By Brian Dipert, Technical Editor

DEINTERLACERS ALL MAY LOOK THE SAME ON PAPER, BUT ENGINEERING INTUITION SUGGESTS THAT THEY PROBABLY DON'T PRODUCE IDENTICAL RESULTS WITH REAL-LIFE VIDEO MATERIAL. *EDN* TAKES A LOOK AT THE CONTENDERS AND THE PRETENDERS.

Image by Chinsoo Chung

Video quality: a hands-on view

VIDEO DEINTERLACING AND SCALING, like many other aspects of multimedia, are deceptively simple in theory but challenging to properly implement when you face imperfect and unpredictable real-life images (**Reference 1**). Full-featured deinterlacers detect and reconstruct computer graphics and NTSC- and PAL-encoded film, progressively scan convert-video fields, handle a mixture of film and video content within the same frame, and tailor their output resolution and aspect ratio to the chosen display device. The numerous techniques for handling these various conversions each have a corresponding set of cost, quality, and other trade-offs.

Predictably, in a situation such as this, the proponents of each method emphasize its strengths and minimize or even "forget" to mention its shortcomings. Every time I encounter such a state of affairs, I'm tempted to do some hands-on analysis of my own. **Table 1** outlines the equipment I've used in this video study. And the **sidebar** "Endless views" directs you to the additional research results.

VISUAL VARIABLES

Before diving into the details, here are a few disclaimers. Before I began in-depth research of video technology, I couldn't tell the difference between the composite-video and S-Video outputs of the DVD player connected to my 31-in. interlaced television. Once I knew what composite-filtering artifacts to look for, they became glaringly apparent. And, after having experienced a progressive-scan, component-video-driven, high-quality display during this project, I'm already scheming (or, more realistically, dreaming) about how I can convince my spouse that we need to upgrade our DVD player and TV, as well as the video-switching home-theater receiver that links them.

Getting a taste of deinterlaced-video quality also motivated me to put an antenna on the roof, borrow a DTV receiver and a few examples of PC-based DTV hardware and software, and tune in to the digital television content that's slowly appearing in the Sacramento, CA, broadcast area. My experiences aren't unique, and they hold clues as to the realistic rate at which consumers will migrate to higher quality video. Until now, I'd been perfectly content with NTSC television, because I hadn't experienced anything better. Yes, I'd seen and appreciated the HDTV and line-doubled NTSC demos at the Consumer Electronics Show and other conferences, but my memory of them had faded by the time I got back home.

The benefits of a progressive-scan display didn't really stick until I compared my television and a progressive-scan monitor side by side. Whether you're evaluating speakers, displays, or lossy multimedia compression algorithms, your ears, eyes, and brain often compensate for imperfections, leaving any one product sounding and looking fine when not in the presence of a clearly better alternative (**Reference 2**). Even with this high-quality monitor, I can't always see all of the deinterlacing characteristics that the vendors' literature touts. Improper field-combination artifacts aren't noticeable, for example, except on carefully crafted test patterns.

Perceived video quality is a function of numerous variables, including the inherent quality of the source. Are you watching a 4:4:4 component video stream or high-resolution computer RGB output, or are you watching a noisy, RF-modulated NTSC composite video broadcast? What type of display are you using to observe the video source? Is it a cheap, 13-in. interlaced television, or a $100,000 front-projection system with a huge screen? Ironically, the more money you invest in your video equipment in search of absolute image perfection, the more noticeable the artifact impediments to that perfection become. A "soft" resolution image on a small screen does an effective job of hiding "feathering," aliasing, analog and digital noise, DCT-pixel-matrix blocking, and other defects.

AT A GLANCE

- ▷ Testing results depend on the video source, the display device, the viewing environment, the viewer, and the testing method.
- ▷ Directly driving a progressive-scan display with video created and stored in RGB or component formats results in minimal degradation.
- ▷ A soft image can effectively hide a host of deinterlacing "sins."
- ▷ Carefully crafted test clips reveal artifacts that real-life video materials obscure.
- ▷ Head to the *EDN* Web site and to the How It Works article in this issue of *EDN* for more on the topic of video quality.

