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The Big Picture: Selection and Design Issues for Image Information Systems

A digital image is just one visible part of an image information system. What takes place behind the screen in order to display that image is the focus of this discussion. Many factors influence the planning and design of an image information system including its purpose, types of images, users and use, desired functions and features, and equipment and software. Also to be considered are file conversion and preparations in case of disaster as well as many social and ethical issues in the use of the system. Relatively new techniques for access and retrieval by image content are being explored with some systems now available. While these new mathematically oriented computer-based systems might, in time, help to alleviate some costly human processing, text documentation will still be necessary to identify the image and to describe such elements as the historical context or the social environment in which the image was created.

INTRODUCTION

Electronic image information systems appear to have emerged from a period of infancy in the mid-1980s to reach active adolescence one decade later, probably because they offer the promise of greater efficiency and lower cost, and because they give a greater richness of the information within the image. Though imaging in early 1996 was listed as a $2.59 billion industry (Haimila, 1996) and has become an everyday procedure in science, medicine, industry, business, museums, and government, there are still many opportunities for imaging to flourish in new directions. One of today's frontier areas is the access and retrieval of electronic images by their content—that is, by the shape, color, texture, pattern, etc.—within the image rather than by surrogates such as title, artist, or subject.

The image, however, is only part of the picture. What takes place behind the scenes to produce that electronic image is what this article is about—i.e., the selection and design issues that go into building the information system that will access and retrieve digital images efficiently, clearly, and relevant to the search request while at the same time meeting the standards set for the system. Not included in this article is a discussion of hardware, software, or vocabulary control except to indicate where they fit into the general system considerations or, as in the case of display, affect the quality of the image.

What goes into the design of an information retrieval system is not new. Many of the principles that we learned in designing textual

information retrieval systems decades ago are still basic today to the success of a project. A review of some of those principles appears in the following sections. Image information systems, however, do have requirements beyond those needed for text, and some of those will be discussed. Also see Lunin (1987) for comparisons of conventional and image databases. In addition, several ethical and social issues having to do with the use of image information systems are described briefly.

ABOUT IMAGES

When we are dealing with electronic images, we are handling a digital representation of an object whether that object is a photograph, painting, drawing, or page of text. Because the image is in digital form, we can manipulate it; enhance it; alter its original colors; reduce its size or enlarge it; and store, print, or send it over networks. To process and transmit images methodically, we need a system.

PLANNING THE IMAGE INFORMATION SYSTEM

Systems analysis is still a basic requirement in planning for an image information system (Lunin, 1990). Figure 1 lists some fundamental aspects.

Overall
- Purpose
- Types and number of images
- Source
- Users: who, how many, types
- Use: when, how, what, where
- Applications
- Access
- Legal issues
- Types of software needed
- Who helps?

Functions and Features
- Indexing/retrieval
- Performance criteria
- Storage
- Integration
- Scanners
- Network
- Costs
- Flexibility
- Standards

Display
- Quality
- Service/support

Imaging System Vendors

File Conversion

Preparation for Disaster

Figure 1. Considerations in the design of an image information system

Overall

Purpose—Why do you or your organization want to have/use image information? What do you expect as the main benefits of installing the system—e.g., to use an image surrogate in order to protect the original images which may be old and rare? To make it possible for many people

to be able to access the image simultaneously? To have near instant access to each image, thus saving the cost and time of searching a manual file, finding and removing what you want to use, then refiling it? Do you want to reduce storage space requirements (as in filing cabinets)? Is better document security a consideration?

Types of Images—What kind of images will be entered into the system? What is the size of the collection, current acquisitions, and anticipated items? Are the items in black and white or in color? And are they all one size or in various shapes, sizes, and forms? Are they in good condition or are they fragile, stained, bent, or torn?

Source of the Images—Where does the image originate? Does it include information about copyright, permissions to use, and restrictions in use?

Users—Who will use the images? How many people and how often? Will the images be used in-house or online? What levels of users do you anticipate: workers in the office, those in the field, visitors, novices, or experts?

