Access Tools, Standards, and Strategies, edited by Murtha Baca (2002b) provides selected essays on the topic of image retrieval, from the point of view of collection managers, cataloguers and users, and although designed specifically with art images in mind, is a useful introduction to many issues raised no matter what the genre of the images in question. The text also contains a wide bibliography on other related, interesting and accessible readings.

Stapleton (2006) provides an overview article on *Image Databases and Access*, addressing questions of database infrastructure, as well as metadata. Anderson and colleagues (2006) provide a useful chapter on image metadata, along with a 'recommended minimum element set for use with archival digital still images' (84–90), using as its source Dublin Core, PREMIS, and a few elements drawn from NISO Z39.87. This overview is a useful starting point for those wishing to begin providing metadata for digital imaging collections. Polfreman and colleagues (2006) provide a comprehensive overview of issues in generating metadata to aid in the resource discovery of digital objects.

The UK's Digital Curation Centre (www.dcc.ac.uk) provides accessible overviews on general metadata issues, such as Higgins (2006), with plenty of external links to related resources. General text books, such as Lazinger (2001); Intner and colleages (2003); and Gorman and Dorner (2004), are useful in understanding wider issues regarding the usefulness of metadata and how it is used throughout the library and archive community.

Chapter 8
Current Issues in Digital Imaging

> As I hold the future well-being of photography very dear I must see to it that these forces which militate against it be opposed and destroyed (Alfred Stieglitz, 1910, 8 cited in Arts Council of Great Britain 1978, 12).

Although digital imaging technologies have evolved and been appropriated over a number of years, and may seem to be present themselves as a mature, stable technology, there are many issues which remain regarding digital image creation, digital image quality, digital image management and digital image longevity. In particular, the issue of accurate colour management, particularly when creating digital surrogates of original objects and documents, remains an area of concern and research. This, in turn, raises questions of quality: how can those creating digital images ensure that they are accurate and truthful representations? The issue of 'truth' in visual evidence is one that has a long history, although the tools available to manipulate digital images make it a pressing issue in the current information environment. Aside from these issues of representation and accuracy, institutions creating and dealing with image material should be very careful of legal issues surrounding digital image material, particularly copyright and rights management. Finally, issues of sustainability and longevity are becoming ever more important as institutions realize that digitization is not only about the creation of digital images: digital image corpora require maintenance and management if they are to survive after the duration of the digitization project itself.

Colour

One of the trickiest issues surrounding the production of digital image surrogates of analogue documents, objects and artefacts is the issue of colour accuracy in reproductions. Colour is a mathematically complex construct, and the diverse imaging devices used to capture, create and display image information, using different techniques to stimulate the human visual system, mean that it is a difficult issue to reconcile when creating digital images for both digital and analogue display. A variety of research has been undertaken into digital colour representation, and nowadays a variety of tools and procedures, including colour management software, regular and systematic calibration of equipment, and manual benchmarking of image quality can ensure that the images produced through digitization are valid and useful representations of the original item or document.

Human beings perceive colour when certain wavelengths of visible light (between 400 and 700 nanometres) strike the retina of their eyes. The human eye perceives shades of green and yellow in much more detail than blue and red frequencies of light (see Green 2006, 294). The appearance of colour to humans is affected by perceptual attributes, which can be absolute and measurable (brightness: where an area exhibits more or less light, usually measured in terms of percentage values from 0 to 100; hue, where an area matches a particular mix of red, yellow, green or blue on a colour wheel; and colourfulness, where an area exhibits more or less of a hue). Alternatively, perceived attributes of colour may be relative to other areas in the image (lightness: where an area is judged in relation to the brightness of another; chroma, where colourfulness is judged in proportion to another white or highly illuminated area of the image; and saturation, where the colourfulness is judged in proportion to brightness by establishing the extent to which a colour is a mixture of white). Perceived attributes of colour may be affected by various factors, including viewing conditions and medium. For example, light transmitted from a monitor is perceived differently from light reflected from paper, the accuracy of colour presented on monitors is highly dependent on the quality of the monitor itself, surrounding colours can impact on how specific colours in a part of an image are perceived, and the colour of ambient lighting (known as 'light temperature'), in either the capture or viewing process, affects the way colour is experienced in an image.

Colour is produced in digital display devices, such as television screens and monitors, from an additive palette of red, green and blue (RGB) emitted light. Different colours are created by varying the intensities of these three primary colours at nearby spots on the display (a very different way of handling colour compared to analogue film photography). A full mix of RGB is used to produce white, and altering the levels of intensity at a given spot can give a full 'gamut', the range of colours capable of being produced by a device, from white light to fully saturated colour. However, individual monitors may show colour differently, even when compared with another monitor of the same model from the same manufacturer, due to physical differences in the monitor's construction. Additionally, individual programs running on the same machine can display colour information from the same image very differently (commonly caused by the different ways in which specific programs use colour Look Up tables (see p. 65) or do not take into account colour profiles (see below)).

Printers produce colour differently from monitors and display devices, using the subtractive colours of cyan, magenta, yellow and black (CMYK) to produce a limited gamut of colours within a specific range (which differs from the range available on display devices). As a result, computer operating systems require colour management programs to assist in colour matching and conversion from one model of colour to another, such as from screen to print, but it is difficult for monitors and printers to reproduce each other's colours accurately and consistently. When switching from RGB to CMYK, colours are often dulled. Additionally, the type of ink, toner and wax used for printing varies from one manufacturer to another, producing different shades of colour, and combining with different types of paper in various ways to form other colours.

