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Technical Guidelines for Digitizing Cultural Heritage Materials

Creation of Raster Image Files

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Source Documents

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Technical Guidelines for Digitizing Cultural Heritage Materials: Creation of Raster Image Master Files *http://www.digitizationguidelines.gov/guidelines/FADGI_Still_Image-Tech_Guidelines_2010-08-24.pdf*	Don Williams and Michael Stelmach
Document Type	Technical Guidelines
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Title	**Authors**
Technical Guidelines for Digitizing Archival Records for Electronic Access: Creation of Production Master Files – Raster Images *http://www.archives.gov/preservation/technical/guidelines.pdf*	Steven Puglia, Jeffrey Reed, and Erin Rhodes U.S. National Archives and Records Administration
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or the creation of textual representations via OCR. In many cases, the derivatives intended to serve end-user access employ lossy compression, e.g., JPEG-formatted images. The formats selected for derivative files may become obsolete in a relatively short time.

File Compression

Compression may be appropriate for both master and derivative files. Significant benefits can result from the appropriate use of file compression. Lossless compression such as LZW and JPEG 2000 (wavelet) are approved for all uses. Lossy compression may be appropriate for specific uses. In considering the use of compression, the combination of the file format and the compression should be evaluated for long term sustainability as a system. Compression techniques using patented or proprietary programs should be avoided due to long term sustainability concerns.

File Format Comparison

The choice of file format has a direct effect on the performance of the digital image as well as implications for long term management of the image.

Additional information on file formats and format selection can be found here:

http://www.digitalpreservation.gov/formats/index.shtml

FADGI Glossary

Please refer to the FADGI Glossary for more extensive definitions of digitization terminology.

http://www.digitizationguidelines.gov/glossary.php

Limitations of the Guidelines

These guidelines are specific to imaging to the four quality levels defined in this document. It is possible to digitize to higher than four star specifications, which may be appropriate for specific applications that demand exceptional quality. Specifications for imaging projects that demand higher than four star performance should be determined after considering the end use of the digital image and the original to be digitized.

The FADGI four star system defines quality standards appropriate for most cultural heritage imaging projects, and takes into consideration the competing requirements of quality, speed of production, and cost. FADGI does not provide recommendations for applications that are either below one star or above four star requirements.

These guidelines do not address archiving/preservation of born-digital materials.

Physical Environment

Standardization of the digitization environment creates a workspace where the variables of visual perception can be controlled. Without standardization, perception of image quality may vary dramatically. In an imaging environment where human judgement is a factor, standardization of the physical environment is critically important to maintaining consistency. The recommendations that follow address the most common issues related to a proper physical environment for digitization. FADGI recommends the following:

Room

The working environment should be painted/decorated a neutral, matte gray with a 60% reflectance or less to minimize flare and perceptual biases.

Monitors should be positioned to avoid reflections and direct illumination on the screen.

ISO 12646 requires the room illumination be less than 32 lux when measured anywhere between the monitor and the observer, and the light a color temperature of approximately 5000K with a CRI above 90. Consistent room illumination is a fundamental element of best practice in imaging. Changes in color temperature or light level from a window, for example, can dramatically affect the perception of an image displayed on a monitor.

Each digitization station should be in a separate room, or separated from each other by sufficient space and with screening to minimize the light from one station affecting another. It is critically important to maintain consistent environmental conditions within the working environment.

Care should be taken to maintain the work environment at the same temperature and humidity in which the objects being imaged are normally kept. Variations can cause stress to some materials and in severe cases may damage the originals. The use of a datalogger in both imaging and storage areas is highly recommended. While specific temperature and humidity recommendations are beyond the scope of this document, adherence to American Institute for Conservation of Historic and Artistic Works (AIC) Guidelines is recommended.

http://www.conservation-us.org

Monitor, Light Boxes, and Viewing Booths

The trio of monitor, reflection viewing booth, and transmission light box can provide a calibrated reference viewing environment to accurately portray physical objects and their digital representation. If designed correctly, these create an environment suitable for cultural heritage digitization.

The lighting parameters described above are too dim to properly evaluate an original against the digital representation on a monitor. For reflective originals, a 5000k viewing booth with a CRI of 90 or better should be placed in proximity to the monitor to provide adequate illumination for comparison. For viewing transparencies, a 5000k transmissive light box, with a CRI of better than 90 should be used.[3] For both reflective and transmissive viewing, the luminance of the light box should be adjusted to match the luminance of the monitor. Viewing of color and black and white negatives does not require a color accurate since no color comparisons can be made with these materials. Areas beyond the reflective or transmissive image should be masked off with neutral material to prevent stray light from altering perception of the originals.

Images must be viewed in the color space in which they will be saved, and the monitor must be capable of displaying that color space. The illuminance of the monitor must be set to a brightness that produces a good white match to the viewing environment for the originals. The graphic card in the computer must be capable of displaying 24 bit color and set to a gamma of 2.2.