Use—How will people use the system and when—daily? around the clock? What will be the frequency of access? The expected speed of access? Will users want to print or download to another system or both? How many users might there be simultaneously? Will they want to browse? Will they want to view images in various sizes and levels of resolution? Will they want functions such as zoom, color change, or annotation? Besser and Trant (1995) discuss use in some detail.

Applications—Will the system be set up for specific topics or for general subjects in many domains? For example, in medicine, will users want images about a particular disease, such as arthritis, or will they want all topics as those in a national library of medicine or consumer health agency?

Access—What categories of information or access points must be searchable? In addition to words in text, identification numbers, keywords, and category, it is now possible in some prototype systems as well as a few on the market to retrieve by color, iconic shapes, and position of elements within the image.

Legal Issues—Will the users have the right to print or download? As Besser (1995) has pointed out, it is necessary to build enforcement of those rules into the systems (more about legal issues appears later in this discussion in the section on social and ethical issues).

Types of Software Needed—Among the software required are programs to integrate a text database, browse thumbnails, and view individual images in detail. And, as Besser and others have pointed out, the integration between text management and browsing tools is still in its infancy; presently, systems have to be glued together rather than linked seamlessly in a sophisticated text management system to high quality image browsers.

Who Helps?—In building the system, consider what groups within your organization should be involved and at what point in the analysis and planning. Also, determine if you want to build your own system, lease one, or purchase.

Functions and Features

Indexing/Retrieval—It is necessary to determine the functions and features desired for the system. For example, do you want full-text searching as well as image retrieval? If so, do you want the images and the text to be retrieved at the same time? Do you want to be able to annotate images as you view them? How do you want to index the images—via a thesaurus or other vocabulary control that you presently use or will you need to construct a new vocabulary control? Do you wish to be able to search the content of the image without the use of such aids as keywords, descriptors, identifying numbers, name, type of image, or title?

In what format will the images be stored—in the record with text or separately? And what about the display—thumbnail, medium scale, full-scale image, or all? And will you need them in black and white, gray scale, or full color? Will you want the image on the screen, in print, or moved to another digital form? And at what resolution?

Performance Criteria—What performance criteria are the most important to you? Landford (1991) has raised many of these issues. For example, she asks what image scanning speed is wanted and at what image resolution? What average search speed and what display resolution and number of visible pixels are required? And what average image retrieval speed is needed? What image print speed is desired? What image compression ratio is wanted and should it be lossy or lossless?

Storage—What will be your document/image storage capacity and environment (CD-ROM, hard disk, juke box, client-server, etc.)? To a large extent, that depends upon the size of the collection and its integration with other databases in the organization.

Integration—What amount of custom integration with other systems is desired? Should it be with your collection management system, online public access catalog, publishing system, and/or other business or administrative systems (Besser, 1995)? Will you want to integrate with other technologies—micrographics? telecommunications? connectivity with other computer systems? (Lunin, 1990).

Scanners—What kind of scanner will be used—desktop? flatbed? high volume? See Besser and Trant (1995) for a brief overview of image capture and of the selection of scanners.

Network—What are the network requirements within the organization or enterprise? What bandwidth is called for; what standards will be followed? As Besser and Trant (1995) have pointed out: "Because image files are so large, the construction of a networked image database is likely

to affect system resources significantly. Therefore, systems architecture and network topology become significant concerns" (p. 33).

Costs—Must the system operate under some cost constraints and, if so, what are they? Image information systems can be costly and perhaps more than an organization can afford. Is it necessary for the system to pay for itself or can it be underwritten by other sources?

What are the implementation costs? Can one use any hardware or software that is currently available? Can you assign staff to the project, either temporarily or on an ongoing basis? Row (1995) raises several issues: what level of training, learning, and organizational change will the new system require? The cost of implementing the technology is fairly easy to estimate but often it is not the largest cost. Training, organizational change, and possible disruption can increase costs enormously. What is the estimate for the total costs of entry, including preparing the materials for scanning, checking the quality of the scans, refiling the original material, indexing the image, and entering the new information into the system?

Flexibility—As for the systems that you are considering, are they flexible? Can they be altered easily and adapted to changing needs? Because it is often impossible to know exactly what you will need until the system is up and running, it is often advisable to do a pilot project that includes all aspects. As Row advises, once installed, a malleable system can be modified to suit individual needs at a time when one really knows what is needed.

