Ethics and Images

Many of my books and other publications deal with the methods by which images can be processed. The important question of what constitutes proper and appropriate processing and what constitutes unethical or even fraudulent manipulation must be considered. The short answer is that anything that alters an image so as to create a false impression on the part of the viewer is wrong. The problem with that answer is that it does not take into account the fact that different viewers will tend to see different things in the image anyway, and that what constitutes a false impression for one person, may not for another.

The first, vitally important rule is always to store a permanent copy of the original image along with relevant data on its acquisition. The second rule is to carefully document whatever steps are taken to process the image, and generally to report those steps when the processed image is published. Most scientific publications, and the editors who review submitted papers, have become more aware in recent years of the ease with which image processing can be performed, and the dangers of inadequate documentation. (For example, see M. Rossner, K. M. Yamada (2004) "What's in a Picture" J. Cell Biology 166:11-15 for that journal's policy on image ethics, and examples of improper manipulation.)

Some procedures, such as rearranging features or combining them within a single image, or differently adjusting the contrast of several images to make them appear more alike, are clearly misleading and generally wrong. Some, such as using copy-and-paste to duplicate a portion of an image, or selectively erasing portions of an image, are out-and-out fraudulent. Editors and reviewers try to catch these problems, but ultimately it is the responsibility of the author to make sure that the data presented (whether images or anything else) are correct. Even selective cropping of an image (or choosing which field of view to record) can create a false impression.

An important but often overlooked concern is to avoid using programs that alter the image without the user being aware of it. For example, carefully correcting the colors in an image using Photoshop and then placing it in Powerpoint for presentation will cause changes even on the same computer screen (as well discarding pixels and reducing resolution if copy-and-paste is used for the transfer). In addition the image may appear different on another computer monitor, or when using a projector. Printing an image will also alter colors unless careful calibration is performed beforehand. Devices to calibrate cameras, scanners, monitors, and printers exist, but are not widely enough used, and even then do not assure accurate reproduction in a publication. Placing images into a figure using Illustrator makes it all too easy to adjust the size or position of an image that will result in interpolation and alteration of pixel values (rotation is especially bad in this regard). Placing images into a web page for viewing can cause all of these problems at once. And using any lossy compression method such as jpeg will discard potentially important information that cannot be recovered.

Some processing operations are used to correct for the conditions under which an image is acquired, or the equipment limitations used to record it. For example, if it is intended to compare the colors in two images of the same scene or object, but they have been acquired under different lighting conditions (for example outdoors or indoors, or fluorescent and incandescent lamps), it is necessary to correct the colors in the images. With conventional film photography, this was typically done in the darkroom by using different colored filters to compensate for the different lighting conditions, and was usually not reported.

With digital images, the corrections are performed in a computer. If this can be done by having recorded a known standard palette of colors in the scene, or if certain assumptions can be made about the presence of neutral (grey) regions in the image, the procedures are straightforward and acceptable. If other assumptions and methods are used, they may be acceptable but they must be fully reported.

Other processing operations that are usually considered non-controversial (but can still be abused) correspond

more-or-less directly to procedures that were applied in the darkroom with conventional film photography. For example, adjustments can be made to brightness and contrast in order to make visible the details in the image that are considered important to show the objects or scene represented. Of course, it is the judgment of the author as to what is important, and since film has a much broader dynamic range than the print, not everything on the film can generally be shown in the print. Details that might be important may be lost, especially if values become completely black or white.

The same thing is true for digital images. Adjusting the sliders for gain and contrast (or more commonly the sliders that define the dark and light limits for the displayed and printed pixels) is a function provided in most programs, such as the ubiquitous Photoshop. But these programs have additional sliders that introduce nonlinearities in the brightness and contrast. When these are used, contrast for some portions of the brightness range can be increased but only by reducing contrast elsewhere. Some pixel values that were originally different will become identical, and this is unrecoverable (another reason why the original camera image must be preserved). If the pixel values recorded by the camera or scanner have direct meaning, such as density values, neither linear or nonlinear adjustments can be permitted.

There is an inherent danger that the various sliders may be moved and adjustments made by someone with independent knowledge (or strong desire) about what the image shows (or should show) and the manipulations will be done to achieve that as a goal, rather than from a proper consideration of what the various adjustments actually do. It takes an investment of time and effort to learn about image processing algorithms, and their implementation in specific programs, so as to understand when and how to use them. Ignoring that requirement is risky. Most scientists accept the fact that they must know how their microscope and other instruments work; knowing how the camera and software function is fully as important but sometimes overlooked.

Software also makes it easy to perform differing adjustments on the brightness and contrast of several images, or even of different regions within an image. If this is done, there must be a good reason (e.g., one part of the scene is in a shadow and the other in direct sunlight) and it must be documented. It can be very difficult to record images with perfectly uniform illumination, and even then many cameras suffer from vignetting (darkening of the corners) due to the optics. Software can correct this, and indeed is necessary to allow thresholding and measurement of features in different regions of the image. But the fact that the step was performed and the method that was used must be reported.

When more aggressive processing is used, such as high pass filters to delineate edges, or deconvolution to correct for focus blur, or Fourier filtering to remove electronic interference, it should also be documented. The general guideline to be considered is that it is ***never*** acceptable to add anything to an image, but it ***may*** be acceptable to suppress or remove some information if it makes the remaining details more accessible, either visually for presentation and communication, or to facilitate measurement. Of course, the procedures used must be reported. For example, the initial Hubble telescope pictures were badly out of focus, but it was possible and acceptable to remove the blur by deconvolution, and this was fully reported. As another example, the location of the edges of features is vital to allow their accurate measurement, and methods that increase their contrast (without causing them to shift) are acceptable and even necessary.

Any of the procedures shown here and in my books (and many others) may be appropriate in a given instance. But they can also be mis-used, and should in any case never be used without understanding and full documentation. The heart of the scientific method is replicability. If adequate information is provided on the processing steps applied, and the original image data are preserved, then the validity of the results can be independently verified.

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