The research on image quality assessment and H.264 video coding technology

A Dissertation Submitted for the Degree of Doctor of Philosophy

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Abstract

More and more images & videos must be transmitted via all kinds of networks such as digital broadcast television network, internet and wireless mobile network etc. But video must be compressed with the optimal visual quality according to the bandwidth before transmitting. Image quality and the bandwidth or bit rate of the digital output signal are significant to video compressing. And image quality assessment and rate control are also two primary issues in video processing.

This dissertation focused on H.264 video coding and image quality assessing. H.264 is the most advanced video coding standard developed by ITU and ISO, which might become the standard for 3G and other device of video storage or transmission. This dissertation could be divided into two parts. One was the image quality assessing and rate control through theoretical analysis and observation. The other was the optimization and implementation of H.264 encoder on the embedded DSP. Some results of this dissertation have been applied into UAV (Umanned Autonomous Vehicle) project.

The distortion of image and video could not be assessed as common signals. Machine learning techniques were introduced with cluster and regression analysis to set up new image quality assessing model. Experiments were made by using JPEG database from University of Texas. Then a new video quality-assessing model was proposed based on single image quality with different weights. The results from simulation experiments showed the model was valid. An HMPIQAM (Hierarchical Multi-Parameter Image Quality Assessment Model) was also proposed based on observations. Firstly, the global quality was obtained by examining the outline distortion factor in time-domain and energy loss in DCT (Discrete Cosine Transform) domain and color distortion factor. Secondly, the detailed image quality assessment was made based on the results of the global quality assessment. Blocking and blurring features were used to define the image detailed quality. Finally, a comprehensive quality assessment model was constructed by using non-linear regressing prediction based on the global and the detailed quality assessment results.

SVM (Support vector machines) and its application were also researched since SVM was used in image and video quality assessing more than once. Wavelet kernel support vector machines was proposed by combining wavelet with support vector machines, which could converge at the same error with better sparsity or under the same error permitted it could get better approximation. Several ways were proposed, in which SVM were used in digital watermarking including embedding, extracting and attacking.

For the future of JVT (Joint Video Team), it’s still the first task to enhance encoder's performance, in which rate control was involved. Several proposals of H.264 rate control, such as JVT-G012, JVT-I049, JVT-O016 etc, which had been adopted by JVT, were analyzed here. An enhanced rate control algorithm was proposed. Different target bits were allocated to the P frames remained with image quality descriptor. Target bits allocation would be more accurate by using the new algorithm. And smaller variation of the bit rate and the image quality were obtained with this algorithm.

The performance of H.264 was high with complexity two times of MPEG-2. To optimize the encoding algorithm and lower its complexity would be very important to the implementation of H.264 based on the embedded DSP. The other part of this dissertation mainly deals with the problem. H.264 video compressing system with image capture and RS422 transmitter based on BF561 was discussed in details.

To improve the efficiency of H.264 video encoder, optimizations on the structure, as well as on the algorithm, were applied to video encoder. A fast algorithm of H.264 inter-frame sub- block mode selection and intra-frame mode selection based on statistic threshold was proposed. Optimizations on structure included less jump instructions and better resource allocation of inside memory. Some time-consumed parts of encoder such as big loop program were rewritten in assemble language and video processing instructions of Blackfin were used in parallel as much as possible.

Key words: signal processing, video coding, H.264 standard, embedded system, image quality assessment