Can the system be expanded to add new functions such as batch scanning and full-text search and perhaps some activities you cannot now anticipate? As technology evolves, can you incorporate innovations? Is the system scalable? Can you go from a few to many hundred workstations without an unbearable strain on the system that affects speed and capacity? Will the current system tolerate migration to a system for the entire organization with support for a wide range of functions and computing platforms and different services?

The foregoing questions are not new. With some exceptions that relate specifically to images, we have asked these kinds of questions in the creation of text information systems during the past thirty-five years or more. Yet, as noted by other papers delivered during this conference, in some ways images are far more challenging than text.

Standards—In the last sentence in his article in *Database*, Besser (1995) states: "For a digital image database to be useful beyond a single short-term project or beyond a narrow user base, the database must be constructed according to common standards in both technical and descriptive areas" (p. 19). To ensure that data will be interchangeable among systems, national and international standards for image file formats and compression methods have been developed and maintained by industry

and other collaborative bodies. Sources for information about standards and methods for describing images are listed in Besser and Trant (1995).

Display

One of the most important aspects of an image information system is the display—it is the face of the system the user sees. Meadows (1995) lists eleven things to look for in an imaging display: Among these are:

- image legibility;
- color or gray scale;
- size of display screen (at least 20 inches diagonal);
- resolution of at least 1600 x 1200 pixels;
- dot pitch of at least 0.28 mm; and
- refresh rate of a minimum of 70 Hz.

Meadows advises that one should not buy a display based on specifications alone. The product data sheets are useful but not good indicators of image quality. And, most important, he adds, is to try a product before you buy. Evaluate the display in your own work environment with your own applications and with the controller you will use. Choose a complete display subsystem from a single source. "Display devices are currently the weakest link in the image quality chain" state Besser and Trant. Also, they note that: "Each model of display and printing device renders color slightly differently" (p. 30).

Quality—Look closely at the image quality. Meadows (1995) discusses three factors that affect image quality that do not appear on data sheets. These factors are focus, convergence, and contrast. "[S]ee if the characters are crisp and if the black-to-white transitions are sharp." Look at the focus in all areas of the screen to make certain that the edge focus is as good as the center. Convergence is how the red, green and blue guns align to form pixels. "Bad convergence shows characters with red, green, or blue edges" which can be distracting" (p. 46). Contrast is important in viewing black and white documents. Because subtle differences become apparent only with extended use, Meadows recommends that, before purchase, users should work several hours on different displays, choose their favorites, and then tell why. Young (1995a) also advises the purchaser to be prepared to spend more money on an imaging display than on a monitor used for viewing word processing files because of the need for higher refresh rate, better resolution, and larger size.

Service and Support—Find out about service and support and the company's commitment to their product before you buy. See if on-site servicing is available. Read the fine print and look for multiyear warranties. This is very important because many companies today are merging

or going out of business. Meadows's (1995) advice: "Look for a display with a 50,000 to 70,000 hours demonstrated MTBF [mean time before failure]" (p. 46) and choose a dependable vendor who has a proven track record and financial strength to stay in the business for a long while.

Imaging System Vendors

If you are going to use vendors, Landford (1991, pp. 39-44) and others offer general questions to use in talking with those vendors. For example, ask the vendor to show you exactly how their company would handle your application. Find out how many installations they have. Ask on which computer systems their system runs and its compatibility with other systems. Learn what upgrade paths they provide.

Determine whether the system is easy to use and to maintain. What does their price include? How long before you can have your system up and running? What happens if your system goes down? What kinds of support do they then provide? What resources does their company use for quality assurance? How many keys can you assign to the image and can you name the ones you want to use? And what about the reliability of the system?

Landford also suggests talking to organizations using the system. Ask the people there: If you could make the decision over again would you choose the same system and why? What are the system's main strengths and shortcomings? How easy is it to use? How well did the system integrate with, or connect to, your existing hardware/software? And how good was the vendor's training and customer support?

