Digital Art in Scholarly Periodical Publishing

Technical and Practical Information

Abstract

Digital art technologies are transforming the way in which medical illustrations are created, processed for publication, and distributed to periodical readers. Although publisher workflows are evolving in response to this new reality, problems with digital art files are still common and contribute to increased production expense, delays, and reduced quality of published images. To address these issues effectively, publishers will need to educate their internal production staff, editorial offices, and authors regarding specifications for digital art submission and issues that may affect production. This paper is designed to assist in this process by presenting a publisher-specific view of digital art, including the following: a brief history of medical illustration and its transition to the digital age; an overview of technical issues and guidelines for digital art submission; a discussion of digital art tools and workflows; and some thoughts on the future of digital art and its importance in the coming world of paperless publishing.

An Overview of Digital Art

A brief history of medical illustration

Medical illustration—broadly defined as any visual portrayal of the human body designed to record, teach, or practice medicine—has been around since prehistoric times. Primitive man made images of the human body in stone or on the walls of caves. Spanish caves were found to contain engravings of a pregnant woman with a fetus inside the womb. Even as early as 1700 BC, the ancient Egyptians had produced a surgical textbook describing the treatment of battle wounds. Though it was not illustrated, the Egyptians did create medically oriented illustrations, mostly sculptured reliefs, in tombs. Other ancient societies in Babylon, China, and India likewise created medical illustrations on a variety of surfaces, including stone, bamboo, silk, and metal.

While certainly remarkable, these illustrations were made with very little knowledge of human anatomy or biology, and as a result were not very realistic. Until such knowledge could be gained through scientific inquiry, medical illustrations would remain relatively simplistic and inaccurate.

Hippocrates and Aristotle were likely among the first individuals to create illustrations based on scientific investigation, probably from dissections of animals. In the fourth century BC, Herophilus of Alexandria was able to dissect some human corpses, but his observations were lost in a fire. Galen, a Greek physician of the second century AD, believed that dissection was essential to medical understanding but was hampered by cultural taboos that forbade human dissection. Although Galen learned some anatomy by tending to wounded gladiators, most of his writings were based on animal dissection and were erroneous when applied to humans.

Many of Galen's misconceptions went unchallenged throughout the Middle Ages, and anatomical knowledge advanced very little during that time. Around the 15th century, however, anatomical dissection became more widely practiced and accepted, in large part because renaissance artists thought that such study would lead to more realistic depictions of the human form in paintings. Leonardo da Vinci was probably the first artist to recognize the scientific and medical applications of such anatomical studies, but his voluminous body of remarkable illustrations was not widely distributed until several hundred years after his death. Instead it was Andreas Vesalius, author of the landmark *De Humanis Corporis Fabrica: Librum Septum* (Seven Books on the Structure of the Human Body), who would revolutionize the worlds of anatomy and medical illustration in 1543. Vesalius, a Belgian surgeon studying in Padua, employed a number of highly skilled artists to make detailed anatomical drawings based on his dissections. The drawings were reproduced onto woodcut blocks, which were then used to print the illustrations as figures accompanying Vesalius' text. The resulting treatise was significant in that it offered evidence that once and for all discredited the flawed theories of Galen. The work also showed the incomparable power of illustration for displaying anatomical details with precision. Whereas most previous texts relied on written descriptions alone to describe the intricacies of human anatomy, an anatomy text without illustrations was henceforth considered unthinkable.

The ensuing centuries brought many new illustrated medical texts, and as technology advanced, so too did the techniques and media used to create and disseminate illustrations. Early illustrators relied on pencil and paintbrush to record important anatomical details, but the range of tools expanded over time to include engraving, wax modeling, photography, cinematography, as well as radiology and other medical imaging techniques. Today, computerized digital imagery can be rendered in both static and dynamic two- and three-dimensional representations that can be transmitted electronically across the world in a matter of seconds.

The use of art as illustrations in scholarly periodicals

Although the use of illustrations has been institutionalized in certain areas of scholarly publishing, such as in anatomical texts and atlases, the practice has been less common in other areas, notably in scientific periodicals. There are probably many elements that have contributed to this, including the fact that periodical authors typically want to publish and disseminate their data as rapidly as possible, and periodical editors typically want to publish authors' data in as few pages as possible. With such a premium placed on speed and space, there is less incentive to provide enhancements (e.g., illustrations) that are not absolutely critical to explaining the research. In addition, the cost of creating and publishing high-quality illustrations may be easier to justify when the end-product is going to be a stand-alone text reference used for teaching, as opposed to a single short journal article that is likely to have a brief "shelf-life."

Despite this text-heavy tradition, scholarly periodicals today are becoming much more visually oriented. One reason is that new technologies have made it much easier for authors to capture and submit images to enhance their articles. Just a few short decades ago it was relatively costly, slow, and difficult—if not impossible—to obtain and submit certain kinds of images for publication. But now computers, digital cameras, and sophisticated software have made it fairly cheap and simple to produce a wide range of hitherto hard-to-publish illustrations—everything from photomicrographs, through astrophotographs, to sophisticated medical imaging readouts, and more.

And perhaps even before these technological barriers began to fall, it appears that periodical authors and publishers are also rediscovering the age-old wisdom of Vesalius and, before him, Confucius. Vesalius was among the first to demonstrate the value of illustration in medical education, but in truth he was merely confirming the ancient axiom often attributed to Confucius: "A picture is worth a thousand words." One modern medical illustrator says that in today's hectic world of science, illustrations are becoming like "medical billboards"—images to be scanned quickly and whose meaning should be grasped in an instant, almost unconsciously, so that the reader can comprehend and move on.

To understand just how this trend is influencing periodical publishers in the current market, it is instructive to look at the *New England Journal of Medicine*. The first issue of the *Journal*, published in 1812, featured mostly text, a few tables, but no drawings or photographs. Now, however, the *Journal* has evolved to a point where it creates its own illustrations, via an in-house art group, to accompany submitted articles. This practice was initiated to enhance reader comprehension of the written material, thereby increasing value to readers. Now it also allows for the illustrations to become part of an illustration bank for future re-use.

Computers and art creation—the digital art file comes of age

Before computer technology became powerful and affordable enough for widespread use, medical art was created using a variety of non-digital techniques and processes, including traditional illustration methods (pen and ink, watercolor, etc.), photography, engraving, and a number of others. Images produced with these methods were prepared for publication using a labor-intensive process that involved photographing the hard copy and then merging this negative with the films that would be used for final production on the printing press. (A more detailed description of this process is provided on pages 7 and 8, under the Line Art and Halftones headings.)

But as digital technology began to infiltrate and influence the fields of science, art, and publishing, it began to produce fundamental changes in the methods used for art production. In science this change was seen in the development of powerful new laboratory and clinical research equipment—everything from electron microscopes, to medical imaging devices, to endoscopic technology—that were capable of capturing and outputting image data as a computer file. The art world was similarly transformed by the development of computer drawing and editing programs, such as Adobe Illustrator and Photoshop, which brought potent new tools to the creative process and made manipulation of images almost as easy as clicking a mouse. And finally, the advent of computerized scanners radically reduced the amount of time and labor needed to capture hard copy images and prepare them for printing.

Digital Art From a Publisher's Perspective

Paradigms shift, problems arise

Digital art came on the radar screen for most publishers in the mid 1990s as scientists began to employ digital processes in generating their artwork for research papers. Researchers were using the following digital approaches:

- Using digital laboratory instruments whose sole output was a digital file.
- Scanning photographs to manipulate the images and placing lettering on them for final presentations.
- Using ancillary/available office equipment to output images.

This transition introduced several challenges to the publishing cycle. For one, the materials sent to printers for scanning were no longer continuous tone photographs but instead came from output devices like laser printers, ink jet printers, and dye sublimation devices. In many instances these devices produced fairly low-resolution images or placed a visible pattern in the image which when scanned created a moiré effect in the final printed version. The only solution for the moirés was to throw the image slightly out of focus and obscure the pattern. Additionally, many of the digital devices lived in the red, green, and blue (RGB) color space. This enabled the use of fabulous fluorescent colors that were scientifically useful, but which were far outside the gamut of colors that could be reproduced on offset presses with the cyan, magenta, yellow and black (CMYK) inks. As these problems became more and more commonplace, printers and publishers started to look for solutions.

