Storing Uncompressed Images of Photographs and Documents

Introduction

Storing uncompressed digital images is a strategy to eliminate questions about at least one part of a digital imaging project. After the other problems surrounding the project are solved, it will be time to revisit the decision to store uncompressed digital images. This article identifies some of the issues surrounding the storing of uncompressed digital images.

"Is the image accurate?"

When storing an image digitally, the question is: "Is the image accurate?" This is a fundamental question and goes beyond the narrow realm of digitizing, or even administrative processing.

Included is the question of whether the original document scanned (or the statue photographed) was authentic. This is a question about the provenance of the object, the history of the object from the time it was created to the time it was imaged. Americans hope that the documents said to be the United States Declaration of Independence and the US Constitution are the original documents and have not be changed by outside parties.

And, beyond that, many authentic objects are not true objects. Many copies of paintings are very good forgeries, and hang in museums because they are great art, but they are not truly from the great masters.

Authentic and Accurate

The Column of Trajan, erected in 113 AD [http://www.stoa.org/trajan], had the history of the Dacian war carved in a spiral, up the column. The column is authentic, in that it is fairly certain not to have changed since its erection. The accuracy of the content of what was carved is less certain that its authenticity. The content of the carved spiral could have been modified in some way, or could have been initially inaccurate before it was carved. The column is an important public record and is described as the birth certificate of the Romanian people, as the Dacian wars extended Roman influence to the area of what is now Romania. The column even presages modern GIS (Geographic Information Systems) in that its height of 100 Roman feet (29.78 meters) is chosen "as an illustration of the height which this hill and place attained, now removed for such great works as these" ("ad declarandum quantae altitudinis mons et locus tantis operibus sit egestus"). http://www.cimec.ro/Arheologie/TrajansColumn.htm/1.htm][http://www.ukans.edu/history/index/europe/ancient_rome/E/Gazetteer/Places/Europe/Italy/Lazio/Roma/Rome/Trajans_Column/John_Pollen/home.html]

Words

Then there are translations. The language in the United States has changed since the US Declaration of Independence was written. Many quotes in the bible, such as the story about the multiplying of the loaves and fishes, are referred to as though they were written in English. The words in the bible are even referred to as though they were written, when in fact the bible was spoken, for a very long period of time, before it was written down. This oral tradition is one reason why there is so much disagreement over what actually constitutes the bible. The bible is a good example of a document that has been kept for six thousand years. And the bible is a good example of the problems of preserving a document for a long period of time.

Because the language in the United States has changed since the US Declaration of Independence was written, an accurate representation of the Constitution requires either the translation of the original, or a glossing of the terms such as the marginalia or interlineations found in bibles. For example the US Declaration of Independence says 'all persons are created equal'. In current English 'all men are created equal' means literally just men are created equal, so an accurate translation of the original 'all men are created equal' requires the phrase 'all persons are created equal'. Interestingly, the US Declaration of Independence was written in the language of the nineteenth century, not the language of the eighteenth century, because the framers of the US Declaration of Independence were intent on leading their aim on the language (and society) by about a century. The clearest precedent for this is Magna Cara of 1215 which leads its society by five centuries in 'given to all the freemen' . . . 'these liberties underwritten'. Although it is not clear that the framers of the Magna Cara intended it meaning to be interpreted nearly as broadly as it is now, or even as broadly as it was interpreted by the framers of the US Declaration of Independence. [http://www.nara.gov/exhall/charters/magnacarta/magtrans.html]

Time

Even fixing a point in time, or a specific date, is no simple matter. On the 'day of two noons, November 18, 1883, the railroads of the United States moved the country to artificial time [http://www.fremo.org/betrieb/timezone.htm]. Before that, the railroads kept natural time, reckoned from noon, at which time the sun was directly overhead. (The US Congress moved to artificial time March 19, 1918, with the Standard Time Act) More fundamentally, Stephen the Short was off by 6 years when he established the calendar for the Catholic Church. The birth year of Jesus Christ was 6 BC (There is no year zero in our system for numbering years.). For six (or seven) years, we were not even sure what millennium we were in. In the preparation for the year 2000 celebrations, the Catholic Church acknowledged this problem.

