

Color Issues to Consider in Pictorial Image Data Bases

Franziska S. Frey
Image Permanence Institute
Rochester Institute of Technology
Rochester, New York
Sabine Süsstrunk
Corbis Corp.
Bellevue, Washington

Abstract

For the last decade, commercial stock houses, libraries, museums, and universities have been experimenting with converting their photo and art archives into digital form. In the past few years, the number of archives and businesses that digitize content has increased exponentially. With recent improvements in scanning and storage technologies, both commercial and academic archives are finding they can cost-effectively capture and store enough image information in digital form for a wide range of uses. However, there are many technical aspects to digital imaging that present libraries and archives with very difficult and complex choices. There are as yet few codified technical standards for image capture, display, and output, all of which affect the image quality, the cost, and ultimately, the success or failure of the entire undertaking.

Introduction

Two basic types of image data base can be defined, each needing different approaches to creation, access, and usage of images. The first one will be built in environments where it is important that the digital image is a "replacement" of the original. Therefore, the digital data has to be captured and archived in such a manner that the original can be reconstructed. The other type of image data base is the one containing large numbers of images, e.g., an image data base for an insurance company, a government agency, or a historical society. In this case, the intent is to have a good quality image in the data base that is not necessarily colorimetrically true to the original. The information content of the image is important. It is agreed upon from the beginning that the digital file in the image data base will not be used to reconstruct the original photograph or scene.

Within these two basic categories there are a number of different reasons why a photographic collection will be digitized. In some cases, it will be for the easier access to the images; in other cases, it will be to preserve the original images through reduced handling.

The role of digital-image conversion in the preservation of photo collections goes considerably beyond the obvious one of reducing handling of originals. It involves a number of complex questions and assumptions about the collection materials, their value and purpose in the institution and in broader culture, and whether or not digital information can be considered to be "permanent" at all.[1]

Preservation or Access?

Most digital-image database projects are justified mainly on the basis of improved access, and so it is easy to avoid confronting preservation-related issues. After all, it is reasoned, replacement-quality images are too expensive, technology will change, and digital images are not permanent, so one might as well go forward and obtain the benefits of better access and not be too concerned about preservation at this stage.

In fact, there are several reasons why preservation is very much an issue for all digital-image database projects. The first is that institutions have finite resources. Any expense on the scale of a large digital-image database project will claim a sizable share of limited budgets, money that could be spent on other venues, including "conventional" preservation in the form of improved enclosures, storage conditions, photographic duplication, preventive conservation, etc. If those two options are presented openly as competitive interests, the outcome might still be to invest in the digital-image database. However, the choice is often not presented in these either/or terms. Such an important policy choice ought to be debated and explored in depth.

The second reason that digital-image database projects impact preservation is that some collection managers already want to use digital files as "preservation masters," i.e., as replacement images, dispensing with the original photographs altogether. As technology improves and costs for high-quality imaging decrease, more and more collection managers will raise the question of what is the best form in

which to retain images.

Collection purposes and contents differ widely. For some, an all-digital collection is out of the question; for others, it represents a welcome change that adds value to the collection. A university slide collection which consists of hundreds of thousands of fading color images, none of which are terribly valuable as artifacts, could well be imagined as existing exclusively in the form of high-quality digital images. They could then be digitally reconstructed and output in slide or print form upon demand.[2] On the other hand, a very valuable collection of 19th-century photographs might be digitized, but definitely will not be discarded. Between these extremes are many other situations where the balance between available reformatting options—none, conventional, or digital—must be struck according to the needs of each collection. Nevertheless, even the best digital copy is no substitute for the original.

Producing the Archive

Digitizing photographs for high-quality applications puts high demands on the imaging system and the human operators involved in the task. Pictures are very dense with information, requiring scanning procedures that capture all the information inherent in an image.[3] Before starting the digitization process, it is necessary to understand the purposes for digitization and the nature of the various photographic originals. Only with this knowledge is it possible to decide on the parameters for the digitization process. Despite all the possibilities for manipulating digital images, image quality choices made when files are first created have the same "finality" that they have in conventional photography.

As the digitization of large image collections is not likely to be attempted more than once a generation due to cost, educated decisions about the scanning and archiving processes are imperative. The term "archive" implies that all digitized images are not only optimized for current work flows and imaging devices, but will continue to be usable on future, as yet unknown delivery and output systems. Any production decisions based on currently available technology have to be made with consideration to future image uses and markets.

When targeting a wide user audience, computer platforms, color management systems, calibration procedures, color space conversions, or output devices cannot be mandated. Almost every institution has a different set-up for access of the images. In addition, at the time of creation, it is usually not known what type of hardware and software are or will be available for access. Furthermore, one has to consider that the users of image data bases are usually not very educated in matters of digital imaging. However, they still are visually sophisticated and are used to the quality they can get from conventional photographic images.

Nevertheless, decisions have to be made about spatial resolution, tone reproduction, and the color space before images are digitized. In most cases, it will not be the goal to reproduce the physical properties of the original, but to reproduce its appearance under certain viewing conditions. This leads to the most important decision, namely, choosing the pictorial rendering intent. Assumptions about the rendering device, color reproduction, and tone reproduction have to be made.[4]

All original artwork cannot be treated equally. Different digitizing approaches have to be established according to the type, condition, and perceived values of the originals. Current scanning technology deals reasonably well with current film emulsions and formats, provided that they have been exposed and processed correctly. However, many collections of high artistic and/or historical value were captured on photographic material that not only isn't available anymore, but also has deteriorated to some degree.

There are several rendering intents that apply while digitizing original artwork.

The photographic image is rendered
In this case, the images are scanned with the intent to match the appearance of the original photographic image. The quality of the digital image can be evaluated by visually comparing the original to a reproduction on a calibrated display device with a similar contrast range. The assumption is made that the original photograph has been exposed and processed perfectly.