Going to the source: capturing original files from authors

The obvious answer to this dilemma was to obtain the digital file directly from the author and avoid the intermediary output that was creating the problem with scanning. This seemed an elegant solution, as it eliminated the redundant step of outputting an image from a digital file, only to create a second-generation digital file through scanning. With a first-generation digital file in hand, the publisher could in theory expect a wide range of benefits, including:

- Improved image quality.
- More rapid publication due to elimination of redundant scanning.
- Potential for future production cost savings due to reduced labor.
- Increased author satisfaction.
- Easier transition to online distribution.

By soliciting original source files, publishers did in some cases realize these expected benefits. But in other cases these benefits were counterbalanced by a set of new and different problems. For instance, although the scan quality issues were now largely circumvented, a new wrinkle emerged in that the author-supplied files would arrive in a bewildering array of formats, many of which were incompatible with the compositor's software. Another, perhaps more frequent problem, had to do with resolution of the images supplied: Many authors did not realize that images prepared for display on a website are usually of much too low a resolution to reproduce well on the printed page. (See the Image Resolution heading on page 10 for a detailed discussion of this occurrence.) These and other problems led to a high rate of rejection for digital art files, more late stage corrections (with corresponding expense), production delays, and a general increase in frustration for authors, publishers, and printers alike.

Introducing new workflows

Through this sometimes painful transition and discovery process another profound workflow and communication change emerged. The previous workflow for art—which involved publication-quality hardcopy being submitted and then scanned by printers—kept all communication with authors between the author and the publisher, while all the technical knowledge related to scanning remained at the printer. Now with digital files the protocol for communication included the composition house or printer having to interact directly with the author to resolve technical issues, and the knowledge about scanning for offset printing standards had to be conveyed from the printer to the publisher and to the author as well. This would have been difficult enough with a small pool of repeat authors, but journals receive submissions from a large and ever-changing base of authors from all over the world.

To a large extent periodical publishers are still dealing with these workflow transition issues, and they are not likely to go away of their own accord. To take full advantage of the new online peer review systems being deployed, authors must submit *all* art as digital files, so that manuscripts can be distributed online to reviewers in Portable Document Format (PDF). This development sets the stage for vastly higher quantities of digital art coming through the production system.

Though the challenges are daunting, the benefits of obtaining source files for digital art are still attainable and may in fact be necessary to remain competitive in today's scholarly publishing arena. Attention to the following issues should help increase the rate of acceptable file submission, while also minimizing the confusion and expense of dealing with files that need work.

Internal issues

The new digital art workflow will not be effective unless a high percentage of authors submit their files in a format that is acceptable for publication. However, publishers cannot simply will their authors to follow new guidelines. To set the stage for increased file acceptability, publishers must take a careful look at their own operations and make appropriate changes. For details on how to implement new workflows in a publishing environment, it may be helpful to review previous Sheridan white papers that address the subject in-depth: *Implementing Information Technology Systems*; *Improving Journal Quality with Process Improvement Methods*; and *Digital Workflow: Managing the Process Electronically*. (See the bibliography for references.) Following are considerations that are particularly pertinent to digital art workflow:

Develop clear and easy-to-follow guidelines regarding submission specifications and procedures for digital files.

Educate production editors regarding digital art issues, so that they can bring this knowledge to bear when dealing with authors.

Prepare editorial offices for workflow changes and soliciting help in dealing with authors.

Implementing workflow change involves a certain amount of self-evaluation, and one natural outgrowth of this process when it comes to digital art is that publishers will need to review their relationship with their service providers and decide the responsibilities of each party with regard to digital art issues. They will need to consider questions such as:

- At what point, if any, will the printer have direct contact with authors regarding technical issues pertaining to digital art files?
- What level of training and responsibility for digital art will be required of the journal's managing editors and the publisher's in-house production editors?

This last question is especially significant considering that, for many publishers, turnover and training costs with these positions already may have been high before digital art appeared on the radar screen. Intensive training in this highly technical area may be seen to exacerbate the situation.

Authors: the key to success

Once the publisher has its own house in order, the challenge remains to implement the new workflow at the author level. This transition can be tricky for a variety of reasons, not the least of which is that publishers have much less influence over their authors than they do their internal staff, production and printing houses, and editorial offices. In addition, the author pool for any given journal is likely to be very diverse and include people with a wide range of computer skill levels, different computer hardware and software, and varying willingness to cooperate. To generalize a bit, researchers will probably be more tech-savvy than their clinical counterparts, and thus more likely to embrace digital innovations. Likewise, contributors to a prestigious research journal with a high manuscript rejection rate may be more disposed to comply with new guidelines than the small-journal author who submits work as a personal favor to the editor. Having established that there are no guarantees, publishers in all environments can increase their chances of successful implementation by:

Giving plenty of advance warning regarding new submission specifications. Changes can be underscored through editorial communications in the journal, revised instructions to authors, and links from the website to new guidelines.

Providing digital art support, both to internal staff and external contributors, via a dedicated digital art help desk and related online help area. Instructions for obtaining help should be well publicized in all communications.

Identifying unacceptable files at the earliest stage possible. Late-stage repairs entail much more energy and expense on the part of all parties, including authors.

In preparing to roll out these changes to the author community, some critical questions will have to be addressed and related policies developed. For example, publishers will have to decide who will be responsible for fixing files that are not acceptable for publication. Certain problems simply cannot be fixed by the publisher or printer and will require resubmission. But what about files that can be repaired to meet specifications? Will the publisher accept the expense of making the needed changes or will the files be returned to the author (who may not have the time, tools, or expertise to do the work)?

It is crucial to maintain a flexible, long-term perspective on such questions. Even with excellent communication and preparation, it is unreasonable to expect authors to embrace a new workflow overnight. With a reasonable adjustment period, however, and authors become more proficient with computers and digital art software tools, the digital model should take hold and lead to more efficient, higher-quality production of periodical illustrations.

Technical Aspects of Digital Art

Having outlined the history of medical illustration and the digital art issues facing publishers today, it is now time to take a closer look at the technical aspects of preparing digital art for publication. Included are some basic definitions of key terms, a discussion of issues that may affect digital art reproduction, and guidelines for digital art submission to scientific periodicals.

What are digital images?

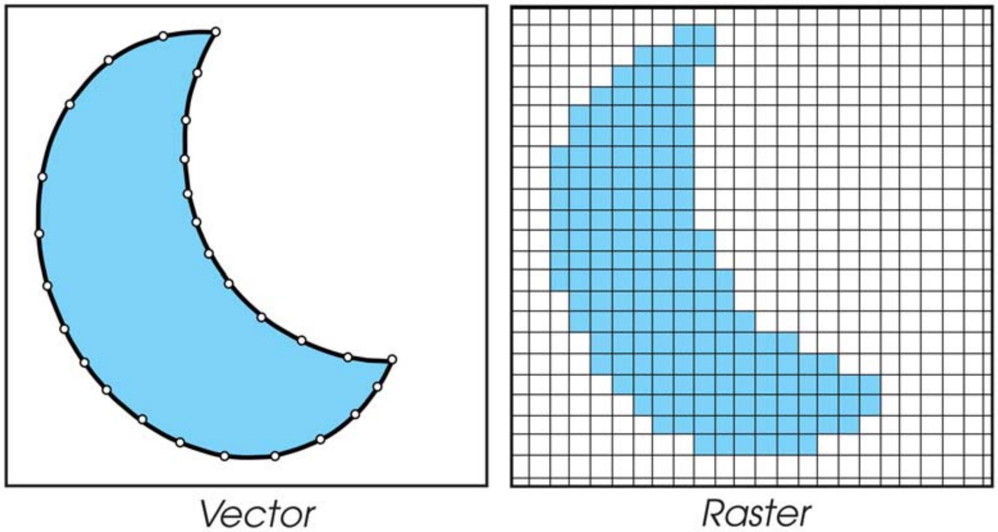
Line Art

Line art is an original piece of art that consists of strictly black and white with no shades of gray. Some people refer to line art images as monochromes. In the years before digital production became a reality, printing or lithographic reproduction of this type of art was performed by making a camera "line shot." This consisted of loading the original art into the copy board of the large format camera, setting the corresponding lens and copy board positions for enlargement or reduction, adjusting the lens aperture, cutting and loading the film on the camera back, and exposing at a preselected time. After processing, the result would be a negative that would have to be physically stripped in place on imposed film flats. Today, line art is more quickly captured by scanners or it is created in software applications, and thus new rules are being crafted in the industry to ensure that the quality of the image is maintained and that the image will be compatible across platforms.

