DIGITAL PICTURE RESTORATION AND ENHANCEMENT FOR QUALITY ARCHIVING

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Abstract: Digital Restoration is a process in which an existing hard copy photograph is converted into a digital image. After an image stack has been acquired it may be preprocessed to improve image quality prior to 3-D reconstruction. The preprocessing usually involves application of image filters (mathematical algorithms implimented in software) to the entire data set to remove noise and artifacts, smooth or sharpen the images, or to correct for problems with contrast and/or brightness. Median and Gaussian filters have the general affect of smoothing images. These are used to eliminate noise and background artifacts and to smooth sharp edges, but also tend to remove some of the detail in small objects.

1. INTRODUCTION

An extremely important topic is gaining attention in 2002 -- the need to preserve, archive and restore old photographs by institutions and individuals. On its face, the issue appears simple -- photographs have a life of between 75-100 years, when stored under good conditions. This means that most photographs captured and printed in the 19th Century and many photographs made in the early-to-mid 20th Century are reaching the end-of-life. For important photographs, including a large number of images maintained by institutions (museums, universities, public archives, journals), a failure to take action will result in the loss of images. Because image deterioration is a progressive process, a delay in preservation/restoration may result in a loss of image quality that makes the inevitable task more complex. Since deterioration occurs over decades, rather than mere years, it is easy to neglect the preservation issue until it is too late. Unfortunately, over long periods of time, normal degradation of the image often is accompanied by "traumatic" damage to photographs -- water, smoke or fire, chemical, and even vermin in some cases. Alinari Photo Archives, the oldest picture library with over 3.5 million images from around the world is a perfect example of this kind of problems.

The aggressive preservation of important historical images is a moral imperative -- and quite arguably a financial and legal imperative. The obvious issues concern an archiving institution's fulfillment of its duty to maintain archives. Allowing historical images (which become more valuable over time) to deteriorate is antithetical to an archivist's role. The practical value of an archive fades as the quality of its materials fades. Finally, artists and others who contribute material to an archive are entitled to know that their contribution will be preserved over time through all reasonably available methods. The failure to preserve an image that is subject to deterioration is "passive destruction."

The simple concept of photograph restoration becomes complex in the details. One would expect most restoration and preservation to employ digital image editing technology. Digital image editing technology, which dates back about 11 years, allows old and damaged photographs to be repaired, restored, preserved, archived and otherwise protected. In comparison with traditional retouching techniques (in effect, painting an image) digital technology allows restoration to be done better, more quickly and less expensively. The demand for photograph restoration by individual consumers has increased dramatically over the past few years. Consumers recognize that they are the archivists of their family histories. Indeed, it is common for a family to have one or more members who are responsible for "the albums." Important images are increasingly being restored, scanned for digital preservation. Early experience suggests that many deteriorating album images are transformed by consumers into gifts and framed decorations.

2. IMAGE ENHANCEMENT

After an image stack has been acquired it may be preprocessed to improve image quality prior to 3-D reconstruction. The preprocessing usually involves application of image filters (mathematical algorithms implimented in software) to the entire data set to remove noise and artifacts, smooth or sharpen the images, or to correct for problems with contrast and/or brightness. While these filters are generally performed

as preprocessing steps, they can also be carried out after a 3-D model has been reconstructed from the image stack.

Median and Gaussian filters have the general affect of smoothing images. These are used to eliminate noise and background artifacts and to smooth sharp edges, but also tend to remove some of the detail in small objects.

Sharpening filters can be used to emphazise details in the image stack, but also have the effect of highlighting noise and other small artifacts. The application of sharpening filters is most useful when the image stack consists of fine structural components of a specimen, or when edge enhancement is desired. The contrast and brightness of the image stack can be adjusted to enhance perception of the sampled specimen. This is usually done by changing the ramping of the grey scale values for the dataset. Histogram equilization can be used to improve contrast by a non-linear mapping of the grey levels in an image. This technique is most commonly used when the grey levels are concentrated in a small portion of the range of possible values. It is important to realise that the application of filters to the data set can ultimately affect quantitative measurements of 3-D reconstructions produced from it. As such, the application of filters in some instances are only used for display purposes, and quantitative measurements are made on the unprocessed data.