ENDLESS VIEWS

I've barely scratched the surface of covering the approaches and trade-offs of video technology. The following lists the topics that I hope to explore in coming months. Look for the results both in a Web-site addendum and in future print articles. I hope to:

- Obtain an evaluation board or other more flexible equipment containing the SiI503 from Silicon Image.
- Re-evaluate the Genesis Microchip GM6010, once its firmware has become matured.
- Further explore the capabilities of the nDSP and Sage evaluation boards using their more flexible PC software-driven parallel-port interfaces.
- Make the horizontal-resolution measurements more quantifiable and therefore more objective by using test patterns on the various benchmarking and calibration DVDs, material I obtained from DisplayMate Technologies, and the calibration images created by Sencore's VP300 video generator. Sencore's CP288 color analyzer will help to quantify color accuracy.
- Subject each of the deinterlacers to popular and known "bad" encoded DVDs.
- Take vertical resolution beyond 480 scan lines for those units that will accept an HDTV input signal or with the ability to scale up a 480-line input source. Can the AF3.0HD display this material, or will Kell factor, shadow mask, or other limitations prevent this ability? The NEC E1100 CRT and Silicon Graphics 1600SW LCD computer monitors will also be helpful in observing 720p and 1080i HDTV horizontal and vertical resolutions. Kayye Consulting has developed high-resolution test patterns based on DisplayMate Technologies' work, and I've got several high-definition MPEG-2 files. Thanks to the Terk TV35 antenna (**Figure Aa**) and a Princeton Graphics HDT-2000F DTV receiver (**Figure Ab**), I can also view live DTV material in my office.

The HDT-2000F isn't the only DTV tuner available. TeraLogic's Janus evaluation board, along with AccessDTV, and Hauppauge boards based on TeraLogic's TL880, perform tuning, transport-stream demultiplexing, and video decoding all in hardware. The Broadlogic DTA-100 card relies on demultiplexing and decoding software from Intervideo, National Semiconductor, and Ravisent Technologies. Speaking of the PC, I'd like to:

- Assess the deinterlacing capabilities of its DVD decoder options: Creative Labs' DXR3 hardware and CyberLink, InterVideo, National Semiconductor, MGI Software, and Ravisent software. Available graphics cards include ATI's All-In-Wonder Radeon and Radeon VE; Matrox's Marvel G450 eTV and Millennium G450; Nvidia's GeForce2 MX, GeForce2 Ultra, and GeForce3; and 3Dlabs' Oxygen VX1-1600SW. Connection alternatives between the graphics card and display include analog, DVI, Open LVDS, and S-Video.
- Test NTSC cable and terrestrial deinterlacing performance to assess the degree of each product's error-rejection capability and evaluate results using Canon Hi-8 and Panasonic PV-DV101 MiniDV camcorders as video sources.

I welcome your feedback on how I prioritize these tests, as well as which tests I may have overlooked. Contact me at bdipert@pacbell.net.

Figure A

(a)

(b)

A rooftop antenna on a 20-foot pole (a) and a DTV receiver (b) enable your progressive-scan monitor to display terrestrial-digital-television broadcasts (courtesy Terk and Princeton Graphics, respectively).

What are the ambient lighting conditions under which you're observing the images, and how close are you to the display? How sharp is your vision, and how much experience do you have searching for image artifacts (**Reference 3**)? Feedback I received from some readers on earlier digital-audio articles indicates that they didn't understand my intent of that meticulous study: to discover how the codecs worked, not to make quality conclusions about them. When I *do* undertake quality evaluations, such as those I describe in this article, I approach them as an average user would. That's why I did no frame-by-frame single-stepping through a video clip looking for minute errors, for example. Such studies are intellectually interesting but of limited practical value (**Reference 4**).

Figure 1

A progressive-scan DVD player (a) also acts as a high-quality video source for other deinterlacers for display on wide-screen CRT (b) and LCD (c) monitors (courtesy Toshiba, Princeton Graphics, and Silicon Graphics, respectively).

GREAT GOBS OF GEAR

I used Toshiba's SD-6200 (**Figure 1a**) as my video source, and it's also one of the deinterlacing alternatives I evaluated. This DVD player outputs interlaced composite video, S-Video, and component video. The two-chip Genesis Microchip set inside it (gmVLX1A-X video processor and scaler, and gmAFMC film mode processor) also enables it to output progressive video over the component connections.

