Color Correction, Enhancement and Creativity:
Advancing the Craft *by Kevin Shaw*

This paper considers the effect of technology on creativity, with specific regard to the advantages of software color enhancement systems.

The benefits of software:

There is a clear interest in software color enhancement both in dedicated systems and as a feature of editing, compositing and effects systems. There are many software-based facilities interested in software color enhancement that would not consider a hardware solution.

However, as a professional colorist I must choose the right tools for the job. So what tools do we colorists want?

We want a high quality, random access source on an open architecture system in a standard format. We want fast, easy access and real time playback and we want the Holy Grail – one master that can produce multiple formats and versions.

We need traditional tools for print and video, plus some new ones for dealing with both, all working in logarithmic and linear space, for film and video outputs. In addition we want some of the software features that have been developed for publishing, compositing and visual-effect systems.

DEFINITIONS:

By *color correction* I mean adjusting the color balance and contrast of an image to compensate for unwanted flaws or deficiencies in a capture or conversion process, so that the image more closely matches the original. Examples of flaws are overexposure, underexposure, or colorcasts, while deficiencies include limited dynamic range or change of color space. Both labs and telecine suites color correct images.

Color enhancement is a change to the image that does not necessarily reflect reality, but which is intended to add emphasis or meaning to the image. Enhancements may or may not be planned at the shooting stage. Enhancements are usually applied to elements within an image and therefore the implication is that it involves a colorist with a more sophisticated post-production color system.

Color creativity does not have an established industry definition, but I use it here to mean the use of color and contrast to define a look or style that is not necessarily related to the original image, but more to an abstract theme or message. The term therefore is wider in concept than color enhancement, and would include art direction and photography as well as direct color manipulation. In theory it should be a preconceived collaborative effort, but that is not always the case.

The system should be intuitive to use, have unlimited layers and windows, and a flexible processing order. We want a system that can incorporate new tools from either the manufacturer or third parties, quickly and easily.

It should run on off-the-shelf hardware that is easy and cheap to upgrade, and which is compact enough to be used in a facility, at home or on location.

We need grades that track re-edits, and conform with transitions. Composites should include an alpha channel, and titles and graphics should be separate from the main

content. The system must manage alternative grades and references. We expect an ergonomic interface and real-time interaction. I would not necessarily want my colorist system tied up conforming or recording different versions, but it should be able to when required.

Storage:
In a traditional telecine session approximately 20% of the time is spent loading, searching and rewinding film. That time not only adds nothing to the creative process, but often interferes with it. Grading direct from telecine has survived for so long because it was the only way to work with the entire dynamic range of film in an uncompressed state. The extra range is much more critical in color correction where images are manipulated, than editing where they are assembled. However, moving material from a scanner to intermediate storage and then to proprietary local storage is also time consuming, is again non-productive and leaves room for errors.

By comparison, video camera footage does not need scanning and is usually graded after editing, not before. The principal advantages of grading a conformed edit are that only the selected frames are graded, and they are graded in the context of the final sequence. These reasons are attractive enough, but if the edit is on a disk, we also have random access. In short, grading a conformed edit from disk can give better results in less time. Working directly off a shared area network (SAN) of sufficient bandwidth saves space and time by allowing multiple tasks to be performed simultaneously on the same source material from different workstations,

A Brief History

Clearly the use of color has always been a powerful tool used by artists to describe, impress and express. Black and white paintings are rare, so it is certain that early films were black and white primarily because of a limitation in film technology. That limitation was adopted and used creatively, but now that color film technology is commonplace, black and white films are far less usual. Black and white film is an example of how technology influences art.

Although early cinematographers could not capture real color, known as “natural color”, they looked for ways to add color. The two earliest processes were tinting the film base and hand tinting frames. On April 23, 1896 Thomas Edison presented the first public motion picture projection at Koster and Bial's Music Hall in New York City. The images were hand tinted. Tinting is a subjective process and is therefore an early example of color enhancement. The need for color probably had as much to do with audience expectations as it did artistic demand.

In the next decade two-color film processes were developed. A contender for the first natural color feature film is *The World, the Flesh, and the Devil* which premiered in London, in 1914 in Kinemacolor. The colors were realistic, but in no way accurate. Two-color processes were used all the way into the 1950s, even though three-color film development began in the early 1930s. The lack of color accuracy in these early processes created the need for color correction.

Electronic color correction begins with television in the 1950s. Prior to the first commercial video tape recorder, the Ampex VR-1000 in_1956, television was either live or broadcast directly from film, via telecine. A feature film would require two telecines to accommodate roll changes. The film prints had much more dynamic range than television systems could deal with and therefore had to be color corrected for television. The telecine grading tools that evolved were designed to adapt the dynamic range of film for television and survive today as separate controls for black, mid and highlight tones. Incidentally, since film prints are designed to compliment the dynamic range of original camera negatives, film laboratories continue to use the simpler system of red, green and blue printer lights.

and it eliminates the need to repeatedly copy and move data.