3. MORAL ISSUE: Is it real or is it altered?

The question is not easy to answer with the imaging software available today. Digital image alteration, photomontage and picture manipulation is very easy to achieve today, with even low end computers. This issue is a hot topic of debate in the publishing industry and important for students everywhere to consider. As suggested by Suzy Hoffmann, pictures have long been considered evidence in court trials, documents in historical exhibits, or as proof you have been somewhere special for vacation. Due to the ease and popularity of photo altering programs, photos must be looked at closely to insure they are real. Consider the two following articles from well know magazines which look at this topic. The first article, WHEN SEEING ISN'T BELIEVING (POPULAR MECHANICS,Electronics, DECEMBER 1997), explores the use of images as evidence in the famous O.J. Simpson trial. In this article, writer Tobey Grumet shows how easy it is to change Mr. Simpson's shoes without ever untying a shoelace. The second article, Believing Your Eyes (Scientific American, From the Editor, August 1988), discusses an image used on the cover of Scientific American's May 1998 issue (Scientific American, May 1998). The altered cover image has astronaut Shannon Lucid looking out a porthole onboard the Russian space station Mir. The picture looks real but is actually an "artists' interpretation," that was created from several photos. Many readers did not read the explanation inside the magazine entitled, About the Cover, and mistakenly assumed it was a real photograph. Read the credits carefully, it might surprise you!

Be careful about where your students obtain photographs and images to use in projects. They need to avoid the temptation of just scanning any interesting image and using it as they wish. Make sure their sources are "ROYALTY-FREE" or you are probably violating copyright laws. Many clipart CD's and Internet sites allow you to use their images, if properly cited. Many of our images are from a site, which charges a very small membership fee. If you use your own photographs this is not an issue. However, most reference works, such as encyclopedias simply license the use of photos and do not own them.

4. APPLIED SCIENCE FICTION SOLUTION [1]

This paper introduces three innovative technologies developed by Applied Science Fiction to address some of the major problems of digital images. Digital ICE™ removes artifacts from digitally scanned images due to surface defects on film and prints. Digital ROC™ addresses color problems of digital images captured from film and prints. Digital GEM™ reduces the noise of digital images that are as a result of grain in the original film target or perhaps introduced during the scanning process. A unique feature of all three technologies is the ability to automatically correct images without the need for user intervention.

Digital ROC uses innovative software signal processing to reconstruct colors of digital images captured from faded media as well as to correct for color cast problems. Noise in digital images is often a result of grain inherent in the digitally scanned film. Photographic film contain grain held on a substrate. The nature of these grains are dependent upon the film type with faster speed films tending to exhibit more graininess. In addition, the scanner device itself may introduce noise into the image during the digitization process. Noise could be introduced in the electrical circuitry or the imaging CCD. Digital GEM uses advanced analysis techniques to identify and reduce grain and scanner noise in captured images. A key aspect of Digital ICE, Digital ROC and Digital GEM technologies is that no user intervention is necessary to achieve proper correction. While similar results might possibly be achieved through manual digital manipulation, the time consumed as well as expertise required would in most cases make manual methods prohibitive. In addition, although these technologies from Applied Science Fiction are totally automatic, controls may optionally be applied according to a user's preference. This paper will discuss the innovative ways in which Digital ICE, Digital ROC and Digital GEM automatically solve particular imaging problems. The discussion will highlight some characteristics of these problems which have until now made effective solutions difficult to attain.

DIGITAL ICE

Digital scanning devices traditionally use visible light sources to capture three channel (red, green and blue) information from the target media. The visible light source is attenuated by the color dyes of the film. This attenuation is captured digitally and thus is what comprises the image content. However, surface defects on film also inhibit light from passing through the film. The more opaque the defect, the less light is passed. Note that at the microscopic level dust is not completely opaque and thus will allow some light to pass. Digital imaging software only techniques generally use feature recognition techniques to identify and remove artifacts caused by surface defects. The IR light source completely passes through the non-defect areas of the target film as it is not attenuated by the film's color dyes. However, when the IR light source encounters a surface defect of the film, then the light source is diffracted. The resultant IR image is an exact map of the image's surface defects. Figure 1 shows an image with its corresponding defect channel. B would be the resultant color value. However, the presence of a surface defect would further reduce the color value to C. In the defect channel, a pixel's value is determined solely either by the presence or absence of a surface defect. The color dyes being transparent to IR have no effect on the defect pixel value. If a defect is not present, then the corresponding pixel will have a value determined directly from the unattenuated IR source. However, if a surface defect is present, the resultant defect pixel value will have value D. dye at that pixel location (value B). If that particular pixel does not have any surface defect at that location then value