On the other end of the video chain is Princeton Graphics' AF3.0HD (**Figure 1b**), a 32-in. (30-in.-viewable), wide-screen HDTV monitor. The AF3.0HD contains a simple "bob"-mode line doubler that operates when you employ the monitor's composite-video and S-Video inputs. The RGBHV (red-green-blue-horizontal vertical sync), VGA, and two sets of component video inputs bypass the monitor's doubler, luma/chroma separator, color decoder, and other intermediary video- processing circuits (**Reference 5**). Silicon Graphics has provided its model 1600SW 1600×1024-pixel, wide-screen-LCD flat-panel monitor and MultiLink adapter (**Figure 1c**), which I plan to add to my imaging testbed. The LCD will enable me to more precisely observe output resolutions and various video artifacts, but I'll need to carefully ensure that the 1600SW's internal scaler and the MultiLink's interface and aspect ratio converters aren't the root cause of any observed image degradation.

Several deinterlacers in the lab sit between the DVD player's interlaced outputs and the Princeton Graphics monitor's component and RGBHV inputs. Silicon Image bases its iScan Pro (**Figure 2a**) on the SiI503 chip. The iScan Pro includes composite, S-Video, and component inputs; accepts NTSC, PAL, and SECAM video formats; and outputs progressive-scan RGB and component video. Focus Enhancements' QuadScan Elite (**Figure 2b**) contains the same two-chip Genesis Microchip set as does the Toshiba DVD player, and it can scale interlaced component, S-Video, and composite inputs all the way up to a 1365× 1024-pixel output resolution.

Three vendors provided evaluation boards. The NV221 demonstration board from nDSP mates over VME to a front-end video-ADC board containing a Micronas VPC3230 video processor. Sage's EVL9200TV board showcases the company's FLI2000S video decoder, FLI2200 digital-video deinterlacer (**Figure 2c**), and FLI2220 digital-video enhancer, along with triple 10-bit video DACs. Both the nDSP and Sage boards can operate in either stand-alone mode or with PC-parallel-port control. So far, I've run both boards in stand-alone mode and have manipulated their functions via DIP switches.

Genesis Microchip also provided me a reference board for their brand-new gm6010 video processor. Its onboard tuner would have enabled me to test its performance not only with composite, S-Video and component inputs, but also with noisy terrestrial and cable-broadcast video signals. However, its subpar deinterlacing results on DVD-player-generated signals indicated immature firmware development. Because competitors' devices are older and therefore offer more fully debugged algorithms, I decided to defer publishing gm6010 testing data. Keep an eye on the *EDN* Web-site article addendum for future results.

To ensure that each deinterlacing alternative had the chance to present itself in the best possible light, I employed high-quality video cables for all connections, including an UltraLink cable with an HD-15 connector on one end and five BNCs on the other end. I viewed the CRT from approximately two feet away. (Hey, it's a small office!) Keep this unnatural viewing position in mind as you analyze the information that follows, and please don't tell my mother that I'm *still* sitting too close to the TV. My results approximate those of an observer looking at a much larger screen at a more normal viewing distance. Someone watching the AF3.0HD from across an average-sized living room probably wouldn't notice the same magnitude of differences among deinterlacing alternatives that I did.

OBVIOUS OBSERVATIONS

I first hooked up the DVD player's composite, S-Video, and component outputs directly to the television. I happened to have a copy of the movie *Starship Troopers* (a lousy movie but with high-quality images) lying about, so I put it into the DVD player, sat back, and toggled between the TV inputs. Composite, as expected, revealed a lot of luminance "dot crawl" at abrupt color transitions, rainbow-color patterns at abrupt luminance transitions, and a generally fuzzy color-resolution presentation. The S-Video connection eliminated the cross-luminance and cross-color artifacts and slightly sharpened the image.

From my theoretical research, I expected to see a less significant quality improvement when switching from S-Video to component video versus the already-observed composite-to-S-Video transition. I was surprised, therefore, when I switched the AF3.0HD over to a mode in which the DVD player's progressive-component outputs were driving it. The images on the screen seemed to jump out at me with enhanced color richness and sharpness that even revealed flaws on the film used to create the DVD master. What happened?

For one thing, I was viewing source material that was stored in 4:2:0 component-video format. Instead of running that component video through multiple bandwidth-reducing format transformations to S-Video or composite video and then transforming it *back* to component video within the TV, I provided the AF3.0HD with signals that it could convert to RGB and drive to the tube with minimal loss. Had the source material been stored, say, on a VHS tape, which separates luma and chroma, or, on a laserdisc, which stores video in high-bandwidth analog-composite form, there would have been no inherent advantage in driving the display's component inputs. The video-generation device would simply be replicating the composite- or S-Video-to-component transformation that would otherwise take place in the TV.

