Framing the Picture

Standards for Imaging Systems[1]

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Introduction

As I struggled with the development of this paper, I was told, I hope jokingly, by a colleague that perhaps I had reached my level of incompetence - as defined by the Peter principle, I guess that makes me an expert. It is certainly true that the more I consider the development of imaging systems, the more I realize there is to know. Technologies are developing rapidly, particularly in the area of networked communication and the capture and distribution of images. Things we only dreamed about 18 months ago are a reality today. The World Wide Web (WWW) is making the 'virtual museum' almost palpable. However, the more we struggle to evaluate and implement imaging technology, the more aware we become of how little we know about visual information and how people use it, and the more friable technological solutions to these issues become.

Developing standards in an environment of constant change could certainly be described as a Sisyphean exercise. The normal life-cycle for the development and acceptance of a standard often far exceeds a generation of technology. We are almost guaranteed obsolescence by the time we reach consensus. But without the development of a common agenda, we risk the creation of disparate and incompatible systems which are not positioned to take advantage of the full potential of developing network communications technologies.

Why Standards?

The case for standards has been made regularly and frequently in the museum documentation community, and in the broader information management community.[2] Standards enable us to share

1 This paper builds on arguments first developed by the author in "The Getty AHIP Imaging Initiative: A Status Report" Electronic Imaging and the Visual Arts, EVA, London, England, July 28, 1995.

2 See for example Developments in International Museum and Cultural Heritage Information Standards. A joint project of the Getty Art History Information Program and the International Documentation Committee

information effectively and efficiently, without fear of data loss or misinterpretation. They safeguard our investment in information, ensuring predictability and consistency. Guidelines provide shared methodologies. They enable collaboration and cooperation through the development of consistent approaches to common problems. Sharing the ways and means of doing things avoids a duplication of effort.

The interconnectivity provided by the Internet and WWW provide further impetus for the development of common approaches to the creation of image databases. In the brief time since the release of NCSA Mosaic, we have seen the potential for the network distribution of visual information about museum collections. Many institutions have begun to make significant portions of their collections available this way. This emerging virtual world provides us with concrete examples of the need for standards for information capture, storage, retrieval and display. To 'put up' museum information on the Web is just the first step.

We must move beyond the present architecture of the WWW, where serendipitous wandering finds some useful and many irrelevant sites; our resources must be inter-related and inter-connected. Pathways to museum information must be clear. Tools must exist to integrate digital information, on the desktop of the user. We must also move beyond the present state of WWW "research", where digital data is downloaded without preserving any notion of its provenance. Museums must be prepared to assert the authenticity of their data, and guarantee its integrity, if the WWW sites of the future are to become valued educational and research tools rather than cabinets of curiosities, or worse, catalogues of clip-art.

Common practices and shared standards are the key to creating a quality information resource. So how can the cultural heritage community approach imaging system standards in such a revolutionary environment? Are there standards that can be employed when developing imaging systems? Are there areas where standards need to be developed? How can we target the limited resources of the cultural heritage community towards areas where advances in common practice are critical to our successful employment of imaging technologies?

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of the International Council of Museums, The J. Paul Getty Trust, 1993; Standards for Archival Description, A Handbook, Society of American Archivists, 1994; David Bearman and John Perkins, CIMI Standards Framework for the Computer Interchange of Museum Information, Museum Computer Network, 1993; Marilyn Courtot, Document Imaging Standards Development: How, Why and For Whom? Association for Information and Image Management, 1992; and Perspectives on ... Information Technology Standard, Journal of the American Society for Information Science, Special Issue, Vol. 43, no. 8, (September 1992).

Which Standards?

Now that we are all convinced that standards are not an evil step-mother but actually a fairy godmother - which standards do we need? There are a veritable smorgasbord of technical standards and standards-making organizations out there, which deal with all aspects of information management: including data storage, retrieval, representation and network communication. The Usenet Standards FAQ[3] [Frequently Asked Questions] includes over 50 pages of references to standards "relevant to computing" for everything from "Paper holes for general filing purposes" (ISO 838) to the "Still image data compression standard" (ISO 10918), widely known as JPEG. Obviously, some standards more of more utility when developing imaging systems than others.

To position such a plethora of information, and to determine which standards are relevant to imaging in the cultural heritage community, requires a review of the various stages in the creation and use of an image database, and an examination of the functions for which image data is captured, stored and distributed. We must be wary of standards for standards sake. Instead, we need to develop a more pragmatic and functionally based assessment of museum information management needs, which focuses not on technology, but on the mission and activities of the cultural heritage community. It is in this knowledge of "what we want to do" that we will find the criteria to assess available technical standards and from which we can develop both needed guidelines for the application and use of technologies and an agenda for our own standards-making activities.[4]

Towards a Standards Framework for Imaging Systems

A standards framework for cultural heritage imaging systems is key. Such a framework must operate within the context of other domains - such as bibliographic systems - and other functions - such as interchange of information. It must accommodate present practice, while pointing the way to future developments. The framework must be generic to apply to a range of systems designed for different functions, yet identify stages or phases specifically enough that standards can be evaluated in their particular context.