There are no right answers

Often, managers search for the simple (and quick) fix. If we just do 'X', it will solve the problem. FedEx [http://www.Fedex.com] will get it there on time. We bought Veritas [http://www.Veritas.com] backup software to keep our electronic records safe. We put our electronic records on a 2 inch (50 mm) square Norsam plate (nickel). [http://www.Norsam.com] so it will last one thousand years (or a billion years for iridium) when stored at 500 degrees Celsius (900 degrees Fahrenheit).

There is no one product, or one simple action, that will solve all future problems. Most fundamentally, a single decision is taken a single point in time, and can only optimize the solution for the conditions existing at that point in time. As time rolls forward, conditions become less and less like the conditions at which the decision was taken, and the decision fits current conditions less and less well. A decision taken at a given point in time can be described as a 'right answer'. The common mistake with right answers is to assume that the right answers persist over time. At each point in time, a new decision must be taken, consistent with current conditions.

There is an inherent dichotomy to decisions. If one changes direction (changes a decision), all of the other systems, created to work with the system defined by the original decision, will fail (or at least have to be modified). If one does not change direction, the existing direction is almost certain not to be consistent with current conditions. The ability to work within this dichotomy was spotlighted by F.(rancis) Scott (Key) Fitzgerald when he said the mark of a successful person is "to hold two opposed ideas in the mind at the same time, and still retain the ability to function." Conversely, during the Scopes Monkey Trial, William Jennings Brian balked at reviewing his stance, saying, "I do not think about things that I do not think about" [http://www.law.umkc.edu/faculty/projects/ftrials/scopes/day7.htm]: reductio ad unum (reduced to a single idea). (His stance was that the bible said what he said, notwithstanding the fact that the bible did not say what he said.) But, it is difficult to avoid mixing personality with technical arguments, and the attack by Clarence Darrow certainly was ad hominem (against the person of) Mr. Brian, as well as against his position. (Similarly, any mention of any technical standard has behind it a political position, on both sides, for and against the use of the standard. In this case it was the standard of scientific inquiry was being championed / attacked.)

The Average Person

Is that which is stored true to what an average person would expect it to be?

Sometimes the information in a document is counter-intuitive in the view of the average person. Rather than avoiding a document for this reason, all that is necessary is to explain the counter-intuitive nature of the information in terms that an average person can understand. The functioning of the democracy in the United States required that the average persons, the voters, have some understanding of Einstein's Theory of Relativity.

A Librarian, An Archivist

Only a person can certify that a document is what it purports to be. Only a person can certify that in the context of a given collection, it makes sense to include a given document (and that all documents of equal value have been included, or their exclusion has been explained).

Storing uncompressed images

For photographic images, this is not a bad idea in the first year or two. Managers must kill the rats first. To do this, it is necessary to create order. Storing uncompressed images is a quick and safe solution to one set of questions, and provides some breathing room for the dispatching of more pressing issues. Similarly, following standards that include the storage of uncompressed images is also safe the first year or two, while the rats are being dispatched.

Photographic or art librarians often do not deal with one-bit, black and white images. It is important, however, to know that a very large industry works in this area, and has supported the creation of a wide array of equipment. For bitonal images, it is easy to follow the CCITT group 4 fax standard for lossless compression. It is well known and proven, and it is the technology used in the Yale project [http://www.dlib.org/dlib/february96/yale/02conway.html] (nb: rather than 36,000 dpsi (dots per square inch) listed the actual effective resolution was 360,000 dpsi) to scan in 2 thousand books in its first phase. Yale's project scanned at 600 dpi (dots per inch) with one bit per pixel or black and white. Most printed books are designed to be read in high contrast black and white, so it makes sense to record images in 1 bit pixels.