Digital files of line art are comprised of a single bit (binary digit) of data and are sometimes referred to as "1-bit" images. Since each bit can only be represented as either a zero or a one, pixels (picture elements) within a monochrome image can exist in only one of two states: black or white. These images are most often produced by digital image capture devices such as digital scanners or by pixel editing programs such as Adobe Photoshop.

Rasters and Vectors

Images produced by a scanner, digital camera or pixel-editing program are known as raster images and are often differentiated from another type of file known as a vector file, which is described below. Raster images are composed of a matrix (grid) or bitmap of pixels. Pixels are squares or rectangles described as black, white, gray or color, but line art images are composed of only black and white. Monochrome images generally require



A comparison of image types: vector vs. raster

Image type	Source	Characteristics	Resolution	File format
Vector	drawing/illustr. application	mathematically-defined	independent	eps
Raster	scan/pixel editing app.	pixel-based	dependent	tiff/eps

higher resolution (more pixels per inch) than tone images in order to prevent aliasing (stair-stepped or jagged appearance) of diagonal lines. So-called “jaggies” are more problematic in line art than in other types of illustrations because there is an abrupt and sharp edge between the black lines of the image and the surrounding white space. By contrast, images that contain shades of gray are usually not so sharply delineated at the edges, and therefore appear smoother and less pixilated at lower resolutions. Typical resolution standards for rendering a high-quality monochrome would be 900 to 1200 DPI/PPI (dots or pixels per inch). Raster images typically are saved as TIFF (tagged-image file format) files, but can be saved as EPS (encapsulated PostScript) files as well.

While it is common for authors to scan their line art and submit the resulting raster file, line art can also be drawn within a software application and then saved in a format known as a vector file. As opposed to raster graphics, which are usually captured by a scanner or camera and represented as pixels on a grid, vector graphics typically are generated using drawing or illustration programs such as Adobe Illustrator or Macromedia Freehand and are composed of mathematically-defined geometric shapes—lines, objects and fills. The major advantage of vector graphics is that they can be easily modified within the creating application and generally are not affected detrimentally by scaling (enlarging or reducing their size). Whereas a scanned raster image will begin to lose detail quality if it is enlarged beyond a certain point, vector images, which are defined mathematically, will retain the quality of the image when enlarged or reduced in size.

While it may sound as though vector files are the more useful of the two formats, this is really not the case. Vectors are incapable of representing the subtle differences of tone found in most photographs, so this file format is unsuitable for a very large number of illustrations. Generally speaking, vector files work well to represent typefaces, charts and graphs, drawings, and other graphics that must have sharp lines when scaled to various sizes. Raster images are the best choice for creating subtle gradations of shades and color, such as in a photograph or in a computer-generated painting. Vector graphics typically are saved in EPS format.

Halftones

A halftone is an image having values of gray, from highlights through shadows, such as in a photographic print. Before computers these continuous-tone images were captured for production using the same lithographic camera method as was used for line art, the only difference being that the image was shot through a glass or film "screen" placed on top of the film. This screen would render a negative comprised of various-sized dots that would visually appear as gray values. In modern parlance we most often use the term “grayscale” to refer to a photograph or an image containing tones. “Grayscale" is sometimes used interchangeably with “halftone.”

Digital files of grayscale images can be captured by scanners and digital cameras, or drawn in software applications and then saved as vector files. Since grayscale images must represent more than the simple black and white of monochromes, digital files of grayscale images are correspondingly more complex. Specifically, whereas a monochrome pixel represents either black or white, grayscale pixels must represent a variety of shades along the scale from black to white. Standards in the printing industry are for grayscale images to be at an 8-bit depth as opposed to 1-bit for line art. In practical terms, the 8-bit file is richer than a 1-bit, as it can render up to 256 different levels of gray. This allows the image to present a relatively smooth transition from one tone to the next. Grayscale images that are composed of less than 8 bits tend to show very abrupt changes or "banding" through a toned area.

From a technical standpoint, the scanning resolution required for grayscale images depends on the resolution of the final output. But for practical purposes, a resolution of 300 DPI is sufficient to achieve high-quality reproduction in most print applications.

Combination Halftones

A combination halftone is pretty much what it sounds like, a combination of line art and a grayscale image. If you had a photograph that needed to be placed within a black and white chart or graph, the final digital file could not be saved as a 1-bit file, as it would not be capable of capturing gray tones. You might assume that such an image should therefore be scanned at 300 DPI, as per the specifications just described for grayscale images. However, a resolution of 300 DPI would be insufficient for high-quality reproduction of the line art chart or graph, which at such low resolution would probably appear aliased.

Instead, these “combo” files are best-created and saved at between 500 and 900 DPI in resolution. While a resolution of 900 DPI would likely assure no aliasing of the line art, one must also consider the fact that such high-resolution scanning of a grayscale image will result in an exceedingly large image file. For example, an 8”x10” grayscale image scanned at 300 DPI will result in an image file approximately 6.8 megabytes in size. By comparison, a grayscale scanned at 900 DPI would come in at a whopping 61.8 megabytes. Files larger than a few megabytes present problems because, in addition to using up significant hard drive memory for storage, they also take more time and /or bandwidth to transfer electronically and may require significant download time when viewing on a computer monitor.

Technical issues affecting production of digital images

Image Resolution

Probably the most frequent reason that author-submitted digital art is unusable is that it does not have sufficient resolution to allow for high-quality print reproduction. This usually comes as a surprise to the author, who will report that the image looked perfect on his computer monitor, printed out fine on an inkjet printer, and is even posted on a website somewhere.

Resolution Terminology
Resolution in its general sense refers to the richness of detail or clarity of an image. Technically speaking, resolution can be expressed in a number of ways, including by counting the number of samples taken per inch (for digital scanners), pixels rendered per inch (for display monitors) or the number of dots printed per inch (for offset presses or other print outputs). Image techies can banter back and forth about the nuances involved with each of these terms, but for most of us the term dots per inch or DPI can be used to refer to the resolution of a scanned digital file, its display output on a monitor, or its print output. Following the industry practice, in this paper we typically use the term DPI to refer to the resolution of any image, regardless of the medium in which it is stored or displayed. For those interested in the specifics, there are numerous web tutorials available on the topic; a good one is available from about.com at http://desktoppub.about.com/library/weekly/aa101800a.htm.

Without getting into too much detail regarding technical considerations, the reason for this is that on a computer monitor, or even on many desktop printers, a resolution of 72 DPI is sufficient to make graphics look clear. However, an offset press outputs at a much higher level of detail than a monitor or inkjet printer can produce. Thus, the same file that looks good when displayed on one of these lower-resolution devices would look fuzzy, grainy, or jagged when printed in a journal. As discussed earlier, black and white line art must be scanned at the highest resolution (900 – 1200 DPI) in order to reproduce well on the printed page.

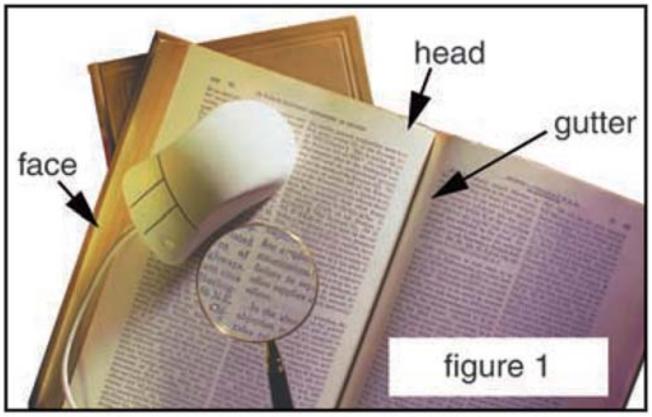
Color

RGB vs. CMYK
Computer monitors emit color as red, green, and blue light. Although all colors of the visible spectrum can be produced by merging red, green and blue light, monitors are capable of displaying only a limited gamut of the visible spectrum.