File Conversion

Most organizations have existing files that they will want to convert to digital form. It is important to estimate correctly the size of the file. Because some documents and images are in less than perfect condition, it is necessary to know how to improve their quality—e.g., how to eliminate extraneous marks, curled edges, and stains. Young (1995b) warned that a serious mistake companies make is estimating how long it will take to complete the job of backfile conversion.

Using a service bureau can also offer advantages:

1. hardware and software support;
2. no productivity losses—your staff keeps working at their regular jobs during conversion;
3. no new employees (temporaries) who learn how to do the work and then leave for a new skilled position;
4. quality of the work;
5. experience in conversion;
6. document preparation (not all materials are ready for scanning);

7. media choices: WORM, CD-ROM, etc.
8. other services should you want them: OCR, ICR, etc.;
9. on-site conversion. This saves the expense of shipping materials and, in addition, you're around to supervise and check;
10. document tracking;
11. accurate time frames: a timetable for the work;
12. no expensive equipment purchases: no capital investment if you do not use the equipment in the future (Young, 1995b).

The cost of conversion depends on many factors: volume, document quality, document size, indexing, your location, time of year, the bureau's workload, your expectations and requirements, shipping, and so on. Service bureaus will try to give you a "vague quote to cover unknowns." Beware of one common practice of quoting low and charging high for any changes. Know in advance what each change will cost. "Talk to people who have done backfile conversions and ask them what changes they had made—and how much each cost" (p. 46).

Compare quotes that you receive. Each bureau has a way of quoting, and items in one quotation might not appear in another. Items that might or might not be included in a quotation are:

- The initial set up: does it include all equipment? Is there an extra charge for new equipment and how much is it?
- Document preparation: Do staples need to be removed and how many? How many folded corners need to be unfolded? If you do it yourself, is what you save worth it in your time?
- Indexing: Do you have an indexing system or do you need to build one? If there's much data entry needed, it might be less expensive to contract out. Make certain that the quotation includes "full indexing."
- Clean-up: Make certain that noise removal is in the quotation.
- Skewed images: Will the service bureau correct the skew in the scanning?
- Sizes: If the material to be scanned is in a variety of sizes, the charge will be more than if it is all one size.
- Re-scan: If you want 100 percent image quality control, that will be expensive. Many service bureaus negotiate an "acceptable" quality control level which means that they will check every first, tenth, or 100th image. The cost can be huge if you want 100 percent accuracy, but also consider the cost if your system is filled with poor images.
- Quality control contract: Put into the contract that you want to check the input periodically.

TIME WARNER'S PHOTO CONVERSION

If all of these details are beginning to feel fairly overwhelming, look at Time Warner's project to digitize more than 20 million photos (Bielski, 1995). Their goal: to digitize and store those photos in a customized system to support research, magazine republishing, and eventually, online versions of the publishing group's magazines including *Time, Sports Illustrated, People,* and *Entertainment Weekly.*

They also need to process the accompanying text for each image, which will be the job of catalogers. The photos will be tagged with identifying text for retrieval. Once implemented, the system will be able to support up to 300 queries simultaneously. The company estimates that all the Time Warner magazines use up to 100,000 new photos annually.

Isolating particular types of images of a much photographed subject is another required capability—e.g., to easily sift through 10,000 or more photos of a well-known person such as Bill Clinton or Barbra Streisand by designating body position, facial expression, or social context.

BEING PREPARED FOR DISASTER

While you hope you never have a flood, hurricane, fire, or explosion hitting your organization, nevertheless, experience teaches us that these events do occur and that systems can be wiped out during a disaster. Prevention is critical but sometimes not possible. Recovery—and as quickly as possible—should be planned for. Preparedness should include routine management tasks as well as recovery from any major injuries to the network and database systems. Document all system information and know how to operate immediately after a disaster (see Lunin, 1994):

- Define your recovery assumptions. List the key ones. For example: personnel should have access to the hard copy files within twenty-four hours.
- Identify and list key departmental functions and the activities performed by each department. List priorities.
- Identify procedural implications. List activities that can be delayed, postponed, or performed manually.
- Identify departmental interfaces. List internal and external departmental interfaces by the functions of each department.
- Identify critical applications. List mainframe, mini- or PC-applications and/or software required to support departmental functions department-wide such as e-mail.

