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Benchmarking for Digital Capture

Wedding Image

The original of this Wedding Image is a continuous tone photograph. It is likely to be an early 20th century black and white developed print of a photograph taken in monotone. The type and date of this photograph are identifiable by the silver-gelatin appearing in the black areas around the edges of the photograph (Frey, 2000, p. 122).

There are several important characteristics of this type of original. One important attribute is the level of detail, such as the lace, the fabrics of the clothing, the eye glasses, the flowers, and the wedding band. Although the photograph is black and white, its color cast is an important feature. Color information contained in the black areas around the edges gives clues regarding the production process used and the probable date range for creation. The photographic finish would also be of interest to users, as this corresponds to photographic techniques used, and relates to the date of the photograph. Dynamic range is "the range of tonal difference between the lightest light and the darkest dark" (Kenney, 2000, p. 37). A scale ranging from 0 to 4 is used to indicate dynamic range. The dynamic range of the wedding image, a reflective type of document, would fall between 1.4 and 2.0, or in the medium area. Although the dynamic range is limited, there are many tones represented. It appears to me that this photograph has been properly exposed. The tonal characterization of a document is subjective, and requires identifying "the most challenging information to capture" (p. 38). My guess is that this is a high-key image, where details of the woman's wedding garments concentrated in the highlights are the most challenging information to capture. Finally, if the original document were to be digitized, its physical size, type, presentation, and condition would be factors to consider. The original photograph is most likely a single-leaf reflective document that can be accommodated by most flatbed scanners. However, its physical condition may have implications for scanning (pp. 31-33). The print may be vulnerable to damage, or may be difficult to scan for various reasons. However, deteriorating condition may provide a compelling reason to create a digital surrogate.

The most important characteristics of this wedding image to capture are its tonal range, color, and details. A scanning system that exceeds the dynamic range of the photo should be used to capture the tonal range (Kenney, 2000, p. 38). The image should be scanned using a color flatbed scanner (p. 39). "In 24-bit color scanning, the tonal values in the original are reproduced from combinations of red, green, and blue (RGB) with palettes representing up to 16.7 million colors" (HATII & NINCH, 2003, p. 107). Scanning the photograph at 24 bit-depth would ensure that meaningful color information, such as the silvering, would be conveyed to the user. Capturing details of a photo in the scanning process is dependent on "resolution, bit-depth, and scanner performance" (Kenney, 2000, p. 44). "In digital imaging, the finest feature should be covered by at least two pixels" (p. 46). The finest line of a continuous tone photograph, such as an individual hair, should be measured with a microscope (p. 45). Scanning at twice visual perception should be sufficient to convey details discernible by the human eye. There is no fixed method to determine resolution for a continuous tone document. Between 400 and 600 dpi is recommended by several experts in the field (p. 47). The Association for Library Collections & Technical Services (ALCTS) (2013) recommends a minimum resolution of 400 ppi for photographic prints less than 8" x 10".

If the dimensions of the original are 3” w x 5” h, the pixel dimensions it would take to scan the document at 300 dpi would be 900 pixels by 1500 pixels. The pixel dimensions it would take to scan the document at 600 dpi would be 1800 pixels by 3000 pixels. Pixel dimensions = (width x dpi) x (height x dpi) (Cornell University, Basic terminology: Pixel dimensions, 2003).

The following calculations show file sizes in bytes and kilobytes for various scanning methods for this Wedding Image, assuming its dimensions are 3" x 5" (Table 1). The formula used to determine file size is: (Height x Width x Bit-depth x dpi^2) / 8 = File size in bytes (Cornell University, Basic terminology: File size, 2003).

Image Type	300 dpi (bytes)	300 dpi (KB)	600 dpi (bytes)	600 dpi (KB)
1-bit bitonal	168,750 bytes	165 KB	675,000 bytes	659 KB
8-bit greyscale or color	1,350,000 bytes	1,318 KB	5,400,000 bytes	5,273 KB
24-bit color	4,050,000 bytes	3,955 KB	16,200,000 bytes	15, 820 KB

Table 1. File sizes (KBs are rounded)**.**

1-bit bitonal calculations:

For 300 dpi	For 600 dpi
(5 x 3 x 1 x 300^2) / 8	(5 x 3 x 1 x 600^2) / 8
= (15 x 90,000) / 8	= (15 x 360,000) / 8
= 1,350,000 / 8	= 5,400,000 / 8
= 168,750 bytes	= 675,000 bytes
168,750 / 1,024	675,000 / 1,024
= 164.794922 KB	= 659.179688 KB