A related area to colour is the issue of gamma, or contrast, in digital images. Nearly all input and output media are limited in the range of lightness and darkness (or 'dynamic range') they can record or output. Additionally, different devices respond to variations in light intensity in different ways: scanners tend to respond in a linear fashion, where twice the brightness of a sampled pixel will yield a brightness value twice as large, but computer monitors have a non-linear response to the voltage sent: double the mathematical value of light intensity does not mean that it will display a pixel twice as brightly. Due to the difference in light intensity of the various elements in the digitization chain (for example, original contrast in the source painting; contrast of the colour photo of the painting; the gamma of the digital input device; the gamma of the monitor for display; and the gamma controls in the software) images that appear correct in one part of the chain may have mid-tones that are too bright or dark on another display device. Additionally, it is important to note the 'white balance' in images: adjustment of the relative colours and contrast values in an image based on areas of white and black, to ensure that neutral colours in an image are displayed correctly. Test shots are also important when creating digital images in the digitization process; digital cameras tend to burn out highlights very easily when creating images, and as with film, once an area in an image is overexposed, the detail is lost and no amount of gamma or white balance correcting can replace it.

Because of these issues with colour and light, it is difficult to reproduce identical colours on different systems or to accurately produce the same colours in print and display, and in some cases it is impossible. It is also difficult to know how images will be viewed by users and the effect that different systems will have on individual image colour:

> If such production steps as color matching present a certain level of complexity in themselves, the prospect of obtaining a consistent collection of images is greatly compounded in difficulty by the many potential junctures for losing control of how images look. Any time an image is captured, changed, or transferred to another system, medium, or device, the outcome may vary from the intended result. The industry is presently at the stage where no transition can be taken for granted (Ester 1996, 14).

Given that colour often imparts much information of importance in cultural and heritage objects and that providing accurate digital images of documents and objects is central to the usefulness of the digitization process, it is obvious that issues of colour and gamma management must be taken seriously by those creating, managing and delivering digital image material in memory institutions, and 'image digitisation should aim for accurate, repeatable, colour from the input phase through the display and to output' (Grout et al. 2000). Handling these problems is largely a matter of knowing the limitations and behaviour of a medium, and making proper adjustments to the data.

Colour management tools and procedures offer a solution for unambiguous exchange of colour information based on preservation of colour appearance. Originally developed for the reproduction of photographic materials on displays and printers, colour management has become increasingly important in digital environments offering 'a means of controlling colour from a source medium when reproduced on some other medium' with the goals of 'interoperability, consistency, and pleasing colour reproduction' (Green 2006, 11), aiming to accurately reproduce the original object when set viewing conditions are established, producing a recognizable, useful, digital surrogate.

Research into colour management has provided a variety of measures and tools which can aid projects in maintaining colour accuracy. Aside from the subjective, human experience of colour, colour can be measured mathematically by devices which can model the physical attributes of a coloured surface, recording brightness, hue and colourfulness, measuring an object in the same way that it would be viewed by an observer. Systems which mathematically represent colours are called colour models or colour spaces, which assign unique codes to each human perceivable colour. Many colour models exist, such as RGB for computer displays, CMYK for printing or YC_rC_b used in JPEG compression (see pp. 76–79). However, prior to 1995, every computer hardware vendor used their own set up for colour models, which were not standardized until the International Colour Consortium (www.color.org), founded in 1993, began to produce recommendations called 'colour profiles', which describe the colour attributes of a device or viewing environment and compute colour conversions between colour models and devices, allowing for sharing images between systems while maintaining the intended colours. Use of the ICC colour profiles was reasonably well understood by the mid-1990s, forming the basis of a colour management solution for digital workflow and is now an accepted part of digital imaging and colour reprographics.

There are many different ICC profiles in existence, but two which are common include Adobe 1998 (the standard colour profile used for producing images for professional print output, popular with photographers, laboratories and agencies) and sRGB (which has a smaller colour range than Adobe 1998 but is a recommended colour profile for digital display, such as for online graphics). At present, most personal computers are sRGB-based and the default setting for colour printers is sRGB. High end digital cameras can allow users to specify a colour profile to work with: sticking to the same colour profile for capture, processing and output can make dealing with colour accuracy less of a headache for digitization projects.

Most manual colour management procedures, and colour management software which facilitates the accurate reproduction of colour between devices and systems, operate on the basis of colour calibration. Calibration is the process of establishing an instrument's accuracy to known standards, to allow adjustment and correction which will enable the output of the instrument to be trusted. With regards to digitization, the technologies involved: cameras, scanners, monitors and printers; all require calibration to ensure that the outcome of the digitization process is predictable and repeatable. In particular, calibration of colour to a defined standard

or profile is necessary to represent colour accurately. Although a time-consuming, and therefore costly, process:

> the effort of implementing this into the normal production cycle is worthwhile, however, as the benefits can quickly be seen. Printing, in particular, becomes a much easier task with less waste and more accurate results (Stevenson 2006, 85).

Calibration of equipment can be achieved by regular, systematic testing. The digitization environment itself can be set up in a specialized manner to meet severe requirements of calibration and workflow, for example, walls can be painted grey to reduce reflectance, fluorescent room lights can have a calibrated colour temperature and atmospheric dust can be kept to a minimum. In addition, the images created by digitization can be accurately reproduced on other, unknown, systems when they are calibrated to 'references' provided within the image itself which will aid users in accurately recreating optimal viewing conditions of the image.