3 Revision 1.17, dated 94/08/01, accessible on-line at http://www.cis.ohio-state.edu/hypertext/faq/usenet/standards-faq/faq.html

4 For an institutional perspective on the standards-making process, see Alan Seal. "Standards and Local Practice: The Experience of the Victoria and Albert Museum." Computers and the History of Art, Vol. 5, Part 1, 1995, pp. 17-24.

What is an imaging system?

For the purposes of this discussion, an imaging system is defined as a computerized information system which manages visual information, and relates it to textual documentation. (Such a system could also be described as "multi-media database," as it contains two or more different kinds of media. However, moving image and sound are beyond the scope of this initial outline.)

Within the cultural heritage community, this definition encompasses a wide range of possible applications. These include interactive installations in the gallery itself - such as those at the Minneapolis Institute of Arts, or the Micro Gallery in the National Gallery of Art, Washington,[5] and electronic exhibitions accessible over the WWW, such as the sites of the National Museum of American Art,[6] or the Canadian Museum of Civilization.[7] They also range from published titles distributed on CD-ROM, such as the *Microsoft Art Gallery*[8] or *With Open Eyes: Images from the Art Institute of Chicago*;[9] to databases designed to archive high-quality digital images for future use – such as those of the Frank Lloyd Wright Foundation, or assemble a corpus of scholarly information, such as the *Census of Antique Art and Architecture Known to the Renaissance*.[10]

Imaging systems can be approached either in terms of the processes through which they are constructed – their technical configuration – or in terms of the functional set of requirements they fulfill. The various stages in constructing an imaging system – image capture, storage, description, retrieval, distribution, and display – offer an appropriate way to cluster the various technologies and standards which apply at each stage in the process. The functional characteristics of imaging systems become important when decisions are made at each of these stages, between competing standards or technologies. The specific restraints of a particular application - for example, the fixed storage capacity

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5 See John Strand. "High Art, High Tech: The National Gallery of Art's New Micro Gallery", Museum News, Vol. 74, no. 4, July/August 1995, pp. 35-39

6 Accessible on-line at http://www.nmaa.si.edu/home.html

7 Accessible on-line at http://www.cmcc.muse.digital.ca/cmc/cmceng/welcmeng.html

8 Microsoft Art Gallery, The Collection of the National Gallery, London. Microsoft Corporation, 1993.

9 With Open Eyes: Images from the Art Institute of Chicago. Voyageur Company, 1995.

10 A review of activities can be found in the proceedings of the Electronic Imaging and the Visual Arts (EVA) Conferences, 1993-1995 and the Hypermedia and Interactivity in Museums (ICHIM) Conferences, 1991, 1993, 1995. See also Jennifer Duran. "Developments in Electronic Image Databases for Art History," VRA Bulletin, Vol. 21, no. 4 (Winter 1994), pp. 15-23.

of a CD-ROM or limited bandwidth of the WWW - may preclude certain options, or dictate a particular course of action.

The following outline is not an exhaustive survey of all of the standards that might apply to cultural heritage imaging systems. Rather, it is an overview of the standards that apply in the areas of Image Capture, Image Storage and Image Use.[11] Existing standards in widespread use – whether official, de facto, or proprietary – are profiles, and areas where standards guidelines are needed are identified, as these together will comprise the agenda for future collaboration. Interchange has not been discussed as it is the object of the work of the Consortium for the Interchange of Museum Information (CIMI).

Image Capture Standards

Image capture is the process of employing a device (such as a scanner or digital camera) to create a digital representation of an image that can then be stored and manipulated by a computer. Image capture can take place either directly from a work of art or artifact, or from an existing photographic image of a work. The circumstances of image capture will have a critical effect on image quality, and therefore on the future utility of a digital image. Key decisions to be made in the image capture phase include capture methodology, digital image resolution and image bit-depth. The cultural heritage community has not developed standards or guidelines to govern image capture activities.

Capture methodology

Projects such as VASARI[12] and MARC [13]have focused on the direct capture of digital image data from the work of art itself, a process which is becoming more a more realistic option with the development of digital camera backs.[14] Others, such as Luna Imaging, have focused on the conversion of existing photographic information into digital form.[15]

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11 This outline is drawn from the schema presented in Howard Besser and Jennifer Trant, Introduction to Imaging: Issues in constructing an image database, Getty Art History Information Program, 1995. Also accessible on-line at http://www.ahip.getty.edu/intro_imaging/home.html

12 Anthony Hamber, "The VASARI Project" Computers and the History of Art, 1:1, (1991) 3-19, and Kirk Martinez, "High Resolution Digital Imaging of Paintings: The VASARI Project" Microcomputers for Information Management 8:4 (December 1991), 227-283.

13 Hervé Derrien, "MARC, A New Methodology for Art Reproduction in Colour" EVA '93.

14 Such as those developed by Leaf and Kodak/Nikon (product information available on-line at http://www.kodak.com)

As collective experience in digitization increases, we will be able to develop guidelines for image capture in particular circumstances. Peter Robinson has begun to identify "Digitization Strategies for Particular Materials", in a study for the Office for Humanities Communication, in the United Kingdom.[16] While focusing primarily on text, this study provides a model for the kinds of guidelines which would be useful for visual materials.

