An Analysis of Frame Interpolation in Video Compression and Standards Conversion

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The interpolation of frames into a video stream is a problem common to the design of video compression techniques [1] and of conversion schemes for the transfer between various video standards and formats, such as frame rate conversion and de-interlacing. For much video material the sampling rate in the spatial domain is sufficiently high that resampling or other processing to change the spatial resolution does not routinely introduce objectionable artifacts. However, the temporal sampling rate, measured in frames per second, is low enough that conversions between framing rates commonly introduce undesirable artifacts.

This study considered metrics for use in assessing the quality of interpolation schemes. Recently, it has been suggested that the L^1 norm is a preferred metric in the comparison of images [2]. We applied both the time-averaged L^1 and L^2 norms ([2]) to video streams, processed according to each of two interpolation schemes. The norms were compared for their ability to detect various levels of interpolation error.

We implemented two interpolation schemes: a frame dropping/repeating scheme, which has roots in telecine conversions, and a linear interpolator. Because the effectiveness of any algorithm is dependent on the motion content in the material to which it is applied, it was necessary to analyze these techniques on 'live video', for which we employed standard material [3]. A simple, yet relatively stringent, test is whether the interpolation algorithm regenerates, with 'small' residual, single frames which have been dropped periodically from the sequence.

The L^2-based norm discriminated between low and high levels of interpolation error more effectively than did the L^1-based norm. Short sequences of interpolated video were generated and viewed in real time to provide a comparison. The study was carried out on a real-time video supercomputer, the Princeton Engine at NIST.

[1] 'Coding of moving pictures and associated audio', Committee Draft of Standard ISO11172: ISO/MPEG 90/176, Dec. 1990.

[2] R. A. DeVore, B. Jawerth, and B. J. Lucier, 'Data Compression using Wavelets: Error, Smoothness, and Quantization', Proceedings DCC 1991, 186-195, Snowbird, Utah USA, 8–11 April 1991.

[3] S. Wolf, M.H. Pinson, S.D. Voran, amd A.A. Webster, 'Objective Quality Assessment of Digitally Transmitted Video', IEEE Pacific Rim Conf. on Comm., Computers, and Signal Proc., Victoria, BC Canada. 9–10, 1991.

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