A variety of ISO standards exist to aid in the objective assessment and calibration of monitors, scanners, cameras and the digitization environment as a whole. For example, the noise produced by still picture cameras can be assessed by ISO 15739. The dynamic range of film scanners can be assessed using ISO 21550. The viewing conditions on monitors may be calibrated through use of ISO 3663, 'Viewing Conditions for Graphic Technology and Photography' which provides specifications regarding exactly how monitors and viewing stations should be set up to allow accurate viewing of images when the access to the original for comparison is not possible. ISO 12646 'Graphic Technology – Displays for Colour Proofing – Characteristics and Viewing Conditions', a later specification which complements ISO 3663, provides specific monitor set up when 'soft proofing' – comparing originals with their digital image surrogates (see also benchmarking, below). A list of useful, objective, standard test methods and a discussion of their application, and a recommended approach, can be found in NARA (2004, 24–28).

One of the most common ISO colour management standards (although most people don't realize it is actually an official standard) is known as IT8, which covers a set of standards produced from 1993 onwards that controls colour specifications and aids in calibration. The set of IT8 standards define input test targets: a reflective standard reference consisting of colour bars and greyscales which contains a number of uniform colour patches, to be photographed under the same environmental conditions as the item being captured. The IT8 7.1 is designed, in particular, to aid in colour management between photographic film and scanners, while IT8 7.2 is designed for photographic paper and scanners and IT8 7.3 is designed to enable colour management between input data and the CMYK printing process. These reference charts are produced by a variety of manufacturers, such as Kodak, Alfa, Fuji Film and Wolf Faust. In addition to the IT8 standards, the Macbeth ColorChecker and Gretag Macbeth DC charts are also available, being particularly suited to profiling the use of colour in digital cameras.

Particular reference charts have even been developed for managing colour when photographing stained glass windows (Macdonald et al. 2006, 417–418).

To aid in colour reproduction and management, these standard reference charts should be included in images of digitized material, to create images that can be displayed and printed with accurate colour representation anywhere. After calibration, software can be used to determine the relationship between the ideal measurements of the target and the actual RGB camera or scanner data captured, mapping the characteristics of each device into and out of a standard colour space. Establishing and sustaining a fully calibrated image chain that enables the colour management of digital images created in photo studios to be passed down through a series of 'digital handshakes' to the digital display or printing press is important for maintaining and ensuring image quality.

Additionally, computer monitors should be regularly calibrated (usually monthly and every time the equipment is moved) to ensure that those working with digital images are viewing them under correct colour and lighting conditions. There are various colour calibration software tools for monitors available. The simplest are software-based solutions, such as Adobe Gamma (which comes installed with PhotoShop, www.adobe.com/support/photoshop/) and Apple ColorSync (for Apple Macintosh, www.apple.com/pro/techniques/colorsync/), which create an ICC profile for the individual monitor and can be used to compensate for a monitor's colour display limitations, making adjustments and displaying a consistent result. There are also more complex software and hardware solutions, which use colour correction software in conjunction with a hardware calibrator that fixes onto the monitor, which are more accurate as they measure colour performance in detail. Commonly used packages include those from Colorvision's Spyder range (www.datacolor.eu/en/products/monitor-calibration/) and Gretag Macbeth's EyeOne range (http://usa.gretagmacbethstore.com/). Although more expensive than software solutions, they are worthwhile investments for a digitization project.

Once a monitor is calibrated, and as long as calibration has been used throughout the digitization chain, projects can be confident that the same colour reproduction will be available to any users with a similarly calibrated monitor. Of course, most home computer monitors have never been calibrated, and it is unlikely that they will be: digitization projects can seldom control the user environment in which images are viewed, only providing guidance and instilling best practice in capture to allow individual users who are dependent on accurate colour reproduction to experience it provided they take the time to set up their own work stations correctly. It is here, again, that documentation of the digitization process and the production of technical and managerial metadata (see Chapter 7) are key.

It would seem, then, that although not an exact science, it is understood that colour management is essential to the digitization process, and there are basic procedures that can be undertaken to ensure colour reproduction is as accurate as possible. There are further points which should be noted with regards to colour management in the library, archive, cultural and heritage sector. Because

of the various issues presented with colour reproduction, the best quality digital images come from digitizing directly form the source, rather than digitizing from available surrogates, such as transparencies or photographs. Problems can arise with focus and the calibration of true colour if using a surrogate: in effect this is taking a copy of a copy. Although many early digitization projects used already available analogue surrogates as an intermediary to the creation of digital images of documents or artefacts, it is now recommended that the original be used as the digitization source to ensure accurate colour reproduction.

Although it is ideal to include the colour reference target in every digital image created in a digitization project, this tends to create large individual images, simply due to the surface area of the target which needs to be captured in addition to the actual document or artefact. Over the duration of an entire project, which may be digitizing hundreds, if not thousands, of documents, this may add substantial costs to storage and maintenance of the image collection. A workaround for this is to scan or photograph a colour reference target at the start of each digitization session – for example, every day, or when the digitization set up is adjusted – and to refer to the image of the reference target in the metadata of the digitized output. Obviously, this is not as ideal as including the reference in each individual image, but is a suitable compromise for projects with budgetary constraints.

Image Quality

Assessing the quality of images produced by the digitization process is a major issue in digitization projects. Ideally, the digital images produced should be consistently and reliably of the best quality possible. How to actually perceive, understand, measure and benchmark digital image quality is an ongoing topic of research.

Quality can be defined as a sense of fitness for purpose. In the case of images, quality can be assessed by considering how effective the image is in communicating its intended purpose or message to the viewer. An image of poor quality may degrade the effectiveness of communication, but what message that image was to portray can only be decided by the creator and deciphered by the user:

> the meaning of the communication, and the criteria by which its quality should be judged, can only be understood in the context of the intentions of the originator and the needs of the receiver. These may include purposes as diverse as entertainment, advertising, information, education, politics, etc (MacDonald and Jacobsen 2006, 353).

