glass Curtain Walls, Tiles, Shell Vaults, Precast Concrete Ribs, Concert Halls, etc.). These different references now make that slide available to those patrons needing examples of different types of materials, structures, and/or designs. It means that a slide of a statue in a fifteenth-century Gothic cathedral is now available to the student or professor of Medieval history who needs examples of armor or dress from the Middle Ages. Viewing a slide as a document instead of as a composition significantly increases its usefulness as a visual resource. While cataloging in this manner is time consuming, the major cost is the labor. Since conversion necessitated recataloging all of the slides, it worked to our advantage to do it at that time. We no longer have to catalog additional slides of the same building; they are just added to the existing record. So the labor cost was mostly up front and the savings came later when slides could be added to an existing record.

Since a single slide can now be approached from many subject paths, there is no longer a need to duplicate slides for filing into various subject categories. Ultimately, this will mean a savings in terms of storage space and collection development.

Development

Once needs were identified and the various options reviewed, it was decided to utilize the computer technologies available at Rensselaer. In 1984, the library had instituted an online information system called INFOTRAX to replace the card catalog. The system uses the Stanford Public Information Retrieval System (SPIRES) database management system operating under the Michigan Terminal

System (MTS). The Architecture Library's holdings were included in this system since patrons were already familiar with it. It was important that the slide database be compatible with this existing system to allow for future integration.

As was previously mentioned, it was also the intention to test the usefulness of the *AAT* terminology in a working slide library. The ways in which it was decided to use the *AAT* hierarchies will become clear once the composition of the data entry worksheet is understood. The structure of the *AAT* Styles and Periods hierarchy was used as the basis for devising a new classification system and the entire *AAT* was used as the authority file.

The first worksheet design (see Figure 1) had twenty-one fields that could be easily manipulated to meet data entry, display, and printing requirements and create indexes. After the original worksheet had been completed and tested, we became aware of the new MARC compatible OCLC Audio Visual Media Format and decided to convert to it to make the slide database more compatible with Rensselaer's online information system. This decision required an expanded definition of the fields and subfields.

This redefinition stage was the most difficult and time-consuming step in the entire process. With the generous help of the cataloging department's staff, an attempt was made to match and merge the devised fields in the first worksheet with the fields and subfields defined by MARC. Difficulties arose during this step because the majority of slides in the collection were either purchased before 1935 (lanterns) or locally produced, thereby lacking the bibliographic documentation needed to develop a standardized MARC record. The slides did not fit neatly into the criteria used by MARC to define its fields and subfields. This situation inevitably led to reinterpreting and expanding the MARC field definitions in a very open ended manner. Instead of trying to adhere strictly to the criteria in MARC, we reinterpreted and expanded several of the field definitions to meet particular needs (e.g., architectural slides, which don't usually have a uniform title as paintings do, were put into 245: the Title Statement field and generic/reference titles into field 242: Translation of Title by Cataloging Agency [see Figure 2]).

During the reinterpretation process, it was attempted to predict the direction of the collection's future development. Fields which were not immediately useful were included in anticipation of future need. In deciding to use MARC field codes and definitions, consistency and compatibility were gained; however, some flexibility and a measure of control over our own work process was sacrificed. It also multiplied the number of necessary fields, nearly doubling the size of the worksheet (see Figure 3).

File Designation: AR FA RF Century:__ __ Country__ __ State__ __
Cutter city/artist __ __ __ __-__ Cutter/site __ __ __ __-__
Cutter/title: __ __ __ __-__ view/type __ Acc # of detail __ __ __
Chronological order __ __ __ __

Name of artist / architect ____________________
Title ____________________
Title of part ____________________
Completion dates __ __ __ __ - __ __ __ __
Geographic Location, country or state ____________________
city ____________________
site ____________________
Medium (Fine Arts) ____________________
Dimensions (Fine Arts) ____________________
Main Entry Subject (Reference)____________________
Descriptor terms (to be printed) ____________________

Descriptior terms (not to be printed) ____________________

Title of Slide Set ____________________
Catalog / Accession # ____________________ Dimensions: 2x2" 3¼x4"
Color / B&W In-House Info: Source____________________
Requested By____________ Date____________ Notes ____________

Figure 1. The Rensselaer online system for slides. First worksheet design.

In retrospect, it appears that we may have attempted to undertake too many tasks at once. It simply wasn't possible to second guess the future and provide for every alternative. In order to keep the worksheets logical and useful to both cataloging and data entry personnel, plans for including printing formats for slide labels and accession cards had to be postponed. Whereas the first worksheet was straightforward enough, it was quite collection-specific and would have eventually proven itself to be just another stop-gap solution. However, the worksheet that was eventually created was so complicated it hardly seemed worth the effort.

```
    *= blank line                                                      Page 1

TYPE "G" (slide)  | ;GMT "SLIDES" | :007 PHYSICAL DESC.                 | RECORD (IRN) #
     "o" (kit)    |               |   "**≠HJ (2x2")   ≠db (b&w)         |
     "K" (2-D)    |               |   "**≠HZ (3¼x4")  ≠dc (color)       |
     'R" (3-D)    |               |                   ≠dz (other)"      |

CALL NUMBERS: ARCHITECTURE                          FINE ARTS               GENERIC
;059                                                ;059                    ;059
"**≠d _______ (AAT List 2)  ≠p _____ (Country)      "**≠ffa                 "**≠frf
   ≠far                     ≠r _____ (State)          ≠n_____.__ (Name)       ≠v__________
   ≠g _______ (AAT List 1)  ≠t _____.__ (Title)       ≠t_____.__ (Title)        __________
   ≠L _______ (Site)        ≠v _____ (AAT List 3)     ≠v________ (AAT #4)     (AAT List #5)
   ≠n _______.___ (City)    ≠z _____ (Detail #)       ≠z________ (Detail #)"

PERSONAL NAMES:
;100  Artist-Architect-Designer etc.
"0"≠a ____________________________________________________(Single name)
"1"≠a ____________________________________________________(Last, First)
"2"≠a ________________________ - _________________________(Hyphenated)
   ≠c ___________________(Title)  ≠d______________________(Dates)

;110  Corporation-Partnership-Firm-Organization
"0"≠a ____________________________________________________(Surname, inverted)
"1"≠a ____________________________________________________(Place name)
   ≠b ____________________________________________________(Dept, Agency)
"2"≠a ___________________________________________________"(Corporation name)

;111  Event-Exhibition-Competition-Project
"0"≠a ____________________________________________________(Personal name)
"1"≠a ________________________ , _________________________(Place name)
"2"≠a ____________________________________________________(Type name)
   ≠n _____________(# in a series)  ≠d____________________(Dates)
   ≠c ___________________________________________________"(Site of event)

TITLES:
;240  FINE ARTS TITLES
"01≠a ____________________________________________________(No article)
 02≠a ____________________________________________________(1 letter article)
 03≠a ____________________________________________________(2 letter article)
 04≠a ____________________________________________________(3 letter article)
   ≠p ___________________________________________________"(View or part)
;242  GENERIC-REFERENCE TITLES
"00≠A ____________________________________________________(Subject-Title)
   ≠p ___________________________________________________"(View or part)
;245  ARCHITECTURAL TITLES
"00≠a ____________________________________________________(Slide title)
   ≠p ___________________________________________________"(View or part)

GENERAL FIELD NOTES:
;500  NOTES
"**≠a ____________________________________________________
      ___________________________________________________"

LIBRARY ACTION INFORMATION:
;583
"**≠a _______________(Action needed)  ≠c _________________(Date accessioned)
   ≠n _______________(Requested By)   ≠j _________________(Source of slide)
   ≠k ____________________________________________________(Library notes)
```

Figure 2. Current worksheet design. Data entry worksheet for the slide collection.

It was at this point that a decision was made to abandon the attempt to incorporate a printing format into the layout of the worksheet because it limited each field to a single line of text with space for only thirty-five characters per line. This limitation seemed counterproductive to the goal of trying to include as much information as possible on the worksheets in order to achieve greater access.

An attempt was also made to streamline the worksheet down to its most basic components, purposely leaving out exact field numbers and dagger letters (see Figure 4). These second and third generation worksheets required the cataloger to provide the basic bibliographic information (title, subject, location, descriptors, etc.), while essentially ignoring the delineators of MARC fields and subfields. The correct field delineators were then determined by the curator and added to the worksheet just before data entry. Therefore, someone with less training could fill in the worksheets by copying the information gathered from books, labels, and accession records. Then the curator would check this information for errors and determine and fill in the appropriate field numbers and dagger letters. Using this third version of the worksheet, the conversion of the slide collection was begun in March 1986.

IMPLEMENTATION

The third worksheet had been used for about three months before data entry actually began. The worksheet, as implemented online, was a list of all necessary fields in numeric sequence. It was discovered that it took approximately twenty minutes to enter the record for one slide! It soon became evident that the third worksheet was not very efficient in terms of data entry and we found it necessary to devise yet another. This latest worksheet (see Figure 5) includes all the necessary fields and subfields, thereby making it easier for untrained staff to move between the paper worksheet and the online data entry worksheet. This worksheet may appear to be very complicated and overworked, but it has cut down on both cataloging and data entry errors and it approaches the process in a very straightforward and logical manner.

Since the Slide Library had been designated as a test site for the *AAT*, a device was needed to monitor its usefulness. It was decided to place all of the *AAT* terms in the 650 field and all non-*AAT* terms in field 653. This distinction allowed monitoring of user terminology by means of transaction logs—a nonintrusive way to observe user activity.

Once we became familiar with the various field definitions, filling in the worksheets required less and less time. The initial research required for each separate building or site varied according to available resources. The conversion process was started with the Prehistoric section for two reasons: first, because it was felt the subject would be a good test area as far as research procedures were concerned, and second, because it was one of the smallest sections in the collection and would serve as a good gauge of time requirements. By the time we were ready to convert information on Stonehenge, it became evident that many of the worksheets pertaining to the same site or building contained almost the same information with only minor variations concerning details. At that point photocopies of the first complete worksheet were made and available information such as accession number and view were added to the copied sheets.

```
IRN = 13102;
DATE-ADDED = 02/10/87;
DATE-UPDATED = 05/31/89
TYPE = G;
GMT = SLIDES;
007 = "  ≠hz≠hj≠db≠dc";
059 = "≠d4≠far≠gf≠np232≠pfr≠tp232≠vg";
100 = "1 ≠aGarnier, Jean-Louis-Charles ≠d1825 - 1898";
245 = "00≠aParis Opera House ≠pcutaway perspective";
500 = "  ≠aCeiling painted by Marc Chagall in 1964. Sculptural groups by J.B. Carpeaux";
583 = "  ≠aNone ≠c1986 ≠hlibrary";
590 = "  ≠aC21841/19:FR:P:OH:2
590 = "  ≠a1660/19:FR:P:OH:6 ≠a6136 ≠a6147 ≠a1741 ≠a1662 ≠a1814 ≠a11304 ≠aC15631 ≠a10942";
650 = " 7≠aOpera houses ≠aperspective drawings ≠aBeaux Art ≠Modern European ≠Baroque
revival ≠amosaics ≠aloggias ≠aarcades ≠acaryatids ≠a bird's eye perspectives ≠aaxial
buildings ≠avaulted ceilings ≠aauditoriums ≠aconcert halls ≠a performing arts buildings";
650 = " 7≠astages ≠astaircases ≠astairways ≠astairs ≠amarble ≠aRococo revival ≠domes
≠aorchestras ≠rotundas ≠ametal domes ≠acopper ≠acolonnades ≠avestibules ≠agabled towers
≠afoyers ≠adressing rooms";
651 = " 0≠aParis ≠aFrance";
653 = "  ≠a1862 -1875
        ≠acandelabras ≠achandeliers ≠aescalier d'honneur ≠a gilt ≠agabled flytowers
≠alateral domes ≠alateral pavilions";
740 = "01≠a2x2 in. slides: ≠a2 perspectives (1 in color) ≠a4 exterior views (1 in color)
≠a2 interior views (1 in color). ≠a3x4 in. slides ≠a1 plan ≠a1 section ≠a2 exterior
views  ≠a2 interior views";
```

```
IRN = 13285;
DATE-ADDED = 02/25/87;
DATE-UPDATED = 06/05/89;
TYPE = G;
GMT = SLIDES;
007 = "  ≠hj≠db";
059 = "  ≠d4≠far≠gf≠nv662.1≠pau≠ts822.6≠vg";
100 = "1 ≠aLoos, Adolf ≠d1870 - 1933";
245 = "00≠aSteiner House ≠pview from the garden, an early photograph";
500 = "  ≠aThe facade on St. Veitgasse has been radically tampered with, the original
curved and plated roof has been replaced by a pitched roof. The interior has also been
subjected to substantial alterations";
583 = "  ≠aNone ≠cNovember, 1979 ≠jRowland: A History of the Modern Movement";
590 = "  ≠a21302/20:AU:VI:STH:6
        ≠a14985 ≠a14986 ≠a14987 ≠a14988 ≠a14989 ≠a14990";
650 = " 7≠aArchitect-designed houses ≠adwellings ≠adomestic architecture ≠aresidences
≠aresidential ≠adetached houses ≠aroofs ≠ametal ≠alaminated ≠aflat roofs ≠abalconies
≠awindows ≠aplaster ≠alime mortar";
651 = " 0≠aVienna ≠aAustria ≠aWien";
653 = "  ≠a1910
        ≠acurved roof ≠awood cement ≠abays";
740 = "01≠a1 plan ≠a1 section ≠a1 elevation drawing ≠a3 exterior views ≠a1 interior view";
```

Figure 3. ROCSS Second Worksheet Design.

This decreased the conversion time, especially when a particular subject such as the Caves at Lascaux, France, contained as many as forty slides. The basic information was constant; it was the particulars that needed to be appended. A backlog of data entry resulted from this increase in worksheet production. In addition, the data entry became repetitive and boring because the same information was being entered repeatedly. A way was needed to create copies of the same entry record which could then be modified to contain the particular information pertinent to each individual slide. The systems

---

• = blank space ǂ = dagger Page 2

LIBRARY INFO: 583 ••
Action needed ǂa ______
Dates ǂc ______
Requested By ǂh ______
Source of photo ǂj ______
Notes ǂk ______

OLD ACCESSION AND
CATALOG NUMBERS: 590•• ǂa ______

SUBJECT NAME: 6 ____• ǂa ______
ǂc ______

DESCRIPTORS: 65 __
LC Headings •0ǂa ______
AAT Terminology •7ǂa ______
Geographic Terms •0ǂa ______

FREE FORM TERMS: 653•• ǂa ______
Dates ǂa ____ - ____
Medium ǂa ______
Dimensions ǂa ______
Terminology ǂa ______
______
______

NAMES: 7_ _
Personal _ _ǂa ______
Corporate _ǂa ______
Project _ǂa ______
Dept. ǂb ______
Place, title ǂc ______
Dates ǂd ____ - ____
Number ǂn ______

SETS OF SLIDES; 740 01ǂa ______

Figure 3 (cont.). ROCSS Second Worksheet Design.

analyst created a "clone" command which duplicated a single entry record as many times as was needed. The data entry person would then go into each of these cloned records and change or add the pertinent information that distinguished that particular slide from others with the same title. The next logical step was to stop photocopying the worksheets and just to make out the primary worksheet and fill in only the information on the subsequent sheets that was distinctive from the primary sheet (i.e., different size, color, source, view, etc.). With each of the learning steps, more and more time was cut from the conversion process.

The "Breakthrough"

Once all these implementation problems were successfully identified and solved, the conversion project proceeded at a slow, yet steady, pace. By the end of 1986, two entire architecture sections had been converted, Prehistoric and Egyptian, and we had just begun converting the 20th Century Architecture collection. It had taken two half-time employees almost eight months to convert and enter approximately 1,300 slides. At that rate it would take fifteen years to convert the entire collection! The National Endowment for the Arts Grant was due to end in February 1987, and at that point we would lose all temporary staff. It was impossible to imagine ever being able to continue, let alone finish, this conversion to an online database. A new strategy was needed.

As we mulled over this problem, it became apparent that one very important factor had been ignored: a computer display or printout would never replace the visual image itself. Since patrons were actually looking for visual images, they would never choose to use a slide based on a written record alone. The online record was simply a step in the process; users would always go to the drawers and pull out the slides to see if they were the images needed. If they were looking for a plan or a cross-section of the Crystal Cathedral by Philip Johnson, all they really wanted to know was whether one was available, and, if so, where it was located. Since all the slides of the Crystal Cathedral are stored together under the same call number and in view sequence, all that was necessary was to treat all slides with the same title as a set. This idea proved to be our "breakthrough."

The solution was to have only one entry record per set or group of slides relating to a building or a work of art. That record contains all the appropriate information pertaining to the building, the accession numbers of the slides in the set, and a holdings listing of the different views contained in that set (see Figure 6). As new slides are added to the set or damaged ones removed, all that is necessary is to update one record by adding the new information to those two fields.

As a result of this change in approach, instead of having to store 70,000+ records, we actually only have to store about 25,000 records. Searching can be greatly simplified because the patron needs only to find one record for the Sydney Opera House instead of fifty, and that one record contains all the necessary information needed to decide if it is worth looking in the cabinets at all. If the record indicates that the holdings on that particular subject are limited to one exterior view and two details and the patron needs a plan, they then know not to bother going to the slide drawers. Also, the sections cataloged first (Prehistoric and Egyptian) using the clone method, have now been collapsed into sets in order to maintain record format consistency throughout the entire database.

The Public Display

Rensselaer's INFOTRAX information system is an integrated set of databases which provides information about the types of resources available at both the Folsom and Architecture Libraries. The catalog database contains a general listing of books, Rensselaer theses, art prints, cassettes, phonograph records, and audiovisual items. The journal database lists journal titles and information on the volumes and inclusive years held by the library. The orders database lists materials on order and materials received but not as yet cataloged.

The homework database contains uncataloged material such as homework answers, lecture notes, and practice exams for many classes. The IEEE database lists abstracts as well as journal articles and conference papers from the Institute of Electrical and Electronic Engineers. This database also lists some materials not owned by the library. INFOTRAX also contains message and news databases.

INFOTRAX was designed in such a way that all fields and subfields are searchable in data entry mode, the mode used to input the worksheets. By using the simple "Find" command, the staff can search fields not available to the patron such as *medium, action needed* (the condition of the slide), *IRN number* (record number), *requestor* (name of person who requested that the slide be purchased or produced), or *source* (the source from which the slide was purchased or produced).

The public can search the database in several ways. Slides may be searched and identified by title or subject, name, geographic location, accession number, call number, date of completion, source and/or descriptors (both *AAT* and non-*AAT*). SPIRES allows the user to search by single words or strings of words. The user begins a search with the command Find.... The search can be expanded with the word OR and narrowed with the word AND. By combining several search terms together (i.e., "FIND subject houses BY Frank Lloyd Wright AND Pennsylvania"), the patrons can very quickly sort out exactly what they need.

CALL NUMBER	Printed on slide label	
059 ≠e	File designation: ____	
≠d	Geographic area: ____	(Pick A-J from AAT Listing # 1)
	Period / Century: ____	(Pick from AAT Styles & Periods List)
≠g	Country: ____ ____	(Pick from OCLC Country Codes List)
≠r	State: ____ ____	
≠n	Cutter # city or artist's name:__ __ __ __ __	
≠t	Cutter # for title: __ __ __ __	
≠v	View or type: ____	(Letter taken from Listing # 3)
≠z	Acc.# of detail: ________	(Numbers 1-10 of different details)
NAMES		
1__ __ 00≠a	Name of artist or achitect: ____________	
10≠a	Corporate names: ____________	
11≠a	Competition / Exhibition: ____________	
≠d	Dates: ____ - ____	
TITLES		
24__ 0 ≠a	Published title:____________	
2 ≠a	Building name/title:____________	
5 ≠p	Reference/Generic title: ____________	
TERMS		
6__ __ 7 ≠a	AAT descriptive terms: ____________	
	Dates of Production: ______ - ______	
GEOGRAPHIC		
651 0≠a	Country, state, city and site: ____________	
	Medium:____________	
	Dimensions of work: ____________	
LOCAL USE		
590 ≠a	Accession # ________	Old Catalog # ________

Figure 4. ROCSS Third Worksheet Design

SUBJECT ENTRIES	Not Printed on slide label
6__ __ ≠a	Subject of the Work: ______________________
0*≠a	LC Headings: ______________________
*7≠a	AAT Terminology: ______________________
	______________________
	______________________
653 **≠a	Free Form Terms: ______________________
	______________________
	______________________
ASSOCIATED NAMES	
7__ __ ≠a	Persons, Firms & Events: ______________________
≠c	Person's Title: ______________________
≠d	Dates: _____ - _____
SLIDE SETS	
740 ≠a	Title of set: ______________________
MATERIAL	
007 ≠h	Dimensions: ___ x ___
≠c	Color or B&W _______
LIBRARY INFO	
583 ≠j	Source of the photo: ______________________
≠a	Type of action needed: ______________________
≠h	Requested by: ______________________
≠c	Date: ______________________
≠k	Notes: ______________________

Figure 4 (cont.). ROCSS Third Worksheet Design

```
■ LOCAL USE NUMBERS
  ;590  CATALOG AND ACCESSION NUMBERS
  "**ǂa ____________________ / _____________________(Accession/Catalog #s)
     ǂa ___________________________________________(List of Acc. numbers
        ___________________________________________"    in the slide set)

■ SUBJECT ENTRIES
  ;600  SUBJECT OF THE WORK OF ART OR PHOTOGRAPH
  "0*ǂa ___________________________________________(Single Name)
  "1*ǂa ____________________ , _____________________(Last, First)
  "2*ǂa ____________________ - _____________________(Hyphenated)
     ǂc __________________________________________"(Title)
■ ;650  LIBRARY OF CONGRESS SUBJECT HEADINGS FOR GENERIC SLIDES
  "-0ǂa __________________________________________"
■ ;650  ART AND ARCHITECTURE THESAURUS TERMINOLOGY
  "*7ǂa ___________________________________________(Primary AAT Terms)
     ǂa ___________________________________________________________
     ǂa ___________________________________________________________
     ǂa ___________________________________________________________
     ǂa ___________________________________________________________
     ǂa ___________________________________________________________
     ǂa _____________________________________________"(Style and Period)
■ ;651  GEOGRAPHIC TERMS
  "*0ǂa _____________(Site) ǂa __________ (City) ǂa _______(State or Province)
     ǂa ______________________ (Country) ǂa _____________"(Alternate spellings)
■ ;653  NON-AAT TERMS, FREE-FORM TERMS AND DESCRIPTORS
  "**ǂa___________________________________________________________
     ǂa ___________________________________________________________
     ǂa ___________________________________________________________
     ǂa ___________________(Medium) ǂa ___________________(Dimensions of work)
     ǂa ______________________"(Dates of Production, Manufacture or Construction)

■ ASSOCIATED NAMES
  ;700  ASSOCIATED ARCHITECTS, ARTISTS, DESIGNERS, PERSON'S NAMES
  "0*ǂa ___________________________________________(Single name)
  "1*ǂa ____________________ , _____________________(First, Last)
  "2*ǂa ____________________ - _____________________(Hyphenated)
     ǂc _______________(Title) ǂd ______________________"(Dates)
■ ;710  ASSOCIATED CORPORATION-PARTNERSHIP-FIRM-ORGANIZATION
  "0*ǂa ___________________________________________(Personal Names)
  "1*ǂa _____________(Place name) ǂb ______________________(Dept or Agency)
  "2*ǂa __________________________________________"(Corporation name)
■ ;711  ASSOCIATED EVENT-EXHIBITION-COMPETITION-PROJECT
  "0*ǂa ___________________________________________(Personal Names)
  "1*ǂa ___________________________________________(Place Name)
  "2*ǂa _____________(Type name) ǂd ______________________(Dates)
     ǂn __________(# in a series) ǂc _____________________"(Site of event)

■ HOLDINGS - SETS OF SLIDES
  ;740  DIFFERENT VIEWS, NUMBER IN EACH SET
  "01ǂa _____(Plans) ǂa _____(Sections) ǂa _____(Drawings) ǂa _____(Aerial views)
     ǂa _____(Exterior views) ǂa _____(Interior views) ǂa _____(Details) ǂa_____(Gardens)
     ǂa _____(Paintings) ǂa_________(Furnishings and Utilitarian items)"
```

Figure 5. Current Worksheet Design. Data Entry Worksheet for the Slide Collection

The visual display format for the public mirrors that used in the general information system:

—The BRIEF command displays Title, Architect/Artist, and Site on one line.

```
LOCAL USE NUMBERS
;590  CATALOG AND ACCESSION NUMBERS
"**ǂa ____________________ / ______________________(Accession/Catalog #s)
   ǂa _____________________________________________(List of Acc. numbers
      _____________________________________________"   in the slide set)

SUBJECT ENTRIES
;600  SUBJECT OF THE WORK OF ART OR PHOTOGRAPH
"0*ǂa _____________________________________________(Single Name)
"1*ǂa ____________________ , ______________________(Last, First)
"2*ǂa ____________________ - ______________________(Hyphenated)
   ǂc _____________________________________________"(Title)

;650  LIBRARY OF CONGRESS SUBJECT HEADINGS FOR GENERIC SLIDES
"*0ǂa _____________________________________________"

;650  ART AND ARCHITECTURE THESAURUS TERMINOLOGY
"*7ǂa _____________________________________________(Primary AAT Terms)
   ǂa ____________________________________________________________
   ǂa ____________________________________________________________
   ǂa ____________________________________________________________
   ǂa ____________________________________________________________
   ǂa ____________________________________________________________
   ǂa ________________________________________________"(Style and Period)

;651  GEOGRAPHIC TERMS
"*0ǂa ______________(Site) ǂa ____________ (City) ǂa ________(State or Province)
   ǂa _______________________ (Country) ǂa _____________"(Alternate spellings)

;653  NON-AAT TERMS, FREE-FORM TERMS AND DESCRIPTORS
"**ǂa ____________________________________________________________
   ǂa ____________________________________________________________
   ǂa ____________________________________________________________
   ǂa ___________________(Medium) ǂa _____________________(Dimensions of work)
   ǂa _________________________"(Dates of Production, Manufacture or Construction)

ASSOCIATED NAMES
;700  ASSOCIATED ARCHITECTS, ARTISTS, DESIGNERS, PERSON'S NAMES
"0*ǂa _________________________________________________(Single name)
"1*ǂa ______________________ , ________________________(First, Last)
"2*ǂa ______________________ - ________________________(Hyphenated)
   ǂc ________________(Title)  ǂd ______________________"(Dates)

;710  ASSOCIATED CORPORATION-PARTNERSHIP-FIRM-ORGANIZATION
"0*ǂa _________________________________________________(Personal Names)
"1*ǂa _____________(Place name) ǂb ____________________(Dept or Agency)
"2*ǂa _________________________________________________"(Corporation name)

;711  ASSOCIATED EVENT-EXHIBITION-COMPETITION-PROJECT
"0*ǂa _________________________________________________(Personal Names)
"1*ǂa _________________________________________________(Place Name)
"2*ǂa _____________(Type name) ǂd _____________________(Dates)
   ǂn ___________(# in a series) ǂc ____________________"(Site of event)

HOLDINGS - SETS OF SLIDES
;740  DIFFERENT VIEWS, NUMBER IN EACH SET
"01ǂa _____(Plans) ǂa _____(Sections) ǂa _____(Drawings) ǂa _____(Aerial views)
   ǂa _____(Exterior views) ǂa _____(Interior views) ǂa _____(Details) ǂa _____(Gardens)
   ǂa _____(Paintings)  ǂa _________(Furnishings and Utilitarian items)"
```

Figure 5 (cont.). Current Worksheet Design. Data Entry Worksheet for the Slide Collection

—The CALL and PRINT commands display and print the above information given in the BRIEF format plus the accession number, original call number (necessary until new call numbers have been assigned), and the size of the slide.

—The DETAIL command gives all of the above CALL command

= blank space   ≠ = dagger   Page 1

Material Type ** ____   GMT **Slides

Dimensions 007**≠ __ __   Color ≠__ __

CALL NUMBERS: 059

ARCHITECTURE		FINE ARTS	
Period	**≠d __	File	**≠ffa
File	≠far	Artist	≠n __ __ __ __.__
Area	≠g __	Title	≠t __ __ __ __.__
Site	≠L __ __ __ __.__	Type of Work	≠v __
City	≠n __ __ __ __.__	Detail #	≠z __ __
Country	≠p __ __ __		
State	≠r __ __		
Title	≠t __ __ __ __.__	GENERIC / REFERENCE SLIDES	
View	≠v __	File	**≠frf
Detail	≠z __ __	Category	≠v __ __

NAMES: 1 __ __

Artist, Architects	__ *≠ __	____________
Firm, Place, Event		____________
Exhibition, Competition:		
Department	≠b	____________
Place Held, Title	≠c	____________
Year, Dates	≠d	______
Number	≠n	______

TITLES: 24 __ 0

Architecture or Generic / Reference	00≠a	____________
	≠p	____________
Fine Arts Slides	0_≠a	____________
	≠p	____________

Figure 6. Catalog Entry Samples

information plus a truncated listing of the subject/descriptor fields, dates, notes and a list of current holdings in the set (see Figure 7).

Changes to the public display format can be made as feedback is received from patrons on what other information they would like to see displayed.

```
   TITLE :  Sydney Opera House; post-1945, aerial view
      BY :  Utzon, Jørn
 SUBJECT :  Opera houses, auditoria, auditoriums, ceremic tiles, performing arts
               buildings, concrete halls, music halls, music auditoria, symphony
               halls, movie theaters, theatres, cinemas, restaurant,  ribbed vaults,
               ribbed arches
            concrete beams, concrete paint, podium, roof trusses, roofing, roofing
               tile, ribs, vaulted roofs, shell roofs, reinforced concrete, lattice
               roofs, shell structures, shell vaults, towers, steel trusses,
               ceremonial ways
            workspaces, workshops, wood walls, wood ceiling, wooden ceilings,
               concrete vaults, concrete structures, concrete pilings, concrete
               joints, glass, glass walls, laminated materials, cables, cable roofs,
               cable-stayed structures, ridge boards, precast concrete, granite,
            granite powder cement, bronze window mullions, ridge beams
    SITE :  Australia, Sydney, New South Wales, Benelong Point
   DATES :  1957 - 1973
    SIZE :  2x2 in. color
HOLDINGS :  3 plans, 11 sections/drawings, 2 aerial views, 29 exterior views,
               3 interior views, 3 details
 CALL NO :  20:AUS:SY:SOH:6
```

```
   TITLE :  The Crystal Cathedral, Garden Grove Community Church: General view,
               exterior.
      BY :  Johnson, Philip
            Johnson / Burgee
 SUBJECT :  Glass, buildings, glass doors, glass roofs, glass windows, glass walls,
               curtain walls, non-bearing walls, enclosure walls, window walls,
               heat-resisting glass, space frames, gussets, web members
            plates, structural frames, steel trusses, chords, pipe, concrete,
               concrete columns, concrete pilings, mechanically operated doors,
               horizontal sliding doors, girders, marble pools, fountains,
            clerestories, porticoes, space trusses, hangar doors, neo-fundamentalist
               church architecture
    SITE :  United States, Garden Grove, California, USA
   DATES :  1983
    SIZE :  2x2 in b&w, color
HOLDINGS :  1 plan, 1 section, 1 aerial view, 6 exterior views (4 in color),
               3 interior views (2 in color)
   NOTES :  Designed for the Reverend Dr. Robert Schuller
 CALL NO :  20:US:CA:GA:CC:6
```

Figure 7. Detail Display Samples

Future Considerations

Rensselaer's Slide System is still not complete. A series of "fine tuning" changes will continue to be made as new problems surface and more refined technologies come into use. As soon as it is economically feasible, the database will be linked to a videodisc of the slide images. This link will allow patrons to scan the videodisc for needed images instead of searching through slide drawers. This will also cut down on slide handling, refiling, breakage, and general wear and tear on the collection.

The use of videodiscs will eliminate the need for a call number altogether and will allow the slides to be filed in accession number order. This also solves storage problems because new slides would be added to the end of the collection and not interfiled as they are now, resulting in the constant shifting and reordering of drawers.

The idea of cataloging a series of same-subject slides as sets has proved to be a significant time-saving device. It does not hamper the patron's ability to retrieve relevant material while at the same time it saves considerable time inputting and updating records. It serves as an optimal compromise. The set method of cataloging has precedent in both the cataloging of monographs under a series entry and the cataloging of sets of records by archivists. By extension, one can even view the cataloging of a monograph as a single record representing a collection of chapters and sections on a single topic. Museums have long used this approach in cataloging items such as sets of dishes, jewelry, silverware, and dresser sets. Using the set method of cataloging puts online conversion within reach of those slide libraries with staff and/or budgetary restrictions.

Conclusion

In response to the questions posed at the beginning of this article, the following is a summary of the conclusions arrived at during the process of developing the *Rensselaer Online Cataloging System for Slides (ROCSS).*

—Was *AAT* terminology useful for catalogers and/or patrons?

The catalogers found the terminology to be very useful, especially the Styles and Periods hierarchy. Any attempt at standardization of terminology in that area is bound to be helpful. The further breakdown by culture and reign is especially helpful in categorizing those historical periods in which several distinctive styles are in evidence during the same period. It also serves as the authority file and as a comprehensive guide for cross-referencing terminology. The *AAT* leads both the cataloger and the patron to terms they would have never thought of using previously. It details particular components in such a way that there can be little room for confusion. Since the database has been available to the public, there has been a positive response from patrons, especially those interested in less-specific subjects such as lighting techniques, construction methods, and stylistic revivals. The use of *AAT* descriptors now allows these users to pull together materials on these subjects quite quickly; it also gives them access to the most recent additions to the collection. Slides produced for a lecture on *sitecast concrete* are now easily retrievable for the patron looking for slides that illustrate different methods of construction. These options are invaluable to patrons using a collection that is classified according to historical periods or artistic styles.

—What were the problems encountered in applying *AAT* terminology to an established collection?

We did not encounter any problems applying the terminology itself. The problems were with learning to deal with the draft printouts of the *AAT* effectively, because each of the twenty-two completed hierarchies had to be searched individually. Until the *AAT* publishes a cumulative cross-referenced alphabetical listing, we may continue to miss a good deal of the appropriate terminology.

—What level of expertise is necessary in order for an indexer or cataloger to use the *AAT* to its fullest extent?

A basic knowledge of art and architectural history and good clerical and research skills are necessary. Undergraduate level coursework in Classical, European, and American history is also very helpful. An initial training period of at least three months was needed before the acceptable level of competence and efficiency was reached. This training period might be shortened if the indexer has had previous cataloging experience, a broad knowledge of art and architectural history, basic familiarity with Latin and other Romance languages, and training in basic logic and critical thinking.

—How much time would be involved in converting a small part of a collection?

After the training period was completed and while still making out one worksheet per slide, it took two half-time employees (or one full-time employee) approximately one month to complete 250 worksheets and enter them into the database. That means that we researched, recataloged, and entered 1.5 slides every hour. The breakdown averaged twenty-seven minutes per worksheet and about ten minutes for data entry. If you were converting a small collection, it would take one full-time employee approximately three and one-half years to complete 10,000 slides. It would take nearly seventeen years to convert 50,000 slides.

After the decision to recatalog sets of slides, it took two half-time employees (or one full-time) one month to research and recatalog approximately 520 slides and enter the same number into the database. At this present rate it will take less than two years to complete 10,000 slides or eight years to convert 50,000 (divide that time by two for every added full-time employee). The major advantage is that once a subject area has been converted, no extra worksheets are needed for additional slides. The existing record is updated by adding the new accession number and any different descriptive terminology that might apply. Worksheets and data entry would only be necessary for new titles or subject areas.

The larger the slide collection the greater the need for an online database. In the three years of the project we have come to appreciate how much less "busy" work needs to be done to keep records up-to-date. Now when a slide is added to the collection, we first check to see if a record for that title already exists in the database. If it does then all we need to do is add the accession number and particular view to the existing record. The majority of new accessions every year are different or better views of existing sets. Once the entire conversion is completed, the time it takes to process a slide and add it to the collection will be cut by 75 percent. Of course worksheets will still have to be completed for new titles, but it is anticipated that these additions will be limited to selected contemporary buildings and works of art. When we eventually devise a format for printing the slide labels and accession cards from online records, we will then be able to significantly reduce that processing time.

Summary

A visual image is a document without literary text. The text is there; it is being translated through our eyes and intellect even as the image is being viewed. Judgments are being made, questions asked, and emotions felt. However, oftentimes the viewers are not fully aware of the processing taking place inside their own minds. A cataloger cannot hope to cover all the personal interpretations or supply all the possible terms by which a particular image can be described by a user, but with the help of current technologies at least greater accommodation can be made. This is certainly a case where more is better than less. Technology is often blamed for limiting personal expression by restricting vocabulary; this may be one of the few instances where it has helped to expand our use of language within the context of an online catalog.