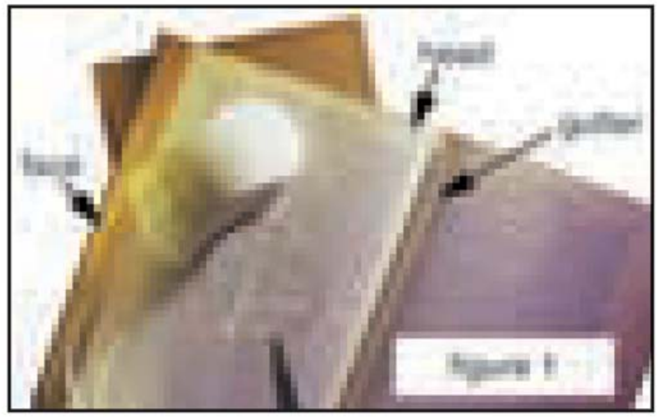
Whereas monitors emit light, inked paper absorbs or reflects specific wavelengths of light to produce the colors that are visible to the eye. Cyan, magenta and yellow pigments serve as filters, subtracting varying degrees of red, green and blue from white light to produce a selective gamut of spectral colors. Like monitors, printing inks also produce a color gamut that is only a subset of the visible spectrum, although the range is not the same for both. Because monitors and printed inks display a different range of colors, the same art file that looks a certain way when shown on a computer monitor may look different when printed on a press. Also, because printing processes such as offset lithography use CMYK inks, digital art must be created as CMYK color or must be converted from RGB color to enable use.

Spot colors
Digital art that is comprised of spot colors (any colors that are not CMYK process colors)

effect of insufficient resolution for combination tone image (simulated)



high resolution



low resolution

generally requires conversion to the CMYK color space. Because color gamuts for spot color libraries, such as those associated with the PANTONE Matching System (PMS), usually extend beyond the ranges of the CMYK color gamut, some spot colors may not be rendered effectively using CMYK process inks.

Half-toning

In offset lithography, the density of CMYK inks cannot be varied in continuous fashion across an image, so a range is produced by means of halftoning. In halftoning, translucent CMYK ink dots of variable size are printed in overlapping grids. Grids are placed at different angles for each of the ink colors. Smaller halftone dots absorb less light, and thus, as a result of an increase in the amount of reflected light, apparent density is decreased and the object appears lighter.

Total Area Coverage

Because process color ink pigments are imperfect, pure black cannot be achieved by overprinting CMY inks. Consequently, black (K) ink is introduced in addition to, or in substitution for, CMY inks. The combined value of all CMYK inks for a particular area or object cannot exceed a specified amount, however, or ink may not transfer effectively and printed sheets may not dry properly. This specified amount, referred to as Total Area Coverage (TAC), typically is limited to 300% for offset lithography using coated paper. Compensation for TAC limitation is accomplished during the separation process, by which RGB color is converted to CMYK, by means of UCR (undercolor removal) or GCR (gray component replacement).

Proofing

SWOP Guidelines

For some of the same reasons that printed digital art may not match the same art viewed on a color computer monitor (e.g., the color gamuts are not the same), digital art printed to a desktop inkjet printer or another printing device may not match when compared to the same art printed using CMYK lithographic processes. To ensure that color gamuts are comparable, proofs should be produced in accordance with SWOP (Specifications Web Offset Publications) guidelines. Note that Gracol has adopted a similar set of guidelines, for sheetfed publications. In the case of contract color proofing (i.e., proofs that serve as a contract between the provider and the printer that an acceptable reproduction can be achieved), since the proof is expected to serve as a predictor of CMYK offset lithographic press output, the proofing system used must have been SWOP-certified, and proofs must have been produced in accordance with the SWOP ADS (Application Data Sheet). Additionally, proofs should include a SWOP proofing bar or GATF proof comparitor so that the conditions of the proof can be measured and verified.

Color management
Because proofing devices can vary significantly relative to color reproduction due to toner/pigment and paper/substrate differences, and because significant variations exist for monitor to proof, and for proof to press, color management techniques have been developed. In order to reconcile the differences between input and output device color gamuts, chosen devices must be capable of consistency. After having been qualified as reliable, each device is calibrated to the defined standard. Devices are subsequently characterized by comparing device output against a standard color gamut, the outcome of which is an ICC (International Color Consortium) profile or tag that serves as a color space description for the device. Conversion is achieved when variations between the input device profile and the output device profile are reconciled by means of a Color Management Module (CMM). Currently, assignment of ICC profiles to digital art image files is not recommended, in part because profiles created using different color management systems may not convert satisfactorily or with consistency.

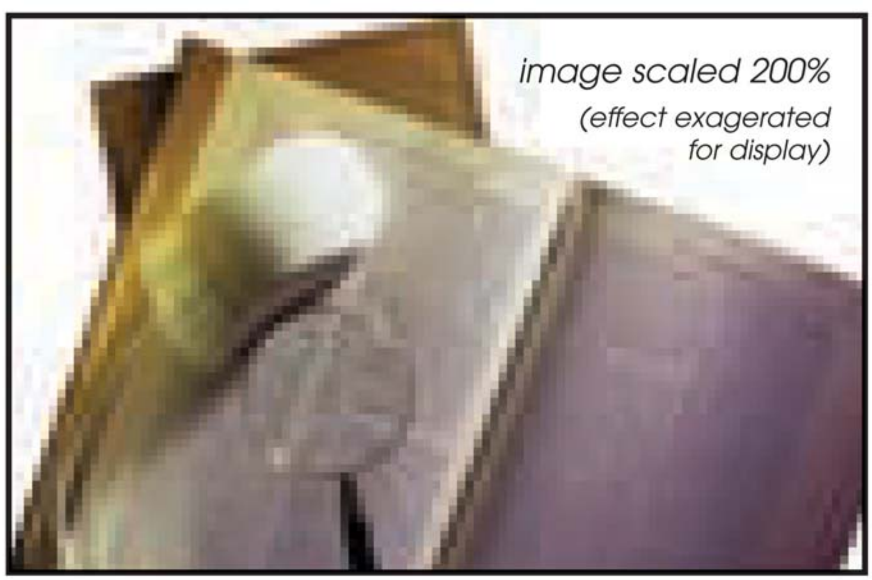
Image sizing/cropping

Since raster images have a specific resolution (i.e., a specific number of pixels per inch), enlarging or reducing a raster image involves changing the distribution of available pixels across the designated space. If an image is enlarged, unless additional pixels have been added by means of interpolation (resampling), then the size of each pixel must be increased proportionally to render the larger image. Since the new image will consist of the same number of pixels spread across a larger space, it will have fewer pixels per inch and a lower resolution. Raster images that are enlarged without interpolation are thus likely to appear jagged and may not be satisfactory for print reproduction.

Conversely, if an image is reduced, unless existing pixels have been discarded (downsampling), the size of each pixel must be decreased, thus creating higher resolution. Although scaling reduction is generally less problematic with respect to visible defects in

effect of scaling for raster tone images

image at 100% size



the printed product, increasing the resolution of digital images also increases their file size, making them more difficult to transfer electronically and more expensive to store.

File Formats

Digital art files can be produced in a wide variety of formats, but of these many options only TIFF and EPS are suitable for high-resolution print production. The primary reason is that most composition software used to lay out journal pages can accept only these two types of files. Internet graphics (e.g., GIF or JPEG formats), clip art, screen captures, and files generated from Microsoft Office applications typically are not suitable for use, unless files have been converted to TIFF or EPS format and can be modified to accommodate recommended digital art file specifications and to satisfy aesthetic requirements.

PDF (Portable Document Format), although the de facto standard file format for page file submission for prepress and print, is not suitable for digital art image file submission. Image files in PDF format should be converted to TIFF or EPS to enable compatibility with composition software.

Application file formats may be effective within the environment of the authoring software; however, recipients of native file formats must have the same version of software as the creator and must have access to graphics and utilized fonts. In addition, matching platforms, operating systems and associated utilities may be required to enable accurate file replication and display. The author should convert the files, if possible, to the recommended TIFF or EPS formats to assure proper reproduction.

Because modern prepress systems utilize composite page workflows, digital art files should not be saved for submission as separated or multi-channel formats, such as DCS (Desktop Color Separations). Although DCS is a version of the standard EPS format, color and other detail may be lost due to composition software incompatibility.