In the case of images created in the digitization process:

> in order to function as intended, digitised surrogates must instil their prospective end-users with the same confidence as (or greater than) earlier forms. This means that the surrogates must prove to be consistently faithful and authentic to the original, having

> captured details in ways that lend confidence to those who would employ the surrogate as they would an original. The digital capture process must be undistorted and reliable (Grycz 2006, 35).

Quality, therefore, can be judged by how accurately the digital image reflects the original artefact it represents, and the relationship of the surrogate to the original. The visual presentation of an image may be affected by its viewing environment (how the observer sees the image, including issues such as lighting and viewing geometry); the medium or device on which the digital image is displayed (issues such as resolution, colour reproduction, colour representation and brightness); characteristics of the image itself (such as tone, sharpness, noise, contrast and identifying technical faults such as moiré patterns[1] and chromatic aberration[2]); and finally the content of the image itself (the composition, stylistic treatment and subject matter, which may be interpreted for meaning) (MacDonald and Jacobsen 2006, 354). Issues of fidelity, usefulness and the perceived quality of the representation can also be used to model image quality (ibid.). As a result, the consistency and accuracy of the image data should be compared with the original photograph or objects, checked for technical errors, optimized for different viewing environments and printed for colour proofing to enable double-checking of colour reproduction.

There are many issues regarding fidelity and representation which are encountered when digitizing collections, not all of which are focused on the technical aspects of the image (such as sharpness and tonal-range). The production of two-dimensional, flat images of often complex, three-dimensional artefacts, can mean it can be difficult to perceive the relative size of objects in their intended environment. Maintaining colour authenticity is problematic (see above). Many art and historical objects were created so that viewers could interact with them from a variety of distances and angles, while the viewer of digital surrogates are often restricted to the static views captured, stored and delivered by the digitization project (the number of images taken of each object may be determined by issues of cost and workflow). Viewing an image of an object, document or artefact can be a very different experience from physically encountering the original and projects have to be careful to frame the objects accordingly, to maintain contextual information. Although there are technical aspects to ascertaining image quality,

1 Many images in books, magazines and articles are printed using a pattern of dots. When scanned or digitally photographed, this pattern can interfere with the arrangement of pixels on the sensor, leading to the creation of visible 'Moiré' patterns in the resulting image, such as wavy lines and false colours.

2 Chromatic Aberration is a lens issue, caused by different wavelengths of light focusing at different distances from the lens, which occurs in both digital and analogue photography. Out of focus subjects in the image can have colour haloes (also known as colour fringing or ghosting).

projects also have to be aware of the wider issues created when presenting digital images to users.

A technique called 'benchmarking' can be used to provide a careful assessment of originals and their digital surrogates to ensure that the attributes of the source material (such as: organization and presentation; size and dimension; detail, tone and colour; and age and condition) are conveyed in the digital reproductions (Chapman 2000, 35). Benchmarks are usually set at the start of digitization projects, where standards of digitization (such as resolution, colour reproduction, etc.) are instigated. Benchmarking then becomes part of the established workflow to ensure that resulting images meet project aims and requirements, and can be viewed as 'a systematic procedure for forecasting a likely outcome' (Kenney and Chapman 1996, iv). The aim of benchmarking is to ensure faithful digital reproductions:

> digital objects that are optimally formatted and described with a view to their *quality* (functionality and use value), *persistence* (long-term access), and *interoperability* (e.g. across platforms and software environments) (Digital Library Federation 2002).

Maintaining quality in digital surrogates is one of the main aims of benchmarking. Image quality can be assessed for single images in isolation or for test images in comparison to a reference image or set of determined criteria, by either human observation, measurement of various attributes or automated computation. Users can also be integrated into the quality assurance workflow, to ensure that their needs have been met within the digitization process (this is especially the case if the images are being created to divert use away from originals towards digital surrogates as a means of preventing handling of fragile or deteriorating documents. The images created would have to be of high enough quality to persuade users that they no longer needed to access the original).

However, although much reference is made to the need for benchmarking, the maintenance of image quality and the integration of benchmarking into digitization project workflow (Hughes 2004, 166), 'ultimately, a human observer must make the visual judgement of whether an image is of acceptable quality' (MacDonald and Jacobsen 2006, 360) and:

> it is still necessary to have knowledgeable and experienced staff to evaluate images visually. At this time, it is not possible to rely entirely on the objective test measurements to ensure optimum image quality. It is still necessary to have staff with the visual literacy and technical expertise to do a good job with digitization and to perform quality control for digital images. This is true for the digitization of all types of archival records, but very critical for the digitization of photographic images (NARA 2004, 25).

Accurate and useful benchmarking and quality assessment is dependent on skilled digitization staff and is limited to the expertise, experience, attention span, mood and even physiological characteristics of the operators undertaking checks against established aims and outcomes: obviously, those undertaking benchmarking should have good eyesight (with or without aids to vision), but less obviously, staff should be checked for colour blindness (which affects around 8 per cent of men, and 0.4 per cent of women, see Birch 2001, 33). Documentation of the benchmarking process should be provided in image or collection metadata (see Chapter 7) to indicate to users that aspects of quality control have been given careful attention in the digitization process.

It should be noted, however, that although ascertaining and maintaining the quality of digital images is not an exact science, our understanding of procedures and techniques to maintain image quality are more sophisticated in the digital realm than they ever were with analogue photography. Film is not an accurate representation of the real world any more than digital is; in both cases a surrogate is produced, but the tools and processes available for checking digital images far exceed the means by which analogue photographs could be benchmarked. A properly managed digital colour and quality workflow can results in improved images above the reproduction capable of traditional film-based imaging: 'image quality, particularly in terms of colour accuracy and dynamic range, were significantly improved over the previous film based process' Hamber (2006, 145). The National Gallery, London, has been taking photographic images of its holdings for curatorial and record keeping purposes from the early twentieth century. Those working in the photographic department have noted that the recent switch to digital photography in the late to mid-1990s has also enabled them to produce consistent high quality images, as the digital imaging technologies allow a range of checks (such as those used to establish colour accuracy) to be undertaken which were not possible with analogue film (White 2007).