There is much concern about the consistency and standardization of descriptive terminology. However, these concerns should not put unnecessary restrictions on our ability to comprehensively catalog unpublished nonbook materials, thereby limiting the users' access to that material. Nonpublished materials such as slides that are generated in-house and are very subject specific (e.g., the Empire State Building) are very difficult to catalog using MARC without some open interpretation of the field definitions. With the Rensselaer Slide System, it was decided to give up some standardization in order to ensure greater access and we consider this a fair tradeoff.

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Automated Access to the NASA-JSC Image Archives

GARY A. SELOFF

ABSTRACT

THE FILM ARCHIVES at NASA's Johnson Space Center in Houston, Texas, houses the still-frame and motion picture documentation of the U.S. Manned Space Flight Program. While few people would have difficulty recognizing the milestone images stored here, the majority of the collection serves a variety of very specific interests. Access to these images has long suffered from limited intellectual control, but currently an effort is underway to remedy this situation. This article will provide background information on the recent state of the Film Archives and will discuss the goals and methodology of the effort to establish intellectual control over the storage and retrieval of images in this collection.

INTRODUCTION

Prior to, and particularly following, the explosion of the space shuttle, Challenger, in January 1986, it had become apparent throughout the National Aeronautics and Space Administration (NASA) that its visual archives were growing out of control. The instant and urgent requirement for all relevant comparative material to the Challenger launch sequence and the failed booster rocket could not be adequately met by the manual retrieval systems highly dependent on the corporate memories of a few dedicated individuals. Image collections, once manageable, had become large and unwieldy.

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The call for a new, automated approach to image management—a space-age solution—was one of the many remedies identified in the analysis of this country's worst space-age disaster.

Since 1986, solutions to the agency-wide problems of image access have been approached mostly piecemeal on a center by center basis. Several facilities quickly purchased off-the-shelf technology, gambling that it could be developed into long-term solutions. At the Lyndon B. Johnson Space Center (JSC) in Houston, Texas—the primary location of the collection of manned space flight imagery—the administration opted to study various strategies in the hopes that a universal solution would emerge.

The automation goals for the JSC film repository are: (1) to provide a standardized method for computer-assisted description and retrieval of visual materials, incorporating the wealth of corporate knowledge of the collection; (2) to create a system less labor-intensive than the manual precursor; and (3) to provide center-wide availability to electronic text and image records, accessible to knowledgeable staff members and novice end-users alike. This article describes the JSC film repository, the development of its automation strategy, and the implementation to date of its automated procedures for image access.

Description of the Collection

The JSC Film Repository houses a collection of more than 1 million negatives and transparencies, as well as around 10,000 motion picture and audio reels, documenting all aspects of the manned space flight program in this country since 1958. It is administered by TGS Technology, Inc., for NASA-JSC's Photography and Television Technology Division (PTTD). Materials archived in the repository are received from a range of sources including actual manned space flight missions, various NASA-JSC divisions, NASA contractors, other NASA centers, and other government agencies. While few people would have difficulty identifying the milestone images stored here, the majority of the images are of very limited or narrow interest. In addition to the widely disseminated space flight views, there is a broad range of subjects such as engineering studies, lunar rock samples, earth observation views, employee award ceremonies and activities, JSC facilities, distinguished visitors, astronaut portraits and astronaut training, manufacturing close-out photography, etc. New images are received at a rate of 25,000 to 65,000 per year depending on the number and nature of missions flown. Film formats include negatives and transparencies, color and black and white, in sizes ranging from 16mm to 8 × 10 inch viewgraphs to 9 inch wide rolls.

While the repository is a circulating collection—items circulate primarily to three on-site photographic labs operated by TGS Technology—it is not a browsing collection. Items are physically organized in large, rotating power files, strictly in numerical sequence by accession number, with no subject grouping. Images are cataloged according to two basic systems. On-board flight images (most of which are earth observations) are described by photographic interpreters using a very terse vocabulary and a relatively sparse format denoting latitude, longitude, altitude, date and time, and a brief reference to geographic locations or features. The resulting scene lists are indexed and published in single volumes by mission.

Nonflight images are initially described in the photographic work order which directs the photographer in acquiring images. After the processed negatives are sent to the film repository, catalogers follow several steps to gather more information, beginning with a visual inspection of each image, a review of related image descriptions, and contact with the requester of the image. A catalog entry is then created which includes the accession number, acquisition date, a physical description of the film type and format, key filing and cross-reference categories, and a free-form textual description of the participants and activities depicted in the scene. As recently as mid-1987, sets of cards were then manually produced and filed in an alphabetical cross-referenced card file system. (This was the first task to be automated utilizing a microcomputer and a traditional database management system.)

The Public Affairs Office (PAO), which is the liaison office between JSC and the general public, including the news media, is the largest requestor of repository images. A majority of their requests to the repository directly reference the image accession number; however, roughly one-third of the requests being made by PAO require research assistance to locate an appropriate subject. In addition, a number of requests from other sources are also received with only varying degrees of content description to indicate the desired image.

Prior to the implementation of automated systems in the summer of 1987, all requests were met through manual methods based on the 100,000 item catalog card file and the expertise of one long-time cataloger. Considering the number of requests and the size of the manual card file, the success rate in locating appropriate images was quite high; however, so was the response time as well as the cost per located image.

STATE OF THE QUESTION

With the growing number of images and catalog cards, and with the inevitable retirement of the expert cataloger looming in the future, the manual image management system was near collapse. Serious dialogue regarding automated image retrieval systems was initiated at JSC in late July 1986 with a call for a working prototype by mid-October. That schedule proved a bit ambitious: more than three years later, the system is only now becoming a reality. In the interim, countless meetings and planning sessions, proposals, demonstrations, conferences, seminars, and small-scale projects served to educate and inform a group of image-user representatives from around the center. This group coalesced to form an ad hoc steering committee to pursue automation goals.

Expert assistance has come from the academic world at several junctures. In December 1986, an agency-wide laserdisc symposium was held in Boston with invited speakers from MIT and Simmons College, among others. A consulting team from these two schools was subsequently selected by the Photography and Television Technology Division at JSC to do a feasibility study for the implementation of an electronic visual database system. The follow-up report to the consultants' intensive two-day visit to JSC in January 1987 served to crystallize the ideas and tentative plans of the ad hoc committee. The recommendations laid out in that report clearly emphasized intellectual considerations (classification and indexing schemes) over technical considerations (hardware) as a critical factor determining flexibility for the widest range of end users. The report suggested the hiring of a consulting information expert, the development of a hierarchical thesaurus of space-related terminology, and a thorough needs assessment as practical first steps prior to actual hardware and software selection.

A poll of various potential users of an electronic image retrieval system at JSC revealed a broad interest in such a system with emphasis on image transmission to various locations and the ability to matrix multiple images on a single display screen for comparison. Projects with similar scope and retrieval criteria were currently under development at MIT (Project Athena), and The University of California at Berkeley (ImageNet). Work in progress at each center demonstrated that the technical capability to manage images in the desired manner was available, if not yet cost effective. However, there was no evidence that an innovative and effective new method for describing and retrieving images had evolved.

The inherent problem of image retrieval within many visual archives—including the NASA-JSC film repository—is both the sparsity and inconsistency of textual descriptors evoked by the visual content of the image. In the JSC film repository, where the cataloging has been done for over a decade by one competent individual, similar images separated by time can vary widely in their textual description. Partly, this can be attributed to evolving vocabulary as programs within the agency mature, but primarily it is due to the highly subjective nature of the task of describing image content. The viewpoint of the cataloger invariably changes from one week to the next and is always different from the perspective of the engineer or the scientist. To locate an item in such a system, the desired image must evoke at least a subset of the descriptors assigned by the cataloger. The wider the disparity in the points of view (for example, the engineer requests an image of a misaligned mounting bracket on a flight hardware subassembly which only exists as an image described by a cataloger as astronaut training aboard the zero-gravity aircraft), the less likely the appropriate item will be retrieved.

Projects under the auspices of the Getty Center (*Art and Architecture Thesaurus*) and the Library of Congress (*MARC for Visual Materials*) evidence a recognized need for standards in image description, but no current system was available for uniformly classifying space-related images or for providing an appropriate retrieval interface for the variety of potential users at JSC. Again, support was enlisted from the academic world with the award of a grant to fund an unsolicited proposal from the Graduate School of Library and Information Science at The University of Texas at Austin. This proposal to design and develop an automated image management system for the JSC archives was based on prior research undertaken through Project Icon at the University of Texas, directed by Mark Rorvig. (Project Icon team members involved with the NASA Visual Thesaurus project, working under the direction of Mark E. Rorvig, include Chris Ladoulis, David McClelland, Jesus Moncada, Richard Reed, Jeff Skaistis, Charles Hudson Turner, and Charles Young.)

Like the projects at MIT and Berkeley, Project Icon is directed toward the automation of image management for academic applications, but its primary focus is on automation of image description and retrieval processes. Part of the experimental work undertaken in the Project Icon lab sought to demonstrate the substitutability of images themselves for the textual descriptions of images in an image retrieval system (Rorvig, 1987). This line of experimentation led to the idea of a "visual thesaurus" as an aid to catalogers and researchers of visual materials, much as a traditional thesaurus is used in textual retrieval systems. While the pragmatists on the ad hoc committee at NASA felt somewhat uncomfortable with some of the theoretical elements of this approach, it presented a relatively low-cost alternative to unproven multimillion dollar turnkey systems from commercial vendors.

IMPLEMENTATION

Meetings between the Project Icon team and the JSC image retrieval committee established the priorities and goals for the automated image retrieval project for the first two years of the grant. Highest on the list was the development of a hierarchical thesaurus tailored to the users of JSC imagery. Once developed, the thesaurus would be incorporated into an easy-to-use, intuitive, system-independent interface. Then, selection would begin for the assembly of hardware and software system components.

For much of the first year, thesaurus development was an all consuming task. Considerable effort was expended to develop or convert algorithms for the automation of the thesaurus term selection processes, based on the work of Gerard Salton (1968). The working vocabulary for this task was drawn from 5,000 randomly selected and machine-scanned cards from the JSC film repository catalog card file (representing twenty years worth of cataloging activity), 5,000 records from a recently implemented computer-based version of the film repository catalog card file, and 4,000 word-processor documents (image descriptions) from the JSC Public Affairs Office.

Some half million terms were processed to derive occurrence counts for each unique term to eliminate noise words (e.g., of, and, the) and to discount terms occurring too frequently or infrequently to be significant. From this analysis, each document was identified by the significant terms it contained, and a term-document matrix was generated. By cross checking each term by each document in the matrix, a coefficient was assigned to all term-pair combinations based on the frequency of co-occurrence of the terms within the documents (McClelland, 1988). Those pairs with coefficients above a set threshold were selected as related terms for the thesaurus. The list of terms and term-pairs was then reviewed manually by a team of four collection administrators and catalogers to delete irrelevant terms and related pairs, and to assign hierarchical relationships. The resulting substantially reduced set of terms and related pairs was then enriched by massaging this list against the much larger *NASA Thesaurus* (1985) of scientific and technical terms to derive additional appropriate related terms from that extensive source.

While work on the thesaurus proceeded, a parallel effort was established to create the user interface incorporating the concept of a visual thesaurus. Acknowledging the progress of the construction of the term thesaurus, the Project Icon team still expressed reservations that any controlled vocabulary could be effectively used in the JSC environment due to the diverse base of images and users. This concern was compounded by limited cataloging resources and by the general idiosyncratic nature of responses of catalogers and users to images in the collection.

Conclusions drawn from experiments testing the substitutability of images for textual descriptions of images in an image retrieval system suggest that human judgments obtained by exposure to images were more robust and more quickly obtained than those derived by exposure to textual descriptions (Rorvig, 1987). This theoretical base supported the proposal to construct a visual thesaurus utilizing equivalent images from the JSC film repository to duplicate the relationships established in the linguistic thesaurus. The two components, if presented together in a single user-interface, would provide the cataloger/searcher with a flexible alternative to the traditional controlled vocabulary utilized for indexing text documents.

Prototyping of the Visual Thesaurus was carried out on an Apple Macintosh II microcomputer with four megabytes of random access memory, utilizing Hypercard® software—an authoring environment well suited to interactive video applications. Two hundred popular images, supplied by the Public Affairs Office, were digitally scanned and linked to associative thesaurus terms. Selection of a descriptive term from the thesaurus retrieved its associated image, as well as broader, narrower, and related terms along with their associated images. The same selections could be triggered by choosing any image on the display screen, or images could be browsed in sequence. In each case, selected terms were added to a temporary buffer which became the search query to be applied against the full textbase of cataloging records or became the key descriptors of a new image being cataloged. Reaction to the prototype by the ad hoc committee was mixed, but eventually the go-ahead was granted to continue this two-pronged approach to system design.

Work continued on the textual thesaurus, while development of the visual interface was switched to a relational database management system called 4th Dimension®, from Acius, Inc. Hypercard had proven an excellent prototyping environment, but the number and complexity of the relationships needed for the actual interface called for a more efficient method of data handling. 4th Dimension offered the same image handling capabilities as Hypercard, combined with a powerful programming language and a flexible data retrieval engine. Several months and almost a hundred pages of codes later, an integrated 4th Dimension application was delivered to the JSC film repository in spring 1989 for beta-testing (see Figure 1).

In this database format, each thesaurus term is a database record with relational links to each broader, narrower, and related term, and to any corresponding digitized images, which are also stored as records. (Since the interface itself is in database form, new thesaurus terms, images, and relationships can be easily added or modified through a maintenance module, shown in Figure 2.) Similar in operation to the prototype, when a user enters a term the system responds with a list of related entries (see Figure 3). Wherever available, the associated images are also displayed. As the user proceeds, one term or image conjures another, thus enriching the descriptive process, and with each selected category, a textual entry is added to a temporary storage buffer. When the process is complete, the buffer is appended to a new cataloging record as a string of keywords, or applied against the database of existing catalog records as a search query, depending on the mode of operation. In fact, until this term/image selection process is completed, there is no distinction between the activity of cataloging versus searching the database.

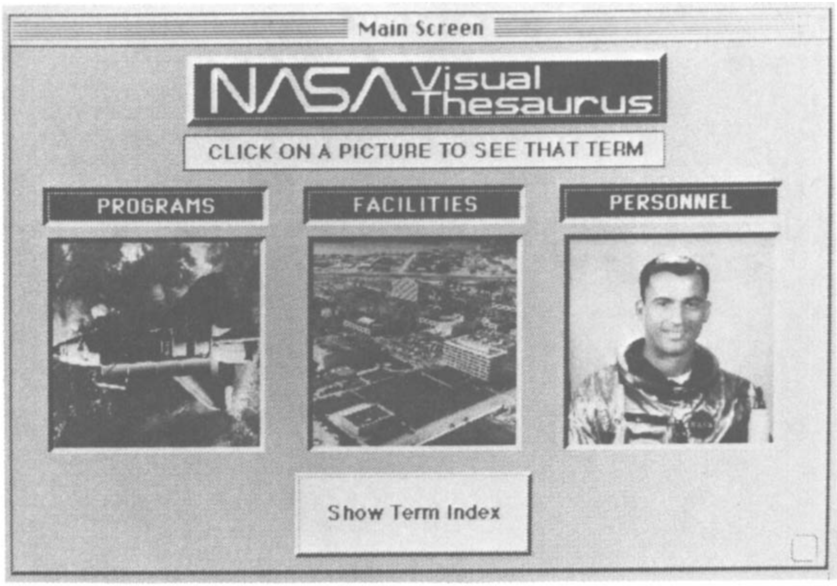

Figure 1. The Main Screen of the NASA Visual Thesaurus

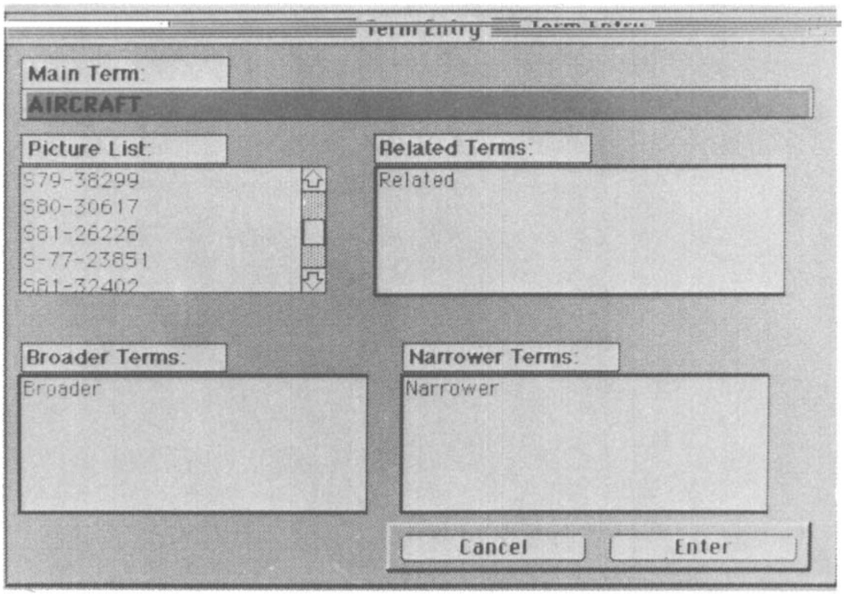

Figure 2. Adding Image Numbers in the Maintenance Module

One of the design goals in creating the visual interface was to maintain independence between it and the data retrieval engine used to search the catalog records, so that the same interface could address existing databases operating on various platforms. For this reason, in part, the interface development was continued in the Apple

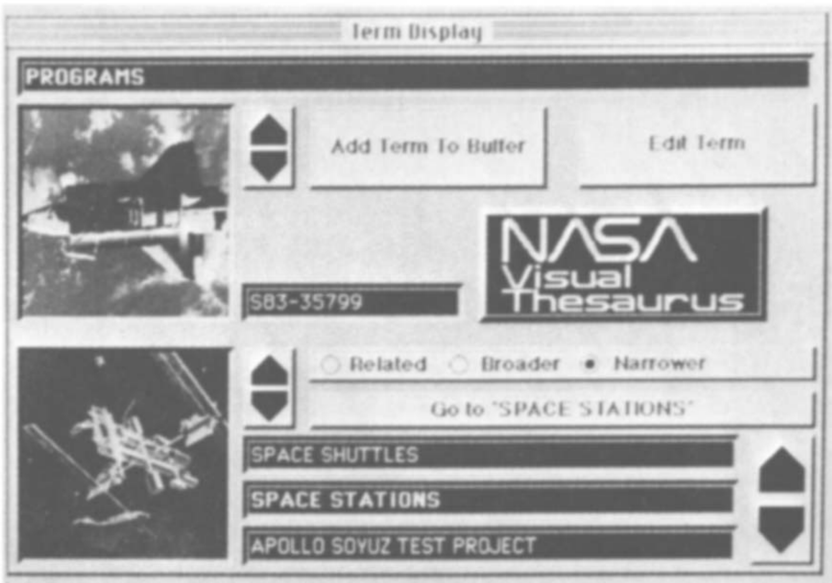

Figure 3. Thesaurus Terms with Related Images

Macintosh environment while the cataloging records were maintained in an MS-DOS environment on IBM-AT compatible machines. In searching, when sufficient search terms have been selected and added to the buffer, the query is passed to the MS-DOS machine (via a null-modem cable and a communications package) to be processed by the data retrieval engine. The results of the search are then passed back and displayed in a window in the visual thesaurus interface, with the entire sequence transparent to the user.

The data retrieval engine selected for this project is almost as unusual as the visual thesaurus interface. Personal Librarian®, from Personal Library Software, is a commercial adaptation of the Syracuse Information Retrieval Experiment (SIRE) developed in the mid-seventies at Syracuse University. Avoiding traditional Boolean search logic, Personal Librarian utilizes a variety of statistically based search algorithms to select documents—ranked in order of relevance—in response to natural language queries. The more terms included in the Personal Librarian query, the better the response, both in recall and precision. An actual search against the JSC film repository 14,000 record cataloging database—a patron requiring all images of "Shuttle Emergency Landing Sites"—contrasts the results of this approach to the standard practice.

A Boolean keyword search for "shuttle" or "emergency" or "landing" or "site" against a traditional database returned over 4,600 records in physical storage order with hits mostly on the commonly used term "shuttle." A modified search for "emergency" or "landing" or "site" brought the number of hits down to 100, again in no meaningful order. A Boolean AND search for "emergency" and "landing" and "site" returned eight records, all right on target but not a comprehensive list.

The same search for "shuttle emergency landing sites" against the Personal Librarian database also returned over 4,600 hits but displayed them in order of statistical relevance. The first eight records were the same as the Boolean AND search, followed closely by "abort landing sites," "trans-Atlantic landing sites," and "ELS," for a total of about twenty relevant records. To deal with more difficult searches, Personal Librarian provides a variety of search functions including an "expand" capability to suggest additional related search terms.

Promise and Pitfalls of a Visual Thesaurus

After several months of thorough beta-testing and modification, a finished version of the visual thesaurus was delivered to the JSC film repository in July 1989. Shortly thereafter, all cataloging and searching activities were switched to the new system. The results to date have been mostly positive: catalog records have become denser with a broader and more consistent descriptive vocabulary for key term assignment while still retaining the flexibility and comprehensiveness of the free-form textual descriptions. (Both key terms and free-form descriptions are searched by the Personal

Librarian retrieval engine.) But while the thesaurus serves as a prompter for the cataloger, suggesting related filing categories, it does not yet compensate for lack of cataloging expertise.

The visual component of the thesaurus is still driven by only about 200 images. Upon completion of the term thesaurus, a routine was written to automatically select the best representative image from the film repository holdings corresponding to each thesaurus term. The approach was intended to isolate statistically the catalog record for which a given term was the most significant descriptor and to pull the corresponding image. Unfortunately, examination of the statistically chosen images revealed, in a majority of cases, ancillary subjects to the target term. For example, the image selected through this algorithm for a term describing a particular test apparatus depicted the item to be tested rather than the apparatus itself. The procedure for scanning and linking new images to terms is in place and is quite simple, but a dedicated effort is needed to manually select the several thousand images required to make this a robust system.

Still, several observations can be made concerning use of the visual thesaurus. Most obvious is the visual component of the interface itself: it is far more interesting and inviting, with its constantly changing display, than a purely textual interface. New users, however, can be somewhat distracted by the images, gravitating toward illustrated categories instead of more appropriate descriptors that currently lack related image representations. This fixation on the image seems to diminish with experience on the system, and reliance shifts more heavily to the textual thesaurus entries.

Initial reactions suggest that, as the interface is more fully developed with images, an appropriate balance will be struck between image and textual stimulus, mitigated, perhaps, by the familiarity of the user with aerospace terminology. For example, a direct search for the terms, "aircraft: T-38" and "Aircraft: C-130" might provide more facility to veteran NASA personnel, whereas visual cues (such as in Figure 4) prompted by the key term "Aircraft," might better serve the neophyte trying to locate or identify "astronaut flight training views" (the T-38 jet trainer, not the C-130 cargo transport).

Search queries constructed with the visual thesaurus work adequately and transparently with the Personal Librarian database, although some of the flexibility available from the Personal Librarian command line interface is lost in the visual thesaurus environment. To date, the search function of the visual thesaurus has suffered because most of the catalog records in the database were entered without the benefit of the controlled key term vocabulary which the visual thesaurus taps. For this reason, experienced collection researchers have preferred searching directly from the Personal

Librarian command line. As the majority of catalog records shifts to the controlled key term vocabulary, the effectiveness of the visual thesaurus interface should improve.

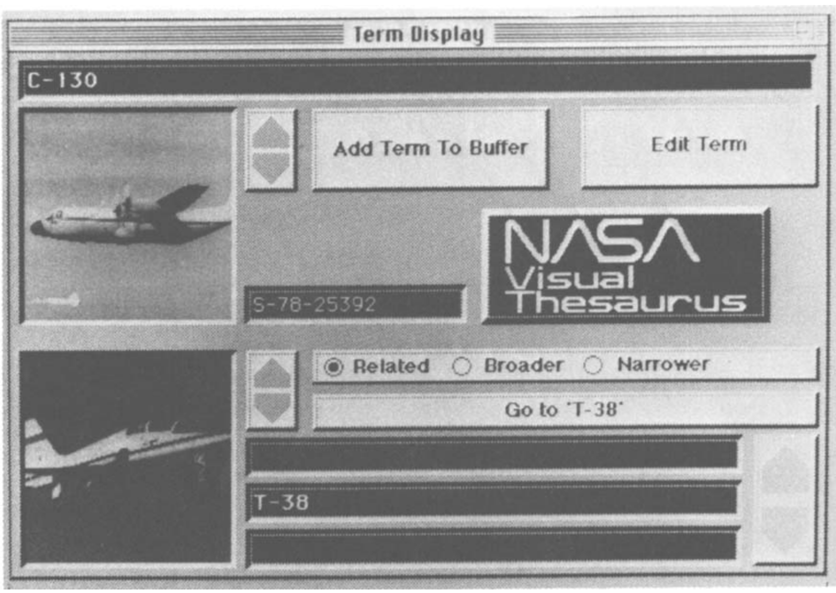

Figure 4. Browsing the Visual Thesaurus

These caveats aside, the real promise of this system is that even in its infancy, it has delivered quantifiable improvements in the cataloging process and has imbued a sense of order and control where chaos threatened to reign.

Future Plans

In spite of the work carried out at MIT and other centers, image management hardware and technology has remained far ahead of the intellectual control processes required to harness its power. Thus the development and implementation of the visual thesaurus cataloging and retrieval interface was the major hurdle in the plan to automate many aspects of image acquisition and retrieval at Johnson Space Center. The next major tasks in this project are the development of an electronic image capture workstation and the development of an electronic image viewing station. Once configured, the viewing workstation will be replicated at various locations around the center and linked together via high-speed communications networks. All new images accessioned into the collection would then be captured and stored electronically, and referenced to the corresponding textual catalog entry, so that images as well as text could be sent to any image viewing station in response to a search. By establishing a uniform system configuration, other NASA centers could also join this network and share both image and data resources.

The benefit of this plan is increased utilization of this valuable and underutilized collection. Cost for access to the collection will be reduced due to more efficient cataloging and searching capabilities. Cost to view or preview selected images will also be reduced: currently, hard copy 8 inch × 10 inch color photographic prints are made to satisfy many requests for which electronic "quick-look" images would suffice. Combined with other current projects which automate work order tracking and circulation of film between the repository and the photographic labs, this effort should provide a generally more responsive system, anticipatory rather than reactionary, to users' needs and effective for years to come. Like many other programs carried out by the National Aeronautics and Space Administration, it may also provide spin-off benefits for a wide spectrum of institutional image collections.

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The Descriptive Challenges of Fiber Art

LOIS F. LUNIN

ABSTRACT

A DEFINITION OF FIBER ART, its history, materials and techniques, vocabularies, and creators and users of those vocabularies offer background for understanding the problems in preparing surrogates of this relatively recent art form for text and image databases. A few image databases are described; record linkage, hypertext, and hypermedia are mentioned. The article explains that the challenges fiber art presents can be extended to the general problem of terminology and description for any visual object.

INTRODUCTION

Fiber art is both a new and an old art form. "The use of fibrous materials as a medium for art works is not new; woven, knitted, printed, and otherwise treated materials have long appeared in the history of mankind" (Henning, 1977). Traditionally, however, they appeared as functional objects. The term *fiber art,* sometimes called art fabric, was introduced after World War II to characterize new art developments in textiles. This article deals only with the fiber art developments since World War II and the challenges presented in describing that art for inclusion in text and image databases. In time, databases may even contain the sounds of fibers as they move in currents of air. For present use, however, it is difficult enough to concentrate on the description of the physical appearance and condition, the composition, content, and design, and the intent of the art.

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DEFINITION

A satisfactory universally accepted definition of fiber art is rather hard to come by. Because definition of any art is difficult, it is satisfying that many artists, writers, and critics agree nontrivially that fiber art is art whose material is fiber—and other components.

Fabric and *textile* are classifications that preceded *fiber art*. Constantine and Larsen (1980) state that the word *fabric* is the generic term for all fibrous constructions. They further explain that the art fabric is a construction, individually created by an artist. It may be woven on the loom or free of the loom, or may be produced by knotting, knitting, crochet, or any other technique. An art fabric, Constantine and Larsen add, is conceived and created by one artist whose efforts, passion, and talent fuse with his/her technical abilities and materials. Artists who work with fiber share the same artistic general art schooling and background, employ technological advances, and enjoy experimentation and manipulation of materials that have stimulated new concepts in all arts of the twentieth century.

HISTORY

Several writers (Constantine & Larsen, 1973; and Brite & Stamsta, 1986, to name a few) agree that the term *fiber art* or art fabric came into use to describe the work of the artist-craftsman following World War II. The term *art fabric* was introduced by Larsen and Constantine "to fill a void since there was no nomenclature to define the work being done in fiber since the 1920s" (Constantine, personal communication, 1990). The loom was reevaluated as an expressive tool, and weavers learned that they could bind fibers into nonfunctional forms with the validity of a work of art (Nordness, 1970, p. 10). Working independently and often in isolation—or, as Corwin says, "ghettoized"—artists in the United States and Europe explored the qualities of fabric or linear elements of linen, sisal, cotton, etc., to develop work that hung on the wall or was free standing, two or three dimensional, flat or volumetric, many stories high or miniature, nonobjective or figurative, and representational or fantasy. Some of the works were rough-textured, some gauze-like. Some were conceived as environmental in that one may walk into and through the structures (DeGraw, 1972). Fiber structure was also created with the use of many nonloom procedures—e.g., knotting, twining, plaiting, coiling, pleating, lashing, interlacing, casting, wrapping, collaging, binding (Perreault, 1986).

In the 1950s came a period of serious recognition of the artist-craftsman's contribution in not only fiber but in several media. During this period the studio artist revolutionized the creative concept of the object. In the late 1950s, Lenore Tawney, a weaver, moved into three dimensional forms with "constructions evoking the power and spatial relationships of sculpture" (Nordness, 1970, p. 13). The opening of Tawney's exhibition at the Staten Island Museum in 1961 was the first major exhibit of American Art Fabrics, an event that marked the point at which "art fabric was healthfully and joyously launched in America" (Constantine & Larsen, 1980).

Taylor (1983) traced the history of the first through tenth Biennales Internationales de la Tapisserie in Lausanne, Switzerland. During that period she found that the content of the exhibitions shifted from tapestries designed by cartoon-painters and executed by artisans to fiber works conceived and executed by an artist; from two-dimensional mural textiles to three-dimensional works; from works with an aesthetic emphasis on their imagery to those which relied upon the textured or structural qualities of textiles, and other changes reflecting aesthetic concerns relevant to all contemporary art forms.

"Fiber R/Evolution," a landmark exhibition in 1986 developed by the Milwaukee Art Museum, contained two parts: the revolution part of the show displayed works by the creators of the new movement such as Sheila Hicks, Ed Rossbach, and Claire Zeigler. The evolution portion of the exhibition showed works by the artists who came later and whose efforts often grew out of, or were stimulated by, the earlier work (Brite & Stamsta, 1986). Today the art trend in fiber continues with an increasing number of exhibitions and concomitantly a growing number of exhibition catalogs.

The abstracting and indexing services for art reflect both the recency of the fiber art field and a paucity of descriptive terminology. Indexing and abstracting services only recently added the term *textiles* (Shaw, 1990). *Art Index* first used the word *fiber* in volume 19, November 1971-October 1972. *RILA, The International Repertory of the Literature of Art,* appears to have used the term *fiberwork* beginning with the 1980-84 issue, and *ART Bibliographies Modern* first used the term in 1988.

Materials

Contemporary fiber artists have access to vast resources of different fiber types. As DeGraw (1972) notes:

> From traditional sources, the artisans may choose the fleece of wild sheep which was first employed by Stone Age hunters some 12,000 years ago. Or they may choose time-honored cotton which...was cultivated on the banks of the Euphrates in 4,200 B.C. Or they may turn to hemp found in China in 3,000 B.C. However, the technology of synthetics has opened new avenues, adding to the visionary impact of the fibre break-through.... (p. 6)

Today artists combine nonfibrous materials with thread, clay, paper, wood; even metal has found its way into the artist's palette. Table

1 is a list of materials and objects culled from the descriptions of

TABLE 1. MATERIALS AND OBJECTS USED IN FIBER ART

abaca	fabric	mylar	rice paper
acrylic	felt	newspaper	rope
agave fiber	fiberboard	newsprint	roving
aluminum	fiberfill	nylon	rubber cables
amate paper	filet netting	nylon mesh	rubber tubing
armature	fire hoses	nylon mono-filament	safety belts
ash splints	fishnet	oil pigment	safety pins
bamboo	flax	paint	seed pods
banana fiber	floss	palm	sequins
bast	foam	palm fronds	shark's teeth
beads	fossil	paper mache	shellac
bittersweet vine	fur	papers of Kozo, abaca, mitsu-mata	shells
bones	gauze	pearl cotton	silk
brocade	gesso	photo	sisal
bronze	gimp	photosensitized surface	stain
buckskin	goatshair	pigment	steel
buttons	gold	pine needles	steel rod
caning	gold leaf	piping cord	stone
canvas	grasses	plastic bags	straw
chamois	gut	plastic disc	styrofoam
chrome plate	hardware	plastic netting	synthetic straw
cloth	hemp	plastic sheet	tennis nets
clothesline	hide	plastic slats	terylene
coco fiber	horsehair	plexiglass	thread
coconut palm	india ink	polyester threads	Tussah silk
coir	ixtle	polyethylene	twill brocade
colored pencils	jingle shells	polyethylene film	twill tape
copper;	jute	tubing	vinyl
copper wire	lace	polyethylene twine	vinyl tape
cordage	lacquer	polypropylene film	viscose straw
corrugated paper	leather	polyurethane	waxed linen
cotton	linen	raffia	white pine bark
cotton batting;	magazine	ramie	willow
floss	manila	rayon	wire
webbing	marble	rayon flock	wire mesh
zippers	masons cord	reed	wire mesh screening
dye (natural)	metal	rhoplex	wood
barberry	metallic gold	ribbon	wood shavings
birch leaves	metallic guimpe		wood spring clothespins
cochineal	metallic silver		wool
greenweed	mirrors		xerox (photo-copy)
indigo	mohair		yarn
madder	monofilament		
oak bark	moosehair		
enamel	muslin		

This list is based on the description of fiber work illustrated in *Fiber R/Evolution* and *The Art Fabric Mainstream,* two publications used as examples of the variety of materials and objects. The list is not comprehensive, merely representative of vocabulary in two publications.

fiber objects illustrated in just two publications—*Fiber R/Evolution* (Brite & Stamsta, 1986) and *The Art Fabric Mainstream* (Constantine

& Larsen, 1980). With this list we begin to illustrate some of the complexities that occur in describing fiber art, that almost everything and anything is fair substance for the contemporary artist.

Techniques

Many processes are employed in producing fiber work. Some of these techniques date back to prehistoric times. Weaving, for example, is one of the earliest techniques but many nonloom procedures—such as twining, knotting, wrapping, sewing, and felting (all earlier than weaving)—were also employed in ancient periods. Today some of these techniques are aided by electronic devices—e.g., the computer-assisted loom. Yet the Jacquard loom—invented in 1780 in France—was controlled by punched cards, a forerunner of the Hollerith cards. Information professionals might be interested to note that it was perhaps Leonardo da Vinci who gave first thought to mechanized weaving when he described the technique: "'This is second only to the printing press in importance; no less useful in its practical application; a lucrative, beautiful and subtle invention'" (DeGraw, 1972, p. 5).

Table 2 lists some techniques used in fiber art. Although most are old, new techniques are developed occasionally, the product of the creative mind, hand, and new technology. A more complete listing of techniques can be found in the *ARTSearch Techniques Table: Field Descriptions and Valid Field Values* (1988). As stated in the description of the "type" field: "Just as there can be several techniques used to create an object, there can be several types within each of these techniques. There is no limit on the number of techniques or types within techniques that can exist for one object." A further description of the structures of fabrics can be found in Emery (1980).