Digital ROC

Conventional color film and prints contain dyes which will fade when exposed to light. The speed of this fading process differs between film and paper print types. Additionally, each color dye layer may fade differently from the others. For example, faded images (as well as color casted images) exhibit color shift in one or more of the channel in comparison to the other channels. Along with color shift, faded images also demonstrate a reduced dynamic range in one or more of the color channels. Different film and prints types have differing cross color behavior. A traditional method to handle such differences in film and print types has been to uniquely characterize each type and given the image source, apply specific color corrections. However, for the inexperienced user, identification of film or print type may be difficult or, in some instances, even unknown. Gamma color correction is another method of color correction that is often used. Through manipulation of various red, green and blue color curves, color fading can usually be eliminated. However, this process requires extensive manual manipulation as well as a high skill level. The first step involves the extraction of color information. The color information of a given image is separated from the image noise and intensity variation. Image noise and variations of intensity tend to hide the true color information. The second step eliminates the cross color between channels. The interference of one color into another color channel is measured and removed. Once each channel is left with a pure signal, then the channels are analyzed to determine original color content before fading. The final step involves color correction using the information derived from the previous analysis step.

DIGITAL GEM

Noise in a digital image is often the result of grain presence in the original film target (usually more apparent in high speed films) or introduced during the digitalization process. The noise level of each color channel is usually different. For example, the blue channel may be noisier than either the red or green channels. In addition, the noise level within an image may be different across different densities (image shadow areas often have more noise than other areas). Image frequency content may also influence the noise level of image areas. Common noise reduction techniques tend to be unsuccessful in retaining image detail. Blurring or softening techniques give the appearance of less grain but often cause smoothing in high frequency image areas. Digital GEM provides sophisticated image analysis to identify and reduce the noise level of each color channel without affecting imaging detail.

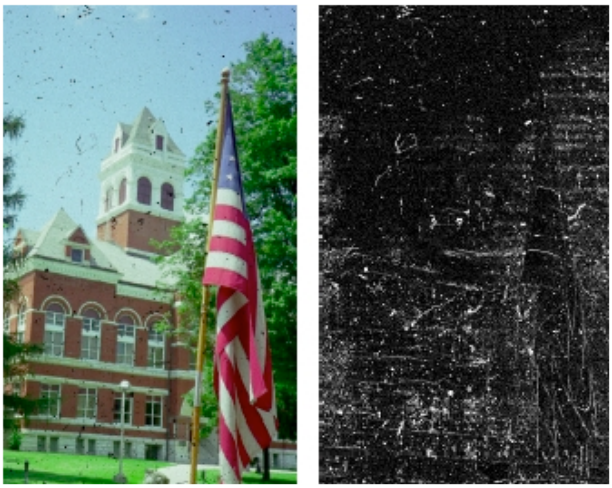

Figure1 ASF: Image defects GEM analysis

RETINEX [2]

The Retinex Image Enhancement Algorithm is an automatic image enhancement method that enhances a digital image in terms of dynamic range compression, color independence from the spectral distribution of the scene illuminant, and color/lightness rendition. The digital image enhanced by the Retinex Image Enhancement Algorithm is much closer to the scene perceived by the human visual system, under all kinds and levels of lighting variations, than the digital image enhanced by any other method. Retinex: automatic image enhancement function that provides automatic simultaneous enhancement of dark and bright regions in

the image, and sharpening of features. Autolevels for automatic histogram modification Levels for manual histogram modification Histogram equalization for automatic histogram modification: uses a different method than autolevels Curves for manual color-map manipulation Gamma for modifying the color-map using the gamma function Sharpen for image sharpening Blur for image blurring: useful for suppressing some noise artifacts Despeckle for removing specular pixels: useful for removing glints Negative for turning an image into a negative Edge detection for converting the original into an edge only.

Figure 2 Retinex image: before correction

Figure 3 Retinex image: after correction

Quantum Image is a tool that lets you apply filters to whole images. The filters can be either space or frequency (FFT) specified. Apart from filter an image you can print, save and examine it. [3]

5. CONCLUSIONS [4]

Photographic restoration and picture enhancement for archival purposes can be addressed, technically speaking, is several ways, as described above. However it is important to understand that technology alone cannot solve the ethical and moral issues that stand behind the original artwork. The restoration of an increasing mass of aged and damaged photographs creates several problems:

1. The need for businesses and organizations that specialize in photograph restoration. The procedures require creative and technical talent. Historical images present a variety of issues, not the least of them is that many were hand-painted.

2. The need to develop ethical principles for photograph restoration.

3. The need to develop a thorough understanding of how copyright and Moral Rights apply to the "restoration imperative." What are the rights and prerogatives of the archivist with respect to restoration and reconstruction? What are the duties of the archivist?

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