The DVD player's setup menu also had edge sharpening enabled in the default settings for the component-video outputs. Sharpening can improve perceived image quality, particularly at extended viewing distances, but when you use it to an extreme, it can inject noise and other undesirable artifacts into the picture. Like many other aspects of video, sharpness is a matter of taste, so for my testing I either set it to a nominal value if I had an "analog" range of options available, or I disabled it if the "binary" options were more limited.

Figure 2 Video-processing equipment (a and b) sits between video sources and display devices, and reference boards let you evaluate other chips that can reside in any of the three locations (c) (courtesy Silicon Image, Focus Enhancements, and Sage, respectively).

TABLE 1—DEINTERLACERS AND TORTURE-TEST RESULTS

Product		Test 1: Line-twitter pattern	Test 2: Oscillating-pendulum pattern	Test 3: Moving-crosshatch pattern	Test 4: Mixed film and video, both moving
Focus Enhancements QuadScan Elite	Auto motion processing	Fails (1)	Fails	Partially passes (2)	Passes
	Film motion processing	Passes	Passes	Passes	Fails
	Video motion processing	Fails	Fails	Fails	Passes
	Still-video motion processing	Passes	Passes	Passes	Fails
nDSP NV221 demonstration board	Deinterlacing mode	Partially passes (3)	Partially passes (3)	Fails	Passes
	Film mode	Passes	Fails (4)	Passes	Fails
	Neither mode	Passes	Fails (4)	Fails	Fails
Princeton Graphics AF3.OHD	Internal deinterlacing	Fails	Fails	Fails	Passes
Sage FLI9200 digital-video-subsystem evaluation board	Intrafield interpolation (no external memory required)	Fails	Fails	Fails	Passes
	Fully adaptive deinterlacing	Passes	Passes	Passes	Passes
Silicon Image iScanPro	Auto processing	Passes	Passes	Fails (5)	Fails
Toshiba SD-6200	Auto deinterlacing	Fails	Fails	Passes	Passes
	Film deinterlacing	Passes	Passes	Passes	Fails
	Video deinterlacing	Fails	Passes	Fails	Passes

=Fails =Partially passes =Passes

Notes:
1. No alternating line flicker when logo is at its widest point.
2. Briefly lost horizontal line "lock" at certain points in square transition.
3. Occasional flicker.
4. Dual pendulum images.
5. Fails, even though the front-panel LED indicates "film" mode.

FILM...VIDEO...ACTION!

For my next set of tests, I turned to the "Montage of Images" section of the *Video Essentials* DVD published by Joe Kane Productions (**Figure 3**). This six-minute-long segment contains a mixture of both video- and film-captured material, intermingled to test a player's ability to quickly transition between various deinterlacing modes. The numerous abrupt chroma and luma edge transitions and other patterns in the images help reveal subpar deinterlacing implementations, and many of the frames contain an image of the human face, an object with which viewers are most familiar and which therefore readily reveals errors.

After repeatedly playing "Montage of Images" through various pieces of deinterlacing equipment, using all possible interconnections and from my intimate vantage point near the screen, I was surprised by how *little* difference I saw between the alternatives. The TV generally produced the softest pictures from both a horizontal- and a vertical-resolution standpoint; the vertical resolution reflects its comparatively trailing-edge line-doubling technology. When composite and S-Video inputs drove the AF3.0HD, it also delivered less "punchy" colors compared with situations when one of the other deinterlacers drove its component, RGBHV, or VGA inputs. Altering the default black level, contrast, color, and tint settings of the set might have resolved the differences. Keep in mind, too, that the AF3.0HD's default color presentation *might* in fact be the most accurate (**Reference 6**).

I don't fault Princeton for the company's line-doubling choice. The set, which has been in production for several years, costs thousands of dollars, and at the time it was in development, robust deinterlacing technology would have further increased the price by hundreds or thousands of dollars. Today, thanks to semiconductor integration, that same level of deinterlacing technology costs only tens of dollars or less. Exemplifying this trend, Princeton Graphics' new AI3.6HD 4:3-aspect-ratio monitor includes an SiI503 deinterlacing processor.