The photographer's intent is rendered
There are many photographs with high content value that were not exposed or processed correctly. They can be color casted, can be over- or underexposed, or can have the wrong contrast. In these cases, the photographer's intent, not the original photograph, needs to be rendered to achieve a pleasing reproduction. The scanner operator has to make decisions about tone and color reproduction by viewing the digitized image on a calibrated output device. This manual intervention determines the quality of the reproduction. Quality becomes highly dependent on the skill and experience of the operator.

The original appearance of the photograph is rendered
Often, older color photographs are faded and no longer have sufficient visual color information to make accurate judgments about the original. Reconstructing these photographs requires special scanning and processing techniques.

The original scene is rendered
When photographic reproductions of original art work are scanned, the original scene has to be rendered and the film characteristics have to be subtracted.

With current scanning and color management technology, the first case can be automated if it is possible to match the dynamic range of the output to the original. All other cases need manual intervention, either in the initial scanning process or in subsequent image processing. Manual intervention is time-consuming and requires highly skilled operators. As a result, production costs remain high for high-quality, visually pleasing digital images. Better automated image processing tools need to be developed to analyze raw sensor data and translate them to pictorially pleasing digital reproductions on defined output devices.

It has been agreed upon in the preservation community that various files are being stored for every image to fulfill all requirements, mainly preservation and access. First, a so-called archive file containing more than 8 bits per channel has to be stored. It should not be treated for any specific output and left uncompressed or lossless compressed. From this archive file various access files can be produced as needed. They are based on choosing a certain usage, tone reproduction, and color reproduction and imply a pictorial interpretation.

Choosing a Color Space

The most important attribute of a color space in an archival environment is that it is well defined. Scanning for an image archive is different than scanning for print. When an image is scanned for archival purposes, the future use of the image is not known, nor are the possibilities of the technology that will be available in a few years from now. Will color profiles still be maintained or even used? An 8-bit-per-color scanning device output might be sufficient for visual representation on today's output devices, but it might not capture all the tonal subtleties of the original.[5] Operator judgments made in terms of color and contrast cannot be reversed in a 24-bit RGB color system. Any output mapping different from the archived images' color space and gamma must be considered. On the other hand, saving "raw" scanner data of 12 or 16 bits per color with no tonal mapping can create problems for future output if the scanner characteristics are not well known and profiled.

As an option, a transformation can be associated with the raw scanner data to define the pictorial intent that was chosen at the time of capture. However, there is currently no software available that allows one to define the rendering intent of the image in the scanner "profile." Rendering intent is usually set during output mapping by the user. There is software available that allows the user to modify the scanner profile for individual images, and therefore to create "image profiles." That process is as work-intensive as regular image editing with the scanner or image processing software. It also assumes that the input profiles can and will be read by the operating system and application the image is used in, not just by current but also by future systems.

Archiving for each image both a raw sensor data file in high bit-depth and a calibrated RGB 24-bit file at high resolution is not an option for a lot of institutions, considering the number of digital images an archive can contain.

Because the output is not known at the time of archiving, it is best to stay as close to the source as possible, meaning the scanning device. In addition, the scanning devices should be very well characterized spectrally, and the information should be readily available from the manufacturers.

New Tools and Developments

Optimally, it would be good to archive 10-bit- to 12-bit-per-channel standardized RGB color space. Having to communicate only one color space (or profile) to the user's CMS would facilitate optimal rendering of all images across all platforms and devices. If the color space is standardized and universally recognized, it would eliminate the need to embed a profile into each image file. Embedding profiles into each image file creates too much of a data overhead when delivering preview files over the Internet. There would also be only one "profile" that needs to be up-dated when color management specifications evolve in the future. The sRGB color space proposed by Hewlett-Packard and Microsoft (or an extended version allowing the accommodation of an unlimited gamut and out-of-gamut colors) is a viable color space choice.[6,7] It is sufficiently large to accommodate most photographic reproduction intents.

Since the first future access to any file will most probably be some kind of a monitor using an RGB color space, choosing to keep the access data in the currently defined sRGB is a valid solution. Images in sRGB will display reasonably well even on uncalibrated monitors. Higher bit-depth per channel would make it possible to communicate the predefined rendering intent for each image, while leaving enough bit-depth for users to modify the image and to map to the intended output device. It would also give a safety factor to the archive file if future high-quality output devices require extensive mapping to as yet unknown color gamut and gamma. Also, colors that currently fall out of gamut could still be accounted for by leaving enough room on both ends of the values scale when defining black and white values. A standard way to deal with higher than 8-bit-per-channel image data across platforms and application has to be developed.

Standardized approaches and data forms are required for interchangeability of the data. To quote M. Ester:[8]

> If I see shortcomings in what we are doing in documenting images, they are traceable to the lack of standards in this area. We have responded to a practical need in our work, and have settled on the information we believe is important to record about production and the resulting image resource. These recording procedures have become stable over time, but the data

would become even more valuable if there was broad community consensus on a preferred framework. Compatibility of image data from multiple sources and the potential to develop software around access to a common framework would be some of the advantages.

Conclusion

It has been encouraging to see the development of high-quality tools destined for digital image applications other than pre-press. However, there is still a need for more integrated systems to truly achieve a seamless, transparent work flow of images across platforms, devices, and, ultimately, time. No one imaging technology manufacturer will ever be able to dictate to the end-user which imaging system to use. Additional standards will have to be developed to facilitate communication between imaging systems and to enable high-quality digital imaging for image data base applications.[9] Without addressing all these issues, many institutions and corporations now starting their high-quality scanning projects will be disappointed sooner or later, because the decisions made were not suitable for the technology of the near and far future.

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