Transparency and/or layers must be flattened prior to image file submission, since most print devices, including RIP devices (raster image processors) and Adobe PDF prior to version 1.4 (associated with Adobe Acrobat 5), are not able to accommodate native transparency data.

File compression techniques can be utilized to reduce physical file size for raster image data, and thereby reduce storage space requirements. Compression methods are classified as either "lossless," for which image detail is not removed, or "lossy," for which detail and color information, if applicable, are removed. Image detail and/or color information discarded using lossy compression techniques cannot be restored.

Common raster image data compression techniques include LZW (Lemple-Ziv-Welch), a lossless method typically used for compressing images containing large flat areas of image information, and JPEG (Joint Photographic Experts Group), a lossy method used for compressing continuous-tone images (e.g., photographic images).

File Sources

For preparing digital art intended for print, The Sheridan Group recommends using professional graphics applications (e.g., Adobe Photoshop and/or Illustrator). Word processors, spreadsheet, and presentation applications, although suitable for creating files for office or Internet use, are not recommended for creating digital art for print. Microsoft Office applications are included in this group. In some cases, such files may be converted so as to enable use (see discussion on page 19).

Guidelines for Submission of Digital Art Files

The following general guidelines seek to minimize image production problems arising from the technical issues discussed elsewhere in this white paper. Readers should feel free to reproduce or borrow from these guidelines for their digital art communications with internal staff, editorial offices and authors.

Image Resolution

Resolution guidelines for raster image files may vary depending upon the output resolution of the device upon which the publication is to be printed. However, for the vast majority of periodicals the following specifications should be acceptable:

- 900 –1200 DPI for monochrome (1-bit) images.
- 300 DPI for tones (either grayscale or color).
- 500 DPI – 900 DPI for combination tones (either grayscale or color).

Color

- Black and white images should be captured as bitmaps (1-bit mode) for monochrome, and in grayscale (8-bit mode) for tones or combination tones.
- Color images should be submitted in CMYK color mode only. Files should not be supplied in RGB color, as these will not separate correctly and may not output to the desired color.
- Files should be free of color functions, including PostScript color management, transfer curves, halftone screen assignments, and black generation functions. Files should not include references to ICC profiles.
- Total Area Coverage (TAC) for black or dark elements or for black areas within color images should not exceed 300%.
- For color images, black text and lines should be specified to overprint.

Image sizing/cropping

- Art should be created or scaled to the size intended for print; no enlargement or reduction should be necessary.
- Digital art files should be cropped to remove non-printing borders. Files should be checked carefully for any type, lines, or other elements outside the illustration that are not intended for print. Such elements should be removed before submission.
- Image orientation should be the same as intended for print.

File Format

- Digital art files should be saved and submitted in TIFF or EPS format. Submission in application file formats (e.g., Photoshop, Illustrator, etc.) or submission as any format other than TIFF or EPS is not recommended.
- Images should be flattened prior to submission; that is, files should not contain layers and/or transparent objects.

Text/Lines

- For vector EPS files, fonts should be embedded or converted to outlines.
- Lines or rules should not be defined as hairline width. Recommended minimum line width is 1/4 point (i.e., 0.0035 inches).

Proofs

- A clean proof of the same size as the digital art should accompany file submission. If the image is in color, the supplied proof should be color as well.
- To ensure color match, the accompanying proof should be generated using a SWOP-certified (Specifications Web Offset Publications) proofing system and should be produced in accordance with the SWOP ADS (Application Data Sheet). It is recognized that most authors and/or publishers will not have access to such a system, in which case it should be understood that precise color match to the submitted proof may not be possible.
- In case the digital art file cannot be used as provided, or the file cannot be converted/modified, the supplied proof will serve as original art for scanning.

Multipanel Figures

- Multipanel figures (i.e., figures with sections labeled a, b, c, d, etc.) should be assembled into a single file for submission. Authors should not submit a separate file for each panel of the figure.

Submission

- Raster images may be compressed using LZW method for TIFF format.
- Application files may be compressed as archive format using WinZIP or PKZip for PC or Aladdin StuffIt for Mac.
- File submission can be accomplished using standard removable storage media (e.g., high-density floppy disk, Iomega ZIP, or CD-R), sending as an e-mail attachment, or via FTP by arrangement.

Acceptability of digital art—a conceptual framework

Education efforts, technical support, and the development and dissemination of digital art submission guidelines should over time increase the percentage of files that meet all specifications required for publication. For the foreseeable future, however, publishers can expect that a substantial number of author submissions will in some way fall short of expectations.

In theory it would be nice to simply reject all art that fails to meet specifications and require that authors fix these files before resubmitting them. But in practice, given the large number of files that are in some way deficient, such a draconian policy would probably be unworkable. Acknowledging this reality, most publishers and printers have developed a system whereby art files are screened to determine whether all submission criteria have been met, and if not, whether the file should be:

a) rejected, because it cannot be fixed and the output as-is will not be satisfactory,
b) repaired, so that the file conforms to specifications, or
c) accepted as-is, because non-compliance will not affect the appearance of the final output.

In many cases this decision-making process requires close consultation with the author, who is the only one qualified to determine whether a deficiency, or the prescribed repair, will cause critical elements of the image to be altered or obscured.

The diagram on page 15 provides a conceptual framework for determining the acceptability of digital art files. In this model the acceptance criteria are broken into two major categories: Technical/Objective and Aesthetic/Subjective.

Technical/Objective

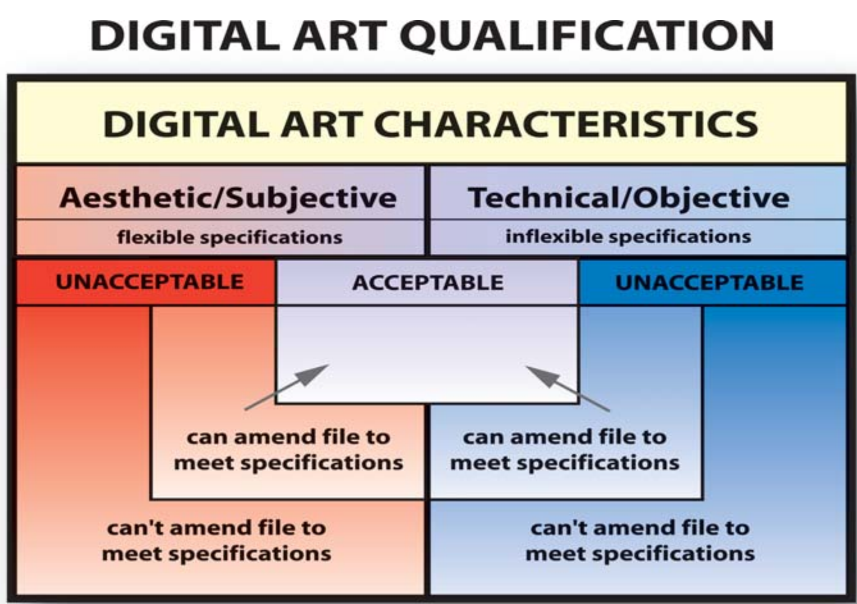
These are specifications that are not open to interpretation and which, if not met, are guaranteed "show-stoppers." File format requirements are a prime example of this kind of criteria; since most commercial composition software is incompatible with files other than TIFF or EPS, there is simply no way to work with the art unless it is supplied in or converted to one of these formats.

This is not to say that a file supplied in a format other than TIFF or EPS must be rejected outright. For certain supported software applications the printer may be able to work with an application file to convert it to the format required for composition. But in such conversions there is always the chance that some subjective aspect of the image (e.g., color gradations representing critical data elements) will be altered beyond an acceptable limit. Schedules and costs may be impacted as well.

Subjective/Aesthetic

These are criteria that involve a personal judgment on the "look and feel" of the art, and as such are more flexible than the Technical/Objective specifications discussed above. The best example of a Subjective/Aesthetic specification is image resolution. Although they may sound quite technical, image resolution requirements seek only to assure that digital art will have a sufficient level of crispness and clarity when it appears in print or on screen. There is no technical reason why a grayscale image scanned at 200 DPI (instead of the recommended 300) cannot be published in print; the issue is that the resulting printed image may look fuzzy or jagged and may do a poor job of representing critical data. Then again, as the term "subjective" suggests, the author may decide that the 200 DPI rendering, although not quite as crisp, isn't substantively different than the original and is acceptable for publication.