Just such SAN storage is now available, and with good planning can be built from cheaper, network attached storage (NAS) when the need arises. The bottom line is, disk storage is now fast enough and cheap enough to record and play uncompressed 10 bit images of 2048 x 1556 at 24 fps. 10-bit log is a slight compromise, but it does allow flat scans with the full dynamic range of film.

The fastest color corrector on the planet is the human brain, and colorists must learn to compensate for its instinctive reactions. Color is like focus, it cannot be achieved in steps. It has to be judged dynamically, by going too far and coming back. It has to be fast, else the brain applies more and more subjective compensation of its own. Other tools colorists rely on to stay objective are waveform, vectorscope and histogram displays, and a reference store.

Playback at the intended viewing speed is a luxury we have grown used to, and that alone is enough to justify it, but if we are going to make selective enhancements, it is essential that we can see them as audiences will see them. It is just as important as replicating the same viewing conditions, which is not so simple either. Nowadays many projects are intended for multi media delivery, to a wide range of markets, so it makes sense to have a high-resolution master, from which all other versions are derived. The current practice often involves replicating the project in another form, which requires a lot of machine and operator time. In contrast, the right tools and technology can generate multiple local versions from a single high resolution master using metadata.

Tools:

Video grading has always consisted of separate controls for shadow, mid tones and highlights. Colorists generally refer to these by their technical titles "lift, gamma and gain". However, there are many subtle variations in their implementation, and there is no standard between telecines, or stand-alone color correctors. That alone need not be a problem, but there is a tendency for manufacturers to deliver a single set, which colorists have to accept without question. Nucoda Film Master currently offers at least three sets that start with very wide overlaps (Balance) and culminate in user defined limits for shadow, mid and highlight controls (Brightness Regions). Tool definitions are faster and cleaner than generating an isolation matte and applying a layer, although that is also an option. A colorist can choose to use any or all of them, and indeed the system allows future variations to be added easily.

Film timers in a lab use printer lights to color balance. Printer lights do not distinguish between shadows and highlights, and are therefore more faithful to the original cinematography. Any system that records back to film should certainly include such an understood tool, but even in the video domain such a film faithful tool is very useful. Part of the charm of film lies in its characteristic way of capturing light, often described as an S-Gamma curve. A few digital color enhancement systems therefore include an S-Gamma control to increase or reduce the effect.

The modern approach of digital grading for both film and video finish, from both film and video sources, has introduced variations of old problems, particularly those related to dynamic range and monitoring. We have had to look for new approaches to emulate viewing conditions, and to deal with limited, or different color spaces. There is a simplistic view that a Look up Table (LUT) will solve all. The search for the magic LUT, has taken us from 1D to 3D tables, a variety of calibration systems, and a great deal of R&D, which is still in progress. Where such research is involved it makes sense for systems to be able to accept third party solutions. It is common practice now to import LUTs, although not all systems can process 3D tables in real time. The more forward thinking designers also allow for color and effects plug-ins from third parties, ideally through an open architecture such as OFX. Examples of current OFX plug in functions are sky replacement, and lens flare.

Then there are tools that are not normally part of the color corrector in the hardware world. Repositioning and noise reduction for example must be part of a software color system, though a hardware color corrector need only control external hardware devices. Some hardware color correctors do include a reference store, but again it is essential in software. Fortunately, there is plenty of opportunity to improve on these tools in their integrated versions. Digital Vision has recognized this in integrating their renowned noise reduction algorithms into the software Film Master product range.

Many inspired tools have been developed for composites and stills, often without the pressure of achieving instant playback. Examples of this category are blending modes, automated object tracking, complex vector based shapes with splines, variable processing paths and unlimited layers. These are tools that are not specifically designed for film or video, but rather take advantage of the capabilities of the software platforms that they run on. Such tools are found in many desktop pc programs, which many colorists use for experimentation and to hone their skills. Widely recognized tools make a system more intuitive, and breed a better understanding of the process.

Workflow

The change would potentially be more dramatic than the effect of non-linear editing.