To use an analogy, many PC manufacturers integrate a basic level of 2- and 3-D graphics function through the core logic and provide options for more robust graphics capability via AGP slot expansion. Similarly, consumers can supplement or even override the TV's basic line doubling by deinterlacing at each video source, including the DVD player, or at a common midpoint, as Focus and Silicon Image do with their video-processing boxes and nDSP and Sage do with their evaluation boards. Exemplifying the option of deinterlacing at each video source, the Toshiba DVD player delivered the cleanest, sharpest picture. The player has access to and passes along to the TV the highest-quality component video. The fields it deinterlaces have not yet seen a digital-to-analog conversion, and the player's deinterlacing processor can reference the DVD's control flags to further guide its efforts.

Figure 3

The "Montage of Images" enables evaluation of proper deinterlacing for both film- and video-derived material, as well as rapidity of switching between deinterlacing modes (courtesy Joe Kane Productions).

"Sharp" doesn't necessarily mean "best," though. The Focus Enhancements, nDSP, Sage, and Silicon Image deinterlacers all seemed to deliver a slightly softer picture than the Toshiba-generated picture. (Further analysis will attempt to quantify this difference via lines-of-resolution measurements.) However, when their algorithms partially or fully failed a deinterlacing test, the "feathering" or other artifacts that resulted were less objectionable than those from the Toshiba. And the aliasing artifacts resulting from diagonal edges in motion were also less objectionable with the softer presentation to obscure them.

Why were the various deinterlacers so similar in their results with film- and video-based material? Part of the reason was undoubtedly the material used to evaluate them. "Video Essentials" is a well-known video-testing and -setup disc, published in DVD format several years ago. It has existed in laserdisc format even longer. It wouldn't surprise me if "Montage of Images" was one of the tests the manufacturers insisted that their units "pass" before full production. Badly edited material and movies with incorrect flag encoding, such as *Austin Powers* or *Titanic*, might reveal more variation among deinterlacing processors. "Montage of Images" also doesn't include clips of objects moving at high speed.

Part of the reason for the similarity might also have been the testing method I chose. I approached the equipment as a consumer would, playing the DVD at normal speed. In other evaluations I've seen, reviewers single-step through the DVD and count the number of fields it takes for the equipment to change to the proper deinterlacing mode when switching from film to video or from video to film. I don't deny that there's a small but lucrative videophile segment of the buying public that will select equipment, regardless of its price, based on a one- or two-frame-delay difference. I'd postulate, though, that most consumers would barely—if at all—perceive such a delay in the context of a 60-frame/sec presentation, and price therefore becomes the primary differentiator.

My close proximity to the screen made for a worst-case viewing position, and I'm confident in my vision, at least when I'm wearing glasses. I'm also confident that the AF3.0HD was able to reproduce the entire 480-scan line vertical resolution. However, some deinterlacing artifacts are subtle and become increasingly noticeable with additional viewing; my job unfortunately doesn't allow me to spend hours watching movies! Also, the switch from one video-equipment arrangement to another took a few seconds' delay at best as I toggled between inputs using the TV's front-panel controls. More often, the switch took a few minutes and involved swapping hardware, software, and cabling. Memory and, with it, discernment, fades during these extended delays.

TORTURE TESTS

In the hope of observing more significant deinterlacing differences in situations that "Montage of Images" might not have encompassed or that my untrained eyes might not have noticed, I next turned to a series of four video clips, three of which came from MadOnion.com's Video2000 benchmarking software. The *line-twitter pattern* demonstrates motion adaptivity (**Figure 4a**). It comprises two labeled sets of horizontal lines, the top set existing only in odd fields and the bottom set existing only in even fields, along with a rotating logo in the bottom right corner of the frame. Deinterlacers that are not motion-adaptive produce a 30-Hz flicker, resulting from each set of lines' turning on and off from field to field.

Deinterlacers that use field-based motion adaptivity should sense the logo motion and switch to intrafield interpolation with the same flickering display result. Deinterlacers with per-pixel motion adaptivity, however, correctly merge fields—that is, employ temporal interpolation, or "weave," in the stationary areas while using spatial interpolation in the moving areas. The ideal result is a stable, flicker-free image with all lines visible on the screen. The ideal rotating logo also looks clean without any feathering artifacts at its edges.

