



O Brother, Where Art Thou? Principal Photography
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Digital Intermediate: The Wave of the Present

A Quantum Leap in Creative Control Over the Final Look of a Film

by Steve Wright

There has been a paradigm shift in the movie making industry in the last few years. Perhaps you have heard of it. It's called "DI", which is short for "Digital Intermediate". DI is the process of color timing (color correcting) a movie using a computer instead of a film lab. The color corrected data is then sent to a film recorder to produce a new color timed negative of the movie. This negative is in turn duplicated and used to create the thousands of prints of the movie that are projected in theatres. This is the film finishing technique that we can all expect to be using in the future as the lab process fades to obscurity, then finally, unavailability.

For the last 100 years of filmmaking, the color timing process has been done in a film lab. The unavoidable variations in exposure

and lighting from shot to shot are removed by re-exposing each shot onto another piece of film using adjustable RGB lights. This "color timed" piece of film is in turn used to strike the many theatrical prints. Beyond just fixing exposure variations, the color timing process is also used to add a "look" to the film – dark, sultry bedroom scenes, dusty hot yellow desert scenes, cool blue winter shots, and so on.

In the Beginning

First introduced in 2000 at Kodak's Cinesite digital film division with *O Brother, Where Art Thou?*, for the first year or two the process was a hard sell. It was expensive, risky, and not altogether reliable to get the film to match the picture you saw in the color



After Digital Intermediate Color Timing
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timing suite on the HiDef monitor (no digital projectors back then). Regardless of the startup travails, the process had one irresistible attraction to filmmakers – vastly more creative control. You could do a hundred times as many creative things to the look of a film than the conventional “wet” process in a film lab.

It was, in fact, this unique creative control that drove the Director of Photography for *O Brother*, Roger Deakins, to risk his project on this new-fangled DI process in the first place. He wanted a unique color treatment for his movie that was unthinkable in a film lab. As you can see by comparing the principal photography to the Digital Intermediate color timed version, an astonishing change in appearance of the picture was achieved. The greens have been turned to a warm gold in such a surgically selective way that the rest of the picture is barely affected. Such exquisite color control is not even remotely possible in a conventional film lab.

But Wait, There's More!

The creative control at your disposal in the DI suite goes far beyond just fancy color timing. Since the entire movie has been digitized and is sitting on huge hard drives, every pixel of the movie is accessible to computer processing. This opens up an entirely new dimension in film finishing known as image processing. Image processing operations come in many forms and are being continuously added to, but today the list includes image sharpening,

degrain operations, resizing, stabilizing, scratch removal, and many, many more. In fact, since the entire movie is digitized, any shot can be handed over to the digital effects department for virtually any kind of fix, alteration, look, or treatment desired.

In addition to powerful color correction capabilities and extensive image processing operations, the mundane things like titles and opticals are also now done digitally. Digital opticals include the little things like dissolves, wipes, supers (super imposing) and speed changes. In the film lab, the only kind of speed changes that can be done are skip printing to speed up the action by skipping or dropping frames, or frame duplication to slow things down by double or triple printing the frames. Needless to say, the results can be quite jarring.

With image processing an advanced computer algorithm called “optical flow” can be used to slow down a shot by actually creating new in-between frames, not just double printing them. These in-between frames are created with a two step process. In the analysis phase, each frame is analyzed by the computer to identify how the pixels have moved from frame to frame. This pixel movement is logged as motion vectors which describes how far and in what direction the pixels moved. In the interpolation phase, the computer picks up a frame plus its motion vector information and figures how to shift its pixels around so that they are half way between it and the next frame. This creates a whole new frame that does not

look exactly like the one before or after it. Of course, the process does have its peculiarities that often produce artifacts which must be fixed by the digital paint department, but the results are truly spectacular.

The DI Workflow

The Digital Intermediate process can be intimidating because it uses newly developed computer technology which is both complex and hard to understand. The situation is made even more difficult by the lack of standards in this rapidly evolving business, so each DI facility has its own way of doing things. However, there are certain over-arching principles that they must all adhere to so we can safely describe a “generic” DI workflow and feel confident that it will not become obsolete – not for at least a few months, anyway.