Bit Depth or Dynamic Range

Bit depth governs the maximum number of colours it is possible for a digital image to represent. While not stated formally, there appears to be a minimal requirement for 24-bit (16 million) colour for "quality" images of works of art, i.e. those used for more than reference or identification purposes.[17] This exceeds the 8-bit (256) colour images now routinely distributed on the WWW or made available in many CD-ROM titles. Recent technological developments have focused on 32-bit (or even 36-bit) image capture. These images are then sampled and stored as 24-bit images. Key to a decision regarding an adequate bit depth for images of cultural heritage is a further understanding of image quality.

Resolution refers to the number of pixels which make up a digital image, and can be expressed as a ratio such as 1,000 x 2,000 or in terms of dots per inch (dpi). DPI (a term inherited from print technology) is a complex and often confusing concept – used to characterize scanning devices, image files and various display devices. It has also been used to compare the pixel dimensions of a digital image to the dimensions of an original object.

Martinez and Hamber[18] present a series of theoretical resolution requirements, based upon the actual dimensions and viewing conditions of a painting. They acknowledge, however that such a measure of scanning resolution requirements may not be appropriate, for "those working in the restoration and conservation departments of galleries and museums often require higher levels of resolution than perceivable by the naked eye".[19] Regardless of the theory, however, compromises are inevitable when

15 Cf, Frank Lloyd Wright: Presentation Drawings and Conceptual Sketches, Oxford University Press: 1994.

16 Peter Robinson, The Digitization of Primary Textual Sources, Office for Humanities Communication Publications, Number 4, 1993.

17 Robinson, The Digitization of Primary Textual Sources, 1993. "24-bit colour images are becoming the standards for computer presentation of colour.... It may be that the emerging agreement on 24-bit colour images as adequate s illusory, and that new generations of computer hardware will go beyond this" For example 32 or 36 bit output now possible from some capture devices. p. 29.

18 Kirk Martinez and Anthony Hamber, "Towards a colorimetric digital image archive for the visual arts" SPIE Vol. 1073, Electronic Imaging Applications in Graphic Arts, 1989, pp. 114-121

creating a working system. "Scanning at the resolution required for scientific studies may be impractical for very large paintings for time/storage reasons, and may necessitate a reduction in scanning resolution."[20] Image capture and storage technologies still limit the resolution it is possible to capture.

Issues in Image Capture: Image Quality

The cultural heritage community has neither a common definition for image quality, nor standards for measuring it. We need to develop benchmarks for measuring quality in the image capture process; The AIIM/ANSI standards for document imaging,[21] and the Commission on Preservation and Access Tutorial Digital Resolution Requirements for Replacing Text-Based Materials,[22] provide useful models. The Kodak Q60 and other colour targets could provide fixed points of reference for ensuring the quality of digital image capture.

Guidelines are also needed regarding the creation of representations of works of art. [23] What makes good documentary photography? [24] For example, colour and scale reference are not routinely included in many museum photographs. Control over the conditions surrounding the acquisition of visual information would certainly help to create a stable and predictable information source.

Image quality standards in the cultural heritage community need to take account of both the technical quality of the image, and its appropriateness for particular uses. Ester has conducted a series of experiments aimed at identifying when additional image information makes an imperceptible difference in the quality of a digital image.[25] We need to build on work regarding viewer perception, to understand

19 Martinez and Hamber, p. 118.

20 Martinez and Hamber, "Colorimetric digital image archive" 1989, 121.

21 Recommended Practice for Quality Control of Image Scanners (ANSI/AIIM MS50-199x - an update of ANSI/AIIM MS44-1988)

22 A useful model for image capture guidelines can be found in Anne R. Kenney and Stephen Chapman, Tutorial: Digital Resolution Requirements for Replacing Text-Based Materials: Methods for Benchmarking Image Quality, Commission on Preservation and Access, April 1995

23 Helene E. Roberts, "Second Hand Images: The Role of Surrogates in Artistic and Cultural Exchange." Visual Resources, Vol. 9, no. 4, 1993, pp. 335-346.

24 See also Michael Ester, Draft White Paper on Digital Imaging in the Arts and Humanities, prepared for the Getty Art History Information Program, March 1994. (Copies are available from AHIP.)

more about who uses visual information and in what way. With this knowledge, we can develop guidelines to ensure that the appropriate amount of image information is delivered as it is needed.

Typologies of image types, representing a series of quality thresholds defined by functional requirements, are widespread use.[26] Each of these types correlates with a particular function of the system. Image types could be identified as thumbnail or browse image, (displayed along with a text record, in-line on a WWW page or with other images on a "lightbox"); a full-screen image (the image displayed to the full pixel dimensions of a user's workstation - alternatively defined according to VGA, SVGA or higher resolutions); a high-resolution image (an image which allows some zooming in on details without pixelation) and an 'archival image' (an image of resolution/dynamic range exceeding today's' display technology, kept off-line and to be used in the future which may also be used to produce high-quality print material.) Lower resolution images are derived from a high-resolution scan.

