Efficient Rate Control for Motion JPEG2000

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Motion JPEG2000\(^1\) is a video compression scheme whereby each frame of a video is encoded with JPEG2000 (in a still image mode) and the resulting compressed frames wrapped in a file format to produce a compressed video stream. A very important attraction of JPEG2000 is accurate rate control due to the embedded nature of the encoding scheme, which allows compressed bit-streams to be simply truncated to fit a rate constraint. Motion JPEG2000 is thus scaleable and better suited to networked and point-to-point environments.

A rate control technique recommended by the JPEG2000 standard to maximise image quality at a given rate is called post-coding rate distortion optimisation (PCRD-opt). The advantage of using this method is that at any given rate, the optimum video quality can be achieved for that rate since the algorithm uses the actual rate and distortion values of each code-block in each frame to arrive to the desired rate. However due to the rate distortion optimisation procedure, each code-block is substantially over-coded. Since the encoding in JPEG2000 is one of the slower operations, too much over-coding is undesirable especially in video applications where video frames need to be compressed in real time. Furthermore, overcoding results in more memory than necessary for buffering the intermediate compressed data.

A technique that minimises the amount of over-coding in the arithmetic encoding step while maintaining image quality is proposed. Minimising the amount of over-coding is achieved by terminating the encoding process of a code-block once termination conditions have been met. For example, while encoding a particular code-block, the rate distortion slope of the next coding pass is first estimated and then determined whether the estimated slope is below an overall cutoff slope threshold for the current video frame. In the case where the estimated rate distortion slope is below the cutoff threshold the encoding process is terminated. The estimation is based on the rate distortion values of the current and the previous coding passes of the code-block. The overall cutoff slope threshold for a video frame is based on the compressed rate of a previous video frame. Other terminating conditions include: (a) do not terminate if there are no non-zero clean-up pass slopes generated so far, (b) a code-block is require to code at least two bit-planes if the corresponding code-block in the previous frame have been coded for more than 2 bit-planes, (c) do not terminate if there are no non-zero clean-up pass rate distortion slope and (d) do not terminate if the codeword length generated by the current coding pass is less than 3 bytes long.

Visually the image quality using the proposed rate control scheme is comparable to that of using PCRD-opt as recommended by the JPEG2000 standard and is about 30% faster. Furthermore the proposed rate control strategy produces a fully compliant JPEG2000 code-stream.

\(^1\) Described in the publication Motion JPEG 2000 Final Committee Draft 1.0, 14 March 2001 ISO/IEC 15444:3 (Part III) 2000