The Format Conversion Problem

futureware

Products for the Broadcast Industry

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The broadcast industry has historically faced compatibility problems. One important conversion problem is adapting film to television (telecine). Film frame rates are 24 frames per second, while American television (NTSC) is 60 fields per second. This conversion is typically performed by "3:2 pulldown", a technique where one film frame is played for three NTSC field times, and the second is played for two NTSC field times (figure 1). This technique results in noticeable motion errors (jitter). The worst case of such a conversion is the apparent fast motion in Charlie Chaplin films, where no allowance is made for the different native frame rate of older film (film has been recorded at 18, 16, 15 and 12 frames per second).

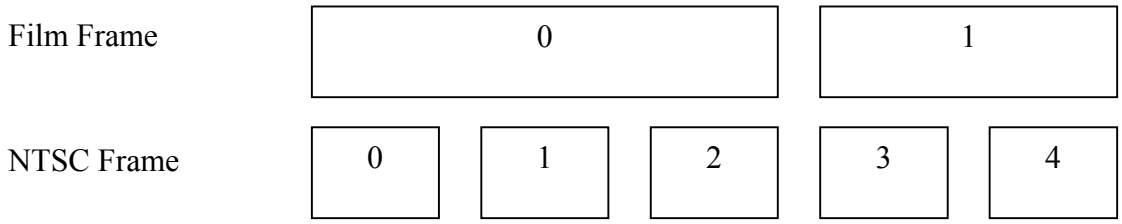

Figure 1. Film is typically converted to NTSC by 3:2 pulldown, which plays film frames for different periods of time (introduces jitter).

American and European television standards (NTSC and PAL respectively) are fundamentally incompatible in the number of lines of resolution (243 vs. 288) and frame rate of display (60 vs. 50), and yet American programs are in great demand in the United

Kingdom, and vice-versa. A long-standing problem has been production of high-quality conversion between these formats.

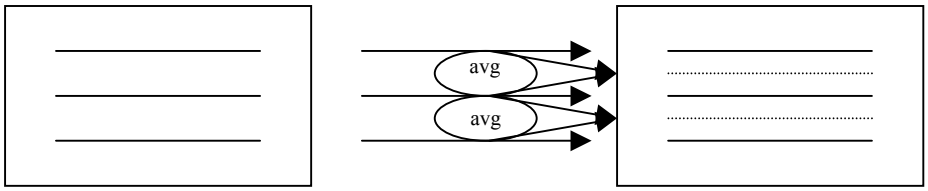

Figure 2. Conversion between lines is done with an averaging algorithm (filter) in typical NTSC to PAL conversions.

Typical techniques use complex averaging algorithms to synthesize the missing lines when converting from the lower resolution NTSC image to higher resolution PAL picture (figure 2). Frame rate conversion is normally done with a similar strategy to the film conversion procedure described above (figure 3).

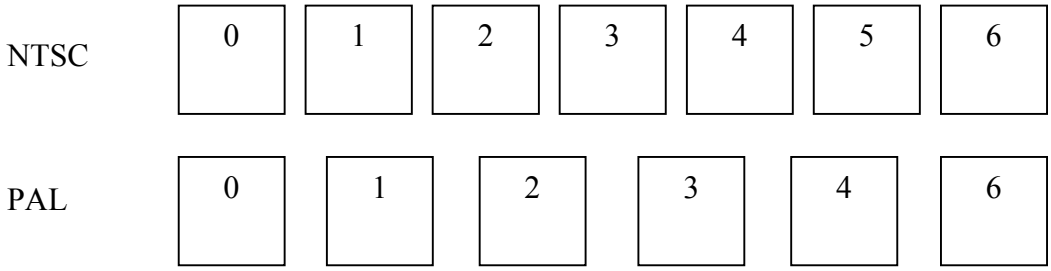

Figure 3. When converting from higher frame rate NTSC (60) to lower frame rate PAL (50), one frame in six is dropped. Going the other way, one frame in five is duplicated (not shown)

Simple averaging between frames is done in higher-end equipment, which reduces jitter at the cost of ghost images. These simple techniques are embedded, at the high end, in products priced between $40,000 and $88,000 (Faroudja).

The most sophisticated system in today's marketplace is known as motion estimation (Snell and Willcox). This technique attempts to determine the position and rate of movement of objects on the screen, then interpolates those positions to create intermediate frames (figure 4).

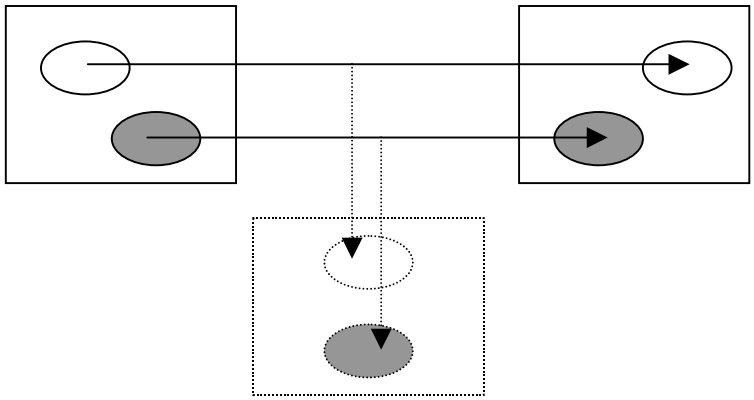

Figure 4. Two moving objects are detected on the screen, and their intermediate position calculated (dashed frame).