Image quality is more complex than an equation balancing bit-depth and resolution. Further study is required to represent the particular needs of specific users and systems. Initiatives such as the Museum Educational Site Licensing (MESL) Project will provide more information about the real users of images and their quality thresholds.[27] As evaluation results are often not reported in the system profiles in the literature, the Imaging Initiative of the Getty Art History Information Program is undertaking a series of Case Studies, which will examine the use of imaging technology in specific institutions and project. With more research into the users of digital images and the functions for which they use image databases, we will be able to balance the different perspectives on imaging and find some common ground upon which to frame guidelines.[28]

25 Michael Ester. "Image Quality and View Perception" Leonardo, 23 (1990), 51-63.

26 20 MB, high resolution, kept off-line and used for printing). See Kirsten Black, "ELISE - an on-line image retrieval system", ASLIB Information, July/August 1993, pp. 293-295, and Alan Seal "The Creation of an Electronic Image Bank: PhotoCD at the V&A" Managing Information, January 94, 1:1, pp. 42-44.

27 For a project profile, see J. Trant. "The Museum Educational Site Licensing Project" Spectra, Spring, 1995.

28 An interesting summary of the areas of importance identified by different groups involved in the creation of a digital image database can be found in John P. Weise, "Emphasizing Image Quality," School of Information and Library Studies, University of Michigan, 1995. Accessible on-line at: *http://www.umich.edu/~jweise/quality/EmphImageQuality.HTML* Weise identifies the concerns of the Copyright Holder, the Image Creator, the Subject Matter Expert, the End User, and the Archivist.

Image Storage Standards

Once an image has been captured, it must be stored, in a particular file format, on a particular storage device. As digital image files are very large image – data is often compressed to reduce the amount of storage space required. Technical file formats, compression schemes and storage media change over time. While the cultural heritage community needs to be aware of these advances, it is beyond its ability to control or develop technical standards.

Image File Formats

The choice of image file format is critical to the interchangability of image data. If images are not stored in a widely supported format, it will be difficult, if not impossible for images to be interchanged. (It may be possible to transmit the file, but not to display its contents.) If images are to be made available on the WWW, a limited number of image formats (including GIF and JFIF/JPEG) can be supported by current generations of browsers (although this is changing rapidly).

The only standard in this area, Standard Recommended Practice, File Format for Storage and Exchange of Images,[29] applies to the area of document imaging and at the present time, deals only with black and white image data. Subsequent additions are being developed to handle colour and gray-scale images.[30] The file format recommended by this standard is TIFF. Of the file formats outlined below, only JFIF (the file format defined with the JPEG compression standard) can be considered a standard. Other image file formats, some proprietary, have become de facto standards through widespread use.[31]

TIFF (Tagged Image File), originally developed by Aldus Corporation. Version 6.0

TIFF files are widely supported, and can store image data captured with up to 24-bits of colour, compressed with LZW, CCITT Group 3, or Group 4, or JPEG. Issues arise with the widespread variance in the use of the tagged data fields in the TIFF file, and in the range of extensions to the format available.[32]

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29 Standard Recommended Practice, File Format for Storage and Exchange of Images, ANSI/AIIM MS53-1993.

30 Pamela R. Mason. "Imaging System Components and Standards" in Digital Imaging Technology for Preservation Proceedings from an RLG Symposium, Cornell University, Ithaca, New York March 17-18, 1994, pp. 25-40.

31 For full details of these and other image file formats see James D. Murray and William Van Ryper, Encyclopedia of graphics File Formats, O'Reilly & Associates, Inc., 1994.

32 Encyclopedia of Graphics File Formats, pp. 663-688, and Mason "Imaging System Components and

GIF (Graphics Interchange Format), originally developed by CompuServe Inc.

Widely supported, and originally the only file format which could be used with WWW documents, GIF is limited in its ability to render only 8-bit colour.[33] The file format and accompanying compression algorithm, LZW, have recently been the subject of a licensing dispute, which originally appeared to threaten the use of the format, but in retrospect appears not to have had a significant effect.[34]

JPEG File Interchange Format (JFIF)

ISO/IEC 10918-1 and ISO/IEC 10918-2

A widely supported file format developed by the Joint Photographic Experts Group, which stores images encoded using the JPEG compression. Stores images in up to 24-bit colour. Now used to distribute images on the WWW, as it is supported by the most recent versions of the Netscape browser software.[35]

Kodak Photo CD (Image Pac), developed by Eastman Kodak

A proprietary CD-ROM based storage medium, which bundles a series of image resolutions into a single "Image pac". For example, the Master Photo CD format offers five resolutions ranging from 128 x 192 pixels to 2048 x 3072 pixels.[36] Stores 24-bit colour images, in PhotoYCC format, a method of representing the colour spectrum where the 24 bits of data per pixel "are distributed among three color components, called Y (luminance information), C1, and C2 (two chrominance channels)."[37] The Photo CD format has become popular because of the ease with which it enables existing photographic collections to be converted to digital form.[38]

Standards", p. 31.

33 Encyclopedia of Graphics File Formats, pp. 309-330.

34 See michael moncur, "The great GIF Licensing Controversy", last updated January 23, 1995; available on-line at http://www.xmission.com/~mgm/gif/

35 Encyclopedia of Graphics File Formats. pp. 377-383; William B. Pennebaker and Joan L. Mitchell. JPEG, Still Image Data Compression Standard, Van Nostrand Reinhold, 1993. See also the JPEG FAQ available on-line from http://www.cis.ohio-state.edu/hypertext/faq/usenet/jpeg-faq/faq.html

36 See The KODAK Photo CD Master Disc, Five Image Resolutions Built In" available on-line at http://www.kodak.com/digitalImages/samples/fiveResolutions.shtml

37 Encyclopedia of Graphics File Formats, p, 386

BMP (Microsoft Windows Bitmap), developed by Microsoft

Microsoft Windows-based format, supporting up to 24-bit colour. Images are most often stored uncompressed, resulting in a larger file size.[39]

PICT (Macintosh Picture), developed by Apple Computer Inc.