Truth and the Digital Image

It has been said that the digital image is 'predicated on fabrication, which can come from a multitude of sources. This changes the role of the photographer from that of a witness to that of an information designer' (Hirsch and Valentino 2001, 218). Some photographic images, taken by a camera, are clearly descended from their analogue ancestors: producing a likeness of something that has a physical presence, through lens and capture-based technology (although distortion of the real world can occur through lens shape and lighting). Others are drawn, or rendered, by computer and are 'digital born': allowing every possible variation and combination of colour, shape and light available, although they may look real to the uninitiated. After creation, computers can be used to affect changes in images which they were not involved in producing.

Early computer-based algorithms developed to process and refine digital images were designed to remove artefacts from photographs, and improve them for human analysis as well as to analyse them automatically (see pp. 21–22). The increasing sophistication and speed of modern computers means that images can

now be successfully manipulated on the majority of home computers. In minor cases, this results in the retouching or airbrushing, of simple aspects in images. More worryingly, it facilitates the construction of images of events which never happened, meetings of people which never existed, and allows the removal of unwanted or unwelcome objects and individuals. We have already seen that images are powerful, and that maintaining image accuracy is crucial: manipulated images, whether intentional or accidental, change our understanding of reality and influence our cultural perception.

In some sense this is nothing new. The defacing or erasing of historical personages, documents, artefacts and architecture is well attested: if you control the image, you control the ideology and the information passed on to the viewer. Classical and medieval documents were scraped clean to allow reuse of scarce resources, sculptures in temples and churches defaced to destroy representations of gods to prevent them being viewed by future generations and bodies mutilated on the battlefield to prevent identification (see Dillon 2006 for an overview of the *Revelation of Erasure*). Although the homily 'the camera never lies' is often repeated, photographic and especially digital images, are very easy to manipulate, raising issues of trust, verification and ethics when using them for proof, research or evidence of any kind.

The issue of the relationship between photography and truth, and the outright manipulation of the photographic image, can be traced back to the work of one of the earliest photographers. Hippolyte Bayard's *Self-Portrait of a Drowned Man* (1840) presents the audience with a record of his apparent suicide: a metaphor for his lack of recognition for his photographic discoveries, as the French authorities failed to acknowledge that his own discovery of the photographic process was equal to Daguerre's pioneering work (Sapir 1994). Photographic manipulation became relatively common in the Victorian era: a close-up photographic portrait of Lillie Langtry (1853–1929, society beauty, actress and mistress of Queen Victoria's son Albert Edward (Edward VII)), taken in 1890 by W & D Downey, shows significant retouching to reduce her waist to waspish proportions (Science and Society Picture Library 2004).

Image manipulation was common in advertising during the twentieth century, ranging from brightening colours, to airbrushing, retouching, inserting or deleting information that was never in the original image. The difference with traditional versus digital image manipulation is that it has become so much *easier*, and does not require specialist expertise or expensive technology: image manipulation is achievable on even the most basic of desktop computers. Some manipulated images seem plausible, yet are deceptive, others are obviously faked. Done well, manipulated images are indistinguishable from reality and there is no way of knowing from a digital image whether or not the content has been fabricated. Although the technology behind manipulating images may have changed, the focus often remains depressingly the same: images of the actress Kate Winslet taken to advertise the February 2003 issue of the men's magazine *GQ* were digitally retouched to reduce her thighs by a third (the image is available at DiscoverKate.

com (2003) should you feel the need to see it. Reassuringly, this was accompanied by a media outcry (The Telegraph 2003)). However, in 2006 Hewlett Packard launched a digital camera feature that applied a 'slimming effect' to any object in the centre of a picture ('a subtle effect that can instantly trim off pounds from the subjects in your photos!' Hewlett Packard 2006). Software exists which is designed to tweak facial images in the direction of the beautiful average face, rejigging the contours of faces to make them more attractive (Anthropics 2006). When images of our own selves are so malleable, what effect does this have on our trust of digital images?

> If it can be assumed that the credibility of photography has rested traditionally on a knowledge of its mechanical rather than manual mode of operation, what will be the 'truth' status of images that look convincingly photographic but have actually been constituted from multiple digitised elements and subjected to re-workings by an operator? .. In this sense [digital imaging] reverses the history of imaging technologies and takes photography back to the ontology of the infinitely manipulable medium of painting (Willis 1990, 200–201).

The ethical issues regarding digital image manipulation first came to public attention in February 1982, when Gordon Gahen at National Geographic magazine, long known for its reputation of photojournalism excellence, used expensive digital manipulation software to reposition one of the Great Pyramids at Giza to make a horizontal image fit its vertical cover format. The editors claimed they did not intend to alter the underlying meaning of the subject but their failure to acknowledge that the image had been reworked upset readers who trusted that the National Geographic would deliver accurate photographs. Tom Kennedy, who became the director of photography at *National Geographic* after the manipulated covers were used, said:

> We no longer use that technology to manipulate elements in a photo simply to achieve a more compelling graphic effect. We regarded that afterwards as a mistake, and we wouldn't repeat that mistake today (personal interview with Carla Hotvedt (1990) cited in Lester 1999, Chapter Six).

