# Digitization workflow for color transparency collections

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## Introduction

A large number of images of artistic, historical and personal value exist in collections of 35mm color transparencies which have been amassed over the past 70 years. The majority of these transparencies have been recorded on Ektachrome™ type media, including Ektachrome, Fujichrome, some Agfachrome, and Ferrania (mostly private label) film stocks.

A major advantage to preservation of these collections in their present form is the eye readability of the images. Indexing these collections, however, is neither straightforward nor standardized. Moreover, even with storage under typical "good" conditions, e.g., in the dark, in metal file boxes, stored in air conditioned environments typical of most commercial or academic buildings, substantial deterioration of the images occurs, including embrittlement of the film base and, more significantly, dye fading. Mold and mildew may be problems on storage under higher humidity conditions, as well. In our experience these problems are more critical in glass-mounted transparencies.

Digitization of these collections can enable indexing and access, as well as incorporating restoration as a routine part of the digitization workflow. In digital form the images can be viewed on various display devices and prints can be easily made from them. Owing to the sheer volume of material often involved, substantial triage may be required, however.

One purpose of creating a digital archive is to provide convenient access to the images in the collection. At the same time the digitally accessed images should provide a viewing experience analogous to that of viewing the projected slides. The dynamic range of projected slides is, however, significantly greater (up to 750:1)[1] than that of typically used soft display devices, for which it may be as low as 30:1.[2] This change in dynamic range is also associated with a restriction in color gamut, which is further reduced by the environment in which most soft displays (computer monitors, portable digital picture frames, etc.) are used. It must be kept in mind, however, that the large dynamic range of the color slides is in a sense artifactual, insofar as the dynamic range of the projected image corresponds to a brightness scale of ca. 160:1 (5 stops) in the original scene being photographed.[1]

The objective of the present work is to establish a workflow, guided by imaging science principles, based on hardware and software typical of that readily available in the consumer marketplace. In the course of this work we also define conditions for making archival, eye-readable hard copies of the images to complement the digital collection.

## Methodology

Ektachrome™-type 35mm color transparencies were scanned on an EPSON Twain transparency scanner at 1200 dpi with automatic exposure control. The resulting file sizes were ca. 5 MB, comparable to images captured in professional and advanced amateur digital photography. Professional scanners used, e.g., in prepress work operate at 3200-3600 dpi, but scanning at these resolutions produces ca. 30 MB files, which are not only unwieldy for the subsequent image processing steps but for rapid access of the imagery when stored remotely from the computer (web storage, dedicated external hard drive, etc.) The 1200 dpi scanning resolution corresponds to a Nyquist frequency of 96 $mm^{-1}$; the resolution limits for typical 35 mm lens-reversal film has historically been in the range of 80-100 lp/mm.

The process was controlled visually using a CRT display; CRT displays, in general, exhibit less variability and better stability than do LCD devices. Captured images were adjusted in RGB color space using Adobe Photoshop™ for histogram equalization, color cast, owing primarily yellow and cyan fading, color saturation, and unsharp masking. High dynamic range images were generally found to require additional characteristic curve shape adjustment to realistically display the range of information on the original transparency within the more limited dynamic range of the soft display devices.

Digitized images were archived in JPEG format at maximum quality (minimal compression). JPEG was selected rather than JPEG2000, owing to the documented superior performance of the former with respect to artifact generation at low degrees of compression.[3] Individual file sizes after processing and compression were typically ca. 850 KB, comparable to consumer digital photos, and suitable for enlargement up to 20 x 30 cm. The corresponding degree of compression is ca. 6, at the boundary between lossless and lossy compression.[4] Files were backed up on Delkin Archival Gold™ DVDs, for which a 100 year life is claimed by the manufacturer.

For an eye-readable archive, prints were made using an EPSON StylusC86 printer and DuraBrite™ pigment inks on Wausau™ acid-free, lignin-free media (67 lb., 96% brightness) at 300 dpi, which required resampling insofar as a 20 x 30 cm print from the digital file as recorded would correspond to 150 dpi, below the 220 dpi required, according to printer manufacturer's recommendation, to avoid visible pixellization. A fine art, rather than a so-called photo quality, paper was selected in part owing to superior abrasion resistance of the printed image and guaranteed archival quality of the paper, even though the density scale and color gamut of such papers are somewhat lower than for state-of-the-art photo grade papers.[5]

## Results and Conclusions

Visual estimation suggested detective quantum efficiency ca. 25% for the overall process, i.e., the sharpness and graininess of a display print, made as described above from a transparency on ISO100 film, corresponded visually to those characteristics which might be expected for an optical print from contemporaneous ISO400 film. A major cause for signal-to-noise degradation may be amplification of grain originally present in the film image on histogram equalization.

Histogram equalization, and in some cases curve shape adjustment, was required insofar as dynamic range of the degraded transparencies may fall far below the capability of the original films, and even below that of the digital capture or display devices (200:1 for soft display or 150:1 for prints on paper). Loss of dynamic range may be exacerbated by incorrect exposure of the transparencies at the time of taking. Application of histogram equalization to undegraded, correctly exposed slides will, however, result in tonal scale compression.

Both high and low contrast originals reproduced well; neutral color balance could be restored with appropriate white point selection, and good color saturation could be achieved even with the oldest (> 40 years) transparencies studied. On the other hand, color balance restoration in highlight areas, e.g., facial features, did not necessarily apply in shadow areas; one cause may be that the degradation product of some cyan dyes is a magenta dye, hence the color balance shifts further towards magenta in high density regions than in low density regions of the image. Color correction, primarily saturation correction, may also accentuate chromatic artifacts, e.g., flare spots, in the original image.

Aliasing was also seen to occur in image areas representing fine, high contrast detail. We concluded that this observation may have been unique to the scan resolution employed (1200 dpi), in which case artifacts should be obviated by use of higher spatial frequency scanning, e.g., 2000 dpi, which we intend to explore in future work. Artifacts also appeared to be exacerbated by the use of unsharp masking, which, however, was necessary, at a 50% level with a 2 pixel radius, in order to obtain a visual sensation of sharpness, comparable to that obtained on viewing the optically projected original transparencies.

Typical 35 mm film-lens combinations were generally capable of yielding display quality 11x14" prints, which would customarily be viewed at a distance of ca. 27". Using the blur detection threshold of 40 arcsec in the visual field[6] we estimate that a 2000 dpi scan would be required to preserve the full information content of these images.

Prints (ca. 8x10") representing various originals, the separate stages in the workflow, and illustrative of some of the artifacts which limit its utility will be exhibited as part of this presentation.

## References


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## Author Biography

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