Macintosh-based format, supporting up to 24-bit color, and used with JPEG compression.[40]

Still Picture Interchange File Format (SPIFF)

ISO/IEC CD 10918-3

A proposal now being developed by Joint Technical Committee 29 of the International Standards Organization and the International Electrotechnical Committee (ISO/IEC JTC 29) "intended to be a generic format that is simple in nature and does not include many of the features found in application specific file formats" Still some years away from implementation.[41]

Image Compression

The large file size of digital images often leads imaging system implementors to compress files in order to reduce the amount of storage space they occupy. Image compression can be either "lossy" a one-way process which results in a reduction of the amount of image data available, or "lossless," a reversible process which maintains the integrity of the original image file. The purpose for which an image file is being created will dictate whether it is possible to tolerate the data loss incurred with lossy compression. Imperceptible changes in an image file may be acceptable for a public access application, or for the distribution of images over network, but be intolerable for an image archive which is designed to have lasting value. Changes in image data, for example, would make automatic comparison of images

38 See Alan Seal "The Creation of an Electronic Image Bank: PhotoCD at the V&A," Managing Information, January 94, 1:1, pp. 42-44.

39 Encyclopedia of Graphics File Formats, pp. 434-443

40 Encyclopedia of Graphics File Formats, pp. 407-410.

41 ISO/IEC CD 10918-3: 1994 E (94-11-11), Annex F, p. 45. Other activities of the ISO/IEC JTC 29 are outlined be Jean Barda, "Still picture interchange" EVA 95, 1995, pp. 69-76.

and their copies impossible, and preclude image processing applications which analyze the statistical characteristics of image files.

The two image compression formats in widespread use are JPEG and LZW.

JPEG (Joint Photographic Experts Group)

ISO/IEC 10918

A lossy compression format, used in JFIF files. JPEG allows for a choice of the level of compression. Various 'Quality' settings within JPEG compliant applications enable the selection of a best possible compression ratio.[42] Compression ratios of 25:1 are common - somewhere between 10:1 and 40:1 is likely to be acceptable for a 'working image'.[43]

LZW (Lempel-Ziv-Welch)

A lossless compression algorithm used in GIF and TIFF files.[44] LZW offers compression ratios between 50 and 90%.[45] The LZW algorithm was at issue in the recent GIF licensing controversy (see above).

CCITT or Huffman Encoding– referred to as CCITT Group 3 and Group 4 – compression formats are commonly used for compressing two-colour images, (page images) and are used in fax machines and fax modems. Their uses are limited within the cultural heritage community which tends to require colour imaging.

Emerging compression technologies, based on wavelets and fractels may provide alternatives to JPEG or LZW compression, but these applications are not yet widely available or supported.

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42 See the Encyclopedia of Graphics File Formats, pp. 159-172, JPEG Still Image Data Compression Standard and the JPEG FAQ.

43 Mason, "Imaging System Components and Standards", 1994, p. 30-31

44 See the Encyclopedia of Graphics File Formats, pp. 142-148

45 Mason, "Imaging System Components and Standards", 1994, p. 33.

Storage Devices

Digital images can be stored on magnetic, magneto-optical or optical media. Storage architectures may employ one or all of these kinds of media, for on-line image storage, backup or long-term storage. The standards which apply to these media are constant regardless of the kind of data written on them. For example, the ISO standard for the CD-ROM file structure (ISO 9660), applies to both image and text data.[46] However, the large size of image databases poses a challenge for image database designers, often resulting in the creation of hybrid information storage architectures, which keep frequently accessed, or low-resolution images quickly accessible on magnetic media (stored on-line on a hard-drive) and rely on media with a slower aces time, such as CD-ROM for the storage of high-resolution images.

Issues in Image Storage: Archival Integrity

Critical to the choice of storage formats for imaging systems are concerns regarding the longevity of media and the migration of data. Migration of data from one generation of technology to another is inevitable; it is necessary to plan for the refreshment of technology, and the migration of data from one format to another. This successive transformation, however, raises concerns about the long-term integrity of digital information. Each migration could either introduce errors, or by altering the physical format of digital data, also alter its interpretation.[47] There is much more to learn about the mechanical and intellectual issues surrounding the integrity of digital information.[48]

The cultural heritage community must heed the discussions and recommendations of the broader Digital Library community. Symposia such as Digital Imaging Technology for Preservation, hosted by the Research Libraries Group in 1994,[49] and the discussions of such interdisciplinary groups as the

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46 For an image-centric discussion of these issues, see Mason, "Imaging System Components and Standards," 1994, pp. 34-36 and Robinson, The Digitization of Primary Textual Sources, 1993, pp. 69-71.

47 See, for example, Jeff Rothenberg, "Ensuring the Longevity of Digital Documents" Scientific American, January 1995, pp. 42-47.