The o*scillating-pendulum pattern* (**Figure 4b**) also contains the letters "O" and "K" at the bottom of the frame, along with the rotating logo first seen in the line-twitter pattern. The letter "O" exists only in odd fields, and the letter "K" exists only in the even fields. Nonadaptive deinterlacers or those that use field-based adaptivity show flicker in this area and blur the letters.

Deinterlacers that always weave the odd and even fields produce feathering along the edges of the pendulum. Motion-adaptive deinterlacers employ spatial interpolation around the pendulum. If they use a constant-proportion interpolation algorithm, however, you'll see visible aliasing along the pendulum edge, especially at shallow angles.

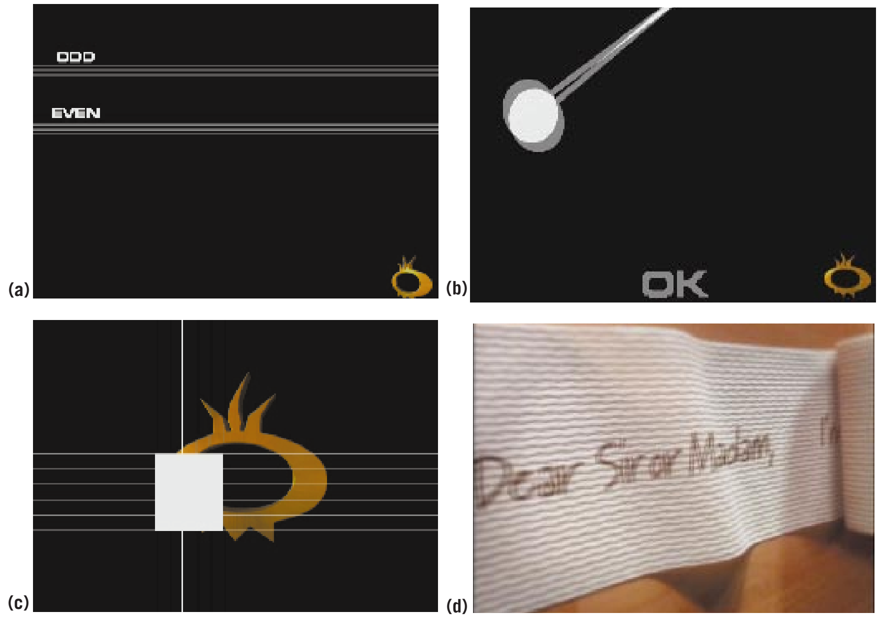

Figure 4 The line-twitter pattern (a), oscillating-pendulum pattern (b), moving-crosshatch pattern (c), and video captions overlaid on film (d) test complex deinterlacing situations (a through c, courtesy MadOnion.com).

The *moving-crosshatch pattern* demonstrates 3:2 pulldown—that is, film-sourced material-detection (**Figure 4c**). It comprises white horizontal and vertical lines moving diagonally from top right to bottom left, forming a crosshatch, with a large rotating logo behind them at the frame's center. The pattern, originally progressively scanned at 24 frames/sec, was "telecine-transformed" to 60-field/sec interlaced video in the same way that movies are converted to NTSC video. Each time the pattern starts at top right, it flickers momentarily while the deinterlacer acquires the 3:2 pulldown pattern.

Ideally, the deinterlacing processor should have acquired the pattern by the time the square box changes from outline to solid white at approximately 50 fields into the sequence. Losing the telecine pattern causes the horizontal lines to flicker. The image contains little motion, because most of it is a stationary black background. The rotating logo, however, produces complex motion, making it difficult for a film-mode detector to find the 3:2 pattern.

The final "torture test" demonstrates content that mixes video and film. This sequence consists of an unrolling roll of toilet paper, shot on film at 24 frames/sec and converted to video using 3:2 pulldown, along with superimposed text that is interlaced video and therefore contains no telecine information. Because most of the image is film, the image can cause deinterlacers that support film mode to employ an inverse-telecine algorithm for the entire frame, a choice that causes severe feathering around the text.

The proper approach to this content is to use a video-deinterlacing algorithm on the frame, which may not produce the optimal progressive-scan conversion of the film regions but results in readable text. Appropriate handling of content that mixes video- and film-based moving objects within a frame is important because entertainment material, such as music videos and commercials, increasingly employs this technique.