In short, these matters require value judgments that are open to interpretation and debate. One author may decide that the time and expense of rescanning an image at a higher resolution is not justified given the slight improvement in clarity that is likely to result. The next author may go to any lengths to assure that his art is rendered exactly as it appeared in the original.



Digital Tools and Workflows

Application programs for creating and enhancing art files

Illustration and photo-manipulation software

Professional editing software has now become so easily available and quickly learned that most anyone with a computer can perform very detailed edits to digital images. This has created some interesting problems and has necessitated changes to the traditional methods of handling artwork. You might think that the quality and accuracy of an image would only increase as the author has the "hands on" ability to make things right, but it also has created some potential pitfalls. If the printer's figure submission specifications are not followed correctly, then the resulting file could be rendered inaccurately or be totally unusable.

The two most widely used editing programs are Adobe Photoshop and Adobe Illustrator, and both can be used on PCs or Apple computers. Photoshop is mainly used to edit raster files and Illustrator is used for editing and drawing with vector files or for placing vector files within an image or drawing. Other popular programs for photo/image editing are Jasc Paint Shop Pro and MicroFrontier Digital Darkroom. For illustrating, some common alternatives are Macromedia Freehand, Deneba Canvas, and Micrografx/Corel Draw and Designer. If you were to perform a web search you might easily find 20 or 30 different products for editing, drawing or converting images, and many of the less robust programs are available as freeware or shareware. Some of these "cheaper" software products may lack the ability to save in the proper format or resolution needed for quality print reproduction.

Photoshop offers a wide range of functionality and allows the user to perform a variety of modifications to the image. The most common and easy image adjustments to make are cropping, rotating, scaling, color balance, brightness/contrast, blurring, adding text, and hue/saturation changes. Other more complex changes would be editing sharpness, changing resolution, adding multiple channels, drawing clipping paths for silhouettes, adding new layers, cloning areas, applying special filters, and converting from RGB to CMYK. All of these adjustments, even the simplest changes, require the operator to know and understand the final end product or printer specifications. As we have emphasized throughout this paper, even though an image may look beautiful on the computer monitor, this doesn't mean that it will be usable or that it will match the final printed sheet.

Drawing applications like Adobe Illustrator are mainly used for producing charts, graphs, and drawings, but in the hands of a highly trained artist, images can be created that may rival a real photograph. The pen tools/strokes, fills, and blends that are made within the drawing will be captured as vector information and therefore the file size will be very small. But if the drawing contains an imported image from a raster application the file size will increase, as it will need to represent the actual data for each pixel in addition to the vector instructions. When an image created in one of these applications requires adjustment, it can be edited in other vector software applications as long as the original file was saved as an EPS file. However, one of the most common problems associated with EPS files is that the font used in a drawing may not be found on the outputting device. When this happens a local active font, which may not exactly match the original, may substitute the font. To prevent this from happening the file should be saved by embedding the fonts, or the fonts can also be "converted to outlines." This creates a file that is entirely useable by itself without the need for other external fonts to be loaded on the outputting device.

An overview of the digital art process

Start with original hardcopy or computer art application file

- Each digital image begins its life either as hardcopy art that can be digitized by a scanner or as digital art created directly in a computer software application such as Adobe Illustrator.

Render illustration using appropriate tools and methods

- Each method of creation has its own strengths and limitations.
- Scanning hardcopy is the only viable option for some art, such as printed photographs. However, scanned images do not scale, and to scan medical images well takes several years of training.
- Art created in a software application can usually be scaled without loss of quality. However, not all software applications will generate a digital art file that can be repurposed both for print and the Internet.

Prepare the art for online or press process

- Each image, whether scanned or created with software, must be rendered for optimal match to its distribution criteria. The file formats and resolutions for the Internet are not the same as the file formats and resolutions for high-quality printing press reproduction.

Proof the image to assure successful reproduction

- Many types of proofing devices exist – from computer monitors to office color printers to expensive digital proofing solutions. Some of these are suitable for print reproduction and some are only to be used for verifying that the digital file is, in fact, the correct image to be reproduced.

Publish the image in print or electronically

- The end distribution method (print publication, electronic dissemination, or both) should be the primary consideration in determining how the art file is created and what its specifications are. If such is not the case, downstream in the production process the file may not be usable for its intended distribution channel.

Archive the image for future use

- Many publishers archive digital imagery for potential use in ancillary products (e.g., compilation issues, book spin-offs) or for possible licensing to other publishers or individuals.

The challenges of specialized scientific software and medical imaging devices

Scientific image capture devices are created for a specific function and need. Whether it's astrophotography, electron microscopy, MRI/X-ray/CT scans, ultrasound, or endoscopic technology, there is data that is captured, recorded and then analyzed and interpreted. Digital management systems have been created in various forms to handle all of this data, and these systems are known as Picture Archiving and Communications Systems (PACS). These PACS are designed to archive the images and then be accessed by remote workstations to download and view the file. A major drawback with these systems, at least initially, was that there were no standards in place to allow these images to be transmitted and viewed on multiple and non-proprietary devices.

In 1988 The National Electrical Manufacturers Association (NEMA) established DICOM® (Digital Image Communications), which has generated a series of publications presenting compatibility standards relating to digital communications in medicine. Although these cross-compatibility standards certainly represented a step forward for science, they did not really address the requirements of the publishing industry. For example, some of these devices produce 12 to 16-bit grayscale images that contain 4096 to 65,536 different shades of gray! This kind of detail is essential in the analysis of images that show very slight differences in tone. But the challenge is being able to take this extended range of gray and convert it to an 8-bit depth for printing without losing the important aspects of the scientific data. If this conversion is performed downstream in the process by a non-scientific professional, then some of this data may be lost without anyone realizing it before the image is published. For this reason these 8-bit conversions should be supervised by the author, who can edit the file and emphasize any detail that may be lost. This is the type of issue that is best remedied by using an application like Adobe Photoshop. To fix this tonal problem, a Photoshop operator would use either the "image curves" or the "brightness/contrast" adjustments.

In recent years there has been tremendous software innovation in medical imaging areas such as radiology, magnetic resonance imaging, and ultrasound. The major thrust has been to develop software system interfaces that can take the raw data and generate images in a variety of formats and resolutions, such as are appropriate for clinical use, or display on a stand-alone computer monitor, or even for high-quality offset printing.

In addition, newer image processing systems in scientific labs or clinics will provide a means for image manipulations such as:

- Retrieval from archive
- Ultra fast previewing
- Flipping and rotating
- Adding annotations

Some medical imaging manufacturers are even bundling Adobe PhotoShop with their equipment. This allows complex image manipulation to take place directly at the user's site prior to the image being exported for monitor or print. Often, however, Photoshop LE (Limited Edition) is the bundled edition, which doesn't support CMYK output.

What about standard "office suite" software?

Why is "office suite" software typically used for the preparation of digital art?

"Office suite" software (e.g., Microsoft Office: MSWord, Excel, PowerPoint) is readily available, particularly for PC/Windows users, and it is generally inexpensive, considering the value provided by the tools. It is also familiar to most computer users, who find it easy to work with.

Another benefit of this software is that it allows the user to preview digital art on a computer monitor, particularly since many picture file formats can be inserted. It also provides a means by which scanned raster art can be combined with vector line art and/or text. In addition, these programs can be used to simulate the appearance of the final layout.

What are some challenges for digital art prepared using "office suite" software?

Output is RGB color mode, so saturated reds, blues and, in particular, greens cannot be represented well using CMYK inks—thus, WYSIWYG is not true for digital art conversion for print. Also, overprints and related concerns are not relevant for monitor display, but are critical for high-quality print.

In addition, while native application file formats may be effective within the environment of the authoring application and may be fine for inter-office document exchange, recipients of native file formats should have the same version of software as the creator, and they must have access to graphics and utilized fonts. Matching operating system and associated utilities may also be necessary to render the file as intended by the author.

Other drawbacks include the fact that files are susceptible to font substitutions and/or text reflow for changes in printer drivers, and that files generally are not importable to page layout and/or composition applications.