48 For a full outline of these issues, see Clifford A. Lynch, "The Integrity of Digital information: Mechanics and Definitional Issues," Journal of the American Society for Information Science, Vol. 45, no. 10, (December 1994), pp. 737-745. See also the recent work of Peter Graham and David Bearman, regarding the creation of systems for secure information interchange and authentication

49 Nancy E. Elkington, ed. Digital Imaging Technology for Preservation, Proceedings from an RLG Symposium held March 17 and 18, 1994, Cornell University, Ithaca, New York, Research Libraries Group,

Task Force on Archiving of Digital Information[50] provide a forum for the definition of the issues, and a means for determining the 'best practices' in this rapidly evolving area. Coordinated action is critical if we are to develop means to ensure the longevity digital information and preserve the integrity of its intellectual content.

Standards and consistent practices offer some reassurance that information migration will at least be predictable. Documentation of image capture methodologies and image file formats is the first step towards ensuring the accurate interpretation of visual information when it is displayed in the future.

Image Documentation

Documenting digital images which depict works of cultural heritage requires recording information both about the work, and about the digital representation of the work. If the digital image was created by scanning an existing photographic reproduction, the characteristics of that reproduction will have an impact on the resulting quality of the digital image, and should be documented as well. The same is true if an image was derived or subsampled from another digital image file.

Describing Content

The cultural heritage community has as history of collaboration centered on the question of content description. Data structure guidelines or standards published in recent years include Spectrum, the Documentation Standard for the United Kingdom,[51] Categories for the Description of Works of Art, the report of the Art Information Task Force,[52] and International Guidelines for Museum Object Information: The CIDOC Information Categories.[53] Available data value standards include the Art and Architecture Thesaurus (AAT)[54] and the Union List of Artists Names. The Canadian Heritage Information Network as recently published Data Content Standards: A Directory.[55] This document

Inc., 1994.

50 A joint project of the Commission on Preservation and Access and the Research Libraries Group. Documents accessible on-line at http://www.oclc.org:5046/~weibel/archtf

51 Alice Grant, Spectrum, The Documentation Standard for the United Kingdom, Museum Documentation Association, 1994.

52 J. Trant, The Art Information Task Force, Categories for the Description of Works of Art, The Getty Art History Information Program, 1995.

53 ICOM/CIDOC, International Guidelines for Museum Object Information: The CIDOC Information Categories, June 1995, Edited by a joint project team of the CIDOC Data and Terminology and the CIDOC Data Model Working Groups.

lists standards, standards organizations and standards development projects, categorizing them by discipline, and by scope. Content documentation standards for imaging systems should conform to those of the relevant subject discipline.

Describing Surrogate Images

The manner in which a work of art or artifact is depicted in a surrogate image can greatly affect the utility of that image. The Data Standards Committee of the Visual Resources Association has drafted "Data Standards for Visual Resources." Although much of this proposed standard relates directly to managing information about a conventional slide collection, it includes a series of Image Elements which are unique to a visual representation. These include the format of the reproduction, and a means of recording the 'vantage point' from which the image was taken.[56]

Describing Digital Image Files

There is as yet no consensus regarding the information required to document digital image files. We need to determine what information should always travel with an image, and therefore must be placed in the image file header, and what can be stored in an accompanying text record. We need to determine how to manage relationships between image files and the text records that describe them.

Discussions of image documentation requirements have taken place within the context of the Coalition for Networked Information, and the Consortium for the Computer Interchange of Museum Information. In the fall of 1994, a preliminary framework was presented for comment, which raised the following questions: What information should be recorded about digital image files? Where and how should image files be documented? What information must be placed in the image header, and what can be placed in an accompanying text record? How should that text record be fielded? How should the relationships between image files and their accompanying text records be managed?[57]

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54 Getty Art History Information Program, Art and Architecture Thesaurus, 2nd ed. Oxford University Press, 1994.

55 Kerridwen Harvey and Patricia Young, Data Content Standards: A Directory, Canadian Heritage Information Network, July 1994.

56 The current chair of the VRA Data Standards Committee is Dustin Weiss, Sterling and Francine Clark Institute, Williamstown, MA, USA.

57 H. Besser and J. Trant. Describing Image Files: The Need for a Technical Standard, Coalition for Networked Information, Fall Meeting, Orlando, Florida, November 30, 1994.

A number of general kinds of information about a digital image were identified:

1) Information required to view the image, including type (bit-mapped, vector, video), format (such as TIFF, GIF, JFIF), compression scheme (such as JPEG, LZW, QuickTime) pixel dimensions and dynamic range, CLUT and color metric (CMYK, RGB);
2) Information about the quality and accuracy of the image, including the source digitized, the source image type, source image identification and the institution responsible for creation of the digital image (this could be a series of recursive relationships when images are derived or scanned from other images);
3) Information about the scanning process, including light source (full spectrum, infrared), resolution, dynamic range, type of scanner (for color correction), date of scan, the identification of the scanning personnel, a record of image manipulation, (cropping, color balancing), and the addition of digital signatures or other methods of authentication;
4) A description of how an original is depicted in a surrogate image, including mention of perspective, position, orientation, aspect, and linking between various views of the same original, or different versions of an image (browse, high-resolution, medium resolution) derived from the same scan;
5) A description of the work depicted, according to a known content standard, such as AACR2 or the AITF Categories for the Description of Works of Art;
6) Rights and Reproduction Information, documenting the copyright of the original, the surrogate image, and the digital image, and including the name of the rights-holder and possible use restrictions (on viewing, printing, or reproduction);
7) Information about how to locate an authentic copy of the image, recorded in a form such as a Universal Resource Name/Number or Universal Resource Locator.