8-bit greyscale or color calculations:

For 300 dpi	For 600 dpi
(5 x 3 x 8 x 300^2) / 8	(5 x 3 x 8 x 600^2) / 8
= (120 x 90,000) / 8	= (120 x 360,000) / 8
= 10,800,000 / 8	= 43,200,000 / 8
= 1,350,000 bytes	= 5,400,000 bytes
1,350,000 / 1,024	5,400,000 / 1,024
= 1,318.35938 KB	= 5,273.4375 KB

24-bit color calculations:

For 300 dpi	**For 600 dpi**
(5 x 3 x 24 x 300^2) / 8	(5 x 3 x 24 x 600^2) / 8
= (360 x 90,000) / 8	= (360 x 360,000) / 8
= 32,400,000 / 8	= 129,600,000 / 8
= 4,050,000 bytes	= 16,200,000 bytes
4,050,000 / 1,024	16,200,000 / 1,024
= 3,955.07813 KB	= 15,820.3125 KB

<u>Text and Photo Image</u>

The text and photo image is a mixed document type, which contains both printed text and a continuous tone image. Its color type is a black and white photograph with "no significant visual information conveyed by the color" (Frey, 2000, p. 122). The dynamic range, which is the range of tonal difference between the lightest light and the darkest dark, can be rated on a scale from 0 to 4. The two distinct areas of this document contain differing dynamic ranges. While the dynamic range of printed material is 1.5, photographic prints are from 1.4 to 2.0 (Kenney, 2000, p. 37). Both the text and photo areas of this image fall in the low to medium dynamic range. It is possible that this photograph has been underexposed with some detail being washed out of the lighter areas. The tonal composition of the photo seems to be balanced, with evenly distributed detail content (p. 38). The details in the photo area of the original contain important information, such as the faces of participants in the lighter areas, and clothing, hair, and room decor in the shadows. Other attributes to consider are its physical size, type, presentation, and condition. The original document appears to be a page of reflective paper extracted from a book or pamphlet. Pages of a bound item should be examined to determine whether they can be unbound for scanning (p. 31). This document could most likely be accommodated by a flatbed scanner, unless it is greater than 8 1/2" x 14" (p. 32). The document appears to be in good physical condition, and not otherwise vulnerable to damage.

To digitize the original image, one would prioritize the most important characteristics to capture. The tonal composition of the original document would determine the necessary bit-depth. "Good digital masters are characterized by having pixels distributed across the tonal range in the image from black to white" (HATII & NINCH, 2003, p. 107). For non-rare books and textual based documents with images, the ALCTS (2013) recommends using a minimum of 8-bit grayscale, but using color (24-bit) whenever possible. While grayscale is sufficient for black and white photos, color scanning could distinguish subtle color variations. The choice would depend on budget, goals, user needs, and a sample testing (HATII & NINCH, 2003, p. 108).

The details in the photograph and in the printed characters are also important attributes to capture. In addition to bit-depth, resolution also determines the level of detail of an image. "Resolution is the key factor in determining image quality for textual material" (Cornell, Quality Control, 2013). For text, detail can be measured in terms of the height of the smallest lowercase printed character. To calculate this measurement, "use an eye loupe (10x) with a scale reticle with increments to the nearest .1 mm" (Kenney, 2000, p. 44). To capture sufficient detail for text legibility in printed text, the quality index (QI) method, which relates resolution to text legibility, should be applied. This involves measuring the height of the smallest character, and using a formula to calculate resolution requirements. QI values range from 8, which indicates excellent rendering, to 5, good legibility, to 3, barely legible (p. 45). If an optical character recognition (OCR) program will be used for full text purposes, a higher resolution is required. Cornell University (Key concepts: Benchmarking text, 2003) recommends 600 dpi for excellent quality of textual information. Since this document is a mixed item, resolution requirements for the continuous tone image must also be considered (Kenney, 2000, p. 45). The finest feature of the image, such as eyeglasses or a pen, should be covered by at least two pixels (p. 46). Measurements of the smallest sharp or crisp detail should be taken using a microscope with a magnification of at least 50x (p. 45). The resolution required to render details in a continuous tone document is subjective. The ALCTS (2013) recommends a minimum resolution of 400 dpi for non-rare books and textual based documents with images.