What are some guidelines for preparing digital art using "office suite" software?

Only Adobe Type 1 fonts should be utilized, and should be restricted to base 14 for native file exchange. TrueType should be limited to the current Microsoft Office font set.

Resolution of inserted color or grayscale pictures (raster art, specifically) should be sufficient for print (after scaling, final effective resolution should be approximately 300 DPI). Also, fills are best defined using fill colors; use of fill effects (i.e., pattern fills) is not recommended.

If possible, "office suite" files should be converted to importable (i.e., TIFF or EPS) or modifiable file formats for which criteria for print has been met or for which files can be amended easily and successfully. All fonts should be embedded, color should be CMYK model, image resolution should be sufficient, and all other file specifications should be met.

Electronic peer review, online submission and digital art

Over the past five years, online services have emerged to help the scholarly publishing industry manage manuscripts through the peer review process. Scholar One's Manuscript Central, Aries Systems' Editorial Assistant, and the HighWire Press Bench>Press system are examples.

These systems typically require the author to submit the manuscript (including text and digital files) over the Internet to the editorial office. Complete PDF article proofs are then produced for author approval. At this point the editor selects manuscripts to be reviewed and chooses appropriate reviewers from a database of candidates. Reviewers display the full text and graphics online, review the manuscript, and provide evaluation scores and comments to the editor and author.

Based on the evaluations, the editor accepts or rejects the manuscript. Or, in many cases, revisions are requested. (Often this includes repairing or replacing digital art files that have been attached to or embedded in the manuscript.) Final, accepted manuscripts are then passed on for printed and online journals.

These electronic workflow systems present a new challenge, as they virtually eliminate hard copy illustrations from the publishing process. In previous workflows digital files were accompanied throughout the publishing cycle by a hardcopy proof that could be compared against the file and scanned to replace the file if necessary. With electronic submission and peer review this is no longer the case, so obtaining high-quality digital files, in the right format, with sufficient resolution and color rendition is critical.

Digital asset management

Digital Asset Management tools function behind the scenes in these electronic workflow systems. Collecting high-quality digital files also requires collecting the appropriate metadata – the information about file properties (format, size, resolution, etc.) and what documents the files are associated with. This information is important to streamlining the workflow process. The high-quality digital files are stored in digital libraries, the metadata about the digital files is stored in an asset management database, and the combination of the two facilitates the distribution and re-purposing of the files for composition, print or online delivery.

The Future of Digital Art

Author, publisher, and vendor expectations for the future

How can we make a virtually flawless workflow?

The workflow that allows us to look beyond traditional print-based distribution of journals requires some fundamental changes in the way we approach preparing content. It is now a reality that an image will need to be suited for print, online HTML presentation, PDF electronic delivery, and reprints. Preparation, storage and management of content must be done in a device- and distribution-neutral format. What this means is that the asset is maintained in a state that allows us to modify it from its current neutral state to the end use. To determine the ideal format, we would look to find the least common denominator of each attribute, and use that as the target.

This neutral concept presents a stark contrast to how we currently approach digital art. Today we work first to satisfy the print-based needs of images, and then work to fit these images into other deliverables. This is because print-based needs are generally the most stringent. While this approach works just fine, in some cases we are limiting the potential to distribute these files via alternate delivery methods.

Recently we have seen a shift in page production techniques. A push has been made to store and manage page content using XML. With this model the content is created and archived as a structured and tagged file, which can then be manipulated for the desired distribution method. For print layout the file can be imported for use by pagination systems, while for electronic delivery, the tags can be remapped to HTML or SGML format as necessary.

This approach of using a neutral or universal format and "donating" it for other purposes can work for digital art as well. We can look to manage and maintain a master or central file that has the least restrictions, and then transform it to be presented in any one of the output channels. Consequently, the digital art file will exhibit characteristics that are acceptable for any purpose or product, whether for print, web or other. This means that the file will comprise the largest possible color gamut, and that the file will maintain device- and resolution-independence, as much as possible, to allow repurposing for any downstream intent.

For example, some specifications for a raster color image to be stored in this neutral format might be:

- **Color space = RGB**: This preserves the largest spectrum of color possibilities, from which device-dependent RGB and CMYK can be determined. ICC color management will play a significant role here in the future, of course – if print output is required, for example, the file can be tagged with the appropriate ICC profile and converted to CMYK for production.

- **Resolution = 300 DPI**: This resolution is sufficient for print output of raster tones, or the file can be downsampled for electronic distribution at 72 DPI. (Note that vector format may be preferable as a donor, if the authoring application generates vector output, because vector files are resolution-independent and because they maintain searchability of text.)
- **Format = TIFF**: This is the most universal, lossless compressed file format. Conversion to any other raster format is achievable, though vector EPS might enable greater independence. Vectors can be transformed to raster with relative ease, but not vice-versa.

All-digital environments in scientific labs

No hardcopy anywhere in the process?

One of the primary reasons that digital art has become more mainstream is that there are now more digital image capturing devices than ever before. Digital cameras, digital microscopes, and digital camcorders are all widely available and used. The digital capture of images allows users to share and distribute them much more easily than with analog materials.

Keeping pace with these advances, new manuscript tracking and peer review systems have been developed to operate in completely digital environments. Authors appreciate the power of these systems, which enable them to leverage their digital content to more potential publication channels, and to do it faster and more effectively than ever before.

The Sheridan Group prepress front-end systems are completely digital, all the way from submission to imaging digital offset plates. But a complete transformation of the publishing workflow for digital art must include processing for all output needs. Processing jobs for the first printing is important, but keeping the assets in a format that is conducive to repurposing is equally important.

All of these technologies must work together so they can provide the maximum benefit. If we have poor quality digital art entering the system at the front end, all of this new technology will simply speed up the time it takes to publish a poor quality image.

Advanced Web-based solutions

Early detection of problematic files is critical

Most printing organizations use “preflight” tools to check digital page files as they are received. *Flightcheck*, *Pitstop* (for PDF files), and *PreflightPro* are examples of popular preflight software packages. While these tools are certainly helpful, they are used by the printer and therefore do not flag problems with digital files until late in the production process – long after authors have submitted their work. With the current workflow, publishers and printers waste precious days at the end of the production cycle trying to contact authors and waiting for repaired files. Often authors need technical help and coaching to understand the problems, their significance, and how to make required corrections.

A much better approach is to identify and correct problems with digital art files at the beginning of the process, at the file submission stage. The Sheridan Group calls this “proflighting,” or proactive file checking. The Sheridan Group has developed systems to check author-supplied files using automated proflight tools that can identify most problems up-front**.** The challenges and their implications are fully described and explained. Also, the procedures an author can use to repair files are presented in a step-by-step fashion. This tool is in live use today, and will become a valuable supplement to online manuscript submission and peer review systems.

Total control of art files throughout the entire publishing process

There are significant opportunities to reduce time-to-publication with early warning systems such as online proflight tools. While this approach fills a certain need, it is still just an interim stop on the road to a truly seamless and user-friendly digital workflow. Because even with up-front identification of problematic art files, authors may not be skilled enough or have the specialized software sometimes needed to make the appropriate repairs. In these cases there will still be significant time and energy expended trying to get a usable high-quality file.

Looking ahead, one can envision a system wherein problematic art is not only identified at an early stage, but is also automatically repaired on a remote web server. In this way the technical savvy of the author becomes almost irrelevant, and the efficiencies of the digital workflow can be fully realized.

Printers are often thought to be the last link in the publishing chain, but in the case of printer-managed editorial and composition, they are typically the first to review digital art files and evaluate their acceptability for publication. The proactive tools to identify and repair bad digital art files need to move upstream and be available to content generators. Electronic submission and peer review systems are the natural place to introduce such tools, as their integration at this juncture will allow for comprehensive and total control of digital art through the entire publishing process.

To learn more about digital art solutions and submission guidelines, visit http://dx.sheridan.com.

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Appendix

Glossary of Terms

Aliasing
Also referred to as jaggies or stairstepping. Visible steps along angled lines, objects or edges of text, more noticeable at lower resolutions. Attributed to harsh tonal contrasts between juxtaposed pixels.

Application File
Native file associated with a particular computer program, usually not transportable to other applications.

Binary
The base-two counting system employed by computers to process data, using only the digits 0 and 1.