Indeed, the ultimate color creativity starts with experiments for a look and style during set and costume design, and continues during shooting. An early grade is applied to dailies for review and editing, and that grade is refined and applied to the conformed master, after which various versions would be created. This level of planning is possible, and often (but not always) practiced today. However, it is difficult to integrate real continuity because the design and color management systems used at each stage are currently very different, incompatible and in the later stages expensive. At best, a director/ cinematographer might have example images to work from, but aesthetic intent is usually left to verbal communication and it is just as common to establish the look after shooting. At a time when there is a great deal of attention on retaining the best

image quality it is surprising how late in the process a colorist gets involved. A system that is small and cheap enough to use at the pre- production stage, and that could share project information on set and at all stages of post-production, would undoubtedly revolutionize color creativity.

The change would potentially be more dramatic than the effect of non-linear editing. Pre-production color decisions could be tested on set, adjusted for dailies and editing, refined during postproduction and then imported as the basis for the final color grade. Artists at each stage could not only see the original intentions of the cinematographer, but because project metadata is non destructive, they could analyze the methods used. The method is becoming increasingly significant since there are now many ways to achieve the same look, each with subtle differences that manifest themselves in the way the moving image reacts to color and light. The product range could include systems for offline color grading, training, and formatting.

Hardware

Such a system would need to run on a single high-end desktop and consist of a range of products, each aimed at specific tasks, yet able to share projects with the others. Systems that rely on multiple PCs are likely to cost tens of thousands of dollars to upgrade, and less likely to have affordable spin-offs. In fact they often have more in common with hardware color correctors. Modern hardware systems are essentially software running on proprietary hardware, so when the configuration of CPUs, GPU, and dedicated storage becomes so sophisticated that only the software supplier can support it, one might as well call it a hardware device. The simpler single PC solution, which is more likely to have efficient algorithms, can be upgraded for as little as a few hundred dollars for a graphics card, because it benefits quickly from the continued improvements in technology of manufacturers supporting the larger gaming and entertainment markets.

The Nucoda implementation of the graphics processor unit GPU) is clever, in that it guarantees real time interaction and playback for one layer of color tools and pan scan regardless of how many layers and effects are applied. This layer is the last in the chain, so that even the most sophisticated grades can be tweaked with full interaction at final acceptance viewing.

"For the Artist, effects are decisive, rather than agents as studied by physics and chemistry"
~Joseph Itten

In addition to raw processing power, a color enhancement system also needs a highly specialized control panel. Early software color correctors were GUI driven, and could usually only adjust a single parameter at a time. Colorists have to work fast for two reasons. Firstly, budgets are tight and there is always much to be done. But secondly, and perhaps more importantly, objective color decisions must be made quickly. The eye does not register the change in color temperature as it moves from tungsten to daylight in the way film does. Instead it compensates. It is always compensating, even as we apply color enhancements. A colorist performs best by adjusting multiple

parameters with multiple tools, simultaneously. There is an element of mystique in the exact technique, but an inspired panel design is itself a source of inspiration. As Joseph Itten said, “For the Artist, effects are decisive, rather than agents as studied by physics and chemistry”. A control panel that adjusts a single parameter at a time might look good, but it does not do the job well. For most colorists interaction of the control panel is even more critical than play back speed.

Finishing

With or without the follow through grading concept, there are significant advantages in grading at the end of post-production. In-context perception and attention to specific frames have already been mentioned. To really profit from these concepts the color corrector must be able to import an edit decision list (EDL) and auto conform the project. That is not to say the colorist now has to be an editor, few want that burden, but a digital intermediate (DI) system, which is to say all software color correctors, should import a project as elements. In this way an edit can be changed, scenes can be stabilized and repaired, and composites can be dropped in as soon as they are available during the color grading, not before or after. This is referred to as a simultaneous workflow. The basic requirement of simultaneous workflow is that the color corrector applies grades to the correct scenes even if the edit is changed and the project re-conformed. This approach is gaining popularity because it is a much more flexible process; when the editor, effects artists, and colorist do not depend on each other to start plying there craft it eases the schedule. The potential drawback is that decisions can be made later, and so the colorist might need to maintain several grades for each scene until a commitment is made. DI color correctors must therefore have more sophisticated list management than traditional telecine systems, and be able to support alternate versions of the edit as well as alternate grades for each scene.

Another reason for importing elements is dissolves. The system should generate dissolves from the EDL, and so offer the choice of grading a scene before or after the dissolve is rendered. It seems a simple thing, but in the traditional telecine workflow there is no choice. Grading selected takes is always before dissolve creation, grading an online sub-master is always after dissolve creation. Each approach is useful on occasion, but having the choice is the better option.

A similar benefit is the use of an alpha channel as a layer isolation. The alpha channel could be a matte created during compositing, but Nucoda Film Master also supports multiple video tracks, which it can composite. This is a huge advancement because a colorist can for example, work on a textless master, yet output the finished program with titles and graphics, which would otherwise require a final edit session. All video tracks can be graded, resized and repositioned if necessary.

Happy Coloring!

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