After the movie is edited in video with an off-line editing system such as Avid or Final Cut Pro, the edit lists and all the camera roll negatives are delivered to the DI facility along with a video tape of the edited version of the movie. The DI facility will later compare their full resolution edited version to this off-line video to check that they have an exact match. The edit lists are used to tell the film scanners which frames to scan from each camera roll. Scanning (digitizing) feature film is still fairly slow and expensive, so only the actual frames used in the final edited version of the movie will be scanned – plus perhaps a couple frames at each end as “handles”.

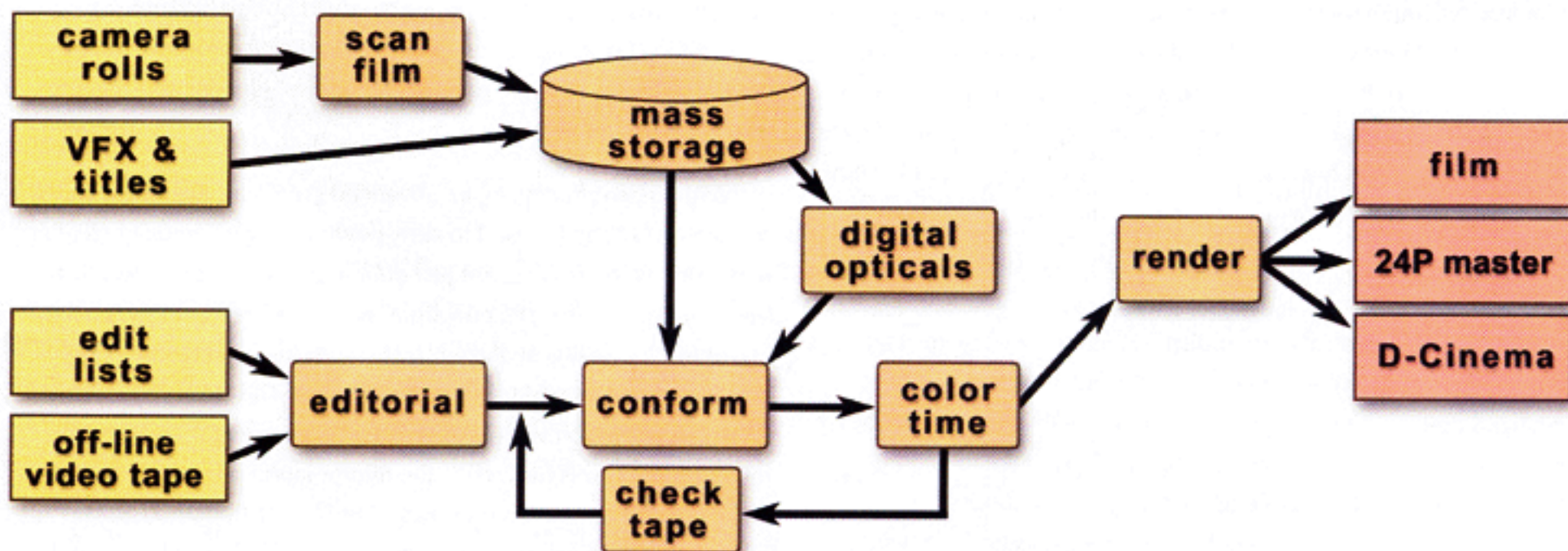
As the film is scanned to a mass storage disk array, the digitized film frames are joined by the visual effects (VFX) shots and titles which are usually done at outside facilities. The film frames are then assembled in the correct editing order using some more of

those edit lists in a process called “conforming”. Once the movie is conformed, the DI facility makes a video tape of it called a “check tape” which is delivered to the client to compare to their own video tape to make sure that all the film frames are where they should be. If not, the movie is re-conformed, and the check tape is re-issued.