600 dpi is the resolution of digital copiers (which must match the physical resolution capabilities of the older analog copiers), and will soon be the standard for document imaging in general. Copiers are designed to fit the needs of top managers, microfilm and document imaging was designed to be adequate for the needs of the clerical staff. As document imaging begins to provide documents to top management, the desire for top quality reproduction will be the impetus for the increase in resolution to 600 dpi. Simultaneously, the cost of storage and data communications is becoming a non-issue. Yale had higher resolution standards than the document imaging industry when it was designed, but soon the document imaging industry will be using the resolution standard set for libraries.

Requirement for a thorough, academic review

In the fullness of time, on the order of a few decades, a more thorough, academic review should be made of the policies and procedures under which documents are stored. This is demanded by academic institutions -- the requirement to know (what is known about) what you are doing. It also makes great practical sense. This paper covers some of the details to be studied in a more thorough review of storing documents and document images.

Over decades, individuals are less important than institutions, although, at any point in time, only individuals matter. A professional career spans at least two generations. (A generation in society is generally assumed to be 20 years.) Archivists did not originally have to know about paper, because originally, paper lasted forever (at least several hundred years). Librarians did not have to know about typewriters, air-conditioning, acid paper, computerized catalogs, or the Internet. In the short term, one can safely assume that not much has changed. In the long term, decisions must be made with a thorough understanding of all circumstances. Decision makers must most fundamentally understand the documents being stored, and therefore should be librarians and archivists. Over time, all librarians and archivists become conversant in new technologies, with the decision makers being highly knowledgeable in technology. It is by this mechanism that decisions in libraries and archives come to understand the constraints, and benefits of new technologies.

Is it cost effective?

Digital photographs are often added to a collection slowly. If the cost of the storage for uncompressed images is less than ten percent (and it is often less than one percent) of the cost of processing the digital photographs, then there is not a cost issue in storing uncompressed images.

Compression Defined

There are many way of defining compression. For example, the original word processor file can be viewed as a highly compressed, and very precisely compressed, version of a scanned image of the document printed from the word processor file.

For the purposes of this article, compression is divided into lossless (non-destructive) compression and lossy (destructive) compression. Simply put, a decompressed losslessly compressed file is identical to the original file. The only difference is that, when the file is in compressed form, the file requires less storage and can be transmitted over the Internet more quickly than the same file in uncompressed form.

Lossy compression is used when a slight change in the image can be tolerated. This is often the case in commercial document management. For example, a photograph of a car that has been in an accident is stored in JPEG (Joint Photographic Experts Group) format using a lossy setting. Kodak PhotoCD [http://www.kodak.com/global/en/professional/products/storage/pcdMaster/aboutPCD.shtml] images are said to be visually lossless (but lossy because they are not digitally identical to the original files). Digitally identical means that each bit (with a value of one or zero), in an original file, is identical to the corresponding bit (with an identical value of one or zero), in the decompressed version of the file.

Many compression algorithms have a lossless and a lossy setting. The lossy setting provides a higher compression ratio (greater degree of compression) (the compressed image requires less storage).

Benefit of Uncompressed Images

By requiring uncompressed storage of images, you do not need to understand compression at all.

Even if you understand what lossless compression is, you may not be able to ensure that you lossless setting in JPEG are not reset to lossy by a helpful assistant.

Insisting on uncompressed images alerts the IT community that you are concerned about image quality issues in general and compression techniques in particular.

Is the scanned image true color?

Understanding the color gamut (range) of the human eye, the scanner, and the digital color space model for the image, can be challenging. As a professional, a librarian should at least look at the scanned images to see if they 'look good'. There are standards, test targets, and measuring devices that can be used to test the quality of scanned color. Ultimately, over a decade or two, the decision maker must understand digital color.

Can the scanner or camera produce a true full color digital image?