Vocabularies

A vocabulary to describe the appearance and the meaning of fiber art is evolving. The terms come from many sources. For example, as part of a submission of work to an exhibition, the artist is often required to write a statement of intent. In judging the work submitted, jurors sometimes use another vocabulary; often curators, art critics, writers and editors of art books, educators, and gallery directors use somewhat different terms. The variety of these vocabularies illustrates still another area of complexity. Table 3 lists some of the descriptive terms taken from the *Fiber R/Evolution* and *The Art Fabric Mainstream* cited previously. This is "an amusing, delightful list," Brandford (personal communication, 1990) commented: "But in the end most if not all of these descriptive terms are not at all specific or unique to fiber." She asks: "Is a new vocabulary necessary?"

TABLE 2. SOME TECHNIQUES USED IN FIBER ART

airbrush	knotting	stacking
applique	layering	stitching
braiding	leno	tapestry
bunching	looping	tufting
carding	molding	twining
coiling	netting	twisting
couching	plaiting	weaving
crochet	pleating	wefting (discontinuous)(tapestry weaving)
embroidery	puckering	winding
flocking	resist dyeing	wrapping
folding	reverse applique	
fraying	riveted	
ikat	shibori	
interlacing	slewing	
interlocking	soldering	
knitting	soumak	

This list is based on the description of fiber work illustrated in *Fiber R/Evolution* and *The Art Fabric Mainsteam*. These techniques are examples only of the variety encountered; the list is not representative of the field. For example, quilting, and piecing—three common techniques—were not encountered in these publications.

DESIGN

The artists whose medium is fiber usually have chosen an aesthetic over a utilitarian need. Rutherford's statement (1989) pertains to fiber art as well as to other arts: the elements of line, color, texture, shape and form, and principles of rhythm, unity, balance, and emphasis provide the foundation for decisions; these are the basic elements and principles of design. Today's artist who works with natural fibers or synthetic yarns uses his materials to produce works possessing form and space with surface and mass interchangeable. The works often express the pure design qualities inherent in the artist's techniques, structure, processes, and materials as well as experience and inspirations. Some works, however, are expressive social commentaries.

Color has always been an important element of fiber. Sometimes it is neutral to emphasize form and sometimes bold to focus attention on massive construction (Brite & Stamsta, 1986).

THE CREATORS AND USERS OF FIBER ART VOCABULARIES

People who describe fiber art according to their specific roles—whether writer, art historian, curator, etc.—use a rich language. Table 4 lists some of the many categories of individuals who use those descriptions. The following paragraphs describe the focus of some of those individuals.

TABLE 3. VOCABULARY OF TERMS USED TO DESCRIBE FIBER ART

- abstract
- accretion systems
- adventure
- agitate
- allusions
- ambiguity
- animate
- anthropomorphic details
- architectural
- assemblages
- associations
- awkwardness
- basket structure
- bold reality
- brooding
- brushed surface
- bubbly surface
- bulbous forms
- ceremonial implications
- chaos
- charge
- clarity
- clear structure
- clumsy
- cluster
- coloration
- compassion
- complete
- compression
- concealing
- confinement
- construction
- containers
- contemplation
- cosmos
- counterpoint the ponderous materials
- crenellations
- cumbersome
- delicate
- dense
- depth
- detail
- dialog
- diaphanous
- dimensions
- discipline
- distancing
- durability
- dustfree
- dynamic
- elasticity
- elegance
- elegant
- emotional
- energy
- energy conductor
- energy ejector
- enshrinement
- ephemeral
- exactness
- expansion
- expressive
- fadeproof
- festive nature
- figurative
- figures
- flat
- forceful
- fragile
- framing
- free
- freedom
- full grown
- geometric
- gestural
- gesture
- glimpses of a total world
- glisten
- gloomy
- gossamer
- grandeur
- gravity
- harmony
- heroic
- illusion
- imagery
- import
- indigenous architecture
- integrity
- intense, lively hues
- intension
- interpretations
- intimacy
- intricate
- intuitive
- juxtaposed
- laminations
- layering
- layers
- liberated
- light refracting potential
- lightness
- linear
- linear qualities
- liveliness
- luminosity
- luster
- lyric
- macabre
- malleability
- mass
- meditative
- memories
- metaphor
- miniatures
- modules
- moire pattern
- monumentality
- mood
- motion
- mysterious
- mysteriousness
- narrative
- narrative content
- neutralization
- nobility
- noble materials
- numerical progression
- opacity
- opulence
- order, ordered
- organic
- organic dynamics
- organic dynamism
- organic shapes
- overtness
- overwhelming
- ovoid form
- palpable
- pebbly surface
- pellucid
- pendulous
- personal language
- pliability
- poetic forms
- portraits
- posture
- potency
- power
- precise
- presence
- protection
- purity
- quietude
- reciprocity of image fabric
- relics
- resolution
- revealing
- rich
- robust
- scale
- sense of drama
- sensory impact
- sensual surfaces
- serenity
- shadow play
- shell
- shimmering
- slit size
- soft
- soft murals
- solid and void
- solidity
- soul/self
- spiny
- spiraling
- spirituality
- standardization
- starkness
- strength
- stripcloths
- sturdy
- suggestion
- support
- surface treatment
- surfaces
- surprise
- synthesis of form and meaning
- system, systematic
- tactile experience
- tempering
- temporariness
- tension
- textile
- textural/sculptural class
- tonal relationships
- topology
- transformation
- translucence
- transparency
- twisted
- vibrancy
- visual metaphor
- voids
- volume
- voluptuous cascades
- voluptuousness
- vulnerability
- weight
- whimsical
- wispy

This list is based on the description of fiber work illustrated in *Fiber R/Evolution* and *The Art Fabric Mainstream,* two publications used as examples.

Registrar

The registrar or collection manager is responsible for the transportation, packing, storage, and all objects brought into the museum for exhibitions, works lent to other institutions, pending acquisitions, and the recording and documenting of these works (Ricciardelli, 1987). Along with basic information, such as museum number, artist, title, date, medium, dimensions, etc., the registrar uses terms to describe the condition of the work.

TABLE 4. CREATORS AND USERS OF FIBER ART VOCABULARIES

art administrator	gallery director
art historian	iconographer
art librarian	insuror
artist	preparator
collector	public
conservator	publisher
crime detection officer	registrar
critic	restorer
curator	student
editor	supplier
educator	writer
fabricator	

Curator

The curator is concerned with planning, conceptualizing, and selecting works for exhibitions, and for research in the collection. As Constantine (1990) explains, exhibitions are often drawn from collections which have been under the care of the curator where a historical frame of reference is of great importance.

> The special knowledge of the field in which the curator works determines the direction. Only by examining what is present in the field; only by examining the tendencies and characteristics of work being done, can a curator determine that indeed there is a cohesive theme running through the work. The cohesion exists in the aesthetic, in structure, and in materials.
>
> A curator may start out by referring to slides and photographs but it is from the work itself that selections are made for exhibitions....Themes come after and not before the work is examined and assembled.

In considering a fiber piece for exhibit or purchase, for example, the curator wants to see the object itself because few pictures can give the feeling of the texture, the luminosity, and the impact that a large piece can produce when seen both at a distance and up close.

Art Historian

The art historian uses a vast network of resources to explore, reaffirm, reorganize, or negate previous assertions about a work and the culture in which it was created. The materials, design symbolism, sex of the artist, and culture of the period are all concerns of the art historian who, like the curator but working for a different purpose, wants to have access to many photos for comparison of details of similar work and perhaps even rituals associated with its creation. Though this article is concerned with art works since World War II, these works include those created throughout the world and in enormously varying cultures. For the art historian, a full description of such art is needed.

Art Conservator

The art conservator is concerned with the preservation of the object. Because fiber artists use many man-made materials—for example, polyurethane, polyethylene tubing, plastic garbage bags, electronic wire, etc.—conservators must continually learn about the aging of these materials. Will they yellow, crack, disintegrate, attract insects, absorb moisture and swell, becoming distorted and thereby place a strain on other fibers in the piece if the work consists of more than one kind of fiber? The conservator is the doctor of textiles, specifying the treatment, stabilization, restoration, and mounting for installation, and draws on physics, chemistry, engineering, and art in the care of the art. Twentieth-century developments challenge conservators two ways: how to conserve the objects composed of materials specific to the twentieth century—i.e., man-made fibers—and how to employ twentieth century technology and materials in the conservation procedures. The Getty Conservation Information Network facilitates the retrieval and exchange of information concerning conservation and restoration of cultural property. The network features three online databases—bibliographic, materials, and suppliers.

In addition to those individuals mentioned, iconographers, crime detection officers, art educators, students, collectors, insurors, gallery directors, art administrators, and the public all are potential users of art information. So are critics, artists, art librarians, editors, publishers, restorers, suppliers, and writers. Each brings his or her particular focus of interest to the search or to the writing, and each uses a somewhat different vocabulary.

The Longitudinal Record

The record of a work of fiber art like other works of art can be compared to a longitudinal medical record. The record begins when the piece is created and includes information on the creator(s), full demographic data, education and accomplishments of the artist—where the work was exhibited, honors received, and reproduction (appearance of the work in a catalog, newspaper article, book, etc.). The health of the work is also important. Is it strong enough to travel? Does it have special requirements for travel? How should it be installed? Does it have a record of repairs and, if so, what kind? All this must be noted in the record. The record must be open ended and continued throughout the life of the object—and perhaps even beyond.

Database Record

For the purpose of this article, the database record structure is not as compelling a challenge as the terminology to use within the fields of the record. However, it is important for each of the various users described earlier to know that the record contains all fields needed. For that reason, some of the relevant fields are listed in Table 5. Scott (1988) reports that the catalog database for sculpture at the National Gallery of Art would use at least 300 tags, "breaking down materials, techniques, iconography, and stylistic factors in detail" (p. 137). The basic information involves *when* was the work done, *where, by whom, how,* and *why.* The same principles apply to fiber art.

Table 5. Suggested Fields for Fiber Art Database Record

Artist	Owner
Title of Work	Provenance
Alternate Titles	Provenience
Execution Date, Year Produced	Reproduction (Photos)
Media-Material-Fiber Content	Bibliographic Reference
Type of Execution (Technique[s])	Exhibition History
Structure(s)	Installation Considerations, Restrictions
Foundry or Weaving Studio	Basic Condition
Type of Equipment Used	Treatment
Theme, Subject	Culture
Style, Period	Gender Issues
Color(s)	Accession Number
Dyes Used	Location
Texture	Appraised Value
Decoration-Surface Embellishment	Insured Value
Design Symbolism	Registration Photo
Pattern Repeat	Year Collected
Size-Dimensions	Remarks
	Key Words (Descriptors)

Coming to Terms with the Information

For some years, the museum specialists described earlier as well as gallery directors, art librarians, educators, writers, etc. have been aware that more facets of information need to be addressed. In the

1960s computers were looked to for help in the organization, storage, search, and retrieval of such information. The standardization and sharing of such information were noted by David Vance (1975).

AAT Thesaurus

It is now more than a decade since the *Art & Architecture Thesaurus (AAT)* was started. The initial intent of the AAT was to provide catalogers with terminology with which to describe objects, documents about objects, and object and document surrogates. As Bearman (1988) notes, the power of the AAT as a descriptive language derives from the explicit genus-species and whole-part relationships, its definition of synonymy, the increasingly complete scope notes, and its identification of the sources that provide warrant for the use of the term. AAT has defined 30,000 terms in thirty-six separate hierarchies. These hierarchies describe physical attributes, styles and periods, agents, activities, and materials and objects, but not subject description.

The AAT offers enormous hope in better integrating various forms of materials: abstract and index, visual object, text sources, and bibliography (Allen, 1989). Yet, originally iconography did not fall within the AAT's scope; this policy has been modified in the face of expressed concern from the museum and library fields (Stanley, 1989). The creation of the two hierarchies—Patterns and Motifs and Visual Genre—was in response to those perceived needs. Stanley (1986) also indicated that the need for a more complex vocabulary becomes clearer when considering the indexing of images or bibliographic material.

What do some art experts think about the description needs for fiber art? In a catalog for the 1972 exhibition of the work of Olga de Amaral, a Colombian artist, Galaor Carbonnel, an eminent Colombian critic wrote:

> One of the most fallacious of the critical judgments of our culture has been that of classifying and establishing hierarchies based on the presence of basic materials and the technical methods applied to those materials. (Constantine & Larsen, 1986, p. 8)

The concern is there for the structural and aesthetic characteristics of the art fabric as an art form, not its materials and methods, although fiber art begins with material and method.

As Stam (1989) has written, the field of art object cataloging is just beginning to recognize the inadequacy of language as a recording medium for describing a work of art.

> There is considerable interest in adding visual components to art object databases, but so far this refinement is quite rare, and while it is an aid to description, it has not in any case solved the problem of retrieval. There seems no way around the problem of developing controlled

> language for description, and that is the aspect of art object cataloging which is now receiving the most attention from theorists. (p. 8)

She continues: a simple description of the physical object is not enough. It is "the significance of the piece—a concept representing a perceiver's judgment—based on any one of several criteria." She lists several groups of data that need to be provided including objective data about the work; subjective or interpretive data; style; evaluation; and even more today—signs, signification, and social context.

Stam sees redefining of the problem as due not only to more sophisticated understanding of art data, but also to several recent technological advances: the hard disc, improved communications modes; fairly standard off-the-shelf software packages with flexibility in field definition and manipulation; and relational databases.

Even though what she calls the harmonization of databases is far from complete, the tendency for catalogers of art objects to look beyond their institutions is expanding to include looking at other fields and other approaches. For example, this includes discussions of archival approaches to describing collections, the linguistic concept of "frames" and its implications for faceted classification, nonverbal classification and retrieval of visual imagery, novel applications of the *Art and Architecture Thesaurus,* and increasingly frequent reference to the MARC format as a suitable framework for art object information.

IMAGE DATABASES

While words can conjure up an image in the mind, these same words can produce as many different mind images as there are people receiving the words. An image surrogate of the work would be useful for many purposes, and image databases can offer other facets of information about fiber art. Unlike text or data, visual material often derives its value from the object itself with much of the message conveyed through design, texture, strength of lines, and artistic subtleties (Lunin, 1987).

Some examples of fiber image information systems and related pilot projects follow. Although few in number, they will undoubtedly grow because technology is available and increasingly lower in cost. New technologies and lowering costs will help to meet the needs of art historians who, in Brilliant's (1988) words have "an ultimately insatiable hunger for images" (p. 125).

The Helen Allen Textile Collection

The Helen Allen Textile Collection, located on the campus of the University of Wisconsin, consists of about 12,000 textiles, costumes, and related objects. Although the chronological scope ranges from pre-Columbian and Coptic fragments to contemporary fiber art, the collection includes objects from folk, tribal, and urbanized cultures around the world. ARTSearch, an interactive laser videodisc computer system, was developed to meet both the intellectual and viewing access needs required of this public resource collection. With a single action the viewer can access the data stored in the computer and view a visual image that is stored on the videodisc.

This database is geared for the most part toward the categorization and cataloging of historic textiles, predominantly flat textiles, although some contemporary fiber works are included in the collection. An additional use of the system allows for a complete condition survey of materials, simplifying a major collections management task. As each object is examined, its condition and current storage can be entered onto ARTSearch with a numerical code and a brief description.

The University of Maryland Historic Textile Database. Established in 1986, the purpose of this database is to create a sophisticated data management program on personal computers to handle the massive amounts of data necessary for research on historic textiles. While the long range goal of this project is to include all flat textiles, the immediate goal was to establish a database on coverlets. The database currently contains information about 10,000 coverlets. The purpose is to be able to search and compare motifs in the same and different geographic areas and study the popularity, uniqueness, origin of motifs, and migration patterns. The system uses PictureWare and an image capture board. While coverlets are not fiber art as defined for this article, this database serves as an example because it does contain textiles and includes images.

The database has five separate segments one of which is the design motifs found in coverlet centerfields, borders, corner blocks, cartouches, and logos. The motif file was established to classify and quantify the use of the design elements. Each record has four fields with the possibility of each coverlet having as many as thirty-five motif records. The motif file will enable users to search and compare motifs with those of other weavers in the same geographic area and those of other weavers in different geographic areas, track the change in motifs over time to determine the widespread use of the design elements, and to determine the popularity and uniqueness of the motifs by quantitative methods (Parsons & Anderson, 1989).

Research and Development

To locate fiber art images in any system, there are still problems in coding, and it is still difficult to recognize an image by its parts or whole. Russell Kirsch, a computer scientist, and Joan Kirsch, an artist, have been working on image recognition by computer for several years. Although their work has focused on paintings, the principles are basic to fiber art—developing a set of rules, a grammar, that would allow someone to analyze the structure of a set of paintings and to generate similar images. While unable to capture the colors, textures, or brushwork of a completed painting, they were able to concentrate on the geometric framework on which the artist, principally Diebenkorn, draped his paint (Peterson, 1986). It takes only about eight bytes of data to describe the rules and steps needed to recreate the basic structure in a typical Diebenkorn painting, while about a million or more bytes of information would be needed to produce a decent representation of one of his pictures by scanning it electronically.

Research on Image Description

Rorvig (1987) measured the effect on human judgment of the inclusion of images in the bibliographic records of archival materials. His research indicates that a thorough reconsideration of both the amount of description for images as well as the relation between the physical data image and its pointer surrogate is required.

Discussion

It is clear that art fabric works have gained status throughout the world. Constantine and Larsen (1986) stated: "While this art form may be in search of nomenclature, it demands and deserves autonomy" (p. 7).

The field still needs more specific as well as broader nomenclature and terminology, as judged from the paucity of terms used by several major abstract and index publications and databases to describe the art. As we have seen, there are varied users with varied needs. For some of those users it would be helpful if the abstracting and indexing services were to include more descriptive terminology, enabling the user to be more specific during a search. Broader coverage of the literature is also desirable, for a review of serials revealed that some of the basic fiber art serials are not covered.

Some users need much description, perhaps even full-text fields. Jost (1986/1987) proposes that art historians would be more inclined to use databases developed for art history if they contained greater amounts of data. He explains that the art historian still prefers to work with a large quantity of information and "will forego the comforts of standardized and integrated systems which offer little [limited] information in favor of a large quantity of less-structured data, even if it means working with several different databases of various listings and thesaurae" (p. 50). He suggests the use of scanners programmed specifically for reading the research materials of art history. This method of input may well be a satisfactory procedure for periodical articles about fiber art. If the articles were prepared in a standardized structured form, an unlikely event in the next several years, the relevant sections could be identified and entered into fields in databases designed for that purpose.

And what of the description of a specific work and its pictorial representation? Who will fill out the long form that is inherent in providing more information proposed for fiber art records? This is a labor intensive process and thus expensive, perhaps prohibitively so.

Images

There appears to be almost universal agreement that the image is desired in the database record together with textual information. Ostby (1987) states that the visual impression is very important for the analysis of objects, and a text cannot compensate for a documentation photo.

The problems in coding fiber images remain. Unfortunately, as Bearman (1989) writes, we still don't know how to "describe" an image, although the work of Kirsch and Kirsch (Kirsch, 1985; Kirsch & Kirsch, 1988) in devising a grammar for the field is providing some understanding. But from a linguistic point of view, indexing the images for access from a multiplicity of interests is still a chancy proposition because it can be perceived from so many different perspectives (Bearman 1988, 1989). From long experience, Bearman explains, we are aware of how poorly words are suited to this task.

Even with a mass of information available to apply to a work, it is difficult to describe the concept and other important aspects with just a few index terms or a classification. While in time the new technology offering image information handling can be a boon to fiber art study, appropriate index terms are still needed to locate a work, and good description is still necessary to provide even a moderate understanding of the work.

There are real and basic differences between the documentation of a bibliographic item and an art object. One set of documentation acts as a pointer to the literature in the book. The other set of documentation acts, as Barnett (1988) explains, as a complete description of an otherwise mute subject. Whatever there is to say about that object may be totally contained in the surrogate record, including an image of that object. She continues: "The real difference between object and bibliographic item information is that the direct description enumerates and the bibliographic content description abstracts..." (p. 200).

Whether the image should be analog or digital is still controversial. When comparing videodisc and digital representation of fiber art, videodisc (analog) seems quite suitable for most needs at the present time and could be useful for many purposes. In the future it may be possible to digitize images of fiber art to enhance the study of the art, to compare images more easily, to rotate, zoom in, give scale, and place the image in an architectural environment as well as to study its structure microscopically. But, at present, a digitized image requires vast amounts of storage space and a large amount of transfer time for its use to be productive.

Record Linkages, Hypertext, Hypermedia

The art historian and others would find it helpful if records could be linked in both hypertext and hypermedia. However, as Bearman (1989) wrote, the technical and conceptual limitations of our approaches to multimedia humanities knowledge bases make it unlikely that we will see any universal products in our lifetimes. However, he holds out the hope that we might still construct quite exciting, if limited, multimedia bases for particular types of users.

Challenges in General

While the problems and challenges in describing fiber art have been examined here more generally, the article shows how the challenges fiber art presents can be extended to the general problem of terminology and description for any visual object. Although pattern recognition techniques are being developed to identify technique, color, and shape, pattern recognition by itself cannot determine the history, cultural interpretations, composition, and intent of some of the elements included in the fiber work. Words still are needed to convey information about the object.

Even more, associated trails to information leading to further understanding of a work can often be helpful, such as those that hypertext and hypermedia can offer. Additionally, the comments of the scholarly users of the system could supplement the record along with a kind of running citation index. In medicine, this would be called a longitudinal health record, beginning with the information about the parents (the creator) and ending only with the death and autopsy report. In art, we hope that there will be no death of the work, that a work of significance will endure, preferably in a museum where it can be cared for by knowledgeable conservators.

Perhaps at this time in the life of fiber art and other art forms what we may need are some basic user studies. In her wrap-up essay to the Authority Control Symposium in 1986, Carol Mandel concluded that "the key to future improvements lies in user studies and intelligent analyses of user behavior" (Muller, 1987, p. 34). Added to this is one more component, the analysis of the information itself, which as Reed and Sledge (1988) point out, is essential to the understanding of information requirements.

The Real Importance of Fiber Art

In the final analysis, however, it is not the intellectual aspects of the fiber work that are important. Rather, the work is significant because of the way it was created and the response it generated—e.g., excitement, a probing intellectual interest, or perhaps even strongly negative fear and revulsion. It may have offered a new way of looking at the world—at human interaction with their own thoughts, with other human beings, with the environment, with the unknown. How to document such intangibles requires keen perception, carefully selected words, and a rapport with the art itself.

In fiber art as in all art, the creative pursuit is, to extrapolate from Brite and Stamsta (1986), to explore new concepts, to push at the boundaries, to investigate a variety of materials and techniques, and to think and do, do and think, until there is some kind of breakthrough when a new world of fresh possibilities appears—an original art form for which there is no precedent. How to describe that art for one's contemporaries and future generations is the real challenge we face.

Summary

The field of fiber art and the art fabric is one of intense activity, deliberation, exploration, and experimentation. Its description should mirror that energy and devotion. This article suggests some kinds of terms needed by people working in aspects of fiber art. How the terms are rationalized should be determined by representation of the information professionals concerned with the use of the terminology at the provider end and by the types of interests reflected at the user end. Also, as many of us who have worked on thesauri and design of information systems recognize, a new field that keeps evolving requires flexibility in its terminology so that terms describing new techniques and materials can be added. While the new technologies that make possible the addition of images is a great step forward, words are still needed to provide a fourth dimension—that of the contextual and intentional information.

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Heraldry and Blazon: A Graphic-Based Information Language

HAROLD E. THIELE, JR.

ABSTRACT

EXAMINATION OF THE VARIOUS descriptive conventions used by heralds over the last 700 years to blazon armorial devices reveals several patterns that can be adapted to form a generalized algorithm to describe trademarks, logos, and other types of graphic designs. The key assumption used in the algorithm is that the graphic design is to be treated as a glyph that is to be painted onto a surface with some form of opaque media. The different design elements of the glyph are described in the order in which they are applied to the surface as one works from the background to the foreground. The algorithm is in the form of a faceted description. Each of the facets of the algorithm deal with a specific function, attribute, or design use. In addition to being able to search for a specific design element, the faceting feature will provide the user with the capability to search for a specific functional use of a glyph.

INTRODUCTION

Graphically based information systems that arose out of twelfth-century Europe and Japan have grown and developed into the institutions of heraldry and family crests that we know today. Metzig (1983) has defined heraldry as "a 'language' used to visually communicate not only a bearer's identity, but many other facts about him" (p. 6). The written or verbal description, the blazon, was used to provide records of the heraldic devices. The blazons allowed the easy transmission of painting instructions so that the graphic designs of the heraldic device could be accurately reproduced at other locations.

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HISTORY

The period between the tenth and twelfth centuries in both Feudal Europe and Feudal Japan was a time of continuing battles between shifting alliances of competing warlords and princelings. The communication problem that needed to be solved was how to identify the various combatants' status and authority across a field of combat that was a swirling confusion of men, animals, equipment, and dust. The solution that evolved to solve this problem led to the development of the Institution of Heraldry in Europe and the System of Family Crests in Japan (Brooke-Little, 1978, pp. 2-7; Dennys, 1982, pp. 29-31; Fox-Davies, 1978, pp. 17-18; Gies & Gies, 1979, p. 183; Pine, 1963, pp. 11-12).

When true heraldry does appear around the twelfth century in Europe, the conventions used in depicting heraldic shields and describing them verbally are derived from the cliches of earlier artists and craftsmen (Brault, 1972, p. 5). The pattern of the description is in the form of painting instructions describing the order in which the elements are to be painted onto the shields. The development of the precision in the blazon around 1250 most likely came about because of the growing legal consequences of the blazon (Brault, 1972, p. 6). The standardization of the blazon patterns in the thirteenth century partly came about to aid the heralds' needs for a mnemonic system to aid in the execution of their professional duties—i.e., in identifying individuals, transmitting verbal or written records of the appearance of the devices to other heralds located in other locations, and consequently for use in legal cases over time to identify heredity and legal claims (Brault, 1972, pp. 6-7).

The most important innovation during this period was the development of the heraldic phrase which specifies the nature of certain charges and lines and indicates the position of all the charges on the shield (Brault, 1972, pp. 10-18). By the mid-thirteenth century, the blazon's lexicon is well established with a rigorous syntax (Barstow, 1974, p. 75). The ordering of the blazon had become established as first the field, followed in order by the principal ordinary, the secondary charges, and finally the marks of difference (Barstow, 1970, p. 87). Later in the medieval period, the counterchange, where colors from the ordinary and field were exchanged, was developed thereby increasing the variety of devices available. Also during this period, the addition of charges on the bands of the ordinaries came about. Subordinaries become defined, and specific terms are introduced to identify precisely the more than 100 combinations of predetermined positions of an animal's body, paws, head, and tail (Metzig, 1983, pp. 25-27, 34).

In the fourteenth century the descriptive phrases became magnified to indicate a distinctive feature. The absolute position of multiple charges or their direction are specified in some cases, and there was a trend to increasing the combinations of charges on the field (Barstow, 1970, pp. 81-82). By the fifteenth century, differences were added to indicate family relationships or feudal ties (Barstow, 1970, p. 83).

In the sixteenth century, with the change in military armor, heraldry was no longer a necessity for recognition in the field of combat. Released from the restraints and simplicity that practical aspects of visibility and clearness across the battlefield had imposed on it, heraldry entered a period of elaboration. The marshaling of several coats of arms onto a single shield was developed far beyond the original purpose of indicating a union of lordships. Heraldry moved from being a practical ancillary for the warrior to a decorative art form (Brooke-Little, 1978, p. 10). The blazon entered a period of unnecessary elaboration, complicated nomenclature and language, unnecessary rules and conventions, and hermeticism that was to last until the Victorian revival in the nineteenth century (Brault, 1972, p. 3; Brooke-Little, 1978, pp. 10-11).

In modern blazoning, the coat of arms is described in the following order: (1) the field of the shield with its divisions and tincture; (2) the principal charge, or group of charges, on the field; (3) the secondary charge, or group of charges, on the field; (4) the objects placed on the charges already mentioned; (5) important charges resting on the field but not occupying a central position; (6) objects placed on the charges mentioned in number 5; (7) cadency marks; and (8) description of the crest, supporters, and mottoes (Brooke-Little, 1978, p. 15; Dennys, 1982, p. 9; Fox-Davies, 1978, pp. 99-105; Metzig, 1983, p. 124). The general rule of a good blazon is that the nomenclature and descriptive terms be correct, and be clear and concise in construction (Brooke-Little, 1978, pp. 15-18).

Descriptive Algorithm

Examination of the various descriptive conventions used by heralds over the last 700 years to blazon armorial devices reveals several patterns that can be adapted to form a generalized algorithm to describe trademarks, logos, and other types of graphic designs. The key assumption used in the algorithm is that the graphic design is treated as a glyph that is painted onto a surface with some form of opaque media. With this assumption in mind, the different design elements of the glyph are described in the order that they are applied to the surface as one works from the background to the foreground.

The algorithm is in the form of a faceted description and is designed for use with some type of mechanical processing. Each of the facets of the algorithm deals with a specific function, attribute, or design use. In addition to being able to search for a specific design element, the faceting feature will provide the user with the capability to search for a specific functional use of a glyph.

The first part of the algorithm, the field facet, is used to describe the shape of the external form of the field or background of the design as a whole. The second part of the algorithm, the principal charge facet, is concerned with the description of the charges or major design elements that rest on the field. The third part of the algorithm, the principal objects facet, is concerned with the description of the objects or minor design elements that are complete in themselves that are located on the charges. The fourth part of the algorithm, the secondary charge facet, is concerned with the description of the charges that are located on the various divisions of the field. The fifth part of the algorithm, the secondary objects facet, is concerned with the description of the objects that rest on the secondary charges. The sixth and last part of the algorithm, the embellishment facet, is concerned with the description of the embellishments or auxiliary design elements associated with the glyph but are not actually a part of the design (see Appendix A for a further description of all facet descriptions).

One or more of the facets may be embedded within another facet when the graphic design being described is extremely complex. Additionally, each facet may be repeated as often as necessary in the description of a design.

Each of the description facets will contain the following segments: (1) a location description segment that is used to describe where a particular graphic element is located in relation to the design as a whole or to a smaller unit of the design; (2) a glyph description segment that is used to describe the shape or form of the particular graphic element; and (3) a color description segment that is used to describe the color of the particular graphic element. One or more of the facets may contain additional description segments that describe other associated attributes (see Appendix A for a description of these description facets).

Vocabulary Control

Over the last 900 years the heralds have developed a rich descriptive language that includes terms for different types of field patterns and divisions, types of lines and objects, and positioning of animal and human bodies. This rich historic tradition provides a strong base on which to build a standardized technical language for the description of graphic forms. The addition of new terms to cover modern developments and non-Western forms, and the use of heraldic *proper* (a term which means to render the object as it is in real life), will provide a controlled vocabulary that will, when combined with this faceted algorithm, make it possible to classify graphic designs so that related design elements, either in part or in entirety, can easily be brought together and compared. The use of symbols to indicate the notation system being used to describe the location, glyph, and color will make the algorithm highly flexible and easily adaptable to various user populations.

The advantage of a mechanical system is that tables of equivalences can be set up to allow the machine to do the comparisons between different systems of notation automatically. This way it is possible to retrieve items described by different notational systems without having to develop search terms in each of the systems. With these three descriptor segments (location, glyph, and color), it is possible to set up a series of correspondences that will automatically search for all search term variants without regard to the descriptive system used originally to describe the object.

Descriptive Applications

This algorithm, with the associated controlled technical vocabularies, will allow the description of trademarks, logos, and other forms of graphic designs in the form of descriptive strings so that they can be accessed by use of online string searching methods. This will make it possible for trademarks, logos, and graphic designs to be located by conducting a search pattern that is based on individual design elements. Because each design element is designated as to location and importance in the overall design, it is possible to compare entire classes of glyphs for design likeness. This type of comparison will be of immense value in rapidly locating similar looking trademarks, logos, or graphic designs.

By the way the description is formulated, it is possible to determine the relative degrees of likeness and/or difference between designs. If you want to compare the design elements in a trademark or logo for possible conflicts, this algorithm will make it very easy to locate any designs that have similar elements in the same locations. For example, if the principal charge of the trademark or logo you are interested in is a red tudor rose, and you enter a global search for red tudor roses, you could get back several different types of responses. One type of response using this algorithm could be descriptions that have a red tudor rose described in the principal charge facet. This is an indication that the described designs need to be examined more closely to see how similar they are to the trademark or logo of your interest. However, if the red tudor rose is described in the secondary object facet, then there is no need to compare the designs for the likeness of the red tudor roses because they do not serve the same design function in the trademark or logo. By a more sophisticated use of the algorithm, i.e., where the string search is made only in the principal charge facet, only the designs that use the red tudor roses as the major design element would be included in the response to the search, making the search effort even more efficient.

The development of trademark, logo, and graphic design databases using this type of descriptive algorithm will allow individuals to use automated online systems quickly to locate designs with similar graphic elements. The descriptive patterning in the algorithm does allow comparisons of how elements are used in different trademarks, logos, or graphic designs. It is possible to compare degrees of similarity and/or differences between designs by assigning numerical weights based on the algorithm's facets and segments. If the design element in question is located in the same facet, a value of 1 is assigned to the design. If located in different facets, a value of 2 is assigned to the design. Within each facet a value of 0.1 can be assigned if the designs are of the same color and a value of 0.2 can be assigned if they are of different colors. Designs with a numerical rating of 1.1 would be more similar to the target design than designs with a numerical rating of 1.2. Designs with a numerical rating of 2.1 or 2.2 would be even more different than the target design. Using a weighting system such as this, numerical comparisons can be developed to give an indication of the design similarity between trademarks, logos, and other graphic designs based on the glyphs, location, and color of the design elements. This type of system has potential uses in comparing designs for trademark or logo conflicts.

In another application, art teachers or graphic artists, can use this system to locate quickly graphic designs that express the use of design elements in the patterns that they want. By being able to specify the type of location and relationship among design elements, this algorithm will allow scholars and students to locate examples that show the wide variety of uses which can result from the combination of glyphs.

SUMMARY

Adapting the principles that have evolved in the development of the heraldic blazon to current needs, an algorithm has been developed to aid in the description of graphic designs. Making use of the flexibility of faceted systems, this descriptive algorithm provides an efficient method of describing trademarks, logos, and other graphic materials so that they can be located quickly using mechanical searching techniques. The faceted divisions allow the development of numerical weighted systems to aid in determining the degree of similarity between trademarks, logos, and other graphic designs. Because the algorithm will be used in a mechanical search environment, the complexity of the algorithm will be transparent to the casual user (see Appendix B for examples of the description algorithm).

APPENDIX A. DETAILED EXPLANATION OF THE DESCRIPTIVE ALGORITHM

The first thing that must be described is the background or field of the design. In the heraldic tradition, the assumption is made that the shape of the background will be in the form of a shield for a man, or in the form of a lozenge (diamond) for a woman, and therefore there is no mention made of the external shape of the field. In describing nonheraldic designs, this assumption is not valid, so allowance must be made for a wide variety of field external shapes. The second assumption made by heralds is that the descriptive directions are always given from the point of view of the individual holding the shield. When directions are given from this point of view, the heraldic terms *sinister* (left) and *dexter* (right) will be used. When the description is given from the point of view of the individual facing the design, the directions left and right will be used.

The algorithm is in the form of a faceted description. The facets are: Field Description, Principal Charge Description, Principal Object Description, Secondary Charge Description, Secondary Object Description, and Embellishments Description. Each of the description facets consists of the following segments: location description segment, glyph description segment, and color description segment. One or more of the facets may contain additional description segments. In addition,one or more facets may be embedded within another facet.

SEGMENT DESCRIPTIONS

Location Description Segment

The symbol used to designate this descriptive segment is the "colon backslash" (:\ ). This segment is used to describe the location of the particular graphic element in relation to the design as a whole or to a smaller unit of the design. When using this segment, any one of several different notations may be used to designate location. Traditional heraldic location terms like *chief* (i.e., the upper portion of the shield [design], usually the upper one-third), *fees point* (i.e., the center point of the shield [design]), and *base* (i.e., the lower portion of the shield [design], usually the lower one-third) can be used to designate locations of glyphs on the design. The insertion of the letter "*h*" after the colon backslash (:\ ), will indicate that heraldic terminology is being used (e.g., :\ *h chief*).

A second notational method is to use common descriptive terminology to indicate the location of the glyph. Location can be indicated by using common location terms like *upper, right,* and *diagonal* bisection. The letter *p* inserted after the colon backslash (:\ *p*) will indicate that common descriptive terminology is being used (e.g., :\ *p upper right*).