A movie may be made up of five or six reels, each 2000 feet long holding up to 32,000 frames each. When a reel is conformed, the color timing on that reel may begin. In actuality, a lot of the process goes on in parallel. While reel 4 is being color timed, reel 2 is being conformed and reel 5 is being scanned, and so on. In fact, the first and last reels are usually the last to be filmed out because this is where the titles appear, and there are usually last minute title issues. This all adds to the fun of trying to keep track of over 180,000 film frames divided into an average of 1500 cuts sorted into perhaps 500 directories on a huge disk array that might have 3 to 10 other movies in progress at the same time.

On the client side, one person is supposed to be the designated decision maker for the look of the film, usually the film’s Director or the Director of Photography (DP). One of the problems with the DI process is that there can be more than one eye approving the work, and this can lead to runaway schedules and blown budgets. Another problem is that there is such a bewildering array of looks and treatments available with digital color timing that the client can burn up a lot of schedule playing “what if”. What if the sky were bluer? What if we highlighted the star’s face a bit here? What if we subdued the lighting in the background? What if we started over with a new look?

Simplified Flow Graph of the Digital Intermediate Production Pipeline



Let's assume the DP is the designated hitter for our generic DI. He will first sit with the colorist to color time several key scenes until he and the colorist get a "shared vision". The DP will then go away so the colorist can color time the rest of the movie, returning days later when the first pass is done to review and revise. Early in this process, some key scenes will be filmed out and projected on film to see how well the film is "tracking" (matching) the digital projector that everybody had been using to judge the picture.

After all the shots of one entire reel are color timed, it will be rendered with the color corrections "baked" in, then sent to a film recorder to be shot out to 35mm film. As each reel is completed in turn, it too is filmed out. Those shots that contain titles will be filmed out a second time without the titles in order to create the textless version which goes to international distribution. Each country can then add titles in their own peculiar language.

Because it is still fairly slow and expensive to film out an entire feature (around \$50,000) only one digital negative is produced. This negative is taken to a conventional film lab to be duplicated, then the theatrical prints are made from those duplicates. A negative can only make about 700 prints and is at risk of being eaten by the equipment, so you don't risk your one \$50,000 digital negative on that. In case you were wondering about the sound, it is laid down alongside the digital negative in the film lab when the duplicates are made.

Digital Mastering


Once you have your 5 or 6 reels of digital negative for the entire movie, you might think you are done, but you are not. The Digital Intermediate process is in actuality the Digital Mastering process where the feature film, the HiDef video, and the Digital Cinema versions of a movie are all mastered at the same time. The color timed digital files are run through a color space conversion and laid down to D5 video tape as a HiDef 24P master (1920x1080 at 24 frames per second, Progressive scan). From this 24P master, all "lower" video versions are made as a simple down-convert - NTSC, 30 fps versions, DVD, etc.

More and more features are having a D-Cinema (Digital Cinema) version made. The color timed digital files are run through yet another color space conversion to create the D-Cinema version. These image data files are then run through data compression and data encryption, and the addition of information about the data is then finally written out to computer data tapes. These data tapes are in turn copied onto the hard drives of servers which stream the data to the big D-Cinema projectors that are starting to appear in our big city theatres.

The Big Finish

The DI process has come a long way in the few years from its first movie in 2000. From a hard sell in the first couple years to the de facto film finishing technique in less than five years is the very definition of a paradigm shift. The reason for the explosive success of DI is simple - it offers a quantum leap in creative control over the final look of a film. And here is one indisputable film fact - after experiencing a DI, no Director or DP has ever wanted to go back.

Steve Wright is a 20 year visual effects veteran with 70 broadcast television commercials and over 60 feature films credits. He was the 2D technical director at Kodak's Cinesite when the digital intermediate (DI) process was first developed there and has been working with the digital intermediate process ever since. He has written several articles on the subject and includes a section on DI in his book "Digital Compositing for Film and Video". Steve now does visual effects and DI consulting, teaching, training, and writing. His website is www.swdfx.com.



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