Does the camera have a prism and three areal image sensors, as do high quality digital television cameras, three parallel linear image sensors, one for each color, or does the camera have a single areal image sensor and a color wheel as did the early color television cameras and the color television camera taken to the Moon on the Apollo missions. Each of these three configurations allows for the collection of all bands of light (red, green, and blue) from each pixel area sample in the image.

What is to be avoided is a camera with a single areal sensor and a pattern of red, green, and blue filters covering images sensors. With this single sensor and patterned filters, each pixel represents a sample of only one color. Full color is produced through image processing which can also introduce digital artifacts such as a moiré. Even though full color images are sensed, and even though a full color value is produced mathematically for each pixel, the resulting image is not acceptable for many purposes. Storing such an image in an uncompressed format does not eliminate this deficiency.

The elegant solution to this problem is the single array, multilevel Foveon image sensor. [http://www.Foveon.com] In a Foveon based camera, each pixel sensor records a full true color value for the pixel that the sensor records.

Will there be better scanners?

Yes. They will be of a higher resolution (use smaller pixels). They will have a wider color range (including at least infrared and ultraviolet). They will provide 3D scans of the surface of objects. They will do molecular analysis of the paint layers on a painting, giving the type and color of paint, and the order in which the brush strokes were made (showing how the painting was actually painted). It should be assumed that paintings (and all documents) will be rescanned at least every 50 years, as scanners improve, until the original documents have deteriorated (not from scanning) beyond use.

Is the digital image just like the original?

Digital images (and images derived from documents that were originally created in digital format) are in a different domain (the domain of mathematics) than the original physical documents. Digital images are made up of ones and zeros that will never change. Light from small square areas the original documents was sampled and averaged. This average number (the color of the small square area) was then compared to each of the colors in the digital color space. The sample color was then changed to match the closest color in the digital color space. In this way, the document was transformed from our analog domain to a digital domain. The incident light (and the angle of the incident light) used for the scanning, along with the adjustment to fit colors within the digital color space, affect the fidelity of the color image. The fitting of the colors to the color space constitutes a digital (mathematical) transformation of the image. The attributes of the incident light and the lenses of the camera constitute an analog transformation of the image. It is these transformations that a librarian labels as reasonable when a digital image is accepted. The color of the universe was recently determined to be beige by reducing the entire universe to one pixel and averaging the light [http://www.cnn.com/2002/TECH/space/03/08/color.of.the.universe.ap/index.html]. Oops! Color of the universe isn't green, it's beige, March 8, 2002 Posted: 4:22 AM EST (0922 GMT)

Additional transformations include converting from RGB (Red Green Blue) to CMYK (Cyan, Magenta, Yellow, blacK), to CIE L*a*b color space [http://www.adobe.com/support/techdocs/34ea.htm] [http://www.efg2.com/Lab/Graphics/Colors/Chromaticity.htm] There is also a Hue, Saturation, and Intensity (HSI) color space as used by Munsell. [http://www.munsell.com/] [graphics.stanford.edu/courses/cs99d-00/projects/ElaineYau-munsell.ppt][http://www.tech.plym.ac.uk/robofoot/robofoot/vision/software/hsi.html] RGB is the additive color space used in television. CMYK is the subtractive color space used in printing. CIE L*a*b is non-linear w.r.t (with respect to) digital recording, but is linear with respect to human vision in that each color pair in CIE L*a*b color space is separated by one delta E unit, which is the smallest resolvable difference at that point in the human vision color space. [http://white.stanford.edu/~brian/scielab/introduction.html] Conversely, RGB, CMYK, and HSI are linear w.r.t digital recording, but are non-linear w.r.t human vision. These last three color spaces can represent multiple color per CIE L*a*b delta E unit in some regions of the human color space. The resolution of these last three color spaces is chosen to be able to resolve at least one delta E unit at all points in the human color space.