A third notational method is to use a 10 × 10 grid square to describe the location of the different graphic elements. The letter *g* will be inserted after the colon backslash (:\ *g*) to indicate that a grid square is being used to describe the location of the design elements. In this case the following conventions need to be followed: (1) the graphic design is enlarged to fill the grid without distortions; (2) the origin or 0.0 point is located at the lower left corner of the grid; (3) the *x*-axis is the horizontal axis; (4) the *y*-axis is the vertical axis; (5) the graph location points will consist of two decimal numbers in the following order: *x*-axis location, *y*-axis location; (6) when these numbers are transcribed into the algorithm the following form will be used: *x*-axis number—*y*-axis number (e.g., :\ *g* 5.3—3.4);

(7) the decimal number can range from 0.0 to 10.0 (the decimal extension can be carried out to the right of the decimal point as far as necessary). In the vast majority of cases, one decimal place will be all that is necessary. Because these are decimal numbers, at a minimum, a .0 will be required after each number); (8) a point location will consist of a single set of *x-y* axis points and will represent the center of mass of the glyph (e.g., :\ *g* 4.0—5.4); and (9) an area location will consist of at least three points and will be listed as *x-y* axis pairs with a space comma space separating each pair of points (e.g., :\ *g* 2.3—3.4 , 5.6—9.2 , 7.1—4.6).

A fourth notational system that can be used to describe locations is coordinate geometry. The letter *c* will be inserted behind the colon backslash (:\ *c*) to indicate that the coordinate system is being used to describe the location of the design elements. When using coordinate geometry, the following conventions will be used: (1) the origin or 0.0 is located in the center of the design; (2) the *x*-axis and *y*-axis will be sized to cover the entire design with maximum values of±/ —10.0 units; (3) the *x*-axis is the horizontal axis; (4) the *y*-axis is the vertical axis; (5) the coordinate positions will consist of two decimal numbers in the following order: *x*-axis location, *y*-axis location; (6) when these numbers are transcribed into the algorithm, the following form will be used: *x x*-axis number—*y y*-axis. number (e.g., :\ + *5.3—y* + *3.4*); (7) the decimal numbers can range from -10.0 to +10.0 (the directional signs, "+" and "-" must be included when transcribing these numbers; (8) a point location will consist of a single set of *x-y* axis points and will represent the center of mass of the glyph (e.g., :\ *x* —*4.5*—y —*3.1*); (9) an area location will consist of at least three points and will be listed as *x-y* axis pairs with a space comma space separating each pair of points (e.g., :\ *x* —*2.3—y* ×*3.4* , *x* ×*5.6—y* —*9.2* , *x* ×*7.1—y* ×*4.6*); and (10) a second method of designating area is to indicate the quadrant involved by using the Roman numerals I (+*x*, +*y*), II (—*x*, +*y*), III (—*x*, -*y*), IV (+*x*, -*y*) (e.g., :\ *I*) indicates that the glyph is in the upper right hand quadrant of the design, and also that it has a positive *x*-axis and a positive *y*-axis).

Glyph Description Segment

The symbol used to designate this descriptive segment is the period backslash (.\ ). This segment is used to describe the shape or form of the particular graphic element. There is a large technical descriptive vocabulary that the heralds have built up over the last 700 years that provides compact names for many design motifs. The inclusion of the letter *h* after the period backslash will indicate that heraldic terminology is being used to describe the design element—e.g., .\ *h checky* indicates a checker-board pattern produced by the combination of a barry field [divided into horizontal divisions] and a paly field [divided into vertical divisions] and .\ *h gyronny* indicates that the field is divided into gyrons [triangular pieces] radiating from a central point. The heralds have also developed a set of terms to describe how human, animal, and plant elements are displayed (e.g., .\ *h lion rampant guardant double-queued* indicates that the lion is drawn in profile with the body pointed toward the dexter side of the design, in an erect posture resting upon its sinister hind-paw, with the head of the lion turned to face the spectator, with two distinct tails issuing from the hindquarters). Additionally, a strong vocabulary has been developed dealing with inanimate objects (.\ *h mullet of six points* is a star with six straight rays, and .\ *h estoile of six points* is a star with six wavy rays).

There also have developed over the last several hundred years technical vocabularies to describe graphic design elements used by artists. A good example of the variations of forms that can be described by combinations of several basic shapes is found in the *Handbook of Designs and Devices* (Hornung, 1946). The inclusion of the letter *g* after the period backslash will indicate that graphic terminology is being used to describe the design element (.\ *g triquetra*) [a three-pointed motif derived from three equal arcs of circles arranged in continuous fashion (Hornung, 1946, plate 64)], and . *g monad* [a plane, geometric figure of a circle divided by two equal tangential arcs with opposite centers (Hornung, 1946, plate 166)].

In addition, there are standardized sets of symbols and glyphs developed by different sciences and fields of enterprise that can also be used in descriptions of the graphic elements of a design. The inclusion of the letter *p* after the period backslash will indicate that proper name terminology is being used to describe the design element—e.g., from the field of biology, the .\ *p DNA molecule* or .\ *p double-helix molecule* (a ladder shape that is twisted into a spiral). There are also common forms that can be described by stating their name (e.g., from the field of aviation, .\ *p aircraft,* that can be made as specific as possible to provide the necessary detail to correctly identify the design element (e.g., .\ *p jet aircraft,* and more specifically .\ *p Boeing 747,* and still more specifically .\ *p United Air Lines Boeing 747*).

Color Description Segment

The symbol used to designate this descriptive segment is the comma backslash (,\ ). This segment is used to describe the color of the particular graphic element. There are many different systems in use today to describe or identify different shades of color. The color elements can be described using a generalized color scale similar to one used by the heralds. The heralds have traditionally used seven color indicators, five dark hues referred to as colors, and two light hues referred to as metals. The inclusion of the letter *h* after the comma backslash will be used to indicate that the heraldic color descriptors are being used (e.g., ,\ *h gules,* the heraldic term for red "color" shades, and ,\ *h or,* the heraldic term for gold or yellow "metallic" shades). In addition to the seven traditional hues, heralds also used the term *proper* to indicate that the object is to be colored in its natural colors.

The more common method of specifying color shades that provides a wider range of discrimination is by use of generally accepted color names in popular use. The inclusion of the letter *p* after the comma backslash will be used to indicate that popular usage color descriptors are being used (e.g., ,\ *p burnt orange,*) or ,\ *p candy apple red*).

A more specific color scale like the Inter-Society Color Council—Natural Bureau of Standards (ISCC—NBS) System that describes the color shade in terms of its three perceptual attributes of hue, lightness, and saturation and its Munsell color notation that describes color by use of numerical scales of hue, value, and chroma can be used instead. The ISCC—NBS System divides the color spectrum into 267 color blocks, each of which defines a specific color name. The inclusion of the letter *i* after the comma backslash will be used to indicate that the ISCC—NBS System is being used to describe the color (e.g., ,\ *i reddish orange* or ,\ *i greenish blue*).

There are several other specialized color description systems that can be used in this color descriptor segment by providing an identifying symbol immediately following the comma backslash.

Facet Descriptions

Field Facet

The first part of the algorithm is the field facet. This part of the algorithm is used to describe the shape of the external form of the field or background of the major portion of the design as a whole. The symbol that is used to designate this facet is *F* backslash backslash (*F*\\ ). This facet consists of five separate parts: (1) the external shape of the field, (2) the partition of the field, (3) the location of each partition, (4) the type of partition, and (5) the color of each field partition. The direction of the description is, in the case of a partitioned field, in a clockwise direction from the upper left hand corner of the field as the describer faces the design. The external form of the field is described immediately after the facet symbol *F*\\ ). The symbol # backslash (#\ ), is used to designate the number of partitions in the field. The location description segment is used to describe the location of each of the partitions, the glyph description segment is used to describe each type of partition, and the color description segment is used to describe the color of each partition. When there are two or more partitions, the descriptive set relating to each partition is grouped together between parentheses.

F\\ external form #\ partitions (:\ location$_1$.\ type$_1$,\ color$_1$) ... (:\ location$_n$.\ type$_n$,\ color$_n$)

An example of this facet follows:

F\\ circle #\ 2 (:\ p upper right.\ p diagonal bisection,\ p red) (\ p lower left.\ p diagonal bisection,\ p white)

Principal Charge Facet

The second part of the algorithm is the principal charge facet. It is concerned with the description of the charges or major design elements that rest on the field, the central character of the design. The designation for this facet is *PC* backslash backslash (*PC*\\ ). It consists of three separate parts: (1) the location of principal charge, (2) the type of charge, and (3) the color of the charge. The location description segment, the glyph description segment, and the color description segment are used to describe the principal charge. When there are two or more principal charges, the descriptive set relating to each principal charge is grouped together between parentheses. When describing each charge, the ordering of the description is with the major element of the charge mentioned first, followed by the lesser elements in order of their color being applied. If there is no obvious ordering, as in the case of the field description, the description is in a clockwise direction from the upper left hand corner of the charge as the describer faces the design. The sequence :\ *location* .\ *glyph* ,\ *color* is repeated as each separate part of the charge is described. If there is more than one major charge in the design, then the ordering to be followed is upper left to lower right or top to bottom. Each group of descriptive elements associated with each charge is to be grouped between a pair of square brackets. If the charge is complex enough to require several levels of description, then additional sets of brackets can be used to group the descriptive elements into units—i.e. {[] []} or {[] [] [] [] [] [] []}.

PC\\ (:\ location$_1$.\ glyph$_1$,\ color$_1$) ... {[:\ location$_{n1}$.\ glyph$_{n1}$,\ color$_{n1}$] [:\ location$_{n2}$\ glyph$_{n2}$,\ color$_{n2}$]}

An example of this facet follows:

PC\ (:\ p circle's midpoint .\ p square ,\ p black)

Principal Objects Facet

The third part of the algorithm is the principal objects facet. It is concerned with the description of the objects of minor design elements that rest on the charge. These are design units that are complete in themselves but are located on the charges. The symbol that is used to designate this facet is *PO* backslash backslash (PO\\ ). This facet consists of three separate parts: (1) the location of the principal object, (2) the type of object, and (3) the color of the object. The location description segment, the glyph description segment, and the color description segment are used to describe the principal object. When there are two or more principal objects, the descriptive set relating to each principal object is grouped together between parentheses. When describing each object, the ordering of the description is with the major element of the object mentioned first, followed by the lesser elements in order of their color being applied. If there is no obvious order, as in the case of the field description, the description is in a clockwise direction from the upper left hand corner of the object as the describer faces the design. The sequence *:\ location .\ glyph ,\ color* is repeated as each separate part of the object is described. If there are several major objects in the design, then the ordering to be followed is upper left to lower right or top to bottom. Each group of descriptive elements associated with each object is to be grouped between a pair of square brackets. If the object is complex enough to require several levels of description, then additional sets of brackets can be used to group descriptive elements into units—i.e. {[] []} or {[] [] [] [] []}.

PO\\ (:\ $location_1$.\ $glyph_1$,\ $color_1$) ... { [:\ $location_{n1}$.\ $glyph_{n1}$,\ $color_{n1}$] [:\ $location_{n2}$.\ $glyph_{n2}$,\ $color_{n2}$] }

An example of this facet follows:

PO\\ (:\ p centered on square .\ p PAX ,\ p gold)

Secondary Charge Facet

The fourth part of the algorithm is the secondary charge facet. It is concerned with the description of the charges or major design elements located on the various divisions of the field. The designation for this facet is *SC* backslash backslash (*SC* \ \ ). This facet consists of three separate parts: (1) the location of principal charge, (2) the type of charge, and (3) the color of the charge. The location description segment, the glyph description segment, and the color description segment are used to describe the secondary charge. When there are two or more secondary charges, the descriptive set relating to each secondary charge is grouped together between parentheses. When describing each charge, the ordering of the description is with the major element of the charge mentioned first followed by the lesser elements in the order of their color being applied. If there is no obvious ordering, as in the case of the field description, the description is in a clockwise direction from the upper left hand corner of the charge as the describer faces the design. The sequence *:\ location .\ glyph ,\ color* is repeated as each separate part of the charge is described. If there is more than one secondary charge in the design, then the ordering to be followed is upper left to lower right or top to bottom. Each set of descriptive elements associated with each charge is grouped between a pair of square brackets. If the charge is complex enough to require several levels of description, then additional sets of brackets can be used to group the descriptive elements together into units—i.e., {[] []} or {[] [] [] [] []}.

SC\\ (:\ $location_1$.\ $glyph_1$,\ $color_1$) ... {[:\ $location_{n1}$.\ $glyph_{n1}$,\ $color_{n1}$] [:\ $location_{n2}$.\ $glyph_{n2}$]}

An example of this facet follows:

SC\\ (:\ p upper right bisection .\ p lily ,\ p white) {[:\ p lower left bisection .\ p rose ,\ p red] [:\ p lower left bisection beneath rose .\ p bowl ,\ p green]}

Secondary Objects Facet

The fifth part of the algorithm is the secondary objects facet. It describes the objects or minor design elements that rest on the secondary charges. These are design units that are complete in themselves but are located on the charges. The designation used for this facet is *SO* backslash backslash (*SO*\\ ). It consists of three separate parts: (1) the location of the principal object, (2) the type of object, and (3) the color of the object. The location description segment, the glyph description segment, and the color description segment are used to describe the secondary object. When there are two or more secondary objects, the descriptive set relating to each secondary object is grouped together between parentheses. When describing each object, the ordering of the description will be with the major element of the object mentioned first, followed by the lesser elements in the order of their color being applied. If there is no obvious ordering, as in the case of the field description, the description will be in a clockwise direction from the upper left hand corner of the object as the describer faces the design. The sequence :\ *location* .\ *glyph* ,\ color will be repeated as each separate part of the object is described. If there is more than one secondary object in the design, then the ordering to be followed is upper left to lower right or top to bottom. Each group of descriptive elements associated with each object is to be grouped between a pair of square brackets. If the object is complex enough to require several levels of description, then additional sets of brackets can be used to group the descriptive elements together into units—i.e., {[] []} or {[] [] [] [] []}.

SO\\ (:\ $location_1$\ $glyph_1$\ $color_1$) ... {[:\ $location_{n1}$.\ $glyph_{n1}$,\ $color_{n1}$] [:\ $location_{n2}$.\ $glyph_{n2}$,\ $color_{n2}$]}

An example of this facet follows:

SO\\ (:\p upper right bisection in center of lily .\h mullet of five points ,\p black) {[:\p lower left bisection on left side of rose .\p lady bug ,\p gold] [:\p lady bug's wings .\p 5 dots ,\p black]}

Embellishment Facet

The sixth and last part of the algorithm is the embellishment facet. It is concerned with the description of the embellishments or auxiliary design elements associated with the design but not actually a part of the design. The symbol used to designate this part of the algorithm is *E* backslash backslash (*E*\\ ). Examples from heraldry are the crests, helms, mantles, supporters, and mottoes associated with a heraldic device but not actually an integral part of the design. These are design units that are complete in themselves but are located externally to the design field. The location description segment, the glyph description segment, and the color description segment are used to describe the embellishments. When there are two or more embellishments, each embellishment's descriptive set is grouped together between parentheses. When describing each object, the ordering of the description will be with the major element of the object mentioned first, followed by the lesser elements in order of their color being applied. If there is no obvious ordering, as in the case of the field description, the description will be in a clockwise direction from the upper left hand corner of the object as the describer faces the design. The sequence :\ *location* .\ *glyph* ,\ *color* will be repeated as each separate part of the object is described. If the embellishment is very complex, it may be necessary to make use of the previous five facets in describing the embellishments. In this case these facets are to be enclosed within the parentheses that enclose the descriptive elements associated with the embellishment. If there is more than one embellishment in the design, then the ordering to be followed is upper left to lower right or top to bottom. Each group of descriptive elements associated with each embellishment is to be grouped between a pair of square brackets. If the object is complex enough to require several levels of description, then additional sets of brackets can be used to group descriptive elements into units—i.e., {[] []} or {[] []} {[] [] []}.

E\\ (:\ location$_1$.\ glyph$_1$,\ color$_1$) ...){[:\ location$_{n1}$.\ glyph$_{n1}$,\ color$_{n1}$] [:\ location$_{n2}$.\ glyph$_{n2}$, color$_{n2}$]}

An example of this facet follows:

E\\ (:\p below the circle .\ p scroll ,\p gold [.\p inside scroll .\p MORTE ,\p red])

Using the descriptive designator symbols, the complete generalized algorithm for graphic descriptions is:

F\\ #\ (:\ .\ ,\) PC\\ (:\ .\ ,\) PO\\ (:\ .\ ,\)
SC\\ (:\ .\ ,\) SO\\ (:\ .\ ,\) E\\ (:\ .\ ,\)

Each of the different descriptive designator units can be expanded as needed by the use of grouping brackets: [...], {[...]}.

Over the last 900 years the heralds have developed a rich descriptive language that includes terms for different types of field patterns and divisions, types of lines and objects, and positioning of animal and human bodies. This rich historic tradition provides a strong base on which to build a standardized technical language for the description of graphic forms. The addition of new terms to cover modern developments and non-Western forms and the use of heraldic *proper* will provide a controlled vocabulary that will, when combined with this faceted algorithm, make it possible to classify graphic designs so that related design elements, either in part or whole, can easily be brought together and compared. The use of the system symbols to indicate the notation system being used to describe the location, glyph, and color will make the algorithm highly flexible and easily adaptable to various user populations.

APPENDIX B. EXAMPLES OF THE DESCRIPTION ALGORITHM

The first series of examples will be of simple heraldic devices described first by blazon and then by the descriptive algorithm. In these instances, the algorithm may appear awkward as compared with the blazon format; however, the algorithm is designed for mechanical processing and the blazon is not. Another item of difference is that in the algorithm all individual facets are presented whether or not there is any graphic element to fill them. The blazon is a shorthand representation that assumes the reader understands how the graphic elements are positioned without extensive details being given (e.g., it is assumed that all graphic elements are centered in their particular space unless otherwise indicated). This assumption cannot be made with the algorithm, and therefore more detail is required.

Figure 1

Blazon: Azure, a bell with a pull argent (Metzig, 1983, pp. 69, 128)

Algorithm: F\\h half-round shield #\ (:\ .\ ,\h azure)PC\\ (:\p centered .\p a bell with two rope pulls ,\h argent) PO\\ (:\p centered on bell .\h cross fleuretty ,\h argent [:\p centered on cross fleuretty .\h cross fillet ,\h sable]) SC\\ (:\ .\ ,\) SO\\ (:\ ,\ ,\) E\\ (:\ .\ ,\)

In this example, an examination of the algorithm reveals that it is much more specific in the quantity and quality of details than is the blazon. The blazon assumes that much of the unstated information is known and will be applied by the heralds at the correct spot in the translation of the description into a graphic image. The algorithm does not make any such assumption. Where the blazon makes the assumption that the external field shape is that of a shield, the algorithm does not and describes the shield shape. Another blazon assumption not made in the algorithm is that the principal charge (i.e., the bell) is centered on the shield unless otherwise stated. The algorithm requires that each item in the description have a stated location. A third difference between the blazon and the algorithm is that the algorithm specifically details the number of the pull ropes associated with the bell and also the ornamentation on the bell, whereas the blazon leaves this to the herald's imagination. A fourth item to be noted is that the algorithm allows the mixing of different description systems to provide a clearer descriptive picture of the icon.

Figure 2

Blazon: Azure, a quill in pale covering a book open under three crowns argent (Metzig, 1983, pp. 69, 128)

Algorithm: F\\ h half-round shield #\ (:\ .\ ,\ h azure) PC\\ (:\ h base .\ p open book ,\ h argent) PO\\ (:\ h in pale from base through fess .\ h quill ,\ h argent) SC\\ (:\h chief .\ h leaf crown ,\ h argent) (:\ h left flank .\ h leaf crown ,\ h argent) (:\ h right flank .\ h leaf crown ,\ h argent) SO\\ (:\ .\ ,\) E\\ (:\ .\ ,\)

The above example demonstrates one way to describe how one icon is superimposed over another (i.e., the quill laying over the book). It also shows how secondary charges are described (i.e., the leaf crowns).

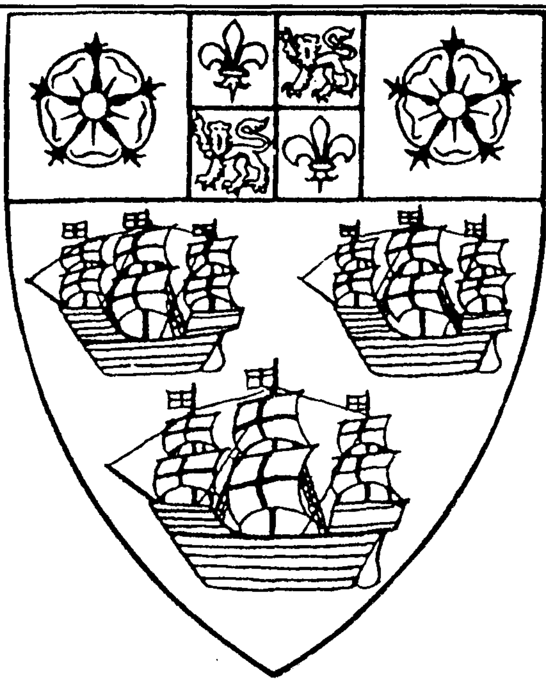

Figure 3

Blazon: Azure, three ships gold, under all their sails garnished with crosses gules, and upon a chief or between two roses proper an additament out of the Arms of England, quarterly azure and gules in the first and last one flower de luce or, and in the second and third a lion passant guardant of the same (Dennys, 1982, pp. 48-49)

Algorithm: F\\ p Shield #\ (:\ .\ ,\h azure) PC\\ (:\ h dexter flank .\ p ship under full sail ,\ h or) (:\h sinister flank .\ p ship under full sail ,\ h or) (:\ h middle base ,\ p ship under full sail ,\ h or) PO\\ (:\ p on sails .\ h crosses ,\ h gules) SC\\ (:\ h chief .\ h chief ,\ h or) SO\\ (:\ h dexter canton .\ h rose ,\ h proper) (:\ h middle chief .\ h Arms of England *[F\\ 4 (:\ p upper left quarter .\ p quarter , \ h azure) (:* p upper right quarter .\ p quarter ,\ h gules) (:\ p lower right quarter .\ p quarter ,\ *h azure) (:\ p lower left quarter .\ p quarter ,\ h gules) PC\\ (:\ p upper left quarter .\h fleur-de-lis ,\ h or) (:\ p upper right quarter . \ h lion passant guardant ,\ h or) (:\ p lower right quarter .\ h fleur-de-lis ,\ h or) (:\ p lower left quarter .\ h lion passant guardant ,\ h or PO\\ (:\ .\ ,\) SC\\ (:\ .\ , \) SO\\ (:\ .\ ,\) E\\ (:\ .\ ,\)\]* ,\ proper) (:\ h sinister canton .\ h rose ,\ h proper) E\\ (:\ .\ ,\)

This example provides an illustration of how to describe a design that includes, as part of the larger overall design, another separate complex design. In this design granted to the East India Company, the Arms of

England are embedded in the upper middle of the design. The way this problem is handled with the algorithm is illustrated in the italicized portion of the description. The Arms of England is a secondary object in the overall design, and described in the secondary object facet. After the name of the design object (i.e., the Arms of England) is mentioned, square brackets are used to set aside a separate complete set of the algorithm that is used to provide a complete description of this design. Following the closing square bracket, the color description segment has the notation *proper* to indicate that the arms are to be colored as described in the preceding description. The algorithm description of the Arms of England has been inserted into the algorithm description of the Arms of the East India Company at the point where Arms of England are named as a graphic element of the design. This type of nesting can be done to whatever level or degree is necessary to provide an adequate description of the design in question. The next group of figures is a series of company logos that present difficulties in being blazoned because they are not based on a shield design but are easily described using the algorithm.

Figure 4

Algorithm: F\\ #\ (:\ .\ ,\) PC\\ (:\ p centered .\ p script "Coca-Cola" ,\ p red) PO\\ (:\ p lower right side .\ p ® ,\ p red) SC\\ (:\ .\ ,\) SO\\ (:\ .\ ,\) E\\ (:\ .\ , \)

The Coca-Cola® logo does not have a prescribed background field so no field is described. The logo itself is a fancy scripted version of the terms Coca-Cola. The ® is a standard graphic mark that indicates the logo has been legally registered and is protected.

Figure 5

Algorithm: F\\p Circle (:\ c radius of 8 units .\ p circle ,\ p orange rimmed in black) PC\\ (:\ c *x*-10—*y* + 3 , *x*-10—*y*-3 , *x*+10—

y+3 , x+10—Y-3 .\ p fess extended beyond circle rim ,\ h argent) PO\\ (:\ h fess .\ p block letters "Gulf" ,\ h sable) SC\\ (:\ .\ ,\) SO\\ (:\ .\ ,\) E\\ (:\ .\ ,\)

In this example, the use of coordinate geometry is illustrated as a method to describe the location of design elements. First, the size and shape of the field is defined as a circle with a radius of eight units. Then the fess structure, which extends beyond the circumference of the circle, is also described by the use of coordinate geometry.

Figure 6

Algorithm: F\\ p Rectangle #\ 3 (:\h chief .\ h chief ,\ h azure) (:\ h fess .\h fess ,\ h argent) (:\h base .\ h base ,\h or)
PC\\ (:\ h fess .\ p block letters "VISA" .\h azure)
PO\\ (:\ .\ ,\) SC\\ (:\ .\ ,\) SO\\ (.\ ,\) E\\ (:\ .\ ,\)

This example illustrates the division of the field into several parts—i.e., the chief, fess, and base. In this case, the use of heraldic terms for the division fits the structure of the design nicely. This also emphasizes that heraldic terms are not restricted to heraldic devices or blazons.

Glossary of Heraldic Terms

argent: silver or white
azure: blue
base: bottom third of the figure
chief: top third of the figure
cross fillet: a plain line cross
cross fleuretty: an ornamental form of the cross
fess: middle third of the figure
flank: side of the figure between the base and the chief
quadrant: profile showing full face
gules: red
or: gold or yellow
pale: vertical middle third of the figure
passant: walking position
sable: black

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ArchiVISTA: A New Horizon in Providing Access to Visual Records of the National Archives of Canada

GERALD STONE AND PHILIP SYLVAIN

ABSTRACT

IN ORDER TO MAKE more accessible to researchers and the general public the 20,000 editorial cartoons and caricatures in its holdings, the National Archives of Canada developed an optical disc imaging system called ArchiVISTA which merges high resolution imaging technology with the power and flexibility of a fourth generation database language. The authors present a case study of this pilot project after briefly outlining earlier developments in bibliographic control and imaging technology as applied to the National Archives of Canada's graphic records.

INTRODUCTION

When the new gallery of the Canadian Centre for Caricature first opened its doors in Ottawa's lively Byward Market district in June 1989, the public was invited not only to view *The Rogues Gallery*—the inaugural exhibition of Canadian political cartooning—but to avail themselves of the centre's new optical disc image retrieval system, ArchiVISTA. Providing online access to a visual catalog of some 20,000 original editorial cartoons and political caricatures, the ArchiVISTA optical disc system heralds an important new milestone in providing intellectual access to the substantial documentary art and photography collections of the National Archives of Canada.

The Canadian Centre for Caricature was established in May 1986 as a program of the National Archives' Documentary Art and Photography Division. One of the chief aims of the new centre was to increase public awareness of the existing body of cartoons which

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had been collected and preserved by the National Archives since 1906 when, as noted by James F. Kenney (1925), authorization was, for the first time, given to the Dominion Archivist to expend money for the purchase of paintings, drawings, and prints. This goal of raising the public profile and improving accessibility to the caricature collection has been vigorously pursued along many avenues including those of exhibition, publication, and the opening of a new gallery, as previously mentioned. It was also decided to explore the feasibility of using state-of-the-art imaging technology to capture and link each image to a brief, descriptive record in a computer database.

The concept of a visual catalog of art holdings is not a new one. The Public Archives of Canada's report for the years 1959-1969 notes that, in 1964, to assist reference and prevent unnecessary handling, photographic reproductions were made of the paintings and drawings, and a contact print was incorporated into the card catalog. A year later, production of the 5 × 8-inch catalog cards with contact prints from 4 × 5-inch copy negatives was extended to the growing collection of historical photographs. Except for minor improvements, these image-bearing catalog cards remained unchanged for nearly twenty years. In April 1983, with the installation of a new microcomputer system in the then National Photography Collection, the typewritten photo caption was superseded by computerized records from which labels were printed and affixed to the catalog cards. Even though the catalog card still looked much the same as it had before, an important difference was the beginning of an automated file or database of the National Archives' visual documents described at the item level.

Other related automation activities included development of a collection level bibliographic database from which were produced two editions (1979 and 1984) of the *Guide to Canadian Photographic Archives* and, in 1984, implementation by the former Picture Division of the current item level database using MINISIS software on a Hewlett Packard HP3000 minicomputer.

A kindling of interest in the potential benefits of videodisc technology paralleled the National Archives' application of computerized bibliographic information storage and retrieval systems to the administrative and intellectual control of its documentary art and photography collections in the late 1970s and early 1980s. A pilot project was initiated in September 1978 to explore the use of the videodisc as a storage medium for archival records (Mole & Langham, 1982). In 1983, further tests were conducted to determine the feasibility of electronically reproducing black-and-white and color photographic prints. The results were low quality prints that could be used as "proofs;" however, the resolution and density range of the reproductions needed to be improved to meet the departmental standards for photographic prints (Public Archives of Canada, Annual Report 1984-1985). The following brief outline serves to show that the development of the ArchiVISTA system has built upon an accumulated store of knowledge and experience in both bibliographic databases and imaging technology.

Planning and Analysis

Two separate studies provided valuable information prior to the development of a detailed set of specifications for an optical disc system. In December 1987, conservator Greg Hill completed the Cartoon Materials Survey to establish how the apparent instability of much of the collection should affect the collection policy of the centre. By means of a literature survey, telephone interviews with cartoonists, and an examination of approximately 10 percent of the existing collection, the Cartoon Materials Survey summarized conservation problems and identified resources necessary for the maintenance of the collection based on recommended conservation, storage, and display requirements. Hill also recommended that all cartoons should be copied onto an easily accessible medium for research purposes to minimize their handling. Steps had already been taken to do just that. In February 1988, the National Archives' optical disc advisor submitted recommendations concerning an optical disc system for the centre following completion of a needs assessment and feasibility study (Sylvain, 1988a).

The expressed need for the centre was for a system that would provide quick and easy visual access to the described caricature holdings of the National Archives without having to handle original items, thus facilitating the long-term storage and conservaiton of the collection. Ten different technological means to achieve this goal were initially considered including various forms of photography, microfilm, and optical disc.

Copying of the caricature collection by means of conventional photography—that is, producing reference prints from 4 × 5-inch copy negatives of each item—would prove too time-consuming and laborious, hence costly, beside which was the added inconvenience of lengthy delays between manual image retrieval from a card catalog or filing cabinet and searching a database for the related descriptive records. This latter problem of separate imaging and descriptive systems and its inconvenience to the user also ruled out the use of microfilm unless the 16mm rolls were integrated into a computer-assisted retrieval (CAR) system. Even then, the image-bearing medium was considered too susceptible to scratching and other forms of degradation from frequent use, while no less than a dozen separate rolls would be required for the storage of the entire collection necessitating excessive handling.

A drawback common to CD-ROM (Compact Disc-Read Only Memory) and videodisc-based systems is the need for factory-mastering which, aside from being costly for small production runs, prohibits subsequent additions or changes to be made to the disc. Owing to the ongoing acquisition of substantial numbers of cartoons by the National Archives, this limitation could not be easily overlooked. North American standard NTSC (National Television System Committee) video has the further disadvantage of a maximum of 480 scan lines per image, insufficient to capture, in a single frame, detail as small as 1/100th of the image height, which is representative of approximately 70 percent of the collection.

A problem of all analog systems, including analog WORM (Write Once Read Many) optical discs, is the lack of error detection and correction of information without a digital intermediate step. This causes analog images to deteriorate over time, necessitating eventual recopying with an unknown amount of generation loss. Based upon information available on digital discs made of the same material, analog optical discs were estimated to last about ten years before requiring recopying. Within the archival context, the inherent long-term instability of analog media was considered too serious a flaw on which to base an advanced technology system.

The technology investigation ultimately revealed digital WORM optical disc as the most promising and likely medium on which to base an image capture system, combining high resolution with error detection and correction capabilities to assure minimal generation loss of image quality over an extended period of time, including the foreseeable migration of data necessary to benefit from future technological advancements. In addition, the discs required no factory mastering and would allow for expansion of the image base as more caricatures and cartoons were acquired.

Our euphoria was soon tempered by a growing realization of the digital disc's few shortcomings. High resolution and other desired features were achievable but at the expense of slower, costlier capture devices and large image file sizes, meaning greater numbers of storage media required and slower retrieval speeds. As a consequence, three different approaches to image capture and retrieval were considered: bit mapping, byte mapping, and a hybrid of video, digital, and analog technology.

In the hybrid system, images would be captured at NTSC video resolution, stored onto digital WORM optical discs, and then transferred to analog WORM optical disc for retrieval. The major disadvantage of this approach lay with the low video resolution which would have necessitated additional scanning of many images in order to preserve important details. In both bit map and byte map systems, images would be digitally scanned, stored, and retrieved from digital

WORM optical discs. While sufficiently high resolution could be obtained using either of these methods, bit mapping, involving the scanning of images at one bit per pixel, could only reproduce two tonal levels, white or black, without resorting to some form of grey scale simulation. Byte mapping or grey scale scanning resolves this problem by scanning images at 8 bits per pixel, permitting the capture of up to 256 grey levels. On the other hand, byte mapping was also more costly than either of these two approaches as can be seen from the cost comparison in Table 1.

TABLE 1. CANADIAN CENTRE FOR CARICATURE COST COMPARISON

Costs[1]	*Photography*	*Microfilm*	*Hybrid*	*Bit Map*	*Byte Map*
Capture Equipment[2]	Included	$ 15,800	Included	$ 8,300	$ 27,650
Media	Included	$ 200	$ 3,300	$ 1,550	$ 12,400
Labor[3]	$214,700	$13,500	$38,000	$21,100	$ 30,000
Development	N/A	N/A	N/A	$20,000	$ 32,650
Retrieval System	$ 21,850	$45,850	$22,400	$46,650	$ 46,600
Total Cost	$236,550	$75,350	$63,700	$97,600	$149,300

Notes:
[1]All costs are in Canadian dollars based on estimates prepared in 1987 with the exception of the byte map system which shows actual costs in 1989 Canadian dollars.
[2]Based upon rental, not purchase, of camera or scanner and related equipment.
[3]Includes cost of labor to perform image capture and tagging only. Does not include the cost of descriptive cataloging or subject indexing.

EVALUATION AND DESIGN

A set of more than seventy criteria, augmented by product demonstrations and test samples, was used to evaluate bit map and hybrid systems in terms of input, storage, indexing, retrieval, output, and general system requirements for the Canadian Centre for Caricature's application as well as for the more varied needs of the Documentary Art and Photography Division, with its holdings of more than 10 million photographs, 200,000 works of art, and a national collection of postage stamps. Each criterion was assigned a weight value from 1 to 10, depending on its relative importance to each application. For example, the capability to scan continuous tone color images was assigned a very low weight for the caricature application, with less than 5 percent of its holdings in color, while having a very high weight for the combined holdings of art, photography, and philately in which color plays a much more prominent role.

Based on this evaluation and market survey, conducted by managers of the Documentary Art and Photography Division in conjunction with the Optical Disc Advisor, a decision was reached to develop a detailed set of specifications for the procurement of an optical disc system with bit map functionality as a minimum but with the desirable capability of byte mapping. This approach was taken partly because, after considerable discussion with numerous industry representatives, it became apparent that no turnkey system then on the market met all needed requirements. At the same time, a responsive chord was struck with a small number of companies who saw in our application an opportunity to develop a market for state-of-the-art imaging systems for cultural property agencies including, but not limited to, archives, museums, art galleries, and libraries in government and the private sector.

While the scope of this article precludes lengthy discussion of all or most of the many system specifications, some key requirements are worth mentioning at this point. Image capture was to be performed on site in order to minimize the stresses or potential hazards to which the collection of archival drawings could be subjected. The image capture subsystem had to be provided on a rental basis and operated as a contracted service since, given the prevailing mood of restraint, the expenditure of any human resource allotment to a function which was not our direct responsibility would be unjustifiable. The image capture device had to accommodate originals ranging in size from 11 × 15 inches or smaller up to 34 × 44 inches and, in tonal characteristics, from black-and-white line and continuous tone drawings with the desirability of handling color. Sufficient resolution was required such that, on printing or display, detail as small as 1/100th of the image height could be seen clearly. The system had to be capable of printing reference-quality prints, although publishable-quality printing was highly desirable. The maximum response time for image display was ten seconds for continuous tone images and five seconds for black-and-white line drawings.