The refinement of this preliminary schema, and the adoption of a standard description of an image file will be critical for the archival integrity of digital visual information. This will be the only way to ensure that as image files are transmitted over networks they carry enough information with them to identify their contents. As we build digital image archives, records of the circumstances of their creation will be an essential key to the future evaluation of their contents.

Data Representation

Standard means of representing the various types of image description will also be critical to their future utility. Within the bibliographic world, content documentation is recorded according to ISO 2709, and its implementation in the MARC format. Within the cultural heritage community, progress has been made in implementing the Standard Generalized Markup Language (ISO 8879) by the Consortium for the Computer Interchange of Museum Information (CIMI). However, we are still some way from standard Document Type Definitions for museum information, as there are for books, articles and serials.[58]Image Use Standards

The usefulness of an image database depends upon the ability to retrieve images which are of interest, to view them (either displaying or to printing) and to manipulate them (sorting, grouping and annotating). Standards are required to support these functions, and to ensure that visual information can be managed alongside other information types in the larger networked information arena.

Retrieval

Textual description remains the key to retrieval of images. As images can be of wide-ranging interest, the process of assigning index-terms when cataloguing is complex. It is difficult to characterize the "subject" of an image. For example "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."[59] Each of these users brings their own perspective, and their own set of retrieval characteristics to an image database.[60]

Further research on the use of visual information as a resource will improve our ability to structure retrieval systems to support broad use. What has been termed "Point of View" is being examined in the context of the work of the CIMI Consortium,[61] and promises an increased understanding of the questions asked of a museum by the general public.

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58 Information and Documentation - Electronic manuscript preparation and markup, ISO 12803, 1994.

59 Howard Besser. "Visual access to visual images; the UC Berkeley Image Database Project. Library Trends, Vol. 34, no 4, (Spring 1990) pp. 788.

60 A fuller outline of "Research Topics in Image and Multimedia Retrieval" has been prepared by Donna M. Romer, for a forthcoming discussion AHIP is hosting on the "Research Agenda for Humanities Computing".

61 Jane Sledge, "Points of View", International Conference on Hypermedia and Interactivity in Museums, 1995. See also Susanne Ornager, "The Image Database, A Need for Innovative Indexing and Retrieval," Knowledge Organization and Quality Management, Advances in Knowledge Organization, Vol. 4, (1994), pp. 208-216, for a discussion of this issue in a more general context.

When images are made available over networks such as the Internet, integrating visual information with other forms of textual information is important. Mapping characteristics of visual information into existing information retrieval standards – such as the Z39.50 protocol – will be critical to the broader accessibility of image data. CIMI's work should prove helpful here as well.

The ability to search image databases based on purely 'visual' characteristics is still in the experimental stage. The Query By Image Content (QBIC) system tries to find images "like" one chosen as an example, or matching a pattern drawn by the searcher.[62] Other systems experimenting with matching pattern, texture and outline in images, to some limited success.[63] Still others are focusing on browsing as a technique for identifying relevant visual images.[64]

Image Display or Output

Viewing a digital image requires its display on a monitor or its output to a printing device.

Display technology is still the weakest link in the image quality chain. For example, an image can be captured at a much higher resolution and dynamic range than it can be displayed on the majority of monitors; SVGA monitors only support 8-bit color, to a maximum resolution of 1280x1024.[65]

Getting an accurate rendering of the digital information in an image file remains difficult. When displayed on a monitor using a cathode ray tube (CRT), colour is represented as three additive values of red, green and blue. Differently calibrated of monitors will render in the same image differently; careful calibration is essential to maintain consistency between images manipulated on different workstations.

62 Bonnie Hold, Laura Hartwick and Stacey Vetter. "Query By Image Content, The QBIC Project's Applications in the University of California Davis's Art and Art History Departments." Visual Resources Association Bulletin, Vol. 22, no. 2, (Summer 1995), pp. 60-66.

63 See A.E. Cawkell, A Guide to Image Processing and Picture Management, Gower, 1994, particularly Chapter 7, "Indexing picture collections".

64 Such as Carolyn Frost's work on the University of Michigan Art History Image Browser. Project Profile accessible on-line at http://www.ahip.getty.edu/ahip/Text_proj-of.html

65 Richard Jackson, Lindsay MacDonald and Ken Freeman, Computer Generated Color, A Practical Guide to Presentation and Display, Wiley, 1994, p. 129.