The appropriate color temperature and illumination level of the monitor may vary based on a number of uncontrollable factors. Adjust the illumination and color temperature of the monitor to provide the best approximation of white in the viewing environment to the digital representation of white on the monitor. Refer to ISO 12646 and 3664 for additional documentation if needed. Be careful not to offset the monitor to compensate for a poor working environment.

The color of the monitor desktop should be set to L*50, a*0, b*0. This establishes a visually neutral mid-gray monitor background.

Careful attention must be paid to the selection of monitors for professional digital imaging. Most monitors in the marketplace cannot display Adobe 1998, ProPhoto or ECIRGBv2 color spaces. Digital images cannot be viewed accurately on a monitor that cannot display the range of color that these color spaces include. The sRGB color space is viewable on most current color monitors. Care must be taken as well in monitor selection to assure that the selected monitor provides an adequate viewing angle without perceptible image change.

In order to meet and maintain the monitor settings summarized above, it is recommended that professional LCD monitors designed for the graphic arts, photography, or multimedia markets be used.

A color calibrator and appropriate software (either bundled with the monitor or a third party application) should be used to calibrate the monitor to Adobe 1998, ProPhoto, ECIRGBv2 or sRGB color space as

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[3] https://en.wikipedia.org/wiki/Color_rendering_index

appropriate. This is to ensure desired color temperature, luminance level, neutral color balance, and linearity of the red, green, and blue representations on the monitor are achieved and maintained.

An ICC profile should be created after monitor calibration for correct rendering of images, and the monitor calibration should be verified weekly, preferably at the beginning of the week's imaging.

Using a monitor calibrator, however, does not always ensure monitors are calibrated well. Practical experience has shown calibrators and calibration software may not work accurately or consistently. After calibration, it is important to assess the monitor visually to make sure that the monitor is adjusted appropriately. Assess overall brightness, and color neutrality of the gray desktop. Then assess a monitor calibration reference image for color, tone scale, and contrast. The use of a monitor calibration reference image is an essential element of creating and maintaining a proper digitization environment.

Cleanliness of Work Area

Keep the work area clean. Scanners, platens, and copy boards will have to be cleaned on a routine basis to eliminate the introduction of extraneous dirt and dust to the digital images. Many old documents tend to be dirty and will leave dirt in the work area and on scanning equipment.

See, for example, NARA's *Preservation Guidelines for Vendors Handling Records and Historical Material* at http://www.archives.gov/preservation/technical/vendor-training.html for safe and appropriate handling of originals. Photographic originals may need to be carefully dusted with a lint-free, soft-bristle brush to minimize extraneous dust.

Vibration

Sources include cooling fans on an imaging sensor, or movement of the sensor/original in a scanner. Even the slightest vibration will have a dramatic effect on image quality. If vibration is determined to be an issue, remedial efforts including changing the scanning speed or adding vibration dampening materials to the scanner may be helpful. For instant capture camera systems, the use of electronic flash lighting can effectively reduce the effects of vibration on image quality.

Flare

Stray light entering a lens can create flare, a condition where the purity of image forming light is degraded by unwanted extraneous light. This can also be caused by lens elements that have hazed over time and either require cleaning or replacement. Check lens condition by looking through the lens at a bright light source (not the sun) and observe the clarity of the glass. While simple, this test is quite effective. The use of a lens hood is highly recommended. Reduction of stray light around the original will considerably reduce flare.

Lighting

All light sources have variations in their spectral distribution. Light sources that have serious deficiencies in their spectral distribution are unsuitable for use in a cultural heritage imaging environment. This parameter is generally measured by the *Color Rendering Index,* which is a measure of how close the spectral distribution is to the reference (the sun). A CRI above 90 is generally accepted as appropriate for most cultural heritage imaging.

Another consideration for lighting is how diffuse the source is. Highly diffuse light sources provide a soft, shadowless wash of light, but this comes at the expense of clear delineation of detail and can reduce color accuracy. On the other extreme, highly collimated, or "point" light creates a harsh rendition which can be just as undesirable. Selection of appropriate lighting is as much art as science, and is highly application specific.

Accessories

A series of specialized aids are useful for cultural heritage digitization. System alignment tools lead the list. An imaging system must be parallel at the sensor, lens, and object planes. There are many aids on the market to accomplish this, the simplest of which is a spirit level, or the electronic level incorporated into many smart phones. A more accurate method involves bouncing light from an emitter device off of a reflector placed over the lens and using the reflection to measure deflection. This method allows very precise alignment with an easy to accomplish process. Proper system alignment is essential for quality imaging.

A tool kit consisting of gloves, spatulas, thin mylar strips, weighted hold down aids, lens wipes, air duster, soft brushes, etc. should be available at each imaging station. The contents can be refined for the specifics of each digitization activity.

Digitization Equipment

It is beyond the scope of this document to provide recommendations on specific digitization equipment, and such advice would quickly become obsolete if we did. However, it is within the scope to discuss classes of digitization equipment and their application to cultural heritage digitization.