Levels of documentation should include user, as well as technical, procedures. Know where your vendors are located and whether they are

still in business. If this is not possible, know who can provide the needed service and where that vendor is located. "Don't wait for an emergency to find out that the plan won't work. Assess the plan periodically. Revise it as necessary. Review the plan every 12 months" (Lunin, 1994, p. 58).

NEW DIRECTIONS FOR IMAGE RETRIEVAL BASED ON CONTENT

New developments for access, search, retrieval, filtering, and categorizing image information are in the works. Some of these developments were shown and discussed at RIAO (1994). Also, Web innovators are being encouraged to create applications and services that exceed the features and functionality of the first generation of Web sites (Feder, 1996). Because of the many directions that research and development are taking are described in other papers in these proceedings, only a few not covered at the 1996 Clinic on Library Applications of Data Processing are described briefly here to add to the sense of breadth of ongoing work.

At RIAO 94, a conference organized by Centre de Hautes Etudes Internationales D'Informatique Documentaire (C.I.D., France) and the Centre for Advanced Study of Information Systems, Inc. (C.A.S.I.S., U.S.), researchers and practitioners from many countries focused on still photographs as well as the extraction and representation of the content from clips and images to satisfy the needs of a wide range of users and purposes (see Lunin, 1995 for coverage of that meeting).

M.I.T.'s Media Streams uses an iconic annotation language to represent knowledge about the video content. Using stream-based annotation of video content together with memory-based representation, researchers can capture the semantic structure of the video. Special tools have been developed that understand enough about the content to help with the annotation process. Determining whether and how clips are similar is an ongoing challenge.

One such software tool, Photobook, takes measurements of image features such as brightness, edges, textures, etc. It then uses a mathematical calculation to obtain a compact description of the set of images concerning their prominent characteristics. One application of "Texture Photobook" is used in the fashion industry.

Another challenge for image database tools like Photobook is how best to describe object shapes. A new mathematical method called modal matching is based on the idea of describing objects by their generalized symmetries.

IBM's Almaden Research Center has been studying ways to query large online image databases using the image content as the basis of the queries. Examples of content are color, texture, shape, size, orientation,

and position of image objects and regions. Query is by image example; retrieval methods use similarity rather than exact match (Lunin, 1995). For more information see Layne (1994), RIAO (1994), Mostofa (1994), and Svenonius (1994).

SOCIAL AND ETHICAL ISSUES

The selection and design of an image access and retrieval system raises many social and ethical concerns, among them accuracy, integrity, authentication, and intellectual property rights.

Header Information

When an image has been produced or scanned into the system, the record's header should contain information about the make of scanner used, the date of the scan, and the identification of the scanning personnel. Other data should include file size, image quality, compression, file format, layered architecture, terminology, technical information, and intellectual property rights (Lunin, 1994b. See also Figure 2). Many issues arise concerning what might happen to an image once it is produced. Discussion of some of these issues follows.

Header information
Accuracy
Integrity
Authentication
Giving credit
Intellectual property
Re-use of images
Off-color images

Figure 2. Social and ethical issues

Accuracy

When accessing information on the Internet, many questions arise. Is the information accurate and are access and use of this information appropriate (Smith & Bellman, 1996)? If the image comes from a respected library or repository, more confidence can be felt about its accuracy.

Researchers can—and have—altered, edited, adjusted, refined, etc. scientific images without leaving a trace in order to fit their hypothesis. Whether to allow any image manipulation or even cosmetic change is becoming a real source of anxiety, for example, to federal agencies such

as the Food and Drug Administration, which relies on scientific images in evaluating drugs for approval. The need is seen "for a clear record of what has been done to an image, from editing to data compression. Without such a record, the image's scientific value becomes questionable" (Anderson, 1994).

Integrity

Related to integrity is whether the image is in its entirety or whether bits have been left out in either purposeful or accidental compression or other activity. Has new information somehow crept in that does not belong to the original image? These are serious concerns and the header information provided in a record might help to check on the accuracy of the image.