Color Resolution

People can only see about 256 (a round binary number) (8 bits) shades of gray, or the color equivalent of 16,777,216 (a round binary number) (24 bits) colors. However, in photography, dodging is used to increase the range of intensity (as done by Ansel Adams)[http://www.anseladams.com] and lenses are used to increase the resolution. Capturing more than people can see is a reasonable thing to do, so 12, 16 and even 24 bits of grayscale can be captured, as well as 36 or 48 bit (tri-color) color. Adjusting the output gamma is necessary to actually see the full range of the scanned images, however.

Output Gamma Function

A manager of digital images should understand that the output format, rendering intents and algorithms, and color space (and other gamma functions) are irrelevant to the integrity of the stored image. However, some output mechanism should be used (and understood) to check to see if the stored image is at least 'reasonable'.

Input Gamma Function

Within the photo sensor, there is a correction for the gamma function of the sensor. This gamma function adjusts the actual functioning of the analog sensor to the response of an ideal sensor. This constitutes another transformation of the digitized image that must be understood.

Why newspapers and magazines require true color

Like art libraries, newspapers and magazines require true color. To subtract out the commercial and marketing requirements from the technology, the commercial and marketing requirements must be understood. Newspapers and magazines require true color because it makes flesh tones look real (People have a very clear and precise definition of the color of flesh tones.). Newspapers and magazines require true color because the color of the advertised item must match the actual item. If this is not the case, then prospective customers will not buy the item they came to buy because it was not the color they came to buy. Conversely, prospective customers who did want the item in its actual color do not come to buy it because they believe that the item is the false color that was printed in the newspaper or magazine. A false color printed in a newspaper or magazine can almost eliminate the possibility of sales based on color.

Newspapers and magazines may also have a color integrity requirement that the color of the images be as true as the text that is illustrated by the images.

Thresholding

Changing the threshold can make things appear and disappear in an image. This is readily apparent in 1-bit black and white scanning. Modifying the filtering and color correction can similarly modify images during the color scanning process.

Raw Images

A raw image is said to be composed of exactly the data values collected while scanning. Because scanners have several thousand to several million-image sensors, and the image sensors vary in their light sensitivity, there is a correction or normalization of the sensors in the sensor array. This normalization process can introduce digital artifacts into the image.

Digital Artifacts

In the analog world, a common imaging artifact is the moiré pattern caused by a beat between the areal frequency of a pattern in the image and the areal frequency of a pattern in the photographic process or the reproduction process. The halftone screen often used in reproduction is a frequent contributor to this problem.

Techniques used to ameliorate this problem themselves contribute artifacts to the imaging process, whether the imaging process in analog or digital.

OK, now you have the digital image

Are you going to transform the color space to a standard color space before you save it permanently? Are you going to put a custom header on the file, to accommodate a file format standard?

Data Spreading

For some media, the files are mixed together and spread around the media. This is true for CDs and DVDs. This is done to avoid the effect of local areas such as fingerprints and scratches. The equivalent of this in magnetic disks is striping in RAID (Redundant Array of Inexpensive Disks). In RAID the data is spread out across all of the disks in the RAID array (set) to speed access. By placing parts of each (image) file on each of the disks, the images can be retrieved faster.

Extra data to correct errors, ECCs

To correct errors, extra data is mixed in with the recorded information. This extra information is called an ECC (Error Correcting Code). By doing the equivalent of cross-footing totals on an expense report, errors in recorded bits can be detected and even corrected. The parity based error correction used in RAID is a simple example of this.

At on time data was just written to tape or burned into optical discs. Then, manufacturers discovered they could greatly increase density (the amount of data recorded on each unit of media) if the resulting errors could be corrected. ECCs make this possible. However, as the density of errors goes up, the amount of data (ECC) that must be mixed into the (image file) data goes up. At some point, more data must be mixed in that the increase in storage that is achieved by the increase in density. This is the point of diminishing returns that determines the density of storage media.