This sophisticated yet error-prone technique (figure 5) comes with a price tag as high as $200,000.

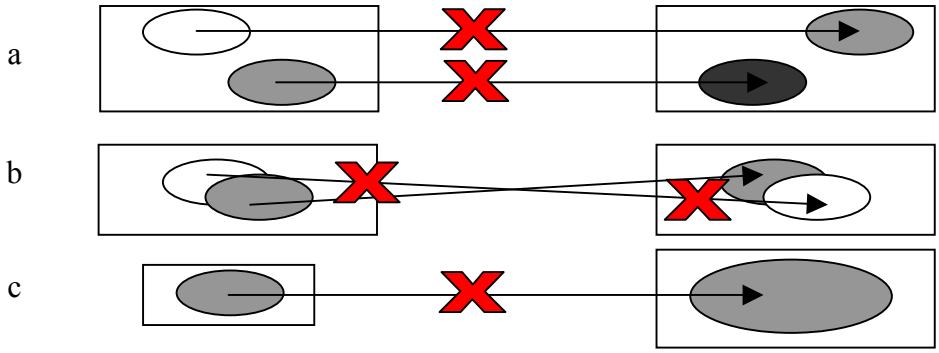

Figure 5a. As objects move, they may move or rotate with respect to the camera, and the lighting may change, causing failure to recognize objects. 5b. Objects also may partially cover one another, revealing unexpected surfaces that cannot be predicted with motion estimation. 5c. Motion estimation cannot help render objects at different resolutions.

The situation worsens when the modern push to digital standards is considered. The Federal government had recommended no fewer than 31 standards by 2001, and 76 standards are on the books today (www.atsc.org). The number of standards that might have to be serviced has grown beyond the reasonable capability of a studio.

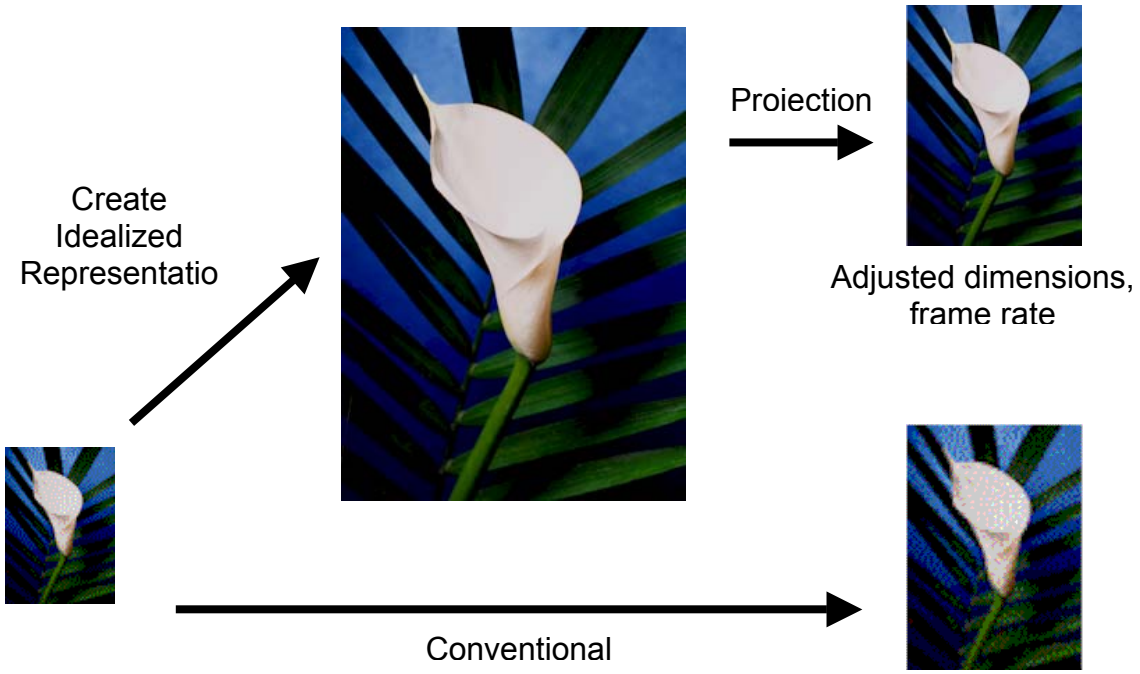

Figure 6. Markvov Prediction extracts all of the information statistically available from an image, and projects that information onto the new resolution.

Futureware developed a technology (Markov-Prediction™) that statistically analyzes the activity in the video and constructs an idealized model of the input video sequence. This idealized model is then sampled at the new display format (figure 6). This technique gives the maximum theoretically possible quality in the conversion, without introducing motion artifacts or stair stepping (aliasing).

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