Performance Analysis of Dual Frame Motion Compensation

Da Liu[1], Xiangyang Ji[2], Debin Zhao[1], Wen Gao[2]
[1]Department of Computer Science，Harbin Institute of Technology，Harbin, China
[2]Institute of Digital Media, Peking University, Beijing, China
dliu @jdl.ac.cn

In dual frame video coding, one short-term reference frame (STR) and one long-term reference frame (LTR) are available for motion compensation. The STR is the previous frame of current frame. The LTR remains static for a few frames, and then jump forward.

In this paper, for different GOP length and bits allocation of the LTR, the coding performance of dual frame motion compensation is analyzed. The rate-distortion modeling of multi-hypothesis motion compensated prediction [1] is employed to analyze the performance of dual frame motion compensation. In [1], $\Phi_{ee}(\omega_x,\omega_y)$ is defined as the power spectral density of the prediction error. For the same signal *s*, if $\Phi_{ee}(\omega_x,\omega_y)$ is smaller, the coding performance is better. In dual frame motion compensation, the STR utilize the LTR as reference picture, the prediction error is small. So the coding of STR has performance gain. With the increase of LTR GOP length, the prediction performance of LTR to the following STR decreases, the power spectral density of the prediction error $\Phi_{ee}(\omega_x,\omega_y)$ in STR increases, the coding performance of STR decreases. The LTR utilize the STR as reference picture, the prediction error from the STR is large. So the coding of LTR has performance loss. At first, the performance gain of STR is larger than the performance loss of LTR, with the increase of GOP length, the performance gain of STR coding decreases, the performance loss of LTR coding increases. So the coding performance of dual frame motion compensation first increases. If the GOP length is larger than a certain point, the coding performance decreases. With the increase of bits allocation in LTR, the average power spectral density of the prediction error $\Phi_{ee}(\omega_x,\omega_y)$ first decreases, the coding performance increases. If the bits in LTR are larger than a certain point, the average $\Phi_{ee}(\omega_x,\omega_y)$ increases, the coding performance decreases.

During the video transmission over noisy channel, the error propagation of dual frame motion compensation is analyzed. The GOP length will influence error propagation. With the enhancement of GOP length, the speed of error propagation will be smaller. The video sequence can get better performance in decoder. And the error concealment can influence error propagation. With the increase of bits allocation in LTR, the error concealment decreases, then the error propagation decreases. Based on the analysis, a different bits allocation and GOP length is given to LTR to enhance error resilience. The LTR GOP length is 1.7 times the GOP length in error-free channel. The allocated bits to LTR are 1.2 times the bits that allocated to LTR in the error-free channel.

Finally the analysis is proved by the experimental results. At encoder, the PSNR gain bringing by the proposed dual frame coding structure is up to 1.5 dB. At decoder, the PSNR gain bringing by the proposed error resilient dual frame motion coding structure is up to 6 dB at different bit error rates, compared with traditional H.264 coding structure.

Reference:

[1] B. Girod, "Efficiency analysis of multihypothesis motion-compensated prediction for video coding," IEEE Trans. Image Process., vol. 9, no.2, pp. 173–183, Feb. 2000.