Similarly, before transmission, image files are cut up, and error detecting, and sometimes error correcting codes are added to the pieces of the files, and then headers are added to the modified pieces of the files,

Unrecorded Compression of Uncompressed Images

Often uncompressed document images are compressed for transmission and storage. This compression is not noted by the information technology (IT) staff (the end user is not notified) because it is SOP (Standard Operating Procedure), and besides, the compression transformation is isomorphic, that is, it can be reversed perfectly. When used in imaging, isomorphic transformation is called lossless or nondestructive compression and non-isomorphic transformation is called lossy or destructive compression.

IT's SOP cannot use non-isomorphic transformations because IT does not know what IT is compressing. Conversely, IT does not care what IT is compressing because IT does use isomorphic transformation (compression). While data may not be compressed on magnetic disk storage, it is often compressed on magnetic tape backups.

If your uncompressed images are being compressed sub rosa, it is probably OK, but it is helpful to know about it.

Encryption, digital signatures, digital seals, and watermarks

To create a digital signature, under US law, all that is necessary is that both parties agree that the bits constitute a digital signature. Thus, any fax, a smiley face character, or an email wink [;)] can constitute a digital signature. There is not authenticity protection defined by the US electronic signature law.

The equivalent of an electronic seal can be created, and is built into most commercial electronic signature products. An electronic seal is created by adding up the ones and zeros of the document file as though they were binary numbers and crating a hashed checksum of the file. The hashing is a sophisticated way of adding the data so that things like reversed numbers such as '34' for '43' can be detected. This hashed number is then encrypted.

To test an image to see if it is the image that was stored and certified by the librarian or archivist, it is necessary to recreate the hashed checksum and to compare with the decrypted electronic seal placed on the file by the certifying librarian or archivist. If the new checksum does match the decrypted electronic seal, then a second (or even third) copy of the file must be retrieved from protected storage and the seal on the newly retrieved copy of the file must be tested.

Digital Watermarks

A digital watermark is a pattern (or digital artifact) that is added to an image so that at a later time it can be proven that the image was misappropriated. The management problem here is that applying a digital watermark is very easy and can be done at many places in the digitizing process, or even during storage. The digital watermarks can be applied to uncompressed images, or compressed images can be uncompressed and the watermark can be applied. Making sure that some 'global' policy decision to apply watermarks to 'all' 'digital assets' does not apply to the archival images requires constant vigilance.

Avoiding global watermarks, accidental watermarks, and other forms of image modification requires knowledge of the associated technologies.

Digital analogs on analog digital media

Our digital images are analogous to the original documents; they are digital analogs of the original documents. All media, and specifically our digital media, for both storage and data transmission, are analog, because everything physical is analog. No voltage can go from one level to another level without passing through every voltage level in-between. No two laser burned pits can be absolutely identical. No laser pit can be place in absolutely the right spot.

Therefore, we record and transmit our digital analog document images on analog digital media. While this is true by definition, because some groups of people have a strong desire to stay in the digital domain, and other people have an equally strong desire to stay in the analog domain, mixing the two domains of digital and analog in a sentence, as the two domains are indeed mixed in the real world, creates an epistemological conundrum for many.

Currently, Norsam is the only true Rosetta format

The *Rosetta Stone* is part of the collection of the British Museum, London, collection number EA 24. "[The Rosetta Stone] ends by saying that it is to be made known (in March, 196 BC, Before Christ) that all the men {people} of Egypt should magnify and honor [King] Ptolemy V, and that the text should be set up in hard stone, at multiple locations, in the three scripts which the Rosetta Stone still bears today (hieroglyphic, Demotic, and Greek)". Thus, the Rosetta Stone contains its own metadata, and a single document reproduced in three formats that are locked (sealed) together in stone, for the purpose of causing the message to last a long period of time; like a permanent virtual fascicle. The Rosetta stone even specified a spatially diverse pattern of storage, which increased its physical longevity. The following provides a Rosetta Stone history: [http://www.thebritishmuseum.ac.uk/egyptian/ea/gall/rosetta.html] The following provides an explanation of the Rosetta Stone text: [http://www.thebritishmuseum.ac.uk/egyptian/ea/further/rosettasay.html]

Norsam [http://www.Norsam.com] writes the digital image as a true raster image so that it can be read using a microscope. For color images, halftones are used with four separations. Norsam describes its document format as a Rosetta format because its decoding is self contained. Rater than using three languages, as did the original Rosetta Stone, Norsam media uses a digital analog image that can be read optically with a microscope to make it possible to decode the image format.