When images are printed using the four-colour process, varying hues are created through combinations of Cyan, Magenta, Yellow and Black. Conversion to CMYK from RGB colour space require considerable care if quality printed output is to match the appearance of a digital files.[66]

Colour management systems are being developed to deal with these issues, but none can be considered standard as of yet.[67]

Image Analysis

The full use of visual information in digital form will depend upon the ability to work with images in a digital environment. Tools which support the analysis of visual information, including image sorting, grouping, annotating and manipulation are only slowly becoming available.[68]

Intellectual Property

Key to the availability of visual information over networks will be the resolution of the current stasis regarding the management of intellectual property rights. The lack of efficient mechanisms for the clearance of rights has made the development of some systems unrealistic. Others bypass the permissions process entirely, relying on gray areas copyright law, or working, in the United States, under a broad interpretation of the doctrine of 'fair use'. Neither of these strategies is satisfactory, from either the perspective of the information user or the information provider.

Developing a appropriate intellectual property framework will require a complex balancing of the interests of rights holders and the desires of those who use images for teaching, research or enjoyment. Progress in this arena has been slow, particularly internationally, as differences in national law have stood in the way of collaboration. One positive sign, on the national level in the United States, is the production Sample CD-ROM Licensing Agreements for Museums, by the MUSE Multi-Media Study Group.[69] Designed to reflect the 'views and opinions of museum professionals" these sample texts with a helpful gloss, offer a starting point for museums faced with negotiating the use of digital images of

66 For an accessible outline of the issues involved in rendering colour see Richard Jackson, Lindsay MacDonald and Ken Freeman, Computer Generated Color, A Practical Guide to Presentation and Display, 1994.

67 Several commercial systems are profiled in Rudolph E. Burger, Color Management Systems, The Colour Resource, 1993.

68 Some of these capabilities are built into commercially available image browsers. The Institute for Advanced Technology in the Humanities at the University of Virginia has developed a promising image annotation tool.

69 MUSE Educational Media. Sample CD-ROM Licensing Agreements for Museums. 1995. Available from

works from their collection in published, commercial, fixed-media titles. This is a significant first step forward, addressing one of the major ways by which digital images of works in museum collections are now distributed. It reinforces the position that contracts reflect a negotiated position, and asserts the rights that the cultural heritage community may wish to protect.

The networked distribution of digital images requires the development and implementation of new paradigms for intellectual property management. Just as our concepts of geography, and "site" are being challenged by a global network that knows no boundaries - so too are our conceptions of "original" and "copy" dissolving into infinitely replicable reality. Our old models of property translate with great difficulty into network space; we need to look for new ways to manage and license the distribution of information.[70]

Museum Educational Site Licensing Project (MESL)

The Museum Educational Site Licensing (MESL) Project offers an opportunity to explore new means of information distribution and new mechanisms for licensing. This two year collaboration brings representative museums, colleges and universities together to define the terms and conditions for educational use of museum images and information on campus-wide networks. MESL will develop methods and guidelines for the educational use of digitized museum materials. This 'good-faith' collaboration is defining define terms for image capture and distribution, and developing guidelines for the educational use of museum images and accompanying information. The Project's goal is to develop and test administrative, technical and legal mechanisms that will enable the delivery of large quantities of high-quality images from any museum to any educational institution.[71]

Muse Educational Media 1 East 53rd Street, 10th floor, New York, NY, 10022-4201.

70 See for example, Ester Dyson. "Intellectual Value". Wired. July 1995, 137-141, 182-4.

71 Launched by the AHIP Imaging Initiative, in association with MUSE Educational Media, MESL participants include the Fowler Museum of Cultural History at the University of California, Los Angeles; The George Eastman House, Rochester; The Harvard University Art Museums, Cambridge, Massachusetts; The Library of Congress; The Museum of Fine Arts, Houston; The National Gallery of Art, Washington, DC.; and The National Museum of American Art, Washington, DC., American University, Washington, DC.; Columbia University, New York, New York; Cornell University, Ithaca, New York; the University of Illinois at Urbana-Champaign; the University of Maryland at College Park; the University of Michigan; and the University of Virginia. Background information on the Museum Educational Site Licensing Project is available by ftp from the Getty Art History Information Program: ftp to ftp.ahip.getty.edu/pub/mesl , log in as 'anonymous' with your email address as the password. A profile of the project can be found in the publication of the Museum Computer Network: . J. Trant. "The Museum Educational Site Licensing Project." Spectra, Spring, 1995.

Conclusion

There are still many areas where standards must be identified and guidelines devised for the creation of image databases documenting our cultural heritage. As we evaluate possible standards, we must do this in the context of a framework for imaging systems, which considers image capture, and image storage in terms of image use. Our efforts should be directed at the defining key issues surrounding image quality, image integrity and image use. Building our knowledge in these areas will further the long-term utility of the image databases we create. Shared standards and common practices must be the foundation upon which networked cultural heritage information resources are constructed.

The 'virtual museum' will only become a reality when it is possible to create coherent integrated intellectual whole. Such a networked information resource will be constructed of more than the binary blobs of uncertain origin we download from the WWW today. It will contain mechanisms to ensure the integrity and authenticity of the information it contains. Sophisticated research requires navigational metaphors will move beyond our current set of 'destinations' towards the user-defined information space which incorporates elements from many sources.

Creating such a truly functional virtual museum depends upon the collaboration of the networked information community. The tools which will enable the retrieval of representations of museum objects in conjunction with rich contextual data will also enable the cooperation essential to ensure we are all contributing to the creation of a distributed knowledge-base of our shared cultural heritage.