Certain requirements were necessitated by departmental or federal policies. In keeping with the Canadian government's official languages policy, for example, the database and user interface had to be fully bilingual. Specification of AT-class machines running on MS-DOS as the departmental standard for workstations precluded serious consideration of other systems such as Macintosh or UNIX.

A Request For Proposal (RFP), together with detailed system specifications (Sylvain, 1988b), was sent out on July 22, 1988 to about twenty potential vendors in Canada and the United States. The specifications were divided into three sections dealing with the image capture subsystem, the image retrieval subsystem, and contract conditions such as acceptance criteria, training, service, maintenance, and financial terms. Specifications were designated as either mandatory, meaning any bid not meeting such a specification would be sufficient reason for disqualification, or desirable, in which case a point rating was assigned by a technical evaluation team. A bidders' conference was held in August to give interested parties an opportunity to ask questions related to the RFP or specifications and to view the collection and facilities provided by the National Archives of Canada for on-site image capturing at its headquarters in Ottawa. Of the six bids that were tendered, that of Fifth Dimension CAD/CAM Systems of Ottawa was selected as the winning proposal, offering all mandatory, and the highest number of desirable, features at the lowest cost.

IMAGE CAPTURE

The image capture subsystem is composed of an Eikonix EC850 planetary photodigitizing camera, an 80386-based IBM AT compatible microcomputer with a VISTA videoprocessor board, VGA controller, a 19-inch 1024 by 768 image monitor, a 14-inch data monitor, and Laserdrive 810 5¼-inch digital WORM optical disc drive. The capture subsystem configuration which shows the system being used for quality control of scanned images is illustrated in Figure 1.

Illumination is provided by two 1 Kilowatt Lowel Tota lights on stands, each equipped with a constant voltage regulator power supply. Neither the high-intensity quartz lamps which came with the Eikonix camera stand nor fluorescent lights proved satisfactory, the former providing too much heat and uneven illumination while the 60 Hertz flicker of the fluorescent lights caused the scanned image to have alternating bands of lighter and darker lines.

Prior to image capture, original drawings were arranged by size groupings and artist on nearby shelving. This minimized the need to adjust the camera head height for every scan and assured whatever similarity might exist in gross image characteristics as a result of an artist's style and use of materials. At the start of each capture session, the system would be initialized so as to establish minimum and maximum density values. After scanning, the original drawings were again placed on shelves from which they were stored away in archival containers by custodial staff.

To scan an image, the camera operator places the original drawing on the illuminated bed of the photodigitizing camera and focuses the 55 mm Nikkon Macro lens using electronic feedback. The thickness of a horizontal bar on the monitor varies as focus is adjusted, displaying the difference in intensity between adjacent pixels. Maximum sharpness is achieved when the focus bar appears thickest. Exposure, affecting image density and contrast, can be adjusted via the lens aperture or by increasing or decreasing the exposure time of each step in the scanning. In practice, the fastest scan rate was usually used with the exposure being adjusted by opening up or stopping down the lens aperture.

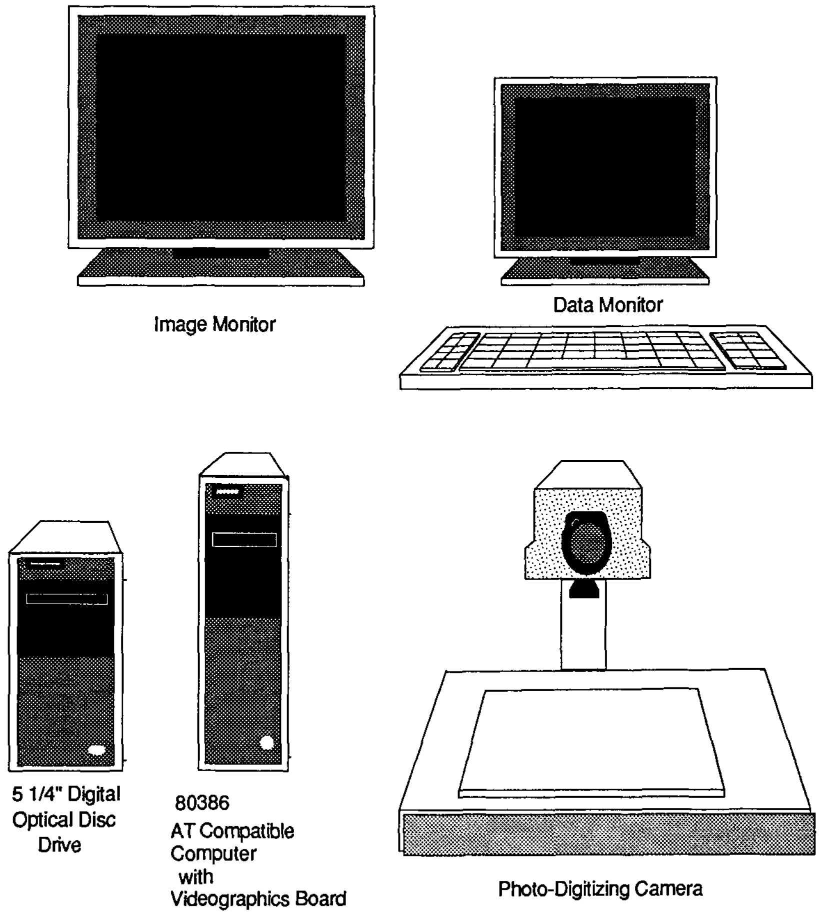

Figure 1. ArchiVISTA Capture Station.

The camera has a small linear array located at the film plane of the lens. As the array moves across the image, each pixel of the element emits an electrical signal which is proportional to the intensity of the light which strikes it. These electrical signals are digitized and stored in the memory of the videoprocessor board. The videoprocessor displays the stored data one scan line at a time, providing the camera operator with instantaneous feedback as the image is gradually built up. This allows the operator to assess the image quality and, if need be, interrupt the scan; adjust variables such as focus, exposure, or lighting; and rescan the image. Once the entire image is scanned, the operator is prompted to accept or reject it.

When a scanned image is accepted, it is stored in the videoprocessor board's 4 megabyte RAM buffer and the operator is prompted to enter image tagging information consisting of essential control data. This includes the accession and item number of the original drawing, the operator's name, and the date of capture. The accession and item number, uniquely identifying every holding within the collection, provides a link to any corresponding descriptive record in the National Archives' MINISIS database and also allows the system to display this number in the upper right hand corner of each image written to optical disc. The system automatically assigns a frame or tag number as well as the number and side of the optical disc in the optical disc drive. Before writing the image to the optical disc and the tagging information to a file on the hard disc, the operator is prompted to verify the accuracy of the tagging information.

The system-supplied tag number serves both as the MS-DOS image and disc header file names, differentiated by the extensions TGA and CRP respectively. The header file, in ten bytes, documents cropping, resolution, and the number of bits per pixel at which each image was scanned. The image file is automatically time and date stamped by the disc operating system (DOS), permitting the number of images scanned per day and time per image to be easily determined. With the exception that partitions can be larger than 32 megabytes, the optical disc software emulates a standard DOS hard disc. This facilitates hardware/software compatibility with, and file transfers to, other DOS-based systems.

Development of the ArchiVISTA image capture subsystem commenced with the awarding of a contract to Fifth Dimension CAD/CAM Systems Inc. in September 1988. After four months of development and testing, the go-ahead was given to begin image capture of the caricature collection. We chose not to use compression methods in capturing after noticing image deterioration in decompressed images which, upon magnification, displayed checkerboard type patterns. This decision reflects the high level of importance that was attached to achieving as faithful a reproduction of the original archival document as possible. Instead, we achieved an even greater economy of scale in the compression of images than had been originally anticipated by opting for storage of the digitally-captured images on a videodisc-based retrieval system, which is described in greater detail under Image Retrieval.

All drawings were scanned border to border so as to capture any inscriptions or annotations outside the cartoon and to preserve the relationship of image to support. A second scan was performed just on the image area of drawings with borders more than 30 percent of the surface area in order to capture sufficient detail without having to scan at a higher, but slower, more space-consuming, resolution. Special attention was also given to ensure that the camera operator preserved, rather than filtered out, any stains, smudges, or what otherwise might be considered undesirable picture elements.

Line art and continuous tone drawings, comprising 70 percent of the collection, were scanned in black and white with eight bits per pixel at 1024 × 768 resolution. The resultant file size of 0.75 megabytes meant that approximately 1,000 images could be stored per 800 MB 5¼-inch digital WORM optical disc. Scanning of these images was completed the first week in July 1989. Later improvements in the scanner interface software increased the capture speed by about 75 percent so that toward the end of the project an average of 250 line art drawings could be scanned per day.

The 25 percent of the collection containing dry transfer materials such as "Lettratone" was scanned in black and white with eight bits per pixel at 2048 × 1536 resolution, at a rate of 150 per day. The 3 MB file size allows approximately 250 of these images to be stored per 800 MB optical disc. The higher resolution was necessary to avoid moire patterns or visual resonance. The frequency of the halftone dots on dry adhesive, used by some cartoonists to simulate grey tones, is higher than the scanning spatial frequency, causing the displayed image to appear to be vibrating. By sampling at a higher frequency, this disturbance was eliminated. Color images, constituting only 5 percent of the collection, were scanned 32 bits per pixel at 1024 × 768 resolution, permitting faithful reproduction on the monitor of a Kodak color test chart. File size of the color images is also 3 megabytes.

Customer acceptance of the contracted image capture and tagging was provided by performing quality control on a random sample of 10 percent of every 2,000 scanned images. A visual inspection of the displayed image and its corresponding database record was compared against the original drawing to verify the accuracy of the tagging information and assess the quality of image reproduction. Fortunately, all quality control checks performed to date have fallen within the 1 percent error rate considered acceptable.

Image Retrieval

Development of the ArchiVISTA image retrieval subsystem prototype started immediately following acceptance of the image capture subsystem. Although we had originally envisaged using digital WORM optical disc for retrieval, the use of videodisc technology was proposed as a superior means of meeting or exceeding the specified speed and resolution for display and printing. This approach involves dividing each digital image into four NTSC video frames using a videoprocessor board and storing these, along with one overall frame of the original drawing, onto 1-inch "C" type videotape for mastering to 12-inch videodisc. Retrieval from the videodisc is accomplished by seamlessly recombining the quadrant images into a single high resolution image. The overall, or fifth, frame will be used for simultaneous viewing of up to four different drawings on a high resolution monitor. In anticipation of the demand for decentralized access, the overall frame can also be used in retrieval systems not equipped with high resolution monitors. Moreover, the videoprocessor's capability to handle real time video display of NTSC resolution opens up the possibility of making available moving images, sound, and data in conjunction with high resolution images to prepare, for example, an audiovisual tutorial.

The database management system (DBMS) selected for ArchiVISTA was ZIM, a fourth generation language product of Zanthe Information Inc. ZIM supported the need for a fully bilingual database and user interface, Boolean searching, and the ability to enter descriptive records composed of variable length and repeatable fields either directly or through file transfers from MINISIS, a minicomputer-supported DBMS widely used within the National Archives of Canada for the description of archival holdings. In addition to a data entry module, the user interface provides a search screen with which the user can specify or browse one or more of the following access points: subject, artist, publication, place, date, and unique item numbers.

When a search is executed, the user is provided the option of modifying the search parameters or viewing the hit file of images and corresponding descriptive records. Current display time is an acceptable seven seconds per image, although some effort is being made to further reduce it to around three seconds. The user can also pan across or zoom in on a portion of a selected image using a mouse while a help feature can be called upon at any time to provide context sensitive assistance. The equivalent of newspaper quality images can be printed on ordinary bond paper using a standard laser printer specially equipped to reproduce 100 line per inch halftone images.

The ArchiVISTA system was demonstrated to senior managers of the National Archives of Canada on March 21, 1989. Spurred by their strong interest and high-level support, work began in earnest to showcase a prototype of the ArchiVISTA retrieval workstation at the official opening of the new exhibition gallery of the Canadian Centre for Caricature on June 22, 1989. An online tutorial was prepared and 250 images were selected and copied onto an analog WORM optical disc using the quadrant method discussed earlier. These were, in turn, linked to their corresponding descriptive records which had been downloaded from MINISIS. Among the final touches, a custom wooden cabinet was made to house an IBM AT 80286 compatible microcomputer with VISTA videoprocessor board, an 8-inch analog WORM optical disc drive, a 14-inch data monitor, a 19-inch high resolution image monitor, keyboard, and mouse (see Figure 2). All was ready. With the ribbon-cutting ceremony marking the official opening of the new gallery of the Canadian Centre for Caricature, ArchiVISTA made its public debut.

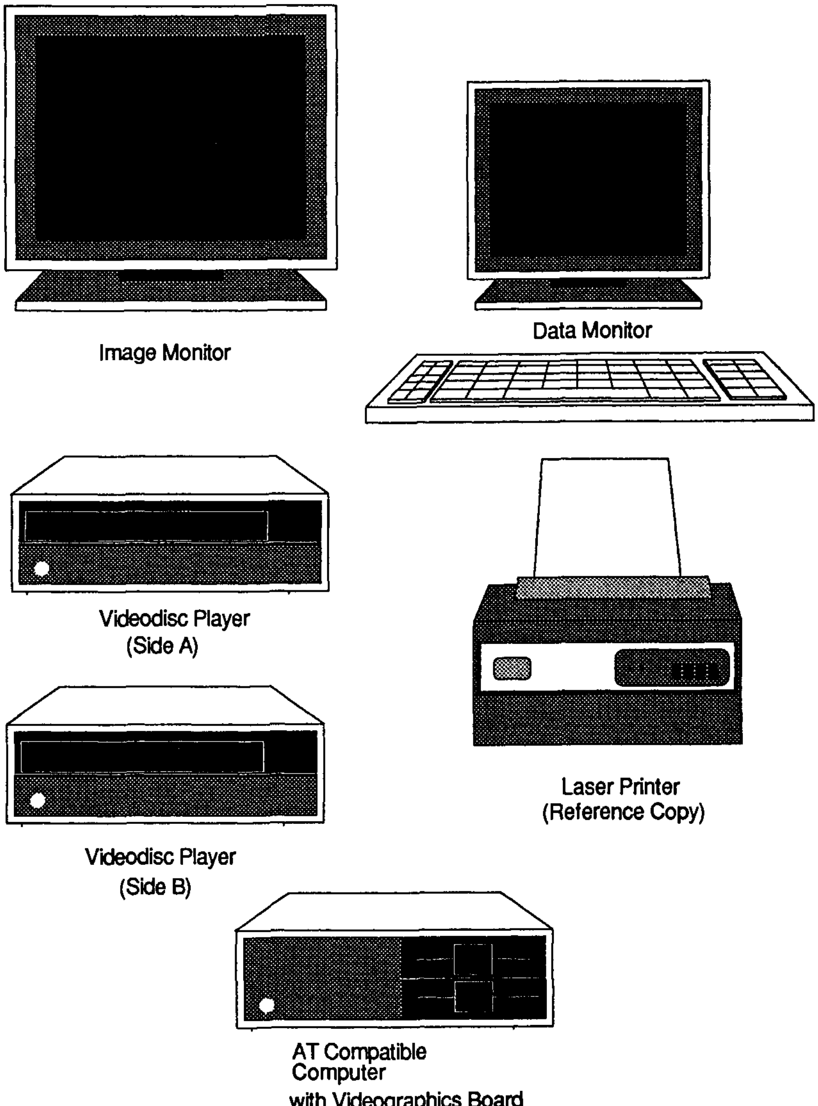

Figure 2. ArchiVISTA Retrieval Station.

CONCLUSION

An application for the transfer of the National Archives of Canada's EDP records to 12-inch digital WORM optical discs for long-term storage began not long after the start up of the Canadian Centre for Caricature's application. With the scanning of the last of the centre's original drawings nearing completion, the contents of the thirty-odd 5¼-inch digital WORM optical discs will soon be copied to the glass-encased 12-inch optical discs as a backup. This should prove more economical than using ArchiVISTA's ability to back itself up onto a second set of 5¼-inch optical discs as well as conform to a standardized procedure for the preservation of electronic data within the National Archives of Canada.

For retrieval purposes, it is anticipated that the entire collection of 20,000 images can be stored on the two sides of one 12-inch videodisc. Once a videodisc has been mastered and copied, the optical disc drive in the retrieval station will be replaced by two videodisc players, each holding one side of the videodisc. Although one player would be sufficient, the use of two will eliminate handling of the image-bearing medium by staff or the general public, simplifying use of the system.

Some improvements to the ArchiVISTA software are still needed, principally in the reduction of printing and display times. Minor enhancements of the retrieval subsystem user interface and implementation of an interactive thesaurus are also planned. In addition to the retrieval station already at the new exhibition gallery of the Canadian Centre for Caricature, the image capture subsystem will be converted to a retrieval station for installation in the Documentary Art and Photography Division's main reference room where it will be used to provide access for researchers at the National Archives' headquarters. Two additional retrieval stations have been purchased, one to enable staff to perform in-depth subject indexing of the caricature collection and support other cataloging and database administration functions, the other to be used in providing a centralized reference service.

Plans are also underway to modify the ArchiVISTA system so that it can be used for the high-resolution capture, display, and printing of continuous tone, black-and-white photographs. A collection of approximately 32,000 photographic negatives documenting various facets of Canadian transportation history has been selected for this purpose. The collection, consisting largely of glass plate, cellulose nitrate, and cellulose acetate negatives, has been physically reorganized, resleeved, and reboxed in archival storage containers and an automated, item-level finding aid prepared. Among the ArchiVISTA system enhancements needed are provision for image capture at 4096 × 3072 resolution and the ability to reverse the polarity of stored images so that negatives can be viewed or printed directly as positives. The success or failure of this project will, undoubtedly, have major implications on the photographic services and preservation copying program of the National Archives of Canada.

At the time of this writing (September 1989), the authors have presented just a preliminary progress report on the pilot application of the ArchiVISTA optical disc system. Though some work remains to be completed for the Canadian Centre for Caricature, the ongoing development and application of the ArchiVISTA system to other collections and functions within the National Archives of Canada is already assured. Significantly, the use of optical disc technology has progressed within the span of a decade from a tentative field of investigation to a practical and effective means of assisting archivists and information specialists in the preservation and control of an important segment of the nation's cultural heritage. The advent of ArchiVISTA ends a quarter-century old tradition of the image-bearing card catalog and spells a new chapter in providing access to the rich visual collections of the National Archives of Canada.

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Access Techniques for Document Image Databases

FRANK L. WALKER AND GEORGE R. THOMA

ABSTRACT

IN THE MOST GENERAL SENSE, "access" evokes the paradigm of a seeker of information asking a question of a machine which searches for and retrieves an answer. In a more practical vein, this entails accessing a bibliographic database by entering a query comprising key words or phrases, either free text or terms out of a controlled vocabulary, and receiving citations to the literature.

In a database consisting of images, say bitmapped digital images of documents stored on high density media such as optical disc, automated access actually may be done in several ways. One way is for the user to first search a bibliographic database, after which the system retrieves citations and links these to corresponding document images on optical disc. Another way is to browse a list of stored document titles, to select one and continue the search through another list at a lower level (e.g., a table of contents in a monograph or a list of articles in a journal issue); then, on making a selection from this latter list, to be presented with the document image retrieved from electronic storage. A third way is to perform a "full-text" search of the machine-readable areas of the stored documents and then have the system retrieve and integrate the text and graphic regions to form composite images that appear similar to the original paper documents.

This article describes the access and retrieval techniques implemented as part of a research and development program in electronic imaging (EI) applied to document storage and retrieval applications at the National Library of Medicine (NLM).

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INTRODUCTION

As part of a research and development (R&D) program to investigate the role of electronic images in document preservation, a prototype Document Conversion System (DCS) was developed. Its purpose was to capture paper-based material as bitmapped images by means of a document capture workstation (DCW), inspect the images for quality by means of a quality control workstation (QCW), and transfer them from temporary magnetic storage onto digital optical WORM discs on an archiving workstation (AW). These three workstations, all subsystems of the DCS, are self-contained devices, each controlled by an IBM AT-class computer, and networked via a token ring Local Area Network (LAN). The system description, experimental objectives and results, and the genesis of the R&D program have been extensively discussed in the citations following the text of this article.

Once archived, the images have to be accessed, retrieved, displayed, and manipulated by a user. The access to and retrieval of document images stored on optical discs may be accomplished in several ways. The system that accesses, retrieves, and displays images is the image retrieval workstation (IRW). Using the IRW, a user gains access to images by either browsing a list of document titles presented on the screen, or by initiating a search of NLM's MEDLINE ® or CATLINE ®. In both cases the IRW software links with the document image through an index via the document's unique identifier (UI) entered by the document capture operator while the paper document is initially scanned. Once the images have been located, they may be retrieved either from a "local" optical disc mounted in a drive that is part of the IRW, or from a "remote" disc drive that is part of an image server (IS).

FUNCTIONS TO ACCESS, RETRIEVE, AND USE IMAGES

There are many functions required to access and retrieve electronically archived documents. These include functions to: determine what documents are available, locate the desired document, retrieve the document (in compressed form) after it is located, expand each compressed image, and then display it. Once the document has been retrieved, there are additional functions for using it. These functions allow the user to manipulate images and to place electronic bookmarks (icons) on important images for later use.

Methods of Access

The two methods of accessing electronic documents are meant to allow the system to accommodate two types of library users. We may call them the "serious researcher" and the "casual patron." The serious researcher is assumed to be searching for all biomedical documents related to an area of interest. First, citations to the documents are obtained by searching NLM's databases. GRATEFUL MED ®, an NLM developed user interface to these databases, is integrated into the image retrieval workstation software and provides a convenient means to retrieve the document citations. After the user enters the key search terms, GRATEFUL MED automatically logs into the NLM mainframe and performs the search in MEDLINE or CATLINE. The returning citations are downloaded to the magnetic disc on the IRW. At this point the user may list or print the citations using GRATEFUL MED or exit. If the user continues to run GRATEFUL MED, he can perform additional searches to narrow or broaden the search strategy. Once the user exits from GRATEFUL MED, the IRW software will list the citations received from the most recent search. If the user is interested in a particular citation, the IRW will extract its unique identifier and check its presence in an index of document images. All document images are indexed by a UI to permit easy linkage with the citations. If the search of the document image index reveals that the corresponding document images exist, the user is so notified. If the user wishes to see them, the first page of the electronic document is automatically retrieved and displayed. Subsequent pages of the document are retrieved and displayed upon command from the user. Once the patron is finished with the first document, the next citation is displayed and linked with the corresponding electronic document if it is available on optical disc. This pattern continues for the rest of the retrieved citations.

The second type of library user, the casual patron, is assumed to be less interested in doing database searches than in browsing through a book or journal issue. The paradigm for this kind of use might be to take a volume off a shelf, skim through the table of contents, and read any chapter or article of interest. To accommodate this kind of usage in an electronic archive, obviously a database search function is inappropriate. To meet this need, the image retrieval workstation provides a browsing facility which alphabetically lists the titles of all available electronic documents. From the title list, the user gains immediate access to the corresponding document images. The browsing function handles both monographs and serials. For monographs, the IRW lists the titles with each corresponding to an archived document. The user can search either on the first letter of the book title or on a string of characters which may appear anywhere in the title. Once the desired title is chosen by the user, the IRW automatically retrieves the first page of the electronic document. Subsequent pages of the document are retrieved and displayed upon command from the user. Similarly, in the case of journals, the IRW lists journal titles from which the user may make a selection. The IRW then lists the issues available for the chosen title. Once the user picks a specific issue, the IRW lists the articles in that issue. After the user chooses an article, the IRW automatically retrieves the first page of the article. As in the case of books, the user controls the retrieval of the remaining pages in the article.

There are tradeoffs in choosing between the database search function or the browsing method to retrieve archived documents. On the one hand, the database search provides all citations which might be relevant to a user's field of interest but, for every citation, an archived document may not actually exist on optical disc. Because the database search function also takes time, the user must be prepared to wait for the citation query to complete. On the other hand, the browsing function guarantees that an archived document is immediately accessible for every listed book or journal title. This function therefore best serves the casual user who simply wants to browse through a collection of books or journals.

Locating the Archived Document

As already mentioned, document images are accessed through the unique identifier which is first associated with the document when it is captured. That is, at the time of capture, the operator enters the UI for that document. When the images are archived to optical disc, the archiving workstation keeps track of the size of each image and its location on the optical disc. After the optical disc has been filled with images, the UI, image size, and location information are written to the disc, these data constituting the disc index.

The next step is to use the index manager software (discussed in a later section) to create indexes of the total optical disc collection and to store these at each retrieval workstation. To make every disc's contents known to all retrieval workstations, the index manager is used to enter the contents of each optical disc in the collection into a master index. The master index is a B-tree index which keeps track of all unique identifiers, the number of page images associated with each UI, the size of each image (in kilobytes), the location of each image on its disc, and the label of the disc on which the images for a particular UI reside. A copy of the master index is then put on the magnetic disc at each retrieval workstation. Later, while displaying citations from a GRATEFUL MED search, the IRW software extracts the UI from the citation and queries its master index. If the document corresponding to that UI is archived on an optical disc, the software will get the label of the disc, the number of pages in the document, and the size and location information for every page image. At this point, the image retrieval workstation can retrieve the images.

In a manner similar to locating images through a GRATEFUL MED search, the browsing function also provides a means for quickly locating document images. This is performed by searching a series of indexes created for browsing by the index manager. When an optical disc's contents are put into the master index, the index manager also creates browsing indexes for books and journals. This is accomplished by using the GRATEFUL MED search engine feature. The index manager first creates a list of the unique identifiers for all archived documents, then invokes the GRATEFUL MED search engine to get all book titles, journal titles, issues and article titles. It extracts this information from the retrieved citations to create B-tree indexes for this information. The resulting browsing indexes are placed along with the master index at every image retrieval workstation on magnetic disc. Then, as a user browses through a title list and selects a title, the workstation software queries the appropriate browsing index to extract the UI corresponding to that title. Next it queries the master index to get the optical disc starting block number for the chosen document images. Once the document has been located, the document images may be retrieved, displayed, and used.

Retrieving the Document Images

Once the electronic document has been located, it may be retrieved either from a local optical disc or from a disc at a remote image server. There are three options available for document retrieval. First, the image retrieval workstation may have a local optical disc drive for accessing images on discs which the workstation user can physically insert and remove. This provides a means of retrieving images from a local collection of discs. The second option for image retrieval is to use an image server. The image server could have several optical disc drives, each containing an optical disc, for sharing archived documents among several workstations. This second option is suitable for those documents which are frequently accessed and perhaps needed simultaneously by multiple users. Finally, as a third option, it is possible for an IRW to have both a local optical disc drive and a connection to an image server over a LAN. This provides access to both a local and a remote collection of archived documents.

One way to organize the collection of document images among discs that are "local" at an image retrieval workstation and those that reside at a remote image server might be to base the distribution on anticipated use. Those documents that are frequently used and in demand by multiple users simultaneously should be at the IS accessible by multiple IRWs. For documents that are infrequently used, it might be sufficient to have them on discs that are locally available for a user to physically remove from a shelf, say, and insert into an IRW when needed. Considering the level of usage of much of the older biomedical literature, the latter might be sufficient. The system has, however, been designed to accommodate more frequently used material as well.

If an image retrieval workstation needs to access documents on optical discs controlled by an image server, a communications protocol is required for quick retrieval over a LAN. A protocol has been developed to permit an IRW to query an IS to find out which optical discs are available for online access over the LAN. The protocol also permits an IRW to reliably retrieve documents from the IS over the LAN. Research into prototype servers and workstations has allowed the design of an image communications protocol that permits images to be retrieved quickly.

Using the Electronic Document

Once the electronic document has been retrieved, the image retrieval workstation provides the user with a variety of functions that promote easy and flexible use. First, the IRW displays the document images in either soft copy form on a high resolution image display device or in hard copy form on a laser printer. The user may "flip" page images forward or backward through the document or go directly to any arbitrary page in the document. The IRW has an image manipulation function to allow the user to zoom into images to see fine detail. The user can also rotate an image 90 degrees right or left to display pages printed in landscape mode in the original paper document. Finally, the IRW provides an electronic "bookmark" function which allows placement of an icon representing a bookmark on an image. Up to ten page images in every document may be marked with no limit on the number of marked documents. The electronic bookmark function permits a user to track important sections in the electronic document in a manner analogous to using a bookmark in a paper book. It permits a direct jump to marked pages in a document, retrieval of the most recently marked document, and movement between the marked section in one document and marked section in another document.

IMAGE RETRIEVAL OPTIONS: DISCUSSION

As mentioned earlier, images may be retrieved either from an optical disc drive locally connected to a workstation or from optical disc drives located at a remote image server. Having a local optical disc drive connected to a retrieval workstation permits a user to choose a disc from a local collection of discs. This self-contained configuration is adequate when the disc collection is not likely to be simultaneously shared by more than one user. The second method, based on an image server, is the best alternative for handling several users needing to simultaneously share a common archive of images stored on multiple discs. With a remote store of images, however, in addition to accessing the image data on disc and its retrieval, there is also the problem of image transmission to the image retrieval workstation possibly located at a distance.

An earlier "baseline" prototype system (Thoma et al., 1985), based on a centralized architecture in which a DEC PDP 11/44 served as system controller, relied upon high-speed point-to-point modems to deliver uncompressed page images over the NLM's Broadband Cable Network. The effort, though technically successful in terms of speed, did not offer a reliable path to scale up the system to a larger number of display terminals. Also, the measured bit error rate was high enough to cause concern over the prospect of transmitting compressed images since errors that are tolerable in uncompressed image transmission could seriously affect the quality of compressed images. With the subsequent refinement of the system concept to a set of distributed IBM AT-based workstations implementing the key functions of capture, quality control, and archiving in the Document Conversion System, the stand-alone image retrieval workstation in which images were retrieved locally from the workstation's optical disc drive was developed. This approach works well for a single user, but does not scale up economically. Not only does each workstation require a relatively expensive optical disc drive (approximately $10K), but the set of optical discs would have to be shared by different users resulting in a wait for the more popular discs. Alternatively, multiple copies of frequently used discs would have to be made available. The solution selected is a document image retrieval network that would allow several image retrieval workstations simultaneous access to a database of document images.

For the transmission of images from an image server to the requesting image retrieval workstation, the point-to-point modem approach did not have the necessary features. In addition to high speed—a feature of point-to-point modems—it was also desirable to have low transmission error rate, built-in error checking, support for multiple stations, and off-the-shelf availability. These requirements led to investigations of local area network technology which has become widely available for all types of computers including machines in the personal computer class. The cost of intercomputer communication varies with bandwidth, buffer size, and software sophistication, but there is a wide and growing selection of reasonably priced LAN interfaces for AT-class computers. It was therefore logical to explore the use of this technology to support document image retrieval.

Furthermore, since the document image retrieval functions are independent of the document conversion functions, it is not necessary that a single LAN or type of LAN support both applications. In the prototype systems developed in the laboratory to evaluate electronic imaging for document preservation, the document image retrieval LAN is completely different from the LAN supporting document conversion: they differ in terms of topologies, physical layers, and protocols. The only point of contact between document conversion and image retrieval is the database of images stored on optical discs created by the document conversion system and utilized by the document image retrieval system. This approach allowed the design and selection of the optimum LAN for each application.

One way to integrate standalone workstations into a networked system would be to connect several standalone workstations to a LAN and to let each access the other's image files. This would require each workstation to serve as both a personal image retrieval workstation and as an optical disc image file server. Controlling these two operations under DOS, a single-tasking operating system, would be difficult. Managing index data in such a configuration would also be awkward.

In light of these factors, it was found that the document image retrieval network is best configured as a file service system similar to the document conversion system. There are key differences, however: the image files to be retrieved are permanently stored on optical discs and are only available for reading; since file servers with drivers for optical discs are not available off-the-shelf, a special purpose image server with an efficient communications protocol was designed for this application.

Image Retrieval Workstation: Functions

The image retrieval workstation permits a user to access, retrieve, and use document images archived on optical disc. The optical disc drives may be local—e.g., connected to the IRW (see Figure 1), or remotely located on a local area network and connected to an image server (see Figure 2). The "local" option is illustrated in Figure 1. Here, the IRW may have one or more optical disc drives. It is controlled by an IBM AT-class personal computer, and it is equipped with a high resolution soft copy image display device for viewing document images and an alphanumeric display for the user interface. It has a laser printer for obtaining hard copies of the document images, and a mouse for manipulating images on the soft copy display. Finally, it has a telecommunications link to NLM's mainframe resident databases MEDLINE and CATLINE.

The remote retrieval option is shown in Figure 2. There may be one or more image servers and several retrieval workstations. Each retrieval workstation has an Ethernet connection to a baseband Ethernet network in place of the local optical disc drive. Here also each IRW has a telecommunications link to NLM's databases.

The local option allows the user to maintain a collection of optical discs, and to use one disc at a time in the drive. The networked

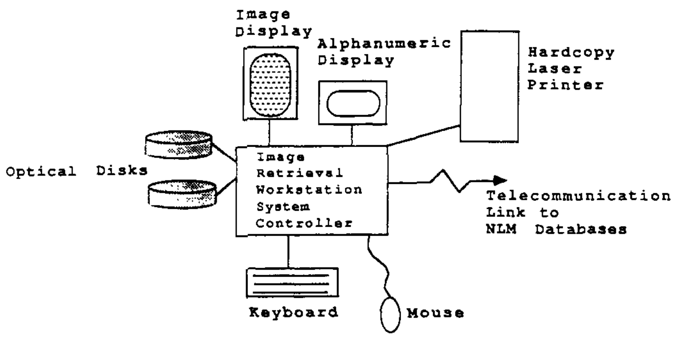

Figure 1. Image Retrieval Workstation (IRW) Accessing Images on a Local Disc

case allows the user access to those disc drives and media connected to the image server. The advantage of a local optical disc drive is that it is suitable for an environment where there are a small number of users, none of whom would need to simultaneously share the same archived collection. The advantage of having a network of one or more image servers and several retrieval workstations is that multiple users can simultaneously access a single archived document collection.

A third case is also possible: where the image retrieval workstation is both networked and "combined" equipped with a local optical disc. This is the most flexible option since it offers the advantages of having a permanent, centrally located collection of archived documents while also offering a user the choice of using discs from a local collection. This case is most useful if the document collection can be classified by different degrees of demand so that those documents frequently accessed might be located at the image server, and those that are infrequently accessed at each user's workstation.

The image retrieval workstation has the following basic functions:

1. A *database search* function which allows a user to perform a bibliographic search in MEDLINE or CATLINE via GRATEFUL MED. Once the database search is complete, the user may view the results of the search—i.e., the retrieved citations—after which the system links each citation to the corresponding document images on optical disc.
2. A *browse* function which presents a user with a list of titles of books or journal articles archived on the optical disc collection.

A user selection of an item from the title list activates the image retrieval workstation to provide an automatic link to the archived document images.

3. A *display* function which permits the document images obtained

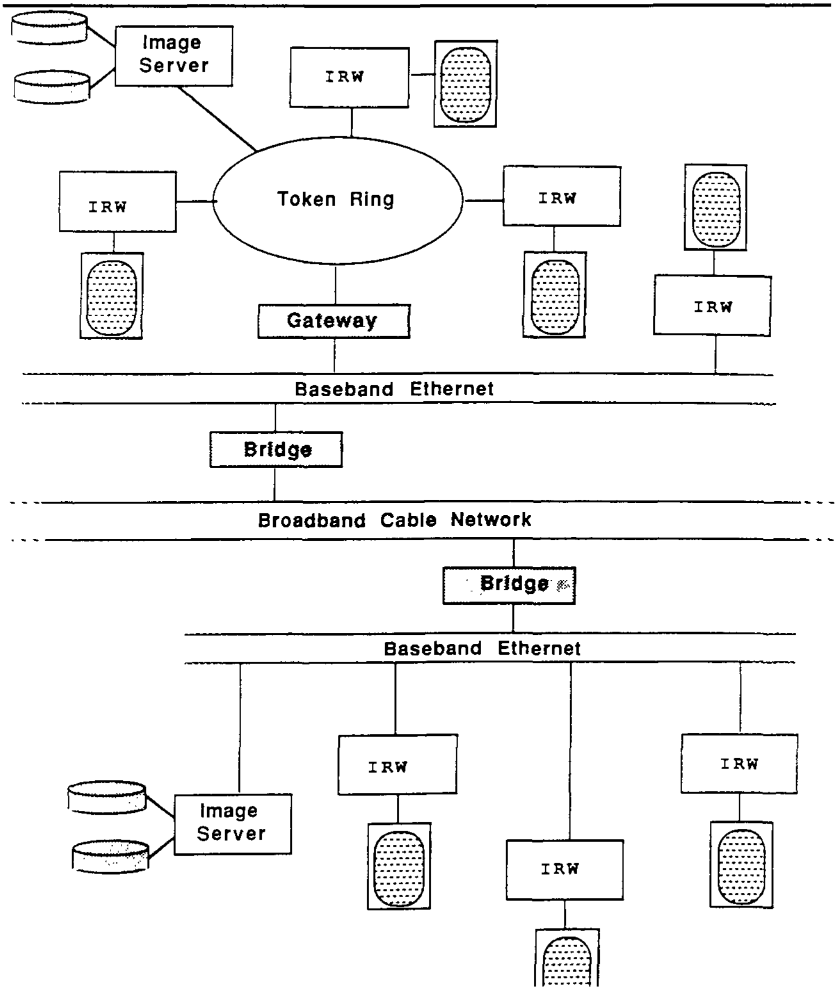

Figure 2. Connecting Token Ring and Ethernet LANs via Gateways and Bridges

from the linkup in 1 or 2 to be retrieved and displayed in soft copy form on the high resolution image display device or in hard copy form on a laser printer.