Manuscript Page Image

This image is a manuscript, with soft-edged characters produced by hand in ink on reflective paper. The important characteristics include its dynamic range, color cast, details, and physical condition. The dynamic range of this manuscript, which is considered a reflective printed material, is 1.5, or in the low to medium range (Kenney, 2000, p. 37). There is a relatively low contrast between the text and the background. The colors in this manuscript are flat and the palette is limited. However, the colors convey important information regarding the age and condition of the document, which would be considered "unintended color" by the

Library of Congress (p. 42). Colors would also reveal clues about the medium and support, which may be of interest for scholarly research. The details of this documents would be important to represent in a digital surrogate. Details of manuscripts are measured in terms of the width of the finest stroke (p. 44). The physical condition of this document is an important feature. It appears to be a single-leaf document that could be accommodated by a flat-bed scanner. It is damaged, old, and discolored, and may require special handling or equipment. The document may require digital capture for preservation purposes. The tonal composition of this manuscript would be low-key, as the details are in the darker text colors, or shadows.

The characteristics of the original document would influence choices of bit-depth and resolution in digital capture. The dynamic range, tonal characteristics, and physical condition of this manuscript would determine the choice of bit-depth. The dynamic range of a manuscript would be rated 1.5 on a scale of 0 to 4 (Kenney, 2000, p. 38). Although 8-bit grayscale scanning is sufficient for documents with a mid- to low dynamic range, an institution may choose to scan this document in 24-bit color to convey important color information (pp.38-39). The color appearance of this document is a subjective measurement of the human eye (p. 43). The stains, markings, and smearing, for instance, would require tonal distinctions to preserve the document's appearance (p. 33). The choice of bit-depth would depend on user needs, cost, and institutional goals. The "Minimum Digitization Capture Requirements" (ALCTS, 2013) recommends a minimum of 24-bit color scanning. Manuscript details involve legibility, and would influence the choice of resolution for digital capture. Details can be measured "by the width of the finest line, stroke, dot, or marking that must be captured in the digital surrogate" (Kenney, 2000, p. 46). "A powerful eye loupe or microscope (minimum 30X) with a light source and scale reticle to the nearest .01 mm" should be used for this measurement (pp. 44-45). The finest line or stroke should be covered by at least two pixels. The ALCTS (2013) recommends a minimum resolution of 400 ppi for manuscripts. Manuscripts are not suited to optical character recognition software.

<u>Color target01 image and Color target02 image</u>

Targets are used to objectively measure tone reproduction, detail and edge reproduction, noise, and color reproduction (Frey & Reilly, 2006, p. 15). Color and grayscale targets are also used for evaluating and characterizing scanning systems and for adjusting the controls of display systems. A color or grayscale target might be included with Color target01 image and Color target02 image for quality control purposes. The targets in these two images could provide a reference point to help ensure proper tone reproduction, which is "the single most important parameter for determining the quality of an image" (p. 17). The color and grayscale targets included in these images may also be used as a control sample to visually assess the colors of the digital reproduction (Kenney, 2000, p. 43).

The Mode tool in Photoshop reveals information about bit depth. The bit depth of Color target01 image is 24 bits (8 bits x 3 channels = 24 bits). The bit depth of Color target02 image is 8 bits.

The brightness and contrast of Color target02 image can be adjusted and the effects can be measured on the image histogram tool in Photoshop. As the brightness is increased, the bars on the histogram shift towards the right, reds and yellows disappear from the histogram, and the colors in the color bar fade. As brightness is decreased, the bars in the histogram shift toward the left, they become more densely spaced, and the colors in the color bar darken. The brightness of an image may be adjusted to compensate for a faded original due to age or other factors. Altering the brightness in a post-processing function would allow a user to view the image as it appeared at the time of creation. However, the brightness tool is not selective: it changes all the pixels evenly. This function should be used sparingly. Fading may give the user important clues about the production processes, medium, support, and age of the original document. Image adjustments also raise concerns about fidelity and authenticity (Cornell University, Key concepts: Scanning factors, 2003). User needs and institutional and project goals should be carefully considered before adjustments are made. Alternatively, a master copy for archival and scholarly research could retain the original attributes, and a duplicate copy for other needs could undergo post-processing functions.