Bit
Binary digit. The smallest unit of measurement in computer terms; either "on" or "off".

Bitmap
A digital image that has been mapped into a raster (grid) of pixels, each having been defined by a specific number of bits.

Blowup
A photographic enlargement.

Break for Color
To separate the parts to be printed in different colors.

Camera ready
Copy that is ready for photography.

CMM
Color Management Module. Interprets the ICC profiles describing the color spaces used in a color management system. Enables color space conversion from source device to destination device.

CMYK
Cyan, Magenta, Yellow, Black. The base colors used in lithographic printing processes. CMY are the subtractive primary colors used in combination with K to effectively create a multitude of other colors.

Color Balance
Correct mixture of CMY to reproduce a photograph.

Color Correction
Any method used to enhance color on a reproduction.

Color Gamut
A physical plot of mathematical equivalencies of perceived color. The range is associated with a particular device or ink/pigment set.

Color Management
A system by which color can be managed across different devices, whether input or output, each of which may have a unique color gamut.
Color Model
Number system to identify colors (eg. CMYK, RGB).
Color Saturation
Amount of ink in particular area of an image.
Color Separation
Process of separating color originals into primary printing color parts in negative or positive form.
Combination Halftone
Halftone and line art in one image.
Combination Tone
A raster image file type comprised of both tone (photographic) elements and text/line art.
Composite
A digital file that contains all required high-resolution color plate information.
Compression
Decreasing image or file size through use of a computer program.
Contract Proof
Image created as prints to match in the final output from the offset press.
Copydot
A method by which existing dots (usually halftone) can be maintained during the process of digital scanning. Copydot scan files are usually comprised of 1-bit data for each of the required color plates.
Crop
To remove portions of an original photograph.
DCS (Desktop Color Separation)
A version of the standard EPS file format; enables the saving of multichannel files or of process color separations. DCS is not a composite file format, in that color plate information must be reconciled by printing to separations from the page layout application. Usually includes a low-resolution color preview.
Density
Degree of darkness of photograph.
Descreen
A method by which dots or other pattern data (such as that applied during the printing or proofing process) is removed or blended during the scanning process.
Digital Color Proof
An off-press color proof made from digital data, not from separation films.
Digital Printing
Printing by plateless imaging systems.
Dot
Individual element of a halftone.
Dot Gain
Defect in which dots print larger than they should and create colors that are too dark or strong.
Downsampling
The removal of pixel data from an image, thus lowering its resolution and resulting in less image detail.
DPI
Dots per inch. The unit of measurement for output resolution; a square function of the number of dots measured both vertically and horizontally.
Effective Resolution
A calculated value that takes into account the actual resolution of an image and any scaling. Enlarging an image will result in decreased effective resolution.
EPS (Encapsulated PostScript)
An electronic file format used to transfer PostScript image information from one program to another. Includes PostScript data and a low-resolution preview of the image for display.
FPO
Low-resolution image serving as placeholder for higher resolution image to be substituted later, short for For Position Only.
FTP
File Transfer Protocol.
A standard means of transmitting digital information from one computer to another via modem or high-speed lines.
GATF
Graphic Arts Technical Foundation
GCR
Gray Component Replacement. Derived from UCR. Method of generating black for print. Used to replace portions of CMY with K in areas of color and in neutral areas.

GIF
Graphic Interchange Format. A standard file format for displaying Internet graphics. Usually low-resolution RGB or indexed color, not suitable for print.
Gray Balance
Proportions of CMY that produce neutral gray.
Grayscale
The palette ranging from black to white. A grayscale image is composed of various levels or shades of gray, 256 levels of which are available for an 8-bit image.
Hairline Rule
A specified rule that will image at the finest resolution of an output device (e.g., 1/300 inch for a 300 DPI device, 1/2400 inch for a 2400 DPI device).
Halftoning
The reproduction of continuous tone artwork, such as a photograph, through a screen. A halftone simulates continuous tones by using black or overlapped colored dots of various sizes and positions.
ICC Profile
International Color Consortium format.
A color space description for a particular input or output device, used in the management of color between devices.
Imagesetter
Film output devices using bitmaps.
Image editor
Software programs such as Adobe Photoshop and Illustrator for working with images.
Image resolution
Print quality measured using the number of DPI.
Indexed color
Color image format with a maximum of 256 colors.
Interpolation
Increase of image resolution by the addition of new pixels, the color of which is based on neighboring pixels.
Jaggies
Uneven appearance caused by images reproduced at too low a resolution.
JPEG
Joint Photographic Experts Group. Format used to display continuous tone images for the Internet. Unlike GIF format, all color information is retained. Selectively discards data to achieve file compression.
Line Art
Image suitable for reproduction without using halftone screen.
Locking a Disk
Making read-only any type of digital storage device.
Lossy
Any compression technique (e.g., JPEG) that removes portions of data to reduce file size.
LPI (Lines Per Inch)
Units of measurement for screen ruling (halftoning).
LZW (Lempel-Ziv-Welch)
A lossless compression technique that can be applied to images. Works best for monochrome images with repeating patterns.
Moiré
Undesirable screen pattern resulting from overprinting or scanning of halftones or incorrect screen angles in
Monochrome
A 1-bit black and white raster image, typically scanned from line art and/or text originals, saved as bitmap mode.
Negative
Film in which the dark areas in the image appear light and vice versa.
OPI
PostScript extension that replaces low-resolution placeholder images with high-resolution images, short for Open Prepress Interface.
PDF (Portable Document Format)
Cross-platform object-based file format from PostScript; can contain all image and font data.
PICT
A type of image format in which most Macintosh illustrations are encoded and which is too low a resolution for film output.
Pixel
Picture Element**.** Each pixel is assigned a color and location value, a grid of which composes a bitmap or raster image.
Platesetter
Recorder that images directly on plate material using a laser.
Positive
Film in which the light and dark areas are the same as the original.

PostScript
Text-based page description language to describe an image for printing, developed by Adobe Systems, Inc.

Preflighting
The process of checking digital files for reproducibility. Checks may include examining the resolution of an image, color rendition, whether needed elements of a document are attached or missing (for example, text fonts, embedded images), file type, etc. Usually preflighting is done when a printer, as the first step in the prepress process, receives files.

Process printing
Printing from a series of at least two halftone plates to create intermediate colors and shades.

Proflighting
Proactively checking digital files as an author submits them. Many of the same checks done during *preflighting* are performed.

Quality (Halftoning) Factor
A multiplication factor applied to halftone screen ruling to determine optimum scan resolution.

Raster image
An image created by figuring the bit maps one pixel at a time.

Raster Grid
A bitmap or raster image is composed of a grid of pixels.

Resolution
The number of pixels assigned per unit (usually per inch) of a raster image or associated with a device. A high-resolution image contains more pixels per inch.

RGB (Red, Green, Blue)
The primary additive colors of the visible spectrum. Used for display by color monitors.

Scaling
Alteration of an image's size by enlarging or reducing. Scaling of a raster image involves redistribution of pixels within a specified space.

Scanner
Electronic device that produces color and tone-corrected separations of images.

Separation
Break down of color image into CMYK for printing.

Spot color
A special color; any color other than CMYK or a CMYK process combination.

SWOP
Specifications Web Offset Publications. A specification employed for offset printing.

SWOP ADS (SWOP Application Data Sheet)
Presents proofer manufacturer's recommendations for best match to SWOP specifications for density, dot gain, substrate, etc.

TAC
Total Area Coverage. Specified as 300% for SWOP CMYK process printing. The total combined value of CMYK for the darkest area of an image or page.

TIFF
Tagged-Image File Format. A flexible image file format for transferring pixel images across platforms and applications.

Tone
Typically captured from photographic originals, a raster file type comprised of 8-bits of data per color.

Transparency
An option that enables saving a file as layers instead of with a defined color background. Primarily for displaying overlapping objects for the web. Transparent objects must be flattened for print.

UCR (Undercolor Removal)
A method by which black can be generated for print. Black is used to replace CMY in neutral areas, resulting in less ink and greater depth in shadows.

Vector Graphics
Resolution-independent mathematically defined geometric shapes (lines, objects and fills), entailing both magnitude and direction.

Visible Spectrum
Portion of the electromagnetic spectrum visible to the human eye.

About the Authors

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