To create the images in **figures 3** and **4**, I captured still frames using PC-based DVD software. Software limitations cause the artifacts you see in the images, such as the pendulum double-image in **Figure 4b**, and they are not present in the properly deinterlaced display.

RESULTS AND RESOLUTION REMINISCING

Table 1 shows the results for each deinterlacer, for which I tested every possible combination of analog video-input modes, including composite, S-Video, and—if supported—interlaced component, and video-output modes, including component and RGBHV. The deinterlacing results for all mode combinations were identical; therefore, I didn't further subdivide the **table** by input and output format. Had I also tested the equipment with a randomly noisy video feed coming from my cable connection or from a terrestrial-broadcast-antenna source, I suspect I'd have seen more variability both between units and between tests on the same unit.

A red box in the **table** indicates that the unit consistently created objectionable artifacts, and a green box indicates that the unit consistently "passed" the test. A yellow box indicates either that the unit occasionally failed the test at certain points within the frame or that the artifacts it produced were judged less objectionable than others I'd seen from units that used a different deinterlacing method.

In analyzing the results, look first at the situations in which I forced the unit into a specific deinterlacing mode: film, video, or still video if available. These tests indicate whether the hardware and corresponding software algorithms inside the unit can properly deinterlace the material. It's obvious that the Focus Enhancements QuadScan Elite and the Toshiba SD-6200 share the same Genesis Microchip deinterlacing subsystem. The Toshiba DVD player's "video" mode appears to use a blend of the Focus Enhancements deinterlacer's "video" and "still-video" modes.

Next, look at the "auto" deinterlacing modes. Poor results here might indicate a software issue, which a firmware upgrade could fix. Such an issue could be, for example, that an algorithm "guessed" wrong when presented with a complex blend of still and in-motion objects or of film- and video-sourced material. Alternatively, the errors might reflect a more fundamental hardware limitation; for example, the chip might have limited buffer memory that forces it to select "film" or "video" mode based only on analysis results of the first few scan lines in each field. The fourth torture test is ideal for assessing this situation because the video-sourced caption location is in the bottom of the frame.

Unfortunately, I had access only to the Silicon Image iScan Pro's "auto" mode, so I wasn't able to fully assess the deinterlacing capabilities of the SiI503 chip inside. Also, the mixed film-and-video green-box result for the Princeton Graphics AF3.0HD is deceptive; because the unit's line doubler offers no film mode, there was no chance that it could fail the test.

One piece of data that the **table** *doesn't* capture is the excellent job that Sage's FLI2200 did deinterlacing diagonal edges. All of the other deinterlacing processors created jagged-edge alias artifacts at the boundary between the pendulum and the black background, particularly when the pendulum was near its apex and more noticeable the sharper the display. With the FLI2200's DCDi enabled, edges were smooth throughout the pendulum cycle. I noted similar quality improvements in "Montage of Images," such as with the clip of the American flag flapping in the breeze, and with other real-life material containing objects in motion at different rates of speed and in different directions.

However, pixel-specific selection of temporal or spatial interpolation and of specific percentages of nearby pixels' information for this interpolation comes with an important caveat: The more pixel-specific the selection criteria, the higher the potential that random analog or

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digital video noise or other extraneous artifacts will fool the algorithm into "thinking" that, for example, motion exists when it really doesn't. I noticed no incorrect decisions with the FLI2200 and the pristine DVD material I fed it, but I'd like to repeat my testing with less forgiving video content.

I have been critical of video subsystems that enable a user to stretch and horizontally distort 4:3-aspect-ratio video material to fill an entire widescreen display (**Reference 1**). In fact, some televisions automatically perform this function when you drive their RGBHV or progressive-component inputs. Some of these sets don't even allow you to disable stretching, necessitating circumventing modes in deinterlacers, such as the "squeeze" function that the Silicon Image iScan Pro offers.

However, the distortion that horizontal stretching causes was less obvious than I'd feared, particularly after my eyes and brain had a chance to compensate after a few minutes' viewing. Both the AF3.0HD and 1600SW support automatic stretching, and I didn't even realize that the AF3.0HD was distorting the 4:3-aspect-ratio torture-test clips until I viewed them on my NTSC television. Similarly, after using my desktop computer hooked to the 1600SW for a while, text looks abnormally tall when I view it on my notebook computer's 4:3 LCD.□

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