Norsam is technically capable of registering the ion milling machine pits in the same way that CD and DVD laser pits are registered for reading. This registration eliminates the Nyquist sampling penalty (Harry Nyquist, "Certain Topics in Telegraph Transmission Theory," *Trans.*, AIEEE, Vol. 47, April 1928, pp. 617-644.) [http://www.efunda.com/designstandards/sensors/methods/DSP_nyquist.cfm] which results in a two to one linear resolution reduction and four to one areal resolution reduction every time an image is converted from analog to digital format or digital to analog format. With registration (Areally synchronous reading), each written bit is read as a single bit, with a value of one or zero.

Paradigms

Different cultures are different paradigms. Language translation is a movement between paradigms. Each person, and each discipline has its own paradigm and language. This is very important when communicating across disciplines. In document and photographic imaging, librarians, archivists, records managers, photographers, digital imaging specialists, computer scientists, data processors, information technologists, data communications specialists, mathematicians, and material scientists (for the deterioration of media) are working together and communicating. Just the meaning of short term and permanent differs between groups. For archivists, short term is less than 100 years, and they are not interested. In IT, 2 year is permanent, because that is a normal rotation in the profession.

Time and Paradigms

The future is a paradigm. Communication with the future requires translation.

Until about 1500 AD, orienting a map meant to put the east at the top, hence the term 'orient'. All of the text on maps was written so that it was right-reading when the east was placed at the top of the user's view of the map. We have changed how we draw maps, but we have kept the term.

The paradigm of the material

The material imaged should have some effect on the system in which it is stored. For example, if maps are imaged, some relationship to mapping may help with the images. A scanned map may be stored as a layer of a GIS (Geographic Information System) system to help users orient themselves and link a historic map to current (and other historic) locations. The GIS system can also allow the user to see a rubber-sheeted map with the historic distortions removed so that the user can see the differences between perceptions contemporary to the system user and perceptions contemporary to the map creator and users. The rubber sheeting can be animated and even dynamic, responding to the user's input.

The maps can also be cataloged using the MARC 034 tag (MAchine Readable Cataloging) (034 Coded Cartographic Mathematical Data Field) that allows searching for documents geographically. [http://lcweb.loc.gov/marc/bibliographic/nlr/nlr0xx.html]

Processing down images

Internet images are much lower resolution that an archival image of a painting, both spatially, and in color gamut. Lower resolution images can be crated from higher resolution images through the mathematical transformation of image processing. Images should always s be captured at an archival quality resolution (or as archival as possible) and then processed down. It is essential to limit the number of times an object is digitally imaged, as the multiple images lead to questions as to which image is which and which is best or most true. If there are two images, the patron will always want to see the other image to make sure that they have seen the best image. Even a low quality Internet image may include image elements that were lost before a second, archival quality image was made. An example is a corner torn from a painting or document that appears in an earlier Internet quality image of the painting or document.