4. An *image manipulation* function which permits an image displayed on the soft copy display device to be zoomed, shrunk, rotated, panned, or scrolled.

5. An *electronic bookmark* function which permits a user to place bookmarks (visual icons marking the displayed page) on up to ten pages in each document with no limit on the number of marked documents. This function permits a user to move from the marked section in one document to the marked section in another, and also to retrieve the most recently marked document.
6. A *list* function displays a list of all optical discs indexed and from which the IRW may access the archived documents.

Image Server: Functions

The image server is essential for remote access and in prototype form uses a 10 Mbits/sec. Ethernet LAN. Ethernet is chosen partly because it is an industry standard with inexpensive and readily available interfaces. It is attractive also because it is available either as a baseband or a broadband LAN. The only difference in equipment is the transceiver; the computer interface hardware and all of the software are suitable for both modes. However, other physical layer protocols need not be excluded from consideration as there are many bridges and gateways currently available to support connecting "local" LANs to an Ethernet backbone. Figure 2 also shows how token-ring LANs and Ethernet LANs could coexist in a document image retrieval application connected by a backbone of broadband and baseband Ethernet. The price of connectivity is the cost of the equipment and some degradation in throughput associated with each bridge or gateway.

The functions of the image server are to:

1. Interface one or more optical disc drives to a 10 Mbits/sec. Ethernet LAN.
2. Retain an index of documents archived on the set of optical discs mounted on those drives. The index is designed to permit fast retrieval of any data record.
3. Respond to a request from an information retrieval workstation to provide a list of disc labels for the optical disc drives connected to the server. Upon initialization, it is necessary for a workstation to be able to determine the total set of optical discs available for online access. This set of discs includes those available at an image server or from a local disc drive connected to the workstation. It is assumed that any indexed disc not online needs to be inserted into the local disc drive. With knowledge of the location of each optical disc, the workstation can retrieve images from the correct source.
4. Respond to a request for an image from a workstation.
5. Give status data to the requesting workstation as to whether there are errors detected in image retrieval, whether excessive delays are expected due to heavy user demand, or if image transmission has

been completed.

Image Retrieval Workstation: Hardware Description

While at various developmental stages it was necessary to design and fabricate individual interface or controller boards, the monitoring of parallel developments in the electronics industry served to identify commercially available alternatives. For example, the high resolution display interface and the compression/expansion subsystem were originally in-house developed board-level prototypes, but they may be replaced by currently available off-the-shelf alternatives. The following list gives the hardware components of the information retrieval workstation as designed and implemented in the laboratory. Where appropriate, optional items are mentioned for equivalent performance.

1. The system controller is the IBM AT (or compatible) personal computer with a CPU having a minimum clock rate of 8 MHz and 512 KB of main memory.
2. An operating system equivalent to DOS version 3.3 or higher.
3. A magnetic disc drive to be used for storage of index information and operating system software. The disc must have a capacity of 110 MB (or sufficient capacity for storing the indexes required to access the archived documents); and an average access time of twenty-eight milliseconds or better. A rough estimate of the required disc size comes from test indexes used in the prototype information retrieval workstation. It shows that 110 MB is large enough to index approximately 3 million images. This estimate assumes an average of ten images per document and that half the documents are books and the other half journals. For other applications, the disc size requirement will be different, depending on the average number of images in a document and on whether the documents are monographs or journal articles.
4. An enhanced graphics adapter (EGA) and EGA color monitor serving as the primary man/machine interface.
5. Two RS-232 serial interfaces and a Centronics-compatible parallel printer interface on a single board. One serial interface controls the mouse, which is used for image manipulation. The second serial interface is used to communicate with the NLM databases. The printer interface is used for printing citations from GRATEFUL MED.
6. A Microsoft-compatible mouse used for manipulating images.
7. A Hayes-compatible 1200 baud modem used by GRATEFUL MED for searching NLM's MEDLINE and CATLINE databases.
8. A 300 dot per inch laser printer, used for producing hard copy printouts of images capable of printing text pages at a speed

of at least six pages per minute. Options include the QMS Kiss or Hewlett Packard Laser Jet Series II printers.

9. A printer interface capable of transferring image data via direct memory access from computer memory to the printer controller.
10. A printer controller capable of accepting both image data as well as ASCII text data to be printed on the laser printer. For image data sent to the printer controller, it has a pixel replication algorithm to magnify the images so that an 8.5 × 11 inch image scanned at 200 dots per inch retains the same dimensions when printed at 300 dots per inch on the laser printer. For text data sent to the printer controller, it passes the data straight through to the laser printer without change in appearance. The printer interface, controller, and printer are capable of printing an image in less than twenty seconds after the initiation of image data transfer to the printer interface.
11. An image expander capable of expanding an image compressed by the CCITT Group 4 two-dimensional compression technique. It can expand an image of a typical NLM page in less than two seconds. A 1 MB onboard memory is recommended for this expander; typically, the memory should be large enough to hold both a compressed and uncompressed image.
12. An interface for controlling a local optical disc drive such as the industry standard small computer system interface (SCSI). This component is required for local image access. The controller must be capable of direct memory access and capable of transferring 33 KB of data (an average compressed page image) from the disc drive to computer memory in 0.6 seconds or less.
13. An optical disc drive used for retrieving document images from a local collection of discs. This component is required for workstations to have a local image access capability. The optical disc drive must be capable of transferring a typical compressed NLM image (33 KB) to computer memory in 0.6 seconds or less.
14. A LAN interface connecting the image retrieval workstation to a LAN; this component is required for the workstation to be used in a networked environment for remote image access.
15. A display interface for transferring image data from the computer memory to the high resolution display monitor; it has 2 MB of internal memory for image manipulation functions, is capable of zooming/shrinking the image 2:1, is able to pan and scroll, and is able to rotate an image clockwise and counterclockwise by 90 degrees.
16. An image display monitor capable of displaying the entire image of a page scanned at 200 dots per inch resolution—i.e., have 1,728 × 2,200 pixel display capability such as the Discorp model VMB 2002.

IMAGE SERVER: HARDWARE DESCRIPTION

The hardware required for the image server used as a file server consists of the following:

1. A small computer equivalent to the IBM AT personal computer with a CPU having a minimum speed of 8 MHz, and 512 KB of main memory.
2. An operating system equivalent to DOS version 3.3 or higher.
3. Ethernet hardware and software interface to the selected LAN.
4. Hardware and software interface to the optical disc drive including:
   —SCSI host adapter (or some standard appropriate for the selected drive)
   —Special hardware and software to ensure maximum transfer rate of the drive when reading data into computer memory
   —Ability to manage data transfer from multiple drives.
5. Sufficient computer memory to hold one uncompressed page image file (one-half MB for 200 dpi images), in addition to program and other data; requires extended memory if an AT-type computer is used.
6. A magnetic disc drive, with minimum capacity of 60 MB to store the indexes required for accessing the archived documents; average access time of twenty-eight milliseconds or better to be used for storage of index information and operating system software.
7. A monitor and adapter for operator interface; may be color or monochrome.

The requirements for the LAN shall be as follows:

1. 10 Mbits/sec. data rate or faster.
2. Cabling for selected speed/distance; recommend shielded twisted pair (Type 6 or better).
3. Should allow adding or deleting nodes without disrupting operations.
4. Should be expandable over greater area as application grows.
5. Data buffers on the interface boards; recommend at least 128 KB.

The requirements for the upper level protocols and application programs are as follows:

1. Permit multiple servers including a jukebox.
2. Accommodate a separate index node.
3. Able to achieve 3 Mbits/sec. or faster memory-to-memory transfer of page image files from server to display workstation.

The last section of this article gives hardware requirements for a version of the image server when it is used as an index server.

IMAGE SERVER COMMUNICATIONS PROTOCOL: RATIONALE AND DESIGN

A communications protocol designated Image Transmission

Protocol (ITP) was developed in-house to support the transmission of images from an image server to image retrieval workstations. This development evolved from research into techniques for high speed reliable image data transmission over the NLM's dual cable broadband cable network (BCN). Originally a 10 MBps point-to-point link was designed for transmission between a single image transmitting station and a single image receiving station using quadrature phase shift keying (QPSK) modems. While the speed was adequate, this technique had disadvantages such as: multiple stations could not be supported and the system included no automatic method of error recovery. To offset these shortcomings, a set of design goals was developed for an image transmission technique that included: operating preferably with a well defined industry standard; a low effective error rate; built-in error checking; support for multiple stations; modularity; and availability of off-the-shelf components. Broadband Ethernet was found to meet these objectives.

Initial studies with off-the-shelf broadband Ethernet modems showed high reliability since the effective error rate was too low to be measured in the laboratory. For the higher layers, the FTP protocol (part of the industry standard TCP/IP) was acquired and evaluated, partly because it is a standard file transfer protocol used by all systems on the Internet. However, using off-the-shelf FTP for image file transfer resulted in very low throughput—less than 100 KBps.

The demonstrated reliability of Ethernet, with the potential for higher throughput than that available from a widely used standard, suggested a reason to design a protocol suitable for image transmission to deliver both speed and reliability objectives.

The ITP is application driven and application dependent. It relies heavily on the low error rate of local transmission provided by the Ethernet hardware and (low level) protocol, on the finite size of a page image file, and on the fact that image files need only be transmitted from a server to a display workstation. Additional assumptions are that the image requesting node wait until the entire image is received. Because of these design assumptions, very little information needs to be transmitted with each image data packet, and very few packets other than data packets need to be transmitted with each page image file, reducing both bandwidth overhead and data processing overhead.

The ITP is therefore a special purpose protocol. It trades flexibility for speed, a more important commodity for an application involving image files almost exclusively. It is not intended for a general purpose application, for instance, to transfer any generic file from one computer to another. It is designed for one purpose: to transfer image files from an image server to an image retrieval workstation at high speed—approximately 3.2 Mbits/sec.—as measured in the laboratory.

The document image retrieval application is less complicated than the document conversion application in that page image files will only be transmitted from the nodes having optical discs (image servers) to the nodes having high resolution displays (display workstations). Also, the numbers of image and index files are relatively static, and the display workstations need not store the image files on local magnetic media. For these reasons, it was possible to design a private, application-driven protocol to manage the transmission of images from image servers to display workstations that exploits the finite requirements of the transaction to achieve very high page image file throughput over Ethernet. The component of the system that predominantly determines server throughput is the optical disc interface which determines the rate at which page image files are read from the optical disc into the server's memory. Appropriate design of the optical disc interface and driver allows data to be retrieved from the opical disc drive at the maximum transfer rate of data from the optical disc platter. This includes the design of the interface of the optical disc drive to the SCSI bus, the SCSI host adapter for the AT-bus, and the software driver. The optical disc drive should have a large (at least 64 KB) internal buffer to accommodate asynchronous data transfer between the AT and the drive. The Optimum 1000 Optical Disk Drive has a maximum transfer rate of 0.48MB/sec.

As shown in Figure 3, there are four basic layers in the ITP. At the lowest level is the physical layer which consists of either baseband or broadband Ethernet. This is the hardware level which facilitates the bit stream signal transmission along the Ethernet cable between the image server and each image retrieval workstation. Immediately above the physical layer is the data link layer, implemented in the prototype IS and IRW systems by means of an Ethernet data link processor which plugs into the computer. The data link processor is responsible for access control, addressing, and a low level of error detection. Above the data link layer is the application layer. The modules of the application layer use the header field of Ethernet packets for communication and error control between the IS and IRW (see the definition of the ITP following this paragraph). Both the IS and IRW have transmit/receive modules which encode and decode the data fields in the Ethernet packets. They are also responsible for data management, packet sequencing, higher level error detection, and queue management. Above this is the user interface software which converts user requests to network activities and provides high level control over error conditions.

Definition of the ITP

The communications protocol is defined by information placed into the header of each Ethernet packet by the image server or the image retrieval workstation. All protocol codes are two bytes in length shown as follows:

HIGH BYTE	LOW BYTE

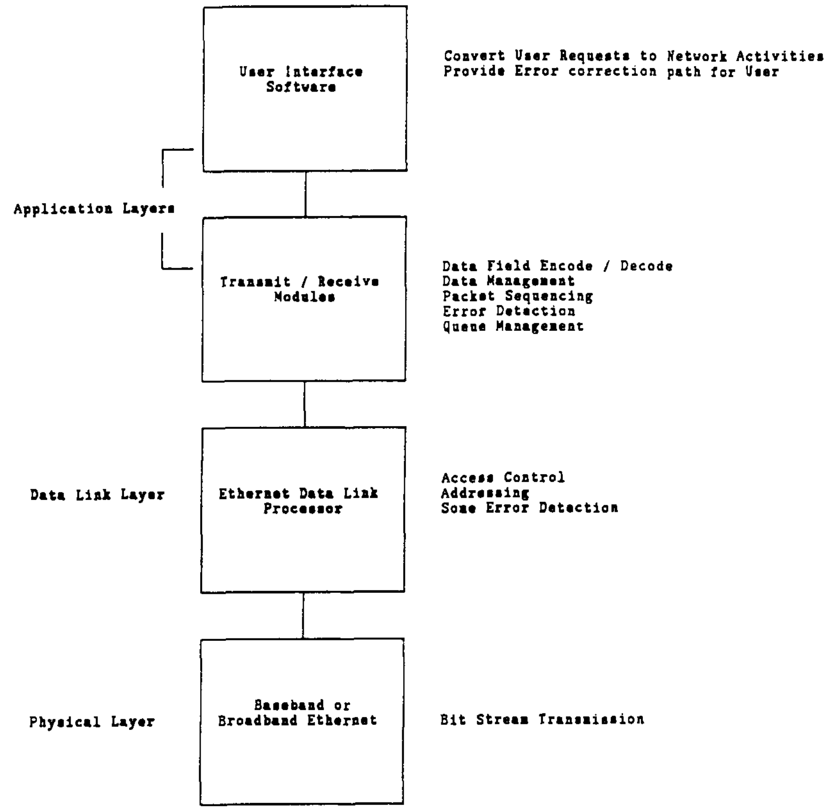

Figure 3. Image Transmission Protocol Layers

The low byte identifies the general form of the data being transmitted or received—e.g., image data, control message, etc. The high byte identifies the specific form of the data being transmitted or received—e.g., first image data packet, number of packets being sent, etc. The following is a description of protocol codes which the image server can transmit:

Low byte = **01** indicates the packet contains image data

High byte = **01** indicates this is the first image data packet
Example:

01	01

High byte = **02** indicates this is an image data packet in the range from 2 through the last packet
Example:

02	01

High byte = **03** indicates the packet contains the number of image data packets transmitted; used for error checking

Low byte =**02** indicates the packet contains nonimage data

High byte = **01** indicates the packet contains labels of discs controlled by the server

High byte =**02** indicates the packet contains queue position data

Low byte = **06** indicates a message sent to the image retrieval workstation

High byte = indicates a nonfatal message; workstation software is to continue

High byte = **02** indicates a fatal message; workstation control software is to be terminated

The following are protocol codes which the image retrieval workstation can transmit:

Low byte = **05** indicates the packet contains a request for an image server

High byte = **01** indicates this is a request for image data

High byte = **02** indicates this is a request to get labels of the discs currently mounted at the image server.

Software for the Image Retrieval Workstation

The prototype image retrieval workstation requires an executable module and a number of index files for operation. The executable module for the prototype image workstation runs under DOS on an IBM AT-class computer and consists of many modules written in the C language as well as assembly language. The C modules were compiled using the Lattice C compiler version 3.1, the assembly modules assembled using Microsoft Assembler version 5.0, and all were linked using the Microsoft Linker version 3.6. The Lattice Windows software package is used to produce the screen displays for user interface. There are several index files required for the image retrieval workstation; they are B-tree index files created and managed using C-tree by Faircom. None of these products is a specific requirement of the workstation; products from other manufacturers and other operating systems (UNIX, AIX, etc.) could be substituted with minor modifications.

Information Retrieval Workstation Manager

The overall flow control for the image retrieval is illustrated in Figure 4. The manager is the main module which controls the process. Four basic functions are initially provided to the user. The first function allows the system to search two of NLM's databases, MEDLINE and CATLINE. If the user chooses this option, the databases module is invoked which permits the user to enter search terms to GRATEFUL MED. GRATEFUL MED logs onto the NLM mainframe, performs the search in MEDLINE or CATLINE, downloads the citations to the magnetic disc on the computer, and logs off the mainframe. Then, in a standalone manner, the workstation will display each citation. For each citation in which the user is interested, the software will check for the existence of the corresponding document images. If the document images exist, the user can view them in soft copy or hard copy form.

The second function provided by the image retrieval workstation manager is a browsing function, which is performed by the browse module. Browsing permits a user to view a list of document titles available in archived form. For books, titles are listed from which the user may choose. For journals, a list of titles are initially given from which the user may choose followed by a journal issue and article within that issue. After a book title or journal article title has been chosen, the system automatically retrieves the corresponding document images for display in either soft copy or hard copy form.

The third function of the manager is an electronic bookmark function performed by the bookmark module. Once a document is marked, it is possible to directly retrieve it later even if the workstation has been turned off after marking.

The fourth function provided by the image retrieval workstation manager permits the user to see a listing of all optical discs which are indexed. The indexes, invisible to the user, keep track of the location of all images on all optical discs plus the book titles, journal titles, issues and article titles for document browsing.

Finally the workstation manager permits the user to exit from this software. In doing so, all appropriate index files are closed upon exiting to the operating system.

Database Function

The function permits a user to perform a search of either MEDLINE or CATLINE, link the resulting citations to the archived

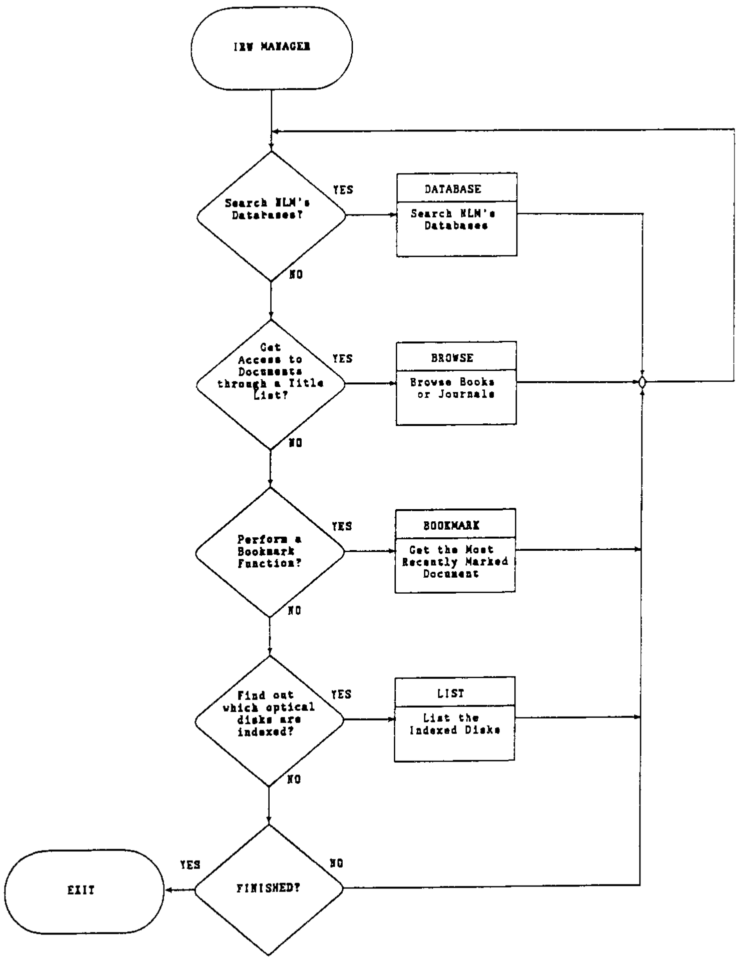

Figure 4. Image Retrieval Workstation Overall Flow Control

store of document images, and retrieve the document images. As illustrated in Figure 5, this function first invokes GRATEFUL MED which permits computer-assisted searches of MEDLINE or CATLINE. Through the assistance of GRATEFUL MED, the user can enter search terms then have the search performed automatically. The search citations are downloaded to the magnetic disc on the workstation, and GRATEFUL MED returns control to the database routine.

The first citation from the database search is displayed on the workstation's color monitor. If the user is interested in the citation, the image workstation software will check the index of unique identifiers to determine whether the document has been archived. If it has been archived and is available for access, the user is notified and is asked whether he wants to see it. If the user answers affirmatively, the display routine is invoked, which permits the user to retrieve the document. After the document has been accessed, or if the user did not want to see the document, the software checks to see if there are more citations that resulted from the GRATEFUL MED search. If more citations are present, they are displayed as before. If there are no more citations, software control returns to the workstation manager.

GRATEFUL MED permits citations to be printed. If the user wants a hard copy of the retrieved citations, a method of switching the hard copy laser printer to text mode is available. This printer is normally used for printing images but can also accommodate text. Once printed, the citations are available for future reference, and the archived documents, if available, can be retrieved by manually entering the unique identifier (part of the citation), as one of three methods for accessing documents from the browse function.

Browse Function

The browse function, invoked by the workstation manager, permits the user to access archived documents without a database search. It is intended for the casual user who wants to browse through the collection of archived documents. By listing all document titles, the browse function provides a one to one correspondence between document titles and archived documents; the user is guaranteed that the document images corresponding to the listed titles are available. This is not the case for the database function, which does not provide such a one to one correspondence. The database function, intended for more serious researchers, lists all citations relevant to a user's search strategy, whether or not they correspond to archived documents. While intended for different purposes, the database and browse functions are both useful and complement each other.

The browse function permits a user to access archived documents either through a list of book titles, a list of journal article titles, or through a unique identifier. If the user is interested in books, the browse function will alphabetically list all available book titles on the color monitor screen. The user may start a search on book titles by entering a single character, which finds the first title beginning with that character. It is also possible to search a string of characters appearing within a title. An example would be to find the next title which contains the word *doctor*. Once a search has been completed, an arrow appears on the screen at the title of interest. The user can move the arrow about the screen to select any other title if he desires. Once a title of interest has been found, the user presses the enter key on the keyboard, and the browse software checks the title index to extract the unique identifier of the document. Then it goes to an image index to retrieve the document images through the display function.

If instead of books, the user is interested in journals, the browse function will list all journal titles of archived journal articles. Once the user selects a journal title, the issues available for that title are listed. After the user picks a journal issue, the browse function lists all articles available for that issue. At this point the user may search on article titles in the same manner available for searching on book titles either by the first letter of the title or through a string search of the contents of all titles. Once an article is selected, the unique identifier is extracted and the display function is invoked to access the article.

The third method of accessing documents through the browse function is to enter the unique identifier of the document. The UI is available from the GRATEFUL MED search in the database function. If the document has been indexed, it can then be accessed and retrieved through the display function.

List Function

The list function lists all optical discs indexed and available for access, either from an image server or from a local optical disc drive; the discs may or may not be currently mounted. The list function reads the volume index and keeps track of the labels of all indexed optical discs. Then it displays the disc labels on the color monitor screen and returns control to the image retrieval workstation manager.

Bookmark Function

The bookmark function, called by the image retrieval workstation manager, provides the user of the workstation a degree of flexible control over the electronic document in a manner similar to the control a reader has over a paper document. Analogous to the case of paper documents where bookmarks keep track of important sections, the electronic bookmark does the same thing for electronic documents. Up to ten pages in every document can be marked with no limit on the number of marked documents. Even when the IRW is turned off, the bookmark information is not lost since it is kept in a file. The bookmark function permits the most recently marked document to be retrieved quickly by invoking the display function which retrieves the most recently marked pages in this document. The display function then permits the user to view the document, to jump to other marked pages in the document, or to jump to other marked documents. This last feature is an advantage an electronic document has since there is no analog to this function in a world of paper documents. Once the user is finished with the bookmark functions through the display module, control is returned to the manager.

Display Function

The display function allows the operator to use the electronic document. Usage includes viewing the document, jumping to any page in the document, placing or removing bookmarks, manipulating images, printing the document, or jumping to other marked documents. Normally the flow control begins with the current page number being set to one. However, if the display function is called from the bookmark function previously described, the current page number is set instead to the most recently marked page in the document. This first image is automatically retrieved from either the local optical disc or image server, expanded and displayed on the soft copy display device. If the image has been previously marked, a bookmark icon is displayed on the image. The user is presented with a menu of choices, each of which invokes a specific function, described as follows:

1. *Next Page.* If the user selects Next Page, the current page number is incremented by one with the largest page number being the number of pages in the document. Then the image of the next page is retrieved, expanded, and displayed. If the new page has been marked, the bookmark icon is also displayed.
2. *Previous Page.* If the user selects Previous Page, the current page number is decremented by one, with the smallest page number being 1. Then the image of the new page is retrieved, expanded, and displayed. Here, too, if the new page has been marked, the bookmark icon is displayed.
3. *Page Jump.* If the user selects Page Jump, he can move directly to a specific page in the document, jump to one of ten marked pages, or jump relative to a marked page. The page jump process returns with an updated current page number. Then the image of the new page is retrieved, expanded, and displayed. If the new page has been marked, the bookmark icon is displayed.
4. *Manipulate Image.* The Manipulate Image process permits the image on the soft copy display device to be zoomed 2:1 or shrunk back to normal size. It also permits the image to be rotated left or right 90 degrees, panned, or scrolled. Panning and scrolling are accomplished through the use of a mouse. After the manipulate process is completed, the software returns control to the user, allowing the selection of another display function. Details appear later.

5. *Mark Page.* If a user selects Mark Page, he can mark the image currently displayed on the soft copy display device with a bookmark icon, or remove this icon if present on the image. This feature also permits the user to remove all bookmarks from the current document or remove all bookmarks from all documents if any exist. After the Mark Page process is completed, the software control returns to display which allows the user to select another function. Details appear later in the Mark Page function section following.
6. *Print Page.* If the user selects Print Page, he is given many printing options: either to print the image currently displayed, part of the current document, all of the current document, or all marked pages in all documents. After the print page process is completed, the software control returns to display which allows the user to select another function. Details appear later in the Print Page section following.
7. *Jump to Next Marked Document.* If there are marked documents following the current document, the Jump to Next Marked Document function is available for use. If the user selects it, the software finds the unique identifier of the next marked document and sets the current page number to the most recently marked page in this document. Then this image is retrieved, expanded, and displayed. The bookmark icon is also displayed on the image.
8. *Jump to Previously Marked Document.* If there are marked documents prior to the current document, the Jump to Previously Marked Document function is available for use. If the user selects it, the software finds the unique identifier of the next marked document and sets the current page number to the most recently marked page in this document. Then this image is retrieved, expanded, and displayed. The bookmark icon is also displayed on the image. Once the user exits from the display function, the software returns control to the calling routine.

Page Jump Function

In addition to the features mentioned earlier, if the user wants a specific page, the page number must be entered. The range of valid page numbers varies from one to the maximum number of pages in the document. If the user types a number larger than the highest numbered page, the software automatically resets to the last page. If the user wants to go directly to a marked page, he can choose the page from a list of marked pages presented on the color monitor by using the cursor keys to highlight the desired marked page number, then pressing the enter key. If the user wants to jump relative to a marked page, it is possible to move forward n pages from a marked page or reverse n pages relative to a marked page. The user must enter the number n and also select the marked page with the cursor keys. Once a page has been chosen from one of these methods, the software returns control to the display function with the updated current page number.

The facility for jumping relative to a marked page helps solve a problem in electronically archived documents—i.e., page number sequencing. It is quite common for the table of contents of a volume to begin with roman numerals (e.g., i, ii, iii), and the first chapter to start with Arabic numerals (e.g., 1, 2, 3). While the workstation permits a direct jump to any page in the document, the page number in the electronic document may not correspond to the real Arabic number in the printed volume. For example, page 50 of the paper book would correspond to the 53rd page of the electronic document if there are three pages (e.g., of the table of contents) preceding Arabic page number 1. Then when the user wants to jump to page 50 the system gives him page 47. This problem is solved through a feature of the workstation termed relative jumping. If a bookmark is placed at page 1 (Arabic) of the document, then by jumping relative to that bookmark, the user is able to move directly to the desired page.

Manipulate Function

The manipulate function permits the existing image on the soft copy image display to be zoomed, shrunk, panned, scrolled, and rotated. A menu permits the choice of zoom/shrink, rotate right 90 degrees, and rotate left 90 degrees. If the zoom/shrink option is chosen and if the existing image is a normal size, the image is zoomed 2:1. If the zoom/shrink option is chosen and if the existing image has previously been zoomed, the image is then shrunk to normal size. A mouse controls the panning and scrolling functions. Here, panning refers to moving the image right and left on the screen. Scrolling refers to moving the image up and down on the screen. The image is panned or scrolled in proportion to the mouse movement and is most effective for images which have been zoomed or rotated. Once the user is finished manipulating the image, software control returns to the display function.

Mark Page Function

The Mark Page Function permits the user to place an electronic bookmark icon on the image displayed on the soft copy image display device. If the user marks the current image, an icon representing the bookmark is overlaid on the image while a file of bookmark data is updated. The bookmark icon may also be removed from the current image if marked. If this option is selected, the bookmark icon is removed from the current image and the original data beneath the bookmark is restored. In addition, all bookmarks may be removed from the current document or all marked documents. If either of these options are chosen, the bookmark data file is updated appropriately. Once the Mark Page Function is completed, system control returns to the display routine.

Print Page Function

In the Print Page Function, the user is presented with a menu of five choices for printing the document. If he chooses to print the page currently displayed on the soft copy image display device, that image is retrieved from either the local optical disc or remote image server, expanded, and printed on the hard copy laser printer. If the user chooses to print the entire document, the retrieval, expansion, and printing functions are automatically repeated for every page image in the document. If the user chooses to print only part of the document, he can specify the starting and ending pages to be printed. The appropriate images are then retrieved and printed. If the user chooses to print all the marked pages in the current document, the system retrieves, expands, and prints those that are marked. Finally, if the user chooses to print all marked pages in all marked documents, the system will do so. Once any of the print subfunctions have been completed, the software returns control to the display module.

SOFTWARE FOR THE IMAGE SERVER

The image server requires an executable module and a number of index files for its operation. As with the software description of the image retrieval workstation a functional description of the IS software will be given from a high-level viewpoint.

As shown in Figure 5, the overall flow control for the image server is simpler than that for the image workstation. Upon initiation, the server manager opens the appropriate index files and reads the labels of all mounted optical discs attached to the image server. Next it stays in one loop which terminates only if any key is pressed on the keyboard. If no keys are pressed, the server checks to see if a request has arrived from a workstation. If a pending request is detected, the software checks to see if it is a request for an image. If it is an image request, the software extracts the requestor's address, page number requested, and unique identifier of the document image requested. If the unique identifier is in the local index file, the image server transfers the image from the appropriate optical disc to memory in the computer, then to the requestor over the LAN. If the unique identifier is not in the local index file of unique identifiers, an error message is sent to the requestor. If the pending request for the image server was for disc information, the image server sends a list of disc labels for all mounted optical discs to the requesting image retrieval workstation. The software continues to check for pending requests or for a pressed key on the keyboard and responds appropriately.

Index Manager Software

The index manager software package runs separately from the

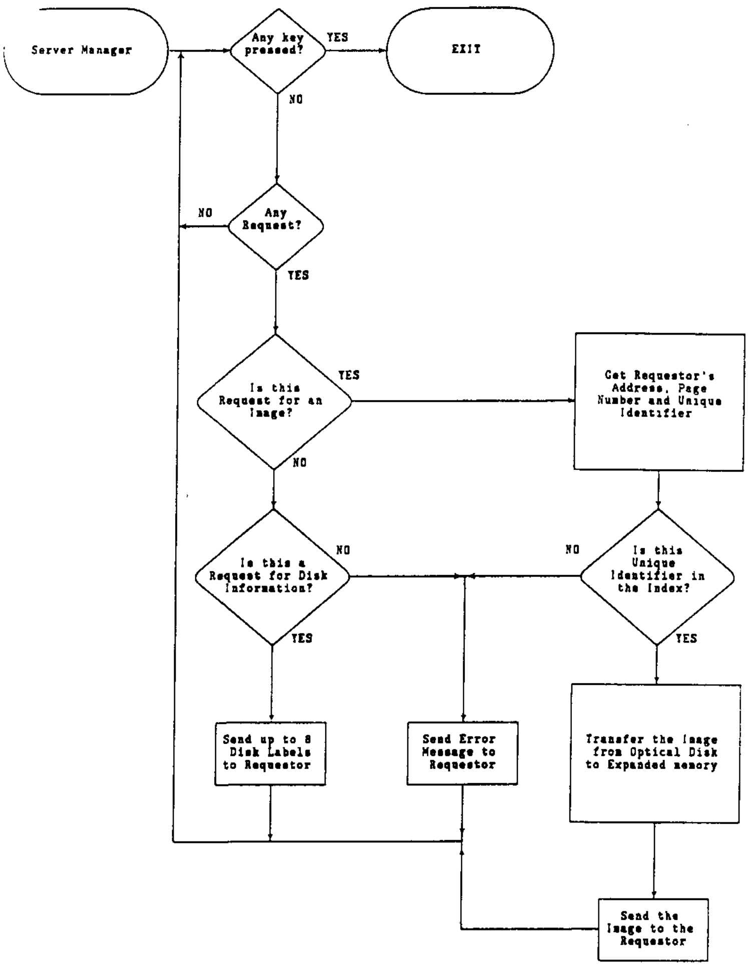

Figure 5. Flow Control for the Image Server

software used in the image retrieval workstation or image server. It is used to create and manage the various index files for the IRW and IS. The index files contain the labels of all indexed optical discs, unique identifiers, images in all documents, titles of archived books, journal titles of archived journal articles, issues of archived journal articles and titles of archived journal articles. The index manager has three basic functions: to create these index files, delete obsolete index file information, and to list the indexed disc labels. The index files are in the form of B-trees to enable quick access. The advantage of using B-trees is that the time required to access records in a file increases very little as the number of records increases. An evaluation of B-tree indexes for this function found that, if ten optical discs are indexed, with an average of 28,800 images on each disc, the average time to access the index information for the first three images of every document was about .15 seconds. This is a very good result, and for this reason it is recommended that B-tree indexes be used for indexing the optical disc information.

The following is a description of the index files implemented in this design. The first thing to appear in each description is the name of the index file and a summary of its purpose. Next is a list of the software packages which use the file. This is followed by a list of the data contained in the file, then by the key required by the requesting software to access the data. To give an example of what this means, for the volume file, to find out whether a given disc label exists and how many documents have been archived on that disc, the requesting software must supply a key field containing the desired disc label.