Authentication

Who really produced the image? Because images can be obtained from databases in various locations and changed or seen in a draft of a work put out by the creator for comments by colleagues, it is difficult to know if the image is in its final form or is still in a working stage and whether it came from the creator or someone who has obtained the image and then altered it.

Giving Credit

An image obtained from the Internet and used in a report should acknowledge the source as clearly as possible, just as print documents should be acknowledged. Also, there is a real issue concerning payment owed for materials obtained on the Internet. In some cases there is a fee for use, although collection mechanisms have not all been worked out (Smith & Kallman, 1996).

Intellectual Property

Generally, anyone who copies the images or text of another person or publisher or organization without permission is guilty of copyright infringement. That person is also subject to actual damages, statutory damages (potentially in the hundreds of thousands of dollars), and impoundment of the infringing materials, and more (Roberts, 1994).

In the recent current legal environment, copyright infringement has occurred when copyrightable subject matter exists, the infringer must have had access to it, and there is substantial similarity between the original work and the allegedly copied work. Roberts (1994) explains that any copying by exact means such as photocopying, photographing, or other direct recording is not considered an original work.

What are the image processing implications?

> If the image processing involves extensive and difficult techniques to achieve an image that is different from the original, such as pixel-by-pixel manipulation of stored data, the image processor may have reached the stage of an independently copyrightable work. Any such work, however, must still pass the test of no "substantial similarity" that will be put to a jury. If, however, the *market* for the new work created from the copying of the original work is different from that of the original creators' and a substantial amount of complex technical work was done by the person copying the original work to give rise to a new image, infringement will not necessarily be found. (Roberts, 1994, p. 93)

The study "Intellectual Property and the National Information Infrastructure" (NII) recommended that this type of electronic transmission of networks be brought under the definition of distribution to avoid any issue of whether this right is somehow not covered by copyright law. Of importance in the imaging area is the thought that importation via transmission of images without the permission of the copyright holder is an infringement of the rights of the copyright owner. "The report noted that copyrighted works should be freely available but not available for free" (Roberts, 1995a, p. 82). While this clever wording states a good principle, the author of the article states that "it does not help those colleges and universities wishing to access and use images in a database, which are accessible over the NII, to use that information without claims of infringement" (Roberts, 1995a, p. 82).

Reuse of Images

The re-use of "owned images" raises some other thorny points. Who is allowed to adapt images in the age of re-purposing? "If you are the commissioning party and owner of the copyright, you control the image reuse. Otherwise, artists are free to reuse their images and customers for those images, should not be surprised by such legal use" (Roberts, 1996).

Off-Color Images

And what about off-color images—and this does not mean fuschia when the color should have been purple. Such images pose a new liability problem. Essentially, the creator should know the contents of the database and whether the contents might possibly be offensive to those who access it.

"A key aspect of your liability is what you knew about not only the contents of your database, but of the laws of the individual jurisdictions from which users might access your information" (Roberts, 1995b, p. 88). If there is any moral in this story, writes Roberts, it is either:

> 1. Understand the contents of your database well, attempt to find objections to the content and take steps to limit the dissemination

of the information only to those jurisdictions where the contents would be legal; *or maybe it's*

2. Pay no attention to the contents of your database. Do not become involved in contributions to it, do not inspect it in any way, and simply be a vehicle in which information can be disseminated to third parties. (p. 88)

DESIGNING THE WAY TO THE FUTURE

Electronic image systems are here now and will become increasingly prevalent. It is obvious that further research and developments in hardware and software will occur and that content retrieval systems will become widely available. An image system with access and retrieval by content offers a radical departure in the way we can deal with images. It also shifts much of processing from humans to computer operations with both positive and negative effects, some of them social and ethical.

The steps in setting up an image access and retrieval system are specific and complex, and increasingly there is more known about the special requirements for designing efficient and effective systems. Thus, system analysis will continue to be important in the design of such systems.

While developing information technology offers the opportunity to do almost incredible things with images, the technology cannot supply the interpretation that can be offered by carefully selected verbal descriptions (Lunin, 1994b). Text documentation will continue to be needed to identify and describe such elements as historical context or the social environment in which the image was produced, while the image itself will speak to us in a way that verbal language cannot.

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