When the caption of the picture in Color target02 image is viewed closely, the text appears pixilated, some color information is missing, and details are lost. There are several reasons for this appearance. The text may appear pixilated due to the choice of low resolution for scanning. Low resolution results in smaller file sizes, but less detail. To capture sufficient detail for text legibility in printed text, the quality index (QI) method should be applied. This involves measuring the height of the smallest character, and using a formula to calculate resolution requirements (Kenney, 2000, p. 45). Another possibility for the loss of detail may be that the original document is quite old, and the ink may have deteriorated and faded. The Photoshop Mode tool indicates that the image was scanned using indexed color, which offers a limited range of possible color values. The faded parts of the text in the caption may have matched more closely to the background color than the color of the ink of the text. If this was the case, the faded areas of the caption text may have been assigned the background color instead of the caption text color for the digital capture. this would result in lost detail.

Beach image

The size of the Beach image is 16.0 megabytes. When "Greyscale" is selected, the size of the image is reduced to 5.3 megabytes. When 400 pixels/inch is selected for output, the size of the image is reduced to 683.6 kilobytes. When the image is exported, saved as a JPEG, and then re-opened in Photoshop, the size displayed in the Photoshop window is 16.0 megabytes (which is very confusing. You'd think the file size would be smaller since the color information has been discarded, but this is what Photoshop says).

When viewing both the original Beach image and the Beach_file001.jpg image side-by-side at 16.7%, there is an obvious difference in color. The original image contains color information that is not represented in the greyscale version. However, it there is no difference in detail that is observable at 16.7%. The histogram of the original image is a continuous curve that is concentrated toward the right. The histogram of the JPEG viewed in greyscale forms a spiked pattern, indicating an uneven distribution of digital values. This is an effect of image processing (Frey & Reilly, 2006, p. 19).

I do not notice any compression artifacts in the GIF version, even when zooming in at 700%. Artifacts likely exist, but I can't see them. However, the JPEG version contains many artifacts, which are obvious when the three versions are compared at 400% (Figure 1). Pixel squares are visible, and fine details, such as fabric textures, hairs, eyelashes, and eyebrows disappear.

Figure 1. Compression artifacts are apparent in the JPEG version (right) when viewed at 400%.

If all three images are viewed at 50%, there is no significant difference in detail (Figure 2.). At 66.67%, pixilation becomes visible in the JPEG version. While the TIFF and the GIF versions are smooth, and the tones are continuous, the JPEG loses the fine details, and pixel squares are visible (Figure 3). Pixilation does not become visible in the GIF and TIFF versions until they are viewed at 500% (Figure 4).

Figure 2. The GIF, the TIFF, and the JPEG files look similar when viewed at 50%.

Figure 3. The GIF (left) and the TIFF (middle) files look similar when viewed at 66.67%. However, the JPEG (right) file begins to look pixilated.

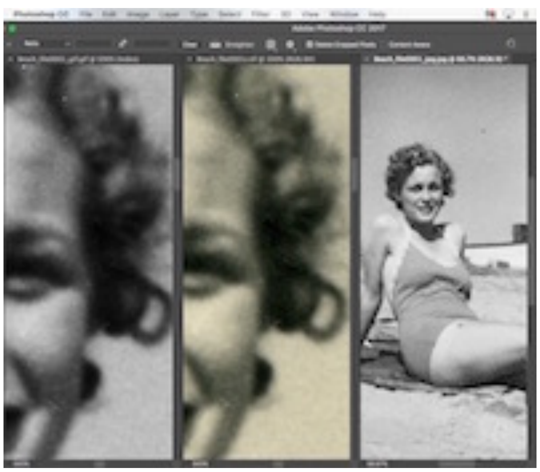

Figure 4. Pixilation does not become apparent in the GIF and the TIFF files until they are viewed at 500%, as compared with 66.67% in the JPEG file (right).

Lower resolution and bit-depth result in smaller file sizes, which reduce storage costs and are quicker to download. However, digital image quality suffers. Institutions should carefully consider the trade-offs between file size and image quality. Future technologies, the goals of the digitization project, and the needs of users should be considered when deciding on resolution and bit-depth. Images should be scanned at a high quality for continued use as technology improves. If the goal of a digitization project is to provide access to materials for scholarly research requiring detailed color reproductions, then it makes no sense to try to save money by capturing images at low resolution and bit-depth. If image quality is too poor for scholarly research purposes, then the digitization project fails, and the entire budget is wasted. If institutions seek to create digital surrogates for preservation purposes, low quality images are useless. Institutions should discover the lowest resolution and bit depth required to meet project goals and user needs. This threshold varies among projects and users, but guidelines are useful in making these determinations.

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