Head movement and eye focus in the preservation of large images

ER Mapper [http://www.ermapper.com] can easily serve uncompressed images of many gigapixels (such as the 50 gigapixels image of the City of Los Angeles [http://navigatela.lacity.org/samples/start]), and even terapixels, over a dialup Internet connection with smooth roaming and zooming from one pixel to the full 50 gigapixel image. The pixels can be 1 bit, 8 bits, 24 bits or even 64 bit or more multispectral images including infrared, ultraviolet, X-ray, and a wide variety of bands of the electromagnetic spectrum used in spatial remote sensing. ER Mapper uses dynamic progressive transmission of resolution to support smooth roaming and zooming to match the interest and point of focus of users. This parallels the user's spatially integrated visual system where the user moves their head and changes the focus of their eyes to take in a large image and integrate multiple views of the image gathered over time. It is this memory of previous dynamic views of an image, gathered in the normal course of moving through life, that help a user maintain their orientation with respect to a visual environment. This is linking an imaged real environment up with the tools and techniques used to deliver the experience of a VR (Virtual Reality Environment) [http://www.ust.ucla.edu/ustweb/ust.html].
Walking up to a painting, walking by a painting, and waking around a statue are valid (and different) ways to view an object and can be accommodated visually. They are not the same as taking a single static photograph, although they frequently can be modeled as a single, very high resolution photograph.

Feeling overly secure

It is possible that reliance on uncompressed images my cause a manager to overlook serious problems. For example, the magnetic disks containing the images may not be backed up. The backup may never have been tested. The backup may be done on the same tape every night wearing out the tape, or if the system fails in the middle of a backup, the previous backup (grandfather tape) has been ruined, so there is no backup. Given the value of the images (equal to at least the cost of processing the digital images), at least seven copies of the images should be made and sent to seven administratively and spatially diverse locations to ensure the survival of at least one copy of the images.

Also easily overlooked is a drift in QC (Quality Control). What was once an efficient and effective organization can be transformed by a change in staff or a change in the life of a staff member. Vendors may change their software, or the meaning of their software configuration settings. An end-to-end reasonableness check should be made at least every week.

New people in management above the imaging project, as well as new people on the staff of the project, or in the IT support staff my not have the same understanding of the project as the people they replaced. Reliance on uncompressed images does not remove the need to review the meaning of all aspects of the project with all levels of management and staff involved with the project at frequent intervals.

Conclusion

It is never possible to dismiss the technology that underlies a project. At best, understanding the technological foundation can be kept at bay, postponed, but not avoided forever. Over time, both the need, and the technical training will appear to make the requisite full academic analysis of a project's technology possible. This analysis is crucial to the integrity of the project.

In the meanwhile, the project should be frequently checked for 'reasonableness'. This is a requisite of good management, to be done regularly while muddling through.

Sidebar: The Open Model for Free Cataloging

There are standards for cataloging as well as for digitizing and often they are tied together under the rubric of high quality standards. Often photographs have been stored in drawers or shoeboxes for decades. Donors make gifts for digitizing. The curator of the photographs holds out for full cataloging to a very high standard before any photographs are scanned and made available over the Internet. There is no technical reason for not sequentially numbering the photographs, scanning the photographs and putting them on the Internet. The photographs would have the same metadata they had before scanning (their position in the drawer and possibly a drawer label). The public would have (open) access to the photographs and could refer to them by the their sequential number. (These sequential numbers could be refereed to as document identification, a simpler form of document indexing, which itself is a simpler form of cataloging.) The public's searches of the photographs and the resulting ad hoc lists of interesting images could be made available along with the photographs. This would provide a better (and free) finding aid than 'no finding aid' provided while the photographs were in the drawer or box. Holding out for a high standard of cataloging is holding the photographs hostage. Part of the process for decided what level of cataloging to do should probably include the intent of the original donor of the photographs, and the donor of the funding to put the photographs on the Internet.

None of the open model for free cataloging has any impact on doing any level of detailed cataloging, to any quality standard, at any point in the future. Both the open and free cataloging and the detailed cataloging done to a standard would both use the same sequential numbers used to control the image. Also, future catalogers could work from anywhere in the world because the collection being cataloged would be on the Internet.

Note to Readers

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When using the information in this article, please check the website www.ArchiveBuilders.com for updates. The version number of this article is just before the page number below. The website also has articles that provide more details on some of the terms and concepts in this article.

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Note to Editors

Paper 22049v002

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