Volume File: Keeps track of the labels of all indexed optical discs.
Used by: Index Manager; Image Retrieval Workstation; Image Server.
Data contained: disc label; number of documents on the disc.
Key required for data access: Disc label

Image Index File: Keeps track of the location of all archived images
Used by: Index Manager; Image Retrieval Workstation; Image Server
Data contained: disc label; Unique Identifier; page number; location of the image; length of the image
Key required for data access: Unique Identifier and page number

Book File: Used for browsing book titles; keeps track of the titles of all indexed books. The data may be accessed from one of three keys
Used by: Index Manager; Image Retrieval Workstation
Data contained: disc label; book title; Unique Identifier
First key required for data access: Disc label and first thirty characters of the book title (used to select titles from a specific optical disc)
Second key required for data access: Unique Identifier
*Third key required for data access:*First thirty characters of the book title (used to select titles from all optical discs)

Journal File Number 1: Used for browsing journals; keeps track of all journal titles archived on all optical discs
Used by: Index Manager; Image Retrieval Workstation
Data contained: disc label; Unique Identifier; journal title; journal issue
Key required for data access: Journal title (used for viewing journal titles on all optical discs)

Journal File Number 2: Used for browsing journals; keeps track of all journal titles and issues archived on all optical discs
Used by: Index Manager; Image Retrieval Workstation
Data contained: disc label; Unique Identifier; journal title; journal issue; year and month of issue
Key required for data access: Journal title and issue (once a journal title has been selected, this file is used for viewing journal issues on all optical discs)

Journal File Number 3: Used for browsing journals; keeps track of all journal titles, issues, and article titles archived on all optical discs
Used by: Index Manager; Image Retrieval Workstation
Data contained: disc label; Unique Identifier; journal title; journal issue; year and month of issue; article title
Key required for data access: journal title and issue (once a journal title and issues have been selected, this file is used for viewing the titles of journal articles from the selected title and issue archived on all optical discs)

Journal File Number 4: Used for browsing journals; keeps track of all unique identifiers
Used by: Index Manager
Data contained: disc label; Unique Identifier; journal title; journal issue; year and month of issue; article title
Key required for data access: Unique Identifier (used by the Index Manager for maintenance purposes only to verify accuracy of data records)

Journal File Number 5: Used for browsing journals; keeps track of all unique identifiers for specific optical discs
Used by: Index Manager; Image Retrieval Workstation
Data contained: disc label; Unique Identifier; journal title; journal issue
Key required for data access: Optical disc label and journal title (used for viewing journal titles from a specific optical disc)

Journal File Number 6: Used for browsing journals; keeps track of all journal titles for a specific optical disc
Used by: Index Manager; Image Retrieval Workstation
Data contained: disc label; Unique Identifier; journal title; journal issue; year and month of issue
Key required for data access: Optical disc label, journal title and issue (used for viewing journal issues from the selected title)

Journal File Number 7: Used for browsing journals; keeps track of all optical discs, journal titles, and issues for a specific optical disc
Used by: Index Manager; Image Retrieval Workstation
Data contained: disc label; Unique Identifier; journal title; journal issue; year and month of issue; article title
Key required for data access: optical disc label, journal title and issue (once a journal title and issue have been selected this file is used for viewing journal articles from the selected title and issue on the selected optical disc)

Figure 6 shows the flow control for the index manager. This software will run on any workstation containing a local optical disc drive and requires a communications link to the NLM mainframe. It has three basic functions: to add a new optical disc index to the indexes, to delete an optical disc index from the indexes, or to list the labels of all discs indexed. If the user wants to add a new optical disc's index content information to the master indexes, he must first mount the optical disc in the workstation's optical disc drive. The software then reads the label of the disc and adds the label to the volume file. Then it reads the index from the optical disc and adds its information to the index file. Next it creates a search strategy for GRATEFUL MED. The purpose of this is to get the appropriate

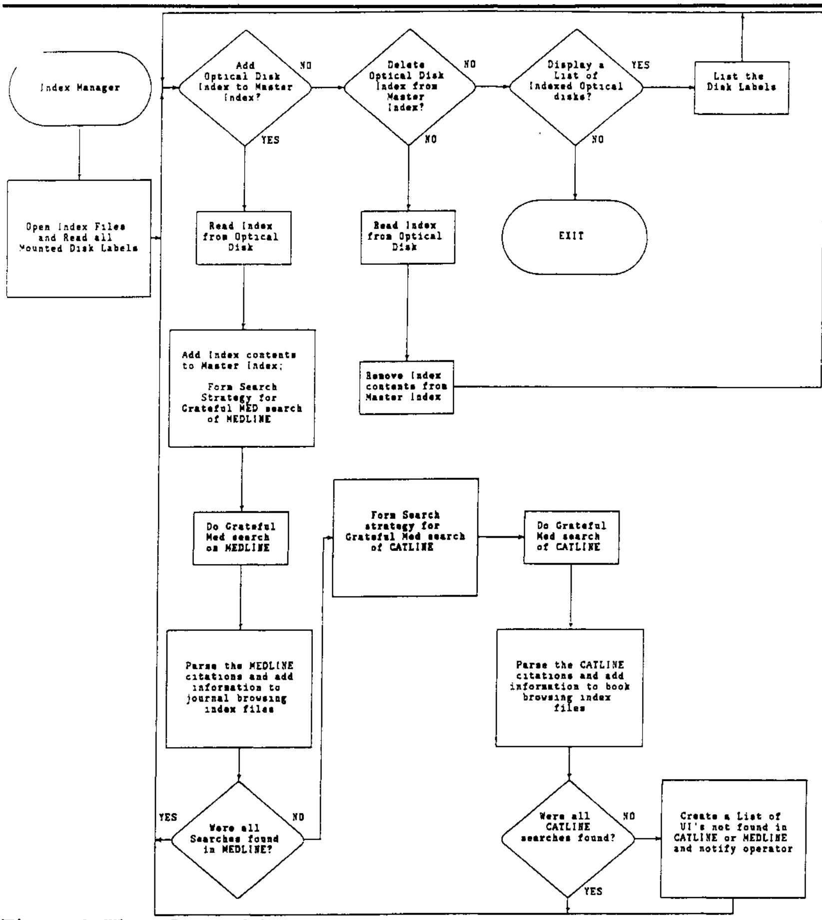

Figure 6. Flow Control for the Index Manager

information to enter into the book and journal index files. The search strategy begins with a list of unique identifiers of the documents from the disc's index file. After the search strategy is formulated, the GRATEFUL MED search engine is invoked, and the MEDLINE file is searched for the list of unique identifiers. After GRATEFUL MED returns control to the index manager, the software parses the citations retrieved and adds the journal title, journal issue, month and year, and article title for each unique identifier into the various journal index files. Then the software checks to see if all unique identifiers from the search strategy were found. If all were found, this indicates that all were for journal articles. If some were not found, this indicates that some were for books so CATLINE must be searched.

A new search strategy is formulated for CATLINE from the unique identifiers not found in MEDLINE. Then the GRATEFUL MED search engine is invoked to search CATLINE. After GRATEFUL MED returns control to the index manager, the software parses the citations retrieved and adds the book titles into the book index files. Then the software checks to see if all UIs from the search strategy were found. If all were found, then this function has completed successfully. If some were not found, the operator is notified, and the UIs not found are written to a "not found" file on the workstation for later review.

The second function of the workstation, to delete optical disc information from the master index files, permits a user to remove unwanted disc index information from the files. The optical disc whose directory information is to be deleted must first be placed in the optical disc drive controlled by the workstation. Then the software reads the index from the disc and removes all data from all index files containing that index.

The third function is identical to that found in the image retrieval workstation: list indexed disc labels. This serves to verify that the two previous functions have completed successfully.

Operation of the Image Server and Image Retrieval Workstation

The operation of the image server begins with turning on all disc drives controlled by the IS with the appropriate discs mounted in each. Then the software is run by the user. There is no further intervention until the user wants to shut down the IS which is done by pressing any key on its keyboard.

The operation of the image retrieval workstation is more complex since there are many levels of menus available for the user. Each menu was designed to provide an error-free system. The system is error free in the sense that it automatically eliminates those options that are logically impossible, thereby preventing errors that users could cause by inadvertently making those selections. The implications of this become clear with a description of each of the menus. The contents of each menu are listed below with a discussion of how the error-free design prevents mistakes that could be caused by users. Each main menu is also described in previous sections of this article.

MAIN MENU
Search NLM's Databases and Display Documents
Browse Documents

Retrieve the Most Recently Marked Document
Display a List of Optical Discs Known to the System
Exit

The third item in the menu, "Retrieve the Most Recently Marked Document," can be selected by the user only if a document has been marked.

DISPLAY MENU
Display Next Page
Display Previous Page
Jump to Page
Manipulate Image
Mark Page
Page Print
Jump to Next Marked Document
Jump to Previously Marked Document

The "Display Next Page" choice is available at all times except when the last page of the document is being displayed. The "Display Previous Page" choice is available only if the first page of the document is not being displayed. The "Jump to Next Marked Document" choice is available only if there is at least one marked document after the current document in the list of marked documents. The "Jump to Previous Marked Documents" choice is available only if there is at least one marked document prior to the current document in the list of marked documents.

PRINT PAGE MENU
Print Page Currently Displayed
Print Entire Document
Print Part of Document
Print All Marked Pages in this Document
Print All Marked Pages in ALL Documents

The fourth choice in the menu, "Print All Marked Pages in this Document," is available only if the current document contains at least one marked page. The "Print All Marked Pages in ALL Documents" choice is available only if at least one document has been marked.

PAGE JUMP MENU
Enter the Page Number:
Go Forward Pages from Selected Bookmark
Go Reverse Pages from Selected Bookmark

The second and third choices in the menu are available only if at least one page in the current document has been marked.

MARK PAGE MENU
Mark Page Currently Displayed
Remove all Bookmarks from this Document
Remove all Bookmarks from ALL Documents

Remove Bookmark from Selected Page

The "Mark Page Currently Displayed" choice is available only if the image displayed is unmarked. The "Remove all Bookmarks from this Document" choice is available only if the current document contains at least one marked page. The "Remove all Bookmarks from ALL Documents" choice is available only if at least one document has been marked. The "Remove Bookmark from Selected Page" choice is available only if at least one page in the current document has been marked.

MANIPULATE IMAGE MENU
Zoom/Shrink
Rotate Right
Rotate Left

The "Rotate Right" choice is available only if the image is upright or has already been rotated to the left. Similarly, the "Rotate Left" choice is available only if the image is upright or has already been rotated to the right.

BROWSE MENU #1
Browse Available Book Titles
Browse Available Journal Titles
Browse by Unique Identifier

These choices are available at all times.

BROWSE MENU #2
All Optical Discs
Currently-Mounted Optical Disc

The browse function permits the user to browse either all optical discs or only optical discs currently mounted in either the server or local disc drive. It is possible for a large number of discs to be indexed in the master B-tree index files, but it may not be possible to have all simultaneously mounted. If the user browses all optical discs (choice 1), and wishes to view a document on an unmounted disc, the system will give him the label of the appropriate disc to insert in the local disc drive if one is controlled by the image retrieval workstation.

BROWSE MENU #3
Search for Letter
Search for String

The browse function also permits the operator to search for a book title or journal article title either by the first letter of the title or by a string of up to 10 characters in length which may appear in any part of the title. If the search is successful, the list of titles is updated with an arrow pointing to the title found.

LARGE IMAGE DATABASES: ISSUES AND DESIGN CONSIDERATIONS

While online access to, and retrieval of, older documents preserved electronically may not be warranted by user demand, some thought was given to a situation requiring online retrieval of images from a large disc collection. The organization of such a collection among multiple servers is considered here.

As suggested in Figure 2, one image server can support several optical disc drives. Many commercially available optical disc drives are compatible with the SCSI interface standard which allows up to eight SCSI controllers on one SCSI bus. At $10K per drive, it becomes uneconomical to have more than a few drives per server or even per network. Having several drives on one server also limits the performance to the extent that it can only retrieve one image at a time; if all drives at a server have discs of "popular" document images, the average queue size at the server and therefore retrieval time will increase in proportion to the number of drives. A possible compromise between cost and performance is illustrated in Figure 7. This system has multiple servers. Those discs most frequently accessed are distributed among the "fast" servers, where they are mounted in drives. The remaining discs are located at the "slow" server which has a jukebox with one or more drives and a collection of discs that are unmounted, but which are mechanically retrieved and mounted when needed. Since jukeboxes are quite expensive, they should be considered only when the anticipated image database is too large to manage economically on a few drives and user requirements permit some delay in file access.

Another issue associated with a large database of image files is location of and access to the database indexes. If the database is small (a few optical discs) and fairly static, it is possible that all servers and retrieval workstations could maintain private copies of all indexes. If the database is large, magnetic storage requirements at retrieval workstations increase the cost of the workstation. And if the database is dynamic and growing, it becomes a significant operational problem to keep indexes at all nodes updated. In commercially available integrated systems, jukeboxes are commonly found attached to a computationally powerful minicomputer performing the functions of host, controller, and index manager. In these systems, the jukebox is generally the only node with optical disc drives, and so it is appropriate that its host/controller maintain the only copy of the indexes.

Figure 7 shows how the indexes might be managed in a system where the image file database is distributed among multiple servers. The index server maintains index data for all optical discs in the system. It also communicates via the network with all servers to establish which discs are currently mounted at each fast server and which are available at the jukebox. Each server then only needs to maintain sufficient index data to access the images on their mounted discs which should help keep both response time and magnetic disc costs down. Retrieval workstations can utilize the index server at several levels depending on their own memory and magnetic disc capacities. Index data for one or more optical discs can be downloaded

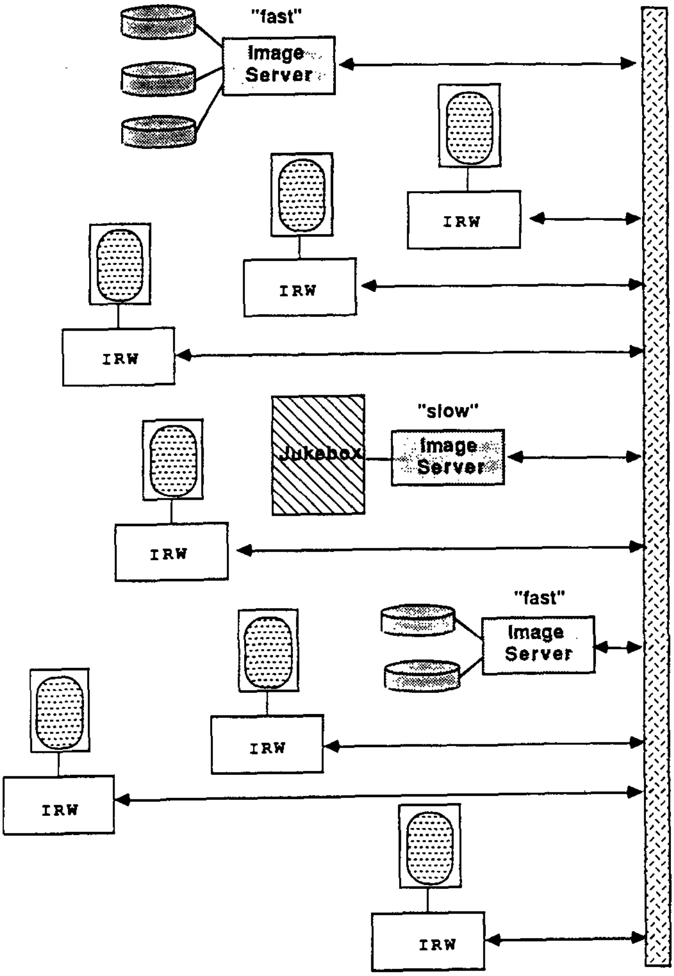

Figure 7. A System with Fast and Slow Image Servers

for local access at the beginning of a session. This would be especially appropriate for the browsing function which uses several index files.

Alternatively, index data can be retrieved on a document by document basis, which might be more appropriate when viewing documents that result from a GRATEFUL MED search.

The hardware requirements for an Index Server are the following:

1. A small computer such as the IBM AT (or compatible) personal computer with an 8 MHz CPU and 512 KB of main memory.
2. An operating system equivalent to DOS version 3.3 or higher.
3. Hardware and software interface to the selected LAN.
4. Sufficient magnetic disc capacity for all programs and utilities plus index files for total system database of document image files.
5. A monitor and adapter for operator interface; may be color or monochrome.

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Visual Access to Visual Images: The UC Berkeley Image Database Project

HOWARD BESSER

ABSTRACT

DESCRIPTIVE TEXT IS USUALLY inadequate for finding the precise visual image for which one is searching. Though a search can be narrowed by using basic terminology (such as subject, date, country, format), its outcome will then often require visually inspecting hundreds of images in order to find the desired one. This creates work for the library/repository (which must retrieve many unneeded delicate images), wear and tear on the collection, and a great deal of inconvenience for the user.

The author proposes a solution to this problem—emphasizing visual browsing tools on high resolution computer workstations. In this model, a user can perform initial online queries using descriptive text, then visually browse through high quality surrogate images of the query results. Several dozen images can be displayed simultaneously, and any single image can be enlarged for closer visual inspection. The University of California at Berkeley prototype implementation of this model is discussed in detail.

THE PROBLEM

The management of image collections in a large organization poses a number of access problems. Chief among these are the intellectual access (finding the image[s] that might meet the user's needs) and the physical access (bringing the user and the image together when collections may be spread across a large physical area, and material may require delicate handling).

Many institutions have large collections of images that need to be managed. Photographs, slides, diagrams, charts, maps, signed documents, security photographs, and slide collections for public speaking are all materials that pose physical and intellectual

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organization problems which cannot be answered by unmodified systems designed solely to answer those problems for collections of books. For the most part, these collections cannot be converted into ASCII text, so adequate representations of them cannot be placed in traditional databases. The objects themselves are difficult to store and handle, and using them tends to be difficult and to accelerate deterioration. Finding the appropriate objects becomes an arduous task, and browsing is almost impossible.

Two interrelated aspects that make the cataloging of images different from that of books are the deliberateness in their creation, and their richness and complexity. Most books are written with clearly defined purposes in mind, and catalogers can expect that most potential users of these books will approach them from that standpoint.

Authors and publishers go to great lengths to tell us what this purpose is, citing it in the preface and introduction, on dust covers, and often even on the book's cover. Images do not do this. To paraphrase one prominent author speaking of museum objects, unlike a book, an image makes no attempt to tell us what it is about. Even though the person who captured an image or created an object may have had a specific purpose in mind, the image or object is left to stand on its own and is often used for purposes not anticipated by the original creator or capturer.

Historically, text-based intellectual access systems have been woefully inadequate for describing the multitude of access points from which the user might try to recall the image. Images are rich and often contain information that can be useful to researchers coming from a broad set of disciplines. For instance, a set of photographs of a busy street scene a century ago might be useful to historians wanting a "snapshot" of the times, to architects looking at buildings, to urban planners looking at traffic patterns or building shadows, to cultural historians looking at changes in fashion, to medical researchers looking at female smoking habits, to sociologists looking at class distinctions, or to students looking at the use of certain photographic processes or techniques.

Both in descriptive cataloging and in providing access points, even extensive text-based descriptions of the images are seldom sufficiently descriptive for the researcher to determine which images are likely to be relevant to his or her needs. Even an enormous amount of descriptive text cannot adequately substitute for the viewing of the image itself.

Yet handling the images can hasten deterioration. Photographs, slides, and objects are not designed to be handled like books. Even a single fingerprint can seriously harm these. Because of this fragility, most image collections will only provide users with what mounts to archival-like access. Pulling items for users requires library staff time, and, in an era of scarce resources, often results in further limiting access to the collection. This kind of limited physical access, necessary for conservation, coupled with a lack of extensive bibliographic description and intellectual access, is one of the key problems posed by collections of images (Lynch & Brownrigg, 1986a; Besser, 1987).

A Case Study: The UC Berkeley Problem

The University of California's Berkeley campus faces image collection access and management problems consistent with those outlined earlier. UC Berkeley has scores of image collections housed in different buildings spread out over more than a square mile of territory. These include photograph or slide collections in the areas of art history, botany, geography, and history, as well as museum or archival object collections in anthropology, art, historical manuscripts, and paleontology. Most of these collections are outside the jurisdiction of the main campus library; though many of the collections are managed by librarians, almost all of these collections are officially administered by individual departments, museums, or other bureaucratic units (Besser & Snow, forthcoming). Less than a handful of these collections have any kind of automated catalog access to the materials, and the few that do have automated catalogs have incorporated only very minimal cataloging. Only the materials belonging to the campus library are cataloged at AACR2's second or above, and most of this material is reflected as collection-level records rather than as individual items. By and large, the intellectual access and description of this material suffer from the same problems outlined in the first section of this article.

On the other hand, the Berkeley campus has promoted the notion of remote access to all campus materials. In recent years the notion of a "scholar's workstation" has become the dominant vision for how scholars on a university campus will do their library-type research in the not-too-distant future. According to this model, all university information resources (online catalogs, bibliographic databases, statistical databases, and eventually even full text of documents) should be available from the researcher's own workstation (Curtis, 1988; Moran et al., 1987; Lynch & Brownrigg, 1986b). Researchers from university campuses and in large organizations which are promoting the idea of a "scholar's workstation" have come to expect intellectual access to all the institution's holdings from a single point.

The Berkeley campus and UC Systemwide Libraries, in cooperation with the campus computer center, have already taken some steps toward the implementation of this model. Journal indexes (such as MEDLINE) as well as bibliographic information on holdings in thirty-six of the campus' library collections are available through

MELVYL (the UC systemwide online catalog) from public terminals throughout the campus, from office workstations connected to the campus high-speed network, and via modems from PCs in individuals' homes (Lynch & Berger, 1989; Lynch & Brownrigg, 1989). The same workstation can be used to search an index or the libary catalog, find a bibliographic citation, and insert the citation into a word-processing document (though the software to do this smoothly has not yet been fully developed and distributed). Researchers are anticipating a situation where all campus resources will be available from any workstation connected to the campus network. Students and faculty have already become accustomed to exercising intellectual access in a single convenient location before having to visit the collection where the material is actually housed. But, while the campus and systemwide libraries have made great strides toward providing remote access to text-based materials, precious little work has been done for access to collections of images.

Proposed Solution

The key elements that would lead a user to the appropriate images are text-based cataloging and indexing sufficient to allow the user to narrow a retrieval set to a reasonable size, coupled with some kind of procedure for browsing through the retrieved set of images. But, as stated earlier, handling images to identify which ones are relevant both adds to their deterioration and takes up valuable staff time.

To solve this problem, a proposal was made to use surrogate images for the browsing portion of the access process. The use of reasonable facsimiles allows the user to determine whether a particular image is relevant or not without having to remove an actual image from storage. The viewing of a surrogate as part of an intellectual access system provides the user with a powerful description for which adequate verbal substitutes may be obtained only at a great, perhaps prohibitively great, cost (Rorvig, 1986).

The proposed solution merges a form of online public access catalog (OPAC) with tools for visually browsing surrogate images. From any networked workstation the user would be able to use relatively standard OPAC-type techniques coupled with more extensive indexing terms than normally provided by LC subject headings to find an initial set of relevant records. The system would then allow the user to browse visually through the group of small surrogate images associated with that initial hit list. Any particular image could then be enlarged and displayed in high resolution on the user's workstation.

Such a system would allow the user to take advantage of the power of indexing terms to identify potentially relevant documents quickly yet still give the user the capability of examining visual representations of the images in the retrieved set to determine which are really relevant. If indexing terms were used by themselves, they would likely turn up many images not quite relevant to the user's search (that is, low precision); if visual browsing tools were used alone it would take too long to look through an entire collection. When combined together, these two tools will offer the potential for the most efficient retrieval of relevant images.

Such a system would also help with conservation problems. By inspecting surrogate images (and even being able to enlarge these to examine them closely), the user will be able to eliminate all but the most relevant images before even visiting the image repository. Only the images that are absolutely needed will have to be handled.

The Berkeley Implementation

In 1986 the managers of image collections on the UC Berkeley campus began concrete discussions with the campus computer center over how such a system might be designed and implemented. This resulted in a "proof of concept" which was exhibited at the ALA conference in 1987. In 1988 the Advanced Technology Planning Group of Berkeley's Computer Center, in association with a number of these colelction managers, began concrete work on the development of "IMAGEQUERY," the software for a prototype system. Collections modeled in the prototype include those of the University Art Museum, the Architectural Slide Library, the Geography Department's Map Library and (later on) the Lowie Museum of Anthropology's collection of photographs of their objects.

In the following pages this prototype and how it would operate, if fully implemented, is discussed. It should be emphasized that this is still only a prototype, and, due to a wide variety of factors (see Besser & Snow, forthcoming), it will be a number of years before it is fully implemented.

The system is based upon the proposed solution outlined in the previous section with a number of extensions designed to match the computing plans and collection needs of the Berkeley campus. The system is designed to work in a distributed fashion on a high speed computer network. Any bit-mapped workstation running X-Windows and connected to the campus network should be able to access the system (currently supported workstations include SUNs, DEC's MicroVaxen, IBM's RTs and PS/2s running AIX, and Apple's Macintosh running AU/X).

The user first uses text-based information to narrow down a search, then can browse through the surrogate images for that initially retrieved set. The user begins by invoking IMAGEQUERY with the name of the collection he or she wants to search (currently art museum, architecture slides, anthropology museum, or geography). A blank spreadsheet is displayed (see Figure 1) where the user will compose his or her query. This is done by using a mouse to pull down menus from the boxes at the top (see Figure 2) in much the same way as on a Macintosh computer. Assume that we want to look for images from particular towns in Italy which are part of the architecture image collection. In this case, we activate the fields menu and see a list of possible search fields offered by the architecture database. We then indicate Place in the menu. When we release the mouse, the name of the field (Place) is then displayed in the menu portion of the spreadsheet.

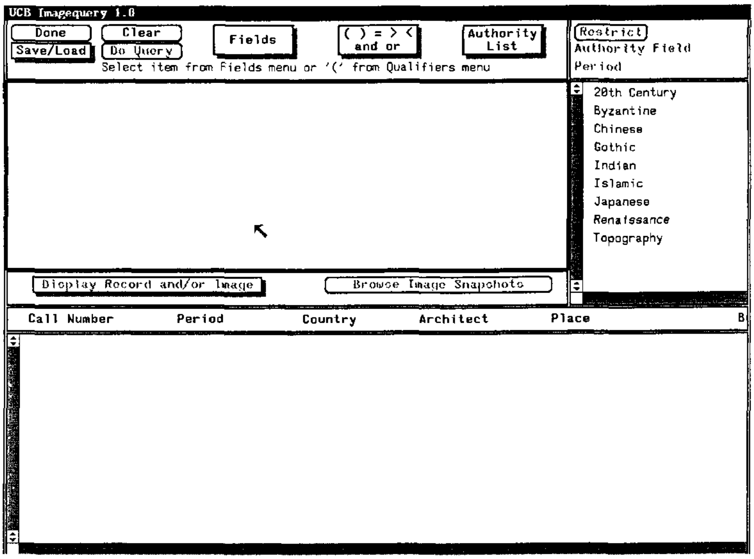

Figure 1

In a similar way, if we pull down an = from the comparison operator menu, the system will place that operator in the main portion of the spreadsheet. If date instead of Artist had been chosen, we might want to choose > or < =.

Having displayed the query Place = in the spreadsheet, the keyboard can now be used to type in the query (wildcard searches are accepted), or the "Authority Values" box can be used to preview the existing entries currently in the catalog/database and selections can be made from there. By merely clicking the mouse on the listing VENICE, for example, that place will be entered into the query on the main portion of the spreadsheet (see Figure 3). This feature both prevents misspellings and allows the user to see what kind of entries are in the database before actually querying it. This should help prevent queries where nothing is retrieved.

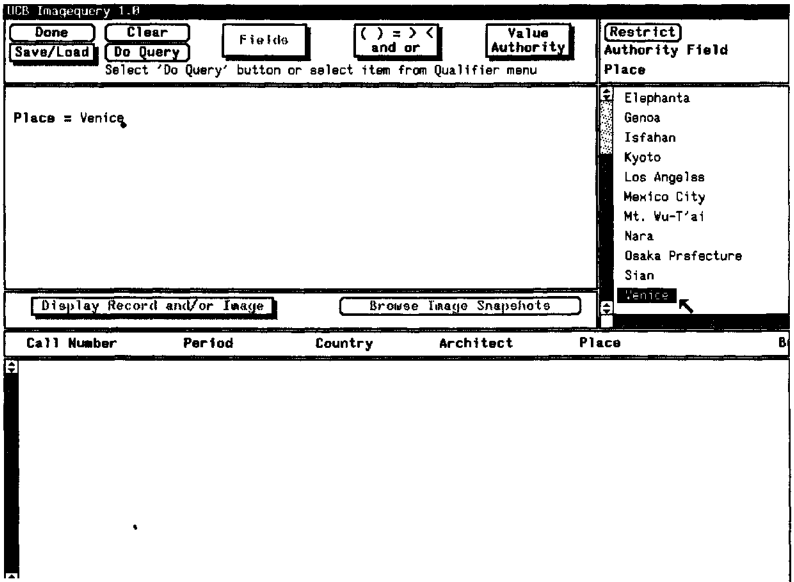

Figure 2

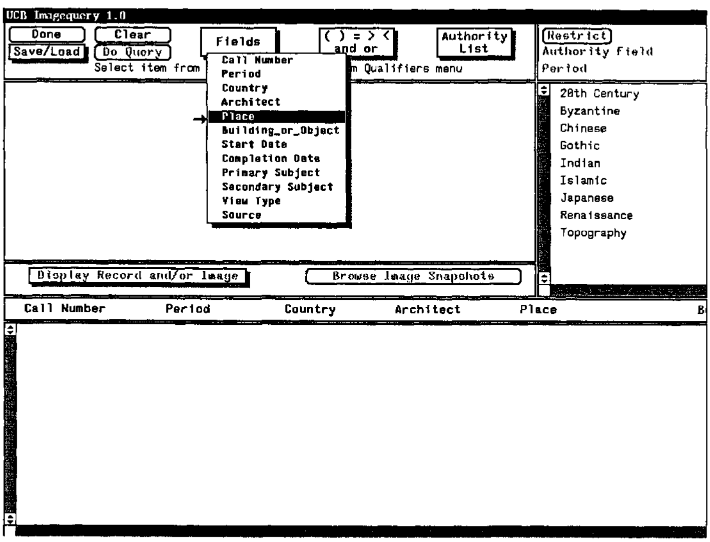

Figure 3

At this point, we can continue building a more complex query in the spreadsheet using Boolean operators from the "comparison operators" pulldown menu, or the "do query" button can be pressed and the results of a query will be displayed as shortened records at the bottom of the screen (see Figure 4).

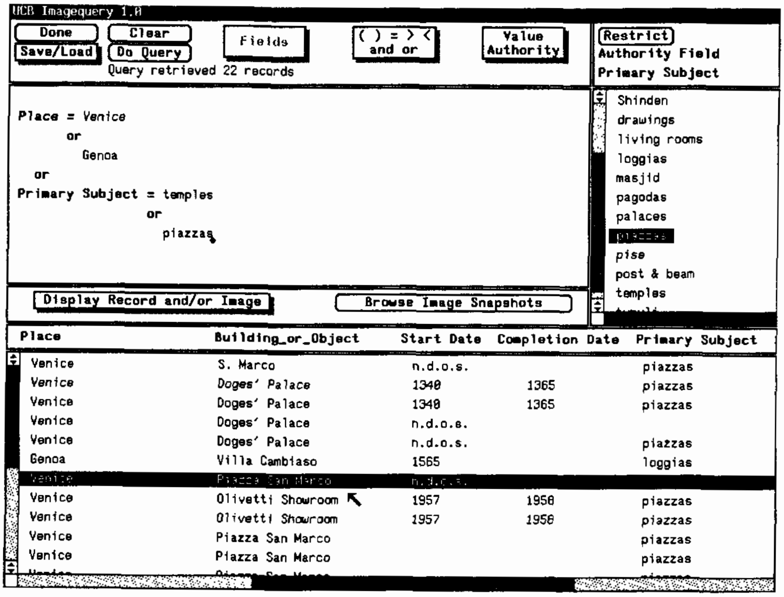

Figure 4

To browse through surrogates of the image records that were found as a result of the initial query, we simply select the "browse" button and slide-sized color images will be displayed on the right portion of the screen (see Figure 5). If brief information about any of the surrogates is needed, we can click on that image and it will be highlighted, as will the corresponding shortened text record underneath the spreadsheet. Or, if we want to see which image a particular text refers to, we can click on the shortened record and both that record and the associated surrogate image will be highlighted.

If we now want to browse through more surrogate images, the screen can be filled with them (see Figure 6). This feature allows quick viewing of several dozen images at once and we can zero in on those that are most relevant. We can then point to any particular image on the screen, pull down a menu and see the complete text record associated with it, or see a high resolution color enlargement of it (a much better surrogate) (see Figure 7).

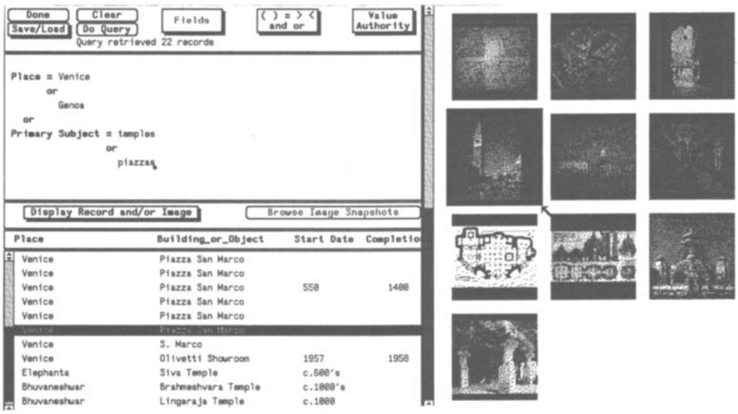

Figure 5

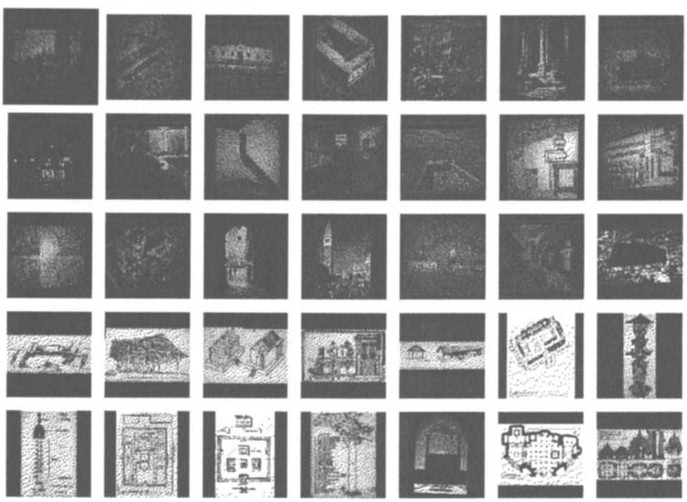

Figure 6

If we want to narrow the query visually, a new set of surrogate images can be created by merely pointing to the ones to be saved, and giving the new group a name. Then the same software can be used to look only at the members of that group, allowing us to pinpoint only the most relevant material.

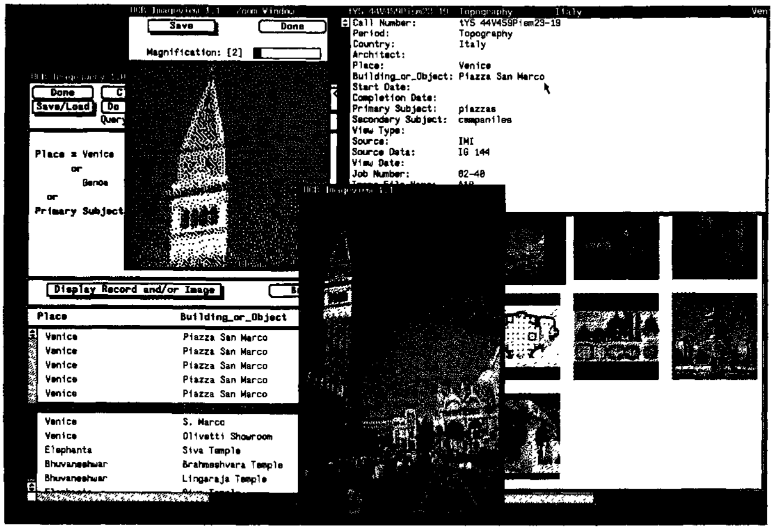

Figure 7

The system provides a uniform user interface to different collections, yet allows each collection to maintain its own set of descriptive and indexing terms; the "look and feel" of searching remains the same, but the searching and descriptive terminology used changes with each collection. Compare the user interface for the anthropology museum (see Figure 8) with that for the architecture collection (see Figure 2). Terms such as *architect* and *building* are irrelevant to the anthropology collection, while terms like *tribe* and *collector* are not very helpful for the architecture collection. The system is based upon a common user interface to independent relational databases (rather than MARC records), which allows descriptive and searching terms to be fine tuned to a particular collection at the expense of not being able to join records from different collections or search across collections. This choice was made because of the widespread availability of, and support for, the relational systems on campus, the perceived lack of suitability of MARC for these kinds of collections with minimum-level cataloging, and because none of the units involved falls under the jurisdiction of the main campus library (see Besser & Snow, forthcoming).

This structure should eventually allow indexing and searching on terms from the *Art & Architecture Thesaurus, Chenhall's Nomenclature,* and other thesauri designed for more specific types of material than the LC Subject Headings.