The ethics of digital image manipulation are important: 'The threat to credibility is irreversible if the public starts to mistrust the integrity of the news photograph' (Lester 1999, Chapter Six). In 1995, The National Press Photographer's Association added to their Code of Ethics a clause to regulate digital image manipulation:

> It is clear that the emerging electronic technologies provide new challenges to the integrity of photographic images ... in light of this, we ... reaffirm the basis of our ethics: Accurate representation is the benchmark of our profession. We believe photojournalistic guidelines for fair and accurate reporting should be the criteria for

> judging what may be done electronically to a photograph. Altering the editorial content ... is a breach of ... ethical standards (NPPA 1995).

Unfortunately, it is becoming even more of a problem:

> The list can go on for pages: NEWSWEEK straightened the teeth of Bobbi McCaughey, the mother of the sextuplets; NEWSDAY ran a photo supposedly showing Nancy Kerrigan and Tonya Harding skating together a day before the event really happened; PEOPLE ran a photo of famous breast cancer survivors made from five separate negatives; The St. Louis Post Dispatch removed a Coke can from a photo of their Pulitzer Prize winner. This just scratches the surface. How many cases have not become known? The cumulative effect is the gradual erosion of the credibility of an entire profession ... We are being bombarded from all sides, from movies, television, advertisements, the Internet, with images that are not real, that are created in computers (Long 1999).

Is this really an issue for the information professional? There is, of course, a difference between images which have been deliberately manipulated to change the information presented to the user and those in which changes happen as part of the production process, perhaps in the resizing, changing of formats or compression (see Chapter 3). Nevertheless, digital images used for pedagogical or research purposes should come with clear provenance and technical and managerial metadata (see Chapter 7) to ensure that the information they display can be trusted. In the field of medical imaging, for example, it is important to retain as accurate a representation of the original as possible. Would you be happy with the use of a medical scan which was only an approximate image as a basis for surgery? The same is true for images which form the basis of expert research. If you were an expert on ancient documents, where the slightest change in marking on the surface of a text can mean the difference between commonly confused words which can give entirely different parses to the same sentence, would you be happy with an approximate representation of a disputed document or would you want the best image possible?

A recent dissertation investigating use and perception of images of digitized medieval manuscript collections highlighted concern over the authority and provenance of digital images: while undergraduate students preferred using digital images to the bother of consulting the originals, postgraduate research students and academics would not base research upon digital images of original manuscripts unless they had been involved in the digitization project themselves and could be sure of the quality of the images they were consulting (Tawse 2003). Findings of the Log Analysis of Internet Resources in the Arts and Humanities (www.ucl.ac.uk/slais/LAIRAH/) project also highlighted that without adequate metadata and technical information, academic researchers in the arts and humanities did not trust online images of artefacts or documents (Warwick et al. 2008). Willis, writing in 1990, predicts a future where digital images cannot be trusted at all, when the photographic medium implodes:

> The archive and history become ruptured. Pictures from the past can no longer be assumed to be a transparent record of the past. An accumulation of imagery travels forward in time as potential raw material for the continual re-invention of history in the present. Conversely it travels backwards as evidence of the archaeology of the technology, thus particular genres, styles, techniques become reference points for photography's own past (206).

If the information profession wishes to ensure the longevity and veracity of digital images, it surely has to engage with such concerns, and be educated in the technological and information infrastructure which underpin the digital imaging medium.

Copyright and Copyright Control

Copyright is the legal right of an author, publisher, individual or institution, to retain ownership of an idea or information and control the production, sale, distribution of reproductions, or derivatives, of the original. Although there are economic grounds for this, there are also moral reasons: original creations should be protected from exploitation from anyone other than the creator.

Understanding, maintaining and exercising copyright rights is a complex activity. In particular, recent advances in the digital information environment do not sit comfortably with established copyright laws and procedures. The fundamental aspects of digital images which make them so attractive to both individuals and institutions pose problems when it comes to copyright:

> The ease with which digital material can be reproduced, disseminated, manipulated, interacted with, stored and compressed at virtually no cost challenge the very concepts at the heart of copyright. This results in a digital landscape where content is very easy to find, but any use of it is restricted within the context of the copyright legislation. Although the copyright legislation is extremely thorough and comprehensive, there are a number of reasons why copyright, as applied to digital images, is neither black nor white and is, more often than not, various shades of grey (TASI 2006f).

Copyright law is highly localized from one country to the next, while the global information environment encourages worldwide use. The legal framework cannot keep up with the pace of technological development. Copyright laws are also full of undefined terms (such as 'original', 'substantial', and 'reasonable'), and case law frequently changes the way legal Acts are understood and applied to changing media. It can be very complicated to manage and clear copyright for items destined for online display, and in the case of digital images, the full impact of copyright law on picture libraries, digitization programs and individual photographers is unclear.

Information professionals often have a duty to care for, and allow access to, other people's works which are in copyright. Additionally, those creating digital image archives will be creating images and databases, each of which have their own copyright considerations, and institutions and individuals will have to consider asserting their own copyright on intellectual effort and the creation of original digital resources. However, the copyright status of images created by the digitization process is uncertain:

> Generally speaking, it is held that if the work is digitized using a scanner and there is no human intervention (like a photocopy), then there is unlikely to be any new copyright created. So a mere scanned copy may not be protected by copyright, but an image that has had a lot of work done on it to enhance its appearance, correct the text, or change the colouring probably will be protected … But even if they are not [enhanced] … the actual collection of images may qualify for database right (sic) if they are organized in a systematic and methodical way (Cornish 2004, 7).

It is necessary, and prudent, for institutions dealing in images of copyrighted material, or producing work under their own copyright, to undertake legal advice on the status of their digitized collections and develop a digital knowledge management strategy to ensure they are not compromising the copyright of others, while safeguarding their own rights.