Camera

Digital cameras have become first line digitization tools in the cultural heritage community in the past few years. It is common to have digital cameras with 50 to 80 MP sensors coupled with very high quality lenses that together provide a fast and high quality digitization system. However, digital cameras have limitations.

The principal limitation is the imaging sensor. The sensors generally used in digital cameras cannot "see" color. To solve this problem micro color filters are coated on each pixel site of the sensors in what is known as the Bayer filter pattern. Each block of four pixels is arrayed to resolve one color, using one red, two green, and one blue filter. Inevitably this leads to reduced resolution and imperfect color. Very sophisticated algorithms translate the information and interpolate full color data for each of the four pixels. In essence, the true resolution is far less than the stated resolution, and the color is interpolated from the data from four pixels.

However, the results are compelling and the cultural heritage community has embraced professional digital cameras. Given the complexity of these imaging systems, it is essential to test the entire imaging system for performance.

A few digital cameras use monochrome sensors, without the Bayer filter. These specialty cameras may be appropriate when imaging monochrome materials, and may be incorporated into digitization systems that use multi-exposure processes to achieve color, hyper-spectral and multi-spectral images.

Scanner

Digital scanners use several different technologies to capture images. The oldest of these is the photomultiplier tube (PMT) used primarily in drum scanners. To this day, drum scanners provide the highest image quality of all imaging devices, but due to the risk of damage to originals and inherently slow speed, they are inappropriate for most cultural heritage digitization.

The predominate technology used in scanners today is the linear, or tri-linear array. This is a one pixel line of sensors the length of the device, sensing only one color through a solid filter, or gray without a color filter. Linear scanners can image both reflective and transmissive, depending on the design of the scanner. These scanners rely on very precise movement of either the original or sensor in relation to the original, capturing data one line at a time as the system "scans" across the object. In a tri-color configuration, there is a distance gap between the three rows of sensors, which is compensated for as the image is constructed in software.

Planetary Scanner

This class of scanner uses one of two methods to capture an image. Either the sensor moves in the camera head capturing the image one line at a time or the sensor remains stationary and the object moves under the camera, again capturing the image one line at a time. Beyond this difference, there is great similarity to a digital camera on a copy stand. Planetary scanners have the advantage of being able to capture images in very high resolution, due to the very long high resolution linear sensors available, and the unlimited ability to add rows of scans in one dimension if the system moves the original under the camera. However, they take time to capture an image and are only efficient for original materials that can be held flat during the long exposure cycle.

Flatbed Scanner

The flatbed scanner has found a home in almost every digitization facility in the world. They can be fast, very high resolution, easy to use and versatile, scanning everything from film to documents. Few of this breed, though, have a place in a cultural heritage digitization effort. Perhaps the best policy to adopt in considering flatbed scanners is you get what you pay for. Beware of fantastic claims of resolution or dynamic range. Rely on DICE testing to verify the results. For almost every application where a flatbed scanner might be used, there is a better solution using other tools. However, FADGI recognizes that flatbed scanners have their place and may be appropriate for some applications.

Lens

High quality optics are critically important in cultural heritage imaging. All lenses are designed and optimized for specific applications, and there may be significant variability in the performance of two identical lenses. DICE testing will validate performance specifications of the lens as integrated in the total imaging system. Generally, apochromatic and macro lenses outperform other lenses for cultural heritage close focusing applications, and lenses designed specifically for digital flat field imaging are best. It is important to assure that the image circle of the lens is appropriate for the imaging sensor used and that the lens is designed to be used at the working magnifications needed.

As digital sensors become available in ever higher pixel counts, the quality of the lens becomes a critical factor in actual system resolution. It has reached the point where the resolution of digital cameras and scanners may be limited by the performance of the lens, and in some cases a theoretically perfect lens cannot match the resolution capability of available digital sensors. More pixels on the sensor may not relate to increased resolution in the digital file.

Film Scanner

Film scanners are perhaps the least understood class of digitization equipment. Under the hood they are really either a planetary scanner or digital camera, with the exception of true drum scanners, which are single point acquisition devices. What makes film scanners unique is the software designed to interpret the film image and convert the digital data into an image file that resembles the final original image, which is a generation away from the film itself in the case of either a color or black and white negative. This is an especially difficult task for negatives since they lack a visual reference, and rely on an operator interpretation of the digitized negative.

Drum Scanner

Drum scanners function by securing either reflection or transmission originals to the surface of a "drum," generally with tape. The drum then spins at high speed and individual pixels are acquired through a focused lens one at a time as the drum spins. Very high quality scans can be produced from high quality drum scanners, but there is risk to the original as it spins attached to the drum. These systems are also quite slow. Given the risk to the original and the method of attachment, these scanners have very limited application in cultural heritage imaging.

Selection of Digitization Equipment

Proper selection of digitization equipment is an essential element of a successful digitization program. Factors to consider are:

- Type of materials to be digitized
- Size of the originals
- Quantity of each type of original
- Condition of the materials and how they can be handled during scanning
- Staff digitization experience and quantity
- Budget
- Physical space available
- Duration of the project