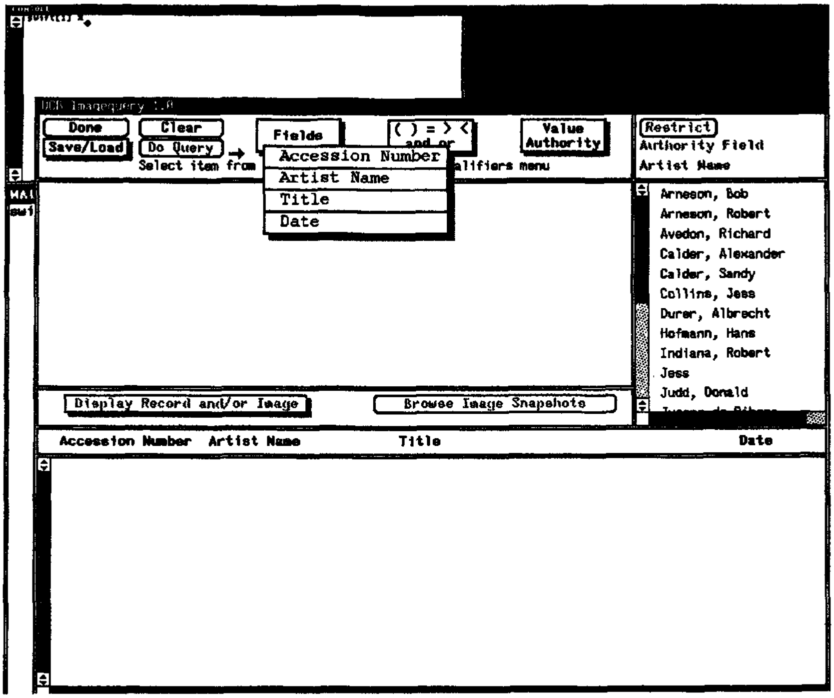

Figure 8

Conclusion

If fully implemented, this prototype would solve a number of the problems outlined in the first section of this article. It would allow the user to retrieve an initial set of records using text descriptors that are more closely adapted to that collection than one would normally find in an online library catalog. It would then allow the user to browse through surrogate images for each of the records initially retrieved, providing visual tools with which to compare and examine them closely. It would allow the user sitting at any workstation on the campus to identify precisely which images he or she would like to view and hence reduce the risk of overhandling the originals. It would also provide a common user interface for searching the various campus image collections.

But, as this design is in the prototype stage, there are still many questions left unanswered. Practical questions include: What revised considerations in design will be necessary to prevent the campus network from becoming overloaded? How should the display be handled when initial retrieval sets are very large? Conceptual questions that need to be resolved have been raised elsewhere. These include: how to link the descriptor terms in different collections to one another so that a single search could be done across multiple image collections (Besser & Snow, forthcoming); what kind of changes will take place in researchers' habits and the way the average person perceives visual images (such as art) as the result of a widespread implementation of systems such as this (Besser, 1987)? None of these questions can be adequately answered without more widespread implementation.

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Impact of CALS on Electronic Publishing Systems and Users

WILLIAM G. BEAZLEY

ABSTRACT

THE U.S. GOVERNMENT, through the National Institute of Standards and Technology (NIST) (formerly the National Bureau of Standards) has long been active in developing standards for information sciences. Recently, several government organizations, particularly the Department of Defense (DoD), have begun using their enormous buying power to enforce standards on automatic data processing (ADP) hardware and software vendors and the contractors that use them. The most forceful of these programs is the DoD Computer-Aided Acquisition and Logistic Support (CALS) program.

INTRODUCTION

One area impacted by CALS is Electronic Publishing Systems (EPS). EPS users doing business with the government (and eventually throughout U.S. industry) will see increased pressure to conform to these standards. The result will be permanent and far-reaching changes in the methods by which engineers and government contractors use EPS and view the databases they create. In particular, the information models developed in support of CALS requirements and standards will provide validated, processable discipline knowledge for design and support of defense and commercial products. The electronic publishing professional will serve as an integrator of document information, assuring its integrity as captured knowledge and its readiness for use in a variety of support applications and media.

The CALS standards and specifications are being developed incrementally. The initial increment, called Phase 1 Core Require-

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ments package, was developed and coordinated during 1987 and 1988. Core requirements refer to the minimum standards or procedures defined for CALS integrated data system procurement. Development of the Phase 1.2 standards and specifications is underway for coordination during 1989 and 1990.

Documents released to date are shown in Table 1. These standards represent the formal release of CALS Phase 1 standards. The remainder to this article will be concerned with CALS standards for electronic publishing.

TABLE 1
CALS DOCUMENTS RELEASED TO DATE

Document	Title, Scope, and Focus
MIL-STD-1840A	"Automated Interchange of Technical Information" (December 22, 1987). Parent document for other CALS standards and specifications. Provides rules for organizing files of digital data into a complete deliverable document.
MIL-D-28000	"Digital Representation for Communication of Product Data: IGES Application Subsets" (December 22, 1987, Amendment 1, December 20, 1988). Defines a series of application-specific subsets of Initial Graphics Exchange Specifications (IGES), the popular name for ANSI Y14.26M.
MIL-M-28001	"Markup Requirements and Generic Style Specification for Electronic Printed Output and Exchange of Text" (February 26, 1988). Defines a profile of Standard Generalized Markup Language (SGML), defined in ISO 8879, for Military documents. Describes tagging a document according to structure and content and will soon add an Output Specification (OS) for tagging format characteristics.
MIL-R-28002	"Requirements for Raster Graphics Representation in Binary Format" (December 20, 1988). Defines engineering drawing and technical manual illustration requirements for raster graphics compressed in accordance with CCITT T.6, FAX Group 4, and FED-STD-1065.
MIL-D-28003	"Digital Representation for Communication of Illustration Data: CGM Application Profile" (December 20, 1988). Defines an application profile for delivery of technical manual illustrations using Computer Graphics Metafile (CGM). CGM has been published as International Standard ISO 8632, ANSI X3.122, and FIPS 128.
MIL-HDBK-59	"CALS Implementation Guide" (December 20, 1988). Provides guidance to military acquisition managers on preparing contract requirements addressing: (1) digital delivery or access to weapon system technical information, and (2) integration of contractor processes that create and use technical information.

Product Definition Standards

The key to understanding how CALS will affect electronic publishing is the emerging relationship between product definition data, information models, and technical publications. Before CALS Phase 1, product definition data denoted the totality of data elements required to completely and accurately define a product. Product definition data includes the geometry, topology, spatial relationships, material characteristics, tolerances, attributes, and features necessary to completely define a component part or an assembly of parts for the purpose of design, analysis, manufacture, test, and inspection. Product definition data underlies: CAD (computer assisted design) data; CAM (computer assisted manufacturing) data; configuration management data; group technology data; process planning and control data; engineering design data; bill of material data; inventory data; technical publications data; and other databases. The result is a body of product data comprised of drawings, analytical models, technical manuals, provisioning plans, training plans, etc.

The scope of product definition data is still expanding within CALS to include more logistic and support concepts. The government's acquisition needs can be much more demanding than in private industry. When DoD acquires a weapon system, it must also acquire technical data to support design, manufacturing, operations, maintenance, and spares procurement. Product data include all product definition data plus data elements necessary to fully support a product for all applications over its expected life cycle, including:

1. maintenance planning;
2. manpower and personnel;
3. supply support;
4. support equipment;
5. technical data;
6. training and training support;
7. computer resources support;
8. facilities;
9. packaging, handling, storage, and transportation; and
10. design interface.

These areas comprise the logistics of using that product. Product definition data under CALS Phase 2 considers the product as fielded, hence, can be expected to include support and logistic data. Logistic Support Analysis (LSA) is the set of tasks which develops this product data.

Much of this fielded support and logistic data is currently produced via electronic publishing technology. Current CALS standards encode the text, illustrations, drawings, photographs, and other representations found in technical publications. Different CALS standards apply in the creation and viewing of technical publications, depending on whether we encode the presentation of source data, or the source data itself. Source data can include the digital text, CAD data, or other original data about the product encoded by the author, designer, or creator.

There are several presentations of source data which might be used to encode technical publications. A raster page image might encode the fully composed physical or electronic representation of a single and complete page of a document (with manuscript text and graphic image combined). The CALS standard MIL-R-28002 defines engineering drawing and technical manual illustration requirements for raster images.

Another presentation of technical data is as a picture where the line work is composed of digital vectors. Vector graphics provide greater flexibility in editing the illustration. Computer Graphics Metafile is an easy to implement format to encode vector technical illustrations and can also be used to exchange pure raster images. The CALS standard MIL-D-28003 defines an application profile for delivery of technical manual illustrations using CGM.

However, the original source data is still the most desirable format. Product data created on a CAD system can be output in digital form and transferred to another CAD system. The main formats targeted by CALS for transferring source CAD product data from one system to another include:

—IGES—Initial Graphics Exchange Specification (ANSI Y14.26)
—VHDL—Very High Speed Logic Integrated Circuit Hardware Description Language (IEEE STD 1076-1987)
—PDES/STEP—Product Data Exchange using STEP/Standard for Exchange of Product Data (ISO/TC184/SC4/WG1)
—EDIF—Electronic Design Interchange Format (ANSI/EIA 548-1988)
—IPC—Institute for Interconnecting and Packaging Electronic Circuits, IPC-D-350, 351, 352, 354
—SGML—Standard Generalized Markup Language (ISO 8879)

Direct translators are not encouraged by DoD.

Product Data Exchange Specification using STEP as a Prototype for Future CALS Standards

The growing interest in access and delivery of source product data means that users will create and maintain data models of the design rather than drawings and other documents which display it. They must develop procedures which maintain and check the product data so it uses only entities required by the standards. They must develop software methods to output the proprietary data in authoring software into the formats required.

Consider the history of the Initial Graphics Exchange Specification. IGES was developed as a format for encoding engineering drawings containing product information. IGES entities were developed from examining what commercial CAD software entities used to support applications. Figure 1 shows the development strategy for IGES (in comparison to PDES).

The drawings are encoded in a standard set of data records or entities. The data needed for each entity and the precise format for type of entity are agreed to in advance by members of the IGES Project. The members, all volunteers, cast ballots on each addition or modification to these entities. This entity selection continued while the CAD software tools themselves were still evolving from drafting tools to full design databases.

As the Initial Graphics Exchange Specification entered actual production use, it became clear that specifying an entity set and format was not enough. Some CAD vendors entities didn't match the IGES entities exactly. Sometimes different vendors had much different ways of encoding the same application information. Some vendors had much more complex application databases than IGES could encode. The members of the IGES Project found themselves constantly modifying the specification to meet the needs of some particular application, user, or vendor. It rapidly became clear that the problem would not be solved by adding entities to IGES. The IGES developer attempted to improve translation results by restricting users to a "subset" of entities, defined for each application. MIL-D-28000 currently requires each application making delivery in IGES to use a small subset of entities to encode its engineering data. Application subsets were defined to completely and unambiguously represent the information requirements of a product for a particular application of digital product definition data. These application subsets are defined for technical publications, engineering drawings, electrical products, and numerical control.

It was determined that the present subset requirement is incomplete. Users found that, to complete a transfer, they first had to "flavor" the data for correct processing on the target system. Flavoring is required because no two systems use the same Initial Graphics Exchange Specification in precisely the same way. Mark Palmer of NIST said: "Just giving a subset of IGES entities and demanding their use in delivery is not enough. A complete protocol is needed to encode and decode the product model in IGES. An application protocol is needed whether IGES, PDES, or any other format is used" (CALS Report, 1988, p. 12).

It is now clear that a complex protocol is needed to successfully transfer data regardless of what format is used. These application

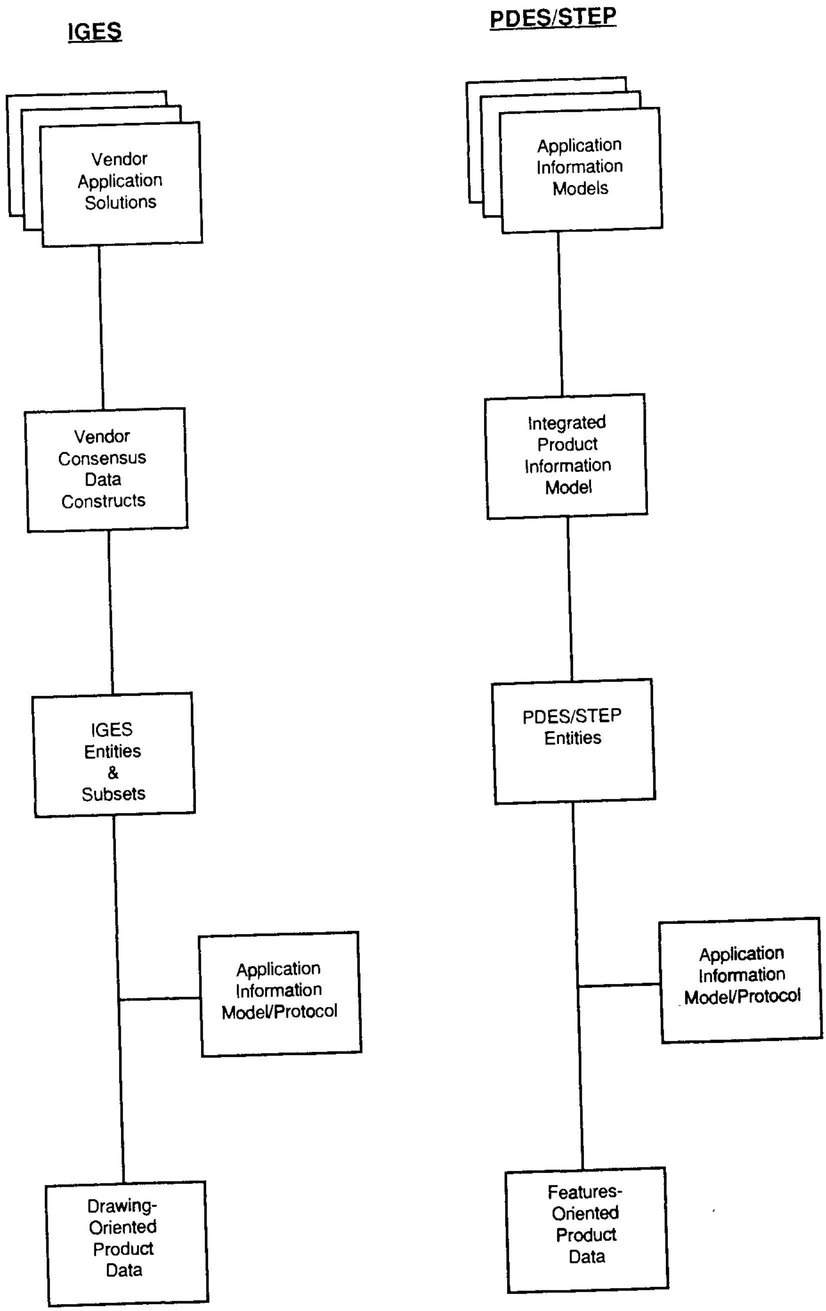

Figure 1. Comparison of IGES and PDES/STEP Development Strategies

protocols are formal data transfer procedures negotiated and used by sender and receiver for use in a particular application. The requirements for application protocols were developed by the IGES/PDES Application Validation Committee.

Application protocols consist of seven components:

1. application conceptual information model which describes the information to be transferred;
2. detailed glossary for the information model to define its data elements;
3. detailed specification of constraints and business rules for the information model;
4. list of permitted IGES (or other format) entities;
5. restrictions on use of the IGES directory entry and parameter data sections for IGES entities;
6. specific rules for the use of each IGES entity; and
7. test cases and accompanying documentation.

With all seven components of the protocol completely described, the transfer of data between users would almost be error free. The CALS program has indicated that application information models available from the Product Data Exchange using STEP and other standards activities would be the point of departure for all digital data delivery negotiations. MIL-D-28000 now has the inclusion of application protocols as a long range goal.

Product Data Exchange using STEP entities will be decided from the information needs of the applications themselves. Table 2 lists some of the current application information modeling efforts underway to guide PDES development. The application committees would create information models of what their disciplines required and a logical set of entities would be defined to encode them. This should give rise to a smaller number of entities with less redundancy. The modeling effort now involves hundreds of members of the PDES Project in the United States and the STEP project worldwide.

The Product Data Exchange using STEP began as an improvement to the Initial Graphics Exchange Specification. Standard for Exchange of Product data is the ISO effort corresponding to PDES. PDES/STEP data entities and relationships are being designed from the common patterns found in many data models of application information. Developing these data models has turned out to be a long and hurculean task. What was once envisioned as a mere extension of the IGES format, however, has now become the largest internationally coordinated knowledge engineering initiative since the emergence of the technical journal.

TABLE 2
SELECTED INFORMATION MODELING EFFORTS (SOURCE: CURTIS PARKS, NIST, OTHERS)

Model ID	*PDES DOC Section*	*Librarian*	*Model Title*	*M*
I/CINT	D	Yuhwei Yang	Core Integrated; includes PSCM, Shape Size, Form Features	U
A/PSCM	4.16	Pete Everitt	Product Structure and Configuration Management	In
A/SINF	4.9	Yuhwei Yang	Shape Interface Data	In
A/SREP	4.7	Yuhwei Yang	Shape Representation	In
A/DRAF	4.15.1	Bob Parks	Drafting, Y14 Requirements	U
A/FFEA	4.8	Mark Dunn	Form Features	In
A/GTOL/C	4.10	Bill Burkett	Geometric Tolerance	In
A/AFEM	4.20	Richard Brooks	Applied Finite Element Modeling	L
A/MATL	4.4.2	Richard Brooks	Materials property	U
A/GEOM	4.5??	Ed Clapp	Geometry	P
A/GCSG	4.7.2.4	Noel Christensen	Geometry using Constructive Solid Geometry data	R
A/BREP	4.7.2.2	Noel Christensen	B-REP Topology data	R
A/TOPO	4.6	Noel Christensen	Topology data	I
A/TOPF	4.3.2.39	Noel Christensen	Topological Functions	
A/TOPA	4.3.1.14	Noel Christensen	Topological Aggregates	
A/EFTL/C	4.19.1	Curt Parks	Electrical Functional	S
A/ELEP/A	4.19.5-10	Larry O'Connell	Electrical Layered Electrical Products or Laminated Parts	S
A/GARM	4.17	Wim Gielingh	General AEC Reference Model	A
A/HVAC			Heating Ventilating and Air Conditioning	A
A/ARCH			AEC Industry View	A
A/ASHP	4.18	Mike Gerardi	AEC Ships Structure	V
A/AHPO		Doug Martin	Ships Outfitting	I
A/LOGR		Rick Bsharah	Product Logistics Requirements	E
A/PRES	4.12	Dick Winfrey	Presentation Data	U

TABLE 2 *(Cont.)*
SELECTED INFORMATION MODELING EFFORTS (SOURCE: CURTIS PARKS, NIST, OTHERS)

A/PREL	4.4.1	Bill Burkett	Product Definition Release Data	I
A/UNIT	4.4.2	Richard Brooks	Units definition	U
A/MECH		Pete Everitt	Mechanical Products data	S
A/SFIN		?	Surface Texture	D i
A/PLAN	4.1.3.2.1	Greg Paul	Manufacturing Process Planning	U
S/EXPL	A	Doug Schenck	Express Language and type definition	S
P/EMAP	C	Jeff Altemueller	Express to Physical Format Mapping	
P/FORM	B	Jeff Altemueller	Physical Format Definition	
S/NDIC		Joan Tyler	Near-term PDES support Dictionary Model	
S/LDIC		Joan Tyler	Unification Dictionary Model	
PTM	CALS	John Bean	NIAM Info Model of SGML for Data Base Interchange for Technical Data (Pageless Tech Manuals)	I
CDM	CALS	David Gunning	Tagset Info Model of SGML for Data Base Interchange for Technical Data (Content Data Model)	D
TRNG	CALS	Barbara Sorensen	DEF1x Information Model for Training	I
LSAR	CALS	Ellis Atkinson	IDEF1x Info Model of MIL-STD-1388-2B (Logistic Support Analysis Record)	D

When ready, the Product Data Exchange using STEP will be used in defense contracts to define the information content of the Integrated Weapon System Data Base (IWSDB), and, as a result, the allowable queries and data available. PDES is a "genetic code" of product features which can be used to make the product, test it, and support it. It will have a major impact on electronic publishing and the CALS standards and requirements that control their creation.

PDES application committees are currently creating information models of their disciplines. Some committees use the IDEF1x language to model their disciplines, others use NIAM, but IDEF1x and NIAM are graphical languages for showing data models by documenting data elements and relationships. This is particularly useful in discussing the models in committee. All models, however, must be converted to a database and must be "compiled"—i.e., the model definitions must be processed. Thus all models are required to be presented in a processable language called EXPRESS. EXPRESS is the only "official" data modeling language for the Product Data Exchange using STEP.

Model-Based Electronic Publishing and New Demands on Systems

Clearly, designing model-based application databases is the final enabling technology for the Integrated Weapon System Data Base. The defense industry is now preparing to offer Contractor Integrated Technical Information Services (CITIS) to create and maintain these IWSDBs for the government. The Product Data Exchange Specification, as the first public attempt to standardize, publish, and implement engineering information models, has captured center stage as a possible IWSDB technology. The CALS vision of PDES for a particular application is not only the specification of a format, but also a knowledge base as well. Electronic publishers will not just dump data out in a prescribed format. They must assure that the data has the right meaning—i.e., it implements the information model in the standard. All technical publications must retain their relationship to the product models they represent.

This will require that vendors design their software products to implement an arbitrary EXPRESS or other processable database definition—a tremendous challenge. Sandy Ressler, of the National Institute of Standards and Technology (NIST), has created the first database automatically generated from an EXPRESS Product Data Exchange using STEP model. The first step uses an extension to the NIST EXPRESS Parser (called "FEDEX") to read in the EXPRESS file. Then a report is generated of XEROX SMALLTALK class definitions. Then, the physical file is parsed to populate the SMALLTALK objects. A SMALLTALK model editor can then query the object base to export the PDES product definition. Ressler is also experimenting with hypertext representations of the PDES standard itself.

Despite this complexity, the NIST prototype demonstrates how model based application protocols will make life easier. The clumsy "flavoring" translations users now program for IGES and other formats would be performed automatically by the CAD and electronic publishing vendor software. There will be standard, published data models to cite in contracts and use on projects. Professional societies could maintain and certify them and the DoD could furnish them to contractors. A host of concurrent engineering software tools could be designed to access them.

The notion of information model guided access to design data is influencing the development of the other CALS standards. Figure 2 shows the emerging information models and application protocols for other selected CALS standards.

The CALS SGML standard for technical publications MIL-M-28001 is based on the existing federal standards for the design, content, and format of technical publications, primarily MIL-M-38784B. Hence its current SGML tag set is oriented toward encoding the structure and layout of the publication, rather than the infomation content of the document itself.

The CALS Industry Steering Group (ISG) Pageless Tech Manual (PTM) subcommittee is concerned with freeing the publication information from the paper medium that presents it. The PTM subcommittee has completed a draft Pageless Tech Manual Specification and forwarded it to the ISG for review (ISG/PTM, 1989). The PTM spec details the conceptual basis for PTM. It also references two information models, the Air Force developed Content Data Model (CDM) and a NIAM information model not yet completed.

The Content Data Model information model for technical publications is under development by David Gunning and Mark Earl of Wright-Patterson AFB (U.S. Air Force, 1989). The information modeled by the CDM represents the core information of many diverse technical publications in use by the Air Force. The CDM model is expressed as the SGML tags needed to identify core information in a technical manual prepared for CALS compliant delivery.

The Content Data Model tags set was developed under the Air Force Human Resources Laboratory (AFHRL) Integrated Maintenance Information System (IMIS) project. The IMIS concept creates a format independent relational database of text fragments. The meaning and content of each fragment is described in the CDM and identified in contract documents by SGML tags. The name and use

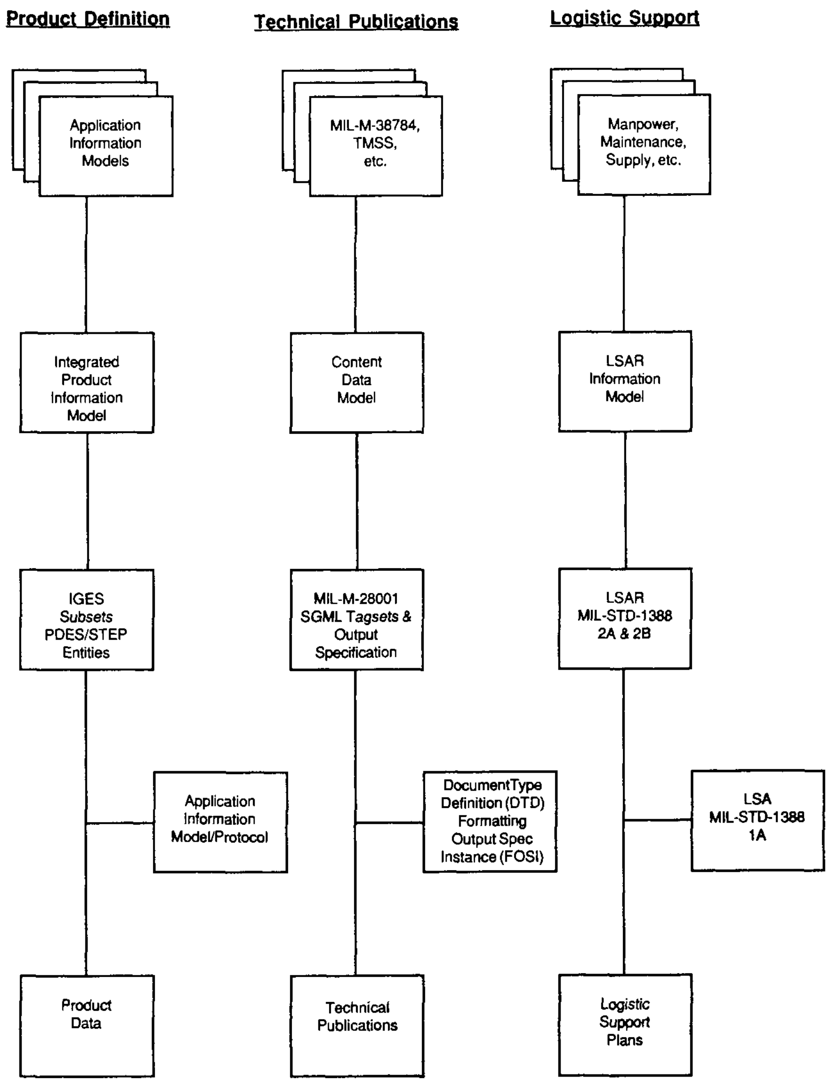

Figure 2. Comparison of Selected CALS Domains and Underlying Information Models

of these tags is guided by the Document Type Definition (DTD) and other application guidance. Eventually, these tagged data may be moved from source documents to the IMIS database management system and be available for all support applications. The Content Data Model will be a component of the joint Air Force/Navy Specification for Digital Type C Technical data (see CALS Report, 1989). The planned outline for the specification is: (1) general content, style, and format; (2) revisable, neutral data; (3) interchange; (4) view package definition; (5) view package formatting; (6) presentation system function requirements; and (7) quality assurance.

The CALS standard for Logistic Support data is based on the various support plans compiled by DoD. An information model for this data is being developed by Battelle Institute and D. Appleton Company under contract to the National Institute of Standards and Technology. Battelle is basing the model on a proposed relational schema design for Logistic Support Analysis Record (LSAR) database documented in MIL-STD-1388 2A and 2B. The guidance for encoding data in LSAR will be given by MIL-STD-1388 1A (LSA [Logistic Support Analysis]).

U.S. Army AMC/MRSA has released a coordination draft of MIL-STD-1388-2B, "DoD Requirements for a Logistic Support Analysis Record." 5 MRSA (Material Readiness Support Activity) is responsible for MIL-STD-1388-2B, which will become the new standard for LSAR as relations in a Relational Database Management System (RDBMS). The new standard will include a government developed Joint Service LSAR Relational ADP System. This ADP System will create LSAR relations in a user-supplied RDBMS and will include the C Language code with embedded Structured Query Language (SQL) calls that will set up the Logistic Support Analysis Record database. This LSAR revision will greatly facilitate its integration with CAD/CAM, Tech Pubs, and other defense applications. The standard is scheduled for release in early 1990.

The continuing relationship between CALS and LSAR is summarized below:

DoD REQUIREMENTS	MODE OF OPERATION	CONTRACTOR SYSTEMS
MIL-STD-1388-2A	Flat Files For Data Delivery Government Batch System	Choice Of Proprietary Interfaces Validate With Test Data
MIL-STD-1388-2B	Relational Tables For Data Delivery Gov't Relational DBMS	Choice Of Proprietary Interfaces Validate With Test Data
Planned MIL-SPEC	Shared Government Access, Delivery Options	Standards For Access & Data Management
	Common Data Model	Validate Mapping To Common Data Model

Robert L. Terrell (1989), division director, Technology & Telecommunications, U.S. Department of Energy (DoE), Office of Scientific and Technical Information, said that federal agencies must tailor and enhance CALS to meet the broader needs for Scientific and Technical Information (STI). STI is used for a variety of support, administrative, scientific, and other purposes and for providing information of different types. Terrell says that CALS' profiles of standards provide a good start on specifying STI delivery in forms suitable for these uses.

The five agencies funding the bulk of the $65 billion federal R&D now participate in an interagency organization called CENDI (pronounced "cendy") derived from the first letter of each agency plus *I* for information. The five federal agencies, who in turn, are served by five STI functional organizations, are:

AGENCY	STI FUNCTIONAL ORGANIZATION
Commerce	National Technical Information Service (NTIS)
Energy	Office of Scientific and Technical Information (OSTI)
NASA	Scientific and Technical Information Division (STID)
Health	National Library of Medicine (NLM)
Defense	Defense Technical Information Center (DTIC)

CENDI is a cooperative organization which develops ways to improve productivity of federal R&D through efficient and responsive information programs.

CENDI established a Working Group on Standards, Guidelines, and Authorities in May 1988. Its purpose is the inventory and coordination of CENDI activities in development of de facto, national, and international standards. The major information sharing/processing issues among CENDI agencies are: (1) electronic publishing; (2) electronic information interchange; and (3) information processing standards applications. The working group sees the lack of acceptable standards as inhibiting development in these areas.

Farrell says that CALS "standards" are really "applications" of those standards to defense support needs. For example, FIPS 152 (SGML) is the civilian citation of SGML but is hard to apply in contracts. MIL-M-28000 is an application of FIPS 152 to technical publications. Farrell says that agencies can use part of the CALS ideas for STI but not the CALS specification verbatim. Federal agencies must develop tag sets for their own needs.

The growing awareness of model-guided data access is leading to the need to combine these "information models" into a super information model of some kind. An advanced version of a Product Data Exchange using STEP is considered a leading candidate for such a super model. DARPA's (Defense Advanced Research Projects Agency) Initiative in Concurrent Engineering (DICE) will probably extend PDES to meet the new integration needs. Concurrent Engineering (CE) refers to consideration of physical and logistic performance of a product early and concurrently in the procurement cycle. The DICE program is combining DoD, university, and industry research on artificial intelligence, informaiton science, man-machine interfaces, and design behavior.

What's Ahead for CALS

Work now underway to define CALS Phase 1.2 and Phase II Core Requirements will broaden the application environment for the current CALS standards, and in selected cases define requirements for additional digital data interchange and access standards. Examples include:

—The Office Document Architecture and Interchange Format (ODA/ODIF) for presentation and layout, and the Standard Page Description Language (SPDL) for image delivery of technical publications. ODA/ODIF is an explicit document architecture and interchange format standard which allows exchange of compound documents (i.e., documents composed of various context types such as character, raster graphics, and geometric graphics content).

—The Information Resource Dictionary System (IRDS) for management of data element definitions and their relationships, and the Structured Query Language for data access. IRDS will be a tool for configuration management of data resources, including structured databases, graphics databases, paper, microfiches, and other media.

—The Pageless Technical Manual joint-service requirements. PTM requirements will be tested on the LHX, A-12, and ATF programs. The draft specification, due March 1990, will cover: content, style, format requirements; revisable source data; extraction and display formatting; presentation systems; quality assurance; etc. After testing, DoD expects to use the standard throughout DoD.

CALS development of these current and future industry standards is being accomplished jointly by DoD, NIST, and by industry users and vendors.

New Roles For The Electronic Publishing Contractor

These changes indicate a new role for the electronic publisher inside a contractor facility. Such a publisher must serve as:

—*Data conversion specialist,* performing and assuring conversion of data into formats compatible with the target system in accordance with required application protocols.

—*Database administrator,* controlling the structure and content of the document in accordance with government-furnished document type definitions or other schemes.

—*Configuration manager,* controlling not only versions of the target document/database but also constituent drawings, tables, illustrations, and other databases. These might be assembled for review, approval, etc. and could be printed, viewed on a screen, transmitted on a network, or even assembled on optical media.

The whole character of a contractor's relationship to his subcontractors will change also. Word processing subcontracts are a favorite way to meet small business subcontracting requirements. Those subcontractors who do not understand or cannot afford to comply with CALS guidelines will require special attention to assure quality and conformance to requirements.

For More Information

For more information on obtaining copies of CALS standards, contact: Ellen Trager, U.S. National Institute of Standards and Technology, Building 233, Room B107, Gaithersburg, MD 20899, 301/975-6642.

For more information on DoD CALS Policy, contact: Michael F. McGrath, director, DoD CALS Policy Office, OASD(P&L), Pentagon, Room 2B-322, Washington, DC, 202/697-0051.

For information on IGES documentation, contact:

IGES Version 4.0 - NTIS	PB 88-235-452	703/487-4650
ANSI Standard ASME	Y14.26M-1987	212/705-7703
Applications Guides	IGES Office	301/975-3547
Testing Methodology	IGES Office	301/975-3547

ISO standards (including ISO 8879) and ANSI standards are available from: the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

For more information on ODA, contact: Lawrence A. Welsch, manager, NIST, Office Systems Engineering Group, ICST, Gaithersburg, MD 20899, 301/975-3345.

Standards Ordering Points

Those who wish to obtain specifications or standards may place phone orders or obtain ordering information, at the following numbers, for documents of the Standards Organizations indicated.

Issuing Organization	*Source for Reprints*	*Phone Number*
CCITT	OMNICOM	703/281-1135
	NTIS	703/487-4650
ANSI/ISO	ANSI/ISO Sales	212/642-4900
FIPS PUBS	NTIS	703/487-4650
SONE Special Pubs	Government Printing Office	202/783-3238
Federal Standards	General Services Administration	202/472-2205
MIL-STDS & MIL-SPECS	NPFC [No Charges]	215/697-3321
	(To order by TOES - see Bulletin 16)	215/697-1187
		AV 442-1187
All Government & Industry Standards	NSA	800/638-8094
EIA	EIA	202/457-4900

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CALS Report, (1988), 1(2), p. 12.

ISG/PTM, Specification. (1989). *MIL-M-28001 supplement: Markup requirements and generic style specifications for Data Base Interchange (DBI) for electronic output of technical data.* For availability, contact John Bean, Northrop Corporation, M/S L595-1Y, 8900 E. Washington Blvd., Pico Rivera, CA 90660-3737, 213/943-6553. Draft dated July 7, 1989.

Terrell, R. L. (1989). *Electronic information interchange and the federal civilian agencies: There's more than CALS.* Paper presented at TECHDOC '89, San Jose, CA. For availability, contact author at Office of Scientific and Technical Information, U.S. Department of Energy, Oak Ridge, TN, FTS 626-8342, 615/576-8342.

U.S. Air Force. (1989). *Content Data Model.* For availability, contact David R. Gunning, research psychologist, Air Force Human Resources Laboratory, AFHRL/LRC, Wright Patterson AFB, OH 45433, 513/255-2606.

U.S. Army AMC/MRSA. *MIL-STD-1388-2B: DoD requirements for a logistic support analysis record.* For availability, contact Ellis O. Atkinson, chief, DoD LSA Support U.S. Army AMC/material Readiness Support Activity (MRSA), Readiness Division, (AMXMD-EL), Lexington, KY 40511-5101, 606/293-3985, AV 745-3985.

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MARK E. RORVIG is the Founding Director of the Project ICON Image Scaling Laboratory at the University of Texas at Austin. He is currently a staff scientist and project manager for image publishing and image access at the Johnson Space Center. He is the inventor of the Visual Thesaurus and has also contributed a number of pattern recognition algorithms. Dr. Rorvig received his M.S. and Ph.D. degrees from Columbia University and The University of California at Berkeley. His dissertation won the Doctoral Forum Award from the American Society for Information Science in 1987.

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Prepared by: Idrisa Pandit

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