> Protecting and managing copyright, and avoiding infringement, is ultimately more a question of risk management than it is of the law … Risk management will require considering the benefits of digitisation (wider access, preservation, greater availability of the materials for research) against the potential risks of infringing copyright – and putting materials on the internet makes it that much more likely that the infringement will be discovered … Where possible, discussing these factors with legal counsel at the outset of a project may help to develop an approach to copyright management that might mitigate any problems throughout the course of a project. Ultimately, certain decisions (such as negotiating with rights holders, or deciding whether or not fees can be paid) will often be made by an institution's legal counsel, who will have the final say in assessing the impact of risk, and deciding how risk averse a project – and the institution – can afford to be (Hughes 2004, 76–78).

Advice should also be taken on other legal issues, such as of publicity (associated with public figures, and the use of likenesses of a well-known person); privacy (designed to protect individuals from intrusion and public disclosure of private information); data protection (regulating the use of information that can identify an individual); and the use of images which may be sensitive, obscene or defamatory (Hughes 2004, 68–71).

An alternative approach to issues of copyright, in the case of asserting copyright for original images and information items, is to look towards the Creative Commons, which is becoming an increasingly popular route for individuals and institutions who wish to assert exactly how the information objects that they are placing online may be used, copied, disseminated and re-appropriated by others. The Creative Commons, a non-profit organization founded in 2001 (http://creativecommons.org/), aims to provide tools for authors and creators which enable copyright holders to grant some or all of their rights to the general public, while withholding others, providing a variety of free licenses which authors can use when releasing their content via the Internet. These licenses can determine how and where content can be used, and if they can be used for profit or commercial gain. Since its launch, the Creative Commons has proved popular: at time of writing there are approximately 60 million digital images licensed with Creative Commons on Flickr (Creative Commons 2008). The use of Creative Commons' licenses is not limited to individuals, as institutions also appreciate the benefits the range of licenses present. Recently, the Wellcome Trust (http://images.wellcome.ac.uk/) made 100,000 digital images from its collection of scientific, research and historical images of '2000 years of Human Culture' available under a non-commercial Creative Commons license, allowing users to download, copy and display JPEG images from their collection, as long as they are used in a non-commercial environment, not altered in any way, and attributed to the Wellcome Trust. Other institutions and initiatives, such as Tufts University Open Courseware (http://ocw.tufts.edu/) and Carnegie Mellon's Open Learning Initiative (www.cmu.edu/oli/) are adopting Creative Commons licenses for the distribution of image, text and other pedagogical material. The control and options offered by the Creative Commons licenses are attractive to both individuals and institutions alike.

This open approach to the delivery of online material can be compared with concerns which dominated early digitization projects: if image material was made freely available online, would this increase the chances of illicit republishing of these materials, where counterfeiters could make a profit from unofficial coffee-table books, greetings cards, tea towels and other unauthorized merchandize? Technical approaches to safeguarding copyright, such as the inclusion of either visible or invisible watermarks, were popular in the late to mid-1990s. Logos, messages or information about how and where the image was accessed were included in the digital image (using a process called digital steganography, literally 'covered writing' in Greek), allowing the image to be traced back to its original source and defacing the image suitably to prevent exploitation:

> A visible watermark can act as an advertisement or as a restriction. For example, you might be willing to give away low-resolution, visibly watermarked images for free, but wish to provide high-resolution unmarked versions of the same images for a fee. Even if the free copies were of the same resolution as the priced ones, the visible watermark can dissuade end-users from improperly misusing them (Mintzner et al. 1997).

The early digitization projects undertaken by the Vatican Library, in conjunction with IBM, used very visible image watermarking (ibid.). The Scottish Cultural

Resources Access Network (SCRAN: www.scran.ac.uk), a nationwide project to digitize the material culture and human history of Scotland, chose to include both visible and invisible watermarking to safeguard their image material:

> [an image is] protected by an invisible 'watermark' (to confirm the resource's copyright status) and 'fingerprint' (to identify who downloaded it and when). To avoid any accusations of 'entrapment', this information is also clearly shown in banners at the top and bottom of the downloaded image (Royan 2000).

However, the inclusion of such watermarks, particularly large, visible, logos, can visibly disrupt the image, threatening its integrity (as pixels are replaced by pixels from the logo), compromising resource quality and preventing users from undertaking valid, useful, advanced research with the image. The images presented in the Mintzner et al. (1997) article as 'good' examples of successful watermarking technology are testament to this. As a result, the use of watermarking has fallen out of favour, and it is now acknowledged that the provision of low resolution, highly compressed JPEG images (see pp. 76–81) or small thumbnail images of digitized holdings, is enough to limit unauthorized repurposing of digital image material, as the quality of image is not high enough to enable professional print-based reproduction. Of course, usable images can still be copied and distributed electronically, but the benefits of providing useful, usable images to researchers and general users far outweighs problems of image integrity and the cost of implementation associated with watermarking technologies.

Access to digital images can also be managed or restricted to prevent unauthorized or unlimited use of materials. Simple methods, such as only allowing users to log on from particular, designated computers within an institution, or from computers with a university or library IP address, can restrict access to those with bona fide reasons for accessing research collections. Likewise, online photo sharing and social networking sites, such as Flickr and Facebook, can allow those uploading digital images to specify groups of users, and limit access to certain images and certain sizes of images. For more advanced control over access, Image Management Systems (IMS, see p. 171) provide facilities for electronic rights management (also known as digital rights management), such as the control of passwords and usernames, managing any subscription payments and different levels of subscription. More contentious facilities available in some IMS (and related digital rights management systems for other types of media) include limiting the number of times images can be accessed, controlling how many times a file may be accessed, opened, copied and printed, and limiting where and how the file may be stored.

Strict Digital Rights Management (DRM) systems have many opponents. Although there are many who advocate the creator's right to prevent unauthorized use of their works, many objectors such as the Free Software Foundation (www.fsf.org) or the Electronic Frontier Foundation (www.eff.org) argue that DRM is often used to attempt to restrict the use of copyrighted material in ways which are not actually covered by the current legal framework (Becker et al. 2003). The use of DRM control is much more prevalent in systems which control access to digital music, film and television than in institutions which primarily provide digital image data to the end user: although institutions should consider issues of access, restriction and control it is unlikely that the digital images created would hold as much interest to counterfeiters as other commercially produced media, and a balance has to be struck between restricting and facilitating access to information and cultural heritage materials.

Sustainability of Collections

A major topic of concern, already covered more fully in Chapter 5, is the issue of sustainability of digital image collections. As with any digital collection, leaving collections of digital images without maintenance and care will mean that access to and use of the collection will become rapidly compromised. This should be of utmost concern to memory institutions undertaking digitization projects, as it is rare that funding is secured to maintain and upkeep a digital collection after project funding ceases. Indeed, many funding bodies, such as the UK's Joint Information System's Committee now insist that, as a requirement of the funding process, institutions will undertake to maintain access to digital projects for a period of up to ten years after the project's end, ensuring that any digitized output will remain available to scholars and the public well after any funding stream has ceased. The maintenance and care of digital collections is time-consuming and costly. Obviously, making any promises to upkeep digital collections requires institutional support and funding, and applicants have to demonstrate that resources are available to ensure sustainability of and access to digital collections.

Other Issues

This chapter has focused on current issues pertinent to those working in professional information environments, such as the production of accurate representations of original documents, objects or artefacts, and the awareness of legal issues such as copyright. Of course, recent changes in the information environment and digital imaging technology have resulted in other issues, some of which have been mentioned or alluded to throughout the book, such as: the proliferation of digital image information and resulting impact on storing and finding image content; the impact the growth of digital imaging has on traditional photographic practice and industry; our changing relationship with images due to the differences afforded by the new capture and networking technologies; the impact digital image technology has had on the modern art sector and creative industries; the changing role of photographic images within our society; the immediacy of digital imaging technologies versus the historicizing nature of analogue photographic technologies;

and so on. Technical issues such as the creation of noise by the sensor in digital imaging, issues in determining the authenticity of digital images and the differing qualities of digital images to film, such as the different treatment of colour and different sensitivities to light, should also be noted. Finally, the expense caused by the regular need to upgrade computing equipment, capture equipment and software when using digital imaging technologies should not be overlooked.

Conclusion

Digital imaging technologies may have seemed to have sprung like Athena, fully formed, from traditional film photography and personal computing technologies in the closing stages of the twentieth century, but the technical, practical, social and theoretical issues which continue to emerge suggest that this is a technology still in development, raising many issues for those handling, storing or facilitating access to images in today's society.

The aim of this text has been to explain the historical background, technical implementation and use of digital imaging technologies, with particular reference to use in and issues concerning the information and cultural and heritage sectors. By understanding and embracing the technological shift in the production of image-based material in modern society, those in the information profession are best placed to create, maintain and deliver high quality image materials in this evolving information environment.

Further Reading

Graham (2005) gives a detailed, though mathematically thorough, introduction to the use of colour in digital imaging. Thorell and Smith (1990) address both practical and theoretical issues when *Using Computer Color Effectively* in an illustrated reference guide. Brown and Shepherd (1995, Chapter 6) give an introduction to colour theory with regard to digital images. Green (2006) provides a useful overview which specifically focuses on the issue of *Colour Management in Heritage Photography*, including a introduction on human colour vision, colorimetry and the characteristics of display devices, before considering the methods and techniques that can be used to ensure accurate colour reproduction.

The National Archives and Records Administration (NARA 2004) provides an excellent, useful overview of how to calibrate a digitization environment and its related technology, providing clear and usable workflows to aid those in setting up their own digitization studio or centre in ensuring the images they capture will be of high quality. Likewise, the Library of Congress guidelines on digitization contain a section on calibration of the digitization environment (2007). MacDonald and Jacobsen (2006) provide a thorough overview of image quality assessment, including technical factors such as tone, sharpness, noise and colour, and image quality metrics.

Lester (1999) and Mitchell (1992) are essential reading for those wishing to know more about the ethics of image manipulation; Willis (1990) is strong on theoretical implications (if technologically rather dated now). Russ (2001) discusses the technical and legal issues regarding the use of digital images as forensic evidence, particularly in court cases. Lipkin (2005) explores the extent to which modern artists are utilizing digital imaging, investigating, in particular, the manipulation of digital images to create photorealistic artworks, and the ethical and artistic concerns this raises.

Cornish (2004) provides an overview of copyright law in the UK, incorporating recent changes in EU law and the consequences this has for the information worker, including recent issues such as electronic rights management and digitization programmes. Norman (2004) is another, readable, general text: Wienand et al. (2000) provide a guide particularly for Museums and Galleries; Padfield's text (2007) is focused on archivists and records managers. TASI (2006f) provides a thorough overview of copyright and digital images, also providing further copyright guides specifically for staff building digital image collections (2006g), and the issue of copyright when using digital images in teaching and research (2006h). Hughes (2004, 53–78) fully explores 'Intellectual property, copyright and other legal issues' with regard to digitization projects. Becker et al. (2003) provides a thorough overview on issues of digital rights management.

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